Basis of Design

This section applies to the design and selection of medium voltage switchgear, primarily for use in substations.

**Design Criteria**

- 13.8kV equipment shall be 15kV class, 4.16kV and 2.4kV equipment shall be 5kV class.
- Equipment must match existing campus switchgear used in similar applications.
- Stacked cubicles shall have cable entrances arranged to allow independent operating clearances for all devices and connecting cables, e.g., offset cable entrances and chimneys in termination compartments.
- Place control wiring in raceways where possible. Where supported with tie wraps, the ties shall be bolted or screwed to their compartment wall. Adhesive supports are not acceptable.
- The enclosures shall have hinged padlockable metal doors on the front and rear of each cubicle (separate doors for upper and lower compartments).
- Design cubicle heaters to operate at half voltage (208V equipment energized at 120V).
- Ground bus attachments shall be via A. B. Chance studs.
- Provide bus to cable termination connections with removable boot insulating covers.
- Main bussing shall run continuously through the lineup and shall include a full sized neutral bus, isolated and supported in the same manner as the phase busses.
- Bus material shall be copper, silver plated at connection points.

**Design Evaluation**

The following information is required to evaluate the design:

- **Programming Phase**: Describe proposed site, power rating, and connection arrangement (ring bus, preferred/alternate, etc.)
- **Schematic Design Phase**: Describe proposed equipment location, sizes, ratings and space requirements for equipment replacement routing.
- **Design Development Phase**: Describe final equipment sizes and ratings. Provide an outline specification and protection/coordination requirements.
- **Construction Document Phase**: Final plans, including front elevation & section views, fault bracing & seismic anchoring information. Detail drawings showing shipping splits, assembly data, wiring diagrams. Complete coordination study and final specifications.
Submittals

- Furnish with each metal-enclosed switchgear assembly a set of drawings complete with a bill of material and showing the following: Typical front views and open side views for each bay as well as typical components, their positions, and available space for cable termination; an anchor bolt plan with dimensions; a one-line diagram; and appropriate wiring diagrams.
- Comprehensive instruction manual for installation and operation of each component
- Certification of ratings of the basic switch and fuse components and the integrated metal-enclosed switchgear assembly consisting of the switch and fuse components in combination with the enclosure(s)
- Certification of voltage, current, fault, and BIL ratings
- Metering equipment and ratings
- Protective equipment shop drawings
- Manufacturer's technical bulletins for each protective relay or device
- Component lists
- Nameplate schedule
- Factory and on-site testing procedures
- Factory test records
- Shipping split and bus connection procedures
- Leveling requirements and tolerances

Products, Material and Equipment

- Approved Switchgear manufacturers:
  1) ASCO-Delta
  2) Russelectric
  3) Cutler Hammer
- Power Circuit Breaker manufacturer:
  1) Cutler Hammer Vacuum Breakers (VCP-W), no exceptions

Installation, Fabrication and Construction

- Incoming line section shall consist of one or more air load interrupter switch(es), quick-make, quick-break, three-pole, gang operated.
- The switchgear assembly shall consist of individual vertical sections housing combinations of circuit breakers and auxiliary equipment, bolted together to form a rigid metal-clad assembly with grounded steel barriers between compartments.
Enclosure Construction

- Construct metal-enclosed switchgear in accordance with the minimum construction specifications of the fuse and switch manufacturer to provide adequate electrical clearances and space for fuse handling.
- Give consideration to all relevant factors such as controlled access; tamper resistance; corrosion resistance; protection from ingress of rodents, insects, and weeds; arcing faults within the enclosure.
- Each bay shall be shall be unitized monocoque construction to maximize strength, minimize weight, and inhibit corrosion.
- Each bay containing high-voltage components shall be a complete unit in itself, with full side sheets resulting in double-wall construction between bays. Side and rear sheets shall not be externally bolted to guard against unauthorized or inadvertent entry.
- To guard against corrosion, all hardware, all operating-mechanism parts, and other parts subject to abrasive action from mechanical motion shall be nonferrous materials, galvanized, or zinc-nickel-plated ferrous materials. Cadmium-plated ferrous parts shall not be used.
- Do not use externally accessible hardware for support of high-voltage components or switch-operating mechanisms within the switchgear.
- The integrated switchgear assembly shall have a BIL rating established by test.

Door Construction

- Doors shall have 90-degree flanges and shall overlap with the door openings. Weld door flanges at the corners and form with a double bend so that the sheared-edge flanges at the top and both sides fold back parallel to the inside of the door.
- Door handles shall be padlockable and, on outdoor gear, shall incorporate a hood to protect the padlock shackle from tampering.
- Provide at least three concealed, interlocking, high-strength latches for doors over 40 inches in height. Provide doors that are less than 40 inches in height with 2 latches.
- Doors giving access to interrupter switches or interrupter switches with power fuses shall be provided with a wide-view window and constructed of an impact-resistant material to facilitate checking of switch position without opening the door.
- Provide doors giving access to high-voltage components with a sturdy, self-latching door holder which shall be zinc-nickel plated and chromate dipped. Provide full-height hinged covers over low-voltage compartments with a galvanized rod-type door holder. In addition provide an internal protective screen, bolted closed, to guard against inadvertent entry when the enclosure door is open.
- Doors giving access to fuses or fused voltage transformers shall have provisions to store spare fuse units, refill units, or interrupting modules.
Insulators and Bushings

- The interrupter switch and fuse-mounting insulators, main-bus support insulators, insulated operating shafts, and push rods shall be of a cycloaliphatic epoxy resin system, with homogeneity of the cycloaliphatic epoxy resin throughout each insulator to provide maximum resistance to power arcs.
- Provide isolating through-bushings for the switchgear assembly between all bays to guard against the propagation of a fault from one bay into the adjacent bay.
- For outdoor or drip-proof applications, install a drain channel above the isolating through-bushings as a backup for the bay-to-bay gasketing to prevent moisture from the bushing or the bus.
- The bushings shall be of a nontracking, self-scouring, nonweathering cycloaliphatic epoxy resin. Such bushings shall be the only dielectric insulating material between the energized bus conductor and the ground plane. Isolating systems that incorporate multiple insulating materials in series shall not be acceptable.
- The overall length of the bushing shall be a maximum of 9½ inches from end to end. The bushings shall provide a minimum of 12½ inches of leakage distance between the energized bus conductor and the ground plane.
- The bus conductor shall not be molded or cemented into the bushing.
- Do not cover the bus conductors with any insulating material in an effort to achieve BIL or increased leakage distance at locations where the bus passes through the bays.
- Close openings between the bushings and bus conductors with a semiconducting grommet. Fiberglass or porcelain shall not be used for such purpose.
- Bushing bus conductors and main bus conductors shall be designed for direct connection and shall not require laminated or flexible bus connections.

High-Voltage and Ground Bus

- Bus supports, bus, and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the switchgear.
- Equip bus to where cable will be terminated with grounding provisions. Provide grounding provisions on the ground bus in such bays as well.
- Bus and interconnections shall consist of copper bar CA110, square edge, hard temper per ASTM B187. Bolted copper-to-copper connections shall have silvered interfaces and shall be made with ½"—13 stainless-steel bolts with two brass flat washers per bolt, one under the bolt head and one under the nut, and with a stainless-steel split lockwasher between the flat washer and the nut. Tighten these bolts to 35 foot-pounds torque.
- Provide a ground bus of short-circuit rating equal to that of the integrated assembly (or ground connection, in single-bay switchgears), maintaining electrical continuity throughout the switchgear.
- In each bay, bolt the ground bus (or connector) to a nickel-plated steel bracket which shall be welded in place.
- For multi-bay metal-enclosed switchgear assemblies, provide two ground cable connectors accommodating No.2 through 500 Kcmil conductors for connection of ground bus to station ground.
Power Circuit Breakers

- Provide Cutler Hammer vacuum breakers (VCP-W), metal enclosed, drawout, motor operated, with auxiliary contacts for remote monitoring of open, closed, and alarm conditions.

Protective Bus Relays

- Provide Schweitzer relays.

Finish and Features

- Achieve full coverage at joints and blind areas by processing enclosures independently of components such as doors and roofs before assembly into the unitized structures.

- All surfaces shall undergo a thorough pre-treatment process comprised of a fully automated system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling before any protective coatings are applied.

- For outdoor switchgear, after pretreatment, apply protective coatings to resist corrosion and protect the steel enclosure. Representative test specimens coated by the enclosure manufacturer's finishing system shall satisfactorily pass the following tests:
  1) 4000 hours of exposure to salt-spray testing per ASTM B 117 with Underfilm corrosion not to extend more than $1/32$ inch from the scribe as evaluated per ASTM D 1654, Procedure A, Method 2 (scraping). Loss of adhesion from bare metal not to extend more than $1/8$ inch from the scribe.
  2) 1000 hours of humidity testing per ASTM D 4585 with no blistering as evaluated per ASTM D 714
  3) 500 hours of ultraviolet accelerated weathering testing per ASTM G 53 using lamp UVB-313 with no chalking as evaluated per ASTM D 659, and no more than a 10% reduction of gloss as evaluated per ASTM D 523
  4) Crosshatch adhesion testing per ASTM D 3359 Method B with no loss of finish
  5) 160-inch-pound impact followed by adhesion testing per ASTM D 2794 with no paint chipping or cracking
  6) Oil resistance testing consisting of a 72-hour immersion bath in mineral oil with no shift in color, no streaking, no blistering, and no loss of hardness
  7) 3000 cycles of abrasion testing per ASTM 4060 with no penetration to the substrate

- For outdoor enclosures, apply a heavy coat of insulating "no-drip" compound to the inside surface of the roof to prevent condensation.

- The finish shall be light gray, satisfying the requirements of ANSI Standard Z55.1 for No. 61 or No. 70. or shall be olive green, Munsell 7GY3.29/1.5 for outdoor switchgear. include an inside baffle with louvered openings. Vents for outdoor switchgear shall be rain-resistant, corrosion-resistant, and shall have an inside screen.

- Lifting eyes shall be removable. Sockets for lifting eyes shall be blind-tapped.

- For outdoor switchgear, door openings shall have resilient compression gasketing to prevent water from entering the enclosure. Gasket seals shall be provided at the top and side edges of adjoining bays to prevent water entry between the double walls.
• For outdoor switchgear, cover the top and both sides of bus openings between bays with channel gasketing as an additional protection against entrance of water.

• Outdoor switchgear roofs shall be weather-sealed in place with a suitable sealant.

• For outdoor switchgear, provide space heaters with sheaths of high-temperature chrome steel to maintain air circulation inside the enclosure. There shall be a space heater in each bay. Heater circuits shall be have low-voltage breakers and thermostats.

• Provide safety grounding cables per switch.

**Delivery, Storage and Handling**

• Package and ship breakers and accessories separately from the switchgear structures.

• Equip switchgear to be handled by crane. Where installation by crane is not possible, switchgear shall be capable of being moved on rollers or skids. Jacking into place shall not damage the equipment.

END OF DESIGN GUIDE SECTION