Metal-Enclosed Switchgear - Advantages

Around industrial plants, universities, waste water treatment facilities, convention centers and similar other large facilities usually there is a need to distribute electrical power located below the ground surface at medium voltage (5kV - 38kV) via cable circuits. Typically, these circuits are connected to a central assembly of switchgear, fed by a main circuit from the local utility, and arranged in lineups of multiple cubicles.

There are basically two types of Medium-Voltage (MV) Switchgear lineups: Metal-Clad (containing drawout circuit breakers) and Metal-Enclosed (containing load-break switches and fuses). The fuses used in Metal-Enclosed equipment can be either expulsion or current-limiting. Figure 1 represents the relative energy-limiting capabilities of MV breakers, expulsion fuses and current-limiting fuses, which in the case of Metal-Enclosed Switchgear utilizes expulsion and current-limiting fuses for protection to provide the best energy limitation.

These two types of medium-voltage switchgear lineups of cubicles are defined in ANSI Standards (C37.20.2 for Metal-Clad and C37.20.3 for Metal-Enclosed). Criteria for selecting one of these two types of switchgear should be: security, ease of operation, the quality of protection offered, first cost and life-cycle cost.

<table>
<thead>
<tr>
<th>Let-through energy (I^2t)</th>
<th>FOR 40KA RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRCUIT BREAKER (5 cycle)</td>
<td>133 x 10^6 A^2 Sec</td>
</tr>
<tr>
<td>EXPULSION FUSE (1/2 x 1 cycle)</td>
<td>20 x 10^6 A^2 Sec (Average)</td>
</tr>
<tr>
<td>CURRENT-LIMITING FUSE (200A)</td>
<td>1 x 10^6 A^2 Sec (Typical)</td>
</tr>
</tbody>
</table>

Figure 1. The dark area under each curve represents the relative energy limitation of damaging let-through currents provided by various protective devices. The curves illustrate that fuses allow through much less damaging let-through currents and, therefore, do a much better job of protecting cables and transformers.
Figure 2 below is a summary table of features favoring the selection of Metal-Enclosed lineups with switches and fuses:

While Metal-Enclosed Switchgear using load-interrupter switches and fuses has many economic and protective advantages over Metal-Clad using circuit breakers, Federal Pacific, whose predominant construction is Metal-Enclosed, will use a drawout circuit breaker to handle high, continuous load-currents that exceed the fuse rating of a switch and fuse combination or for automatic reclosing. Since faults on industrial power systems are almost always “permanent”, automatic reclosing is not desirable because subsequent reclosing will only cause further damage to cables and equipment. Thus, Metal-Enclosed switchgear lineups are the better choice.

### Advantages of Metal-Enclosed over Metal-Clad

- Lower Initial Cost per cubicle (Metal-Enclosed = 1/3 of Metal-Clad)
- Better protection for cables and transformers
- Significantly lower let-thru currents (mechanical energy)
- Significantly lower let-thru I²T (thermal energy)

(Breakers take 5 cycles from relay sensing to circuit interruption. Power fuses require no more than 1 cycle for circuit interruption.)

- Lower installation cost (simple field assembly)
- No auxiliary power or VTs are needed
- No maintenance required for fuses
- No possibility of reclosing on a fault with fuses
- Single-phase protection: Shunt trip of three-phase switch in feeder cubicle when a fuse operates

### Dimensions for Federal Pacific Metal-Enclosed Switchgear

<table>
<thead>
<tr>
<th>Voltage Class</th>
<th>Type of O.C. Protection</th>
<th>Width (in inches)</th>
<th>Height (in Inches)</th>
<th>Depth (in Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Manual Operated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5kV</td>
<td>Current Limiting</td>
<td>36</td>
<td>36</td>
<td>90</td>
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<tr>
<td></td>
<td>Draw-out VCB</td>
<td>—</td>
<td>90</td>
<td>94</td>
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<tr>
<td></td>
<td>Expulsion Fuse</td>
<td>41</td>
<td>41</td>
<td>90</td>
</tr>
<tr>
<td>15kV</td>
<td>Current Limiting</td>
<td>36</td>
<td>36</td>
<td>90</td>
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<tr>
<td></td>
<td>Draw-out VCB</td>
<td>—</td>
<td>90</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Expulsion Fuse</td>
<td>41</td>
<td>41</td>
<td>90</td>
</tr>
<tr>
<td>25kV</td>
<td>Current Limiting</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<tr>
<td></td>
<td>Expulsion Fuse</td>
<td>48</td>
<td>53</td>
<td>120</td>
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<tr>
<td>35kV</td>
<td>Current Limiting</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Expulsion Fuse</td>
<td>60</td>
<td>60</td>
<td>130</td>
</tr>
</tbody>
</table>

*Dimensions are for standard production products.
*Add 5.5 inches to the height for Outdoor NEMA 3R enclosures.
*If rear-entry compartment is needed, increase the depth of the compartment by the following dimensions:
  - 5 kV-add 16 inches
  - 15 kV-add 16 inches
  - 25 kV-add 24 inches
  - 35 kV-add 30 inches
Metal-Enclosed Switchgear Application

Federal Pacific Metal-Enclosed Load-Interrupter Switchgear provides a secure, convenient method for switching and overcurrent protection of high-voltage cable systems. The switchgear may be located indoors or outdoors. Typical applications include:

- Service entrance switching.
- Transformer primary and secondary switching.
- Isolation and protection of feeder circuits.
- Loop circuit sectionalizing.
- Manual and automatic transfer from preferred to emergency circuits.

Federal Pacific Metal-Enclosed Switchgear has been designed to meet the most rigid requirements for this class of equipment. High-grade 11-gauge steel panels are designed so that each switchgear bay is an individual self-supporting unit with double walls between bays on multiple bay lineups.

Corrosion-resistant cabinets are assured by chemical cleaning and phosphatizing (or zirconization) followed by a rust-resistant baked powder epoxy prime coat followed by a baked-on polyester finish coat that is UL® Listed for NEMA1 and NEMA 3R installations. Powder coats are applied using electrostatic deposition. Standard color is light gray, ANSI 61.

The Auto-Jet® II load-break switch is equipped with a quick-make, quick-break stored-energy mechanism. The operating handle is mounted on the right front of the unit at a convenient level with a maximum upward swing of 78" above ground level. The maximum operating force is 60 pounds. The standard manual operating handle may be padlocked either open or closed. A mechanical interlock is provided as standard to prevent opening the door with the switch closed or closing the switch with the door open. Optional key interlocks to replace mechanical interlocks as well as other key-interlock systems are available. Inspection windows are located so that the position of the switch blades may be checked with the exterior bulkhead door closed.

Standard switchgear main bus is rated 600 amperes, 40,000 asymmetrical rms amperes momentary. Optional main bus rating of 1200 amperes is available to 61,000 asymmetrical amperes momentary.

<table>
<thead>
<tr>
<th>kV</th>
<th>Nom. Design</th>
<th>Max.</th>
<th>Continuous &amp; Interrupting</th>
<th>Momentary RMS ASYM</th>
<th>Fault-Closing RMS ASYM</th>
<th>BIL kV</th>
<th>60 HZ Withstand kV</th>
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<tr>
<td>4.8</td>
<td>5.5</td>
<td>600</td>
<td>40,000</td>
<td>40,000</td>
<td>60</td>
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<td>4.8</td>
<td>5.5</td>
<td>1200</td>
<td>40,000</td>
<td>40,000</td>
<td>60</td>
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<tr>
<td>14.4</td>
<td>17.0</td>
<td>600</td>
<td>40,000</td>
<td>40,000</td>
<td>95</td>
<td>36</td>
<td></td>
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<tr>
<td>14.4</td>
<td>17.0</td>
<td>1200</td>
<td>40,000</td>
<td>40,000</td>
<td>95</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>14.4</td>
<td>15.5</td>
<td>1200</td>
<td>61,000*</td>
<td>61,000*</td>
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<td>27</td>
<td>600</td>
<td>40,000</td>
<td>40,000</td>
<td>125</td>
<td>60</td>
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<tr>
<td>25</td>
<td>27</td>
<td>1200</td>
<td>40,000</td>
<td>40,000</td>
<td>125</td>
<td>60</td>
<td></td>
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<tr>
<td>34.5</td>
<td>38</td>
<td>600</td>
<td>40,000</td>
<td>40,000</td>
<td>150</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>34.5</td>
<td>38</td>
<td>1200</td>
<td>61,000</td>
<td>40,000</td>
<td>200</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

* The switch has a 1200 ampere continuous current rating only.

Applicable Industry Standards

C37.20.3 - IEEE Standard for Metal-Enclosed Interrupter Switchgear
C37.20.4 - IEEE Standard for Indoor AC Switches (1kV-38kV) for use in Metal-Enclosed Switchgear
ANSI C37.22 - Preferred Ratings and Related Capabilities for Indoor AC Medium-Voltage Switches Used in Metal-Enclosed Switchgear
IEEE C37.30 - Requirements for High-Voltage Air Switches
ANSI C37.32 - High-Voltage Switches, Bus Supports, and Accessories - Schedules of Preferred Ratings, Construction Guidelines, and Specifications
ANSI C37.34 - Test Code for High-Voltage Air Switches
ANSI C37.57 - Metal-Enclosed Interrupter Switchgear Assemblies – Conformance Testing
ANSI C37.58 - Indoor AC Medium-Voltage Switches for use in Metal-Enclosed Switchgear – Conformance Test Procedures
Most single-bay Metal-Enclosed Switchgear is applied for the HV Switch and Fuse protection of medium-voltage industrial transformers either liquid filled or dry-type in the 500-5000 KVA range. This switchgear can be furnished in NEMA 1 and NEMA 3R construction in the cabinet security classifications of Category A, Category B or Category C.

There are two important economic considerations for selecting the design of single-bay assemblies for transformer switching applications. First, there will be considerable savings by having the switchgear cubicle “closely coupled” to the transformer primary either by flange connection or throat connection. This configuration eliminates the need for additional cable and stress relieving terminations in both the switchgear and transformer and also eliminates the need for an additional rear-entry compartment when bottom cable entry and bottom cable exit are required from a “stand-alone” cubicle.

Second, strong consideration should be given to selecting current-limiting fuses for circuit protection inside the cubicle. Current-limiting fuses provide significantly better fault energy limitation than expulsion fuses in terms of lower “peak let-thru current” (mechanical energy that deforms windings) and lower I²T energy (thermal energy that damages insulation). The initial cost of ME cubicles housing current-limiting fuses is about 25% less than ME cubicles housing expulsion fuses, which during operation can leave significant residue on insulating barriers and cabinet walls.

Exterior view of an outdoor, Category A, single-bay 15 kV metal-enclosed switchgear enclosure containing an Auto-jet®II load-interrupter switch with power fuses.

1. Lifting angles, at top of enclosure (shown on next page) are removable with bolt holes blind-tapped.
2. Screened ventilation perforations include an internal backup plate.
3. Weather sealant between roof and enclosure and between bus extension cover plate and enclosure.
4. Heavy-gauge steel cover plates over main and ground bus openings.
5. Security cover (optional) over viewing window is hinged and padlockable for Category A installations.
6. Security cover (optional) over switch operating handle can be positioned over handle in either the open or closed position and is padlockable in either location for Category A installations. Lower location shows bottom position of cover when switch handle is in open position.
7. Door handle is recessed, includes penta-head bolt and is padlockable. (Category A only).
8. Channel base of heavy-gauge steel supports enclosure of outdoor units only.
Enclosure door is open to show internal screens with openings for viewing switch position and blown-fuse indicators.

9. Stainless-steel door hinges and pins ensure easy movement of doors throughout equipment life.
10. Windows of a polycarbonate material are weather-sealed using gasketing and sealants on outdoor units.
11. Three-Point high-strength door latches and door rods.
12. Backup plate for ventilation openings on outdoor units.
13. Storage box for replacement fuses.
15. Gasketing around enclosure entry on outdoor units compresses against back of door when closed to prevent water entry.
16. Sturdy internal screens provide a second barrier to shield against accidental contact and perforated to allow visual inspection.
17. Door interlock prevents access to fuses unless switch is open.
18. Sturdy operating handle with cast-aluminum housing includes provisions for padlocks and key interlocks.
1. Main bus is rated for 600 amperes, 1200-ampere bus is also available.

2. Auto-Jet® load-interrupter switches, rated 600 and 1200 amperes, are UL® recognized and feature an industry-leading three-time duty-cycle fault-closing rating of 40,000 amperes asymmetrical and a one-time duty-cycle fault-closing rating of 61,000 amperes asymmetrical.

3. Unit can be furnished with a variety of power fuses which are current-limiting or expulsion fuses.

4. Ground studs on fuse terminal and provisions on ground bus.

5. GP0-3 fiberglass barriers isolate phases and ground plane.

6. Heater in fused circuit inside outdoor units (not visible on sidewall of enclosure).

Door and screens open showing clear space for terminating cables and replacing fuses.
Features (Single-Bay & Multi-Bay)

- Standard doors are full height. Inner screen doors control access to fuses and other energized components.
- Metering transformers may be located in switch-fuse compartment or may be located in a separate adjacent compartment.
- Switch position can be seen through sealed, clear polycarbonate window and perforated inner screen.
- Bulkhead doors feature 3-point latching, a captive hex-head security bolt, padlockable flush mounted handle, self-latching doorstop and stainless steel concealed hinges. Category A security features are available as an option.
- Switch handles have provisions for padlocking in the opened or closed positions and can accommodate a Portable Remote Operating Mechanism (see optional features).
- Standard ventilation louvers are included at top and bottom on front and back of each bay. All louvers on outdoor assemblies are tamper resistant and have internal screens with filters.
- Mechanical interlock prevents opening door with switch closed or closing switch with door open.
- Bus bars are aluminum (copper optional).
- Ground bus in each compartment is aluminum (copper optional).
- Hinged inner steel door guards against contact with the switch and is perforated to allow view of switch blades.
- "Danger — High Voltage" signs are located on inside on screen doors.
- Rear access is not required except to accommodate special entrance requirements.
- Fuses may be current limiting or expulsion type with exhaust control devices.

Outdoor Units (NEMA 3R)

- Roof weather sealed to enclosure.
- Adjacent bays are sealed to keep water out from between the double walls.
- Roof caps over joints between bays are provided as an added measure to exclude water.
- A space heater (on a fused circuit) in each unit eliminates excessive condensation.
- Externally removable filters provided with outdoor features.
- Formed steel channel base on each individual unit has an insulating coating applied.
- Underside of all roofs have a heavy coat of anti-condensation compound.

Optional Features and Accessories

- Portable Remote Operating Mechanism - fits over manual handle and allows switch to be opened or closed from outside the arc-flash boundary.
- Mimic Bus
- Single-Phase Protection
- Blown Fuse Indication
- Analog or Digital Customer Metering
- Utility Metering
- Drawout VTs or CPTs
- Undervoltage Trip
- Overvoltage Trip
- NEMA 3R Enclosure
- UL Listing (5 and 15kV)
- Station, Intermediate and Distribution Class Surge Arresters
- Key Interlocks
- Motor Operator, Auxiliary Switches, Operation Counter
- Current Transformers
- Special Paint
- Special Enclosure Material (304 or 304L Stainless Steel)
- Close Coupling to Transformers, Existing Switchgear, or Retrofit
Federal Pacific has developed a portable remote operating mechanism (PROM) that can be applied for operation of manually-operated Auto-jet® switches from a location outside the critical arc-flash boundary zone. The fittings required to accommodate the portable mechanism can be retrofitted onto switchgear already installed in the field. Alternately, the fittings can be provided as an option on new switchgear.

Designs of the Federal Pacific PROM Portable Mechanism are available for operation of Auto-jet® switches rated through 38kV on both metal-enclosed switchgear and pad-mounted switchgear. The portable remote operating mechanism is capable of opening and closing the switch from a distance of up to 50 feet.

**Features:**
1. Extendable 50-foot Air Hose With Fast-On Pneumatic Coupler for Connection to An Air Cylinder and CO₂ Tank
2. Gusseted Mounting-Frame Weldment of Portable Mechanism
3. Ring Bushing With Set Screw Secures Operating Lever to Switch-Operating Handle
4. Lifting Eyes (2)
5. Operating Lever of Portable Mechanism
6. Handle Grip for Portable Operating Station
7. Portable Operating Station Holds Portable Mechanism and CO₂ Tank
8. Shield Isolates Chain-Drive Assembly
9. Mounting Bolts (2) Secure Portable Mechanism Onto Portable Operating Station
10. Air Cylinder With Fast-On Pneumatic Coupler for Connection of An Air Hose
11. Optional Two-Wheel Dolly is Permanently Secured to Portable Operating Station
12. CO₂ Tank, 15 lbs., Provides Approximately 150 Operations
13. Bottom of Portable Operating Station is Formed With a Channel Base to Readily Accommodate a Two-Wheel Dolly When That Option is Not Selected
This checklist is an aid to establish the desired configuration of metal-enclosed switchgear. This page can be used as a guide of what is to be furnished.

These pages contain information for defining the entire lineup and for setting the contents of each bay in the lineup. Insert in the space below each bay the cubicle number shown on “page 132”. The cubicle number and the information in the ‘Unit Requirements’ matrix (below) will allow a clear understanding of what is to be furnished.

There are two basic metal-enclosed switchgear arrangements. One is a single-bay transformer primary that is almost always used for a fused HV switch connected to a liquid-filled or dry-type transformer, or can add-on bay to an existing switchgear assembly. It is suggested that this single cubicle be attached (closely coupled or throat connected) to a transformer to eliminate costly extra terminations and rear cable entry compartment needed for “bottom cable entry” and “bottom cable exit” in the same cubicle.

The second type of switchgear arrangement is a multi-bay lineup containing two (2) or more cubicles. Within this type of arrangement there are several basic types of cubicles:

- Incoming (sometimes fused)
- Feeder (almost always fused)
- Transition (main bus is redirected from a top routing to a bottom routing or vice versa)
- Metering (includes current and voltage transformers)

Regarding cubicles with fuses, Federal Pacific recommends that current-limiting fuses be selected wherever possible for better energy limiting protection without the exhaust gases typically associated with expulsion fuses, whose pressures are contained by the cubicle and whose arcing products are de-ionized through an exhaust control device. Cubicles with current-limiting fuses have a significantly lower initial cost than expulsion fuses.

For Incoming Cubicles connected to circuits at 15 kV that are above 400 continuous load amperes, Federal Pacific offers the choice of a metal-clad drawout vacuum circuit breaker that contains in a single module all of the CTs, relays, etc. necessary for operation, and which can be provided with a UL® listing in a standard 36” wide x 90” high cubicle or parallel arrangements of expulsion fuses, which require bays of up to 60 inches in width. Current-limiting fuses can be used in Incoming Cubicles at 5kV up to a continuous ampere rating of 1100 amps.

### METAL-ENCLOSED SWITCHGEAR CHECKLIST APPLICATION GUIDELINES

**Unit Requirements - Applies to the entire lineup**

<table>
<thead>
<tr>
<th>System Voltage:</th>
<th>12000 Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fusing:</td>
<td>![Select Current Limiting] ![Select Expulsion]</td>
</tr>
<tr>
<td>Enclosure:</td>
<td>![Select NEMA 1 (indoor)] ![Select NEMA 3R (outdoor)]</td>
</tr>
<tr>
<td>Bus:</td>
<td>![Select Aluminum] ![Select Tinplate] ![Select Copper] ![Select Silver Plate] ![Select Other]</td>
</tr>
<tr>
<td>Construction:</td>
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<td>Special Seismic Requirements:</td>
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<td>Category (Cabinet Security):</td>
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<tr>
<td>UL® Listed:</td>
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<tr>
<td>Finish:</td>
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<tr>
<td>Door:</td>
<td>![Select Flush Door Handle (Available with Category A only)] ![Select Grip Handle Lever]</td>
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<tr>
<td>Interlocks:</td>
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<tr>
<td>Utility-Type Metering Bay:</td>
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</tr>
</tbody>
</table>

Enter in space below each bay # at right applicable cubicle number from One-Line Diagrams on Page 132.

<table>
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<tr>
<th>Bay #1</th>
<th>Bay #2</th>
<th>Bay #3</th>
<th>Bay #4</th>
<th>Bay #5</th>
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<th>Bay #9</th>
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<td>![Select (Y or N)]</td>
<td>![Select (Y or N)]</td>
<td>![Select (Y or N)]</td>
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<tr>
<td>1-Phase Protection (Shunt Trip)</td>
<td>![Select (Y or N)]</td>
<td>![Select (Y or N)]</td>
<td>![Select (Y or N)]</td>
<td>![Select (Y or N)]</td>
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<td>![Select (Y or N)]</td>
<td>![Select (Y or N)]</td>
<td>![Select (Y or N)]</td>
</tr>
</tbody>
</table>
Typical One-Line Diagrams for Individual Bays of the Lineup Showing the Applicable Cubicle Number and Cubicle Description.

1. **Incoming Vacuum Circuit Breaker** for circuit protection at 15 kV of load currents greater than 400 A.
2. **Bus Entrance**, main bus top, provision for bottom entry.
3. **Switch Only**, main bus top, bottom cable entry.
4. **Switch Only**, main bus bottom, top cable entrance.
5. **Switch/Fuse**, main bus bottom, top cable entrance.
6. **Bus Transition**.
7. **Incoming Cubicle Switch/Fuse**, main bus top, bottom cable entry.
8. **Feeder Cubicle Switch/Fuse**,

10. **Feeder Cubicle Switch/Fuse Only**, main bus top, bottom entry (or exit).
11. **Main-Bus Metering**, provisions for CTs and drawout fused PTs.
12. **Main-Bus Metering**, provisions for CTs and fixed fused PTs.
13. **Bus-Entrance Metering**, main bus top, provisions for CTs and fused PTs, bottom entry.
14. **Switch/Fuse Metering**, main bus top, provisions for CTs and fused PTs bottom exit.
15. **Bus-Transition Metering**, provisions for CTs and fused PTs.

Typical Single Units

- **Switch/Fuse** top cable entrance, bottom cable exit.
- **Switch/Fuse**, bottom cable entrance on side, bottom cable exit.
- **Switch/Fuse** with bottom rear cable entry and with transformer transition.
- **Switch Only**, top cable entrance, bottom cable exit.
- **Switch/Fuse Metering**, bottom rear cable entrance, bottom front cable exit.

Component Standard Symbols

* +* Typical units with corresponding footnote symbols can accommodate the associated components.
A. General

1. Product

The metal-enclosed switchgear shall be in accordance with the applicable plans, drawings and one-line diagrams and shall conform to these specifications.

2. Assembly

The metal-enclosed switchgear assembly shall consist of one or more indoor, outdoor self-supporting bays, containing interrupter switches and/or power fuses with the necessary accessory components, all completely factory assembled and operationally checked.

3. Ratings

a) Ratings for the integrated switchgear assembly shall be as designated below. Select appropriate column.

<table>
<thead>
<tr>
<th>System Voltage Class</th>
<th>5kV</th>
<th>15kV</th>
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<th>25kV</th>
<th>35kV</th>
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<tr>
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<td>kV, BIL</td>
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<td>Main Bus</td>
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<tr>
<td>Continuous Load</td>
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<td>1200</td>
<td>600</td>
<td>1200</td>
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<td>Switch Load</td>
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<tr>
<td>Interrupting</td>
<td>600</td>
<td>1200</td>
<td>600</td>
<td>1200</td>
<td>600</td>
<td>1200</td>
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</tbody>
</table>

b) The manufacturer shall furnish upon request certification of ratings for the basic switch and fuse components and/or the integrated metal-enclosed switchgear assembly consisting of the switch and fuse components in combination with the enclosure(s).

5. Compliance with Standards and Codes

a) ANSI C37.20.3 and IEEE Standard 27 (Standards for Switchgear Assemblies including Metal-Enclosed Bus).

b) Applicable safety and health standards promulgated pursuant to Federal Occupational Safety and Health Act of 1970.

c) Article 490.21(E) "Load Interrupter" in the National Electrical Code, which specifies that the interrupter switches in combination with power fuses shall safely withstand all possible currents up to the assigned maximum short-circuit rating.

d) (Optional) The switchgear assembly shall be UL listed. (Available on 5kV and 15kV switchgear only.)

B. Construction — Assembly:

1. Insulators

The interrupter-switch and fuse-mounting insulators shall be a cycloaliphatic epoxy resin system with material characteristics and restrictions as follows:

a) Operating experience of at least twenty (20) years under similar conditions.

b) Ablative action to ensure non-tracking properties.

c) Adequate leakage distance established by test per IEC Standard 60507.

d) Adequate strength for short-circuit stress established by test.

e) Conformance with applicable ANSI and IEEE standards.

f) Homogeneity of the cycloaliphatic epoxy resin throughout each insulator to provide maximum resistance to power arcs. Ablation due to high temperatures from power arcs shall continuously expose more material of the same composition and properties so that no change in mechanical or electrical characteristics takes place because of arc-induced ablation. Furthermore, any surface damage to insulators during installation or maintenance of the metal-enclosed gear shall expose material of the same composition and properties so that insulators with minor surface damage need not be replaced.

2. High-Voltage Bus

a) Bus and interconnections shall consist of aluminum bar of 56% IACS conductivity.

b) Bolted aluminum-to-aluminum connections (copper is optional) shall be made with a suitable number of non-corrosive bolts and nuts, and with two Belleville spring washers per bolt, one under the bolt head and one under the nut or with a wide, flange-head carriage bolt and one Belleville spring washer per bolt. As an alternate, bolted aluminum-to-aluminum connections shall be made with a suitable equivalent surface area, i.e. I-bolt and spring washer. Bolts shall be tightened to proper torque for the particular Belleville washer.
3. Ground Bus
   a) A ground bus of short-circuit rating equal to that of the integrated assembly (or a ground connection, in the case of single-bay switchgear) shall be provided, maintaining electrical continuity throughout the integrated assembly.
   b) The ground bus shall consist of aluminum bar of 56% IACS conductivity.
   c) In each bay, the ground bus (or connector) shall be bolted to a stainless steel bracket, which shall be welded to the enclosure (copper is optional).

C. Construction - Enclosure & Finish

1. Enclosure
   a) The enclosure of each bay shall be constructed of heavy-gauge formed steel panels that maximize strength, minimize weight, and inhibit internal corrosion. (Optional all welded construction is also available.) For Category A only: externally removable bolted panels will not be accepted unless specified and when specified must be installed with tamper-resistant hardware.
   b) The basic material for the enclosure, roof and doors shall be 11-gauge, hot-rolled, pickled-and-oiled steel sheet.
   c) Each bay containing high-voltage components shall be a complete unit in itself, with full side sheets resulting in double-wall construction between bays. To guard against unauthorized or inadvertent entry, side and rear sheets shall not be externally attached with removable bolts except where tamper-resistant hardware is specified.
   d) Sufficient space shall be allowed for ease of cable pulling and installation. Space shall be free from fixed structural members or electrical devices.
   e) On multi-bay units when “thru-bushings” between the cubicles are specified, the thru-bushings should be shipped completely assembled to the cubicle and shall not require field assembly of semi-conducting grommets.

2. Doors
   a) Doors shall be constructed of 11-gauge hot-rolled, pickled-and-oiled steel sheet.
   b) Door edge flanges shall overlap with door opening flanges and shall be formed to create a mechanical maze that shall guard against water entry and discourage tampering or insertion of foreign objects.
   c) Doors shall have an appropriate number of hinges based on door height and, in no case, less than three when door height exceeds forty (40) inches. The hinges and hinge pins shall be stainless steel and secured in place to guard against tampering.
   d) In consideration of controlled access and tamper resistance, each door shall be equipped with a positive-action three-point latching system.
   e) Doors providing access to fuses shall have provisions to store spare fuse units or refill units.
   f) Each door is provided with a door holder to hold the door open against inadvertent closing. It shall be integral with the door and frame and shall self-secure when the door is fully opened.

For units specified with optional Category A features:
   g) Each door shall be provided with a recessed stainless-steel door handle. The door handles shall be padlockable and shall incorporate a hood to protect the padlock shackle from tampering. Each handle shall be provided with a recessed (select the hex or penta-head) bolt for additional security.

3. Access Control
   a) Doors providing access to interrupter switches with power fuses shall be mechanically or key interlocked to guard against:
      1) Opening the door if the interrupter switch on the source side of the power fuse is closed, and
      2) Closing the interrupter switch if the door is open.
   b) Doors providing access to interrupter switches only shall have provisions for padlocking.
   c) Each bay or compartment thereof containing high-voltage components shall be provided with a protective screen or second door, bolted closed, to guard against inadvertent entry entry to bays containing these components when the enclosure door is open.
   d) Access to the enclosure shall be from the front only, unless otherwise specified (for example) for cable termination at rear.

4. Vents
   Ventilation openings shall be provided at the top and bottom of the unit as required for proper air circulation. Vents shall have stainless steel screened interior baffles to prevent entrance of foreign objects.

5. Lifting Eyes
   Lifting provisions shall be removable and shall not permit entry into the interior when removed.

6. Finish
   a) Full coverage at joints and blind areas shall be achieved by processing enclosure panels or welded enclosures independently of components such as doors and roofs before assembly into the unitized structures.
   b) All surfaces shall undergo a chemical cleaning, phosphatizing or zincation and sealing before any protective coatings are applied in order to remove oils and dirt, form a chemically and anodically neutral conversion coating, improve the finish-to-metal bond, and retard underfilm propagation of corrosion.
   c) The finishing system shall be applied without sags or runs for a pleasing appearance.
   d) After the enclosure is completely assembled and the components (switches, bus, etc.) are installed, the finish shall be inspected for scuffs and scratches. Blemishes shall be carefully touched up to restore the protective integrity of the finish.
   e) Unless otherwise specified, the color shall be ANSI 61 Light Gray.
   f) To assure that the finishing system is capable of resisting corrosion, the manufacturer shall provide if requested certification that representative test panels, protected by the manufacturer’s finish system, have passed the following tests:
      1) Salt spray (relates to coastal environments and/or presence of snow-melting salts or fertilizers). Scribe to bare metal and test for 2000 hours in a 5% salt spray per ASTM B-117. Loss of adhesion from bare metal
should not extend more than 1/8" from the scribe. Underfilm corrosion should not extend more than 1/16" from the scribe.

2) **Crosshatch adhesion** (relates to adhesion after scratching of the finish). Scribe to bare metal a crosshatch pattern of 100 1/16" wide squares. Apply Scotch 710 tape and rapidly remove. There should be 100% adhesion to the bare metal and between layers.

3) **Humidity** (relates to environments with high humidity). Test for 1000 hours subject to 100% humidity at 45-50°C per ASTM 2247. There should be no blisters.

4) **Impact** (relates to transit and handling damage and abuse by public). Impact the test panel with a 160 in.-lb., falling dart per ASTM D-2794. There should be no cracking or chipping of the paint on the impact side of the test panel.

5) **Oil Resistance** (relates to probable contact with mineral oil). Immerse two test panels in mineral oil for 3 days, one at room temperature and one at 100°C (212°F). There should be no apparent changes, such as color shift, blisters, loss of hardness or streaking.

6) **Ultraviolet Accelerated Weathering Test** (Relates to exposure to sunlight and rainfall, loss of gloss, color fading, and chalking). Continuous exposure to ultraviolet light for 500 hours per ASTM G-53 with a cycle of 4 hours ultraviolet followed by 4 hours of condensation. Loss of gloss should not exceed 50% of original gloss per ASTM D-523.

7) **Water Resistance** (relates to rainfall or dew). Immerse a test panel in distilled water for 3 days at room temperature. There should be no apparent changes, such as blistering, color shift, loss of hardness or streaking.

8) **Adhesion** — Fed Spec. 141A, Method 6301.1 (relates to adhesion after scratching the finish). Immerse test panel in distilled water for 24 hours. Make two parallel scratches 1" apart. Apply Scotch 710 tape and rapidly remove. There should be 100% adhesion to the bare metal and between layers.

9) **Abrasion Test** — Taber Abrader (relates to wear encountered during installation). Prepare a panel coated with the component of the finish intended to provide abrasion resistance. Test using a CS-10 wheel, 1000 gram weight, 3000 cycles, per Fed. Spec. 141, Method 6192. This provides a comparative test between samples.

g. To guard against corrosion, all hardware (including door fittings, fasteners, etc.), all operating-mechanism parts, and other parts subject to abrasive action from mechanical motion shall be of nonferrous materials, galvanized, or zinc chromate plated ferrous materials. Cadmium plated ferrous parts shall not be used.

**D. Basic Components:**

1. **Interrupter Switches**

   a) Interrupter switches shall have a three-time duty-cycle fault-closing rating equal to or exceeding the short-circuit rating of the integrated switchgear assembly. These ratings define the ability to close the interrupter switch either alone (un-fused) or in combination with the appropriate fuses three times against a three-phase fault with asymmetrical current in at least one phase equal to the rated value, with the switch remaining operable and able to carry and interrupt rated current. Tests substantiating these ratings shall be performed at maximum design voltage with current applied for at least 10 cycles. Certified test abstracts establishing such ratings shall be furnished upon request.

   b) Interrupter switches shall be completely assembled and adjusted by the switch manufacturer on a single rigid mounting frame.

   c) Interrupter switches shall be provided with contact blades and interrupters for circuit closing, including fault-closing, continuous current carrying, and circuit interrupting. Interrupter switches with auxiliary blades shall not be permitted.

   d) Interrupter switches shall be positively and inherently sequenced with the blade position. It shall not be possible for the blade and interrupter to get out of sequence.

   e) Interrupter switches shall have a readily visible open gap when in the open position to allow positive verification of correct switch position.

   f) Each interrupter switch shall be provided with a switch operating handle. The handle shall be non-removable, and provisions shall be provided for padlocking in open or closed position.

   g) Interrupter switches shall utilize a quick-make, quick-break mechanism installed by the switch manufacturer. The quick-make, quick-break mechanism shall be integrally mounted on the switch frame, and shall swiftly and positively open and close the interrupter switch independent of the speed of the switch operating handle.

2. **Fuses**

   a) Fuses shall be solid-material power fuses or current-limiting fuses as specified by the equipment purchaser.

   b) Each bay containing fuses shall be equipped with grounding provisions on the load side of the fuses and on the ground bus.

3. **Metering**

   a) Primary-metering compartment shall be provided as required.

   b) Access to metering compartment shall be provided with a protective screen or second door, bolted closed to guard against inadvertent contact with energized parts when the main enclosure door is open.

   c) Metering transformers shall be mounted such that established electrical clearances are maintained.

   d) All low-voltage wiring shall be located as required to minimize exposure to high voltage.

**E. Labeling**

1. **Hazard-Alerting Signs & Labels**

   a) All external doors and hinged bolted panels providing access to high voltage shall be provided with suitable hazard-alerting signs.

   b) All internal screens or doors providing access to high voltage shall be provided with “Danger” signs.

   c) All internal screens or doors providing access to interrupter switches shall be provided with danger signs indicating “Switch Blades May Be Energized in Any Position”.

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Metal-Enclosed Switchgear
d) All internal screens or doors providing access to fuses shall be provided with danger signs indicating “Fuses May Be Energized in Any Position”.

2. **Nameplate, Ratings Labels, & Connection Diagrams**
   a) The outside of a single or multi-compartment switchgear assembly shall be provided with a nameplate indicating the manufacturer’s name, catalog number, date of manufacture, and serial number.
   b) The inside of each door shall be provided with a ratings label indicating the following: voltage ratings; main bus continuous rating; short-circuit ratings (amperes rms symmetrical and Mva three-phase symmetrical at rated nominal voltage); the type of fuse and its ratings including duty-cycle fault-closing capability; and interrupter switch ratings including duty-cycle fault-closing and short-time (momentary, amperes rms asymmetrical and one-second, amperes rms symmetrical).
   c) A one-line connection diagram showing interrupter switches, fuses, bus, and auxiliary equipment shall be provided as a drawing with each switchgear assembly.

F. **Accessories**
   1. Fuse units or refill units, and voltage-transformer fuses for original installation and for spares shall be furnished as specified by the equipment purchaser.
   2. A fuse handling tool as recommended by the fuse manufacturer shall be furnished as specified by the equipment purchaser.

G. **Routine Production Tests**
   Production tests are those tests made to check the quality and uniformity of the workmanship and materials used in the manufacture of the switchgear. The unit shall meet the production tests described below, 1 through 3 inclusive.

1. **Circuit Resistance Test**
   The purpose of this test is to verify that all load-interrupter switch contacts have been properly aligned and current transfer points have been properly assembled. The DC resistance of the current carrying circuit of each switch phase from terminal to terminal of each pole in the closed position shall be measured with current of at least 10 amperes flowing. The resistance shall not exceed a limit specified by the manufacturer.

2. **Dielectric Tests**
   Insulation withstand tests are made of the completely assembled unit to determine the ability of the insulating materials and spacing to withstand overvoltages for a specified time without flashover or puncture.

3. **Operating Assurance Tests**
   Each switch shall be operated mechanically and tested to verify:
   a) That the switch position indicators and contacts are in correct position for both open and closed positions.
   b) That the unit circuit configuration is shown correctly.

H. **Outdoor Units**
   In addition to the above requirements, outdoor units shall be provided with space heaters in each bay. The space heaters shall be enclosed within a perforated guard. Heater shall be fused and wired to a terminal block.

   The edges of the top and sides of adjacent bays shall be covered to prevent water entry. Roof and bay interface shall be covered between each bay to prevent water entry.

   For multi-bay units the roof construction shall be made with a roof cap channel where the cubicles are joined as shown in the drawing entitled Outdoor Roof Construction. (See Figure 8.)

   Louvers on outdoor units shall include backup plates with stainless steel screens.

<table>
<thead>
<tr>
<th>Power Frequency Withstand Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Max. Voltage, kV</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>5.5</td>
</tr>
<tr>
<td>17</td>
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<td>27</td>
</tr>
<tr>
<td>38</td>
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<tr>
<td>38</td>
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</table>
The Metal-Enclosed Switchgear must comply with the applicable sections in the following ANSI Standards:

- IEEE C37.20.3 – IEEE Standard for metal-enclosed interrupter switchgear
- IEEE C37.20.4 – IEEE Standard for indoor AC Switches (1kV - 38kV) for use in metal-enclosed switchgear
- ANSI C37.22 – Preferred Ratings and Related Capabilities for Indoor AC Medium-Voltage Switches Used in Metal-Enclosed Switchgear
- IEEE C37.30 – Requirements for High-Voltage Air Switches
- ANSI C37.72 – High-Voltage Switches, Bus Supports, and Accessories – Schedules of Preferred Ratings, Construction Guidelines, and Specifications
- ANSI C37.34 – Test Code for High-Voltage Air Switches
- ANSI C37.57 – Metal-Enclosed Interrupter Switchgear Assemblies – Conformance Testing
- ANSI C37.58 – Indoor AC Medium-Voltage Switches for use in Metal-Enclosed Switchgear – Conformance Test Procedures

Dimensions for Federal Pacific Metal-Enclosed Switchgear

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<thead>
<tr>
<th>Voltage Class</th>
<th>Type of O.C. Protection</th>
<th>Width (in inches)</th>
<th>Height (in Inches)</th>
<th>Depth (in Inches)</th>
</tr>
</thead>
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<td></td>
<td>Manual</td>
<td>Motor Operated</td>
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<tr>
<td>5kV</td>
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<td></td>
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<td>Expulsion Fuse</td>
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<td>Draw-out VCB</td>
<td>60</td>
<td>—</td>
<td>130</td>
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</tbody>
</table>

Notes for Dimensions Table:

1. Dimensions are for standard production products.
2. Add 5 inches to the height for Outdoor NEMA 3R
3. G&W Commutating Current-Limiting fuses are available for all voltages 5-38kV. Contact factory for dimensions.
4. If Rear-Entry Compartment is needed, increase the depth of the compartment by the following dimensions:
   - 5kV: add 16 inches
   - 15kV: add 16 inches
   - 25kV: add 24 inches
   - 35kV: add 30 inches

Figure 8. Outdoor Roof Construction with gasket between roof and enclosure flanges.
## Circuit Protection Devices Available From Federal Pacific

### Power Fuses Ratings - Expulsion Type

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<tr>
<th></th>
<th></th>
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### Power Fuses Ratings - Current Limiting

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1. Includes CLE, HLE, BHLE, and HCL medium voltage current-limiting fuses.
2. PAF® is a commutating current-limiting fuse, per ANSI C37.48.1, suitable for higher current applications, through 630A.