METAL-ENCLOSED SWITCHGEAR

INDOOR AND OUTDOOR DISTRIBUTION 5kV THROUGH 38 kV

Automatic Source Transfer

Manual with Metering Bay
Category B Enclosure

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.

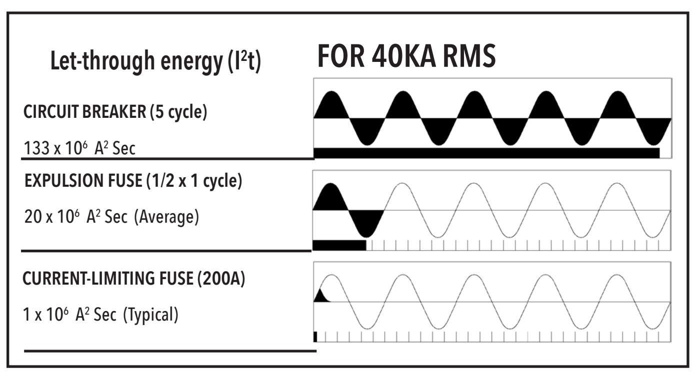


Figure 1. The dark area under each curve represents the relative energy limitation of damaging let-through currents provided by various protective devices. The curves illustrate that fuses allow through much less damaging let-through currents and, therefore, do a much better job of protecting cables 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 I^2T (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

Figure 2. Advantages of Metal-Enclosed Switchgear compared to Metal-Clad Switchgear.

Dimensions for Federal Pacific Metal-Enclosed Switchgear ①

Voltage Class	Type of O.C. Protection	Width (in inches)		Height (In Inches) ②	Depth (In Inches) ③
		Manual	Motor Operated		
5kV	Current Limiting	36	36	90	46
	Draw-out VCB	36	–	90	94
	Expulsion Fuse	41	41	90	46
15kV	Current Limiting	36	36	90	46
	Draw-out VCB	36	–	90	94
	Expulsion Fuse	41	41	90	46
25kV	Current Limiting	–	–	–	–
	Expulsion Fuse	48	53	120	48
35kV	Current Limiting	–	–	–	–
	Expulsion Fuse	60	60	130	60

①Dimensions are for standard production products.

②Add 5.5 inches to the height for Outdoor NEMA 3R enclosures.

③If 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.

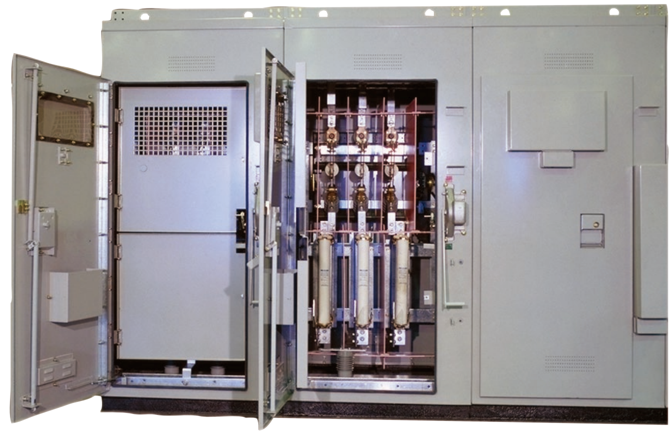
The Auto-Jet® II load-break switch is equipped with a quick-make, quick-break stored-energy mechanism. The operating handle is mounted on the right front of the unit at a convenient level with a maximum upward swing of 78" above ground level. The maximum operating force is 60 pounds. The standard manual 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.

Switch Ratings						
kV		Amperes				60 HZ Withstand kV
Nom.	Max. Design	Continuous & Interrupting	Momentary RMS ASYM †	Fault-Closing RMS ASYM †	BIL kV	
4.8	5.5	600	40,000	40,000	60	19
4.8	5.5	1200	40,000	40,000	60	19
14.4	17.0	600	40,000	40,000	95	36
14.4	17.0	1200	40,000	40,000	95	36
14.4	15.5	1200	61,000†	61,000†	110	36
25	27	600	40,000	40,000	125	60
25	27	1200	40,000	40,000	125	60
34.5	38	600	40,000	40,000	150	80
34.5	38	1200*	61,000	40,000	200	60

† The Auto-jet® Switch has a three-time fault-close capability at 40kA and a single-time fault-close capability at 61kA per ANSI standards.

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



- UL® Listed (5 & 15kV)
- Meets ANSI C57.12.28 enclosure security requirements
- 11-gauge steel
- Auto-jet® II puffer-type load-interrupter switch
- Three-time duty-cycle fault-closing switch
- No rear access required
- Easy inspection and maintenance
- A Portable Remote Operating Mechanism is available as a separate purchase to permit operating manual switches outside the arc flash hazard zone.

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

Single-Bay Manual Metal-Enclosed Switchgear - Construction

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 enclosure (and Metal-Enclosed Switchgear in general) can be constructed for indoor or outdoor applications.

- **Indoor applications** - Routinely called NEMA-1 Type Construction* (default value)
- **Outdoor applications** - Routinely called NEMA-3R Type Construction*

* By strict definition, these NEMA construction types apply to applications of 1000V or less.

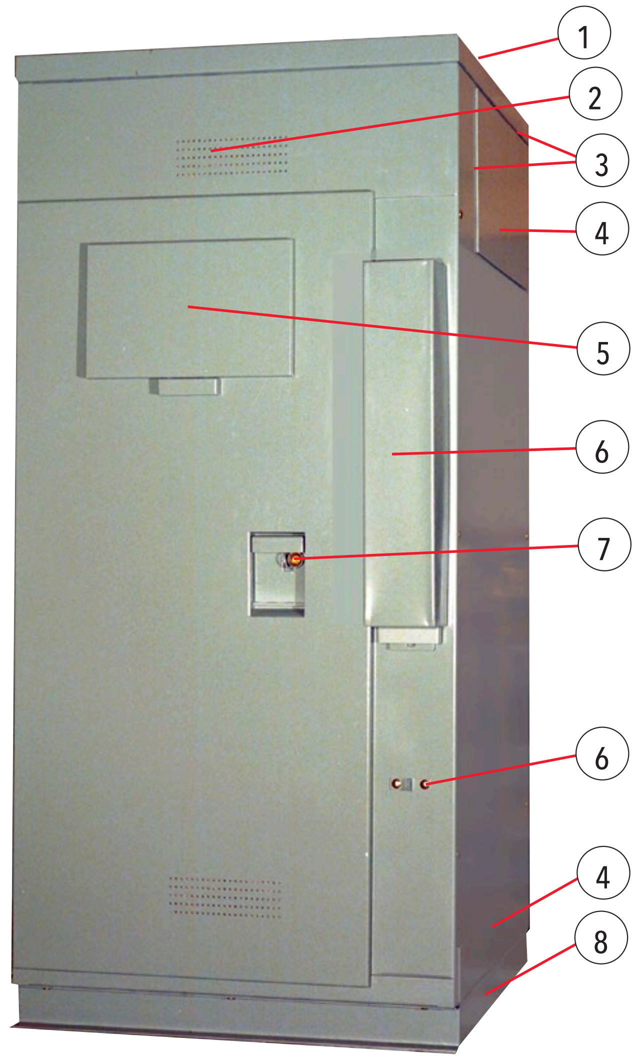
Cabinet security classifications Category A or Category B are available for this and other Metal-Enclosed Switchgear designs.

- **Category A** - Suitable for "general public access". Category A covers the concept of tamper-proof. Typically used in areas with "unsupervised access".
- **Category B** - Suitable for "authorized access". (Default) Category B represents "standard" basic metal-enclosed switchgear construction. Typically used in areas with "supervised" or, more commonly, **no** public access.

Note - Category C (which allows exposed bushings, bus, or terminals) is not available from Federal Pacific.

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.

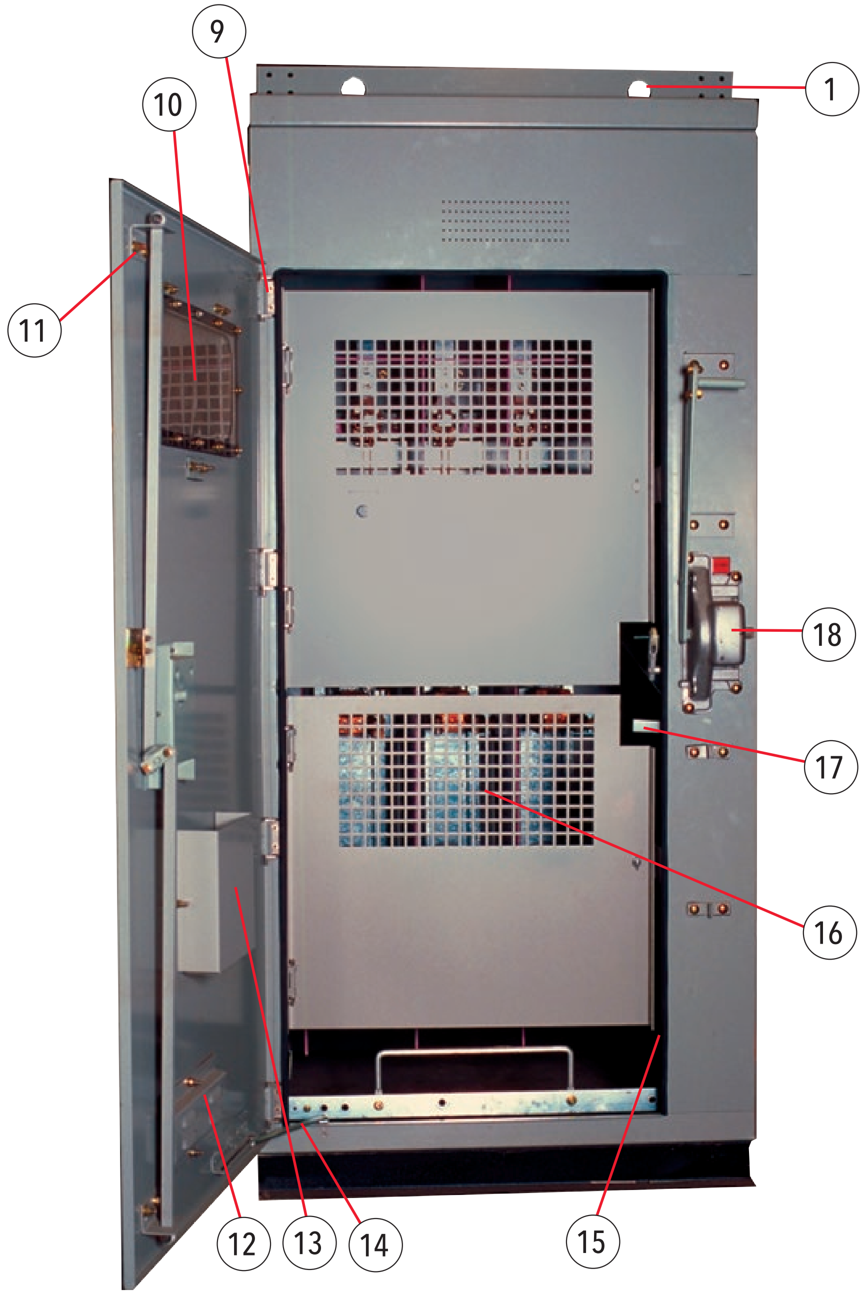
Second, strong consideration should be given to selecting current-limiting fuses for circuit protection inside the cubicle. Current-limiting fuses provide significantly better fault energy limitation than expulsion fuses in terms of lower "peak let-thru current" (mechanical energy that deforms windings) and lower I^2T 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.

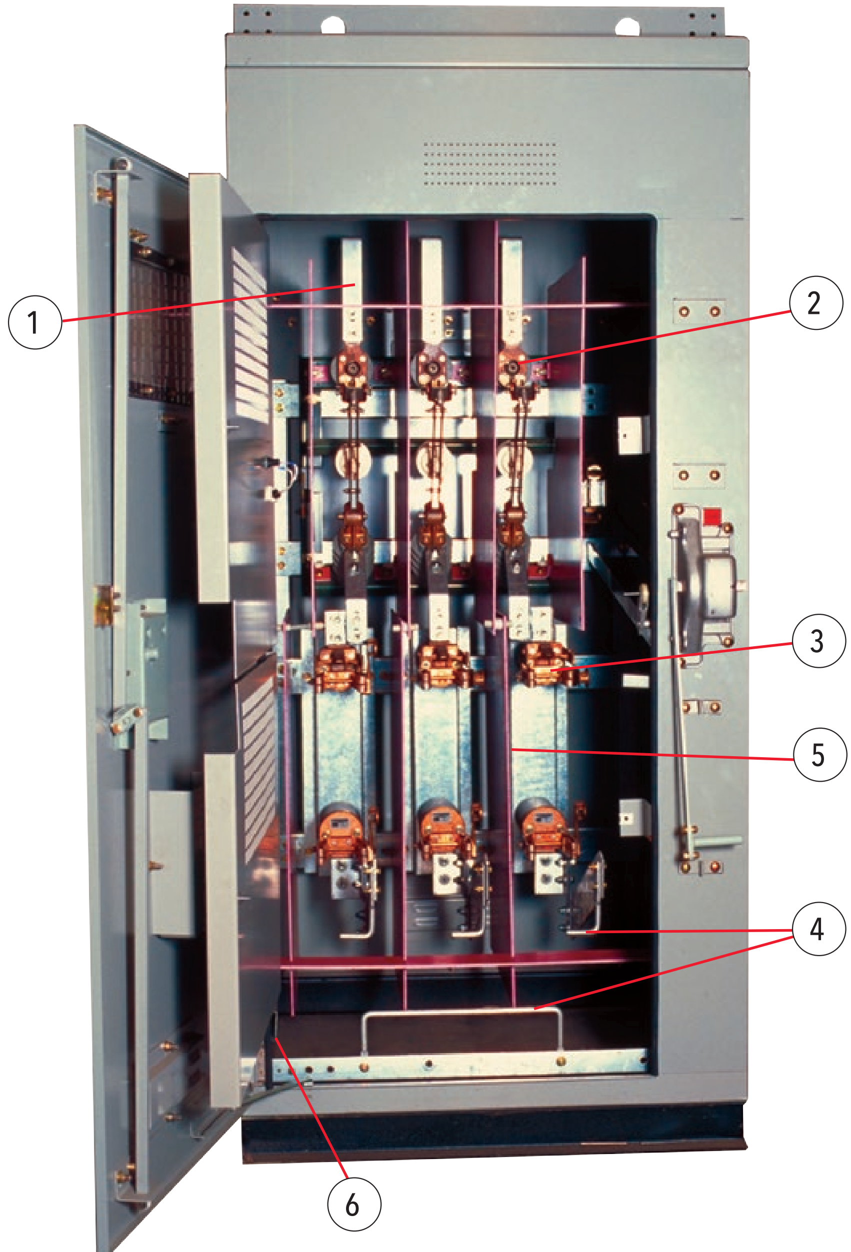
1. Lifting angles, at top of enclosure (shown on next page) are removable with bolt holes blind-tapped.
2. Screened ventilation perforations include an internal backup plate.
3. Weather sealant between roof and enclosure and between bus extension cover plate and enclosure.
4. Heavy-gauge steel cover 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.

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.
14. Self-latching door holder keeps door fixed open.
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.



Enclosure door is open to show internal screens with openings for viewing switch position and blown-fuse indicators.

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. GPO-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.

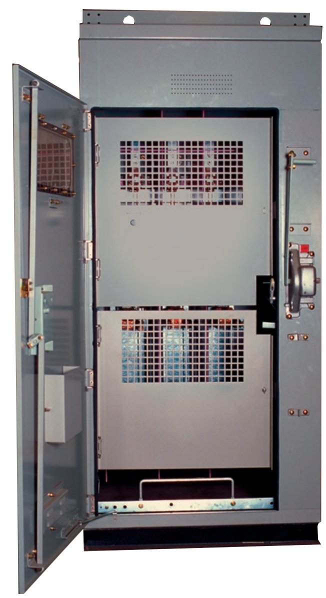
Outdoor Units (NEMA 3R)

- 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.

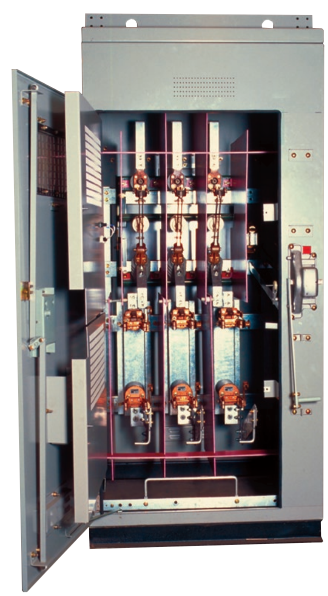
Optional Features and Accessories

- 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

Exterior of Switch/Fuse Bay With Category A Security Features



Open Door View of Switch/Fuse Bay Showing Internal Screens



Interior View of Switch/Fuse Bay

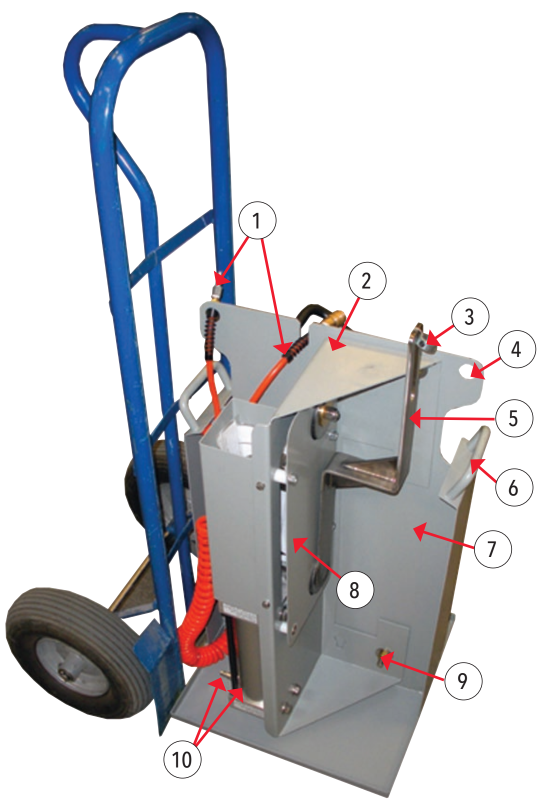
PORTABLE REMOTE OPERATING MECHANISM FOR MANUAL SWITCHES MITIGATES EXPOSURE TO ARC-FLASH HAZARDS

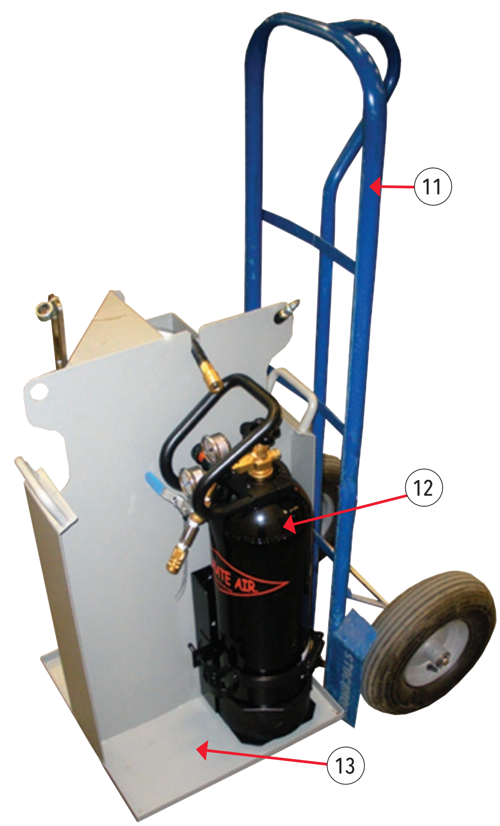
Federal Pacific has developed a portable remote operating mechanism (PROM) that can be applied for operation of manually-operated Auto-jet® switches from a location outside the critical arc-flash boundary zone. The fittings required to accommodate the portable mechanism can be retrofitted onto switchgear 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 CO_2 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 CO_2 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. CO_2 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





METAL-ENCLOSED SWITCHGEAR CHECKLIST APPLICATION GUIDELINES

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.

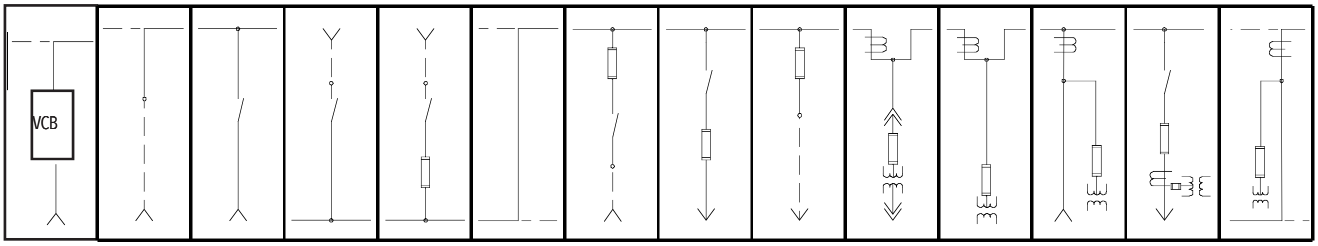
For Incoming Cubicles connected to circuits at 15 kV that are above 400 continuous load amperes, Federal Pacific offers the choice of a metal-clad drawout vacuum circuit breaker that contains in a single module all of the CTs, relays, etc. necessary for operation, and which can be provided with a UL® 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.

Unit Requirements - Applies to the entire lineup

System Voltage: ______________________ Volts			
Fusing:	☐ Current Limiting	☐ Expulsion	
Enclosure:	☐ NEMA 1 (indoor)	☐ NEMA 3R (outdoor)	
Bus:	☐ Aluminum ☐ Tinplate	☐ Copper ☐ Silver Plate	☐ Other
Construction:	☐ Bolted	☐ Welded	☐ Other
Special Seismic Requirements:	☐ None ☐ 300%g ☐ 200%g		
Category (Cabinet Security):	☐ A	☐ B	☐ C
UL® Listed:	☐ Yes	☐ No	
Finish:	☐ ANSI 61	☐ Other (Specify)	
Door:	☐ Flush Door Handle (Available with Category A only)		☐Grip Handle Lever
Interlocks:	☐ Mechanical	☐ Key	☐Other (Specify)
Utility-Type Metering Bay:	☐ Required	☐ Not Required	

Enter in space below each bay # at right applicable cubicle number from One-Line Diagrams on next page.	Bay #1	Bay #2	Bay #3	Bay #4	Bay #5	Bay #6	Bay #7	Bay #8	Bay #9	Bay #10	Bay #11
Switch (Amps) for each cubicle											
Fuse (Amps) for each cubicle											
Bushings between Cubicles	(Y or N)										
LA ____________ __________ MCOV ☐ Dist. ☐ Int. ☐ Stat.	(Y or N)										
Power Operated	(Y or N)										
Automatic Transfer	(Y or N)										
Fast-Trip Transfer	(Y or N)										
Run & Trip	(Y or N)										
With SCADA	(Y or N)										
1-Phase Protection (Shunt Trip)	(Y or N)										

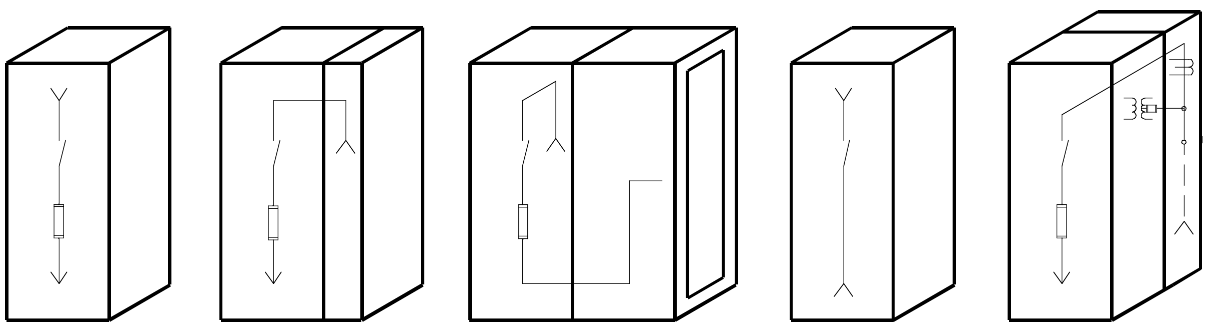
Typical One-Line Diagrams for Individual Bays of the Lineup Showing the Applicable Cubicle Number and Cubicle Description.



Cubicle Number: 1 2 3* 4* 5* 6 7* 8* 9 10● 11⁺ 12⁺ 13⁺* 14⁺

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

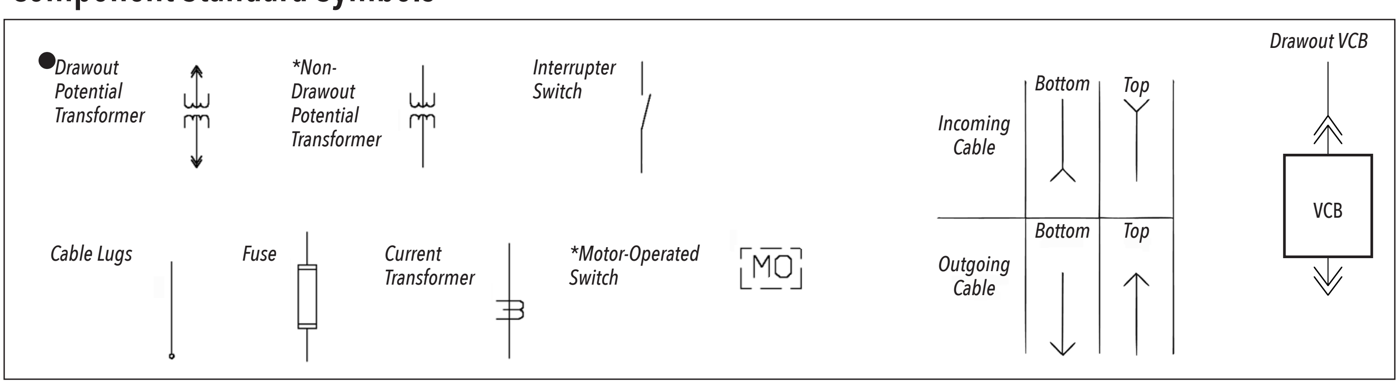
Typical Single Units



Cubicle Number: 15* 16* 17* 18* 19*⁺

15. Switch/Fuse top cable entrance, bottom cable exit.
16. Switch/Fuse, bottom cable entrance on side, bottom cable exit.
17. Switch/Fuse with bottom rear cable entry and with transformer transition.
18. Switch Only, top cable entrance, bottom cable exit.
19. 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.

STANDARD SPECIFICATIONS FOR MANUAL METAL-ENCLOSED SWITCHGEAR

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.**

	System Voltage Class							
	5kV		15kV		25kV	25kV	35kV	35kV
kV, Nominal	4.16		14.4		24.9	24.9	34.5	34.5
kV, Maximum Design	5.5		17.5		27	27	38	38
kV, BIL	60		95		125	125	150	200
Main Bus Continuous Amp	600	1200	600	1200	600	1200	600	1200
Switch Load Interrupting	600	1200	600	1200	600	1200	600	–
Short-Circuit Ratings ①								
Amps, RMS Symmetrical	25,000	38,000	25,000	38,000	25,000	25,000	25,000	38,000*
MVA 3-Phase Symmetrical at Rated Nominal Voltage	180	275	625	950	1,000	1,000	1,500	1,500
Fault-Closing Amps, RMS Asym 3-Times Duty-Cycle ②	40,000	40,000	40,000	40,000	40,000	40,000,	40,000	–
Fault-Closing Amps, RMS Asym 1-Time Duty-Cycle ③	–	61,000	–	61,000	–	–	–	–

① *These are nominal switch ratings. Integrated switchgear unit may be limited by fuse ratings. Use the fuse ratings charts in this publication to adjust short circuit ratings, when applicable.*

② *The three-time duty-cycle fault-closing rating means that the switch can be closed 3 times into rated fault amperes and remain operable and able to carry and interrupt its rated load current.*

③ *The one-time duty-cycle fault-closing rating means that the switch can be closed 1 time into rated fault amperes and remain operable and able to carry and interrupt its rated load current.*

* *The asymmetrical rating is 61,000 amperes, one-second.*

b) For cubicles or bays in which overcurrent circuit protection is required on circuits, where the continuous load amperes exceed the maximum continuous ampere rating of a single fuse, a drawout circuit breaker should be specified in preference to employing paralleled expulsion fuses whose arcing products and pressures may be substantial during the interruption of fault current.

4. Certification of Ratings

a) The integrated metal-enclosed switchgear assembly shall be designed and built by the manufacturer of the basic interrupter switch who shall be completely and solely responsible for the performance of these basic components as well as the complete integrated assembly as rated.

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 the effects of closing, carrying, and interrupting 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 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 zirconization 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".

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.)

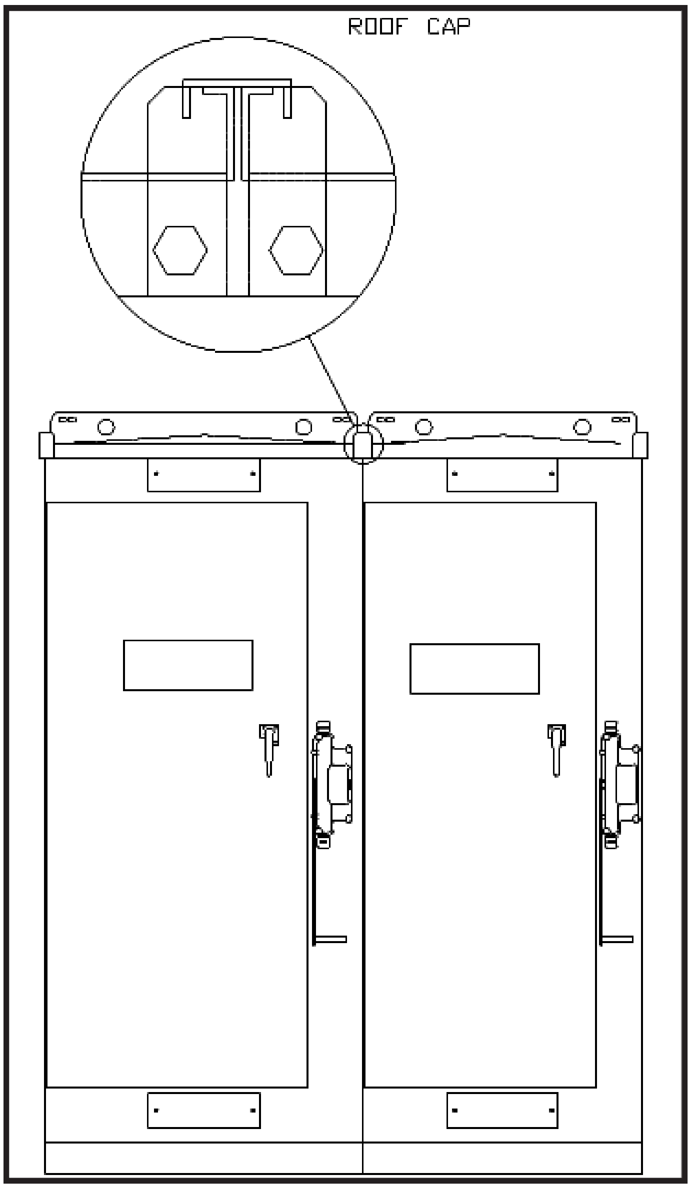
Louvers on outdoor units shall include backup plates with stainless steel screens.

Power Frequency Withstand Test

Rated Max. Voltage, kV	Rated Withstand Impulse Voltage, kV	Production Test, kV, RMS 60 Hz
5.5	60	19
17	95	36
27	125	60
38	150	80
38	200	80

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 ①

Voltage Class	Type of O.C. Protection	Width (in inches)		Height ② (In Inches)	Depth ③ (In Inches)
		Manual	Motor Operated		
5kV	Current Limiting ③	36	46	90	46
	Draw-out VCB	36	–	90	94
	Expulsion Fuse	41	46	90	46
15kV	Current Limiting ③	36	46	90	46
	Draw-out VCB	36	–	90	94
	Expulsion Fuse	41	46	90	46
25kV	Current Limiting ③	–	–	–	–
	Draw-out VCB	48	53	120	48
35kV	Current Limiting ③	–	–	–	–
	Draw-out VCB	60	–	130	60

Notes for Dimensions Table:

①Dimensions are for standard production products.
②Add 5 inches to the height for Outdoor NEMA 3R
③G&W Commutating Current-Limiting fuses are available for all voltages 5-38kV. Contact factory for dimensions.
④If 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

Circuit Protection Devices Available From Federal Pacific

Power Fuses Ratings - Expulsion Type

Nom. Voltage in kV	Max. Cont. Amps.	Expulsion Fuse Type	Manufacturer	Circuit Max. Available Fault-Current in Amps Sym.	Max. Fault-Current in Amps Asym.	Three-Phase MVA Sym.
4.16	200	DBU	Cutler-Hammer	22,400	14,000	200
4.16	200	RBA-200	Cutler-Hammer	19,000	30,000	237
4.16	200	SM-4	S&C	17,200	27,500	125
4.16	200	SM-5	S&C	37,500	60,000	200
4.16	400	RBA-400	Cutler-Hammer	37,500	60,000	270
14.4	200	DBU	Cutler-Hammer	14,000	22,400	350
14.4	200	RBA-200	Cutler-Hammer	14,400	23,000	350
14.4	200	SM-4	S&C	12,000	20,000	310
14.4	200	SMU-20	S&C	14,000	22,400	350
14.4	400	RBA-400	Cutler-Hammer	29,400	47,000	730
14.4	400	SM-5	S&C	25,000	40,000	620
24.9	200	DBU	Cutler-Hammer	12,500	20,000	500
24.9	200	RBA-200	Cutler-Hammer	6,900	11,100	410
24.9	200	SM-4	S&C	9,400	15,000	410
24.9	200	SMU-20	S&C	12,500	20,000	540
24.9	400	RBA-400	Cutler-Hammer	21,000	33,500	840
24.9	400	SM-5	S&C	20,000	32,000	860
34.5	200	DBU	Cutler-Hammer	10,000	16,000	800
34.5	200	RBA-200	Cutler-Hammer	6,900	11,100	410
34.5	200	SM-4	S&C	6,250	10,000	370
34.5	200	SMU-20	S&C	8,450	13,500	500
34.5	400	RBA-400	Cutler-Hammer	16,800	26,800	1,000
34.5	400	SM-5	S&C	17,500	28,000	1,045

Drawout Vacuum Circuit Breaker

Nominal Voltage in kV	Max. Cont. Amps	Manufacturer	Circuit Max. Available Fault-Current in Amps. Sym.	Max. Fault-Current in Amps Asym. (1.6x sym.)	Three-Phase MVA Sym.
14.4	2000	Cutler-Hammer Mini-Vac	40,000	64,000	500
14.4	1200	Siemens GMI	23,000	37,000	500

Cutler-Hammer MiniVac® Circuit-Breaker Module With Integral CTs and Relay

Power Fuse Ratings - Current Limiting

Nom. Voltage in kV	Max. Cont. Amps.	Current-Limiting Fuse Type	Manufacturer	Circuit Max. Available Fault-Current in Amps Sym.	Peak Let-Thru Current in Amps on Max. Available Fault-Current Circuit	Three-Phase MVA Sym.
4.16	450	CLE/HLE ①	Cutler-Hammer	63,000	47,000	450
4.16	450	EJO-1	General Electric	50,000	40,000	350
4.16	600	CL-14	Ferraz-Shawmut	63,000	–	450
4.16	600	PAF ②	G&W	40,000	20,000	275
4.16	750	CLE	Cutler-Hammer	40,000	75,000	275
4.16	900	BOLT-AZ055B1DARO	Ferraz-Shawmut	63,000	–	450
4.16	900	EJO-1	General Electric	50,000	80,000	360
4.16	1100	151D870G01	Cutler-Hammer	70,000	85,000	640
4.16	1350	141D870G02	Cutler-Hammer	90,000	85,000	650
14.4	200	CS-3	Ferraz-Shawmut	50,000	14,000	1350
14.4	200	EJO-1	General Electric	50,000	30,000	1350
14.4	600	CL-14	Ferraz-Shawmut	50,000	15,000	1350
14.4	300	CLE/HLE ①	Cutler-Hammer	63,000	35,000	1500
14.4	300	EJO-1	General Electric	50,000	37,000	1342
14.4	600	PAF ②	G&W	60,000	60,000	1492
24.9	600	PAF ②	G&W	40,000	40,000	1700
34.5	600	PAF ②	G&W	40,000	40,000	22400

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.*