

Type PM Motor Operators for Padmounted Switchgear Automatic-Source Transfer and Scada-Controlled Applications



SCADA Controlled
Padmounted Switchgear



Federal Pacific Type PM Switch Operators are side mounted to units of 15kV and 25kV livefront or deadfront padmounted switchgear and provide motor-operated switching for automatic-transfer and remote supervisory-controlled applications on underground power distribution systems. Automatic transfer unit pictured above illustrates motor operator mounting at left and foreground enclosure on side at right. Far enclosure at right contains microprocessor control and associated wiring.

Federal Pacific Motor Operators to Automate Underground Distribution Systems

Federal Pacific 15kV and 25kV Manual Models of Pad-Mounted Switchgear can be equipped with motor operators either for automatic-source transfer applications, designated as ATPSI/II Models for Livefront units and ATPSE Models for Deadfront units, or for Scada-controlled applications, designated as SCPSI/II Models for Livefront units and SCPSE Models for Deadfront units. When equipped with motor operators, FP Models of Pad-Mounted Switchgear will effect switching operations in a run (charge-spring) and trip sequence. The FP Type PM Motor Operator, dubbed the run-and-trip motor operator includes all the features that have been provided in the past for motor operators used in remote-supervisory control applications. The operating speed is approximately 4-5 seconds from the instant the motor is actuated through to completion of switch opening or closing. Operation can be effected either automatically when combined with an FP OCS-300 Microprocessor Control or remotely when combined with appropriate communications components. Operating time does not include time required for sensing or time delays required to establish system conditions.

The Federal Pacific Type PM Switch Operator is designed primarily for use on FP units of padmounted switchgear, replacing the manual-operating handle and placed over the manual operating shaft. However, it may also be applied for specific unique applications when side mounted to bays of metal-enclosed switchgear. The run-and-trip motor operator is direct, side-connected to the enclosure of padmounted switchgear and can be similarly connected on bays of metal-enclosed switchgear where space and configuration arrangements permit. A direct, front-connected arrangement is also available for metal-enclosed switchgear (refer to the Federal Pacific publication on Type ME Motor Operators). All of these direct-connected arrangements are accomplished without the use of chains.

The motor-operator enclosure is a NEMA 3R, which is rated for outdoor service. The door opening is fully gasketed and seals tight against the door to prevent entry of rain and contamination. The door includes a stainless-steel handle, a continuous, stainless-steel hinge, a storage pocket for the instruction manual, a mounting clip for storage of spare secondary control-circuit fuses, a manual operating handle with storage provisions, and a wind brace to support the door open.

Remote-Supervisory Control Applications

The motor operator includes LOCAL/REMOTE selector switch, local controls, control and battery charger/manager electronic components, AC power and control cable connections, provision for other optional controls and provision for an RTU and radio/phone. The electronically controlled motor unit is suitable for operation of both 600-ampere and 1200-ampere FP Auto-jet® Load Interrupter Switches.

The motor unit also includes a decoupler that when decoupled from the switch allows exercising the motor without operating the disconnect switch. The decoupler thus allows functional operation of the motor to be performed as a part of normal maintenance and checkout procedure. The Type PM Motor Operator uses a solid-state controller, which provides consistent and accurate



Figure 1. FP motor operator enclosures include many features providing convenience and security.

control at each end of the interrupter switch operating stroke. It has a user programmed electronic control that responds to an electronic sensor v

enclosed within the motor housing. Limit positions are programmed from the control panel. The controller also provides open and closed position status outputs for an RTU.

The operating controls are mounted on a panel inside the enclosure and consist of the Local-Remote Selector Switch, the Close-Open Switch and two Indicator Lights to show switch position. Three push buttons, which set and adjust the motor-limit controls are mounted below the control switches behind a secured protective cover. Programming controls have safety covers to prevent accidental contact with the limit control during normal local operations.

When a CLOSE or OPEN command is given from either the "Remote" or "Local" position, the command is "sealed in." This means the motor will run to its established limits of travel and cannot be stopped at an intermediate position. The Type PM unit, in most situations, uses 120 volts AC in tandem with DC power supplied by the battery backup system to operate the load interrupter switch. An electronic battery charger and battery manager system maintains battery voltage and provides battery condition status output signals for an RTU.

Modular construction and plug-in connections make maintenance and service easy.

The unit weighs approximately 100 Lb. (45 Kg) without the packing.

For the motor operator in remote-supervisory control applications, a 12-volt, 33-amp-hour battery supplies power to the motor-operator assembly and has adequate capacity to power associated components, including an optional radio and RTU. A 24-volt dc battery and charging system is also available. A system combining a battery and 120-volt ac input to a battery charger permits motor operation even when there is a weak battery voltage.

The battery charger is temperature compensated. With loss of input power from the charger, the battery can typically maintain the RTU and radio loads for 24 hours. The system includes an electronics package that provides (1) battery overcharge protection and (2) battery testing. Status outputs wired for input to an RTU include: Switch Position, Battery Condition, and Monitoring of Controller Status.

Sufficient open space is provided on the internal mounting plate for installation of communications components -- both a remote-terminal unit (RTU) and radio or other communications portal -- for remote-supervisory control operations. If specified when ordering, an antenna can be installed or provisions can be provided on the enclosure.



Figure 2. Motor operator provides space for an RTU, radio and antenna, power supply, control power source and associated components.

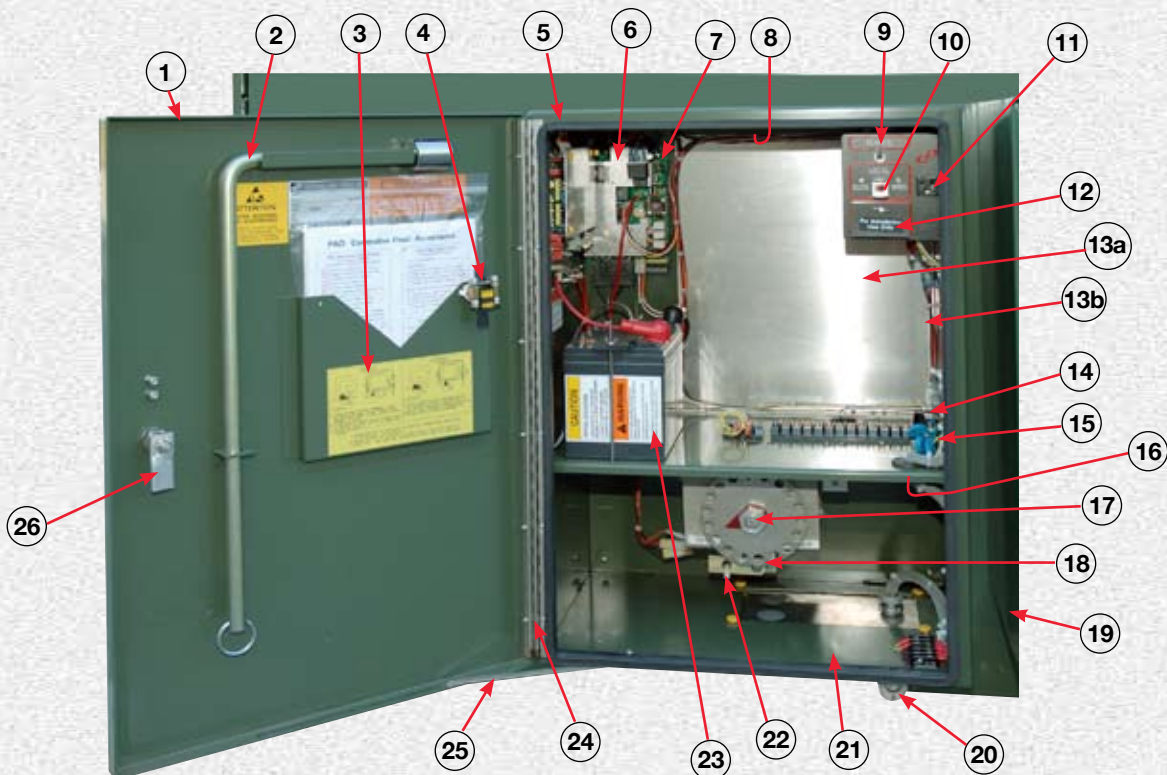


Figure 3. Features of FP Type PM Motor Operator.

- 1 **Aluminum Enclosure** – Heavy-gauge and corrosion resistant construction with door overlapping opening.
- 2 **Manual Switch-Operating Handle** – For use in the event control power is lost - with storage provisions.
- 3 **Instruction Manual Storage Pocket** – Provides convenient holder for easy reference.
- 4 **Storage Clip for spare secondary fuses** – Backup protection for vulnerable control circuits.
- 5 **Fully Gasketed Door** – Combined with rigid construction and deep overlap with door opening provides protection from the environment.
- 6 **Control Module with LED Status** – Provides intelligence for controlling operations and status outputs.
- 7 **Power Module with Battery Charger** – Insures availability of adequate control power for switching operations.
- 8 **Ribbon Cable Wiring System** – Simplifies interconnecting control wiring for easy identification and maintenance (on underside of roof).
- 9 **Local/Remote Selector Switch** – When in Local, allows operation at the unit while blocking remote operation; remote operation is enabled when in remote.
- 10 **Open/Close Operating Switch with Indicating Lamps** – Permits local electrical switching and annunciates switch position.
- 11 **Fused AC Receptacle** – Provides power outlet for connection of secondary load.
- 12 **Motor-Travel Set Controls** – Secured behind cover, allows adjustment of the travel limits for the motor operator
- 13a **Mounting Plate** – Provides space for installation of RTU.
- 13b **Radio Provisions (radio by customer)** – Space permits installation of a radio for communication with a master station.
- 14 **Disconnecting Fuses** – Protect ac circuits and facilitate easy replacement.
- 15 **Smurff™ Surge Protector** – Provide surge protection for control circuits.
- 16 **Heater with Thermostat** – Keeps interior dry, eliminating potentially damaging moisture.
- 17 **Open/Close Motor-Position Indicator** – Semaphore target provides indication of actual motor position and switch position when coupled.
- 18 **Padlockable Motor Assembly** – Insures personnel security against inadvertent operation.
- 19 **Gasketing Shroud** – Seals motor-operator enclosure to padmounted switchgear enclosure. (Not visible)
- 20 **Ground Connector** – On exterior of enclosure allows connecting enclosure to system ground.
- 21 **Removable Access Plate** – Allows installation of a knockout for entry of control wiring
- 22
- 23
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- 25
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- 22 **Padlockable Motor Decoupler** – Facilitates testing of motor and controls while providing easy secure method of isolation for operating personnel.
- 23 **Battery with Venting Hose** – Maintains power availability for motor operation and control equipment.
- 24 **Stainless-Steel Door Hinge** – Continuous hinge insures smooth door opening throughout unit life.
- 25 **Door Holder** – Secures door open.
- 26 **Stainless-Steel Door Handle & Latch** – Durable components that insure easy operation.

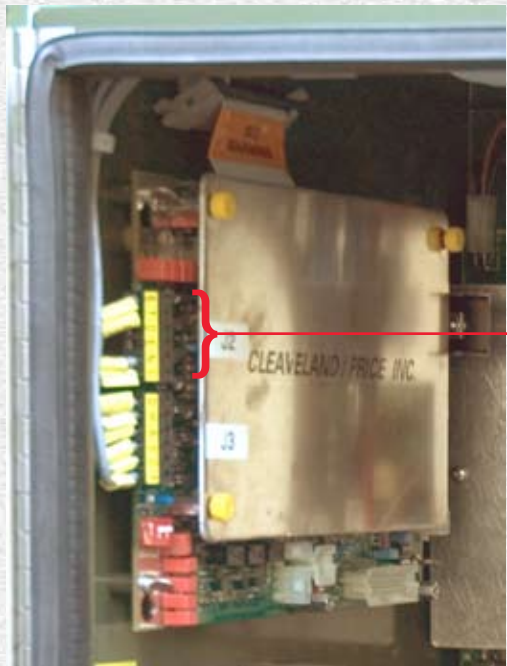


Figure 4. Control module with LED status lamps.

Status Outputs

- a. Loss of AC Power/Loss of Charger Alarm
- b. No-Go Alarm
- c. Motor Open Status
- d. Motor Closed Status
- e. Low Battery Alarm
- f. Remote Status
- g. Push Button

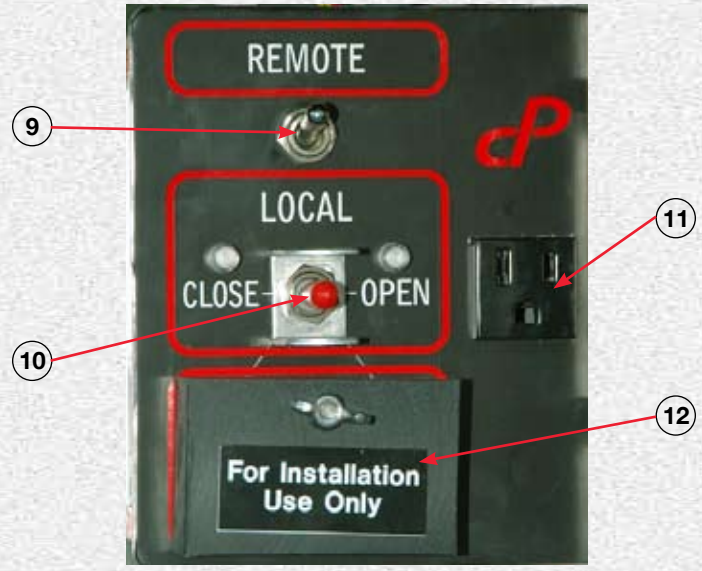


Figure 5. Panel with local controls and motor travel set controls.

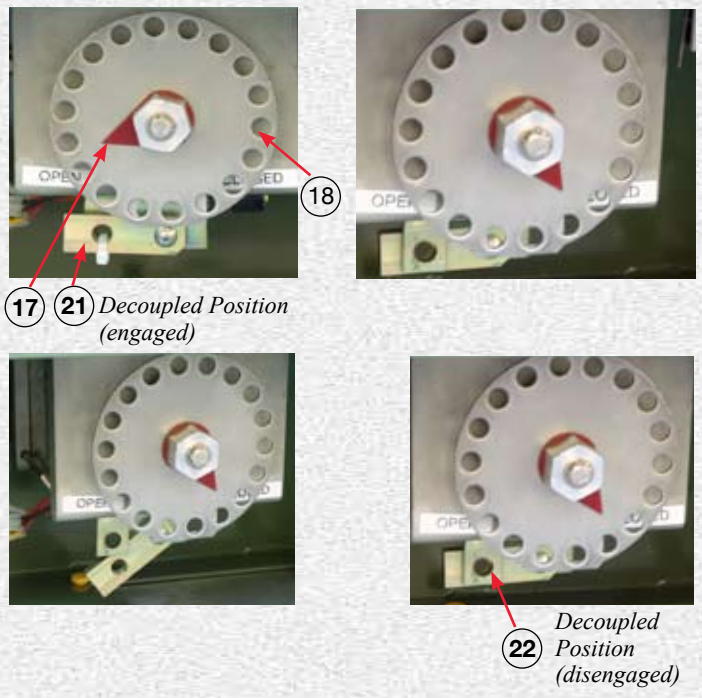


Figure 6. Padlockable motor and decoupler. Photo at top left show decoupler in coupled (engaged) position - Photo at bottom right shows decoupler in decoupled (disengaged) position.

Automatic Source-Transfer Applications

The run-and-trip motor operator will also be the primary device to effect switching operations in automatic source-transfer applications for FP Padmounted Switchgear. Each switch in the source-transfer scheme will be automated using a run-and-trip motor operator. The control providing the intelligence for automatic switching operations will be the revolutionary FP Touch-Pad OCS-300 Microprocessor Control. In automatic source-transfer applications, the motor operators charge the spring of the associated Auto-jet® switch and synchronously effect a transfer operation from one (preferred) source to the second (alternate) source following loss-of-source voltage (or reduction of voltage below a predetermined, field selectable level) on the preferred source. Switching functions are all pre-programmed and controlled by the OCS 300 microprocessor and certain functions are field selectable.

transfer applications where speed of operation is not a significant consideration. There are only two transfer times of significance: (a) 1/4 cycle (5 milliseconds) and 2 cycles (33 milliseconds). For the former, transfer operations in 1/4 cycle allow computers and relays circuits to remain intact without losing power. For the latter, transfer operations in 2 cycles will allow metal halide lamps to remain illuminated, keeping stadium and arena lights on. Beyond these two extremely short time duration requirements, speed of operation is not a significant application consideration. And, therefore, motor operators effecting a transfer operation in 10-cycles, which does not include the minimum required 1/4 second time delay to establish that an outage is extended, is of little advantage over one that effects a transfer operation in a few seconds. Consequently, run-and-trip motor operators are more than adequate for the vast majority of automatic-transfer operations.

Run-and-trip motor operators are employed in automatic-



Figure 7. Automatic source transfer operations are monitored and controlled by FP Type OCS-300 Micro-Processor Control, which is mounted in a separate, secure enclosure, which is open above.

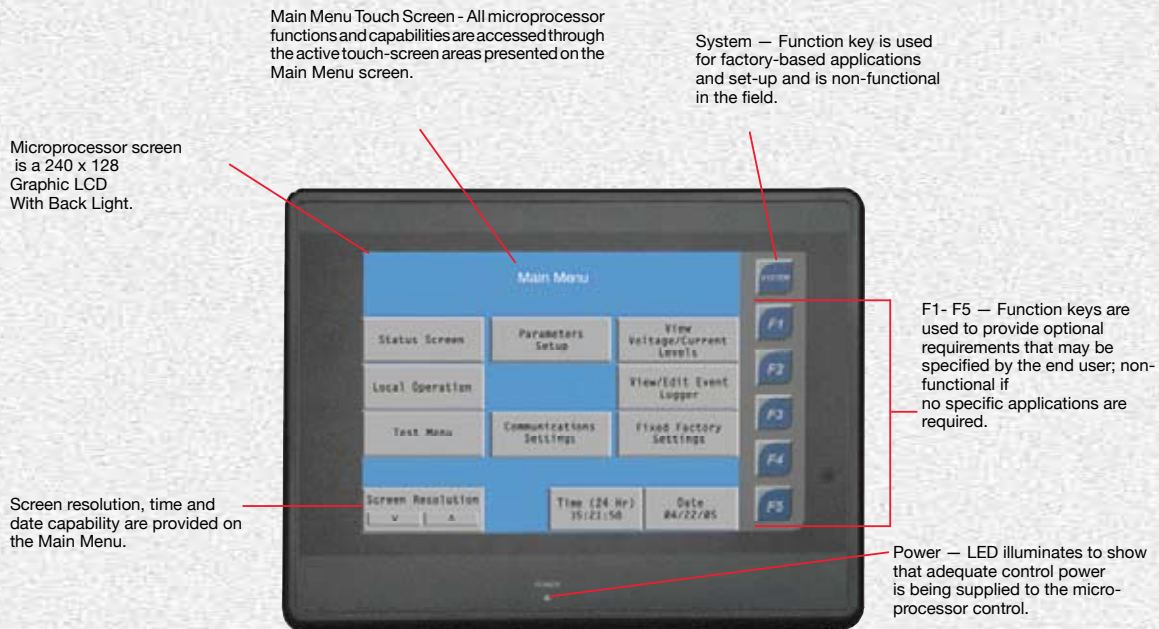


Figure 8. Federal Pacific Touch Screen OCS-300 Automatic-Transfer Micro-Processor Control features a large color graphic, backlit, LED display with all functions accessible through a "Main Menu" screen. The touch-screen functions allow setting of field adjustable timers and operating parameters — automatic or hold return, open or closed transition return and preferred-source selection. The micro-processor control is mounted on a hinged panel allowing access to connections and associated wiring.

Optional Features

- K3 – Key Interlock** – Prevents access to fuse-compartment unless associated switch is locked open.
- T1 – Installation of RTU** – User provided RTU.
- T11 – Installation of FRTU** – FP purchased and installed (type as specified by user)
- T2 – Installation of Radio** – User provided Radio
- T21 – Installation of Radio** – FP provided and installed Radio (type as specified by user)
- T3 – Installation of Antenna** – User provided Antenna
- T31 – Installation of Antenna** – FP provided and installed Antenna (type as specified by user)
- X1 – Cold-Temperature Package** – Modification to allow operation under low-temperature condition to -40°F (-40°C)
- X2 – Temperature Compensation for Battery** – Device to cool battery in hot climates to extend battery life and warms the battery to improve performance under cold conditions.
- X3 – Auto Actuate Unit** – Device allows automatic opening or closing of the associated switch in response to line voltage changes.
- X4 – Intruder Alarm** – Sends alarm if enclosure door is opened.
- X5 – Self Tagging Device** – Electronic interlocking to preclude motor operation
- X6 – Operation Counter** – Records operation of the motor operator (not switch)

STANDARD SPECIFICATION FOR LIVE-FRONT SCADA CONTROLLED PADMOUNTED SWITCHGEAR

A. General

1. Plans

The padmounted gear shall be the SCPSI/II design as manufactured by Federal Pacific and shall conform to the following specification.

2. Assembly

The basic padmounted gear shall consist of a single self-supporting enclosure, containing interrupter switches and power fuses and separate, integral enclosure(s) including switch operator(s), controls, and control-power supply; and shall also provide the necessary accessory components, including sensing, controls, and control power input, all completely factory-assembled and operationally checked.

3. Ratings

- a) Ratings for the integrated padmounted switchgear assembly shall be as designated below: (Select 15KV or 25KV sets of ratings from the tables below)

System Voltage Class		
	15KV	25KV
KV, Nominal	14.4	25
KV, Maximum Design	17	27
KV, BIL	95	125
Main Bus Continuous, Amps	600	600
Load Interrupting, Amps	600	600
Fuse Load Interrupting, Amps	200	200
Switch Short-Circuit Ratings*		
Amps, RMS Symmetrical	25,000	25,000
MVA, 3-Phase Symmetrical at Rated Nominal Voltage	620	1,080
Fault Closing Amps, RMS, Asym., 3-Time Duty Cycle**	40,000	40,000

* These are nominal switch ratings. Integrated padmounted unit may be limited by fuse ratings. Use fuse rating chart in next column to select proper short circuit ratings.
 ** The three-time duty-cycle fault closing rating means that the switch can be closed three times into rated fault amperes and remain operable and able to carry and interrupt its rated load current.

- b) The momentary and three-time duty-cycle fault-closing ratings of switches, momentary rating of bus, interrupting ratings of fuses with integral load interrupter shall equal or exceed the short-circuit ratings of the pad-mounted switchgear.

4. Certification of Ratings:

The manufacturer shall be completely and solely responsible for the performance of the basic switch components as well as the complete integrated assembly as rated.

The manufacturer shall furnish, upon request, certification of ratings of the basic switch components and/or the integrated padmounted switchgear assembly consisting of the switch and fuse components in combination with the enclosure.

Fuse Ratings						
Fuse Manufacturer	Fuse Type	Three-Phase MVA Sym	Amps RMS Asym	3-Time* Fault Close Asym	Cont. Amps	Load* Break Amps
14.4 KV Nominal Voltage						
S&C	SM-4	310	20000	20000	200	200
S&C	SMU-20	350	22400	22400	200	200
S&C	SM-5†	—	—	—	—	—
Cutler-Hammer	DBU	350	22400	22400	200	200
Cooper (M-E)	NX	620	40000	40000	100**	100
Cooper (Kearney)	Q	620	40000	40000	100	100
Cooper (CT)	X-Limiter	620	40000	40000	140	140
25 KV Nominal Voltage						
S&C	SM-4†	540	20000	20000	200	200
S&C	SMU-20	540	20000	20000	200	200
S&C	SM-5†	—	—	—	—	—
Cutler-Hammer	DBU	540	20000	20000	200	200
Cooper (M-E)	NS	1080	40000	40000	40	40
Cooper (Kearney)	Q	1080	40000	40000	100	100
Cooper (CT)	X-Limiter	1080	40000	40000	140	140

* When assembled with Auto-Jet End Fittings.
 ** 100 amp @ 13.5 KV max or 80 amp @ 15 KV.
 † Applicable to solidly grounded neutral systems only with fuses connected by a single conductor concentric neutral type cable to a transformer or transformers. Rating is 9,400 amperes RMS symmetrical, 15,000 amperes RMS asymmetrical (405 MVA symmetrical) for all other applications.
 ‡ Contact factory for SM-5 applications.

5. Compliance with Standards and Codes

The pad-mounted switchgear shall conform to or exceed the applicable requirements of the following standards and codes:

- All portions of ANSI C57.12.28, covering enclosure integrity for pad-mounted equipment.
- Article 100-II 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.
- All portions of IEEE C37.73 and IEEE C37.74 and all portions of ANSI C37.72 covering switch testing.
- All portions of ANSI, IEEE, and NEMA standards applicable to the basic switch components.

6. Enclosure Design

- To ensure a completely coordinated design, the pad-mounted gear shall be constructed in accordance with the minimum construction specifications of the fuse and/or switch manufacturer to provide adequate electrical clearances and adequate space for fuse handling.

- b) In establishing the requirements for the enclosure design, consideration shall be given to all relevant factors such as controlled access, tamper resistance, and corrosion resistance.

B. Construction - Assembly

1. Insulators

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

- a) Operating experience of at least 15 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 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 pad-mounted gear shall expose material of the same composition and properties so that insulators with minor surface damage need not be replaced.
- g) Each insulator shall be x-rayed to assure it is void free. An alternate testing method may be used only by approval of the engineer.

2. High-Voltage Bus

- a) Bus and interconnections shall consist of aluminum bar with an oxide-inhibiting agent on all bus joints.
- b) Bus and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the pad-mounted switchgear.
- c) Bolted aluminum-to-aluminum connections shall be made with a suitable number of 1/2" - 13 stainless steel bolts and with two Belleville Spring washers per bolt, one under the bolt head and one under the nut. Bolts shall be tightened to an appropriate foot-pounds torque.
- d) Before installation of the bus, all electrical contact surfaces shall first be prepared by abrading to remove any aluminum-oxide film. Immediately after this operation, the electrical contact surfaces shall be coated with a uniform coating of an oxide inhibitor and sealant.

3. Ground-Connection Pads

- a) A ground-connection pad shall be provided in each compartment of the pad-mounted gear.
- b) The ground-connection pad shall be constructed of 1/4" thick steel (stainless steel or galvanized), which shall be welded to the enclosure, and shall have a short-circuit rating equal to that of the pad-mounted gear.

4. Low-Voltage Components

- a) All low-voltage components, including switch operators, controls, and control-power source shall be located in a grounded, steel-enclosed compartment separate from high voltage to provide isolation and shall be arranged to allow complete accessibility for test and/or maintenance without exposure to high voltage.
- b) Low-voltage wiring, except for short lengths such as at terminal blocks and the secondaries of sensing devices, shall be shielded where necessary for isolation from high voltage.

C. Construction - Enclosure & Finish

1. Enclosure

- a) The pad-mounted gear enclosure shall be of unitized monocoque (not structural-frame-and-bolted-sheet) construction to maximize strength, minimize weight, and inhibit corrosion.
- b) Separate integral, grounded, steel-enclosed low-voltage control compartments shall be provided for the switch operators, controls, and related communication equipment.
- c) The basic material shall be 11-gauge hot-rolled, pickled and oiled steel sheet.
- d) All structural joints and butt joints shall be welded, and the external seams shall be ground flush and smooth. Bolted structural joints are not permitted.
- e) To guard against unauthorized or inadvertent entry, enclosure construction shall not utilize any externally accessible hardware.
- f) The base shall consist of continuous 90-degree flanges, turned inward and welded at the corners, for bolting to the concrete pad.
- g) The door openings shall have 90-degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between doors and door openings to guard against water entry.
- h) Three resilient material cushions shall be placed on door-opening edges to prevent metal-to-metal contact that would damage finish and lead to premature corrosion.
- i) Flanges at door openings of the low-voltage control compartment shall be provided with resilient compression gasketing around the entire door opening, and shall provide strength and rigidity for effective compression of the gasketing to prevent water entry.
- j) Enclosure top side edges shall overlap with roof side edges and form an internal maze to create an interface which shall allow ventilation of high-voltage compartments to help keep the enclosure interior dry while discouraging tampering or insertion of foreign objects.
- k) A heavy coat of insulating "no-drip" compound shall be applied to the inside under surface of the roof to minimize condensation of moisture thereon.
- l) Insulating interphase and end barriers of NEMA GP0-3 grade fiberglass-reinforced polyester shall be provided for each interrupter switch and each set of fuses where required to achieve BIL ratings.

- m) Full-length steel barriers shall separate side-by-side compartments and barriers of the same material shall separate the front compartments from the rear compartments.
- n) Lifting tabs shall be removable and sockets for the lifting-tab bolts shall be blind-tapped. A resilient protective material shall be placed between the lifting tabs and the enclosure to help prevent corrosion by protecting the finish against scratching by the tabs. To further preclude corrosion, this material shall be an open mesh to prevent moisture from being absorbed and held between the tabs and the enclosure in the event that lifting tabs are not removed.
- o) A steel-compartmented base spacer shall be provided to increase the elevation of live parts in the pad-mounted gear above the mounting pad by 24 inches and to house voltage transformer(s) required for control voltage input to battery charger or other optional sensors.
- p) A closed-cell gasketing material shall be placed on the bottom flange as a protective interface between the steel enclosure and the mounting pad.
- q) Interrupter switches shall be provided with dual-purpose front barriers. These barriers, in their normal hanging positions, shall guard against inadvertent contact with live parts. It shall also be possible to lift these barriers out and insert them (but only for a temporary time interval not to exceed one week) into the open gap when the switch is open. A window panel shall be provided to allow viewing of the switch position without removing the barriers. These barriers shall meet the requirements of Section 381G of the National Electrical Safety Code (ANSI Standard C2).
- r) Each fuse with an integral load interrupter shall be provided with a dual-purpose front barrier. These barriers, in their normal hanging positions, shall guard against inadvertent contact with live parts. It shall also be possible to lift these barriers out and insert them (but only for a temporary time interval not to exceed one week) into the open gaps when the fuses are in the disconnect position. These barriers shall meet the requirements of Section 381G of the National Electrical Safety Code (ANSI Standard C2).

2. Doors

- a) Doors shall be constructed of 11-gauge hot-rolled, pickled and oiled steel sheet.
 - b) Doors providing access to high voltage shall have door-edge flanges that shall overlap with door-opening flanges and shall be formed to create an interface that shall guard against water entry and discourage tampering or insertion of foreign objects, but shall allow ventilation to help keep the enclosure interior dry.
 - c) Doors providing access to the low-voltage control compartment shall have 90-degree flanges providing a deep overlap with the door openings. To keep low-voltage components clean and dry, these doors shall be fully gasketed.
 - d) Doors shall have a minimum of three (for the basic enclosure) or two (for the low-voltage enclosure) stainless steel hinges with stainless steel hinge pins to provide strength, security, and corrosion resistance. Mounting hardware shall be stainless steel or zinc-plated steel, and shall not be externally accessible to guard against tampering.
- e) In consideration of controlled access and tamper resistance, each set of double doors providing access to high voltage and doors providing access to controls and switch operators shall be equipped with an automatic three-point latching mechanism.
 - 1) The latching mechanism shall be spring loaded, and shall latch automatically when the door is closed. All latch points shall latch at the same time to preclude partial latching.
 - 2) A pentahead socket wrench or tool shall be required to actuate the mechanism to unlatch the door and, in the same motion, recharge the spring for the next closing operation.
 - 3) The latching mechanism shall have provisions for padlocking that incorporate a means to protect the padlock shackle from tampering and that shall be coordinated with the latches such that:
 - i) It shall not be possible to access the pentahead actuator until the padlock is removed.
 - ii) It shall not be possible to unlatch the mechanism until the padlock is removed, and
 - iii) It shall not be possible to insert the padlock until the mechanism is completely latched closed.
 - f) As an alternate, doors providing access to low-voltage components may be equipped with a three-point latching mechanism, that need not be automatic.
 - g) Doors providing access to solid-material power fuses shall have provisions to store spare fuse units or refill units.
 - h) Each door shall be provided with a door holder located above the door opening. The holder shall be hidden from view when the door is closed, and it shall not be possible for the holder to swing inside the enclosure.

3. Ventilation Openings

- a) Rain-resistant vents shall be provided on doors providing access to the low-voltage control compartment.
- b) Each vent shall have an inside stainless steel screen and a baffle to protect against insertion of foreign objects and entry of insects.

4. Finish

- a) Full coverage at joints and blind areas shall be achieved by processing enclosures independently of components such as doors and roofs before assembly into the unitized structures.
- b) All exterior seams shall be filled and sanded smooth for neat appearance.
- c) To remove oils and dirt, to form a chemically and anodically neutral conversion coating to improve the finish-to-metal bond, and to retard underfilm propagation of corrosion, all surfaces shall undergo a thorough pretreatment process comprised of a system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling before any protective coatings are applied.
- d) The finishing system shall be applied without sags or runs for a pleasing appearance.
- e) After the enclosure is completely assembled and the components (switches, bus, etc.) are installed, the finish shall be inspected for scuffs and scratches.

- f) Blemishes shall be carefully touched up by hand to restore the protective integrity of the finish.
- g) Unless otherwise specified, the color shall be Munsell No. 7GY3.29/1.5, dark green.
- h) To assure that the finishing system is capable of resisting corrosion, the manufacturer shall provide on request, certification that representative test panels, protected by the manufacturer's finish system, have passed the coating system performance requirements in section 5.4 of ANSI C57.12.28-1999.
- i) 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 either nonferrous materials, or galvanized or zinc chromate plated ferrous materials. Cadmium-plated ferrous parts shall not be used.

- g) To further insure arc extinction, air shall be compressed and simultaneously injected into the arcing area to cool the arc and thereby not rely solely on blade travel to insure arc extinction.
- h) Arc extinction shall not rely on gases generated by ablative action of the arc playing on any interrupter switch components or materials which will carbonize, deplete or erode such components and materials.
- i) Ground studs shall be provided at all switch terminals. Ground studs shall also be provided on the ground pad in each interrupter switch compartment. The momentary rating of the ground studs shall equal or exceed the short-circuit ratings of the pad-mounted gear.

The following optional components can be selected:

- j) Bracket-mounted distribution-class surge arresters, metal-oxide type (specify rating), shall be provided at all source switch terminals.
- k) Switch terminals shall be provided with adapters to accommodate two cables per phase.
- l) Mounting provisions shall be provided to accommodate one three-phase fault indicator with three single-phase sensors in each interrupter switch compartment.

D. Basic Components

1. Interrupter Switches

- a) Interrupter switches shall meet the preferred ratings in IEEE C37.74, including a three-time duty-cycle fault-closing rating equal to or exceeding the short-circuit rating of the pad-mounted gear. These ratings define the ability to close the interrupter switch 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 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 operated by means of switch operators installed by the switch manufacturer.
- c) Each interrupter switch shall be completely assembled and adjusted by the switch manufacturer on a single rigid mounting frame. The frame shall be of welded steel construction such that the frame intercepts the leakage path which parallels the open gap of the interrupter switch to positively isolate the load circuit when the interrupter switch is in the open position.
- d) Interrupter switches shall be provided with a single-arm blade construction with parallel current paths for each phase for circuit closing including fault closing, and continuous current carrying, and separate contacts for circuit interrupting. Spring-loaded auxiliary blades that can become out of sequence with a main blade shall not be permitted. Interrupter switch blade supports shall be permanently fixed in place in a unified hinge contact assembly utilizing a louvered contact band configuration that provides expansion and, therefore, increased pressure at the contact transfer point for a stable interface during momentary currents.
- e) Circuit interruption shall be accomplished by use of an interrupter which is positively and inherently sequenced with the blade position. It shall not be possible for the blade and interrupter to get out of sequence. Circuit interruption shall take place completely within the interrupter, with essentially no external arc or flame.
- f) To increase contact separation speed, interrupter switch contacts on both sides of the arcing area shall be spring assisted to reduce arcing time.

2. Fuses

- a) Fuses shall be solid-material power fuses or current-limiting fuses as specified by the equipment purchaser.
- b) Fuse-mounting jaw contacts in live-front pad-mounted switchgear shall incorporate an integral load interrupter that shall comply with the test requirements in IEEE C37.74 to permit live switching of fuses with a hookstick.
 - 1) The integral load interrupter housing shall be of the same cycloaliphatic epoxy resin as the insulators.
 - 2) The integral load interrupter shall be in the current path continuously during circuit interruption. Auxiliary blades or linkages shall not be used.
 - 3) Live switching shall be accomplished by a firm, steady opening pull on the fuse pull ring with a hookstick. No separate load-interrupting tool shall be required.
 - 4) The integral load interrupter shall require a hard pull to unlatch the fuse to reduce the possibility of an incomplete opening operation.
 - 5) Internal moving contacts of the integral load interrupter shall be self-resetting after each opening operation to permit any subsequent closing operation to be performed immediately.
 - 6) Circuit interruption shall take place completely within the integral load interrupter with essentially no external arc or flame.
 - 7) The integral load interrupter and the fuse shall be provided with fault-closing contacts and current-carrying contacts and separate contacts for circuit interrupting. The fuse hinge shall be self-guiding and, together with the fault-closing contacts, shall guide the fuse into the current-carrying contacts during closing operations. Circuit-closing inrush currents and fault currents shall be picked up by the fault-closing contacts, not by current or interrupting contacts.

- 8) Integral load interrupters for fuses shall have a three-time duty-cycle fault-closing capability equal to the interrupting rating of the fuse at 14.4kv or 25kv. The duty-cycle fault-closing capability defines the level of available fault current into which the fuse can be closed the three-times without a quick-make mechanism and when operated vigorously through its full travel without hesitation at any point, with the integral load interrupter remaining operable and able to carry and interrupt currents up to the emergency peak-load capabilities of the fuse.
 - 9) To further insure arc extinction, air shall be compressed and simultaneously injected into the arcing area to cool the arc and thereby not rely solely on blade travel to insure arc extinction.
 - 10) Arc extinction shall not rely on gases generated by ablative action of the arc playing on any interrupter switch components or materials which will carbonize, deplete or erode such components and materials.
- c) Fuse terminal pads shall be provided with a two-position adapter, making it possible to accommodate a variety of cable-terminating devices.
 - d) Ground studs shall be provided at all fuse terminals. One ground stud shall also be provided on the ground pad in each fuse compartment. The momentary rating of the ground studs shall equal or exceed the short-circuit ratings of the pad-mounted gear.
 - e) Fuse-mounting interrupter housing shall be provided with a target that protrudes and becomes visible only after the fuse has become fully latched, secured closed and ready for opening.
- g) Switch operators shall be equipped with indicators to show whether the associated source interrupter switch is in the open or closed position.
 - h) Switch operators shall be provided with a decoupling feature to permit decoupling of the operator from the associated interrupter switch for testing and exercising of the switch operator and controls without opening or closing the interrupter switch and without exposure to high voltage.
 - i) When the switch operator is decoupled, the associated interrupter switch shall be locked in the position it was in at the time of decoupling. It shall not be possible to recouple the switch operator to the source interrupter switch unless the switch operator is in the same position (open or closed) as the interrupter switch.

The following optional feature can be selected:

- j) Switch operators shall be provided with an extra 4-PST auxiliary switch coupled to the source interrupter switch.

4. Interface For Remote Operation

a) Interface Connections

- 1) The switch operator shall provide for interfacing with a remote-terminal unit (RTU). The RTU shall be provided and installed by the user or may be optionally provided and installed by the supplier of the pad-mounted switchgear, or provided by the user and installed by the switchgear supplier, as designated in the user's specification.
- 2) The interface shall include terminal points for connection to the RTU that allow for determination of whether the switch is in the open position or in the closed position.
- 3) The interface shall include terminal points for connection to the RTU that allow for determination of whether the battery (if so equipped) is providing adequate voltage for operating the system.
- 4) The interface shall include terminal points for connection to the RTU that allow for remote operation of the switch operator to open and close the switch when coupled.
- 5) The interface shall include terminal points for connection to the RTU that allow for remote indication of the status of the Local/Remote Selector Switch (if furnished) — either in the LOCAL or REMOTE position.

b) Control Features

- 1) A Local/Remote Selector Switch shall be furnished for choosing operating mode. In the "local" mode, electrical trip-open and trip-closed operation by means of pushbuttons shall be enabled while remote switching shall be inhibited.
- 2) The battery and battery charger, if furnished, shall be located in a grounded, steel-enclosed low-voltage compartment. The control compartment shall provide isolation from high voltage.

The following optional features can be selected:

- 3) Light-emitting lamps shall be furnished for indicating the presence of acceptable voltage on the high-voltage source.

3. Switch Operators for Remote-Supervisory Control

- a) Switch-operators for remote-supervisory control shall be provided to operate the high-voltage source interrupter switches. They shall be motor charged to trip-open and trip-close the switches.
- b) Switch operators shall charge and trip a quick-make quick-break mechanism on the switch installed by the switch manufacturer, and shall have sufficient mechanical energy to open or close the associated interrupter switch. The quick-make quick-break mechanism shall swiftly and positively open and close the interrupter switch independent of the speed of the charging motor or manual handle.
- c) Switch operators shall charge and trip the associated source interrupter switch in response to a remote control signal.
- d) Pushbuttons shall be provided to permit local electrical trip-open and trip-closed operation. Local pushbutton electrical operation shall be prevented when the operator is in the remote mode.
- e) Switch operators shall be provided with a charging shaft and a removable manual handle to allow manual charging and tripping of the quick-make quick-break mechanism in the event control power is lost.
- f) Switch operators shall be located in a grounded, steel-enclosed low-voltage compartment. The compartment shall provide complete isolation from high voltage to help protect operating personnel.

- 4) Separate light-emitting lamps shall be furnished for indicating the switch positions, and the control operating mode (Local/Remote).

c) Voltage Sensing and Control Power

- 1) Voltage sensing and control power input shall be provided by one or more voltage transformers on the load side of the source interrupter switch.
- 2) The output of the voltage transformers shall be directly proportional to line-to-ground voltage and shall have accuracy over an ambient temperature range suitable for the application.
- 3) Constant current devices vulnerable to being open circuited and requiring a protective device for such eventuality and shorting-type terminal blocks shall not be used to provide voltage sensing or power for operation.

d) Current Sensing

- 1) Current sensing shall be provided to detect the level of load current as well as for fault detection and measurement. The feature shall include a light-emitting lamp for indicating when a fault condition has occurred, a reset button for manually resetting the overcurrent condition, and three current sensing devices for each source.
- 2) Provisions shall be furnished for manually resetting the overcurrent condition from a remote location.

The following optional features can be selected:

e) Voltage Sensing

Three-phase voltage sensing shall be provided. Voltage sensing devices for three-phase sensing shall be furnished on phases where voltage transformers are not utilized.

f) Remote Indication

Remote-indication provisions shall be provided to permit remote monitoring of the presence or absence of source voltage and the operating mode — Local/Remote.

g) Supervisory Control

Supervisory control provisions shall be provided to permit switch operation from a remote location.

E. Labeling

1. Warning Signs

- a) Each external door providing access to high voltage shall be provided with a suitable hazard-alerting sign.
- b) The inside of each door providing access to high voltage shall be provided with a "Danger-High Voltage — Keep Out — Qualified Persons Only" sign.
- c) Each barrier providing access to an interrupter switch shall be provided with a sign indicating that "Switch Blades May Be Energized in Any Position" on both sides.
- d) Each barrier providing access to a fuse shall be provided with a sign indicating that "Fuses May Be Energized in Any Position" on both sides.
- e) Any barrier used to prevent access to energized live parts shall be provided with a "Danger-High Voltage-Keep Out-Qualified Persons Only" sign on both sides.

2. Nameplate, Ratings Labels, & Connection Diagrams

- a. The outside of both the front and back shall be provided with nameplates indicating the manufacturer's name, catalog number, model number, and date of manufacture.
- 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 capability and amperes, short-time, RMS (momentary asymmetrical and one-second symmetrical).
- c. A three-line connection diagram showing interrupter switches, fuses and bus along with the manufacturer's model number shall be provided on the inside of both the front and rear doors, inside the door of each motor operator, and on the inside of each switch operating hub access cover.

F. Accessories

1. Furnish fuse components of the type specified by the purchaser. No fuse units shall be supplied unless actually noted by the purchaser in the specifications available to the switchgear manufacturer at the time of quotation.
2. A fuse handling tool (for use on a customer furnished hotstick) as recommended by the fuse manufacturer shall be furnished.

STANDARD SPECIFICATION FOR DEAD-FRONT SCADA CONTROLLED PADMOUNTED SWITCHGEAR

A. General

1. Plans

The padmounted gear shall be the SCPSE design as manufactured by Federal Pacific and shall conform to the following specification.

2. Assembly

The basic padmounted gear shall consist of a single self-supporting enclosure, containing interrupter switches and power fuses and separate, integral enclosure(s) including switch operator(s), controls, and control-power supply; and shall also provide the necessary accessory components, including sensing, controls, and control power input, all completely factory-assembled and operationally checked.

3. Ratings

a) Ratings for the integrated padmounted switchgear assembly shall be as designated below:

System Voltage Class	Fuse Ratings	
	15KV	25KV
KV, Nominal	14.4	25
KV, Maximum Design	17	27
KV, BIL	95	125
Main Bus Continuous, Amps	600	600
Switch Load Interrupting, Amps	600	600
Switch Short-Circuit Ratings*		
Amps, RMS Symmetrical	25,000	25,000
MVA, 3-Phase Symmetrical at Rated Nominal Voltage	620	1,080
Fault Closing Amps, RMS, Asym., 3-Time Duty Cycle**	40,000	40,000

* These are nominal switch ratings. Integrated padmounted unit may be limited by fuse ratings. Use fuse rating chart in next column to select proper short circuit ratings.

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

b) The momentary and three-time duty-cycle fault-closing ratings of switches, momentary rating of bus, interrupting ratings of fuses shall equal or exceed the short-circuit ratings of the pad-mounted switchgear.

4. Certification of Ratings:

The manufacturer shall be completely and solely responsible for the performance of the basic switch components as well as the complete integrated assembly as rated.

The manufacturer shall furnish, upon request, certification of ratings of the basic switch components and/or the integrated padmounted switchgear assembly consisting of the switch and fuse components in combination with the enclosure.

5. Compliance with Standards and Codes

The pad-mounted switchgear shall conform to or exceed the applicable requirements of the following standards and codes:

Fuse Ratings						
Fuse Manufacturer	Fuse Type	Three-Phase MVA Sym	Amps RMS Asym	3-Time* Fault Close Asym	Cont. Amps	Load* Break Amps
14.4 KV Nominal Voltage						
S&C	SM-4	310	20000	20000	200	200
S&C	SMU-20	350	22400	22400	200	200
S&C	SM-5 [‡]	—	—	—	—	—
Cutler-Hammer	DBU	350	22400	22400	200	200
Cooper (M-E)	NX	620	40000	40000	100*	100
Cooper (Kearney)	Q	620	40000	40000	100	100
Cooper (CT)	X-Limiter	620	40000	40000	140	140
25 KV Nominal Voltage						
S&C	SM-4 [†]	540	20000	20000	200	200
S&C	SMU-20	540	20000	20000	200	200
S&C	SM-5 [‡]	—	—	—	—	—
Cutler-Hammer	DBU	540	20000	20000	200	200
Cooper (M-E)	NS	1080	40000	40000	40	40
Cooper (Kearney)	Q	1080	40000	40000	100	100
Cooper (CT)	X-Limiter	1080	40000	40000	140	140

*100 amp @ 13.5 KV max or 80 amp @ 15 KV.

†Applicable to solidly grounded neutral systems only with fuses connected by a single conductor concentric neutral type cable to a transformer or transformers. Rating is 9,400 amperes RMS symmetrical, 15,000 amperes RMS asymmetrical (405 MVA symmetrical) for all other applications.

‡SM-5 fuses cannot be used in SCPSE Padmounted Switchgear. Contact factory for SM-5 applications.

- All portions of ANSI C57.12.28, covering enclosure integrity for pad-mounted equipment.
- Article 100-II 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.
- All portions of IEE C37.73 and C37.74, including all preferred and optional ratings, and all portions of ANSI C37.72 covering switch testing.
- All portions of ANSI, IEEE, and NEMA standards applicable to the basic switch components.

6. Enclosure Design

- To ensure a completely coordinated design, the pad-mounted gear shall be constructed in accordance with the minimum construction specifications of the fuse and/or switch manufacturer to provide adequate electrical clearances and adequate space for fuse handling.
- In establishing the requirements for the enclosure design, consideration shall be given to all relevant factors such as controlled access, tamper resistance, and corrosion resistance.

B. Construction - Assembly

1. Insulators

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

- a) Operating experience of at least 15 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 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 pad-mounted gear shall expose material of the same composition and properties so that insulators with minor surface damage need not be replaced.
- g) Each insulator shall be x-rayed to assure it is essentially void free. An alternate testing method may be used only by approval of the engineer.

2. High-Voltage Bus

- a) Bus and interconnections shall consist of aluminum bar with an oxide-inhibiting agent on all bus joints.
- b) Bus and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the pad-mounted switchgear.
- c) Bolted aluminum-to-aluminum connections shall be made with a suitable number of 1/2" - 13 stainless steel bolts and with two Belleville Spring washers per bolt, one under the bolt head and one under the nut. Bolts shall be tightened to an appropriate foot-pounds torque.
- d) Before installation of the bus, all electrical contact surfaces shall first be prepared by abrading to remove any aluminum-oxide film. Immediately after this operation, the electrical contact surfaces shall be coated with a uniform coating of an oxide inhibitor and sealant.

3. Ground-Connection Pads

- a) A ground-connection pad shall be provided in each compartment of the pad-mounted gear.
- b) The ground-connection pad shall be constructed of 1/4" thick steel (stainless steel or galvanized), which shall be welded to the enclosure, and shall have a short-circuit rating equal to that of the pad-mounted gear.

4. Low-Voltage Components

- a) All low-voltage components, including switch operators, controls, and control-power source shall be located in a grounded, steel-enclosed compartment separate

from high voltage to provide isolation and shall be arranged to allow complete accessibility for test and/or maintenance without exposure to high voltage.

- b) Low-voltage wiring, except for short lengths such as at terminal blocks and the secondaries of sensing devices, shall be shielded where necessary for isolation from high voltage.

C. Construction - Enclosure & Finish

1. Enclosure

- a) The pad-mounted gear enclosure shall be of unitized monocoque (not structural-frame-and-bolted-sheet) construction to maximize strength, minimize weight, and inhibit corrosion.
- b) Separate integral, grounded, steel-enclosed low-voltage control compartments shall be provided for the switch operators, controls, and related communication equipment.
- c) The basic material shall be 11-gauge hot-rolled, pickled and oiled steel sheet.
- d) All structural joints and butt joints shall be welded, and the external seams shall be ground flush and smooth.
- e) To guard against unauthorized or inadvertent entry, enclosure construction shall not utilize any externally accessible hardware.
- f) The base shall consist of continuous 90-degree flanges, turned inward and welded at the corners, for bolting to the concrete pad.
- g) The door openings shall have 90-degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between doors and door openings to guard against water entry.
- h) Three resilient material cushions shall be placed on door-opening edges to prevent metal-to-metal contact that would damage finish and lead to premature corrosion.
- i) Flanges at door openings of the low-voltage control compartment shall be provided with resilient compression gasketing around the entire door opening, and shall provide strength and rigidity for effective compression of the gasketing to prevent water entry.
- j) Enclosure top side edges shall overlap with roof side edges and create an interface which shall allow ventilation of high-voltage compartments to help keep the enclosure interior dry while discouraging tampering or insertion of foreign objects.
- k) A heavy coat of insulating "no-drip" compound shall be applied to the inside under surface of the roof to minimize condensation of moisture thereon.
- l) Insulating interphase and end barriers of NEMA GP0-3 grade fiberglass-reinforced polyester shall be provided for each interrupter switch and each set of fuses where required to achieve BIL ratings.
- m) Full-length steel barriers shall separate side-by-side compartments and barriers of the same material shall separate the front compartments from the rear compartments.

- n) Lifting tabs shall be removable and sockets for the lifting-tab bolts shall be blind-tapped. A resilient protective material shall be placed between the lifting tabs and the enclosure to help prevent corrosion by protecting the finish against scratching by the tabs. To further preclude corrosion, this material shall be an open mesh to prevent moisture from being absorbed and held between the tabs and the enclosure in the event that lifting tabs are not removed.
- o) A steel-compartmented base spacer shall be provided to increase the elevation of live parts in the pad-mounted gear above the mounting pad by 12 inches and to accommodate optional sensors that may be required.
- p) A closed-cell gasketing material shall be placed on the bottom flange as a protective interface between the steel enclosure and the mounting pad.

2. Doors

- a) Doors shall be constructed of 11-gauge hot-rolled, pickled and oiled steel sheet.
- b) Doors providing access to high voltage shall have door-edge flanges that shall overlap with door-opening flanges and shall be formed to create an interface that shall guard against water entry and discourage tampering or insertion of foreign objects, but shall allow ventilation to help keep the enclosure interior dry.
- c) Doors providing access to the low-voltage control compartment shall have 90-degree flanges providing a deep overlap with the door openings. To keep low-voltage components clean and dry, these doors shall be fully gasketed.
- d) Doors shall have a minimum of three (for the basic enclosure) or two (for the low-voltage enclosure) stainless steel hinges with stainless steel hinge pins to provide strength, security, and corrosion resistance. Mounting hardware shall be stainless steel or zinc-plated steel, and shall not be externally accessible to guard against tampering.
- e) In consideration of controlled access and tamper resistance, each set of double doors providing access to high voltage and doors providing access to controls and switch operators shall be equipped with an automatic three-point latching mechanism.
 - 1) The latching mechanism shall be spring loaded, and shall latch automatically when the door is closed. All latch points shall latch at the same time to preclude partial latching.
 - 2) A pentahead socket wrench or tool shall be required to actuate the mechanism to unlatch the door and, in the same motion, recharge the spring for the next closing operation.
 - 3) The latching mechanism shall have provisions for padlocking that incorporate a means to protect the padlock shackle from tampering and that shall be coordinated with the latches such that:
 - i) It shall not be possible to access the pentahead actuator until the padlock is removed.
 - ii) It shall not be possible to unlatch the mechanism until the padlock is removed, and
 - iii) It shall not be possible to insert the padlock until the mechanism is completely latched closed.

- f) As an alternate, doors providing access to low-voltage components may be equipped with a three-point latching mechanism, that need not be automatic.
- g) Doors providing access to solid-material power fuses shall have provisions to store spare fuse units or refill units.
- h) Each door shall be provided with a door holder located above the door opening. The holder shall be hidden from view when the door is closed, and it shall not be possible for the holder to swing inside the enclosure.

3. Ventilation Openings

- a) Rain-resistant vents shall be provided on doors providing access to the low-voltage control compartment.
- b) Each vent shall have an inside stainless steel screen and a baffle to protect against insertion of foreign objects and entry of insects.

4. Finish

- a) Full coverage at joints and blind areas shall be achieved by processing enclosures independently of components such as doors and roofs before assembly into the unitized structures.
- b) All exterior seams shall be filled and sanded smooth for neat appearance.
- c) To remove oils and dirt, to form a chemically and anodically neutral conversion coating to improve the finish-to-metal bond, and to retard underfilm propagation of corrosion, all surfaces shall undergo a thorough pretreatment process comprised of a system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling before any protective coatings are applied.
- d) The finishing system shall be applied without sags or runs.
- e) After the enclosure is completely assembled and the components (switches, bus, etc.) are installed, the finish shall be inspected for scuffs and scratches.
- f) Blemishes shall be carefully touched up by hand to restore the protective integrity of the finish.
- g) Unless otherwise specified, the color shall be Munsell No. 7GY3.29/1.5, dark green.
- h) To assure that the finishing system is capable of resisting corrosion, the manufacturer shall provide on request, certification that representative test panels, protected by the manufacturer's finish system, have passed the coating system performance requirements in section 5.4 of ANSI C57.12.28-1999.
- i) 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 either nonferrous materials, or 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 pad-mounted gear. These ratings define the ability to close the interrupter switch 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 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 operated by means of switch operators installed by the switch manufacturer.
- c) Each interrupter switch shall be completely assembled and adjusted by the switch manufacturer on a single rigid mounting frame. The frame shall be of welded steel construction such that the frame intercepts the leakage path which parallels the open gap of the interrupter switch to positively isolate the load circuit when the interrupter switch is in the open position.
- d) Interrupter switches shall be provided with a single-arm blade construction with parallel current paths for each phase for circuit closing including fault closing, and continuous current carrying, and separate contacts for circuit interrupting. Spring-loaded auxiliary blades that can become out of sequence with a main blade shall not be permitted. Interrupter switch blade supports shall be permanently fixed in place in a unified hinge contact assembly utilizing a louvered contact band configuration that provides expansion and, therefore, increased pressure at the contact transfer point for a stable interface during momentary currents.
- e) Circuit interruption shall be accomplished by use of an interrupter which is positively and inherently sequenced with the blade position. It shall not be possible for the blade and interrupter to get out of sequence. Circuit interruption shall take place completely within the interrupter, with essentially no external arc or flame.
- f) To increase contact separation speed, interrupter switch contacts on both sides of the arcing area shall be spring assisted to reduce arcing time.
- g) To further insure arc extinction, air shall be compressed and simultaneously injected into the arcing area to cool the arc and thereby not rely solely on blade travel to insure arc extinction.
- h) Arc extinction shall not rely on gases generated by ablative action of the arc playing on any interrupter switch components or materials which will carbonize, deplete or erode such components and materials.
- i) Switch terminals shall connect to 600-ampere bushings to accommodate 600-ampere elbows.

The following optional components can be selected:

- j) Mounting provisions shall be provided to accommodate one three-phase fault indicator with three single-phase sensors in each interrupter switch compartment.

2. Fuses

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

- b) Fuse terminals shall incorporate 200-ampere loadbreak bushing wells.

3. Switch Operators for Remote- Supervisory Control

- a) Switch-operators for remote-supervisory control shall be provided to operate the high-voltage source interrupter switches. They shall be motor charged to trip-open and trip-close the switches.
- b) Switch operators shall charge and trip a quick-make quick-break mechanism on the switch installed by the switch manufacturer, and shall have sufficient mechanical energy to open or close the associated interrupter switch. The quick-make quick-break mechanism shall swiftly and positively open and close the interrupter switch independent of the speed of the charging motor or manual handle.
- c) Switch operators shall charge and trip the associated source interrupter switch in response to a remote control signal.
- d) Pushbuttons shall be provided to permit local electrical trip-open and trip-closed operation. Local pushbutton electrical operation shall be prevented when the operator is in the remote mode.
- e) Switch operators shall be provided with a charging shaft and a removable manual handle to allow manual charging and tripping of the quick-make quick-break mechanism in the event control power is lost.
- f) Switch operators shall be located in a grounded, steel-enclosed low-voltage compartment. The compartment shall provide complete isolation from high voltage to help protect operating personnel.
- g) Switch operators shall be equipped with indicators to show whether the associated source interrupter switch is in the open or closed position.
- h) Switch operators shall be provided with a decoupling feature to permit decoupling of the operator from the associated interrupter switch for testing and exercising of the switch operator and controls without opening or closing the interrupter switch and without exposure to high voltage.
- i) When the switch operator is decoupled, the associated interrupter switch shall be locked in the position it was in at the time of decoupling. It shall not be possible to recouple the switch operator to the source interrupter switch unless the switch operator is in the same position (open or closed) as the interrupter switch.

The following optional feature can be selected:

- j) Switch operators shall be provided with an extra 4-PST auxiliary switch coupled to the source interrupter switch.

4. Interface For Remote Operation

a) Interface Connections

- 1) The switch operator shall provide for interfacing with a remote-terminal unit (RTU). The RTU shall be provided and installed by the user or may be optionally provided and installed by the supplier of the pad-mounted switchgear, or provided by the user and installed by the switchgear supplier, as designated in the user's specification.

- 2) The interface shall include terminal points for connection to the RTU that allow for determination of whether the switch is in the open position or in the closed position.
- 3) The interface shall include terminal points for connection to the RTU that allow for determination of whether the battery (if so equipped) is providing adequate voltage for operating the system.
- 4) The interface shall include terminal points for connection to the RTU that allow for remote operation of the switch operator to open and close the switch when coupled.
- 5) The interface shall include terminal points for connection to the RTU that allow for remote indication of the status of the Local/Remote Selector Switch (if furnished) — either in the LOCAL or REMOTE position.

b) Control Features

- 1) A Local/Remote Selector Switch shall be furnished for choosing operating mode. In the "local" mode, electrical trip-open and trip-closed operation by means of pushbuttons shall be enabled while remote switching shall be inhibited.
- 2) The battery and battery charger, if furnished, shall be located in a grounded, steel-enclosed low-voltage compartment. The control compartment shall provide isolation from high voltage.

The following optional features can be selected:

- 3) Light-emitting lamps shall be furnished for indicating the presence of acceptable voltage on the high-voltage source.
- 4) Separate light-emitting lamps shall be furnished for indicating the switch positions, and the control operating mode (Local/Remote).

c) Voltage Sensing and Control Power

- 1) Voltage sensing and control power input shall be provided by one or more voltage transformers on the load side of the source interrupter switch.
- 2) The output of the voltage transformers shall be directly proportional to line-to-ground voltage and shall have accuracy over an ambient temperature range suitable for the application.
- 3) Constant current devices vulnerable to being open circuited and requiring a protective device for such eventuality and shorting-type terminal blocks shall not be used to provide voltage sensing or power for operation.

d) Current Sensing

- 1) Current sensing shall be provided to detect the level of load current as well as for fault detection and measurement. The feature shall include a light-emitting lamp for indicating when a fault condition has occurred, a reset button for manually resetting the overcurrent condition, and three current sensing devices for each source.
- 2) Provisions shall be furnished for manually resetting the overcurrent condition from a remote location.

The following optional features can be selected:

e) Voltage Sensing

Three-phase voltage sensing shall be provided. Voltage sensing devices for three-phase sensing shall be furnished on phases where voltage transformers are not utilized.

f) Remote Indication

Remote-indication provisions shall be provided to permit remote monitoring of the presence or absence of source voltage and the operating mode — Local/Remote.

g) Supervisory Control

Supervisory control provisions shall be provided to permit switch operation from a remote location.

E. Labeling

1. Warning Signs

- a) Each external door providing access to high voltage shall be provided with a suitable hazard-alerting sign.
- b) The inside of each door providing access to high voltage shall be provided with a "Danger-High Voltage — Keep Out — Qualified Persons Only" sign.
- c) Any barrier used to prevent access to energized live parts shall be provided with a "Danger-High Voltage-Keep Out-Qualified Persons Only" sign on both sides.

2. Nameplate, Ratings Labels, & Connection Diagrams

- a. The outside of both the front and back shall be provided with nameplates indicating the manufacturer's name, catalog number, model number, and date of manufacture.
- 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 capability and amperes, short-time, RMS (momentary asymmetrical and one-second symmetrical).
- c. A three-line connection diagram showing interrupter switches, fuses and bus along with the manufacturer's model number shall be provided on the inside of both the front and rear doors, inside the door of each motor operator, and on the inside of each switch operating hub access cover.

F. Accessories (Optional Features)

1. Furnish fuse components of the type specified by the purchaser. No fuse units shall be supplied unless actually noted by the purchaser in the specifications available to the switchgear manufacturer at the time of quotation.
2. A fuse handling tool (for use on a customer furnished hotstick) as recommended by the fuse manufacturer shall be furnished.
3. Grounding elbows as recommended by the switchgear purchaser.