1.0 GENERAL

1.1 The pad-mounted gear shall be in accordance with the single-line diagram, and shall conform to the following specification.

1.2 The pad-mounted gear shall consist of a single self-supporting enclosure, containing interrupter switches and power fuses with the necessary accessory components, all completely factory-assembled and operationally checked. The interrupter switches and fuses shall be enclosed within an inner grounded steel compartment for electrical isolation and for protection from contamination. Switch terminals shall be equipped with bushings rated 600 amperes continuous, and fuse terminals and bus terminals shall be equipped with bushing wells rated 200 amperes continuous to provide for elbow connection. Bushings and bushing wells shall be mounted on the walls of the inner compartment and shall extend into termination compartments. A termination compartment shall be provided for each three-phase switch, each three-phase set of fuses, and each three-phase set of bus terminals.

1.3 Ratings

The ratings for the integrated pad-mounted gear shall be as designated below. *(Select values from the table on page 2.)*

Nominal Voltage, kV. . . . . ____________
Maximum Voltage, kV . . . . ____________
BIL Voltage, kV . . . . ____________
Short-Circuit
  Peak Withstand Current, Amperes, Peak . . . . ____________
  One-Second Short-Time Withstand Current,
    Amperes, RMS, Symmetrical . . . . ____________
  MVA, Three-Phase Symmetrical, at Rated
    Nominal Voltage . . . . ____________
Main Bus
  Continuous Current, Amperes. . . . . ____________
  Peak Withstand Current, Amperes, Peak . . . . ____________
  One-Second Short-Time Withstand Current,
    Amperes, RMS, Symmetrical . . . . ____________
  Three-Pole Interrupter Switches
    Continuous Current, Amperes. . . . . ____________
  Load Dropping Current, Amperes . . . . ____________

Peak Withstand Current, Amperes, Peak . . . . ____________

One-Second Short-Time Withstand Current,
Amperes, RMS, Symmetrical . . . . ____________

Three-Time Duty-Cycle Fault-Closing Current,
Amperes, RMS, Symmetrical . . . . ____________

Three-Time Duty-Cycle Fault-Closing Current,
Amperes, Peak. . . . . ____________

Fuses

Maximum Current, Amperes . . . . ____________

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

SELECTION OF 60-HERTZ RATINGS

Nominal Voltage, kV Maximum Voltage, kV BIL Voltage, kV		14.4 17.0● 95	25 27 125
Short-Circuit①	Peak Withstand Current, Amperes, Peak	36 400●■▲	32 500
	One-Second Short-Time Withstand Current, Amperes, RMS, Symmetrical	14 000●■▲	12 500
	MVA, Three-Phase Symmetrical, at Rated Nominal Voltage	350●■▲	540
Main Bus	Continuous Current, Amperes	600	600
	Peak Withstand Current, Amperes, Peak	65 000◆	32 500
	One-Second Short-Time Withstand Current, Amperes, RMS, Symmetrical	25 000◆	12 500
Three-Pole Interrupter Switches	Continuous Current, Amperes	600	600
	Load Dropping Current, Amperes	600	600
	Peak Withstand Current, Amperes, Peak	65 000	32 500
	One-Second Short-Time Withstand Current, Amperes, RMS, Symmetrical	14 000	12 500
	Three-Time Duty-Cycle Fault-Closing Current, Amperes, Peak	36 400	32 500
Fuses	Maximum Current, Amperes	200, 200E, or 200K	200, 200E, or 200K

① Short-circuit rating of complete pad-mounted gear may be limited by ratings of bushing inserts, elbows, T-bodies, fuses, and cables used.

● 14.4-kV gear, when furnished with switches only (and no fuses), has the following ratings:

- 17.5 kV maximum voltage
- 65,000 amperes, peak, short-circuit peak withstand current
- 25,000 amperes, RMS, symmetrical, short-circuit one-second short-time withstand current
- 620 MVA, three-phase symmetrical, at rated nominal voltage

■ 14.4-kV gear, when furnished with fuses using refill-unit-and-holder construction, has the following ratings

- 32,500 amperes, peak, short-circuit peak withstand current
- 12,500 amperes, RMS, symmetrical, short-circuit one-second short-time withstand current
- 310 MVA, three-phase symmetrical, at rated nominal voltage

▲ 14.4-kV gear, when furnished with current-limiting fuses having a rated maximum interrupting current of at least of 25,000 amperes, RMS, symmetrical, and limiting the instantaneous peak let-through current to less than 36,000 amperes, has the following ratings:

- 65,000 amperes, peak, short-circuit peak withstand current
- 25,000 amperes, RMS, symmetrical, short-circuit one-second short-time withstand current
- 620 MVA, three-phase symmetrical, at rated nominal voltage

◆ Applicable to four-compartment models. Two-compartment models have the following ratings:

- 36,400 amperes, peak, short-circuit peak withstand current
- 14,000 amperes, RMS, symmetrical, short-circuit one-second short-time withstand current

1.4 Certification of Ratings

(a) The manufacturer of the pad-mounted gear shall be completely and solely responsible for the performance of the basic switch and fuse components as well as the complete integrated assembly as rated.

(b) The manufacturer shall furnish, upon request, certification of ratings of the basic switch and fuse components and/or the integrated pad-mounted gear assembly consisting of the switch and fuse components in combination with the enclosure.

1.5 Compliance with Standards and Codes

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

(a) All portions of ANSI C57.12.28, covering enclosure integrity for pad-mounted equipment.

(b) Article 710.21(e) 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.

(c) All portions of ANSI, IEEE, and NEMA standards applicable to the basic switch and fuse components.

The following optional feature should be specified as required:

(d) UL Listing.

1.6 Enclosure Design

(a) 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.

(b) In establishing the requirements for the enclosure design, consideration shall be given to all relevant factors such as controlled access, tamper resistance, corrosion resistance, and resistance to entry of foliage, animals, and airborne contaminants.

2.0 CONSTRUCTION—Insulators, High-Voltage Bus, Provisions for Grounding, Bushings and Bushing Wells, and Termination Compartments

2.1 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 25 years under similar conditions

(b) Adequate leakage distance established by test per IEC Publication 507, “Artificial Pollution Test on High Voltage Insulators to be Used on AC Systems”

(c) Adequate strength for short-circuit stress established by test

(d) Conformance with applicable ANSI standards

(e) Homogeneity of the cycloaliphatic epoxy resin throughout each insulator to provide maximum resistance to power arcs (Ablation caused by 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.)

2.2 High-Voltage Bus

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

(b) Bus and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the pad-mounted gear.

(c) Bolted aluminum-to-aluminum connections shall be made with a suitable number of galvanized steel bolts, with two Belleville spring washers per bolt, one under the bolt head and one under the nut. Bolts shall be tightened to 50 foot-pounds torque.

(d) Before installation of the bus, all electrical contact surfaces shall first be prepared by machine-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.

(e) Tie bus, where furnished, shall consist of continuous, one-piece sections of aluminum bar with no intermediate splices. Flexible braid or cable shall not be used.

2.3 Provisions for Grounding

(a) A ground-connection pad shall be provided in each termination compartment of the pad-mounted gear.

(b) The ground-connection pad shall be constructed of steel no less than ⅜-inch (10-mm) thick. It shall be nickel plated and welded to the enclosure, and shall have a short-circuit rating equal to that of the pad-mounted gear.

(c) Ground-connection pads shall be coated with a uniform coating of an oxide inhibitor and sealant prior to shipment.

(d) A copper rod, connected to the ground-connection pad, shall be provided in each termination compartment for switches and bus. The rod shall have a diameter no less than ⅜-inch (10-mm) and extend across the full width of the compartment to allow convenient grounding of cable concentric neutrals and accessories, and shall have a short-circuit rating equal to that of the pad-mounted gear.

(e) Continuous copper ground bus shall be provided across the full width of each termination compartment for fuses. For each fuse mounting, there shall be a ground ring made of ⅜-inch (10-mm) diameter copper rod bolted to the ground bus and placed to allow convenient grounding of cable concentric neutrals and accessories. Ground rings and bus shall have a short-circuit rating equal to that of the pad-mounted gear.

2.4 Bushings and Bushing Wells

(a) Bushings and bushing wells shall conform to ANSI/IEEE Standard 386.

(b) Bushings and bushing wells shall be of a cycloaliphatic epoxy resin system with characteristics and restrictions as follows:

(1) Operating experience of at least 15 years under similar conditions.

(2) Adequate leakage distance for in-air application established by test per IEC Publication 507, "Artificial Pollution Test on High Voltage Insulators to be Used on AC Systems."

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

(4) Conformance with applicable ANSI standards.

(5) Homogeneity of the cycloaliphatic epoxy resin throughout each bushing or bushing well 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.

(c) Bushings and bushing wells shall be mounted in such a way that the semiconductive coating is solidly grounded to the enclosure.

(d) Bushings rated 600 amperes continuous shall have a removable threaded stud so that the bushings are compatible with all 600-ampere elbow systems—those requiring a threaded stud as well as those that do not.

2.5 Termination Compartments

(a) Termination compartments for switches shall have bushings, and termination compartments for fuses shall have bushing wells to permit connection of elbows. The bushings and bushing wells shall be mounted on the interior walls at a minimum height of 33 inches (84 cm) above the enclosure base.

(b) Termination compartments for bus shall have bushing wells to permit connection of elbows. The bushing wells shall be mounted on the interior walls at a minimum height of 25 inches (64 cm) above the enclosure base.

(c) Termination compartments for bushings rated 600 amperes continuous shall be of an adequate depth to accommodate two 600-ampere elbows mounted piggyback, encapsulated surge arresters or grounding elbows mounted on 600-ampere elbows having 200-ampere interfaces, or other similar accessory combinations without the need for an enclosure extension.

(d) Termination compartments for bushing wells rated 200 amperes continuous shall be of an adequate depth to accommodate 200-ampere elbows mounted on portable feedthrus or standoff insulators, or other similar accessory combinations without the need for an enclosure extension.

(e) Termination compartments shall be provided with one parking stand for each bushing or bushing well. The parking stand shall be located immediately adjacent to the associated bushing or bushing well and shall accommodate standard feedthrus and standoff insulators, and other similar accessories.

(f) Each termination compartment for a switch shall be equipped with a viewing window to allow visual inspection of interrupter switch blades to allow positive verification of switch position.

(g) Each termination compartment for a set of fuses shall be equipped with a set of viewing windows to allow visual inspection of blown-fuse indicators.

3.0 CONSTRUCTION—Enclosure, Doors, Roof, and Finish

3.1 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) The basic material shall be 11-gauge hot-rolled, pickled and oiled steel sheet.

(c) All structural joints and butt joints shall be welded, and the external seams shall be ground flush and smooth. The gas-metal-arc welding process shall be employed to eliminate alkaline residues and to minimize distortion and spatter.

(d) To guard against unauthorized or inadvertent entry, enclosure construction shall not use any externally accessible hardware.

(e) The base shall consist of continuous 90-degree flanges, turned inward and welded at the corners, for bolting to the concrete pad.

(f) 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.

(g) Gasketing between the roof and the enclosure shall guard against entry of water and airborne contaminants and shall discourage tampering or insertion of foreign objects.

(h) An internal steel-enclosed compartment shall encase the interrupter switches and fuses for electrical isolation and protection from contamination. The compartment shall have a galvanized steel sheet floor to exclude foliage and animals. The floor shall have screened drain vents to allow drainage if the enclosure is flooded. The top of this compartment shall be gasketed to provide sealing with the enclosure roof.

(i) Insulating barriers of NEMA GPO3-grade fiberglass-reinforced polyester shall be provided for each interrupter switch where required to achieve BIL ratings. Additional insulating barriers of the same material shall isolate the tie bus (where furnished).

(j) Full-length steel barriers shall separate adjoining termination compartments.

(k) Lifting tabs shall be removable. Sockets for the lifting-tab bolts shall be blind-tapped. A resilient 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 closed-cell to prevent moisture from being absorbed and held between the tabs and the enclosure in the event that lifting tabs are not removed.

(l) The enclosure shall be provided with an instruction manual holder.

The following optional feature should be specified as required:

(m) To guard against corrosion due to extremely harsh environmental conditions, the entire exterior of the enclosure shall be fabricated from 11-gauge Type 304 stainless steel.

3.2 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 to discourage tampering or insertion of foreign objects.

(c) Doors shall have a minimum of two extruded-aluminum hinges with stainless steel hinge pins, and interlocking extruded-aluminum hinge supports for the full length of the door to provide strength, security, and corrosion resistance. Mounting hardware shall be stainless steel or zinc-nickel-plated steel, and shall not be externally accessible to guard against tampering.

(d) Doors shall be hinged at the sides to swing open with minimum effort. Doors hinged at the top requiring significant effort to lift open shall not be allowed.

(e) In consideration of controlled access and tamper resistance, each door (or set of double doors) 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 unlatch the mechanism until the padlock is removed, and

(ii) It shall not be possible to insert the padlock until the mechanism is completely latched closed.

(f) Doors providing access to solid-material power fuses shall have provisions to store spare fuse units or refill units.

(g) Each door shall be provided with a zinc-nickel-plated steel 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.

3.3 Roof

(a) The roof shall be constructed of 11-gauge hot-rolled, pickled and oiled steel sheet.

(b) A heavy coat of insulating “no-drip” compound shall be applied to the inside surface of the center roof section to minimize condensation of moisture thereon.

(c) Roof sections over termination compartments shall be liftable and hinged to allow room for cable pulling during installation. Each roof section shall require minimal effort to open and close and shall have a retainer to hold it in the open position.

(d) A mechanical interlock shall be provided to ensure the roof sections over the termination compartments are closed and secured before allowing full engagement of the door latching mechanism described in Section 3.02(e).

(e) Roof sections over high-voltage compartments shall be bolted to the enclosure with no exposed fasteners.

3.4 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 fully automated system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling before any protective coatings are applied. By using an automated pretreatment process, the enclosure shall receive a highly consistent thorough treatment, eliminating fluctuations in reaction time, reaction temperature, and chemical concentrations.

(d) After pretreatment, protective coatings shall be applied that shall help resist corrosion and protect the steel enclosure. To establish the capability to resist corrosion and protect the enclosure, representative test specimens coated by the enclosure manufacturer's finishing system shall satisfactorily pass the following tests:

(1) 4000 hours of exposure to salt-spray testing per ASTM B 117 with both:

(i) Underfilm corrosion not to extend more than 1⁄32-inch (0.8 mm) from the scribe, as evaluated per ASTM D 1645, Procedure A, Method 2 (scraping)

(ii) Loss of adhesion from bare metal not to extend more than 1⁄8-inch (3 mm) from the scribe

(2) 1000 hours of humidity testing per ASTM D 4585, with no blistering as evaluated per ASTM D 714.

(3) 500 hours of accelerated weathering testing per ASTM G 53 using lamp UVB-313, with no chalking as evaluated per ASTM D 659, and no more than 35% reduction of gloss as evaluated per ASTM D 523.

(4) Crosshatch-adhesion testing per ASTM D 3359 Method B, with no loss of finish.

(5) 160-inch-pound impact, followed by adhesion testing per ASTM D 2794, with no chipping or cracking.

(6) 3000 cycles of abrasion testing per ASTM D, with no penetration to the substrate.

Certified test abstracts substantiating the above capabilities shall be furnished upon request.

(e) After the finishing system has been properly applied and cured, welds along the enclosure bottom flange shall be coated with a wax-based anticorrosion moisture barrier to give these areas added corrosion resistance.

(f) A resilient closed-cell material, such as PVC gasket, shall be applied to the entire underside of the enclosure bottom flange to protect the finish on this surface from scratching during handling and installation. This material shall isolate the bottom flange from the alkalinity of a concrete foundation to help protect against corrosive attack.

(g) After the enclosure is completely assembled and the components (switches, fuses, bus, etc.) are installed, the finish shall be inspected for scuffs and scratches. Blemishes shall be touched up by hand to restore the protective integrity of the finish.

(h) The finish shall be olive green, Munsell 7GY3.29/1.5.

The following optional feature should be specified as required:

(i) The finish shall be ANSI 70 Outdoor Light Gray.

3.5 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-nickel-plated ferrous materials. Cadmium-plated ferrous parts shall not be used.

4.0 BASIC COMPONENTS

4.1 Interrupter Switches

(a) Interrupter switches shall be enclosed in an inner steel compartment and shall be provided with bushings rated 600 amperes continuous to permit connection of elbows external to the switch compartment.

(b) 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.

(c) Interrupter switches shall be operated by means of an externally accessible ¾-inch hex switch-operating hub. The switch-operating hub shall be located within a recessed stainless steel pocket mounted on the side of the pad-mounted gear enclosure and shall accommodate a ¾-inch deep-socket wrench or a ¾-inch shallow-socket wrench with extension. The switch-operating-hub pocket shall include a padlockable stainless steel access cover that shall incorporate a hood to protect the padlock shackle from tampering. Stops shall be provided on the switch-operating hub to prevent overtravel and thereby guard against damage to the interrupter switch quick-make quick-break mechanism. Labels to indicate switch position shall be provided in the switch-operating-hub pocket.

(d) Each interrupter switch shall be provided with a folding switch-operating handle. The switch-operating handle shall be secured to the inside of the switch-operating-hub pocket by a brass chain. The folded handle shall be stored behind the closed switch-operating-hub access cover.

(e) Interrupter switches shall use 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 switch-operating-hub speed.

(f) 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.

(g) Interrupter switch contacts shall be backed up by stainless steel springs to provide constant high contact pressure.

(h) Interrupter switches shall be provided with a single blade per phase for circuit closing, including fault closing, continuous current carrying, and circuit interrupting. Spring-loaded auxiliary blades shall not be permitted. Interrupter switch blade supports shall be permanently molded in place in a unified insulated shaft constructed of the same cycloaliphatic epoxy resin as the insulators.

(i) 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 no external arc or flame. Any exhaust shall be vented in a controlled manner through a deionizing vent.

The following optional features should be specified as required:

(j) Key interlocks shall be provided to prevent paralleling the two source interrupter switches.

(k) Key interlocks shall be provided to guard against opening the door(s) of fuse-termination compartment(s) unless all switches are locked open.

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

(m) Interrupter switch bushings rated 600 amperes continuous shall be provided without studs.

4.2 Fuses (*Select either solid-material power fuses or electronic pow*er fuses.)

(a) Solid-Material Power Fuses

(1) Solid-material power fuses shall use refill-unit-and-holder or fuse-unit-and-end-fitting construction. The refill unit or fuse unit shall be readily replaceable and low in cost.

(2) Fusible elements shall be nonaging and nondamageable so it is unnecessary to replace unblown companion fuses following a fuse operation.

(3) Fusible elements for refill units or fuse units, rated 10 amperes or larger, shall be helically coiled to avoid mechanical damage due to stresses from current surges.

(4) Fusible elements that carry continuous current shall be supported in air to help prevent damage from current surges.

(5) Refill units and fuse units shall have a single fusible element to eliminate the possibility of unequal current sharing in parallel current paths.

(6) Solid-material power fuses shall have melting time-current characteristics that are permanently accurate to within a maximum total tolerance of 10% in terms of current. Time-current characteristics shall be available which permit coordination with source-side and load-side protective relays, automatic circuit reclosers, and other fuses.

(7) Solid-material power fuses shall be capable of detecting and interrupting all faults, whether large, medium, or small (down to minimum melting current); under all realistic conditions of circuitry; and with line-to-line or line-to-ground voltage across the fuse. They shall be capable of handling the full range of transient recovery voltage severity associated with these faults.

(8) All arcing accompanying solid-material power fuse operation shall be contained within the fuse, and all arc products and gases evolved shall be effectively contained within the exhaust control device during fuse operation.

(9) Solid-material power fuses shall be equipped with a blown-fuse indicator that shall provide visible evidence of fuse operation while installed in the fuse mounting.

(b) Electronic Power Fuses

(1) Electronic power fuses shall use an expendable interrupting module and a reusable control module.

(i) The interrupting module shall consist of a main-current section and a fault-interrupting section. These sections shall be arranged coaxially and contained within the same housing.

(ii) The main-current section shall carry current under normal operating conditions.

(iii) The fault-interrupting section shall operate only under fault conditions. It shall not carry current continuously and shall not determine the minimum operating time-current characteristic curve shape.

(iv) The current-limiting-section fusible element shall not be subject to damage due to current surges.

(v) All arcing accompanying operation of the electronic power fuse shall be contained within the interrupting module and fuse operation shall be silent, without any exhaust.

(vi) The control module shall continuously monitor the line current through an electronic sensing circuit.

(vii) The electronic components shall be located within a cylindrical cast-aluminum housing that shall serve as both a path for continuous current and as a shield to protect the electronic components against interference from external electric fields.

(viii) To prevent damage to the control-module circuits by surges (such as due to lightning or inrush currents), the control module shall be free of external control wiring and connections to ground, and shall incorporate a device that acts as a buffer to isolate the electronic components at a level of current well below their surge-withstand capability.

(ix) The control module shall be factory-sealed to assure a dry, contaminant-free environment for the electronic components.

(x) The control module shall be self-powered with the capability to supply power for operating the sensing logic circuits and to actuate the interrupting module when a fault occurs.

(xi) The control module shall include one or more integrally mounted current transformers to provide both the sensing signal and the control power.

(xii) The current transformer used to provide control power shall be designed to act as a buffer against surges in the line by saturating at a level of current well below the surge-withstand capability of the electronic components.

(xiii) No leads (including coaxial leads) between the current transformers and the electronic components shall be exposed.

(2) To ensure the integrity of the electrical connection between the interrupting and control modules is independent of the mechanical force with which the modules are joined, the connection shall be through a louvered ring-type sliding contact.

(3) Electronic power fuses shall be equipped with a blown-fuse indicator that shall provide visible evidence of fuse operation while installed in the fuse mounting.

(4) It shall not be necessary to replace unblown companion interrupting modules following operation of an electronic power fuse.

(5) Electronic power fuses shall have time-current characteristics that are permanently accurate. Time-current characteristics shall be available which permit coordination with source-side and load-side protective relays, automatic circuit reclosers, and other fuses.

(6) Mountings for electronic power fuses shall also accommodate current-limiting fuses.

(c) Fuse mountings shall be enclosed in an inner steel compartment and shall be provided with bushing wells rated 200 amperes continuous for elbow connection.

(1) Each fuse mounting shall be an integral part of a fuse handling mechanism that does not allow access to the fuse until the elbow for that fuse has been disconnected. To access a fuse it shall be necessary to:

(i) Disconnect the elbow for that fuse and move it to the appropriate parking stand.

(ii) Actuate a mechanical interlock to unlock the fuse-access panel. It shall not be possible to disengage this interlock before the elbow is moved.

(iii) Unlatch and then pivot the fuse-access panel to electrically isolate the fuse so that it can be removed from the fuse mounting with a shotgun stick.

(2) The opening into the component compartment shall be covered by the fuse-access panel in both the open and closed positions to help prevent inadvertent access to high voltage.

(3) To protect the fuse-handling mechanism from corrosion, all mechanism parts shall be painted or made of corrosion-resistant materials, or otherwise be protected from corrosion. All latches and pivots shall be stainless steel or zinc-nickel-plated steel with nylon or plastic bushings.

(4) Cable guides shall be provided in each termination compartment for a set of fuses, to prevent cables from interfering with rotation of the fuse-access panel.

The following optional feature should be specified as required:

(d) A fuse-storage feature shall be provided in *(one, two)* source interrupter-switch compartment(s). Each fuse-storage feature shall provide space for storing three spare fuse holders or fuse units with end fittings for solid-material power fuses, or two spare electronic power fuse holders.

5.0 LABELING

5.1 Hazard-Alerting Signs

(a) All external doors shall be provided with "Warning—Keep Out—Hazardous Voltage Inside—Can Shock, Burn, or Cause Death" signs.

(b) The inside of each door shall be provided with a "Danger—Hazardous Voltage—Failure to Follow These Instructions Will Likely Cause Shock, Burns, or Death" sign. The text shall further indicate that operating personnel must know and obey the employer's work rules, know the hazards involved, and use proper protective equipment and tools to work on this equipment.

(c) Termination compartments shall be provided with "Danger—Keep Away—Hazardous Voltage—Will Shock, Burn, or Cause Death" signs.

5.2 Nameplates, Ratings Labels, and Connection Diagrams

(a) The outside of each door (or set of double doors) shall be provided with a name-plate indicating the manufacturer's name, catalog number, model number, date of manufacture, and serial number.

(b) The inside of each door (or set of double doors) shall be provided with a ratings label indicating the following:

(1) Overall pad-mounted gear ratings: nominal voltage, kV; maximum voltage, kV; BIL voltage, kV; power frequency, Hz; short-circuit peak withstand current, amperes, peak; short-circuit one-second short-time withstand current, amperes, RMS, symmetrical; and short-circuit MVA, three-phase symmetrical, at rated nominal voltage.

(2) Main bus ratings: continuous current, amperes; peak withstand current, amperes, peak; and one-second short-time withstand current, amperes, RMS symmetrical.

(3) Switch ratings: continuous current, amperes; load splitting current, amperes; load dropping current, amperes; peak withstand current, amperes, peak; one-second short-time withstand current, amperes, RMS, symmetrical; and three-time duty-cycle fault-closing current, amperes, RMS symmetrical and amperes, peak.

(4) Fuse type and ratings: maximum current, amperes and interrupting current, amperes, RMS, 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 each door (or set of double doors), and on the inside of each switch-operating-hub access cover.

6.0 ACCESSORIES *(Specify as required.)*

6.1 End fittings and fuse unit, holder and refill unit, or interrupting module and control module shall be furnished for each fuse mounting. In addition, one spare fuse unit, refill unit, or interrupting module shall be furnished.

6.2 A voltage tester with audio-visual signal capability shall be provided, along with batteries, shotgun clamp-stick adapter, and storage case.

6.3 A shotgun clamp stick (6 ft.–5½ in. [197 cm], 8 ft.– 5½ in. [258 cm]) in length shall be provided complete with canvas storage bag.

7.0 ANALYTICAL SERVICES

The following analytical services should be specified as required:

7.1 Short-Circuit Analysis

(a) The manufacturer shall provide a short-circuit analysis to determine the currents flowing in the electrical system under faulted conditions. Since expansion of an electrical system can result in increased available short-circuit current, the momentary and interrupting ratings of new and existing equipment on the system shall be checked to determine if the equipment can withstand the short-circuit energy. Fault contributions from utility sources, motors, and generators shall be taken into consideration. If applicable, results of the analysis shall be used to coordinate overcurrent protective devices and prepare an arc-flash hazard analysis of the system.

(b) Data used in the short-circuit analysis shall be presented in tabular format, and shall include the following information:

(1) Equipment identifications

(2) Equipment ratings

(3) Protective devices

(4) Operating voltages

(5) Calculated short-circuit currents

(6) X/R ratios

(c) A single-line diagram model of the system shall be prepared, and shall include the following information:

(1) Identification of each bus

(2) Voltage at each bus

(3) Maximum available fault current, in kA symmetrical, on the utility source side of the incoming feeder or first upstream device

(4) Data for each transformer

(i) Three-phase kVA rating

(ii) Percent impedance

(iii) Temperature rise, 65°C (149°F) and 55° (131°F)/65°C (149°F)

(iv) Primary voltage

(v) Primary connection

(vi) Secondary voltage

(vii) Secondary connection

(viii) X/R ratio

(ix) Tap settings and available settings

(d) The manufacturer shall use commercially available PC-based computer software such as Power System Analysis Framework (PSAF—Fault) from CYME International, CYMDIST, and/or SKM Power Tools® for Windows with the PTW Dapper Module to calculate three-phase, phase-to-phase, and phase-to-ground fault currents at relevant locations in the electrical system, in accordance with ANSI Standards C37.010, C37.5, and C37.13. If applicable, an ANSI closing-and-latching duty analysis shall also be performed to calculate the maximum currents following fault inception.

7.2 Overcurrent Protective Device Coordination Analysis

(a) The manufacturer shall provide an overcurrent protective device coordination analysis to verify that electrical equipment is protected against damage from short-circuit currents. Analysis results shall be used to select appropriately rated protective devices and settings that minimize the impact of short-circuits in the electrical system, by isolating faults as quickly as possible while maintaining power to the rest of the system.

(b) As applicable, the analysis shall take into account pre-load and ambient-temperature adjustments to fuse minimum-melting curves, transformer magnetizing-inrush current, full-load current, hot-load and cold-load pick-up, coordination time intervals for series-connected protective devices, and the type of reclosers and their reclosing sequences. Locked-rotor motor starting curves and thermal and mechanical damage curves shall be plotted with the protective-device time-current characteristic curves, as applicable.

(c) Differing per-unit fault currents on the primary and secondary sides of transformers (attributable to winding connections) shall be taken into consideration in determining the required ratings or settings of the protective devices.

(d) The time separation between series-connected protective devices, including the upstream (source-side) device and largest downstream (load-side) device, shall be graphically illustrated on log-log paper of standard size. The time-current characteristics of each protective device shall be plotted such that all upstream devices shall be clearly depicted on one sheet.

(e) The manufacturer shall furnish coordination curves indicating the required ratings or settings of protective devices to demonstrate, to the extent possible, selective coordination. The following information shall be presented on each coordination curve, as applicable:

- (1) Device identifications
- (2) Voltage and current ratios
- (3) Transformer through-fault withstand duration curves
- (4) Minimum-melting, adjusted, and total-clearing fuse curves
- (5) Cable damage curves
- (6) Transformer inrush points
- (7) Maximum available fault current, in kA symmetrical, on the utility source side of the incoming feeder or first upstream device
- (8) Single-line diagram of the feeder branch under study
- (9) A table summarizing the ratings or settings of the protective devices, including:
  - (i) Device identification
  - (ii) Relay current-transformer ratios, and tap, time-dial, and instantaneous-pickup settings
  - (iii) Circuit-breaker sensor ratings; long-time, short-time, and instantaneous settings; and time bands
  - (iv) Fuse type and rating
  - (v) Ground fault pickup and time delay

(f) The manufacturer shall use commercially available PC-based computer software such as CYMTCC from CYME International and/or SKM Captor to create the time-current characteristic curves for all protective devices on each feeder.

(g) As applicable, a technical evaluation shall be prepared for areas of the electrical system with inadequate overcurrent protective device coordination, with recommendations for improving coordination.

7.3 Arc-Flash Hazard Analysis

(a) The manufacturer shall provide an arc-flash hazard analysis to verify that electrical equipment on the system is “electrically safe” for personnel to work on while energized. An arc flash is a flashover of electric current in air—from one phase conductor to another phase conductor, or from one phase conductor to ground—that can heat the air to 35000°F (19427°C). It can vaporize metal and cause severe burns to unprotected workers from direct heat exposure and ignition of improper clothing. And the arc blast resulting from release of the concentrated radiant energy can damage hearing and knock down personnel, causing trauma injuries.

(b) The arc-flash hazard analysis shall include the following:

(1) Identification of equipment locations where an arc-flash hazard analysis is required

(2) Collection of pertinent data at each equipment location, including:

(i) Transformer kVA ratings, including voltage, current, percent impedance, winding ratio, and X/R ratio, plus wiring connections

(ii) Protective device ratings, including current, time-current characteristics, settings, and time delays

(iii) Switchgear data, including conductor phase spacing, type of grounding, and appropriate working distances

(3) Preparation of a single-line diagram model of the system

(4) Preparation of a short-circuit study to determine the three-phase bolted fault current at each location

(5) Preparation of arc-flash calculations in accordance with NFPA 70E and IEEE 1584, including:

(i) Calculation of arc current in accordance with applicable guidelines

(ii) Determination of protective device total-clearing times based upon the time-current characteristics

(iii) Calculation of arc-flash incident energy level based on the protective device total-clearing times and appropriate working distance

(6) Determination of appropriate personal protective equipment in accordance with risk levels defined in NFPA 70E

(7) Calculation of the arc-flash protection boundary distance

(8) Documentation of the results of the analysis, including:

(i) Preparation of a written report

(ii) Preparation of single-line diagrams

(iii) Preparation of arc-flash hazard labels to be affixed to the equipment

(9) The manufacturer shall use commercially available PC-based computer software such as the arc-flash module in SKM Power Tools® for Windows to calculate the incident energy category levels, in accordance with IEEE 1584.

7.4 Analytical Service Site Visits

(a) The manufacturer shall perform a site walk-down to gather:

(1) Transformer ratings, including voltage, current, power, percent impedance, winding ratio, and X/R ratio, plus wiring connections

(2) Protective device ratings, including current, time-current characteristics, settings, and time delays

(3) Switchgear data, including conductor phase spacing, type of grounding, and appropriate working distances