1.0 GENERAL

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

1.02 The pad-mounted gear shall consist of a single self-supporting enclosure, containing interrupter switches and power fuses with the necessary accessory components, including sensing, controls, and control power supply, all completely factory-assembled and operationally checked.

1.03 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 . . . . ____________

Fuses with Integral Load Interrupters
Maximum Current, Amperes . . . . ____________
Load Dropping Current, Amperes. . . . . ____________
Duty-Cycle Fault-Closing Current Capability,
Amperes, RMS, Symmetrical . . . . ____________

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

SELECTION OF 60-HERTZ RATINGS

Nominal Voltage, kV		14.4	25
Maximum Voltage, kV		17.0	27●
BIL Voltage, kV		95	125
Short-Circuit	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	36 400	32 500
	One-Second Short-Time Withstand Current, Amperes, RMS, Symmetrical	14 000	12 500
Three-Pole Interrupter Switches	Continuous Current, Amperes	600	600
	Load Dropping Current, Amperes	600	600
	Peak Withstand Current, Amperes, Peak	36 400	32 500
	One-Second Short-Time Withstand Current, Amperes, RMS, Symmetrical	14 000	12 500
	Three-Time Duty-Cycle Fault-Closing Current, Amperes, RMS, Symmetrical	14 000	12 500
Fuses with Integral Load Interrupters	Maximum Current, Amperes	200E, 200K, or 200	200E, or 200K
	Load Dropping Current, Amperes	200	200
	Duty Cycle Fault Closing Current, Amperes, RMS, Symmetrical	14 000★■	12 500♦

● 29kV for pad-mounted gear furnished with switches only and for pad-mounted gear furnished with electronic power fuses

★ Three-time duty-cycle fault-closing capability

♦ Two-time duty-cycle fault-closing capability

▲ 14.4-kV gear, when furnished with fuses utilizing 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.

■ 12 500 amperes for pad-mounted gear when furnished with fuses utilizing refill-unit-and-holder construction.

1.04 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.

1.05 Compliance with Standards and Codes

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

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

(b) Article 490.21(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) Canadian Standards Association listing.

1.06 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 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.

2.0 CONSTRUCTION— Insulators, High-Voltage Bus, Ground-Connection Pads, and Low-Voltage Components

2.01 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 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.

2.02 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 1/2—13 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.

2.03 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 3/8 in. thick steel. 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.

2.04 Low-Voltage Components

(a) All low-voltage components, including stored-energy operators and source-transfer control, shall be located in a grounded, steel-enclosed compartment separated 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 in grounded conduit or raceways where necessary for isolation from high voltage.

3.0 CONSTRUCTION—Enclosure, Doors, Ventilation Openings, and Finish

3.01 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) A separate grounded, steel-enclosed low-voltage control compartment shall be provided for the source-transfer control and stored-energy operators.

(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. The gas-metal-arc welding process shall be employed to eliminate alkaline residues and to minimize distortion and spatter.

(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. 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.

(h) Polyurethane self-adhesive bumpers shall be placed on the left-hand door channel to prevent the right-hand door from abrading the paint, and on the center door divider to prevent the left-hand door from rubbing against the center door divider.

(i) Enclosure top side edges shall overlap with roof side edges to create a mechanical maze which shall allow ventilation of high-voltage compartments to help keep the enclosure interior dry while discouraging tampering or insertion of foreign objects.

(j) A heavy coat of insulating "no-drip" compound shall be applied to the inside surface of the roof to minimize condensation of moisture thereon.

(k) Insulating interphase and end barriers of NEMA GPO3-grade fiberglass-reinforced polyester shall be provided for each interrupter switch and each set of fuses where required to achieve BIL ratings. Additional insulating barriers of the same material shall separate the front compartments from the rear compartments and isolate the tie bus.

(l) Full-length steel barriers shall separate side-by-side compartments.

(m) 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 into the open gap when the switch is open. These barriers shall meet the requirements of Section 381G of the National Electrical Safety Code (ANSI Standard C2).

(n) Interrupter switches shall be provided with window panels to allow viewing of the switch position without removing the dual-purpose front barriers. Window panels shall be removable to facilitate phasing and shall be secured to the enclosure with stainless-steel or zinc-nickel plated hardware.

(o) Each fuse 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 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).

(p) The low-voltage control compartment shall be provided with an instruction manual holder.

(q) 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.

The following optional feature should be specified as required:

(r) 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.

(s) Inner barrier panels that meet the Rural Utility Service requirements for "dead-front" and the requirements of Section 381G of the National Electrical Safety Code (ANSI Standard C2) shall be provided—one for each door opening providing access to high voltage. These panels shall be secured in place with recessed pentahead bolts. When so secured, they shall guard against inadvertent contact with live parts.

(t) A steel *(compartmented, noncompartmented)* base spacer shall be provided to increase the elevation of live parts in the pad-mounted gear above the mounting pad by *(6, 12, 18, 24)* inches.

3.02 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 overlap with door-opening flanges, and shall be formed to create a mechanical maze that shall guard against water entry and discourage tampering or insertion of foreign objects, 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 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.

(e) In consideration of controlled access and tamper resistance, each 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.

3.03 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 screen and baffle to protect against insertion of foreign objects.

3.04 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 utilizing 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:

(i) Underfilm corrosion not to extend more than 1/32 in. from the scribe, as evaluated per ASTM D 1645, Procedure A, Method 2 (scraping); and

(ii) Loss of adhesion from bare metal not to extend more than 1/8 from the scribe.

(2) 1000 hours of humidity testing per ASTM D 4585 using the Cleveland Condensing Type Humidity Cabinet, 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 10% reduction of gloss as evaluated per ASTM D 523.

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

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

(6) 3000 cycles of abrasion testing per ASTM 4060, 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 outdoor light gray, satisfying the requirements of ANSI Standard Z55.1 for No. 70.

3.05 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

4.01 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 stored-energy 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 switch contacts shall be backed up by stainless-steel springs to provide constant high contact pressure.

(e) 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.

(f) 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.

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

(h) 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 rating of the pad-mounted gear.

The following optional feature should be specified as required:

(i) Mechanical antiparalleling shall be provided to prevent manual and automatic paralleling of the two source interrupter switches.

(j) Key interlocks shall be provided to guard against opening fuse-compartment door(s) unless both interrupter switches are locked open.

(k) Base-mounted distribution-class surge arresters, metal-oxide type rated (*9 kV*★, *10 kV*★, *12 kV, 15 kV, 18 kV*▲), shall be provided at all source switch terminals.

(l) Mounting provisions only for base-mounted distribution-class surge arresters rated (*9 kV*★, *10 kV*★, *9/10 kV*★, *12 kV, 15 kV, 18 kV*▲) shall be provided at all source switch terminals.

(m) Mounting provisions for porcelain terminations shall be provided *(G&W PAT and PSC Cable Terminators)* at all switch terminals.

(n) Switch terminals shall be provided with adapters to accommodate two cables per phase.

(o) Cable guides shall be provided to help orient cables at switch terminals.

(p) Mounting provisions shall be provided accommodating one three-phase fault indicator with three single-phase sensors in each interrupter switch compartment.

4.02 Fuses (*Select either solid-material power fuses or electronic power fuses.)*

(a) Solid-Material Power Fuses

(1) Solid-material power fuses shall utilize 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. Fuse mountings shall be disconnect style.

(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.

★ 14.4-kV models only.

▲ 25-kV models only.

(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 utilize 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 arc 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.

(iix) 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. Fuse mountings shall be of the disconnect style.

(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-mounting jaw contacts shall incorporate an integral load interrupter that shall permit live switching of fuses with a hookstick.

(1) The integral load interrupter housing shall be of a thermoplastic material.

(2) The integral load interrupter shall be in the current path continuously. 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, reducing the possibility of an incomplete opening operation.

(5) Internal moving contacts of the integral load interrupter shall be self-resetting after each opening operation, permitting a closing operation to be performed immediately.

(6) Circuit interruption shall take place completely within the integral load interrupter with no external arc or flame.

(7) The integral load interrupter and the fuse shall be provided with separate fault-closing contacts and current-carrying contacts. 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 the current-carrying contacts or interrupting contacts.

(8) Integral load interrupters for fuses for 14.4 kV rated pad-mounted gear shall have a three-time duty-cycle fault-closing capability equal to the interrupting rating of the fuse. Integral load interrupters for fuses for 25 kV rated pad-mounted gear shall have a two time duty-cycle fault-closing capability equal to the interrupting rating of the fuse. The duty-cycle fault-closing capability defines the level of available fault current into which the fuse can be closed the specified number of times (twice or

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.

(d) Fuse terminal pads shall be provided with a two-position adapter, making it possible to accommodate a variety of cable-terminating devices.

(e) 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 rating of the pad-mounted gear.

The following optional feature should be specified as required:

(f) Cable guides shall be provided to help orient cables at fuse terminals.

(g) A copper ground stud shall be provided for each terminal and ground pad in the *(fuse compartments, switch and bus compartments)*.

4.03 Stored-Energy Operators

(a) Stored-energy operators shall be provided to operate the high-voltage source interrupter switches. They shall be motor charged with solenoid trip-open and solenoid trip-closed operation.

(b) Stored-energy operators shall be equipped with an integral quick-make quick-break mechanism installed by the switch manufacturer. The mechanism shall store 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 source interrupter switch independent of the speed of the charging motor or manual handle.

(c) Stored-energy operators shall be equipped with a tripping solenoid to release the stored energy to open or close the associated source interrupter switch in response to a control signal.

(d) Stored-energy operators shall be equipped with a charging motor that shall charge the quick-make quick-break mechanism after each trip operation when voltage is present on the associated source.

(e) Push buttons shall be provided to permit local electrical trip-open and trip-closed operation. Local electrical operation shall be prevented when the source-transfer control is in the automatic mode.

(f) Stored-energy operators shall be provided with an operation selector that shall have the following three positions:

(1) An operating position. When in this position, mechanical or electrical opening or closing of the source interrupter switch is permitted.

(2) A lock position. When padlocked in this position, mechanical and electrical operation is prevented.

(3) A charging position. When in this position, manual charging of the quick-make quick-break mechanism is permitted, but mechanical and electrical operation is prohibited.

(g) Stored-energy operators shall be provided with a charging shaft and a removable manual charging handle to allow manual charging of the quick-make quick-break mechanism in the event control power is lost. The manual charging shaft shall be accessible only when the operation selector is in the "charging" position.

(h) Stored-energy operators shall be equipped with provisions for local mechanical trip-open and trip-closed operation in the event control power is lost.

(i) Stored-energy operators shall be located in a grounded, steel-enclosed low-voltage control compartment. The control compartment shall provide complete isolation from high voltage to help protect operating personnel.

(j) Stored-energy operators shall be equipped with indicators to show whether the quick-make quick-break mechanism is charged or discharged; whether the associated source interrupter switch is in the open or closed position; and whether the stored-energy operator is in the switch-open or switch-closed position.

(k) Each stored-energy operator shall be equipped with an operation counter.

(l) Stored-energy operators shall be provided with a decoupling feature, permitting decoupling of the stored-energy operator from the associated source interrupter switch for testing and exercising of the stored-energy operator and source-transfer control without opening or closing the interrupter switch and without exposure to high voltage. A tool shall not be required for decoupling or coupling the switch and switch operator. An indicator shall be provided to show whether the operator is coupled or decoupled. When the stored-energy operator is decoupled, the associated source interrupter switch shall be locked in the position it was in at the time of decoupling. It shall not be possible to recouple the stored-energy operator to the source interrupter switch unless the stored-energy operator is in the same position (open or closed) as the source interrupter switch.

The following optional features should be specified as required:

(m) Stored-energy operators shall be provided with an extra 4-PST auxiliary switch coupled to each source interrupter switch.

(n) Stored-energy operators shall be provided with an extra 4-PST auxiliary switch coupled to each stored-energy operator.

(o) Mechanical cable interlocks shall be provided between each stored-energy operator and the associated switch-compartment door to prevent operation of the source interrupter switch when the associated compartment door is open.

(p) A receptacle shall be provided for attachment of a remote-control station to allow electrical trip-open and trip-closed operation from an adjacent area.

4.04 Source-Transfer Control

(a) Operating Description

(1) Transfer on Loss and Return of Source Voltage

(i) The source-transfer control shall utilize the common-bus primary-selective system. The normal condition shall be with one source interrupter switch (for the preferred source, as field-programmed) closed to energize the high-voltage bus, and with the other source interrupter switch (for the alternate source) open with its associated circuit available as a standby.

The control shall monitor the conditions of both power sources and initiate automatic switching when the preferred-source voltage has been lost (or reduced to a predetermined level) for a period of time sufficient to confirm that the loss is not transient. Automatic switching shall open the preferred-source interrupter switch and then close the alternate-source interrupter switch to restore power to the high-voltage bus.

(ii) When normal voltage returns to the preferred source for a preset time, the control shall initiate retransfer to the preferred source if in the automatic return mode, or await manual retransfer if in the hold return mode. In the hold return mode, if the alternate source fails and the preferred source has been restored, the control shall initiate automatic retransfer to the preferred source.

(iii) In the automatic return mode, the control shall provide either open transition (nonparalleling) or closed transition (paralleling) on retransfer, as field-programmed.

(2) Transfer on Unbalance Condition

(i) A field-programmable unbalance detection feature shall initiate automatic switching on detection of source-side open-phase conditions at the same system voltage level as the pad-mounted gear, whether caused by utility-line burndown, broken conductors, single-phase switching, equipment malfunctions, or single-phasing resulting from blown source-side fuses. The control shall continuously develop and monitor the negative-sequence voltage to detect any unbalance present as a result of an open-phase condition. Automatic switching shall occur when the system unbalance exceeds a predetermined unbalance-detect voltage for a period of time sufficient to confirm that the condition is not transient.

(ii) When normal phase voltages return to the preferred source, the control shall initiate retransfer as described in 4.04 (a) (1) (ii) and (iii).

(b) Control Features

(1) The operating characteristics of the source-transfer control and its voltage-, current-, and time-related operating parameters shall be field-programmable and entered into the control by means of a keypad. To simplify entry of this information, a menu arrangement shall be utilized including keys dedicated to the operating characteristics and to each of the operating parameters. Entry of an access code shall be necessary before any operating characteristic or operating parameter can be changed.

(2) All operating characteristics and operating parameters shall be available for review on a liquid-crystal display with backlighting.

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

(4) A light-emitting diode lamp shall be furnished for indicating that both stored-energy operators are coupled to their respective interrupter switches and in the correct positions, the control is in the automatic mode, the operation selector for each stored-energy operator is in the operating position, and all control circuitry is properly connected for automatic transfer. The display specified in 4.04 (b) (2), when not being used to show menu information, shall show messages explaining why this lamp is not lighted.

(5) A selector switch shall be furnished for choosing manual or automatic operating mode. In the manual mode, local electrical trip-open and trip-closed operation by means of push buttons shall be enabled while automatic switching shall be inhibited.

(6) Test keys shall be furnished for simulating loss of voltage on each of the two sources, as well as for checking the functioning of the lamps, display, and keypad.

(7) The control shall include built-in diagnostics for analyzing system events. The device shall automatically record system status and source-transfer control status every time a control operation occurs. All such operations shall be indicated by the illumination of a light-emitting diode lamp and shall be available for display by means of a dedicated event key.

(8) The present source voltage and current inputs, and the present status of discrete inputs to and outputs from the control shall be available for display by means of a dedicated examine key.

(9) The control shall have the capability to automatically calibrate to a known voltage on each source. This capability shall be keypad-selectable.

(c) Construction Features

(1) The source-transfer control shall use an advanced microprocessor and other solid-state electronic components to provide the superior reliability and serviceability required for use in power equipment. All components shall be soldered on printed-circuit boards to minimize the number of interconnections for increased reliability.

(2) All interconnecting-cable connector pins and receptacle contacts shall be gold-over-nickel plated to minimize contact pressure.

(3) The surge withstand capability of the control shall be verified by subjecting the device to both the ANSI/IEEE Surge Withstand Capability Test (ANSI Standard C37.90.1) and to a 5-kV, 3.75-joule capacitive-discharge test. For the capacitive-discharge test, a suitable capacitor shall be charged to 5 kV, and shall then be used to discharge 3.75 joules into each input circuit and each output circuit of the device.

(4) To identify and eliminate components that might be prone to early failure, the control shall be subjected to a dielectric test, a functional check, and a 48-hour screening test followed by a second functional check. For the screening test, the device shall be energized at rated control voltage while subjected to 48 hours of temperature cycling repeatedly between -40° C and +65° C.

(5) The control shall be located in the grounded, steel-enclosed low-voltage compartment/enclosure, with the operators. The compartment shall provide isolation from high voltage.

(d) Voltage Sensing and Control Power

(1) Voltage sensing shall be provided by three capacitively coupled voltage sensors on the line side of each source interrupter switch.

(2) To maximize usable cable-training space within the pad-mounted gear, the voltage sensors shall directly replace the lower apparatus insulators of the source interrupter switches. Furthermore, the voltage sensors shall be constant-current-output devices that do not require primary fuses.

(3) The output of the voltage sensors shall be directly proportional to line-to-ground voltage and shall have relay accuracy over an ambient temperature range of –40°F to +160°F.

(4) Each voltage sensor shall be equipped with a secondary-side protective device to prevent damage to the voltage sensor in the event that the secondary circuit is inadvertently opened or the burden is removed.

The following optional features should be specified as required:

(e) An overcurrent-lockout feature shall be provided to prevent an automatic transfer operation that would close a source interrupter switch into a fault. The feature shall include a light-emitting diode lamp for indicating when a lockout condition has occurred, a reset key for manually resetting the lockout condition, and three current sensors for each source. Provisions shall be furnished for manually resetting the overcurrent-lockout feature from a remote location. Test keys shall be provided for simulating an overcurrent condition on each source.

(f) Remote-indication provisions shall be provided to permit remote monitoring of the presence or absence of preferred- and alternate-source voltage; the operating mode of the source-transfer control (i.e., automatic or manual); and the status of the indicating lamp furnished in 4.04 (b) (4), the indicating lamp furnished in 4.04 (b) (7), and (where applicable) overcurrent lockout.

(g) A test panel shall be provided to permit the use of an external, adjustable three-phase source to verify, through independent measurement, the response of the control to loss-of-source, phase-unbalance, and (where applicable) overcurrent-lockout conditions.

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

(i) A communications card shall be provided to permit local loading, to a user-furnished personal computer, of system events recorded by the source-transfer control; operating characteristics and voltage-, current-, and time-related operating parameters programmed in the control; discrete inputs and outputs from the control; and messages explaining why the indicating lamp furnished in 4.04 (b) (4) is not lighted. The communications card shall also permit local downloading of the user's standard operating parameters from the personal computer to the control.

5.0 LABELING

5.01 Hazard-Alerting Signs

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

(b) The inside of each door providing access to high voltage 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) Interrupter switch compartments shall be provided with "Danger" signs indicating that "Switches May Be Energized by Backfeed."

(d) Fuse compartments shall be provided with "Danger" signs indicating that "Fuses May Be Energized by Backfeed."

(e) Barriers used to prevent access to energized live parts shall be provided with "Danger—Keep Away—Hazardous Voltage—Will Shock, Burn, or Cause Death" signs.

5.02 Nameplates, Ratings Labels, and Connection Diagrams

(a) The outside of each set of double doors providing access to high voltage shall be provided with a nameplate indicating the manufacturer's name, catalog number, model number, date of manufacture, and serial number.

(b) The inside of each 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.

(4) Fuse type and integral load interrupter ratings and capabilities: maximum current, amperes; load splitting current, amperes; load dropping current, amperes; and duty-cycle fault-closing current, amperes, RMS symmetrical or asymmetrical.

(c) The inside of each set of double doors shall be provided with a three-line connection diagram showing interrupter switches, fuses with integral load interrupters, voltage sensors, and bus, along with the manufacturer's model number.

6.0 ACCESSORIES *(Specify as required.)*

6.01 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.

6.02 A fuse handling tool as recommended by the fuse manufacturer shall be furnished.

6.03 A total of _____ set(s) of three grounding jumpers, 3 feet in length, shall be provided, complete with a storage bag for each set.

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

6.05 A shotgun clamp stick *(6 ft.–5 1/2 in., 8 ft.–5 1/2 in.)* length shall be provided, complete with canvas storage bag.

6.06 A portable remote-control station with 50-foot cord shall be provided to permit open/close operations of the interrupter switches from an adjacent location.

6.07 A test accessory shall be provided to permit preliminary checkout of the source-transfer control using a separate single-phase control source before high-voltage connections are made to the source-transfer pad-mounted gear.

6.08 A maintenance cable shall be provided for connecting the optional source-transfer control communications card to a user-furnished personal computer having a *(25-pin, 9-pin)* serial communication port.

7.0 ANALYTICAL SERVICES

The following analytical services should be specified as required:

7.01 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 and 55/65°C

(iv) Primary voltage

(v) Primary connection

(vi) Secondary voltage

(vii) Secondary connection

(iix) 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.

7.02 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.

7.03 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 35,000° F. 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.

7.04 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.

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