1.0 GENERAL

1.1 The switchgear shall be in accordance with the single-line diagram and shall conform to the following specification.

1.2 The switchgear assembly shall consist of Visi-Gap® Load-Interrupter Switches, resettable Visi-Gap® Fault Interrupters with isolating disconnects (visible open gaps), and a self-powered microprocessor-based overcurrent control. The load-interrupter switches and fault interrupters shall be molded of a cycloaliphatic epoxy resin system; no SF_6 gas shall be allowed. Load-interrupter switch terminals shall be equipped with bushings rated 600 amperes continuous, and fault-interrupter terminals equipped with bushing wells rated 200 amperes continuous, to provide for elbow connection.

1.3 Ratings

The ratings for the integrated switchgear shall be as designated below. (Select values from the ratings table on page 2.)

Switchgear Assembly

Voltage, kV

System Class . . . . ________________

Maximum . . . . ________________

BIL . . . . ________________

Frequency, Hz . . . . ________________

Main Bus, RMS

Continuous Current, Amperes, RMS . . . . ________________

Short-Circuit Current, Amperes, RMS, Symmetrical . . . . ________________

Three-Pole Load-Interrupter Switches

Continuous Current, Amperes . . . . ________________

Live Switching: Load-Splitting and Load-Dropping
Current, Amperes . . . . ________________

Momentary and Three-Second Short-Time Withstand,
Amperes, RMS, Symmetrical . . . . ________________

Fault-Making Current, Duty-Cycle Three-Time,
Amperes, RMS, Symmetrical . . . . ________________

Fault Interrupters

Continuous Current, Amperes . . . . ________________

Live Switching: Load-Splitting and Load-Dropping
Current, Amperes . . . . ________________

Short-Circuit Interrupting Current,
Amperes, RMS, Symmetrical . . . . ________________

SELECTION OF RATINGS		IEEE		IEC	
Voltage, kV					
	System Class	15	27	12	24
	Maximum	17.5	29	12	24
	BIL	95	125	75	125
Frequency, Hz		60	60	50	50
Main Bus	Continuous Current, Amperes, RMS	600	600	630	630
	Short-Circuit Current, Amperes, RMS, Symmetrical	16 000	12 500	16 000	12 500
Visi-Gap Load-Interrupter Switches	Continuous Current, Amperes	600	600	630	630
	Live Switching: Load Splitting and Load Dropping, Amperes①	600	600	630	630
	Momentary and Three-Second, Short-Time Withstand, Amperes, RMS, Symmetrical	16 000	12 500	16 000	12 500
	Three-Time Duty Cycle Fault Making, Amperes, RMS, Symmetrical②	16 000	12 500	16 000	12 500
Visi-Gap Fault Interrupter	Continuous Current, Amperes③	200	200	200	200
	Live Switching: Load Splitting and Load Dropping, Amperes①③	200	200	200	200
	Short-Circuit Interrupting, Amperes, RMS, Symmetrical	12 500★	12 500	12 500★	12 500

① Parallel or loop switching.

② Applicable to fault closing into closed position.

③ 600 amperes if fault interrupters are furnished with optional 600-ampere bushings in lieu of 200-ampere bushing wells.

★ 16 000 amperes if fault interrupters are furnished with optional 600-ampere bushing wells.

1.4 Usual Service Conditions

(a) Outside

(1) -40°F (–40°C) to +104°F (+40°C)

(b) Altitude

(1) 3281 feet (1000 m) or less. Performance at altitudes up to 16,404 feet (5000 m) shall be determined, and appropriate correction factors, if different from those listed in the standards, shall be provided.

(c) Submersibility

(1) The switchgear assembly, including all controls and wiring shall have a submersibility rating of IP-68.

(i) Dust tight.

(ii) Continuous submersion to 10 feet (3 m) for 30 days.

(d) Corrosive or Chemical Agents

(1) The switchgear assembly shall not be damaged by incidental exposure to corrosive or chemical agents such as salt water, fertilizer, motor oil, or cleaning solvents spilled directly on the switchgear assembly, emptied into the vault containing the switchgear assembly, or carried there by wind or by run-off water.

(e) Extreme Conditions

(1) Extreme environments such as tidal waters, continuous submersion, abnormally high concentration of certain contaminants, or unusually high or low pH levels shall be evaluated on a case-by-case basis.

1.5 Certification of Ratings

(a) The manufacturer of the switchgear shall be completely and solely responsible for the performance of the load-interrupter switch and fault interrupter as well as the complete integrated assembly as rated.

(b) The manufacturer shall furnish, upon request, certification of ratings of load-interrupter switches, fault interrupters, and the integrated switchgear assembly consisting of load-interrupter switches and fault interrupters.

1.6 Compliance with Standards and Codes

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

(a) Switchgear Assembly

(1) IEEE C37.20.3 *(IEEE Standard for Metal-Enclosed Interrupter Switchgear)*.

(2) IEEE C37.74 *(IEEE Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Ac Systems Up to 38 kV)*.

(3) IEEE C57.12.28 (*IEEE Standard for Pad-Mounted Equipment Enclosure Integrity)*.

(4) IEEE C57.12.29 *(IEEE Standard for Pad-Mounted Equipment Enclosure Integrity for Coastal Environments)*.

(5) IEC 60529 *(Degrees of Protection Provided by Enclosure)*.

(b) Load-Interrupter Switches

(1) IEEE 1247 *(IEEE Standard for Interrupter Switches for Alternating Current Rated Above 1000 Volts)*.

(2) IEC 62271-103 *(High-Voltage Switches—Part 1—Switches for Rated Voltages Above 1 kV and Less Than 52 kV)*.

(c) Fault Interrupters

(1) IEEE C37.60 *(IEEE Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Subsurface Automatic Circuit Reclosers and Fault Interrupters for Ac Systems Up to 38 kV)*.

(2) IEC 62271-111 *(High-Voltage Switchgear and Control Gear—Part 111—Overhead, Pad-Mounted, Dry-Vault, and Subsurface Automatic Circuit Reclosers and Fault Interrupters for Ac Systems Up to 38 kV)*.

(d) Isolating Disconnect

(1) IEC 62271-102 *(High-Voltage Switchgear and Control Gear—Part 102—Alternating Current Disconnectors and Earthing Switches)*.

(e) Separable Insulated Connector System

(1) IEEE 386 *(IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V)*.

(2) IEEE 592 *(IEEE Standard for Exposed Semiconducting Shields on High-Voltage Cable Joints and Insulated Connectors)*.

(f) Voltage Indicating Subsystem

(1) IEC 62271-206 *(Voltage Presence Indicating Systems for Rated Voltages Above 1 kV and Up to and Including 52 kV)*.

1.7 Environmental Considerations

(a) Ability to be recycled

(1) Switchgear shall have greater than 90% recyclable components.

(2) A breakdown of the various raw materials used in a typical switchgear assembly shall be provided. Breakdown shall indicate the percentage of the total weight of each recyclable material and how that material should be recycled.

1.8 Factory Testing

(a) All fully assembled ways shall undergo leak testing for the entire way in a specialized leak detection chamber.

(b) Fully assembled line-ups, consisting of all specified ways and main bus, shall undergo partial discharge and power frequency withstand testing.

2.0 CONSTRUCTION

2.1 Provisions for Grounding

(a) One ground-connection pad shall be provided on each load-interrupter switch and fault interrupter.

(b) Ground-connection pads shall have a short-circuit rating equal to that of the switchgear.

(c) Ground connection pads shall have NEMA 2-hole terminal pad drilling.

(d) No less than two enclosure ground pads shall be provided.

(1) They shall be nickel plated and welded to the enclosure.

(2) They shall be coated with a uniform coating of an oxide inhibitor and sealant prior to shipping.

The following optional feature should be specified as required:

(e) Continuous ground bus. Mounts to ground-connection pad on each load-interrupter switch and fault interrupter in the assembly; facilitates attachment of cable concentric neutrals and separable connector drain wires.

3.0 BASIC COMPONENTS

3.1 Visi-Gap Load-Interrupter Switches

(a) Load-interrupter switches shall be manually operated three-pole devices.

(b) Each load-interrupter switch shall be made of three individual pole-units consisting of a vacuum interrupter in series with an isolating disconnect molded using a solid-dielectric insulation system and attached to a three-pole manual operating mechanism.

  (1) A cycloaliphatic epoxy resin (Cypoxy™ Insulator) system shall be used.

  (2) No SF_6 gas shall be used.

  (3) Pole-units shall be coated in a semi-conductive paint to maintain each pole-unit at ground potential.

(c) Load-interrupter switches shall be capable of 2000 mechanical operations.

(d) Load-interrupter switches shall exhibit the low probability of restrike performance equivalent to a C1 rating per IEC Standard 62271-100.

(e) Load-interrupter switches shall have a three-time duty-cycle fault-closing rating as specified under "Ratings." This rating defines the ability to close the switch the designated number of times against a three-phase fault with asymmetrical (peak) current in at least one phase equal to the rated value, with the switch remaining operable and able to carry and interrupt rated current. Certified test abstracts establishing such ratings shall be furnished upon request.

(f) Each load-interrupter switch shall have an isolating disconnect to provide a visible open gap that is readily seen through a large viewing window; this gap eliminates the need for cable handling and exposure to high voltage to establish a visible opening.

  (1) The isolating disconnect chamber shall be filled with a silicone fluid to facilitate a smaller size and to provide better long-term performance compared to a simple air gap having the same electrical ratings.

  (2) The chamber shall be totally sealed and shall have a pressure-compensation system to ensure leak-free performance over wide temperature excursions.

  (3) The isolating disconnect shall have a full dielectric rating (BIL etc.); this is in addition to the series vacuum interrupter that also has a full dielectric rating.

  (4) The open gap shall be sized to allow cable testing through a feedthrough bushing or through the back of the elbow.

  (5) The viewing window shall be at least 3 inches (76 mm) wide by 5 inches (127 mm) high to facilitate easy visual verification of the position of the isolating disconnect (closed or open).

  (6) The isolating disconnect contacts shall be visible while standing at a distance at least 5 feet (152 cm) away from the viewing windows.

  (7) The isolating disconnect shall be operable in the same motion used to operate the vacuum interrupter. The isolating disconnect shall not have a separate operating lever or handle.

(g) Load-interrupter switches shall be covered by stainless steel panels to protect the pole-units from physical damage during handling and installation, and to help keep all components at ground potential.

3.2 Visi-Gap Fault Interrupters

(a) Fault interrupters shall be manually operated three-pole devices.

(b) Each fault interrupter shall consist of three individual pole-units consisting of a vacuum fault interrupter in series with an isolating disconnect molded using a solid-dielectric insulation system, and attached to a three-pole manual operating mechanism.

(1) A cycloaliphatic epoxy resin (Cypoxy™ Insulator) system shall be used.

(2) No SF_6 gas shall be used.

(3) Pole-units shall be coated in a semi-conductive paint to maintain each pole-unit at ground potential.

(c) Fault interrupters shall be capable of 2000 mechanical operations.

(d) Fault interrupters shall exhibit low probability of restrike performance equivalent to a C1 rating per IEC Standard 62271-100.

(e) Each fault interrupter shall have an isolating disconnect to provide a visible open gap that is readily seen through the large viewing window; this gap eliminates the need for cable handling and exposure to high voltage to establish a visible gap.

(1) The isolating disconnect chamber shall be filled with a silicone fluid to facilitate a smaller size and to provide better long-term performance compared to a simple air gap having the same electrical ratings.

(2) The chamber shall be totally sealed and shall have a pressure-compensation system to ensure leak-free performance over wide temperature excursions.

(3) The isolating disconnect shall have a full dielectric rating (BIL etc.); this is in addition to the series vacuum fault interrupter that also has a full dielectric rating.

(4) The open gap shall be sized to allow cable testing through a feedthrough bushing or the back of the elbow.

(5) The viewing window shall be at least 3 inches (76 mm) wide by 5 inches (127 mm) high to facilitate easy visual verification of the position of the isolating disconnect (closed or open).

(6) The isolating disconnect contacts shall be visible while standing at a distance at least 5 feet (152 cm) away from the viewing windows.

(7) The isolating disconnect shall be operable in the same motion used to operate the vacuum interrupter. The isolating disconnect shall not have a separate operating lever or handle or require additional operations.

(f) Each fault interrupter shall be covered by stainless steel panels to protect the pole-units from physical damage during handling and installation and to help keep all components at ground potential.

3.3 Operating Mechanisms

(a) Load-interrupter switches and fault interrupters shall be operated by means of a manual quick-make, quick-break mechanism.

(1) The operating mechanism shall operate smoothly and consistently.

(2) The operating mechanism shall fully operate each load-interrupter switch or fault interrupter in a single continuous movement; additional operations shall not be required to complete an opening or closing operation.

(b) A manual operating handle shall be furnished. It shall be permanently attached to the switchgear assembly with a thin wire cable to ensure the handle is always present.

(c) It shall be possible to manually operate the load-interrupter switches or fault interrupters from one or both ends of the switchgear assembly:

(1) By hand using the manual handle;

(2) By using a piece of rope attached to the manual handle; or

(3) By using a shotgun clamp stick attached to the manual handle.

(d) The position of the load-interrupter switch or fault interrupter shall be clearly visible from the normal operating position.

(1) The operating mechanism shall have a pointer attached to the operating shaft to provide visual feedback to the user that the mechanism has reached the end of its travel and that the opening or closing operation is complete. Mechanical stops shall be provided to prevent overdriving the operating mechanism.

(2) The operating mechanism shall feature a mimic bus with in-line semaphores to indicate the position of the load-interrupter switch and its isolating disconnect or the fault interrupter and its isolating disconnect.

(3) The operating mechanism shall also have separate color-coded targets to indicate the position of the load-interrupter switch and its isolating disconnect or the fault interrupter and its isolating disconnect.

(i) Green = Open/Reset.

(ii) Red = Closed.

(e) There shall be complete mechanical "coordination" between the load-interrupter switch or fault interrupter and the isolating disconnect. The load-interrupter switch or fault interrupter opens before the isolating disconnect. The isolating disconnect is closed first before the load-interrupter switch or fault interrupter is closed.

(f) Operating mechanism shafts shall be padlockable in either position to prevent operation.

(g) The operating mechanism housing shall be pressurized with a mixture of dry nitrogen and helium to a total pressure of 12 psig to keep moisture out of the mechanism to reduce the possibility of corrosion.

The following optional feature should be specified as required:

(h) Reverse color of the Open/Reset and Closed indicators.

(1) Green = Closed.

(2) Red = Open/Reset.

3.4 Interconnection Bus

(a) The interconnection bus shall be covered with a molded solid-dielectric insulation.

(b) The interconnection bus components shall have a semi-conductive coating to provide fully shielded connections.

(c) The interconnection bus components shall have a separate drain wire to ensure that they are solidly grounded to the switchgear assembly.

(d) The interconnection bus assembly shall withstand the stresses associated with short-circuit currents up through the maximum rating of the switchgear.

(e) The phase connections of the interconnection bus shall match that of the equivalent PMH or PME model.

3.5 Overcurrent Control

(a) A microprocessor-based overcurrent control shall be provided to initiate fault interruption.

(b) The control shall be mounted in a submersible enclosure.

(c) Control settings shall be field-programmable using a personal computer connected via a USB port to the control. The USB port shall be accessible from the exterior of the enclosure. All programming software is resident on the control and can be accessed via personal computer using the Internet Explorer or Firefox web browser. Energization of the gear shall not be required to set or alter control settings.

(d) Power and sensing for the control shall be supplied by integral current transformers.

(e) The control shall provide time-current characteristic (TCC) curves, including standard E-speed, K-speed, T- speed, coordinating-speed tap, coordinating-speed main, and relay curves per IEEE C37.112-1996 and IEC 60255-151:2009. Coordinating-speed tap curves shall optimize coordination with load-side weak-link/backup current-limiting fuse combinations, and coordinating-speed main curves shall optimize coordination with tap-interrupter curves and upstream feeder breakers.

(f) The standard E-speed curve shall have phase-overcurrent settings ranging from 7E through 400E. The standard K-speed curve shall have phase-overcurrent settings ranging from 8K through 200K. The standard T-speed curve shall have phase-overcurrent settings ranging from 8T through 200T. The coordinating-tap curve shall have phase-overcurrent and independent ground-overcurrent settings ranging from 15 amperes through 400 amperes. The coordinating-main curve shall have phase-overcurrent and independent ground-overcurrent settings ranging from 25 amperes through 800 amperes.

(g) Time-current characteristic curves shall conform to the following IEEE

C37.112-1996 IEEE and IEC 60255-151:2009 Standard Inverse-Time Characteristic Equations for Overcurrent Relays: U.S. Moderately Inverse Curve U1, U.S. Inverse Curve U2, U.S. Very Inverse Curve U3, U.S. Extremely Inverse Curve U4, U.S. Short-Time Inverse Curve U5, I.E.C. Class A Curve (Standard Inverse) C1, I.E.C. Class B Curve (Very Inverse) C2, I.E.C. Class C Curve (Extremely Inverse) C3, I.E.C. Long-Time Inverse Curve C4, and I.E.C. Short-Time Inverse Curve C5.

(h) The control shall have two independently settable and field-adjustable definite-time delay settings. (A definite-time delay setting can be configured to be an instantaneous trip setting if the definite-time delay is set to 0 milliseconds.)

(i) The minimum trip current shall be 14 amperes for Vista switchgear with 660:1 ratio current transformers, and 28 amperes for models with 1320:1 ratio current transformers.

(j) Event records shall be easily viewable from the control using a personal computer connected to the USB port. The event log shall capture the last 64 events recorded by the overcurrent control.

(k) The control shall store sufficient energy to operate the fault interrupters without affecting the accuracy or coordination under fault conditions.

3.6 Motor Operators and Portable Remote Control Pendant

(a) Motor Operators

(1) Motor operators for local or remote operation of load-interrupter switches and fault interrupters shall be available.

(2) Motor operators shall have a submersibility rating of IP-68.

(3) Motor operators shall be available in the following ways:

(i) Factory-installed and wired for permanent installations.

(ii) User-installed and wired for permanent installations.

(iii) For portable use to operate individual load-interrupter switches or fault interrupters from a distance.

(4) Switchgear assemblies furnished with one or more factory-installed and wired motor operators shall have auxiliary contacts wired to the motor operators to track the position of the isolating disconnect.

(5) Operating times to open or close a load-interrupter switch or fault interrupter shall be no longer than 3 seconds.

(6) Motor operators shall be easy to install and remove.

(i) Motor operators shall weigh no more than 25 lbs (12 kg).

(ii) Motor operators shall not require the adjustment of any external linkages or operating shafts for installation.

(iii) Permanently installed motor operators shall be held captive using simple hardware requiring only simple tools to install or remove.

(iv) Installation of portable motor operators shall not require the use of any hardware or tools.

(7) Motor operators shall be easy to decouple in a pull-and-swing motion, performed by hand or using a shotgun clamp stick, from load-interrupter switches and fault interrupters to allow testing of the motor operator, the control scheme (if applicable), or both. Removal of hardware and adjustment of operating shafts or levers shall not be required in order to couple or decouple a motor operator. It shall not be possible to recouple a motor operator to a load-interrupter switch or fault interrupter when the two devices are not in the same position (open or closed).

(8) Motor operators shall have a submersible connector for the attachment of a portable remote control pendant.

(9) Motor operators shall have a submersible connector for the attachment of a cable from the operating mechanism carrying auxiliary contact information (position of the isolating disconnect).

(10) Control power for motor operators (100-240 Vac, 50/60 Hz) shall be provided by the user.

The following optional feature should be specified as required:

(11) Auxiliary contacts for load-interrupter switches or fault interrupters not furnished with motor operators.

(b) Portable Remote Control Pendant

(1) The portable remote control pendant shall have a submersibility rating of IP-68.

(2) The portable remote control pendant shall be available with either a 25-foot (7.6 m) or 50-foot (15.2 m) control cable.

(3) The portable remote control pendant shall have the following pushbuttons:

(i) OPEN/RESET

(ii) CLOSE

(iii) ENABLE

(iv) LAMP TEST.

(4) To prevent accidental or inadvertent operation of the motor operator, the ENABLE pushbutton must be depressed and held down while the OPEN/RESET or the CLOSE pushbutton is depressed.

(5) The portable remote control pendant shall be easy to operate while wearing 25-kV rated high-voltage rubber gloves and protectors or other suitable hand protection approved for the task.

3.7 Optional Potential Indication Feature

(a) When specified, the potential indication feature shall be provided for each load-interrupter switch and fault interrupter.

(b) Sensing of potential shall be by means of a capacitive voltage divider built into each molded pole-unit, thereby eliminating the need for cable handling and exposure to high voltage to test the cables for voltage.

(c) The potential indication feature shall also be used for phasing.

(d) The potential indication feature shall include industry standard "banana jacks," one for each phase conductor plus the neutral.

(e) The "banana jacks" shall be located behind an IP-68-rated submersible cover.

(f) Accuracy of the voltage indication subsystem shall be +/– 10 percent.

4.0 PAD-MOUNT ENCLOSURE

(a) Enclosure

(1) The switchgear shall be provided with a pad-mounted enclosure suitable for installation of the gear on a concrete pad.

(2) The enclosure shall be attached to the switchgear assembly to facilitate easy installation (single lift).

(3) The basic material shall be 14-gauge hot-rolled, pickled, and oiled steel sheet.

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

(5) The termination compartment shall be of an adequate depth to accommodate encapsulated surge arresters or grounding elbows mounted on 600-ampere T-bodies having 200-ampere interfaces, or other similar accessory combinations without the need for an enclosure extension.

(6) The termination compartment shall be of an adequate depth to accommodate 200-ampere load-break elbows mounted on portable feedthroughs or stand-off insulators, or other similar accessory combinations without the need for an enclosure extension.

(7) 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 guard against 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 features should be specified as required:

(8) To guard against corrosion caused by extremely harsh environmental conditions, the entire enclosure shall be fabricated from Type 304 stainless steel.

(9) A steel non-compartmented base spacer shall be provided to increase the elevation of bushings and bushing wells in the switchgear assembly above the mounting pad by 6 inches (152 mm) or 12 inches (305 mm).

(10) Hexhead bolt in lieu of pentahead bolt.

(b) Doors

(1) Doors shall be constructed of 14-gauge hot-rolled, pickled, and oiled steel sheet.

(2) Door-edge flanges shall overlap with door-opening flanges and shall be formed to create a mechanical maze that shall guard against water entry and discourage tampering or insertion of foreign objects, but shall allow ventilation to help keep the enclosure interior dry.

(3) 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.

(4) 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.

(a) 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.

(b) 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.

(c) 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.

(5) Each door shall be provided with a stainless steel door-holder mechanism located at the top of the door opening. The holder shall be hidden from view when the door is closed.

(c) Enclosure Finish

(1) Exterior welded seams, if any, shall be filled and sanded smooth for neat appearance.

(2) 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.

(3) 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 manufacturer's finishing system shall satisfactorily pass the following tests:

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

(i) Underfilm corrosion not to extend more than 1⁄32 inch 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 ⅛ inch from the scribe.

(b) 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.

(c) 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 a 10% reduction of gloss as evaluated per ASTM D 523.

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

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

(f) 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.

(4) The finish shall be inspected for scuffs and scratches. Blemishes shall be touched up by hand to restore the protective integrity of the finish.

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

The following optional feature should be specified as required:

(6) The finish shall be outdoor light gray, satisfying the requirements of IEEE Standard Z55.1 for No. 70.

(7) The finish shall be outdoor equipment green, Munsell 9GY1.5/2.6.

(8) The finish shall be outdoor seafoam green, Munsell 4.82G4.07/3.35.

(9) The finish shall be a user-specified custom color.

(d) Connections

(1) Load-interrupter switches shall be equipped with 600-ampere bushing adapters with threaded studs.

(2) Fault interrupters shall be provided with 200-ampere bushing wells.

The following optional feature should be specified as required:

(3) Bushing adapters rated 600 amperes continuous shall be provided without threaded studs.

(4) Fault interrupters shall be provided with 600-ampere bushing adapters either with or without studs.

(5) Cable-centerline adapters shall be provided to reposition termination interfaces to approximately match the cable centerlines of similar PMH and PME Pad-Mounted Gear models.

(e) Termination Interfaces

(1) Termination interfaces shall be replaceable in the field.

(2) Termination interfaces shall have a semi-conductive coating.

(3) Termination interfaces shall have a separate drain wire or other equivalent means to ensure they are solidly grounded to the switchgear assembly.

5.0 LABELING

5.1 Hazard-Alerting Signs

(a) The exterior of the pad-mounted enclosure (if furnished) shall be provided with "Warning—Keep Out—Hazardous Voltage Inside—Can Shock, Burn, or Cause Death" signs.

(b) Each unit of switchgear shall be provided with one or more "Danger—Hazardous Voltage—Failure to Follow These Instructions Will Likely Cause Shock, Burns, or Death" signs. 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) Each unit of switchgear shall be provided with one or more "Danger—Keep Away—Hazardous Voltage—Will Shock, Burn, or Cause Death" signs.

5.2 Nameplates, Ratings, and Labels

(a) Each unit of switchgear shall be provided with a nameplate indicating the manufacturer's name, product name, catalog number, model number, serial number, date of manufacture, type and volume of isolating disconnect insulating material (if applicable), and total mass.

(b) Each unit of switchgear shall be provided with a ratings label indicating the following: voltage rating, main bus continuous current rating, short-circuit rating, fault-interrupter short-circuit interrupting rating, and load-interrupter switch ratings including duty-cycle fault-closing and short-time.

6.0 OPTIONS, REPLACEMENT PARTS, AND ACCESSORIES (Specify as required.)

6.1 Options

(a) Mounting provisions for fault indicators (with or without viewing window in door).

(b) Parking stands for cable terminations.

(c) Key Interlocks. Locks load-interrupter switches or fault interrupters in the open position.

(d) Alternate language labels (specify Spanish, Portuguese, French, Chinese, or Arabic.)

(e) International crating (kiln-dried wood).

6.2 Replacement Parts

(a) 600-ampere bushing adapter kit.

(b) 200-ampere bushing-well adapter kit.

(c) Tool for removing/installing bushing and bushing-well adapters.

6.3 Accessories

(a) Shotgun clamp stick (specify length).

(b) Storage bag for shotgun clamp stick (specify length).

(c) Pentahead socket.

(d) Length-adjustable operating handle (from 35¼ inches (895 mm) to 59¼ inches (1505 mm) in 6-inch (152 mm) increments).

(e) Motor operator; facilitates power operation of load-interrupter switches and fault interrupters. Can be permanently attached to load-interrupter switches and fault interrupters or can be used as a portable operator to effect operation of load-interrupter switches and fault interrupters from a remote location. Requires user-furnished 100-240 Vac 50/60-Hz control power source.

(f) Portable remote control pendant. Includes OPEN/RESET, CLOSE, and ENABLE pushbuttons, motor operator and isolating disconnect position-indicating lamps, and lamp test button. Pendant shall be fully submersible.

(i) With 25-foot (762 cm) control cable.

(ii) With 50-foot (1524 cm) control cable.

(g) Touch-up kit components (primer, finish etc.) for pad-mounted enclosures.

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. Because 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 whether 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, 149°F (65°C) and 131°F/149°F (55°C/65°C).

(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 IEEE Standards C37.010, C37.5, and C37.13. If applicable, an IEEE 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 the 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 so all upstream devices are 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 the 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.
  - (i) Documentation of the results of the analysis, including: Preparation of a written report.
  - (ii) Preparation of single-line diagrams.
  - (iii) Preparation of arc-flash hazard labels to be affixed to the equipment.
- (8) 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 survey 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.