Note to specifiers: Where applicable throughout the text, select the appropriate text inside “<>” and delete the text that does not apply to your application needs.

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 shall consist of a <gas-tight tank containing SF_6 insulating gas> or <hermetically sealed tank containing CO_2 mix insulating gas>, load-interrupter switches and resettable fault interrupters with visible open gaps and integral visible grounds, sensing, motor operators and controls, a low-voltage compartment/enclosure, a microprocessor-based overcurrent control for the fault interrupters, and a microprocessor-based source-transfer control. Load-interrupter switch terminals shall be equipped with bushings rated 600 or 900 amperes continuous, and fault-interrupter terminals shall be equipped with bushing wells rated 200 amperes continuous or bushings rated 600 or 900 amperes continuous (as specified) to provide for elbow connection. (200-A bushing wells are supplied with SF_6 models only.) Manual operating mechanisms and viewing windows shall be located on the opposite side of the tank from the bushings and bushing wells, so that operating personnel shall not be required to perform any routine operations in close proximity to high-voltage elbows and cables.

1.3 Ratings

The ratings for the integrated switchgear shall be as designated below. *(Select values from the table on page 3.)*

Frequency, Hz . . . . ____________
Short-Circuit Current, Amperes, RMS, Symmetrical . . . . ____________
Voltage Class, kV . . . . ____________
Maximum Voltage, kV . . . . ____________
BIL Voltage, kV . . . . ____________
Main Bus Continuous Current, Amperes . . . . ____________
Three-Pole Load-Interrupter Switches
  Continuous Current, Amperes . . . . ____________
  Load-Dropping Current, Amperes . . . . ____________

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

Ten-Time, Amperes, RMS, Symmetrical . . . . ___________
Ten-Time, Amperes, Peak . . . . ___________
Fault Interrupters
Continuous Current, Amperes . . . . ___________
Load-Dropping Current, Amperes . . . . ___________
Fault-Interrupting Current, Duty-Cycle
Three-Time, Amperes, RMS, Symmetrical . . . . ___________
Ten-Time, Amperes, RMS, Symmetrical . . . . ___________
Fault-Closing Current, Duty-Cycle
Three-Time, Amperes, RMS, Symmetrical . . . . ___________
Three-Time, Amperes, Peak . . . . ___________
Ten-Time, Amperes, RMS, Symmetrical . . . . ___________
Ten-Time, Amperes, Peak . . . . ___________

TABLE 1. SELECTION RATINGS①

		IEC			ANSI		
Frequency, Hz		50 or 60			50 or 60		
Short-Circuit Current, Amperes, RMS, Symmetrical		12 500			12 500		
Voltage Class, kV		12	24	36	15.5	27	38
Maximum Voltage, kV		15.5	29	38	15.5	29	38
BIL Voltage, kV		95	125	150	95	125	150
Main Bus Continuous Current, Amperes②		630	630	630	600	600	600
Three-Pole Load-Interrupter Switches	Continuous Current, Amperes Load	630	630	630	600	600	600
	Dropping Current, Amperes	630	630	630	600	600	600
	Fault Closing Current, Duty-Cycle						
	Three-Time, Amperes, RMS, Symmetrical	16 000	16 000	16 000	16 000	16 000	16 000
	Three-Time, Amperes, Peak	41 600	41 600	41 600	41 600	41 600	41 600
	Ten-Time, Amperes, RMS, Symmetrical	16 000	16 000	16 000	16 000	16 000	16 000
	Ten-Time, Amperes, Peak	41 600	41 600	41 600	41 600	41 600	41 600
Fault Interrupters	Continuous Current, Amperes	200●	200●	200●	200●	200●	200●
	Load Dropping Current, Amperes	200●	200●	200●	200●	200●	200●
	Fault Interrupting Current, Duty-Cycle						
	Three-Time, Amperes, RMS, Symmetrical	12 500	12 500	12 500	12 500	12 500	12 500
	Ten-Time, Amperes, RMS, Symmetrical	12 500	12 500	12 500	12 500	12 500	12 500
	Fault Closing Current, Duty-Cycle						
	Three-Time, Amperes, RMS, Symmetrical	12 500	12 500	12 500	12 500	12 500	12 500
	Three-Time, Amperes, Peak	32 000	32 000	32 000	32 000	32 000	32 000
	Ten-Time, Amperes, RMS, Symmetrical	12 500	12 500	12 500	12 500	12 500	12 500
	Ten-Time, Amperes, Peak	32 500	32 500	32 500	32 500	32 500	32 500

		IEC			ANSI		
Frequency, Hz		50 or 60			50 or 60		
Short-Circuit Current, Amperes, RMS, Symmetrical		25 000			25 000		
Voltage Class, kV		12	24	36	15.5	27	38
Maximum Voltage, kV		15.5	29	38	15.5	29	38
BIL Voltage, kV		95	125	150	95	125	150
Main Bus Continuous Current, Amperes②		630	630	630	600	600	600
Three-Pole Load-Interrupter Switches	Continuous Current, Amperes Load③	630	630	630	630	630	630
	Dropping Current, Amperes③	630	630	630	630	630	630
	Fault Closing Current, Duty-Cycle						
	Three-Time, Amperes, RMS, Symmetrical	25 000	25 000	25 000	25 000	25 000	25 000
	Three-Time, Amperes, Peak	65 000	65 000	65 000	65 000	65 000	65 000
	Ten-Time, Amperes, RMS, Symmetrical	16 000	16 000	16 000	16 000	16 000	16 000
	Ten-Time, Amperes, Peak	41 600	41 600	41 600	41 600	41 600	41 600
Fault Interrupters	Continuous Current, Amperes③	630	630	630	600	600	600
	Load Dropping Current, Amperes ③	630	630	630	600	600	600
	Fault Interrupting Current, Duty-Cycle						
	Three-Time, Amperes, RMS, Symmetrical	25 000	25 000	25 000	25 000	25 000	25 000
	Ten-Time, Amperes, RMS, Symmetrical	25 000	25 000	25 000	25 000	25 000	25 000
	Fault Closing Current, Duty-Cycle						
	Three-Time, Amperes, RMS, Symmetrical	25 000	25 000	25 000	25 000	25 000	25 000
	Three-Time, Amperes, Peak	65 000	65 000	65 000	65 000	65 000	65 000
	Ten-Time, Amperes, RMS, Symmetrical	16 000	16 000	16 000	16 000	16 000	16 000
	Ten-Time, Amperes, Peak	41 600	41 600	41 600	41 600	41 600	41 600

① Actual capabilities may be limited to lower values by the bushing inserts, elbows, and cables used on these units. (200-A ratings are available in SF_6 models only.)

② 1200-ampere bus rating is available.

③ 900-ampere load interrupting and fault interrupting ratings are available.

● Ratings are 600 amperes (630 amperes for IEC) continuous and load dropping when the fault interrupters are furnished with 600-ampere bushings.

1.4 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 the load-interrupter switch, fault interrupter, and the integrated switchgear assembly consisting of switches and fault interrupters in combination with the <gas-tight> or <hermetically sealed> tank.

1.5 Compliance with Standards and Codes

The switchgear 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) The applicable portions of IEEE C37.74, IEEE C37.60-2012, IEC 62271-100, IEC 62271-200, and IEEE C37.20.7 which specify test procedures and sequences for the load-interrupter switches, fault interrupters, and the complete switchgear assembly

2.0 CONSTRUCTION

2.1 <SF_6 -Gas Insulation>

(a) The SF_6 gas shall conform to ASTM D2472.

(b) The switchgear shall be filled with SF_6 gas to a pressure of 7 psig at 68° F (20°C).

(c) The <gas-tight> or <hermetically sealed> tank shall be evacuated prior to filling with SF_6 gas to minimize moisture in the tank.

(d) The switchgear shall withstand system voltage at a gas pressure of 0 psig at 68° F (20°C).

(e) A gas-fill valve shall be provided.

(f) A temperature-compensated pressure gauge shall be provided that is color coded to show the operating range. The gauge shall be mounted inside the <gas-tight> or <hermetically sealed> tank (visible through a large viewing window) to provide consistent pressure readings regardless of the altitude at the installation site.

<CO_2 Mix - Gas Insulation>

(a) The CO_2 mix shall be composed of CO_2 and C4-FN insulating gas.

(b) The switchgear shall be filled with CO_2 mix gas to a pressure of 14.5 psig at 68°F (20°C).

(c) The hermetically sealed tank shall be evacuated prior to filling with CO_2 mix gas to minimize moisture in the tank.

(d) The switchgear shall withstand system voltage at a gas pressure of 0 psig at 68º F (20ºC).

(e) The gas fill port shall be sealed to prevent field access as standard.

(f) A temperature-compensated pressure gauge shall be provided that is color coded to show the operating range. The gauge shall be mounted inside the hermetically sealed tank (visible through a large viewing window) to provide consistent pressure readings regardless of the temperature or altitude at the installation site.

2.2 <Gas-Tight> or <Hermetically Sealed> Tank

(a) The tank shall be submersible and able to withstand up to 10 feet (305 cm)of water over the base.

(b) The tank shall be of welded construction and shall be made of 7-gauge mild steel or Type 304L stainless steel, as specified in Section 4.0.

(c) A means of lifting the tank shall be provided.

2.3 <Gas-Tight Tank Finish> or <Hermetically Sealed Tank Finish> (for mild steel only)

(a) After pretreatment, protective coatings shall be applied that shall help resist corrosion and protect the mild-steel surfaces of the <gas-tight> or <hermetically sealed> tank. To establish the capability to resist corrosion and protect the mild steel, representative test specimens coated by the manufacturer's finishing system shall satisfactorily pass the following tests:

(1) 1500 hours of exposure to salt-spray testing per ASTM B 117 with both:

(i) Underfilm corrosion not to extend more than $\frac{1}{32}$-in. (0.79 mm) from the scribe, as evaluated per ASTM D 1645, Procedure A, Method 2 (scraping)

(ii) Loss of adhesion from bare metal not to extend more than $\frac{1}{8}$-in. (3.18 mm) 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) Crosshatch-adhesion testing per ASTM D 3359 Method B, with no loss of finish

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

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

(c) The finish shall be indoor light gray, satisfying the requirements of ANSI Standard Z55.1 for No. 61.

2.4 Viewing Windows

(a) Each load-interrupter switch shall be provided with a large viewing window at least 6 inches (15 cm) by 12 inches (30 cm) to allow visual verification of the switch-blade position (Closed, Open, and Ground) while shining a flashlight on the blades.

(b) Each fault interrupter shall be provided with a large viewing window at least 6 inches (15 cm) by 12 inches (30 cm) to allow visual verification of the disconnect-blade position (Closed, Open, and Ground) while shining a flashlight on the blades.

(c) Viewing windows shall be located on the opposite side of the gear from the bushings and bushing wells, so operating personnel shall not be required to perform any routine operations in close proximity to high-voltage elbows and cables.

(d) A cover shall be provided for each viewing window to prevent operating personnel from viewing the flash that may occur during switching operations.

2.5 High-Voltage Bus

(a) Bus and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the switchgear.

(b) Before installation of aluminum bus, all electrical contact surfaces shall first be prepared by machine-abrading to remove any oxide film. Immediately after this operation, the electrical contact surfaces shall be coated with a uniform coating of an oxide inhibitor and sealant.

2.6 Provisions for Grounding

(a) One ground-connection pad shall be provided on the <gas-tight> or <hermetically sealed> tank of the switchgear.

(b) The ground-connection pad shall be constructed of stainless steel and welded to the <gas-tight> or <hermetically sealed> tank, and it shall have a short-circuit rating equal to that of the switchgear.

(c) When an enclosure is provided, no less than one enclosure ground pad shall be provided.

The following optional feature should be specified as required:

(d) One ground-connection pad per way shall be provided.

2.7 Connections

(a) *For gear rated 12.5 kA short circuit*, load-interrupter switches shall be equipped with 600-ampere bushings, and fault interrupters shall be equipped with 200-ampere bushing wells. (200-A bushing wells are supplied with SF_6 models only.)

(b) *For gear rated 25 kA short circuit*, load-interrupter switches and fault interrupters shall be equipped with 600- or 900-ampere bushings.

(c) Bushings and bushing wells shall be located on one side of the gear to reduce the required operating clearance.

The following optional feature should be specified as required:

(d) Bushings rated 600 or 900 amperes continuous shall be provided without a threaded stud.

For gear rated 12.5 kA only, the following optional features should be specified as required:

(e) Fault interrupters shall be equipped with 600-ampere bushings.

(f) Load-interrupter switches shall be equipped with 200-ampere bushing wells for SF_6 models only.

2.8 Bushings and Bushing Wells

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

(b) Bushings and bushing wells shall include a semiconductive coating.

(c) Bushings and bushing wells shall be mounted in such a way that the semiconductive coating is solidly grounded to the <gas-tight> or <hermetically sealed> tank.

3.0 BASIC COMPONENTS (Select applicable component specifications from those that follow.)

3.1 Load-Interrupter Switches

(a) The three-phase, group-operated load-interrupter switches shall have a three-time and ten-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.

(b) With the exception of the bus-tie switch in split-bus configuration switchgear, each switch shall be provided with an integral Ground position that is readily visible through the viewing window, eliminating the need for cable handling and exposure to high voltage to ground the equipment.

(c) The ground position shall have a three-time and ten-time duty-cycle fault-closing rating.

(d) The switch shall be provided with an open position that is readily visible through the viewing window to eliminate the need for cable handling and exposure to high voltage to establish a visible gap.

(e) The open gaps of the switch shall be sized to allow cable testing through a feedthru bushing or the back of the elbow.

3.2 Fault Interrupters

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

(b) The fault interrupter shall be provided with a disconnect with an integral Ground position readily visible through the viewing window to eliminate the need for cable handling and exposure to high voltage to ground the equipment.

(c) The Ground position shall have a three-time and ten-time duty-cycle fault-closing rating.

(d) The disconnect shall be provided with an Open position that is readily visible through the viewing window to eliminate the need for cable handling and exposure to high voltage to establish a visible gap.

(e) The fault interrupter, including its three-position disconnect, shall be a single integrated design, so operation between the Closed and Open positions or the Open and Ground positions is accomplished with a single, intuitive movement.

(f) The open gaps of the disconnect shall be sized to allow cable testing through a feedthru bushing or the back of the elbow.

(g) An internal indicator shall be provided for each fault interrupter to show when it is in the Tripped condition. The indicator shall be clearly visible through the viewing window.

3.3 Operating Mechanisms

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

(b) The manual handle shall charge the operating mechanism for closing, opening, and grounding of the switches and fault interrupters.

(c) A single, integrated operating mechanism shall fully operate each fault interrupter or load-interrupter switch in a continuous movement, so additional operations are not required to establish Open or Ground positions.

(d) Operating mechanisms shall be equipped with an operation selector to prevent inadvertent operation from the Closed position directly to the Ground position, or from the Ground position directly to the Closed position. The operation selector shall require physical movement to the proper position to permit the next operation.

(e) Operating shafts shall be padlockable in any position to prevent operation.

(f) The operation selector shall be padlockable to prevent operation to the Ground position.

(g) The operating mechanism shall indicate the switch position, which shall be clearly visible from the normal operating position.

3.4 Overcurrent Control

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

(b) For dry-vault-mounted style and pad-mounted style switchgear, the control shall be mounted in a watertight enclosure. For UnderCover™ Style and wet-vault-mounted style switchgear, the control shall be mounted in a submersible enclosure. The control shall be removable in the field without taking the gear out of service.

(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 Microsoft Edge 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 C37.112-2018 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 C37.112-2018 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 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.

3.5 Source-Transfer Control

(a) Operating Description (*Select one of the three operating descriptions.*)

(1) Transfer on Loss and Return of Source Voltage in Common-Bus Primary-Selective Systems

(i) The normal condition shall be with one source load-interrupter switch (for the preferred source, as field-programmed) closed to energize the high-voltage bus and with the other source load-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 shall 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 the loss is not transient. Automatic switching shall open the preferred-source load-interrupter switch and then close the alternate-source load-interrupter switch to restore power to the high-voltage bus. The total transfer time from the preferred to the alternate source shall be approximately 6 seconds.

(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 Loss and Return of Source Voltage in Split-Bus Primary-Selective Systems

(i) The normal condition shall be with the two source load-interrupter switches closed and with the bus-tie load-interrupter switch open so each section of high-voltage bus is energized by its associated, separate source.

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

(ii) When normal voltage returns to the affected source for a preset time, the control shall initiate retransfer to the original configuration if in the Automatic Return mode or await manual retransfer if in the Hold Return mode. In the Hold Return mode, if the source in use fails and if voltage on the other source has been restored, the control shall initiate automatic retransfer to the restored source.

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

(3) 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 switchgear, 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 3.5 (a) (1) (ii) and (iii) for common-bus primary-selective systems or 3.5 (a) (2) (ii) and (iii) for split-bus primary-selective systems.

(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 used, 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 the control is in the Automatic mode, the operation selector for each operator is in the operating position, and all control circuitry is properly connected for automatic transfer.

The display specified in 3.5 (b) (2), when not being used to show menu information, shall show messages explaining why this lamp is not lit.

(5) A selector switch shall be furnished for choosing Manual or Automatic operating mode. In the Manual mode, local electrical Open and Closed operation by means of pushbuttons 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) For use in analyzing system events, the control 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 ANSI Standard C62.41 Category B Power Line Surge.

(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 (-40°F) and +65°C (+149°F).

(5) The control shall be located in the grounded, steel-enclosed low-voltage compartment/enclosure, with the motor-operator controls. 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 load-interrupter switch.

(2) The output of the voltage sensors shall be directly proportional to line-to-ground voltage.

(3) Control power shall be provided by unfused voltage transformers internal to the tank.

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 load-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 3.5 (b) (4), the indicating lamp furnished in 3.5 (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 3.5 (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.

3.6 Low-Voltage Compartment/Enclosure and Components

(a) The low-voltage compartment/enclosure shall be a separate, grounded structure, and shall allow complete accessibility for test and/or maintenance without exposure to medium voltage. The low-voltage compartment shall be mounted on the outside of the pad-mounted enclosure for pad-mounted style switchgear. The low-voltage enclosure shall be mounted to a vault wall for vault-mounted style switchgear. The low-voltage enclosure shall be mounted on a user-supplied pad above grade level for UnderCover™ Style switchgear.

(b) The low-voltage compartment/enclosure shall be large enough to house all motor-operator controls and the source-transfer control.

(c) All low-voltage components, including the batteries, shall operate over the temperature range of -40°C (-40°F) to +65°C (149°F).

(d) To guard against unauthorized or inadvertent entry, the low-voltage compartment/enclosure shall not have any externally accessible hardware.

(e) The low-voltage compartment/enclosure shall include appropriate vents to prevent moisture buildup. Vents shall be screened and filtered to prevent entry of insects and shall be mounted to prevent rain entry and to minimize entry of dust into the enclosure.

(f) For submersible applications, all motor operator wiring between the switchgear tank and the low-voltage compartment/enclosure shall be submersible.

(g) For submersible applications, all current- and voltage-sensing wiring between the switchgear tank and the low-voltage compartment/enclosure shall be submersible.

(h) Low-voltage wiring, except for short lengths, such as connections to terminal blocks, shall be shielded for isolation from medium voltage.

(i) The low-voltage compartment/enclosure shall be made of 14-gauge mild steel.

(j) Control cabling between the tank and the low-voltage enclosure 15 feet (457 cm) or greater in length shall be furnished with a braided shield to protect electronic components from damage under surge and transient conditions.

(k) Single-point grounding methods shall be used on cabling between the tank and the low-voltage enclosure to protect electronic components from damage under surge and transient conditions.

The following optional feature should be specified as required:

(l) To guard against corrosion caused by extremely harsh environmental conditions, the exterior of the compartment/enclosure shall be fabricated from Type 304 stainless steel.

3.7 Motor Operators and Controls

(a) Motor operators shall be furnished for the load-interrupter switches.

(b) Each motor operator shall have its own control board located within the low-voltage compartment/enclosure.

(c) The control board shall have pushbuttons for locally operating the switches between the Closed, Open, and (except for the bus-tie switch in split-bus configuration switchgear) Grounded positions.

(d) Each control board shall have position-indicating lamps to show the Closed, Open, and Ground state of the motor operator.

(e) Each motor operator control board shall have a non-resettable, four-digit-minimum operation counter, which will only increment on a closed-to-open transition.

(f) Each motor operator control board shall have a connector for a portable remote control device, which will allow the user to activate the motor operator at a maximum distance of 50 feet (1524 cm) from the gear.

(g) No decoupling or any adjustments shall be required to manually operate a motor operator.

(h) Removing the motor operator for decoupling shall be a simple, quick process requiring only standard tools.

(i) Only one Local/Remote switch shall be required for the entire gear.

(j) The motor operator shall be watertight. Each unit shall be submersion-tested to verify that water under pressure does not enter the operator housing.

(k) It shall not be possible for the motor operator to be changed from the Closed position directly to the Ground position using local pushbutton or remote control. The Ground position shall be directly accessible only from the Open position.

(l) A mechanical interlock shall be provided to prevent a decoupled motor operator from being incorrectly recoupled.

(m) An integral means shall be provided for testing the position indicating lamps on the motor controls.

(n) Controls shall be easy to operate with or without 25-kV high-voltage rubber gloves and protectors.

3.8 Optional Voltage Indication (*Specify one of the following as required.*)

(1) Voltage indication shall be provided for each load-interrupter switch and fault interrupter by means of capacitive taps on the bushings, eliminating the need for cable handling and exposure to high voltage to test the cables for voltage prior to grounding. This feature shall include a flashing liquid-crystal display to indicate the presence of voltage for each phase and a solar panel to supply power for testing of the complete voltage-indication circuit.

(2) The voltage-indication feature shall be mounted on the covers for the viewing windows, on the opposite side of the gear from the bushings and bushing wells, so operating personnel shall not be required to perform any routine operations in close proximity to high-voltage elbows and cables.

4.0 SWITCHGEAR STYLE (*Select UnderCover™, wet-vault-mounted, dry-vault-mounted, or pad-mounted style.*)

4.1 UnderCover Style

(a) The switchgear shall be suitable for subsurface installation.

(b) The switchgear shall be operable from grade level without exposure to high voltage.

(c) Operating personnel shall be able to verify the positions (Closed, Open, and Ground) of the load-interrupter switches and fault interrupters while standing.

(d) To guard against corrosion caused by extremely harsh environmental conditions, the <gas-tight> or <hermetically sealed> tank shall be made of Type 304L stainless steel.

(e) The tank shall be designed for use in typical subsurface electrical manholes and vaults that are subject to occasional flooding to a maximum head of 10 ft (3 m) above the base of the tank. The water in these vaults may also contain typical levels of contaminants such as salt, fertilizer, motor oil, and cleaning solvents. Extreme environments, such as tidal waters, continuous submersion, abnormally high concentration of certain contaminants, or unusually high or low pH levels, should be evaluated on a case-by-case basis.

(f) For gear rated 12.5 kA short circuit, the switchgear shall conform to or exceed the requirements of applicable portions of IEC 62271-200, covering arc resistance through 12.5 kA for 15 cycles.

(g) For gear rated 25 kA short circuit, the switchgear shall conform to or exceed the requirements of applicable portions of IEC 62271-200 , covering arc resistance through 25 kA for 15 cycles.

4.2 Wet-Vault-Mounted Style

(a) The switchgear shall be suitable for installation in a vault.

(b) To guard against corrosion caused by extremely harsh environmental conditions, the <gas-tight> or <hermetically sealed> tank shall be made of Type 304L stainless steel.

(c) The tank shall be designed for use in typical subsurface electrical manholes and vaults that are subject to occasional flooding to a maximum head of 10 ft (3 m) above the base of the tank. The water in these vaults may also contain typical levels of contaminants such as salt, fertilizer, motor oil, and cleaning solvents. Extreme environments, such as tidal waters, continuous submersion, abnormally high concentration of certain contaminants, or unusually high or low pH levels, should be evaluated on a case-by-case basis.

The following optional features should be specified as required:

(d) *For gear rated 12.5 kA short circuit*, the switchgear shall conform to or exceed the requirements of applicable portions of IEC 62271-200, covering arc resistance through 12.5 kA for 15 cycles.

(e) *For gear rated 25 kA short circuit*, the switchgear shall conform to or exceed the requirements of applicable portions of IEC 62271-200, covering arc resistance through 25 kA for 15 cycles.

4.3 Dry-Vault-Mounted Style

(a) The switchgear shall be suitable for installation in a vault.

(b) The <gas-tight> or <hermetically sealed> tank shall be made of 7-gauge mild steel.

The following optional features should be specified as required:

(c) To guard against corrosion caused by extremely harsh environmental conditions, the <gas-tight> or <hermetically sealed> tank shall be made of Type 304L stainless steel.

(d) *For gear rated 12.5 kA short circuit*, the switchgear shall conform to or exceed the requirements of applicable portions of IEC 62271-200, covering arc resistance through 12.5 kA for 15 cycles.

(e) *For gear rated 25 kA short circuit*, the switchgear shall conform to or exceed the requirements of applicable portions of IEC 62271-200, covering arc resistance through 25 kA for 15 cycles.

4.4 Pad-Mounted Style

(a) The <gas-tight> or <hermetically sealed> tank shall be made of 7-gauge mild steel.

The following optional feature should be specified as required:

(b) To guard against corrosion caused by extremely harsh environmental conditions, the <gas-tight> or <hermetically sealed> tank shall be made of Type 304L stainless steel.

(c) For gear rated 12.5 kA short circuit, the switchgear shall conform to or exceed the requirements of applicable portions of IEC 62271-200, covering arc resistance through 12.5 kA for 15 cycles.

(d) For gear rated 25 kA short circuit, the switchgear shall conform to or exceed the requirements of applicable portions of IEC 62271-200, covering arc resistance through 25 kA for 15 cycles.

(e) Enclosure

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

(2) The pad-mounted enclosure shall be separable from the switchgear to allow clear access to the bushings and bushing wells for cable termination.

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

(4) The enclosure shall be provided with removable front and back panels and hinged lift-up roof sections for access to the operating and termination compartments. Each roof section shall have a retainer to hold it in the Open position.

(5) Lift-up roof sections shall overlap the panels and shall have provisions for padlocking that incorporate a means to protect the padlock shackle from tampering.

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

(7) Panel openings shall have 90-degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between panels and panel openings to guard against water entry.

(8) For bushings rated 600 amperes continuous, the termination compartment shall be of an adequate depth to accommodate encapsulated surge arresters mounted on 600-ampere elbows having 200-ampere interfaces. (200-A bushing wells are supplied with SF_6 models only.)

(9) For bushing wells rated 200 amperes continuous, the termination compartment shall be of an adequate depth to accommodate 200-ampere elbows mounted on feed-through inserts. (200-A bushing wells are supplied with SF_6 models only.)

(10) An instruction manual holder shall be provided.

(11) Non-removable lifting tabs shall be provided.

The following optional feature should be specified as required:

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

(f) Enclosure Finish

(1) All exterior welded seams 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:

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

a. Underfilm corrosion not to extend more than $\frac{1}{32}$-in. (0.79 mm) from the scribe, as evaluated per ASTM D 1645, Procedure A, Method 2 (scraping)

b. Loss of adhesion from bare metal not to extend more than $\frac{1}{8}$-in. (3.18 mm) from the scribe

(ii) 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

(iii) 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

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

(v) 160-inch-pound (18-Nm) impact, followed by adhesion testing per ASTM D 2794, with no chipping or cracking

(vi) 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 ANSI Standard Z55.1 for No. 70.

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 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) Each unit of switchgear shall be provided with a "Danger—Keep Away—Hazardous Voltage—Will Shock, Burn, or Cause Death" sign.

5.2 Nameplates, Ratings Labels, and Connection Diagrams

(a) Each unit of switchgear shall be provided with a nameplate indicating the manufacturer's name, catalog number, model number, date of manufacture, and serial number

(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 ratings, including interrupting and duty-cycle fault-closing; and load-interrupter switch ratings, including duty-cycle fault-closing and short-time.

6.0 ACCESSORIES (*Specify as required.*)

6.1 A USB cable kit shall be provided for connecting the overcurrent control to a user-furnished personal computer.

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, 65°C (149°F) and 55/65 °C (137°F/149°F)

(iv) Primary voltage

(v) Primary connection

(vi) Secondary voltage

(vii) Secondary connection

(viii) X/R ratio

(ix) Tap settings and available settings

(d) The manufacturer shall use commercially available PC-based computer software such as Power System Analysis Framework (PSAF – Fault) from CyME International, CyMDIST, and/or SKM Power Tools® for Windows with the PTW Dapper Module to calculate three-phase, phase-to-phase, and phase-to-ground fault currents at relevant locations in the electrical system, in accordance with ANSI Standards C37.010, C37.5, and C37.13. If applicable, an ANSI closing-and-latching duty analyses 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 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 preload 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 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 (19,427°C). It can vaporize metal and cause severe burns to unprotected workers from direct heat exposure and ignition of improper clothing. And the arc blast resulting from release of the concentrated radiant energy can damage hearing and knock down personnel, causing trauma injuries.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(i) Preparation of a written report

(ii) Preparation of single-line diagrams

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

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

7.4 Analytical Service Site Visits

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

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

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

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