



Process Industry Practices
Electrical

PIP ELSSG02
Design and Fabrication of Medium Voltage
Metal-Clad Switchgear from 4.76 kV to 38 kV

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1. Introduction

1.1 Purpose

This Practice provides requirements for the design and fabrication of metal-clad switchgear.

1.2 Scope

This Practice covers minimum requirements for design, fabrication, inspection, testing, shipment, and documentation, for metal-clad switchgear containing insulated buses, draw-out power circuit breakers, control, instrumentation, and metering, for indoor installation in unclassified areas. This Practice also covers remote monitoring and control requirements.

2. References

Applicable parts of the following Practices, industry codes and standards, and references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP ELSBD01 – *Design and Fabrication of Metal-Enclosed Nonsegregated-Phase Bus Duct Assemblies*
- PIP ELSBD01D – *Data Sheet for Design and Fabrication of Metal-Enclosed Nonsegregated-Phase Bus Duct Assemblies*
- PIP ELSSG02D – *Data Sheet for PIP ELSSG02 Design and Fabrication of Medium Voltage Metal-Clad Switchgear from 4.76 kV to 38 kV*

2.2 Industry Codes and Standards

- Institute of Electrical and Electronic Engineers (IEEE)
 - IEEE C37.20.2 – *Standard for Metal-Clad Switchgear*
 - IEEE C37.20.7 – *Guide for Testing Medium-Voltage Metal-Enclosed Switchgear for Internal Arcing Faults*
- American Society for Testing and Materials (ASTM)
 - ASTM D1535 – *Standard Practice for Specifying Color by the Munsell System*

3. Definitions

arc resistant accessibility Type 1: Equipment with arc-resistant designs or features at the freely accessible front of the equipment only

arc resistant accessibility Type 2: Equipment with arc-resistant designs or features at the freely accessible exterior (front, back, and sides) of the equipment only

arc resistant accessibility Type 1C: Equipment with arc-resistant designs or features at the freely accessible front of the equipment only, plus the additional requirements of ANSI C37.20.7 Annex A, which are intended to reduce the collateral damage to adjacent compartments and equipment, and should not be interpreted to indicate any additional degree of protection for personnel

arc resistant accessibility Type 2C: Equipment with arc-resistant designs or features at the freely accessible exterior (front, back, and sides) of the equipment only, plus the additional requirements of ANSI C37.20.7 Annex A, which are intended to reduce the collateral damage to adjacent compartments and equipment, and should not be interpreted to indicate any additional degree of protection for personnel

arc resistant equipment: Equipment designed to withstand the effects of an internal arcing fault, as indicated by meeting test requirements of ANSI C37.20.7

internal arcing fault: An unintentional discharge of electrical energy in air within the confines of an electrical equipment enclosure

owner: The party who owns the facility wherein the medium voltage metal-clad switchgear will be used

metal-clad switchgear: The term metal-clad switchgear, in this Practice, is in accordance with switchgear features and requirements for metal-clad switchgear given in Section 3.1.5 of *IEEE C37.20.2-1999 (R2005)*.

purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner's authorized agent.

purchaser's inspector: The purchaser's authorized representative with authority to act in the interest of, and on behalf of, the purchaser in all quality assurance matters

supplier: The party responsible for manufacturing, furnishing, and/or installing the medium voltage metal-clad switchgear

4. Requirements

4.1 Service Conditions

Unless otherwise specified on the purchaser's *PIP ELSSG02D* Data Sheet, equipment shall be designed to perform satisfactorily under the following ambient conditions:

- a. Ambient conditions within the limits of -30°C (-18°F) and 40°C (104°F)
- b. Altitude of installation does not exceed 1000 m (3300 feet)
- c. Humidity within the limits of 0 - 95% non-condensing

4.2 Ratings

4.2.1 The ratings of the switchgear assemblies and the system parameters shall be in accordance with the purchaser's *PIP ELSSG02D* Data Sheet and as given in this Practice.

- 4.2.2 Surface temperature on any external part of the switchgear shall not exceed 50°C (122°F) at 40°C (104°F) ambient when carrying rated continuous current at rated voltage and rated frequency.
- 4.2.3 Hottest spot temperature rise for the buses and connectors shall not exceed 65°C and hottest total temperature shall not exceed 105°C (221°F) at 40°C (104°F) ambient when carrying rated continuous current at rated voltage and rated frequency.
- 4.2.4 The above temperature limitations are based on the use of 90°C (194°F) insulated power cables.

4.3. Basic Construction

4.3.1 Switchgear Assembly

- 4.3.1.1 The switchgear assembly shall include, but not be limited to, metal-clad free-standing vertical steel structures containing power buses, a ground bus, removable (drawout) vacuum circuit breakers, auxiliary control devices, instrumentation, metering, and protective equipment in accordance with the one-line diagram and the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.3.1.2 All enclosures shall be fabricated from free-standing steel frames and steel panels with doors formed to provide a strong and rigid structure.
- 4.3.1.3 Panels and doors shall be Manufacturer Sheet Gage (MSG) #12 minimum thickness.
- 4.3.1.4 Enclosures shall be Category B with requirements as defined in Annex A of *IEEE C37.20.2-1999* (R2005), Table A.1.
 - Comment:* Category B enclosures are intended for use in installations that are not subject to deliberate unauthorized acts of the unsupervised general public and for providing a degree of protection to untrained personnel against incidental contact with enclosed equipment.
- 4.3.1.5 All front, rear, instrument, and control compartment doors shall have either continuous steel hinges or a minimum of two separate hinges to prevent the doors from sagging and shall be provided with door stops.
- 4.3.1.6 All front doors shall be provided with hand-operated latches and shall have provisions for padlocking. All rear doors shall be hinged and bolted.
- 4.3.1.7 Incoming breakers and tie breakers shall be one-high configuration.
- 4.3.1.8 Feeder breakers may be one-high or two-high configuration as specified on the purchaser's *PIP ELSSG02D* Data Sheet.

- 4.3.1.9 If auxiliary devices such as ramps or lift trucks are required for installation or removal of breakers, they shall be provided with the switchgear assemblies.
- 4.3.1.10 All ventilation and cooling openings shall be provided with vermin-proof, 1/8-inch (3 mm) opening mesh Type 304 stainless steel screens on the inside of the switchgear.
- 4.3.1.11 An external positive indicator to show the breaker position during closed-door breaker racking and breaker mechanical open/close status shall be provided.
- 4.3.1.12 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, a view window with a clear, shatter-proof polycarbonate cover in compliance with *IEEE C37.20.2-1999 (R2005)*, Annex A, Section A.3.6, shall be provided. A 60 watt, 120 volt incandescent light with an On-Off switch on the door shall be provided inside each cubicle containing a circuit breaker to permit the following:
 - a. Viewing the breaker position during closed door breaker racking
 - b. Viewing the breaker mechanical open/closed status indicator
- 4.3.1.13 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, viewer ports shall be provided. The viewer ports shall be located to permit infrared scanning of all three phases of the field medium voltage power cable terminations.
- 4.3.1.14 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, partial discharge sensors and associated equipment shall be provided.
- 4.3.1.15 Switchgear shall be designed for expansion on both ends and the enclosures shall be of modular design so that additional units can be safely and readily installed. This shall include, but shall not be limited to predrilled buses, terminal blocks for secondary wiring, and removable insulated enclosure end covers secured by captive hardware on the structure. At least two covers shall need to be removed to access the bus bar.
- 4.3.1.16 All spaces shall be fully-equipped complete with Truck Operated Cell (TOC) switches, stationary Mechanism Operated Cell (MOC) switches, current transformers, and all monitoring and relaying equipment as shown on the one-line diagram, except for the roll-out breaker element.
- 4.3.1.17 Energized bare parts mounted on doors shall be provided with guards.

4.3.2 Power Cable Terminations

- 4.3.2.1 Provisions for cable terminations shall be provided for each breaker as defined on the one-line diagram.
- 4.3.2.2 The depth of all units shall be sufficient to allow top or bottom entrance and bending and termination of shielded power cables.

- 4.3.2.3 The cable entry shall be as specified on the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.3.2.4 The distance from the cable entry point to termination location shall be 36 inches (914 mm) or greater.
- 4.3.2.5 Non-metallic supports for power cables and cable terminators shall be provided so that the weight of the cables is not imposed on the terminations. The supports shall be located 6 inches (152 mm) from the entry and 18 inches (457 mm) from the connection points. At no position shall any power cable span more than 18 inches (457 mm) without support inside the switchgear.
- 4.3.2.6 Power cable termination pads shall be plated and suitable for four two-hole connectors.
- 4.3.2.7 All termination pads shall have NEMA standard bolt pattern (9/16 inch (14.3 mm) by 3/4 inch (19 mm) slotted holes spaced 1-3/4 inch (44.4 mm) center to center).
- 4.3.2.8 Unless otherwise specified on the purchaser's *PIP ELSSG02D* Data Sheet, connectors (lugs) for incoming and outgoing cables shall be provided by the purchaser.
- 4.3.2.9 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, all customer power connection points shall be provided with inter-phase barriers, ground barriers, and phase to ground barriers.
 - a. For bottom entry cables, the barriers shall extend a minimum of 12 inches (305 mm) below and 6 inches (152 mm) above the termination point.
 - b. For top entry cables, the barriers shall extend a minimum of 6 inches below and 12 inches (305 mm) above the termination point.
- 4.3.2.10 In a two-high configuration, a metallic enclosure shall be provided for power cable routing to the top or bottom compartment, depending on whether it is top or bottom feed.

4.3.3 Bus Duct Terminations

If bus duct is specified on the purchaser's *PIP ELSSG02D* Data Sheet, the bus duct shall be in accordance with *PIP ELSBD01* and *PIP ELSBD01D*.

4.4 Additional Requirements for Arc-Resistant Switchgear

- 4.4.1 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, the switchgear shall be arc-resistant design as described below.
- 4.4.2 Switchgear shall be tested in accordance with *IEEE C37.20.7*.
- 4.4.3 Unless otherwise specified on the purchaser's *PIP ELSSG02D* Data Sheet, switchgear shall be arc-resistant construction Type 2 (switchgear with arc-resistant construction at front, rear, and sides).

- 4.4.4 A written certificate of successful type testing, including all the parameters used in the testing, shall be submitted to the purchaser. Testing shall be based on prospective current of the highest rated circuit breaker without insertion of any current limiting device in the test circuit.
- 4.4.5 Circuit breakers, PT and CPT drawers, and switchgear shall be designed for closed door racking. Arc-resistant integrity shall be maintained during closed door racking.
- 4.4.6 Relay compartment door(s) shall be designed and tested to allow the compartment door to be opened without affecting the arc-resistant rating of the switchgear.
- 4.4.7 The front and rear compartment doors shall be designed to withstand the effects of an internal arcing fault.
- 4.4.8 The Potential Transformer (PT) compartment door and the instrument and control compartment doors shall have steel hinged doors that are in accordance with *IEEE C37.20.7* testing requirements.
- 4.4.9 The design of openings shall pass the requirements of *IEEE C37.20.7*, with respect to the emission of arc/flash products.
- 4.4.10 Openings intended to close on initiation of a fault to preserve arc-resistant construction shall be provided with the necessary guards on top and sides to prevent dropping of any foreign material that will prevent openings from closing.
- 4.4.11 Design and construction of the switchgear shall prevent effects of any fault in the high voltage compartment from entering the low voltage or instrument compartment.
- 4.4.12 All opening cover plates provided to preserve arc-resistant construction shall be accessible for inspection.
- 4.4.13 Unless specified otherwise on the purchaser's *PIP ELSSG02D* Data Sheet, door interlocks shall be provided that offer the following functions:
 - a. Prevent opening of the breaker compartment door unless the circuit breaker is in the disconnected or test position and the safety shutters are closed.
 - b. Prevent racking the breaker from disconnected position unless the door latch is fully closed and latched.
- 4.4.14 Means to manually trip the breaker without requiring opening the door and compromising the integrity of arc-resistant construction shall be provided.
- 4.4.15 Provisions for closed door manual racking of the circuit breaker while maintaining the integrity of arc-resistant construction shall be provided.
- 4.4.16 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, rear door(s) shall be interlocked to prevent opening the rear door(s) unless the breaker in the corresponding front compartment is in the disconnected position. If interlocked rear door(s) is not specified on the purchaser's *PIP ELSSG02D* Data Sheet, the rear door(s) shall be equipped with a padlock provision.

- 4.4.17 Where interlocked rear door(s) are specified on the purchaser's *PIP ELSSG02D* Data Sheet, a means shall be provided to defeat the interlocks by a deliberate act that is not considered part of a normal operating procedure for maintenance purposes. The interlock shall be reset by closing the door after the interlock has been circumvented.
- 4.4.18 A single-handle latch system with position labeling and provision for padlocking shall be provided on each door such that arc-resistant integrity is maintained when the latch is in closed position. No additional tie down bolts or latches shall be required on the doors to maintain arc-resistant construction.
- 4.4.19 Personnel shall be protected from arc products and noise expelled from the switchgear enclosure. Unless specified otherwise on the purchaser's *PIP ELSSG02D* Data Sheet, a plenum system shall be provided as described below:
 - a. Plenum system shall exhaust arc products from the switchgear room.
 - b. Exhaust outlet shall be weatherproof and directed to an area that minimizes personnel exposure.
 - c. Plenum minimum volume shall be tested and certified in accordance with *IEEE C37.20.7*.

4.5 Power Circuit Breaker

- 4.5.1 Circuit breakers shall be electrically operated, drawout type, and of vacuum interrupter-type design.
- 4.5.2 Circuit breakers shall be rated for interrupting and close and latch current rating as specified on the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.5.3 Circuit breaker internal supports shall be porcelain or cycloalaphatic type epoxy supports.
- 4.5.4 Each circuit breaker shall be equipped with "stored energy operation" type anti-pump operating mechanism.
- 4.5.5 Grounded metal shutters shall be provided to prevent access to the primary contacts if the circuit breaker is withdrawn or removed. The action of the shutters shall be aligned to the position of the circuit breaker removable element. The mechanism by which the shutters are operated shall be redundant and use balance of forces to avoid "wedging" shutters in place.
- 4.5.6 Shutters shall be clearly marked with an inscription indicating "Connected to incoming or outgoing cable" or "Connected to bus side" as applicable. This inscription shall be minimum 1/2-inch (13 mm) high white lettering on a red background.
- 4.5.7 Means shall be provided to manually rack the circuit breaker into or out of the compartment with the compartment door closed and latched.
- 4.5.8 Circuit breaker open and closed positions shall be specified by means of color coded flags on the front of each circuit breaker.
 - 4.5.8.1 The flag color red shall indicate the "closed" position.

- 4.5.8.2 The flag color green shall indicate the “open” position.
- 4.5.8.3 These flags shall be observable with the compartment door closed.
- 4.5.9 Circuit breaker padlocking provisions shall be provided for padlocking the removable element in the disconnected and test position only.
- 4.5.10 Circuit breakers of the same rating shall be interchangeable and interlocked with the breaker cubicle so that a breaker with a lower continuous or interrupting rating cannot be inserted into a higher rated compartment.
- 4.5.11 A TOC switch and a MOC switch shall be provided for each cubicle:
 - a. The TOC and MOC switches may be located in the circuit breaker cell. No other devices shall be located in the circuit breaker cell.
 - b. Each cell switch shall have a minimum four Normally Open (NO) contacts and four Normally Closed (NC) contacts provided for the purchaser’s use.
 - c. All cell switch contacts shall be wired out to terminal blocks in the instrument and control compartment so that they can be easily accessed for test purposes.
- 4.5.12 Unless specified otherwise on the purchaser’s *PIP ELSSG02D* Data Sheet, all circuit breakers shall be closed and operated by 125 volts DC nominal voltage.
 - 4.5.12.1 For 125 volt DC systems, the circuit breaker close coil shall be designed to operate within a voltage range of 100 to 140 volts DC and the circuit breaker trip coil shall be designed to operate within a voltage range of 70 to 140 volts DC.
 - 4.5.12.2 For systems with AC control voltage, a capacitive trip device shall be provided if specified on the purchaser’s *PIP ELSSG02D* Data Sheet.
 - 4.5.12.3 Automatic trip or alarm contacts upon detection of failure of capacitive trip device shall be provided as specified on the purchaser’s *PIP ELSSG02D* Data Sheet.
- 4.5.13 Breakers for motor control shall be provided with a single trip coil. Unless otherwise specified on the purchaser’s *PIP ELSSG02D* Data Sheet, breakers for generator control shall be provided with two (2) trip coils. Each trip coil shall be connected for operation on a separate trip circuit.
- 4.5.14 Provisions shall be made to manually trip the circuit breaker (on loss of trip circuit) without opening the door.
- 4.5.15 One set of accessories required for safe operation and maintenance (such as handling device, racking handle, test plugs, test cabinets with a set of secondary couplers, breaker maintenance closing device, manual charging device, transport truck, etc.) shall be provided for each switchgear lineup, unless otherwise specified on the purchaser’s *PIP ELSSG02D* Data Sheet. A list of required accessories shall be provided by the supplier to the purchaser with proposal.

4.6. Buses

4.6.1 Power Bus

- 4.6.1.1 All buses and primary connections shall be copper.
- 4.6.1.2 Phase of polarity arrangements shall be “1, 2, 3” from front to back, top to bottom, or left to right as viewed from front.
- 4.6.1.3 All sections of the main bus shall have continuous ampacity equal to the main bus continuous ampere rating as specified on the purchaser’s *PIP ELSSG02D* Data Sheet or one-line diagram.
- 4.6.1.4 Bus contact areas shall be silver-plated or tin-plated as specified on the purchaser’s *PIP ELSSG02D* Data Sheet.
- 4.6.1.5 All bus insulators and bus bar inserts shall utilize either wet-process glazed porcelain or cycloaliphatic epoxy material as specified on the purchaser’s *PIP ELSSG02D* Data Sheet.
- 4.6.1.6 Bus insulation, except at the joints, shall be bonded to the bus bar and shall be either liquid dipped or fluidized bed epoxy.
- 4.6.1.7 Insulating materials for buses and connections shall be flame-retardant, non-hygroscopic, and track-resistant throughout.
- 4.6.1.8 Sleeve type or heat shrink tubing type insulating systems shall not be permitted.
- 4.6.1.9 All bus bar joints shall be covered with formed insulating boots and reusable non-metallic hardware. Termination connections for the purchaser’s cable connections shall also have insulating boots provided with reusable non-metallic hardware.
- 4.6.1.10 Taping of bolted joints is not acceptable.
- 4.6.1.11 Insulating materials for barriers, cable supports, and spacers shall be made of flame-retardant, track-resistant, non-hygroscopic materials in accordance with the same requirements of insulating materials covering buses as defined in *IEEE C37.20.2-1999 (R2005)*, Section 7.9.
- 4.6.1.12 All connections to PT or Control Power Transformer (CPT) primary stationary stabs shall be made with a rigid bus.
- 4.6.1.13 All bolted power bus connections shall be secured with corrosion-resistant, silicon-bronze hardware, including bolts, locking washers, and nuts or jam nuts.
- 4.6.1.14 Connections shall be made with a minimum of two bolts.
- 4.6.1.15 Bus connections with contact area of 9 square inches (5806 mm²) or 2000 amperes or higher shall have a minimum of four bolts.
- 4.6.1.16 A label shall be posted inside each cubicle listing torque requirements for bolted connections.

4.6.2 Ground Bus and Connections

- 4.6.2.1 A copper ground bus, minimum 2 inches (51 mm) by 1/4 inch (6.4 mm) copper, that extends throughout the length of the stationary structure shall be provided.
- 4.6.2.2 The ground bus shall be designed to carry rated short time current of the highest rated device in the assembly for minimum 2 seconds.
- 4.6.2.3 Ground bus shall electrically connect together the structures in a switchgear assembly in or on which primary equipment or devices are mounted.
- 4.6.2.4 Provisions for connection of NEMA two-hole connectors at each end of the bus shall be provided (9/16-inch (14.3 mm) diameter holes spaced 1-3/4 inch (44.4 mm) center to center).
- 4.6.2.5 Ground connections shall be provided for all removable elements to ensure that the frame and mechanism are grounded until the primary circuit is disconnected and the removable element is moved a safe distance.
- 4.6.2.6 Connections to the ground bus shall be designed so that it is not necessary to remove or discontinue the ground bus if any connections are made or removed from the ground bus.
- 4.6.2.7 A separate connection point shall be provided for each ground wire connected to the ground bus.
- 4.6.2.8 Ground bus connections shall be solidly bolted. Use of self-tapping screws or bolts shall not be permitted for ground bus connections.

4.6.3 Maintenance Grounding Provisions

- 4.6.3.1 In each cubicle, the ground bus shall be extended toward the incoming power cable termination points to allow easy access for safety grounding connection of a portable grounding clamp device.
- 4.6.3.2 Each phase bus power cable termination shall be provided with an apparatus ground clamp cable connection for voltage testing and grounding.
- 4.6.3.3 The ground clamp cable connection shall be a grounding ball stud, mounted as close as possible to the phase bus cable termination point.
- 4.6.3.4 Ground and test devices shall be provided if specified on the purchaser's *PIP ELSSG02D* Data Sheet.

4.7. Control and Secondary Circuits and Devices

4.7.1 General

All voltage circuits used for control, relaying, or metering shall be protected within the switchgear as follows:

- 4.7.1.1 All cubicles supplied from Alternating Current (AC) or Direct Current (DC) external power sources shall have overload and short

circuit protection, individual disconnecting means, and provisions for locking in the disconnected or off position.

- 4.7.1.2 The following caution plate, shown in Figure 1, shall be provided on the door of each cubicle with external power.



Figure 1

- 4.7.1.3 All circuits supplied from internal power sources (AC) shall have overload and short circuit protection within the same section as the supply source.

4.7.2 Remote Control of Circuit Breakers

- 4.7.2.1 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, provision to remotely open and close the circuit breakers shall be provided via a seller supplied remote control panel or hand-held control station.

- 4.7.2.2 If a remote control panel is supplied, it shall meet the following requirements:

- a. It shall be tested in accordance with *ANSI/IEEE C37.21*.
 - b. It shall be configured as shown on a layout sketch supplied by the purchaser.
 - c. It shall contain control switches, metering, mimic bus, and any other devices specified by the purchaser and shown on layout sketch.
 - d. As a minimum, the mimic bus shall show buswork, circuit breakers, supply sources, load descriptions, voltage transformers, and current transformers.
 1. Breaker control switches shall be located beside the breaker symbol.
 2. Devices shall be labeled using engraved laminated plastic.
 3. The mimic buswork and components shall be attached with stainless steel screws.
 - e. All auxiliary components used in the control panel shall meet the same requirements as if they were in the main switchgear.
 - f. Terminal strips shall be mounted inside the control panel with terminal designations matching those of the corresponding terminal strips in the main switchgear. All connections shall be brought to the terminal strips.
- 4.7.2.3 If a hand-held control station is supplied, it shall include open and close pushbuttons and 25 feet (7.6 m) of cord with plug for connection to the front door of each switchgear cubicle. A spare

hand-held control station shall be provided if specified on the purchaser's *PIP ELSSG02D* Data Sheet.

- 4.7.2.4 A remote racking device to electrically rack the breaker shall be provided if specified on the purchaser's *PIP ELSSG02D* Data Sheet and shall include 25 feet (7.6 m) of cord. Means shall be provided to shut off the remote racking device when breaker is in the "connected" position.

4.7.3 Power and Control Devices and Wiring

- 4.7.3.1 All wiring shall be flame-resistant, 600 volts rated insulation, Type SIS flexible insulated stranded copper wire with insulation rated for 90°C (194°F) conductor temperature.
- a. Power wiring shall be minimum No. 12 American Wire Gauge (AWG).
 - b. Control wiring, for use between component devices or parts of switchgear assemblies, shall be No. 14 AWG minimum size.
 - c. Wiring that crosses hinged doors or panels shall be the extra flexible type with 37 or more strands.
 - d. Wire bundles shall be arranged in a spiral configuration, so that the bundle twists rather than bends when door or panel is opened.
 - e. Wire bundles shall be protected against mechanical damage or contact with sharp edges by plastic spiral wrap.
 - f. Unless otherwise specified on the purchaser's *PIP ELSSG02D* Data Sheet, wiring, except for CT circuits, shall be terminated with insulated locking fork type connectors. Ratchet type crimpers shall be used to positively crimp the connectors.
 - g. Unless otherwise specified in this Practice or as specified on the purchaser's *PIP ELSSG02D* Data Sheet, manufacturer's standard color insulation shall be used for power and control wiring.
- 4.7.3.2 Current Transformer (CT) secondary circuits shall be minimum No. 10 AWG copper conductors with Type SIS.
- a. The two individual leads from each CT shall be wired to front accessible, shorting terminal blocks. CT grounding shall also be connected on these blocks.
 - b. CT circuits shall be provided with compression type, insulated sleeve, seamless ring tongue connectors.
- 4.7.3.3 Unless otherwise specified on the purchaser's *PIP ELSSG02D* Data Sheet, all grounding conductors shall be made with green insulated wires.
- 4.7.3.4 Control and secondary wiring shall be of one continuous length from terminal to terminal.

- a. Splicing shall not be permitted.
 - b. All control wiring leaving a compartment shall leave from terminal blocks, not from devices in the compartment.
- 4.7.3.5 The terminal blocks shall be NEMA style general industrial type for internal panel application:
- a. All blocks shall be 600 volt, 20A, minimum, fix mounted design, fully shielded construction to protect live parts.
 - b. All blocks shall be suitable for insulated locking fork type or ring type connectors.
 - c. A maximum of two wires may terminate at each terminal.
 - d. Terminal blocks shall be arranged and positioned to provide easy access for carrying out external cable terminations, testing, inspection, and maintenance.
 - e. A minimum of 20% spare terminals shall be provided.
- 4.7.3.6 The ends of each wire shall be tagged with the origin and destination points.
- a. Each wire shall be permanently marked at both ends in accordance with the wiring diagrams.
 - b. All wires shall be properly identified with heat-shrink wire markers.
 - c. Adhesive-back wire markers, labels, and wire holders shall not be permitted.
- 4.7.3.7 Each relay, fuse block, circuit breaker, terminal block, control switch, auxiliary switch, instrument transformer, and other auxiliary devices shall be permanently labeled in accordance with the schematics and wiring diagrams.
- 4.7.3.8 Each circuit breaker, fuse block, or isolating knife switch shall be clearly identified to indicate the source and its purpose.
- 4.7.3.9 Fuse holders rated 30 amperes or less, shall be modular type, dead front construction, rail or screw panel mounting.
- a. Fuse holders shall provide open fuse indication light and an NC contact if specified on the purchaser's *PIP ELSSG02D* Data Sheet.
 - b. The design of the fuse holders shall be finger safe, requiring that fingers cannot touch any live parts.
- 4.7.3.10 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, wiring for bus differential relays shall be color coded as follows:
- Phase A - Red
 - Phase B - Blue
 - Phase C - Yellow

If color coding is specified, a second differential relay, if specified, shall utilize colors other than the primary bus differential color scheme.

4.7.4 Potential Transformers

- 4.7.4.1 Potential Transformers (PTs) shall be provided in accordance with the one-line diagram.
- 4.7.4.2 PTs shall be mounted in a separate compartment on a tilt-out or draw-out type carriage with two handles. Means shall be provided to ground the unit if the unit is withdrawn.
- 4.7.4.3 Means shall be provided to limit access to the bus bar contacts if the PT carriage is withdrawn.
- 4.7.4.4 The PT basic insulation level (BIL) at minimum shall be the same as the switchgear BIL.
- 4.7.4.5 All PT primaries shall be protected with current limiting fuses. Secondary circuits shall be protected by fuses or circuit breakers.
- 4.7.4.6 Provisions to padlock the PT in the disconnected position shall be provided and shall be visible from outside the door.
- 4.7.4.7 For arc-resistant switchgear, PT disconnects shall be operable with the door closed while maintaining the integrity of arc-resistant construction.

4.7.5 Current Transformers

- 4.7.5.1 CTs shall be window type and installed in a manner that can be readily maintained or replaced.
- 4.7.5.2 All CTs shall be designed to mechanically withstand the short circuit stresses imposed by the rating of the associated circuit breaker for a minimum of two seconds.
- 4.7.5.3 Current transformers for use in switchgear shall be suitable for use with an internal enclosure air temperature of at least 55°C (131°F).
- 4.7.5.4 Except for zero sequence CTs, CTs shall have a 5 ampere secondary winding rating, voltage rated insulation, and ANSI metering and relaying accuracy classification to meet the system parameters as shown on the purchaser's *PIP ELSSG02D* Data Sheet. CT accuracy class ratings shall be in accordance with *IEEE C37.20.2-1999*, Table 4.
- 4.7.5.5 CTs shall be rated and selected for the proper application to avoid relay misoperation due to saturation at the fault current specified on the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.7.5.6 CT polarity marker shall be visible from the front of the switchgear with shutters open or rear of the switchgear with the door open.
- 4.7.5.7 Opening of zero sequence CTs shall be large enough to accommodate purchaser's power cables.

4.7.5.8 CT secondary circuits shall be routed away from high voltage components.

4.7.6 Control Power Transformers

4.7.6.1 Control Power Transformers (CPTs) shall be provided in accordance with the one-line diagram.

4.7.6.2 CPT and primary fuses shall be mounted on a tilt-out or draw-out type carriage with two handles. Means shall be provided to ground the unit if the unit is withdrawn.

4.7.6.3 CPTs larger than 15 KVA can be fix-mounted type but their primary protective fuses must be installed in a draw-out truck or tilt-out tray.

4.7.6.4 Means shall be provided to limit access to the bus bar contacts if the CPT carriage is withdrawn.

4.7.6.5 The CPT BIL rating at a minimum shall be the same as the switchgear BIL rating.

4.7.6.6 All CPT primaries shall be protected with current limiting fuses. Secondary protection may be either fuses or circuit breakers. Secondary protection shall be mechanically interlocked with the primary fuse compartments to prevent opening of the primary device unless all loads have been removed by the secondary protection device.

4.7.6.7 Provisions to padlock the CPT in the disconnected position shall be provided and shall be visible from outside the door.

4.7.6.8 For arc-resistant switchgear, CPT disconnects shall be operable with the door closed while maintaining the integrity of arc-resistant construction.

4.7.7 Instruments, Meters, Control Devices, and Indicating Lights

4.7.7.1 Each circuit breaker shall be provided with the following devices:

- a. Red indicating light – Breaker closed
- b. Green indicating light – Breaker open
- c. Amber indicating light – Breaker tripped by relaying
- d. Other indicating lights, such as lockout relay coil monitor, trip coil monitors, etc., as described in the purchaser's *PIP ELSSG02D* Data Sheet
- e. Control switch for breaker operation (open-closed)
- f. Local-Remote Control switch if specified on the purchaser's *PIP ELSSG02D* Data Sheet
- g. Metering as specified on the one-line diagram

4.7.7.2 All meters shall be digital read out type except for the space heater ammeters, synchronous motor field current meters, synchronous motor power factor meters, and synchrosopes.

- 4.7.7.3 Test switches to isolate potential and current inputs shall be provided to allow safe removal for calibration and repairs.
 - a. Test jacks and test plugs shall be ABB Type FT-1 or approved equal.
 - b. Each test jack shall be wired to provide three-phase bus potential and three-phase line current for field monitoring and shall be wired in the current circuits.
 - c. The blades of all test switches shall be de-energized when open.
- 4.7.7.4 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, microprocessor-based monitoring devices shall be provided. Monitoring devices may be integrated into the protective relays as specified on the one-line diagram.
- 4.7.7.5 Unless otherwise specified on the purchaser's *PIP ELSSG02D* Data Sheet, space heater ammeters shall be provided, and shall be miniature type, 2% accuracy class, for indicating and monitoring space heater circuits.
- 4.7.7.6 Control switches shall be rotary cam type with engraved dial plates, Electros witch Series 24, or purchaser-approved equal.
 - a. Selector type control switches shall have oval handles.
 - b. Circuit breaker control switches shall have "pistol grip" handles.
 - c. Lockout relay (Device 86) shall be manually reset type with oval or pistol grip handles.
- 4.7.7.7 Indicating lights shall be cluster type LED lamps with front replaceable lamps and colored caps. The dropping resistor, if required, shall be integral with the lights and not mounted external to the lights.

4.7.8 Protective Relaying

- 4.7.8.1 Relaying shall be as specified on the one-line diagram or on attachments as to manufacture, type, quantity, and style numbers.
- 4.7.8.2 Substitution shall not be made of an equivalent relay without the written approval of the purchaser.
- 4.7.8.3 The protective relays can be microprocessor multi-function type, solid state electronic type or discrete electro-mechanical type as specified on the one-line diagram or the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.7.8.4 Separate multi-function relays are acceptable for the following applications:
 - a. Feeders
 - b. Transformers
 - c. Main and tie circuit breakers

- 4.7.8.5 The supplier shall supply all software and complete documentation for configuration, analysis, and monitoring of all protective relays and related auxiliary devices required by the purchaser.
- 4.7.8.6 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, provisions shall be made for remote monitoring of the equipment operation by a central control system.
- 4.7.8.7 Separate relays shall be provided for bus differential protection if this requirement is specified on the one-line diagram or checked on the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.7.8.8 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, each breaker shall be provided with a Trip Circuit Monitoring (TCM) relay or light.

4.7.9 Space Heaters

- 4.7.9.1 The metal-clad switchgear assembly shall be equipped with space heaters to minimize condensation.
- 4.7.9.2 Space heaters shall be externally powered.
- 4.7.9.3 Each vertical unit shall be provided with a space heater, rated 240 volts, and operated at 120 volts.
- 4.7.9.4 The space heater shall be provided with high temperature wiring within 6 inches (152 mm) of the heater terminals.
- 4.7.9.5 Space heaters shall be mounted on a stand-off insulator and provided with an expanded metal cage for personnel protection.
- 4.7.9.6 A caution plate, as shown in Figure 2, shall be provided on the door of each cubicle that contains space heaters:



Figure 2

- 4.7.9.7 An over-current protection/disconnect for each space heater circuit shall be provided in each vertical section.
- 4.7.9.8 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, each vertical section space heater shall be controlled by a humidistat or thermostat. The humidistat or thermostat shall be equipped with an ammeter and a bypass switch as specified.
- 4.7.9.9 The following devices shall be provided for all circuit breakers specified as motor starters:
 - a. A circuit breaker in the control compartment for each motor space heater. Circuit breaker shall provide protection for each ungrounded conductor.

- b. Unless otherwise specified on the purchaser's *PIP ELSSG02D* Data Sheet, one analog ammeter in each heater circuit to monitor circuit continuity shall be provided.
- c. One heater control relay to energize the heater if the breaker is open or in the disconnected position. The relay shall be controlled by the breaker MOC contact with a normally closed relay contact in the motor space heater circuit.
- d. One test switch to momentarily test the heater circuit with the motor running shall be provided.
- e. If specified on the purchaser's *PIP ELSSG02D* Data Sheet, a heater circuit current monitoring relay shall be provided.

4.8. Finish

- 4.8.1 The switchgear enclosures shall be cleaned and treated for rust resistance.
- 4.8.2 The inside of the switchgear control compartment shall be painted as specified on the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.8.3 Finish color for switchgear shall be ANSI No. 61, light gray in accordance with *ASTM D1535-01* (Munsell notation 8.3.G6.10/0.54) unless specified otherwise on the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.8.4 One quart of touch-up paint shall be furnished for each five vertical sections and for each paint color used.

4.9. Test and Inspection

4.9.1 Design Tests

Copies of Certified Reports of all design tests described in *ANSI/IEEE C37.20.2-1999 (R2005)*, Section 6.2, shall be available for review by the purchaser upon request.

4.9.2 Production Tests

- 4.9.2.1 The entire switchgear must be electrically and mechanically assembled into one single line-up prior to final testing, inspection and shipment.
- 4.9.2.2 Certified Reports of all production tests described in *ANSI/IEEE C37.20.2-1999 (R2005)*, Section 6.3 shall be provided.
- 4.9.2.3 The control wiring insulation test shall be performed by applying 1500 volts to ground, 60 Hertz for 1 minute.
- 4.9.2.4 Switchgear mounted devices that have been individually tested may be disconnected with the permission of the purchaser.
- 4.9.2.5 All control and protective circuits of breakers shall be checked for functional operation, which shall verify the correctness of wiring.
- 4.9.2.6 All polarity verification shall be performed using primary injection.
- 4.9.3 To meet conformance requirements, all assemblies shall successfully pass all tests described above.

- 4.9.4 The purchaser reserves the right to observe the manufacturing, fabrication, or any part of work which concerns the subject equipment, inspect materials documents and manufacturing operations, witness the final test, and evaluate results of nondestructive examinations, if specified on the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.9.5 The purchaser or purchaser's inspector shall be provided with free plant access, suitable facilities, and seven working days notice of scheduled work on the contract.

4.10. Nameplates

- 4.10.1 Permanent engraved lamacoid nameplates shall be provided identifying each compartment front mounted instruments and devices, including transformers, circuit breaker, and auxiliary compartment.
- 4.10.2 Equipment and terminal blocks within the compartments shall be suitably identified.
- 4.10.3 Relays shall be designated as to use and the phase to which they are connected.
- 4.10.4 Unless otherwise specified on the purchaser's *PIP ELSSG02D* Data Sheet, nameplates shall be mounted with self-tapping stainless screws.
- 4.10.5 A caution plate, shown in Figure 3, shall be provided on the door of each cubicle that contains devices such as PTs connected to the line side of the incoming main breaker:



Figure 3

- 4.10.6 All devices inside the cubicles shall be identified with engraved lamacoid nameplates mounted with stainless steel screws. Adhesive-backed plastic labels shall not be permitted.
- 4.10.7 A stainless steel nameplate showing supplier's name, type and identification number, year of manufacture, continuous current rating, interrupting rating in amperes, and maximum voltage rating shall be provided on each circuit breaker and switchgear assembly. Lineup nameplate shall also include bus bracing in kA (asymmetrical) along with the description of arc-resistant type construction, if applicable.
- 4.10.8 Nameplates shall be of following background color and engraving:
 - a. Identification nameplates – White background with black engraving
 - b. Caution nameplates – Yellow background with black engraving
 - c. Warning nameplates – Red background with white engraving
 - d. Grounding PTs and devices – Green background with white engraving

- 4.10.9 The supplier shall provide a 6 inch by 6 inch (150 mm by 150 mm) blank space on cubicle doors for installation of arc-flash warning labels by the purchaser.
- 4.10.10 If specified on the purchaser's *PIP ELSSG02D* Data Sheet, a mimic bus shall be included on the front doors of the switchgear.
 - 4.10.10.1 As a minimum, it shall show buswork, circuit breakers, supply sources, load designations, voltage transformers, and current transformers.
 - 4.10.10.2 If breaker control switches are located on the doors, they shall be beside the breaker symbol.
 - 4.10.10.3 Devices shall be labeled using engraved laminated plastic.
 - 4.10.10.4 The mimic buswork and components shall be attached with stainless steel screws.

4.11 Documentation

4.11.1 Documentation Content

- 4.11.1.1 Drawings for each lineup of the switchgear shall have a unique number provided by the purchaser.
- 4.11.1.2 Drawings shall have a space on the right hand bottom corner for the purchaser's title block.
- 4.11.1.3 Schematic drawings shall include the following information as a minimum:
 - a. Complete schematic diagram with item numbers corresponding to bill of materials
 - b. Operation and contact arrangement of over-current and control relays, and all switches
 - c. Contact position of all components in shelf (normally de-energized) position
 - d. Cross-reference to bill of materials and other drawings

4.11.2 Drawing and Data Requirements

- 4.11.2.1 One reproducible set of drawings shall be provided plus the specified number of copies of all documentation and operating manuals as specified on the purchaser's *PIP ELSSG02D* Data Sheet.
- 4.11.2.2 Unless otherwise specified on the purchaser's *PIP ELSSG02D* Data Sheet, format for reproducible drawings shall be CAD convertible .DXF electronic format.
- 4.11.2.3 Drawings and data requirements shall be as shown in Table 1.

Table 1. Documentation Requirements

A With Bid	B For Review	C Final Certified	D As Built	Description
	X	X	X	Bill of materials giving schematic identification, quantity, make, rating, model, and manufacturer of component
X				Extended warranty information
X				Proposed layout of equipment, showing estimated dimensions and weights
	X	X	X	Equipment drawings, showing floor plans, front view elevations, relay and control device panel layouts, typical sectional views. Drawings shall show all locations of all equipment and devices.
	X	X	X	Installation drawings, showing dimensions and weights of all shipping sections and location and type of all interconnections between shipping splits
	X	X	X	Connection wiring diagrams for all electrical equipment
	X	X	X	3-line, and control schematic diagrams
		X		Certified Test Reports
		X		Installation, Operation, and Maintenance Manual
			X	Complete parts list
		X		Recommended spare parts list with pricing
Notes: A. These documents shall be provided with the proposal. B. These documents shall be provided for the purchaser's review and authorization to proceed before fabrication. C. These documents shall be provided as part of the final certified document submittal. (1) Equipment shall be shipped with one set of installation, operation, and maintenance manuals. D. The final as-built documents shall be provided within 2 weeks following shipment.				

4.12. Shipment

- 4.12.1 Details on shipping requirements shall be furnished in the purchase order.
- 4.12.2 All temporary shipping braces shall be painted yellow and marked, as shown in Figure 4.

REMOVE BEFORE EQUIPMENT IS PLACED IN SERVICE

Figure 4

- 4.12.3 Instructions for storage of equipment shall be attached to the equipment.
- 4.12.4 Removable elements or items shipped separately from the switchgear shall be clearly identified with proper description and location of installation.
- 4.12.5 Equipment shall be protected from weather elements during shipping.
- 4.12.6 One set of installation, operation, and maintenance manuals shall be shipped with the equipment.

- 4.12.7 All breakers shall be shipped separately. If specified on the purchaser's *PIP ELSSG02D* Data Sheet, breakers shall be in weather-tight packaging, suitable for outdoor storage.

4.13. Conflict Resolution

Any conflicts between the reference documents shall be identified in writing to the purchaser for resolution. If resolving conflicts, the following order of precedence shall apply:

- a. Purchase Order
- b. One-line diagram and associated documents
- c. *PIP ELSSG02D* Data Sheet
- d. This Practice, *PIP ELSSG02*
- e. Referenced Standards