

Process Industry Practices
Electrical

PIP ELSSG01
Design and Fabrication of
Low-Voltage Metal-Enclosed
AC Power Circuit Breaker Switchgear

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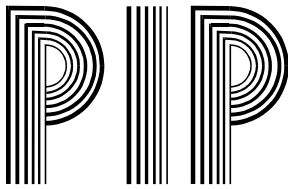
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1. Introduction

1.1 Purpose

This Practice provides requirements for design, fabrication, and testing of metal-enclosed, low-voltage AC power circuit breaker switchgear assemblies.

1.2 Scope

This Practice describes the requirements for metal-enclosed power switchgear assemblies employed in three-phase AC electrical systems having a voltage not higher than 1000 volts and located in a nonclassified area.

2. References

Applicable parts of the following Practices and industry codes and standards 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 will be 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 ELSGS01 - *Design and Fabrication of High-Resistance Grounding System (600 Volts or below)*
- PIP ELSGS01D - *Data Sheet for Design and Fabrication of High-Resistance Grounding System (600 Volts or below)*
- PIP ELSSG01D - *Data Sheet for Design and Fabrication of Low-Voltage Metal-Enclosed AC Power Circuit Breaker Switchgear*

2.2 Industry Codes and Standards

- American National Standards Institute, Inc. (ANSI)
 - ANSI C37.50 - *Switchgear - Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures*
- Institute of Electrical and Electronic Engineers (IEEE)
 - IEEE C37.13 - *Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures*
 - IEEE C 37.20.1 - *Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear*

- National Electrical Manufacturers Association (NEMA)
 - NEMA C37.16 - *Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors—Preferred Ratings, Related Requirements, and Application Recommendations*
 - NEMA C37.17 - *Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers*
- Underwriters Laboratories (UL)
 - UL 1558 - *Standard for Safety Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear*

3. Definitions

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

supplier: The party responsible for furnishing the low-voltage metal-enclosed AC power circuit breaker switchgear

4. Requirements

4.1 Switchgear Assembly

- 4.1.1 The switchgear assembly shall consist of metal-enclosed freestanding vertical steel structures containing power buses, a ground bus, low-voltage power circuit breakers, and auxiliary control devices in accordance with the attached purchaser's *PIP ELSSG01D* Data Sheet and one-line diagram(s).
- 4.1.2 The switchgear shall be designed such that the breakers can be tripped and closed and the breaker position can be viewed with the doors closed.
- 4.1.3 If specified on the purchaser's *PIP ELSSG01D* Data Sheet, red and green indicating lights shall be provided to indicate breaker closed and open positions, respectively.
- 4.1.4 All enclosures shall be fabricated from freestanding steel frames and steel panels, and doors shall be formed to provide a strong and rigid structure.
- 4.1.5 Enclosure panel and doors shall be 14-gage minimum thickness.
- 4.1.6 Enclosures shall be NEMA 1 unless specified otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.1.7 All bolted doors and removable panels shall be secured with captive slotted fasteners or machine screws or machine bolts engaging captive nuts or tapped holes in structural members. Self-tapping sheet metal screws shall not be permitted.
- 4.1.8 Any removable panels weighing more than 50 pounds (23 kg) shall have two lifting handles.

- 4.1.9 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, all rear access doors shall be full height, hinged, and bolted. All rear access doors shall have provisions for padlocking.
- 4.1.10 All doors shall have hinges. The hinges may be either continuous or separate. If separate hinges are used, a minimum of three hinges shall be provided on full-height doors.
- 4.1.11 Provisions shall be made for the addition of vertical sections with future breakers at open ends of the line-up. This shall include removable plates or side sheets furnished on the end of vertical sections.
- 4.1.12 All breaker compartment doors shall be provided with door handle latches.
- 4.1.13 Provisions shall be made for padlocking breakers in the test and disconnected positions.
- 4.1.14 In double-ended switchgear, each main and tie breaker shall be in separate vertical sections.
- Comment:* This does not preclude metering, auxiliary equipment, or a feeder breaker being in the same vertical section with the main breaker or tie breaker.
- 4.1.15 The purchaser shall be notified of any breaker-derating factors caused by ambient conditions and the cumulative circuit loads in the vertical sections with multiple breakers in accordance with *IEEE C37.20.1 - 2002*, Section 8.4.2.3.
- 4.1.16 Spaces shall be provided for future use as indicated on the one-line diagram. Spaces shall be of three types: equipped, unequipped, and blank. Spaces shall be configured as follows:
- Equipped and unequipped spaces shall be capable of being modified to add future circuit breakers of the same ampere rating without a shutdown of the switchgear.
 - Equipped spaces shall be furnished with all hardware, wiring, doors, and miscellaneous equipment including current transformers and monitoring devices required to permit completion of the unit by the addition of only a circuit breaker.
 - Unequipped spaces shall be provided with doors but with no other equipment for future use except the power stabs. Unequipped spaces shall not be used for mounting control switches and other auxiliary equipment.
 - Power stabs (both line and load side) shall be provided with covers to prevent accidental contact with live parts when door is opened.
 - Blank spaces shall be completely empty cubicles with doors but without power stabs or other equipment.
- 4.1.17 Automatic shutters shall be provided over the power stabs unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.

- 4.1.18 Removable vertical barriers shall be provided in the rear cable compartments to prevent accidental contact of personnel with all energized buses. The barriers shall not cover load connections.
- 4.1.19 Sheet steel barriers shall be provided between power and control compartments.
- 4.1.20 Unless otherwise specified on the purchaser's *PIP ELSSG01D* Data Sheet, full height and depth barriers shall be provided between adjacent vertical sections in the rear load terminal compartments.
- 4.1.21 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, sheet steel barriers shall be provided between breaker compartments in vertical sections.
- 4.1.22 Equipment shall be designed to be shipped completely assembled if practical.
- 4.1.23 If equipment must be disassembled for shipment, material and instructions shall be provided for assembling shipping sections, including making main power bus connections at shipping splits.
- 4.1.24 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, enclosure vent openings shall be provided with stainless steel screens having a maximum opening size of 1/16 inch (1.6 mm).
- 4.1.25 Breaker control power shall be as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.1.26 Nonflashing indicator lights shall have replaceable, cluster-type LED lamps and colored lens.
- 4.1.27 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, thermography windows shall be provided. Location of windows shall be as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.1.28 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, the switchgear assembly shall be UL labeled.

4.2 Power Circuit Breakers

- 4.2.1 Low-voltage power circuit breakers shall be air break type and shall be designed, rated, manufactured, and tested in accordance with *IEEE C37.13*, *NEMA C37.16*, *NEMA C37.17*, and *ANSI C37.50*.
- 4.2.2 Breakers shall be of the stored-energy type with standard draw-out construction for both power and control circuits. They shall be three-pole and complete with necessary operating mechanisms.
- 4.2.3 Breakers shall be operated electrically or manually as indicated on the purchaser's *PIP ELSSG01D* Data Sheet. Electrically operated breakers shall also be capable of manual operation.
- 4.2.4 Direct-acting overcurrent trip devices shall be solid state RMS sensing, unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet, and shall incorporate time delay characteristics, as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.2.5 The trip device display shall be visible with the cubicle door closed.

- 4.2.6 If required, current-limiting fuses shall be provided to extend the breaker rating and shall cause the breaker to trip if any of the fuses operate. The purchaser shall be notified if these fuses are required.
- 4.2.7 Each low-voltage power circuit breaker or each breaker in combination with current-limiting fuses shall be capable of interrupting the available short-circuit current in accordance with the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.2.8 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, mechanism operated contacts (MOCs) and truck operated contacts (TOCs) shall be supplied as two normally open (N.O.) and two normally closed (N.C.) each, wired out to terminals.
- 4.2.9 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, electrically operated breakers shall have provisions for remote operation by a hand-held control station.
- 4.2.9.1 The control station shall have 20 ft (6 m) of type SO cord with a polarized plug on the end.
- 4.2.9.2 The control station shall have two guarded pushbuttons, a green button for opening and a red button for closing.
- 4.2.10 If remote operation is indicated, a matching receptacle complete with a threaded cover shall be installed in the breaker compartment door.
- 4.2.11 If remote operation is indicated, a local electrically operated close button or switch shall not be provided on the front of the compartment.

4.3 Bus Work

- 4.3.1 The power buses shall be uninsulated unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.3.2 Bus material shall be copper unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.3.3 Bolted joints shall be tin-plated unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.3.4 All horizontal and vertical bus and bus supports shall be designed and braced to withstand the short-circuit current in accordance with *IEEE C 37.20.1 - 2002*, paragraph 5.4.4, unless a higher level is indicated on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.3.5 A 1/4-inch by 2-inch minimum copper ground bus shall be provided at the rear and for the entire length of the assembly.
- The bus shall be drilled at each end for a NEMA two-hole lug.
 - Ground bus joints shall be solidly bolted.
 - Self-tapping bolts and screws shall not be used.
 - Copper compression type lugs shall be provided if indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

- 4.3.6 The ground bus shall be firmly secured in each vertical section.
- 4.3.7 If a neutral bus is indicated on the purchaser's *PIP ELSSG01D* Data Sheet, it shall extend the full length of the switchgear and be insulated from ground.
- 4.3.8 Unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet, the neutral bus shall have the same continuous current rating as the phase bus.

4.4 Voltage Transformers

- 4.4.1 Voltage transformers for metering or protective relaying purposes shall be protected by disconnecting-type current-limiting primary fuses.
- 4.4.2 Secondary voltage shall be 120 volts, with primary voltage as indicated on the one-line diagram.
- 4.4.3 Each transformer shall have a fused secondary winding.
 - 4.4.3.1 Secondary fuses shall be located in the low-voltage control compartment.
 - 4.4.3.2 Fuse holders shall be labeled to indicate size and type of fuse and to identify the transformer (e.g., Phase "A" PT).

4.5 Control Power Transformers

- 4.5.1 The primary fuses shall coordinate with the magnetizing inrush current and the secondary protection of the control power transformer.
- 4.5.2 The kVA rating of the control power transformer(s) shall be determined by the supplier, taking into account any additional loads external to the switchgear, as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.5.3 A form C contact shall be provided for remote alarming of any loss of control power.
- 4.5.4 Secondary voltage shall be 240/120 volts, with primary voltage as indicated on the one-line diagram.
- 4.5.5 Primary and secondary windings shall be protected by disconnect-type current-limiting fuses.
- 4.5.6 Transformers shall be located in the low-voltage control compartment.

4.6 Current Transformers

Current transformers for metering or protective relaying purposes shall be rated in accordance with purchaser's *PIP ELSSG01D* Data Sheet or the one-line diagram.

4.7 Switches

- 4.7.1 Ammeter and voltmeter switches shall be provided if indicated on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.7.2 Ammeter switches shall be the four-position rotary type.
- 4.7.3 Voltmeter switches shall be the four-position rotary type unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.

4.8 Metering

- 4.8.1 Switchgear metering shall be provided in accordance with the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.8.2 Communication capabilities shall be provided if indicated on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.8.3 All metering and control equipment shall be accessible from the front of the switchgear.
- 4.8.4 If analog-type metering is specified on the purchaser's *PIP ELSSG01D* Data Sheet, it shall be of the circular 250-degree-scale switchboard type, 1% accuracy, 4-1/2 inch square, and flush mounted.
- 4.8.5 Control power for microprocessor-type metering shall be as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.9 Space Heaters

- 4.9.1 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, space heaters shall be provided in each vertical section.
- 4.9.2 An expanded metal cage shall be provided around the heaters to guard against accidental contact. Caution signs with black engraving on yellow background shall be provided on each vertical section stating the following:

CAUTION: SPACE HEATERS MAY BE ENERGIZED INSIDE.
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- 4.9.3 The power supplies to the heaters shall be from the source indicated on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.9.4 The heaters shall be rated at 240 volts and shall be sized to provide the required heat output when operated on a 120-volt system.
- 4.9.5 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, a panel-type indicating ammeter shall be provided in each main heater circuit, with "normal current" range indicated on the ammeter scale.
- 4.9.6 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, thermostats shall be provided.
- 4.9.7 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, a push-to-test pushbutton shall be installed parallel with the thermostat for testing the space heaters.

4.10 Breaker Interlocking and Transfer Schemes

- 4.10.1 If a breaker interlocking or transfer scheme is indicated on the purchaser's *PIP ELSSG01D* Data Sheet and one-line diagram, it shall be arranged to operate as indicated on the diagram and any supplemental descriptions provided.
- 4.10.2 The transfer scheme shall be disabled if any of the transfer breakers are in the test position.

4.11 Wiring and Terminations

- 4.11.1 Control wiring shall be flame retardant, 600-volt, type SIS switchboard copper wire (or an equivalent in accordance with *IEEE C37.20.1 - 2002*, Section 7.1.3.1.4) and shall be continuous from terminal to terminal without splices and tagged at both ends with permanent plastic sleeve-type wire markers.
- 4.11.1.1 Adhesive-type markers shall not be permitted.
- 4.11.1.2 Locking fork-type lugs shall be provided.
- 4.11.1.3 Minimum conductor size shall be 14 AWG.
- 4.11.1.4 Wire markers shall match the supplier's interconnection drawing.
- 4.11.2 Wiring for current transformer secondary leads shall be crimped in self-insulated ring-type lugs and terminated on shorting screw-type terminal blocks at the first connection after the transformer. Minimum conductor size shall be 10 AWG unless otherwise indicated on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.11.3 All wiring harnesses shall be securely bundled and shall be protected from rubbing against other parts within the enclosure.
- 4.11.3.1 Bushings, grommets, or other mechanical protections shall be provided if wiring is installed through barriers, around edges of metal sheets, or raceways.
- 4.11.3.2 Adhesive-type supports shall not be permitted.
- 4.11.4 Wiring shall be connected to only one side of all field wiring terminal blocks, and no more than two wires per terminal shall be permitted.
- 4.11.4.1 Terminal blocks for field wiring to the main and tie breakers and for any transfer scheme shall not be located in the rear load terminal compartments.
- 4.11.4.2 Terminal blocks for field wiring to feeder breakers shall be located in the rear load terminal compartments.
- 4.11.5 Terminal blocks shall be supplied and clearly marked for wiring that will be installed by the purchaser, including wiring between shipping sections.
- 4.11.6 Spare terminal blocks shall be provided in accordance with the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.11.7 Power cable lugs will be provided by the purchaser.
- 4.11.7.1 The bus drilling shall be for NEMA two-hole lugs.
- 4.11.7.2 The size and quantity of cables shall be as indicated on the one-line diagram or purchaser's *PIP ELSSG01D* Data Sheet.

4.12 Bus Ducts

- 4.12.1 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, the bus ducts shall be furnished and coordinated with the respective switchgear assemblies, the supply transformers, and other associated equipment.

- 4.12.2 Dimensions and details of transformer throats or other equipment connections shall be supplied by the responsible party noted on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.12.3 Design of the bus duct shall be in accordance with *PIP ELSBD01* and *PIP ELSBD01D*.

4.13 Nameplates

- 4.13.1 Permanent nameplates shall be provided to identify each circuit breaker, source disconnect point, instrument, instrument switch, relay, and auxiliary component and to identify all equipment and terminal blocks within each assembly.
- 4.13.2 All nameplates shall be made of laminated plastic at least 3/32 inch thick and shall be affixed with stainless steel hardware.
- 4.13.3 Switchgear assembly-identifying nameplate may be supplier's standard showing manufacturer, shop order number, and date as a minimum.
- 4.13.4 Door-mounted devices shall be identified inside the compartment, in addition to the external identification. The inside nameplates may be adhesive type.
- 4.13.5 Nameplates for each circuit breaker compartment shall be white with 1/4-inch-high engraved black lettering.
- 4.13.6 Warning nameplates shall be provided on each compartment door in which an external voltage source is terminated. Lettering shall be black on yellow background and shall be a minimum of 1/4 inch high. The nameplate shall read as follows:

CAUTION: THIS UNIT IS SUPPLIED BY AN EXTERNAL VOLTAGE SOURCE.
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- 4.13.7 A nameplate schedule will be provided by the purchaser.

4.14 Finish

- 4.14.1 Finish color shall be *ANSI 61* light gray unless otherwise specified on the purchaser's *PIP ELSSG01D* Data Sheet.
- 4.14.2 For outdoor and indoor service in noncorrosive environments, the manufacturer's standard surface preparation and coating system are acceptable.
- 4.14.3 The finish coat shall be free from craters, pinholes, holidays, embedded foreign matter, and other visual defects.
- 4.14.4 The topcoat shall provide complete hiding, consistent coverage and thickness, and uniform color.
- 4.14.5 For service in corrosive environments, the finish and protective coatings shall be in accordance with the specification shown on the purchaser's *PIP ELSSG01D* Data Sheet.

4.15 Secondary System Grounding

- 4.15.1 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, a high-resistance grounding system shall be provided and incorporated in the switchgear assembly in accordance with *PIP ELSGS01*.
- 4.15.2 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, a ground detection system on individual feeder breakers shall be provided in accordance with the one-line diagram.

4.16 Accessories

The following switchgear accessories shall be furnished:

- a. A breaker-lifting device supplied at one per switchgear assembly. Lifting capacity shall be shown on the lifting device.
- b. Hand crank or handle for moving the breaker into the "connected," "test," or "disconnected" position
- c. Device for manually charging the stored energy operating mechanism of electrically operated breakers
- d. Test plugs for draw-out relays
- e. Portable test kit for solid-state trip units (quantity of kits as indicated on the purchaser's *PIP ELSSG01D* Data Sheet)

4.17 Shipping

- 4.17.1 Preparation for shipment shall be in accordance with supplier's standards unless otherwise noted on the request for quotation and/or purchase order. The supplier shall be solely responsible for the preparation for shipment.
- 4.17.2 Loose equipment, such as auxiliary test devices, charts, replacement parts, manual operating handles, packing devices, etc., shall be appropriately packaged, tagged for easy identification, and secured for shipment inside the switchgear.
- 4.17.3 All moving parts shall be securely blocked and braced in relays, contactors, and other components with moving parts that might be damaged in shipment.
- 5.17.4 Additional shipping and handling requirements that appear in the individual equipment specifications shall be strictly adhered to, if applicable.
- 5.17.5 If the switchgear is shipped in more than one section, each open shipping split shall be protected with plywood or other approved method.

4.18 Inspection and Testing

- 4.18.1 The following tests shall be performed:
 - a. A complete functional and operational test on the wiring, control devices, relays, and breaker trip and close circuits
 - b. A dielectric test on the control wiring at 1500 volts minimum and 60 hertz for 1 minute
 - c. Supplier's standard routine tests

- d. Production tests defined in *IEEE C37.20.1 - 2002*, Section 6.3. Tests shall be conducted with all draw-out elements racked in and breakers closed.

4.18.2 The purchaser shall be notified 2 weeks in advance of testing.

4.18.3 The purchaser or the purchaser’s representative reserves the right to inspect and observe the tests at the factory.

4.19 Documentation

All drawings and other documents shall be furnished as indicated in Table 1 as a part of the purchase order.

TABLE 1 - SUPPLIER DRAWING AND DATA REQUIREMENTS FOR LOW-VOLTAGE METAL-ENCLOSED SWITCHGEAR

A	B	C	D	DESCRIPTION
	X	X	X	One-line diagram, three-line diagram, control elementary, and connection diagrams
X	X	X	X	General layout of equipment, showing all dimensions, weights, and required clearances.
X	X			Circuit breaker data, including detailed description of breakers, rated insulation level (BIL), and rated short-circuit current.
X	X	X		Bus data, including the insulation and bracing materials and methods
	X	X		Current transformer data, including type, class, accuracy, and saturation curves
	X	X		Potential transformer data, including the type, class, and accuracy
	X	X	X	Detailed plans and elevation drawings showing location of all components
X	X	X		Solid-state trip unit data, including the model number, technical information, and time-current curves
	X	X		Meter data, including the model number and technical information of all meters and transducers
		X		Certified type test reports
	X	X		Foundation loading diagrams and soleplate details
	X	X	X	Individual cell schematics
	X	X	X	Individual cell connection wiring diagrams
G	D		D	Detailed (D) or general (G) bill of material including name of the manufacturer and catalog number of all components
		X(1)		Installation, operation, and maintenance manual
		X		Recommended spares parts list

- A. These documents shall be provided with proposal.
- B. These documents shall be provided for purchaser's review and authorization to proceed before fabrication.

- C. These documents shall be provided as part of the final certified document submittal.
 - (1) One additional set of installation, operation, and maintenance manuals shall be included with the equipment when shipped.
- D. The final as-built shall be provided within 2 weeks following shipment.

Comment: One reproducible set of drawings shall be provided plus the specified number of copies of all documentation and operating manuals as indicated on the purchaser's *PIP ELSSG01D* Data Sheet. Format for final as-builts reproducibles shall be CAD convertible .DXF electronic format unless other wise indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.20 Conflict Resolution

Any conflicts among the referenced documents shall be identified to the purchaser in writing for resolution. When resolving conflicts, the following order of precedence shall apply:

- a. Purchase order
- b. One-line diagram(s) and associated drawings
- c. Data sheet, *PIP ELSSG01D*
- d. This Practice, *PIP ELSSG01*
- e. Referenced standards