

User Manual



Isolated Power Panels

For Healthcare Facilities



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1. Introduction

1.1 General Description

This document states how to install, operate, and maintain BENDER isolation panels for hospital isolated power systems.

This document is for the use of qualified electricians. Refer to National Electric Code (NEC) Article 517, National Fire Protection Association (NFPA) 99, and all other applicable national and local codes and standards. Refer to Section 2 of this document for other safety instructions.

The panel types included in this document are listed in the following sections.

1.1.1 Standard Isolated Power Panels (IP)

The standard isolation power panel is a single-voltage, single-system panel. Contains one (1) LIM2010 Line Isolation Monitor (LIM).

1.1.2 IP Panels with Receptacles And/Or Ground Jacks

Contains the features of the standard isolated power panel, as well as provisions for power receptacles and/or ground jacks, located on the faceplate of the panel.

1.1.3 IP Panels with Circuit Control

Contains the features of the standard isolated power panel, as well as circuit interlock control via a programmable logic controller (PLC) and contactors.

1.1.4 Dual Voltage Isolated Power Panels (ID)

Provides two separate output voltages from one isolation transformer. Contains two (2) LIM2010 Line Isolation Monitors.

1.1.5 Dual System Isolated Power Panel (IX)

Provides two separate voltages from two isolation transformers. Contains two (2) LIM2010 Line Isolation Monitors, as well as two sets of secondary branch breakers. This system is equivalent to two independent IP panels in one enclosure.

1.2 Components

The specifications listed below are standard for the United States unless otherwise noted. Contact the manufacturer for more information pertaining to custom orders. Ensure all purchased equipment obeys all national and local codes and standards before purchasing.

1.2.1 Backbox Package

The backbox consists of a minimum 14 GA galvanized steel, flush- or surface-mounted piece. Flush mounting is standard. A request is required during the purchasing process to the manufacturer for surface mounting. Surface mounted backboxes are finished with a coat of hospital ivory baked enamel, or equivalent.

1.2.2 Interior Package

The interior consists of a single component subpanel, containing a prewired fixture plate, a dead front panel, and LIM2010 Line Isolation Monitor.

1.2.3 Isolation Transformers

Transformers for single isolated power panels, dual voltage isolated power panel, and dual system isolated power panels provided by the manufacturer have ratings which include 3, 5, 7.5, 10, 15, and 25 kVA. The fixed primary voltage for these transformers is in the range of 110 V to 480 V. The fixed secondary voltage for these transformers is in the range of 110 V to 240 V. The fixed voltages are set at the manufacturer and depend on the specific equipment requirements.

Transformers for isolated power panels with circuit control have ratings of 15 or 25 kVA. The fixed primary voltage for these transformers is in the range of 110 V to 480 V. The fixed secondary voltage is in the range of 110 V to 240 V. The fixed voltages are set at the manufacturer and depend on the specific equipment requirements.

1.2.4 Circuit Breakers

The primary circuit breakers installed in all panels are sized in accordance with NFPA 70, Article 450-3(b)1(1). The quantity of secondary circuit breakers installed varies by panel style:

- Standard isolation power panels and isolation power panels with receptacles are factory installed with eight (8), 20 A secondary circuit breakers. Panels are field-convertable up to sixteen (16) secondary circuit breakers (the maximum allowed by UL).
- Dual system panels are installed with two sets of eight (8), 20 A secondary circuit breakers. Each system is field-convertable up to sixteen (16) secondary circuit breakers.
- Isolated power panels with circuit control serve a maximum of eight (8) secondary circuits. The number of secondary circuits, as well as which circuits receives power, is set at the factory.
- For dual voltage panels, the 120 VAC side ("low" side) is installed with eight (8) secondary circuit breakers, field expandable up to sixteen (16). The 240 VAC side ("high" side) has either one (1) or two (2) secondary circuit breakers.

1.2.5 Line Isolation Monitor (LIM)

Each isolated power panel comes with one or more LIM2010 Line Isolation Monitor (LIM) manufactured by BENDER. The function of the LIM is to monitor the impedance to ground of the entire isolated power system. This value is used to calculate the Total Hazard Current (THC), in units of milliamperes (mA). The standard THC alarm value set at the factory is 5 mA. The value may be switched to 2 mA to meet applicable certification requirements.

For more information on installation, settings, and operation of the LIM, refer to the LIM2010 user manual, document NAE2025011.



1.2.6 Front Trim Package

The front trim for all panels is manufactured from minimum 14 GA, type 304 stainless steel. It contains a door with hidden hinges and a flush mounted key lock. The front trim may be combined with a flush-mounted or surface-mounted backbox. For flush mounted panels, the front trim extends one inch on all sides of the backbox. For surface mounted panels, the front trim has the same height and width dimensions of the backbox.

1.2.7 Accessories Package

For information on installation and setup of optional accessories, refer to the applicable documentation for each accessory.

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2. Safety Instructions



DANGER

Hazard of Electric Shock, Burn, or Explosion

Only qualified maintenance personnel shall operate or service this equipment. These instructions should not be viewed as sufficient for those who are not otherwise qualified to operate or service this equipment. This document is intended to provide accurate information only. No responsibility is assumed by BENDER for any consequences arising from use of this document.

Turn OFF all sources of electric power before performing any inspections, tests, or service on this equipment. Assume all circuits are live until they have been properly de-energized, tested, grounded, and tagged. Failure to observe these precautions will result in equipment damage, severe personal injury, or death.

Proper operation of this equipment depends on proper installation. Refer to NFPA 99, NFPA 70E, CSA Z32, and other relevant standards and codes for installation standards. Neglecting fundamental installation techniques will result in equipment damage, severe personal injury, or death.

Do not make any modifications to the equipment. Failure to observe this precaution will result in equipment damage or personal injury.

Use only manufacturer's and manufacturer recommended accessories with this equipment. Failure to do so may damage the equipment beyond repair.

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3. Receiving, Handling, and Storage

3.1 Receiving

Verify details of purchase order before filing a shortage claim. Upon request, backboxes may arrive first to allow sufficient time for contractors to fit panels to their destination.

Inspection of the equipment should occur upon receipt of order. If damage or mishandling is evident, a damage claim should be filed with the carrier immediately. The manufacturer's local representative and field office should also be notified of damages.

3.2 Handling

Due to the very large weight of isolated power equipment, the use of equipment suitable for lifting and transporting heavy goods is necessary.

DANGER

Use equipment suitable for lifting and transporting heavy loads. Failure to do so will result in equipment damage or severe personal injury.

3.3 Storage

Isolated power equipment must not be stored in dusty or damp locations.

4. Installation

4.1 Support Requirements

Prior to installation of the panel, the weight of the equipment must be considered when selecting the correct structural support. The minimum load bearing requirements are listed below.

Panel Type	Weight (lb)	Weight (kg)
Standard IP panel, up to 10 kVA	300	136
Standard IP panel, 15 to 25 kVA	505	230
IP panel with receptacles	310	141
IP panel with circuit control	505	230
Dual voltage panel	560	255
Dual system panel	675	310

4.2 Preparation and Assembly

DANGER

Isolated power panels contain knockouts for additional circuit breakers. An electrical consultant must be contacted before adding additional circuit breakers. Failure to do so will result in severe personal injury or death.

Follow the general steps listed below to install an isolated power panel:

- Mount the backbox. Refer to Section 4.3 for more information.
- Install the interior package and any optional accessories into the backbox. Refer to Section 4.4 for more information. NOTE: If the panel is fitted for any accessory or accessories, the closure plate on the front trim must be removed in order to complete the installation.
- Install the isolation transformer. Refer to Section 4.5 for more information.
- Install the electrical connections to the loads being served (receptacles, surgical lighting, x-ray film viewers, etc.). See section 4.6 for more information.
- Install deadfront panel and stainless steel trim panel.

4.3 Backbox Mounting

Sections 4.3.1 through 4.3.5 show possible placements for routing conduit and fittings. Locate the drawing applicable to the panel being installed.

No knockouts or holes for conduit are provided in the backbox. Drilling excess holes for non-standard mounting counting entrances is at the responsibility of the installer. Front and rear backbox dimensions are the same.

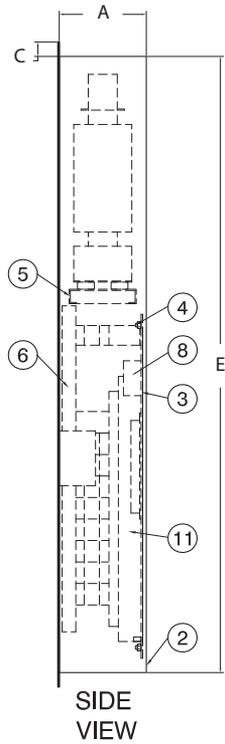
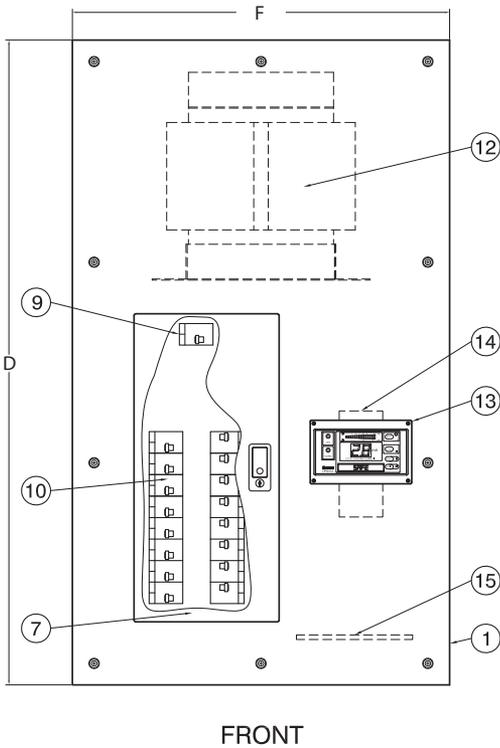
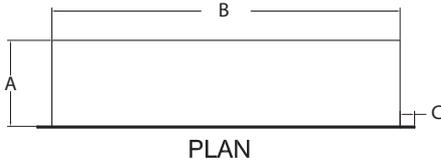
Mounting hole location and size are at the discretion of the installer. Install the backbox even with the finished wall or recess no more than 1/4" (6.35 mm).

The backbox should not protrude pas the finished wall.

Panel Type	Refer To
Standard IP Panel	page 16
IP Panel with Receptacles	page 18
IP Panel with Circuit Control	page 20
Dual System Panel (IX)	page 22
Dual Voltage Panel (ID)	page 24

4.3.1 Backbox Mounting, Standard IP Panel

Legend and dimensions are located on the following page.



Legend:

1	Stainless Steel Front Trim
2	Backbox, Galvanized Steel
3	Backplate
4	Backplate Mounting Studs
5	Transformer Shelf
6	Breaker Deadfront
7	Stainless Steel Door w/ Lock
8	Distribution Block, 2P

9	Circuit Breaker: Main, 2P
10	Circuit Breaker: Branch, 2P
11	Load Center
12	Isolation Transformer, 1Ph.
13	Line Isolation Monitor, 1Ph.
14	LIM Connector Plate
15	Ground Bus

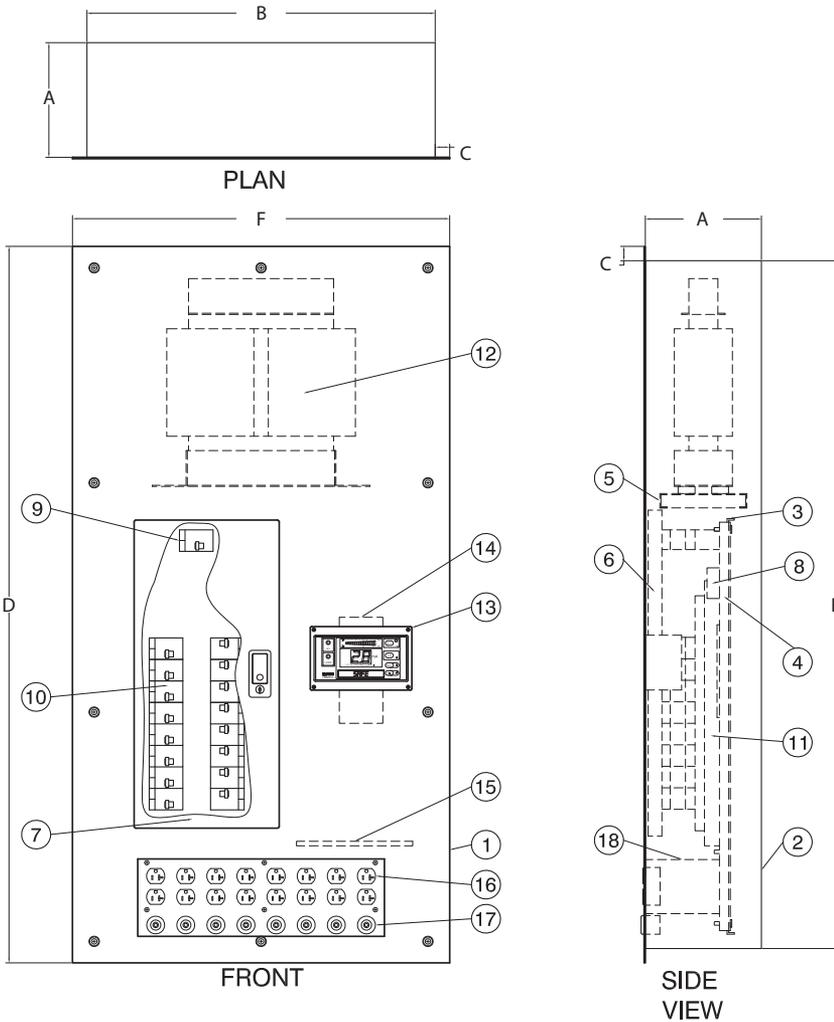
Dimensions:

Dimensions are listed in inches (mm).

	3, 5 kVA	7.5, 10 kVA	15 kVA	25 kVA
A	6" (152)	8" (203)	12" (305)	14" (356)
B	24" (610)	24" (610)	30" (762)	30" (762)
C	Flush: 1" (25) Surface: 0" (0)			
D	Flush: 45" (1143) Surface: 43" (1092)	Flush: 45" (1143) Surface: 43" (1092)	Flush: 53" (1346) Surface: 51" (1295)	Flush: 53" (1346) Surface: 51" (1295)
E	43" (1092)	43" (1092)	51" (1295)	51" (1295)
F	Flush: 26" (660) Surface: 24" (610)	Flush: 26" (660) Surface: 24" (610)	Flush: 32" (813) Surface: 30" (762)	Flush: 32" (813) Surface: 30" (762)

4.3.2 Backbox Mounting, IP Panel with Receptacles

Legend and dimensions are located on the following page.



Legend:

1	Stainless Steel Front Trim
2	Backbox, Galvanized Steel
3	Backplate
4	Backplate Mounting Bracket
5	Transformer Shelf
6	Breaker Deadfront
7	Stainless Steel Door w/ Lock
8	Distribution Block, 2P
9	Circuit Breaker: Main, 2P

10	Circuit Breaker: Branch, 2P
11	Load Center
12	Isolation Transformer, 1Ph.
13	Line Isolation Monitor, 1Ph.
14	LIM Connector Plate
15	Ground Bus
16	Duplex Receptacle, Hosp. Grade
17	Ground Jack, Hosp. Grade
18	Receptacle Hat Station

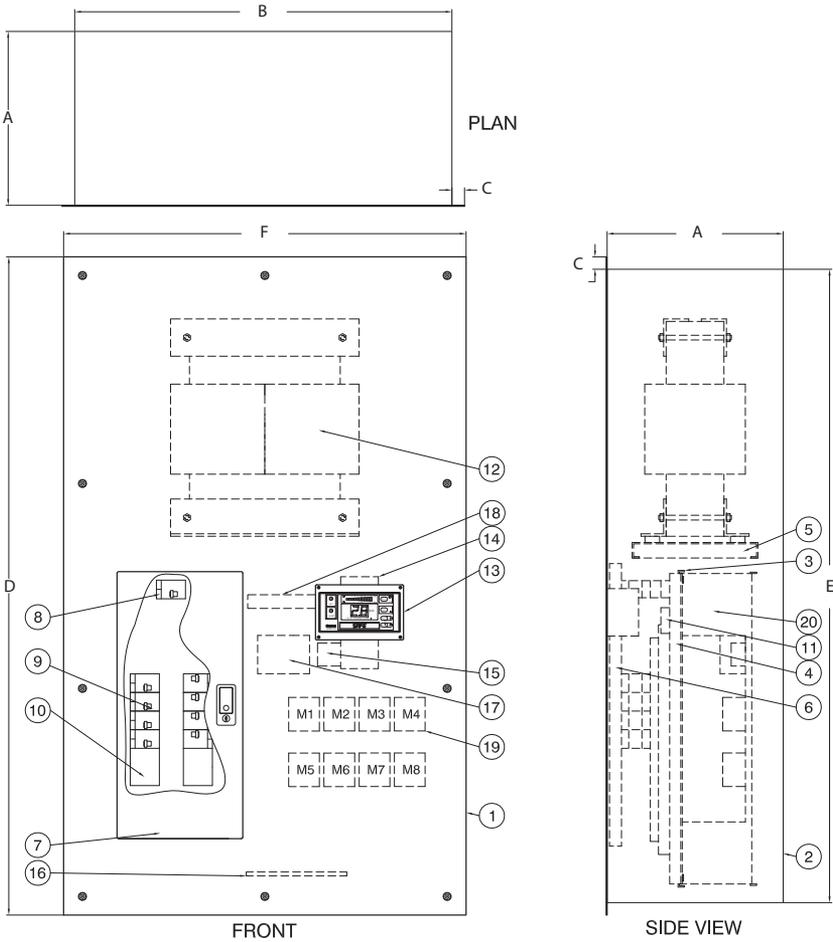
Dimensions:

Dimensions are listed in inches (mm).

	3, 5, 7.5, 10 kVA
A	8" (203)
B	24" (610)
C	Flush: 1" (25) Surface: 0" (0)
D	Flush: 50" (1270) Surface: 48" (1219)
E	48" (1219)
F	Flush: 26" (660) Surface: 24" (610)

4.3.3 Backbox Mounting, IP Panel with Circuit Control

Legend and dimensions are located on the following page.



Legend:

1	Stainless Steel Front Trim
2	Backbox, Galvanized Steel
3	Backplate
4	Backplate Mounting Bracket
5	Transformer Shelf
6	Breaker Deadfront
7	Stainless Steel Door w/ Lock
8	Main Circuit Breaker, 2P
9	Branch Circuit Breakers, @P
10	Provision for Expansion

11	Distribution Block, 2P
12	Isolation Transformer, 1Ph.
13	Line Isolation Monitor, 1Ph.
14	LIM Connector Plate
15	Control Transformer w/ Fuses
16	Ground Bus
17	Programmable Logic Controller
18	Terminal Block
19	Circuit Contactors, 2P (M1-M8)
20	Auxiliary Backplate

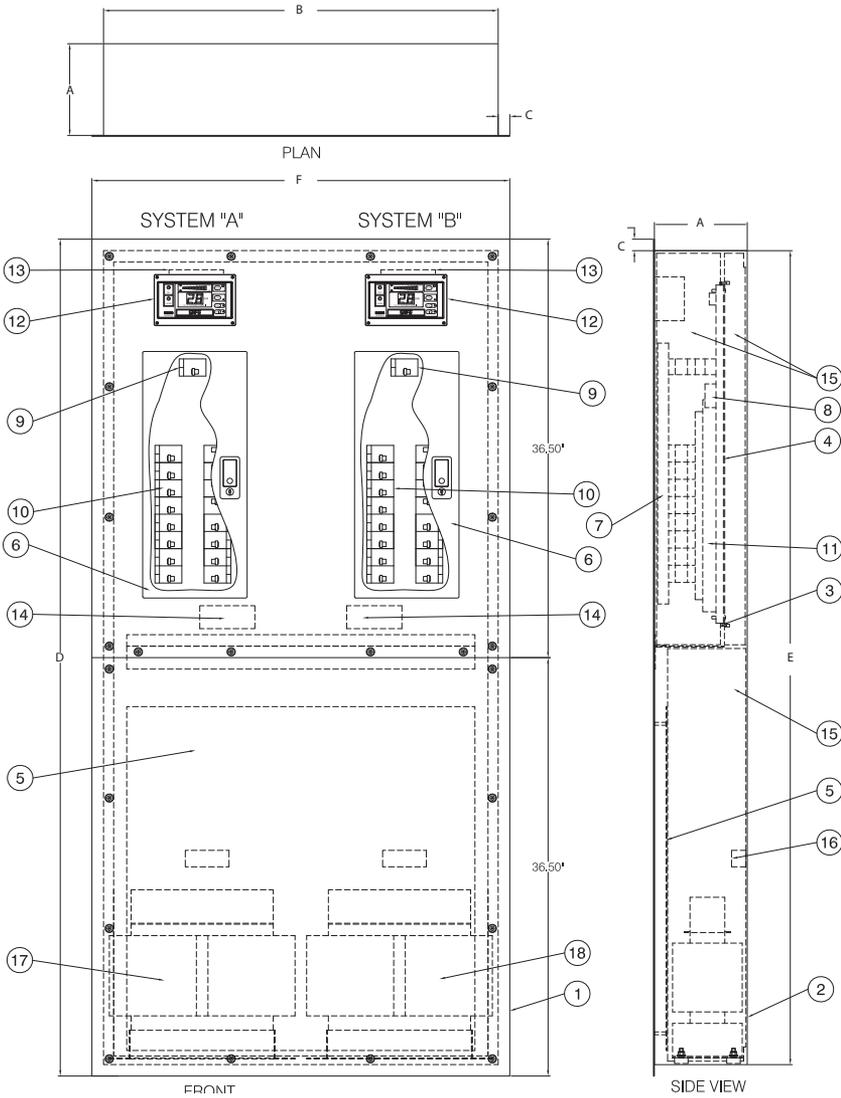
Dimensions:

Dimensions are listed in inches (mm).

	15 kVA	25 kVA
A	12" (305)	14" (356)
B	30" (762)	30" (762)
C	Flush: 1" (25) Surface: 0" (0)	Flush: 1" (25) Surface: 0" (0)
D	Flush: 53" (1346) Surface: 51" (1295)	Flush: 53" (1346) Surface: 51" (1295)
E	51" (1295)	51" (1295)
F	Flush: 32" (813) Surface: 30" (762)	Flush: 32" (813) Surface: 30" (762)

4.3.4 Backbox Mounting, Dual System Panel (IX)

Legend and dimensions are located on the following page.



Legend:

1	Stainless Steel Front Trim (2 pc.)
2	Backbox, Galvanized Steel
3	Backplate, Galvanized Steel
4	Backplate Mounting Bracket
5	Heat Shield
6	Stainless Steel Door w/ Lock
7	Breaker Deadfront
8	Distribution Block
9	Main Circuit Breaker, 2P

10	Branch Circuit Breakers, 2P
11	Load Center
12	Line Isolation Monitor, 1Ph.
13	LIM Connector Plate
14	Ground Bus
15	Barriers Between Systems
16	Terminal Blocks
17	Isolation Transformer, System A
18	Isolation Transformer, System B

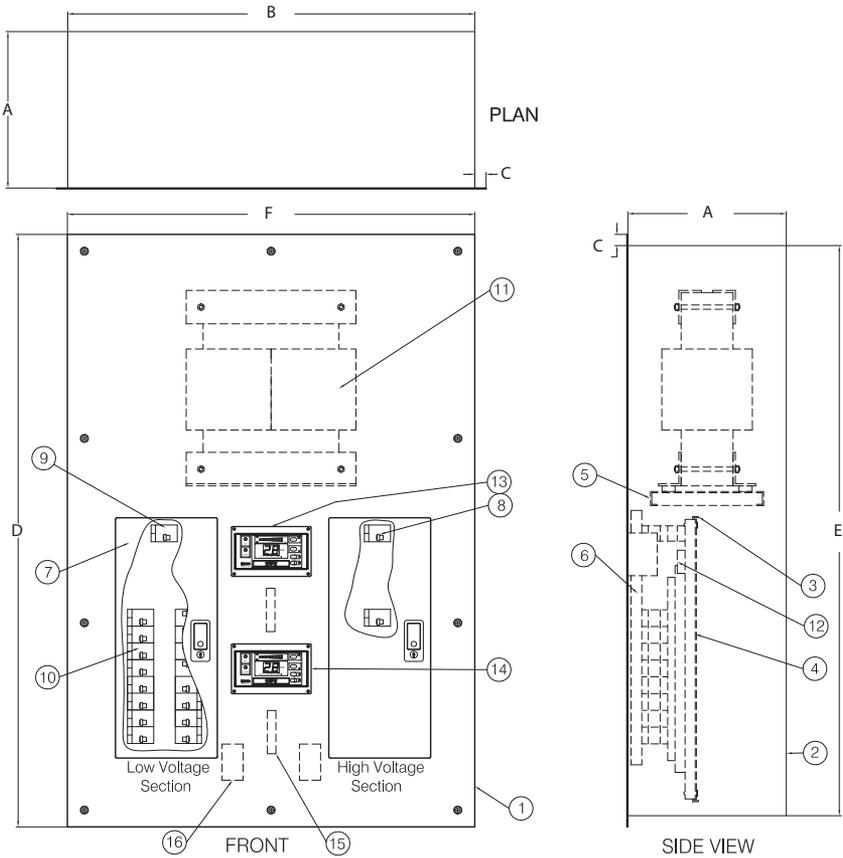
Dimensions:

Dimensions are listed in inches (mm).

	5, 7.5, 10 kVA Per System
A	8" (203)
B	34" (864)
C	Flush: 1" (25) Surface: 0" (0)
D	Flush: 53" (1346) Surface: 51" (1295)
E	51" (1295)
F	Flush: 36" (914) Surface: 34" (864)

4.3.5 Backbox Mounting, Dual Voltage Panel (ID)

Legend and dimensions are located on the following page.



Legend:

1	Stainless Steel Front Trim
2	Backbox, Galvanized Steel
3	Backplate
4	Backplate Mounting Bracket
5	Transformer Shelf
6	Breaker Deadfront
7	Stainless Steel Door w/ Lock
8	Main Primary Breaker, 2P

9	Main Secondary Breaker, 2P
10	Branch Circuit Breakers, 2P
11	Isolation Transformer, Dual Secondary, 1Ph.
12	Distribution Blocks
13	Line Isolation Monitor, 1Ph. Low Voltage Section
14	Line Isolation Monitor, 1Ph. High Voltage Section
15	LIM Connector Plate
16	Ground Bus

Dimensions:

Dimensions are listed in inches (mm).

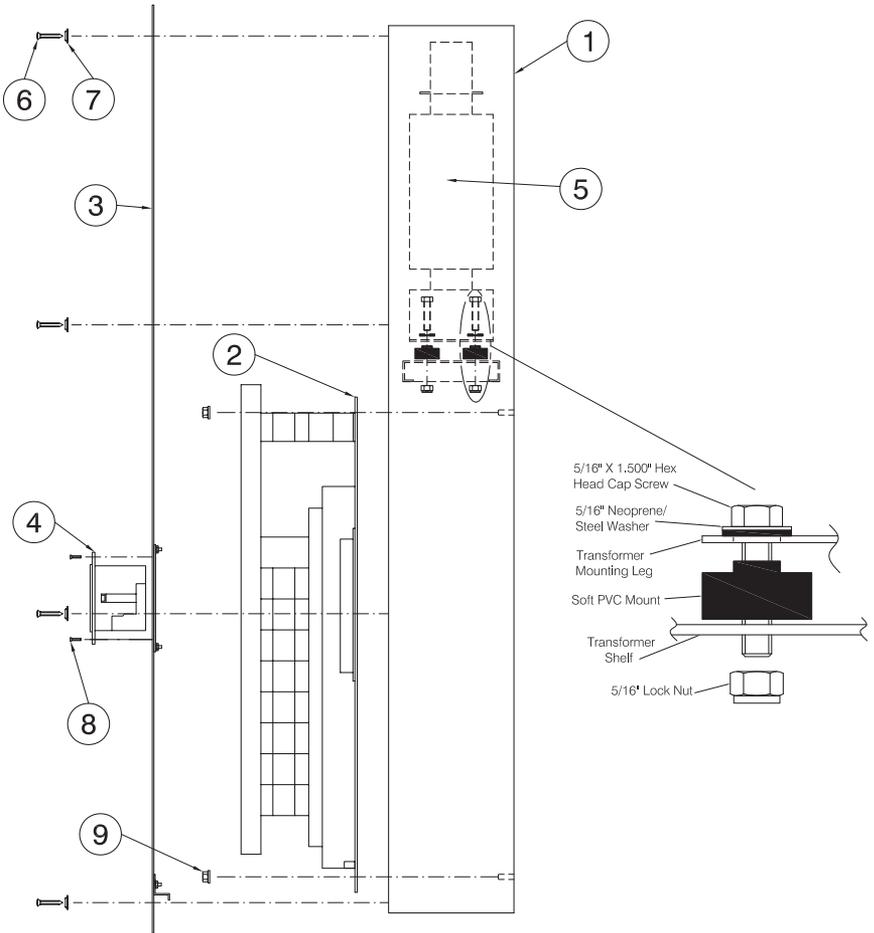
	25 kVA
A	14" (356)
B	34" (864)
C	Flush: 1" (25) Surface: 0" (0)
D	Flush: 53" (1346) Surface: 51" (1295)
E	51" (1295)
F	Flush: 36" (914) Surface: 34" (864)

4.4 Assembly

Sections 4.4.1 through 4.4.6 show assembly diagrams. Locate the drawing applicable to the size and type of panel installed. For further information on transformer installation, refer to section 4.5.

Panel Type	Refer To
Standard IP Panel - 3 kVA and 5 kVA	page 27
Standard IP Panel - 7.5 kVA to 25 kVA	page 28
IP Panel with Receptacles	page 29
IP Panel with Circuit Control	page 30
Dual System Panel (IX)	page 31
Dual Voltage Panel (ID)	page 32

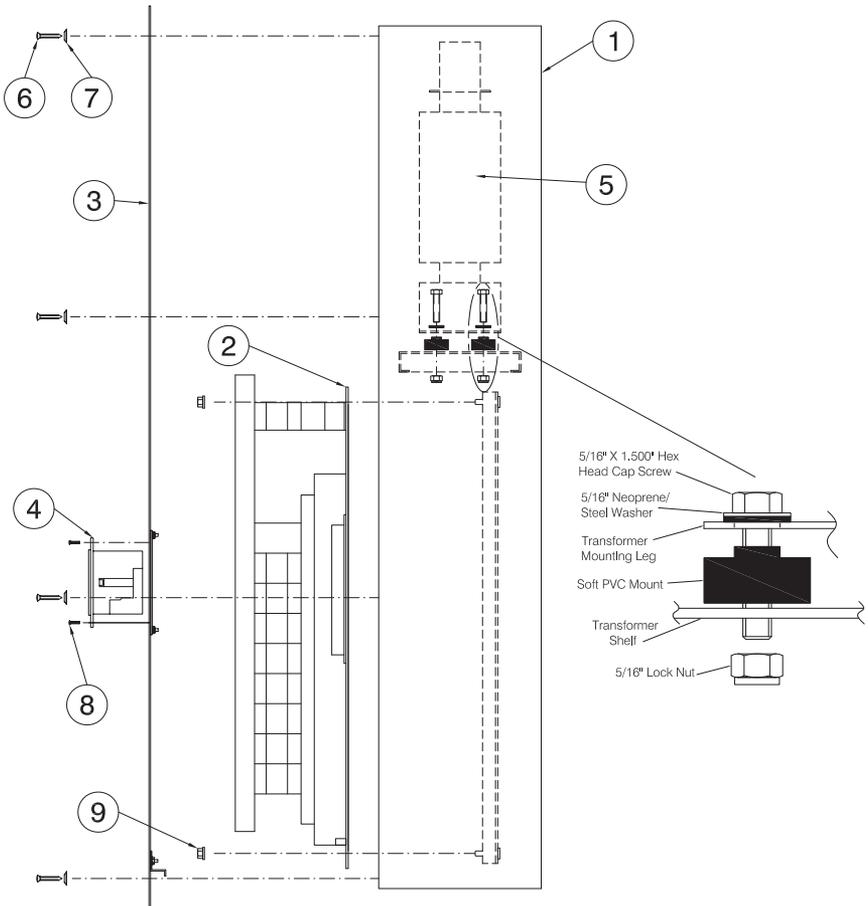
4.4.1 Assembly: Standard IP Panel, 3 kVA, 5 kVA



1	Backbox w/ Wide Panel Clip Nuts
2	Interior Assembly
3	Front Trim Assembly
4	Line Isolation Monitor
5	Isolation Transformer

6	#10 x 1.25" Oval Head Panel Screw
7	#10 Flanged Finishing Washer, SS
8	#4-40 Black Oxide Screws
9	1/4"-20 Hex Lock Nut

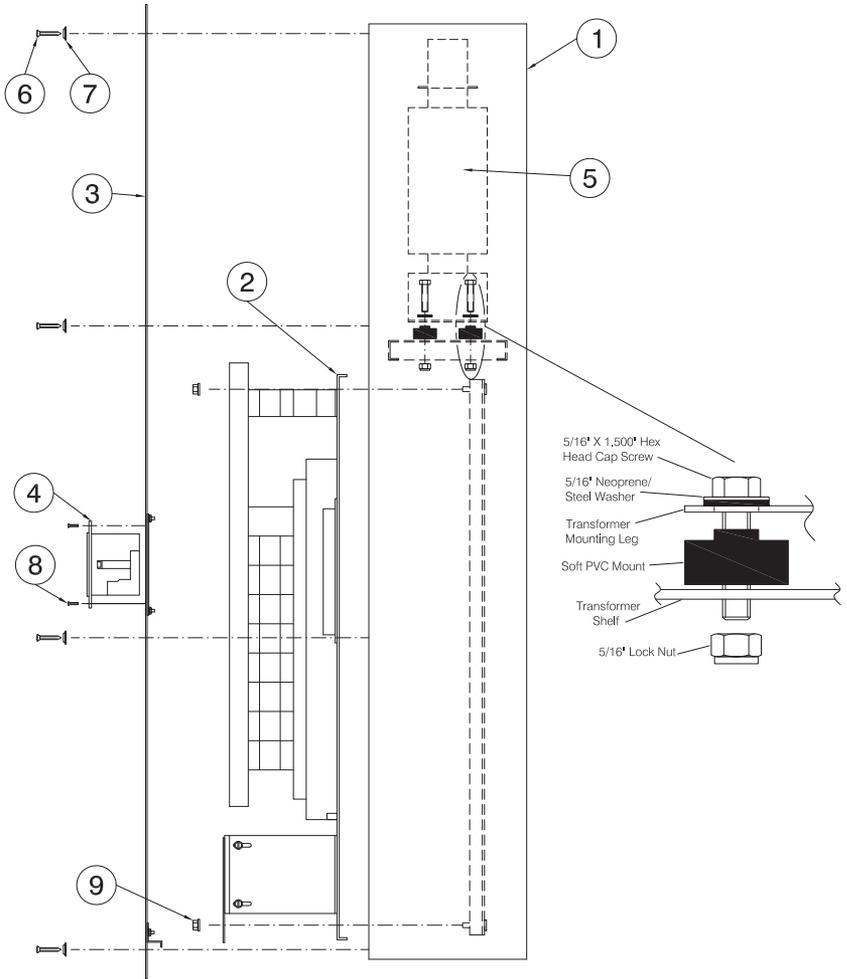
4.4.2 Assembly: Standard IP Panel, 7.5 kVA to 25 kVA



1	Backbox w/ Wide Panel Clip Nuts
2	Interior Assembly
3	Front Trim Assembly
4	Line Isolation Monitor
5	Isolation Transformer

6	#10 x 1.25" Oval Head Panel Screw
7	#10 Flanged Finishing Washer, SS
8	#4-40 Black Oxide Screws
9	1/4"-20 Hex Lock Nut

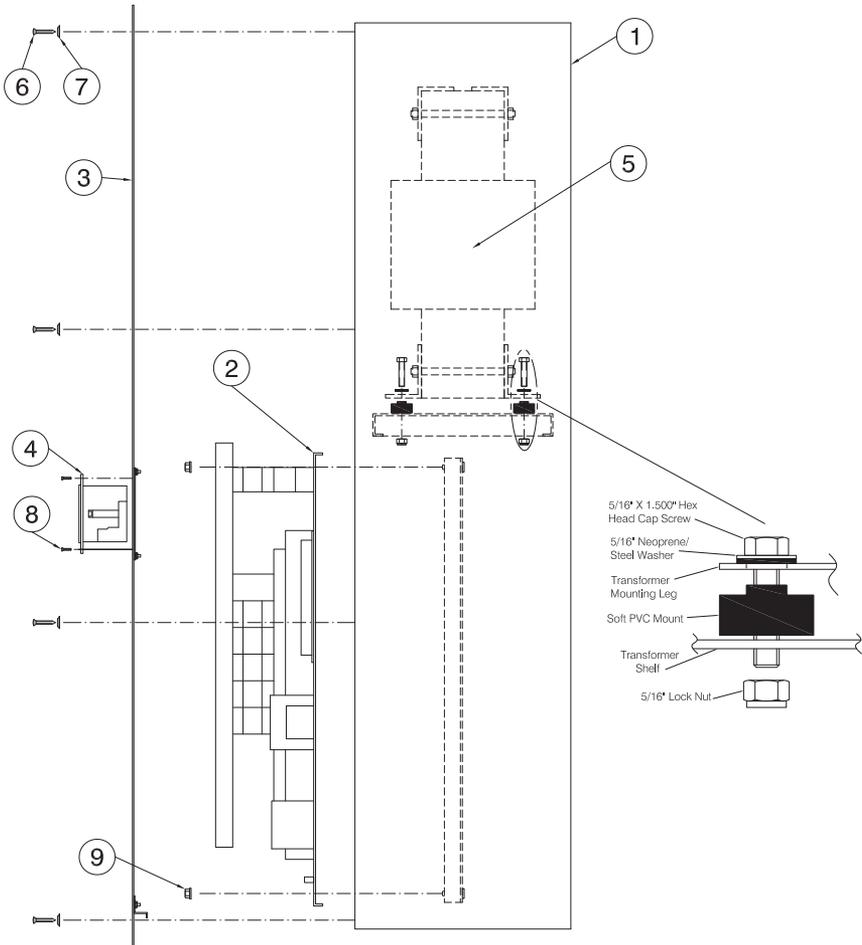
4.4.3 Assembly: IP Panel with Receptacles, 3 kVA to 10 kVA



1	Backbox w/ Wide Panel Clip Nuts
2	Interior Assembly
3	Front Trim Assembly
4	Line Isolation Monitor
5	Isolation Transformer

6	#10 x 1.25" Oval Head Panel Screw
7	#10 Flanged Finishing Washer, SS
8	#4-40 Black Oxide Screws
9	1/4"-20 Hex Lock Nut

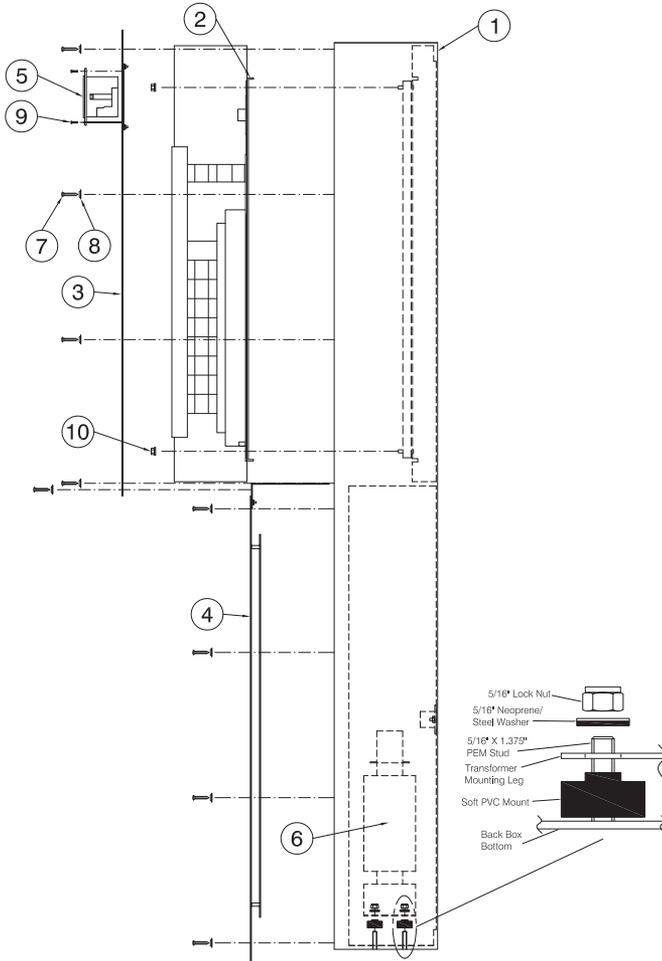
4.4.4 Assembly: IP Panel with Circuit Control, 15 kVA, 25 kVA



1	Backbox w/ Wide Panel Clip Nuts
2	Interior Assembly
3	Front Trim Assembly
4	Line Isolation Monitor
5	Isolation Transformer

6	#10 x 1.25" Oval Head Panel Screw
7	#10 Flanged Finishing Washer, SS
8	#4-40 Black Oxide Screws
9	1/4"-20 Hex Lock Nut

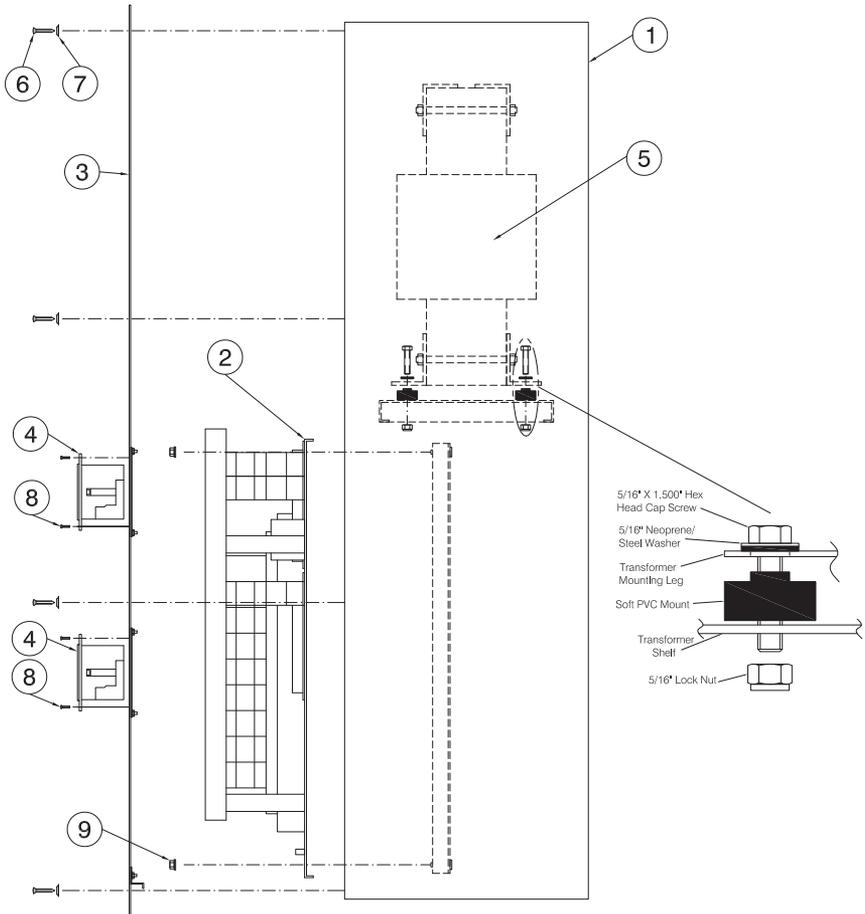
4.4.5 Assembly: Dual System Panel (IX)



1	Backbox w/ Wide Panel Clip Nuts, Barriers, and Terminal Blocks
2	Interior Assembly w/ Barrier
3	Front Trim Assembly, Upper Section
4	Front Trim Assembly, Lower Section
5	Line Isolation Monitor

6	Isolation Transformer
7	#10 x 1.25" Oval Head Panel Screw
8	#10 Flanged Finishing Washer, SS
9	#4-40 Black Oxide Screws
10	1/4"-20 Hex Lock Nut

4.4.6 Assembly: Dual Voltage Panel (ID)



1	Backbox w/ Wide Panel Clip Nuts
2	Interior Assembly
3	Front Trim Assembly
4	Line Isolation Monitor
5	Isolation Transformer

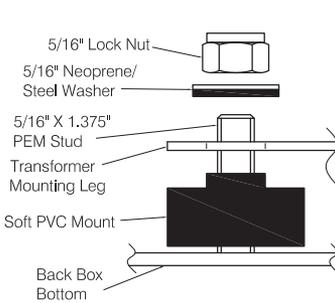
6	#10 x 1.25" Oval Head Panel Screw
7	#10 Flanged Finishing Washer, SS
8	#4-40 Black Oxide Screws
9	1/4"-20 Hex Lock Nut

4.5 Transformer Installation

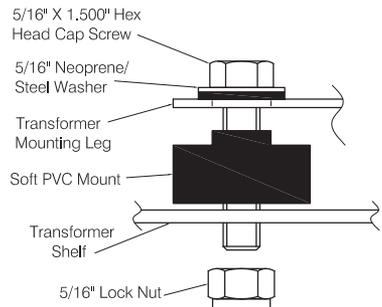
All transformers must be installed into the panel at the end location.

4.5.1 Vibration Pads and Mounting Hardware

Mounting hardware is provided with each transformer. The hardware includes vibration pads. Install hardware in accordance to the appropriate diagram below. Do not compress the vibration pads. If compressed, the pads may not dampen noise.



Dual System Panels



All Other Panels

4.5.2 Transformer Installation

Isolation transformers may weigh up to 500 lb (1100 kg), and require special handling. Depending on the isolated power panel design, the transformer(s) may be installed in either the top half or bottom half of the enclosure. Refer to the appropriate assembly drawing in section 4.4, as well as the approved submittal drawings for the specific locations. If located in the top half of the enclosure, place transformer on transformer shelf provided with the panel. If located in the bottom half of the panel, place the transformer on the provided studs. Orient the transformer(s) in the enclosure to allow the leads to extend from the front to facilitate the process of wiring the primary circuit breaker and load center.

4.5.3 Transformer Electrical Connections

Refer to Section 4.6 for information on making electrical connections to the isolation transformer(s).

4.6 Electrical Connections

Sections 4.4.6 through 4.4.10 show specific connections for isolated power panels. Locate the drawing specific to the type of panel being installed.

DANGER

- This equipment must be installed and serviced only by qualified electrical personnel.
- Turn off all sources of power before servicing.
- Do not use wire pulling lubricant of any type on secondary circuits.
- Conduit must be clean and dry.
- Maintain identical phasing throughout the installation.
- Replace all devices, doors, and covers before powering the equipment.

Failure to do so will result in severe personal injury or death.

Electrical connections required on site are as follows:

- Connection of main power feeders
- Connection of reference ground bus to ground lug on terminal board, if not factory installed
- Connection of remote indicator(s) to the Line Isolation Monitor, if required
- Connection of secondary circuits to the conductors or panel board circuit breakers on the sub-panel. The contactors are marked and have lugs to ease connecting. The specifier or consulting engineer chooses the proper wire size.

The color coding of the secondary circuit conductors, in accordance with NFPA 70, Article 517, are as follows:

- Isolated conductor no. 1: Orange with at least one distinctive colored stripe OTHER THAN white, green, or gray along the entire length of the conductor
- Isolated conductor no. 2: Brown with at least one distinctive colored stripe OTHER THAN white, green, or gray along the entire length of the conductor
- Equipment grounding conductor: Green with or without yellow stripe

4.6.1 Wire Quality Requirements

BENDER recommends using cross-linked, polyethylene wire with a dielectric constant of 3.5 or less. The most widely available wire for this application is low-leakage wire type XHHW or XHHW-2.

Avoid wire with high carbon fiber filler, as this produces substantial leakage in an isolated power system. Ensure the wire is the appropriate size for the transformer and meets national and local code requirements.

4.6.2 Grounding

DANGER

Before proceeding, read this section, all wiring diagrams, and all applicable code requirements to thoroughly understand the special requirements for grounding this type of system. Failure to do so will result in severe injury or death.

Isolated power systems for healthcare facilities are not grounded in the same manner as many other types of electrical equipment. They have special grounding requirements to reduce electrical hazards to patients and staff. The reference grounding point is NOT the earth ground or neutral conductor. The ground bus in the isolation panel is the reference grounding point for the room, as defined by NFPA 70, Article 517.

Use only one conductor to connect the reference ground bus in the isolated power panel to the ground bar of the facility's main grounding system. The main grounding system is the distribution panel that feeds power to the isolated power panel. Connect all green ground conductors from the equipment in the patient care area served by the isolated power panel to the ground bus of that panel.

If more than one isolated power panel serves the same area, refer to NFPA 70, Article 517.14 for grounding requirements.

To ground transformers, connect a green ground conductor from the lug on the electrostatic shield of the transformer to the reference ground bus of the isolated power panel.

4.6.3 Additional Wiring Requirements: Fault Location

If ground fault location has been preinstalled in the interior, terminal blocks for landing the secondary circuits are provided. For panels without installed ground fault location, secondary circuits are landed on the contactors or panel board circuit breakers as noted in Section 4.4.

The required RS-485 connections for ground fault location for a single panel are pre-wired to the LIM2010 connector plate at the factory.

4.6.4 Additional Wiring Requirements: Remote Indicators

This section applies to MK2000 series remote indicators. Refer to the installation bulletin for the appropriate remote indicator for additional wiring requirements for installing the remote indicator.

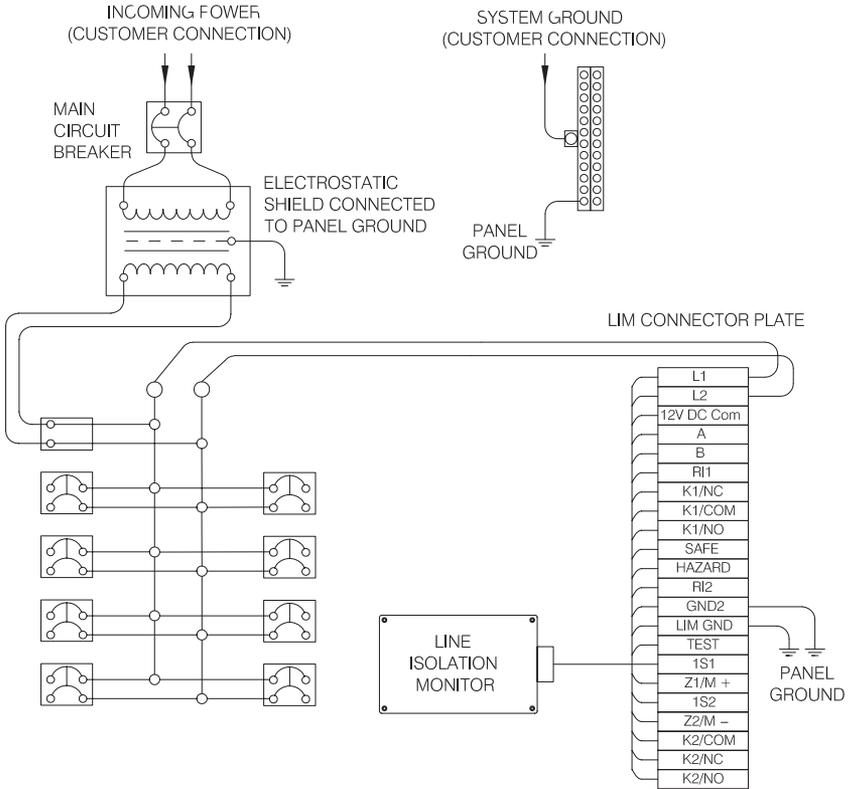
4.6.5 Additional Wiring Requirements: Communication

Additional RS-485 wiring may be required when one or more panels are connected to each other for one of the following reasons:

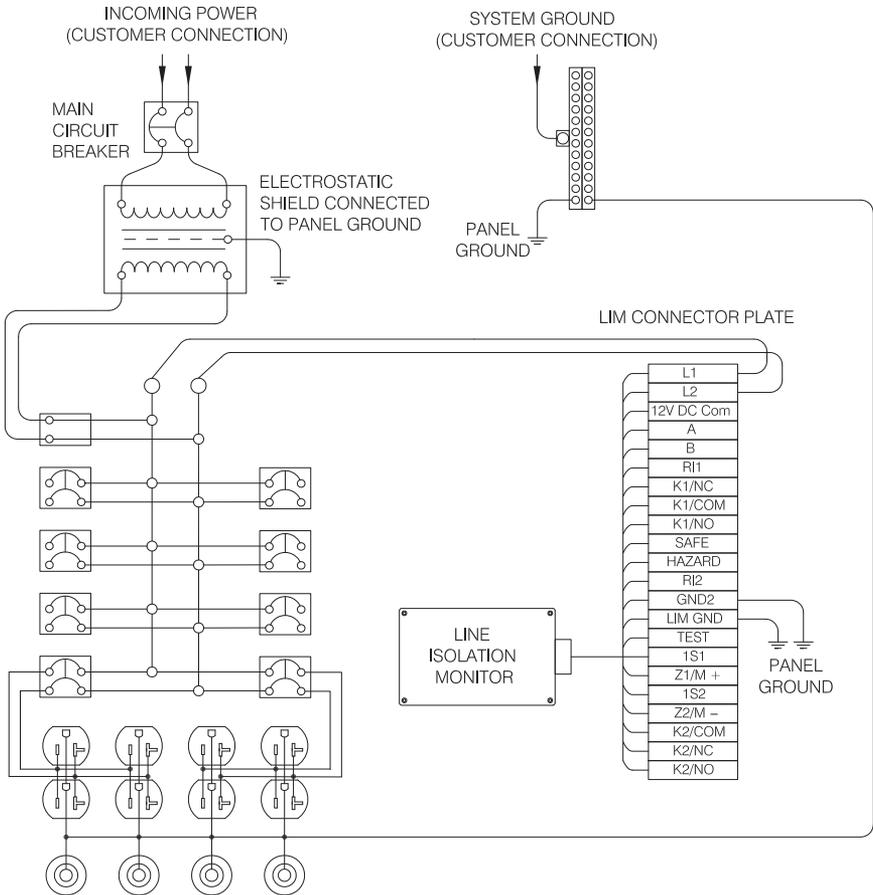
- Connecting to MK2430 / MK800 remote indicating station
- Connecting to COM460IP communication module for Ethernet or Modbus/TCP communication
- Connecting to FTC470XMB communication module for Modbus/RTU communication

RS-485 connections will be required at the LIM2010 connector plate located in the interior. For more information on setting up RS-485 communication for medical panels, refer to LIM2010 user manual, as well as the user manual for the respective communication device.

4.6.6 Wiring: Standard IP Panel

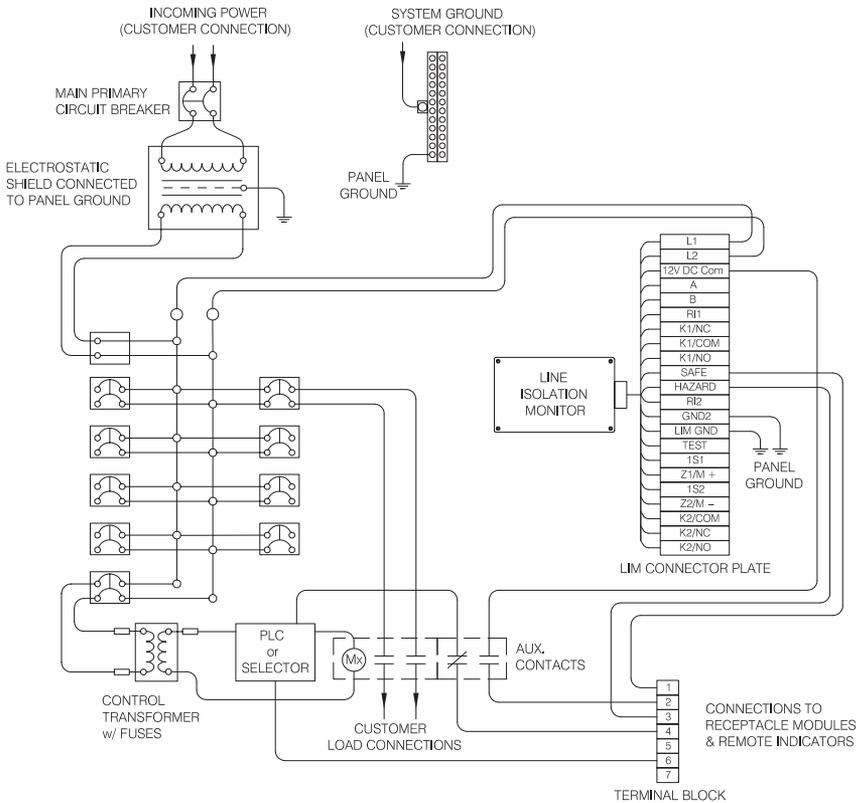


4.6.7 Wiring: IP Panel with Receptacles



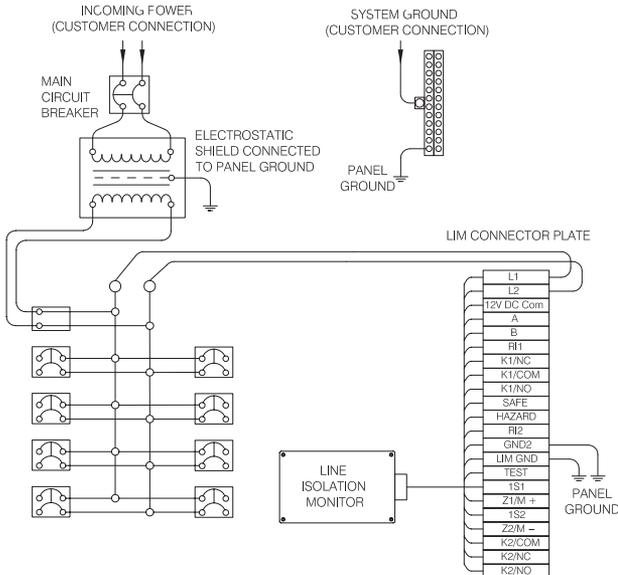
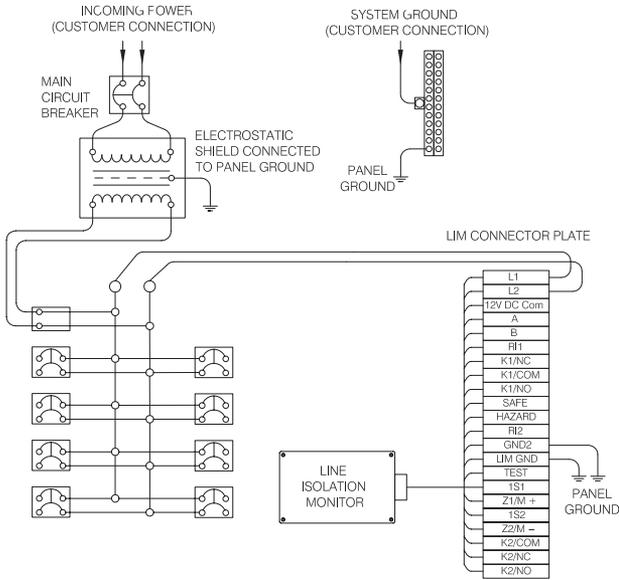
NOTE: Typical schematic. Quantity of receptacles and ground jacks may vary by application.

4.6.8 Wiring: IP Panel with Circuit Control

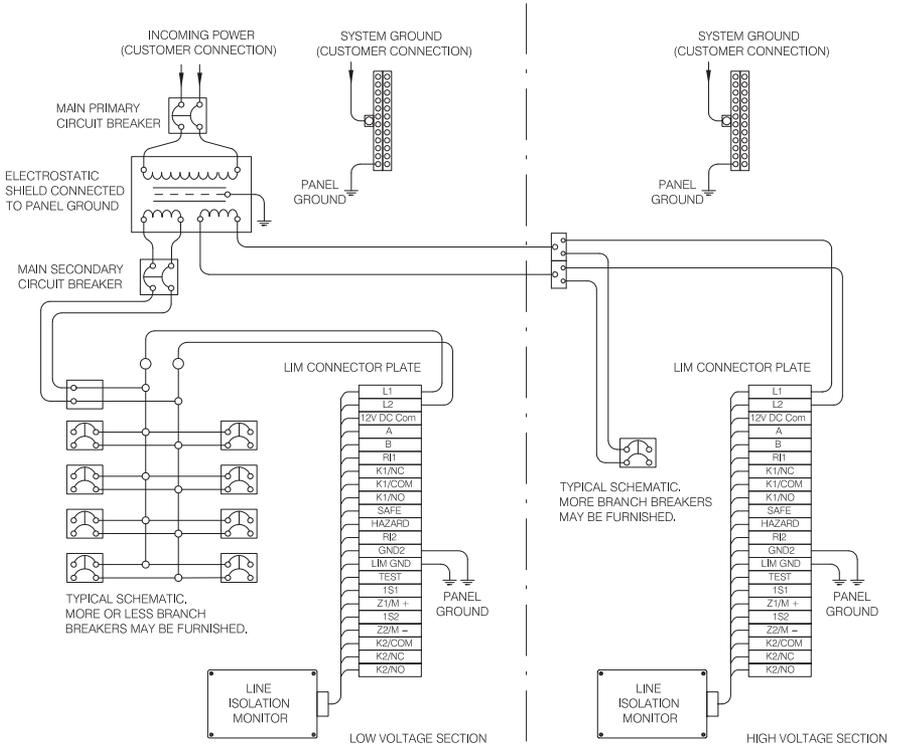


NOTE: Typical schematic. Quantity of circuits controlled by PLC may vary by application. Connections may vary when controlled by selector.

4.6.9 Wiring, Dual System Panel (IX)



4.6.10 Wiring: Dual Voltage Panel (ID)



4.7 Final Inspection and Testing / Maintenance

NFPA 99 requires testing of isolated power systems prior to placing them into service and at regular intervals thereafter. Warranty shall not be issued on isolated power panels unless final inspection and testing has been conducted by an authorized manufacturer representative.

BENDER recommends testing isolated power systems not less than once every twelve months. The testing is intended to maintain the minimum levels as described in NFPA 99. Testing should be both resistive and capacitive to verify proper functionality of the Line Isolation Monitor.

BENDER further recommends pressing the TEST button not less than once a month to verify proper operation of the Line Isolation Monitor.

Consult your local representative or the manufacturer for more information.

5. Operation and Settings

5.1 Line Isolation Monitor

Refer to LIM2010 user manual, document, NAE2025011, for additional information on installing, setting, and operating the Line Isolation Monitor.

5.2 Operation of IP Panel with Circuit Control

IP panels with circuit control are designed to provide power to portable equipment outlets, such as surgical lasers. Multiple branch circuits may be controlled from this type of panel. The configuration of which circuits receive power is configured at the factory. No power will be delivered to a secondary circuit until the secondary breaker is closed.

A BENDER XRM series receptacle module is shown below, with door contact-enabled circuit control.



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