

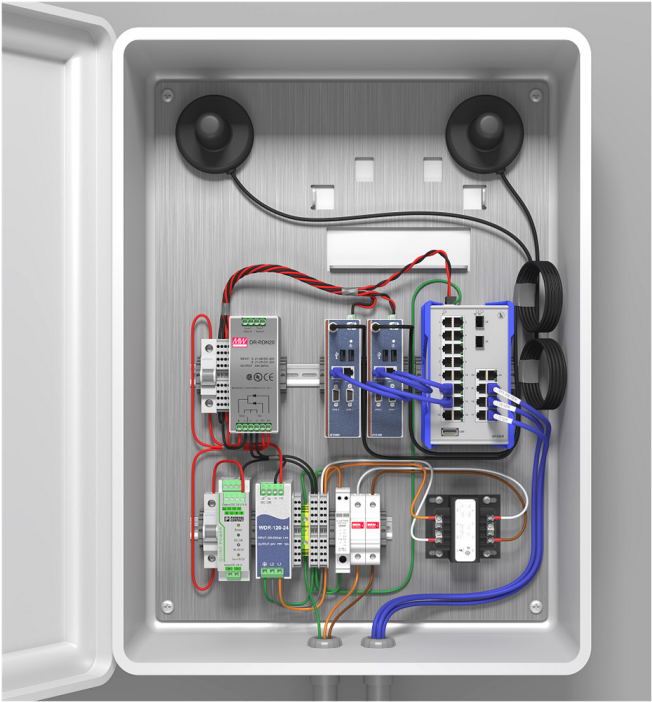
STANDARD TESLA SYSTEM CONTROLLER ENCLOSURE

The **Standard Tesla System Controller Enclosure** hosts the **Standard Tesla System Controller**, the site-level interface that controls non-residential Tesla battery energy storage systems and commercial solar projects. The Standard Tesla System Controller interacts with each inverter block in a site, collects feedback data, and runs algorithms to optimize system operations. In addition, the Standard Tesla System Controller Enclosure is designed with built-in redundancy at the Standard Tesla System Controller level.

The Standard Tesla System Controller:

- Communicates with overall systems through each inverter or other access point to control the entire energy site
- Hosts the control algorithm that dictates advanced charge and discharge functions
- Is the single point of interaction with external parties
- Supports a number of site configurations, including grid-tied and microgrid

Tesla offers a 10-year warranty at no additional cost. Extensions are also available under certain conditions.



Fully Loaded Standard Tesla System Controller Enclosure

ELECTRICAL

Nominal Input Voltage Range	120–480 VAC
Nominal Frequency	50 or 60 Hz
Operating Power Consumption	100 W maximum
Overvoltage Protection	Category III

COMMUNICATIONS

Protocol	Modbus TCP DNP3 Rest API
Connectivity	Ethernet Cellular

MECHANICAL AND MOUNTING

Enclosure	IP67 / NEMA 4
Dimensions	Width: 560 mm (22 in) Depth: 255 mm (10 in) Height: 724 mm (29.2 in)
Weight	22.4 kg (49.4 lbs)
Operating Ambient Temperature	–30°C to 50°C (–22°F to 122°F)
Maximum Altitude	3000 m (9842 ft)
Relative Humidity	100% condensing, wet location rated

REGULATORY

Safety Certifications	UL 61010-1 CSA-22.2 IEC-61010-1
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VinylWood®

(3 1/2" x 5" mesh — near total privacy)
Patent Pending



VinylWood® is a durable chain link fence with wood-grained slats inserted into the chain link at our factory that look just like real wood. It is an excellent choice in fencing when you want the look and feel of wood, but not the headaches of natural wood upkeep.

It offers the lasting qualities of chain link, double-wall slats made from tough HDPE and "factory inserted" into the chain link for easy installation. There is no staining or painting required.

VinylWood® Benefits:

- Requires no painting or staining
- Little or no maintenance
- Available in 3 to 12 foot heights
- Slats manufactured from high-quality HDPE and "factory inserted" into the mesh
- Materials are much stronger and more durable than wood
- 15 year pro-rata limited warranty

Heavy-duty HDPE Slats

VinylWood® features strong and durable double wall slats "factory inserted" into the wire mesh. We've closely matched the color of the fused and bonded vinyl coating with the color of the wood grained slats to provide a beautiful finished appearance.

Vinyl Coated Chain Link Fencing

The vinyl coating on VinylWood®'s chain link mesh is created by the thermally fused and bonded method with a 9 gauge finish, 10 gauge core wire.

Galvanized Chain Link Fencing

We fabricate our chain link mesh using only the highest grade 9 or 10 gauge galvanized wire. Our state-of-the-art manufacturing process ensures a consistent weave and product quality.

ASTM Designations

Meets ASTM Designations (see chart on the next page)



YOUR TOTAL FENCING SOURCE

Technical Data

VinylWood® Specifications

Wind load and privacy factor - approximately (Based on wire/mesh used-stretch tension)	98%
3 1/2" x 5" Mesh	✓
Manufactured up to 12' high	✓
Available in 9 gauge galvanized before weaving (GBW) per ASTM A392 and A817, Type II, class IV wire (1.20 oz.)	✓
Available in 10 gauge galvanized before weaving (GBW) per ASTM A392 and A817, Type II, class IV wire (1.20 oz.)	✓
Available in 9 gauge galvanized before weaving (GBW) per ASTM A392 and A817, Type II, class V wire (2.0 oz.)	✓
Available in 9 gauge finish 10 gauge core fused & bonded vinyl coated wire per ASTM F668, class 2B	✓
Available in 9 gauge aluminized before weaving wire per ASTM A491, Type 1	✓
Self-locking double wall slats (with or without staples)	✓
Slats meet ASTM F3000 and F3000M designations	✓
Available in a 25' roll 5' minimum increments thereafter	✓
Fifteen year pro-rata limited warranty	✓

Standard Wire Colors

Galvanized or wood grain

Standard Slat Color

Wood grain

*Please refer to actual color samples for accurate color. **Samples available upon request.***



Every VinylWood® slat is carefully crafted to replicate as closely as possible the actual grain and color of wood. A close-up view clearly shows the rich, wood grained texture.

HDPE Technical Properties

Property Values

Melt Index	(.35) Optimum extrusion processing conditions for Fence Slats
Density	(.945) Polyethylene ranges anywhere from .914 to .960 in density
Minimum Temp.	(-70° F) Under no stress, HDPE remains flexible at this temperature
Maximum Temp.	(180° F) Under no stress, HDPE will not distort at this temperature
Strength	(4,000 psi) HDPE will not distort at lesser loads or impacts



MADE IN USA



YOUR TOTAL FENCING SOURCE

COMMERCIAL, INDUSTRIAL & RESIDENTIAL FENCE PRODUCTS
AND ACCESSORIES FOR THE FENCE PROFESSIONAL!

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Medium-voltage power distribution and control systems >

High resistance grounding— medium voltage

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More about this product
Eaton.com/mvhrhg



Complete library of design guides
Eaton.com/designguides

General Description

Medium-Voltage High Resistance Grounding System



C-HRG Free-Standing NEMA® 1 Unit

Where continuity of service is a high priority, high resistance grounding can add the safety of a grounded system while minimizing the risk of service interruptions due to grounds. The concept is a simple one: provide a path for ground current via a grounding transformer (with adjustable resistance across its secondary) that limits the current magnitude and a monitor to determine when an abnormal condition exists.

The ground current path is provided at the point where the service begins, by placing a predominantly resistive impedance in the connection from system neutral to ground. Control equipment continuously measures ground current; a relay detects when the current exceeds a predetermined level. An alarm alerts building personnel that a ground exists. The system has built-in fault tracing means to assist in finding the source of the ground. A 120 Vac supply (remote) is required for control power for the system.

The C-HRG is used to protect an electrical distribution system from damaging transient overvoltages caused by ground faults. It also provides a means to locate the ground fault, therefore extending the life of the distribution system.

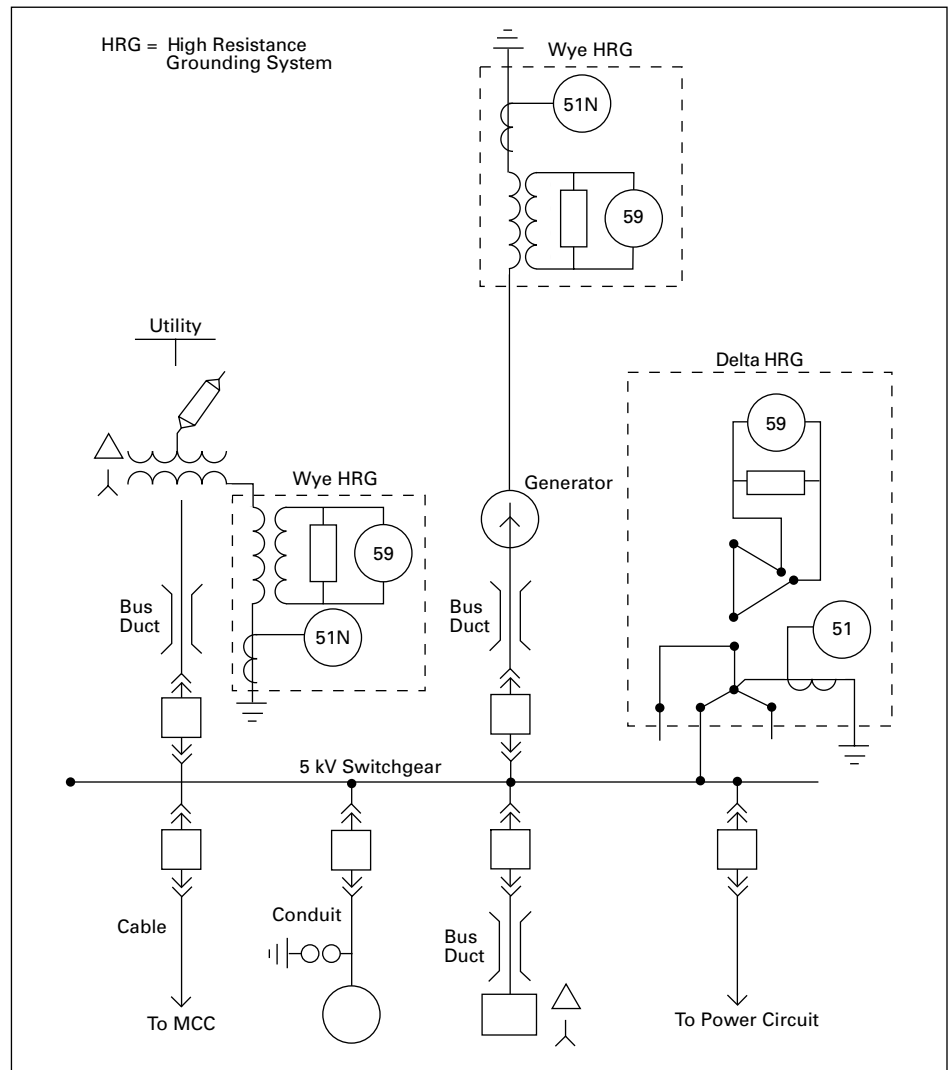


Figure 36.1-1. HRG—High Resistance Grounding System

Ratings and Configurations

The C-HRG MV is offered at the 5 kV class rating. It can be applied to delta or wye ungrounded three-wire distribution systems. Standard dimensions are 36.00-inch (914.4 mm) W x 40.00-inch (1016.0 mm) D x 92.00-inch (2336.8 mm) H.

Application Issues

4200 V (Maximum) Delta Systems

To add high resistance grounding to an ungrounded delta-connected system, a neutral point must be created. Three single-phase transformers can be interconnected in a wye-broken delta configuration to provide such a neutral point. The transformers and grounding resistors are chosen to limit the ground current to a maximum value of 6 A.

Note: The neutral point may not be used to serve phase-to-neutral loads. Also, this technique may be applied on wye-connected sources when the neutral point is not conveniently accessible from the service entrance location. One delta high resistance grounding would ground the 5 kV system.

4200 V (Maximum) Wye Systems

To add high resistance grounding to a wye-connected system, resistors are placed across the secondary of a grounding transformer whose primary is placed in series with the neutral-to-ground connection of the power source. The resistors are chosen to limit the current to a maximum value of 6 A.

Note: Per 1999 NEC® 250.36(4), line-to-neutral loads may not be connected to a system that the neutral is resistance-grounded. Also, if the system has two switchable sources not permanently connected to the bus, two wye-type grounding systems are required as shown in **Figure 36.1-1**.

Ground Current Detection

Any time a system is energized, a small ground current called the “capacitive charging current” will be observed. For medium voltage (4200 V and below) systems, this naturally occurring current is typically 3 A or less.

When one phase becomes grounded, additional current above the charging level will flow. As all ground current must flow through the grounding resistor/grounding transformer assembly, an ammeter in this circuit will read the total amount of ground current. By placing a current-sensing relay in series with the ammeter, the current relay can be adjusted to pick-up at a level in excess of the capacitive charging current, thus indicating the abnormal condition.

Alternatively, an optional voltmeter-relay can be connected across the grounding resistors. The voltage across the resistors is proportional to the amount of ground current. The voltmeter-relay’s pickup adjustment is set above the capacitive charging current, to the desired detection level.

In both current and voltage detection methods, the ground current ammeter provides a direct reading of the total actual ground current present in the system at that time. It will be helpful to periodically note the ammeter’s reading: a trend toward higher values may indicate the need for equipment maintenance, and hence reduce the occurrence of unplanned shutdowns.

Indication and Alarm Circuits

When a fault is detected, an adjustable time delay is provided to override transients. When the time delay has been exceeded, the green “normal” light will turn off, the red “ground fault” light will turn on, and the ground alarm contacts will transfer. If equipped with the optional alarm horn, it will sound.

The grounding transformer secondary breaker must be closed for the system to be operational. Should this breaker be opened at any time, the system will signal a ground fault condition as a fail-safe feature. The breaker must be closed to clear the alarm signal.

When the fault is cleared, the current/voltage relay will reset. If the reset control is set on “auto,” the lights will return to “normal” on, “ground fault” off, and the ground alarm contacts will re-transfer. If the reset control is set on “manual,” the lights and relay contacts will remain latched until the operator turns the reset control to “reset.” The lights and ground alarm contacts will then return to normal. The system can be reset only if the fault has been cleared.

During a fault, the optional alarm horn can be silenced at any time by using the “alarm silence” pushbutton. It will not re-sound until either the system is reset, or the re-alarm timer expires. The re-alarm timer is activated by the “alarm silence” control. If the horn has been silenced but the fault has not been cleared, the timer will run. It has a range of 2–48 hours. When the timer times out, the horn will re-sound, alerting maintenance personnel that the fault has not been cleared.

Test Circuit

A test circuit is provided to allow the user to quickly determine that the system is working properly. The test circuit will operate only under normal conditions—it will not allow testing if the system is sensing a fault. The test operation does not simulate an actual system ground fault. It does, however, test the complete controls of the fault indication and pulsing circuitry. The system then reacts as it would under actual system ground conditions—lights transfer, alarm contacts transfer and the (optional) horn sounds.

Pulser Circuit

The pulser circuit offers a convenient means to locate the faulted feeder and trace the fault to its origin. The pulser is available any time a fault has been detected. The pulse intervals are controlled by an adjustable recycle timer. The “pulse” light flashes on and off, corresponding to the on-off cycles of the pulser contactor. The pulser contactor switches a bank of resistors on and off, thus allowing a momentary increase in the ground current (approximately a 4 A current pulse above the ground current).

Locating a Ground Fault

The current pulses can be noted with a clamp-on ammeter when the ammeter is placed around the cables or conduit feeding the fault. The operator tests each conduit or set of cables until the pulsing current is noted. By moving the ammeter along the conduit, or checking the conduit periodically along its length, the fault can be traced to its origin. The fault may be located at the point where the pulsing current drops off or stops.

If little or no change in the pulsing current is noted along the entire length of a conduit, then the fault may be in the connected load. If the load is a medium voltage distribution equipment or motor control center, repeat the process of checking all outgoing cable groups and conduits to find the faulted feeder. If the fault is not found in an outgoing feeder, the fault may be internal to that equipment.

Note: It may not be possible to precisely locate faults within a conduit. The ground current may divide into many components, depending on the number of cables per phase, number of conduits per feeder, and the number and resistance of each ground point along the conduits. The resulting currents may be too small to allow detection or may take a path that the am-meter cannot trace. An important note to keep in mind is that while the pulser can greatly aid in locating a fault, there may be certain conditions under which the pulses cannot be readily traced, and other test procedures (megohm, high-potential, etc.) may be needed.

Sequence of Operations

Normal

- Green “normal” light on
- Red “ground fault” light off
- White “pulse” light off
- System control switch in “normal” position
- Reset control switch in either “auto” or “manual”

Test

Turn and hold the system control switch in the “test” position. This mode will test the control circuitry only. It will bypass the sensing circuit and cause the green “normal” light to turn off and the red “ground fault” light to turn on. The pulser will be activated as well. The white “pulse” light will turn on and off as the pulser contactor closes and opens. However, the ground current ammeter will not display the total ground current, including the incremental pulse current. When ready, return the system control switch to “normal.”

The pulser will stop. If the reset control is in the “manual” position, turn it to “reset” to reset the fault sensing circuit. The red “ground fault” light will turn off, and the green “normal” light will turn on. Test mode is not available if the system is detecting a ground. The sensing circuit will disable the test circuit.

Ground Fault

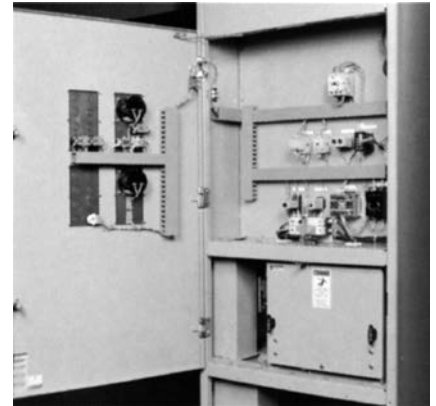
When the sensing circuit detects a fault, the green “normal” light will turn off and the red “ground fault” light will turn on. The ground current ammeter will indicate the total ground current. To use the pulser, turn the system control switch to “pulse.” The pulser contactor will cycle on and off as controlled by the recycle timer relay. Use the clamp-on ammeter to locate the faulted feeder. Open the feeder and clear the fault. If the reset control switch is in the “manual” position, turn it to “reset” to reset the sensing circuit. (If reset control is in “auto,” it will reset itself.) When ready to restore service to the load, close the feeder. Return the system control to “normal.”

Application

When a ground fault occurs on an ungrounded system, high transient voltages can occur, which may cause more frequent equipment failures than if the equipment were grounded. These transient overvoltages, as high as four times the normal voltage, reduce the life of the system’s insulation resulting in:

- Motor failure
- Transformer failure
- Coil failure
- Electronic equipment failure
- Cable insulation failure

By using a high resistance grounding system, many facilities can gain the benefit of a grounded system without impairing the continuity of service to their equipment. The concept behind high resistance grounding is to provide a path for the ground current to flow while limiting its magnitude by using a resistor. The ground current path is provided at the point where service begins. Control equipment continuously monitors the magnitude of the ground current. When the ground current exceeds a predetermined level, the built-in alarm relay alerts building personnel that a ground fault exists. In addition, the C-HRG MV “Safe Ground” system has a built-in fault pulsing as a means to assist in finding the source of the ground fault without interrupting service.



C-HRG Unit Shown with the Door Open

Product Features

- Tapped resistors (limits primary current to 3–6 A)
- Current sensing ground fault detection (2–10 A pickup/0.5–20 second delay)
- Ground current transformer (10/10 ratio)
- Control circuit pull fuseblock
- Ground current ammeter (0–10 A, 1% accuracy)
- Indicating lights:
 - Red (ground fault)
 - Green (normal)
 - White (pulse)
- Adjustable pulsing timer (0–10 seconds)
- 3-position selector switch (normal, pulse, test)
- Control switch for manual or automatic reset
- Ground fault contacts (1NO/1NC)
- Shorting terminal block for ground current CT
- UL® label
- Wiremarkers

The system is completely assembled, wired and tested at the factory in accordance with NEMA and UL requirements. A certified production test report is shipped with the unit.

Ratings

Table 36.1-1. CH MV HRG Systems Application Table

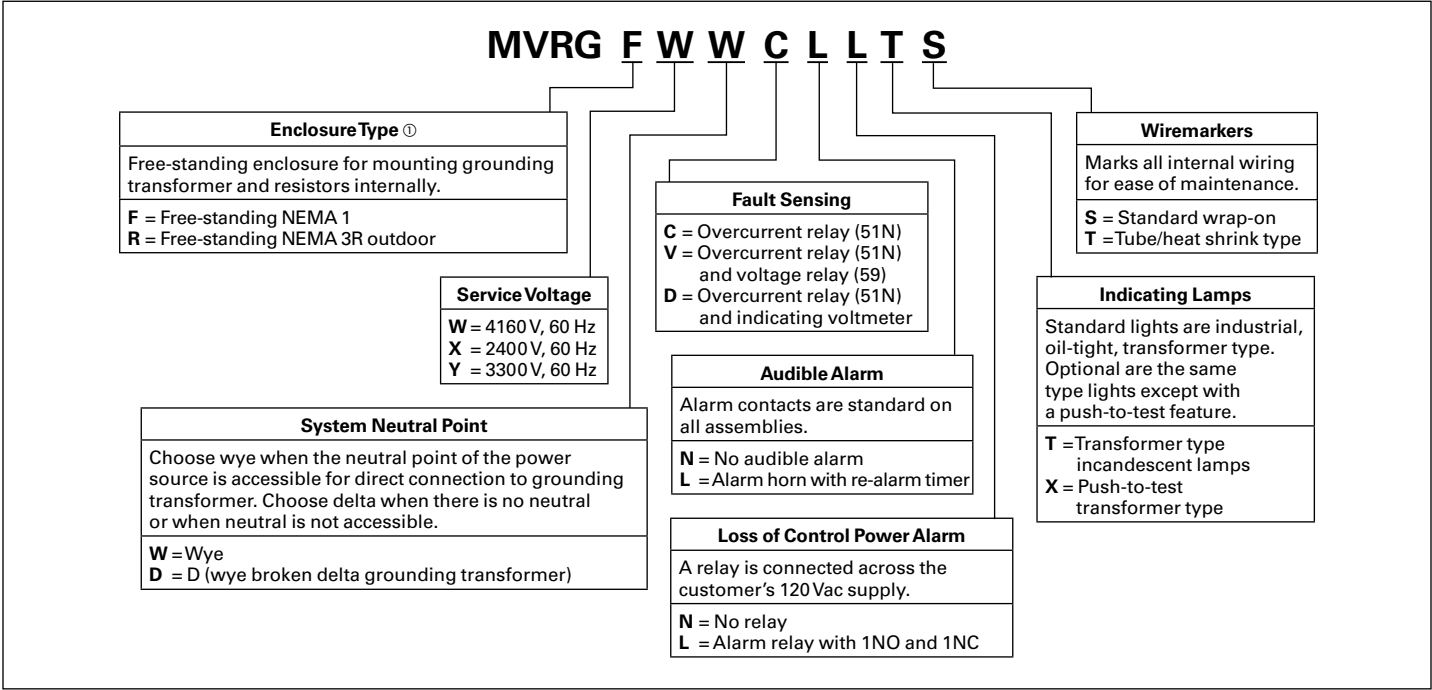
Resistor Tap	System	System Voltage	Primary Ground Current Total	CPT Ratio	CPT kVA/Ph	Secondary Ground Current	Resistance for Ground Current (Ohms)	Pulsing Resistor Value (Ohms)	Pulsing Secondary Current	Pulsing Primary Total Current	Resistor Watts Dissipated (kW)				
											Watts Ground	Watts Pulsing	Total Watts	Average Watts	
2400V ①															
1	Delta	2400	3.0	2400/120	10	20.00	10.40	7.80	26.70	4.0	4.16	5.55	9.77	6.94	
2	Delta	2400	4.0	2400/120	10	26.70	7.80	7.80	26.70	4.0	5.55	5.55	11.10	8.33	
3	Delta	2400	5.0	2400/120	10	33.30	6.24	7.80	26.70	4.0	6.93	5.55	12.48	9.71	
4	Delta	2400	6.0	2400/120	10	40.00	5.20	7.80	26.70	4.0	8.32	5.55	13.87	11.10	
1	Wye	2400	3.0	1400/140	15	30.00	4.62	3.46	40.00	4.0	4.16	5.54	9.70	6.94	
2	Wye	2400	4.0	1400/140	15	40.00	3.46	3.46	40.00	4.0	5.54	5.54	11.08	8.32	
3	Wye	2400	5.0	1400/140	15	50.00	2.77	3.46	40.00	4.0	6.93	5.54	12.47	9.71	
4	Wye	2400	6.0	1400/140	15	60.00	2.31	3.46	40.00	4.0	8.31	5.54	13.85	11.09	
3300V ①															
1	Delta	3300	3.0	3600/120	10	30.00	6.35	4.76	40.00	4.0	5.72	7.62	13.34	9.53	
2	Delta	3300	4.0	3600/120	10	40.00	4.76	4.76	40.00	4.0	7.62	7.62	15.24	11.43	
3	Delta	3300	5.0	3600/120	10	50.00	3.81	4.76	40.00	4.0	9.53	7.62	17.15	13.44	
4	Delta	3300	6.0	3600/120	10	60.00	3.18	4.76	40.00	4.0	11.43	7.62	19.05	15.24	
1	Wye	3300	3.0	1950/195	25	30.00	6.35	4.76	40.00	4.0	5.72	7.62	13.34	9.53	
2	Wye	3300	4.0	1950/195	25	40.00	4.76	4.76	40.00	4.0	7.62	7.62	15.24	11.43	
3	Wye	3300	5.0	1950/195	25	50.00	3.81	4.76	40.00	4.0	9.53	7.62	17.15	13.44	
4	Wye	3300	6.0	1950/195	25	60.00	3.18	4.76	40.00	4.0	11.43	7.62	19.05	15.24	
4160V ①															
1	Delta	4160	3.0	4160/120	15	34.67	6.00	4.50	46.22	4.0	7.21	9.61	16.82	12.02	
2	Delta	4160	4.0	4160/120	15	46.22	4.50	4.50	46.22	4.0	9.61	9.61	19.22	14.42	
3	Delta	4160	5.0	4160/120	15	57.77	3.60	4.50	46.22	4.0	12.01	9.61	21.62	16.82	
4	Delta	4160	6.0	4160/120	15	69.33	3.00	4.50	46.22	4.0	14.42	9.61	24.03	19.23	
1	Wye	4160	3.0	2400/240	25	30.00	8.00	6.00	40.00	4.0	7.20	9.60	16.80	12.00	
2	Wye	4160	4.0	2400/240	25	40.00	6.00	6.00	40.00	4.0	9.60	9.60	19.22	14.40	
3	Wye	4160	5.0	2400/240	25	50.00	4.80	6.00	40.00	4.0	12.00	9.60	21.60	16.80	
4	Wye	4160	6.0	2400/240	25	60.00	4.00	6.00	40.00	4.0	14.40	9.60	24.00	19.20	

① Resistances and currents listed are an engineering guide only. Final results may differ somewhat from those listed because of resistor limitations.

Product Selection

Eaton’s C-HRG High Resistance Grounding Assembly can be completely described by an 8-digit catalog number: MVRG-_____

Table 36.1-2. High Resistance Pulsing Grounding Systems Catalog Numbering System



① MV HRG is available for outdoor application—contact Eaton.
Example: MVRG-FWWCLLTS defines a free-standing NEMA 1 enclosure, 4200 V / 60 Hz, wye-connected system, current-sensing control scheme, alarm horn with re-alarm timer, alarm relay with 1NO and 1NC, transformer type incandescent lights, wrap-on wiremark.

Dimensions

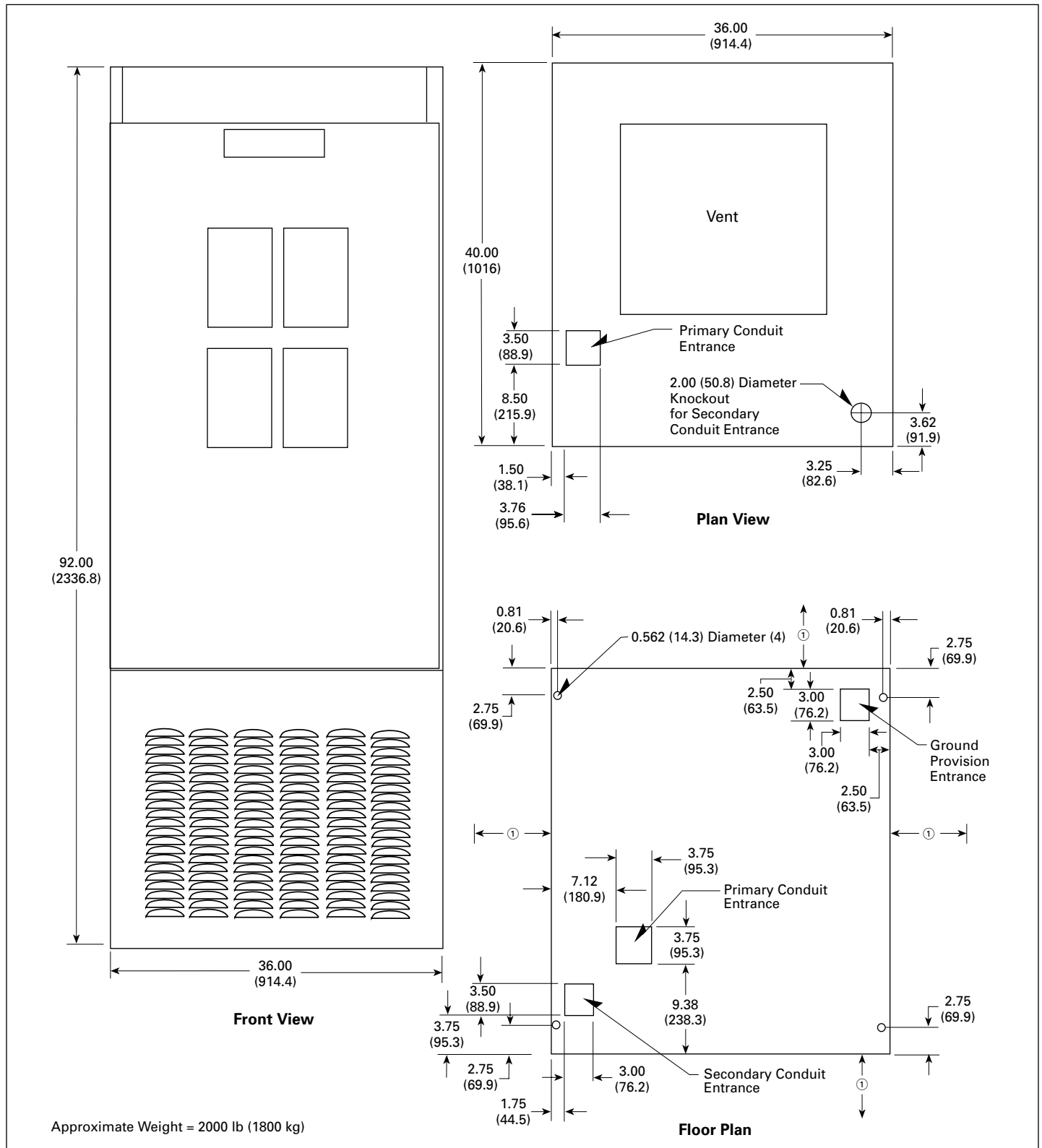


Figure 36.1-2. NEMA 1 Free-Standing—Dimensions in Inches (mm)

① Minimum required clearances are: front 36.00 inches (914.4 mm), rear 30.00 inches (762.0 mm), left or right sides—6.00 inches (152.4 mm).

Circuit Diagrams

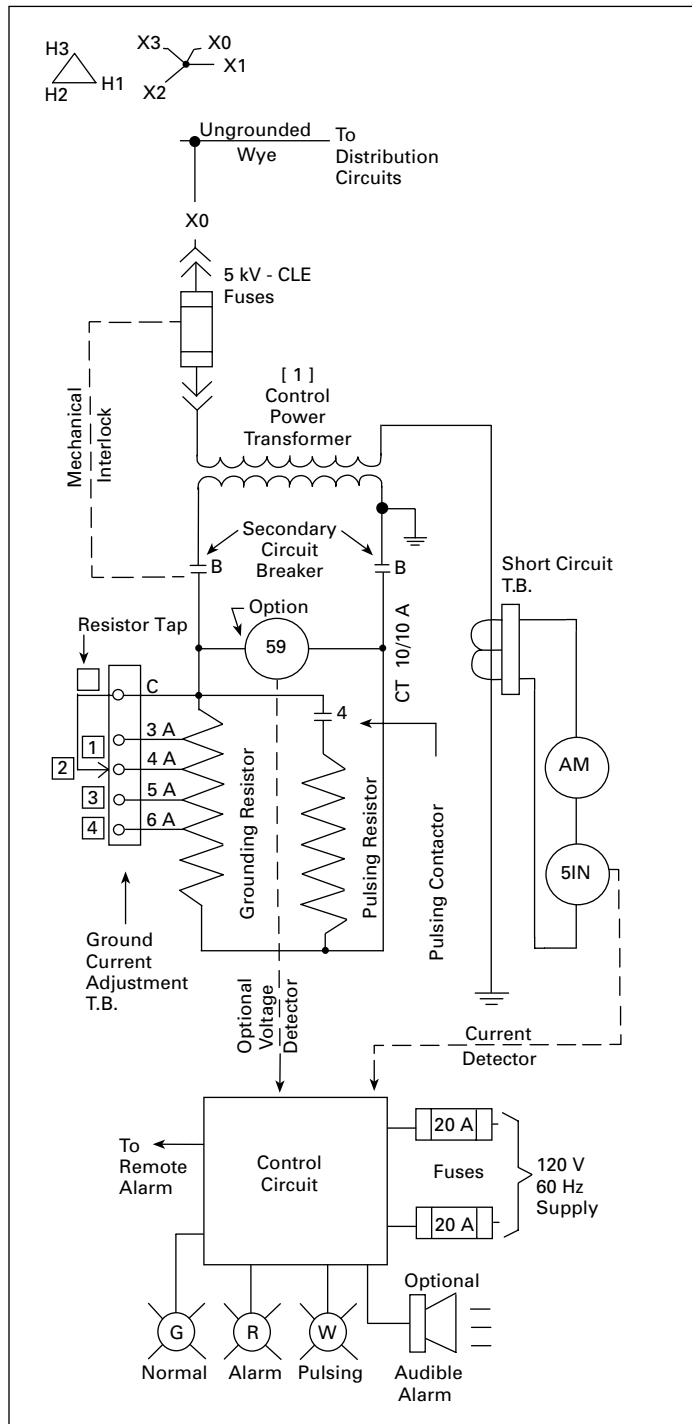


Figure 36.1-3. Ungrounded Wye System (With Standard Current and Optional Voltage Relay Fault Detectors)

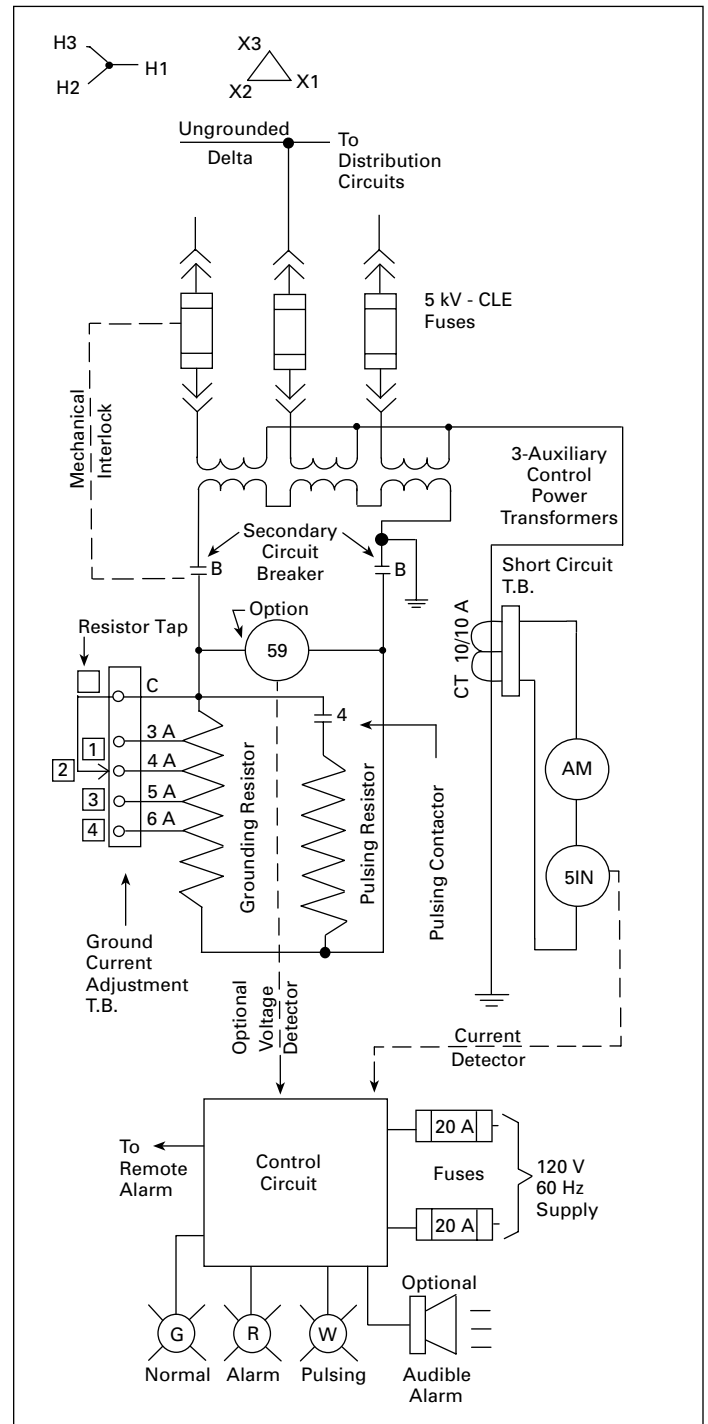


Figure 36.1-4. Ungrounded Delta System (With Standard Current and Optional Voltage Relay Fault Detectors)

Three-phase pad-mounted compartmental type transformer



General

At Eaton, we are constantly striving to introduce new innovations to the transformer industry, bringing you the highest quality, most reliable transformers. Eaton's Cooper Power™ series transformer products are ISO® 9001 compliant, emphasizing process improvement in all phases of design, manufacture, and testing. In order to drive this innovation, we have invested both time and money in the Thomas A. Edison Technical Center, our premier research facility in Franksville, Wisconsin. Such revolutionary products as distribution-class UltraSIL™ Polymer-Housed Evolution™ surge arresters and Envirotemp™ FR3™ fluid have been developed at our Franksville lab.

Eaton transformer sizes range from 45 kVA to 12 MVA with high-voltage ratings from 2400 V to 38 kV. From fabrication of the tanks and cabinets to winding of the cores and coils, to production of arresters, switches, tap changers, expulsion fuses, current-limiting fuses, bushings (live and dead) and molded rubber goods, Eaton has the products to meet your application needs. Eaton's Cooper Power series transformers are available with electrical grade mineral oil or Envirotemp™ FR3™ fluid, a less-flammable and bio-degradable fluid. Electrical codes recognize the advantages of using Envirotemp™ FR3™ fluid both indoors and outdoors for fire-sensitive applications. The bio-based fluid meets Occupational Safety and Health Administration (OSHA) and Section 450.23 NEC® requirements.



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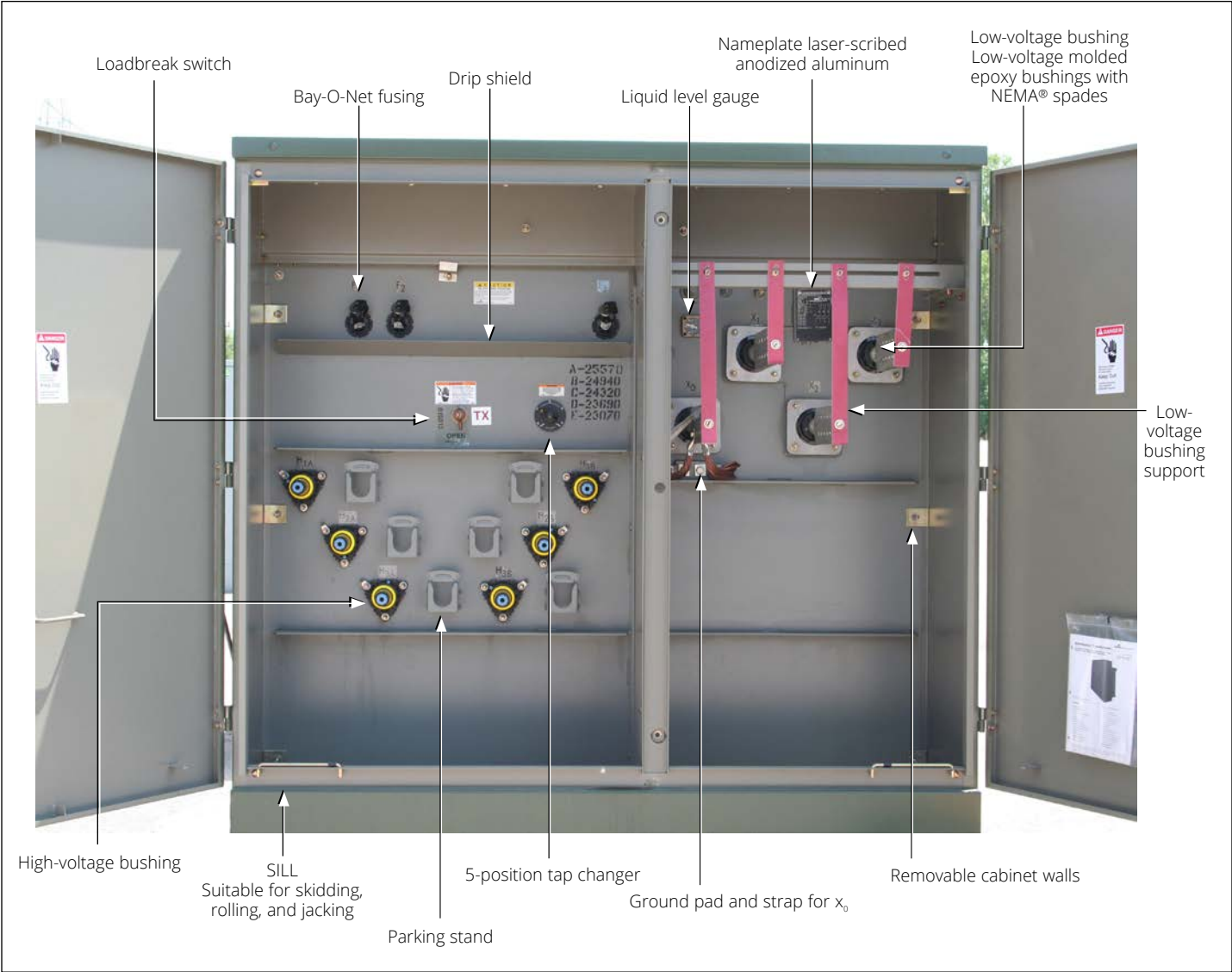


Figure 1. Three-phase pad-mounted compartmental type transformer

Table 1. Product scope

Description	Specification
Type	Three-phase, 50 or 60 Hz, 65 °C Rise (55 °C, 55/65 °C), 65/75 °C, 75 °C
Fluid type	Mineral oil or Envirottemp™ FR3™ fluid
Coil configuration	2-winding or 4-winding or 3-winding (Low-High-Low), 3-winding (Low-Low-High)
Size	45–10,000 kVA
Primary voltage	2400–46,000 V
Secondary voltage	208Y/120 V to 14,400 V
Specialty designs	Inverter/rectifier bridge K-Factor (up to K-19) Vacuum fault interrupter (VFI) UL® Listed and labeled and classified Factory Mutual (FM) Approved® Solar/wind designs Differential protection Seismic applications (including OSHPD) Hardened data center

Table 2. Three-phase ratings
Three-phase 50 Hz or 60 Hz

kVA available ③

45, 75, 112.5, 150, 225, 300, 500, 750, 1000, 1500, 2000, 2500, 3000, 3750, 5000, 7500, 10,000

③ Transformers are available in the standard ratings and configurations shown or can be customized to meet specific needs.

Table 3. Impedance voltage

Rating (kVA)	Low-voltage rating		
	≤ 600 V	2400–4800 V delta	6900 V delta – 13,800GY/7970 or 13,800 V delta
45–75	2.70–5.75	2.70–5.75	2.70–5.75
112.5–300	3.10–5.75	3.10–5.75	3.10–5.75
500	4.35–5.75	4.35–5.75	4.35–5.75
750–2500	5.75	5.75	5.75
3750	5.75	5.75	6.00
5000	—	6.00	6.50

Note: The standard tolerance is ±7.5%.

Table 4. Audible sound levels

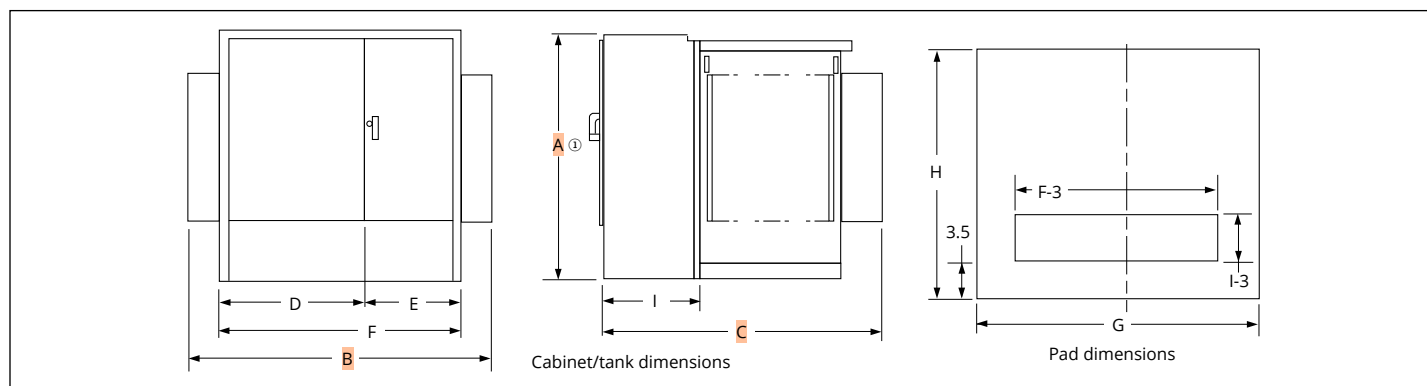
Self-cooled, two-winding kVA rating	NEMA TR-1 average Decibels (dB)
45–500	56
501–700	57
701–1000	58
1001–1500	60
1501–2000	61
2001–2500	62
2501–3000	63
3001–4000	64
4001–5000	65
5001–6000	66
6001–7500	67
7501–10,000	68

Table 5. Insulation test levels

kV class	Induced test 180 Hz or 400 Hz 7200 cycle	kV BIL distribution	Applied test 60 Hz (kV)
1.2	Twice rated voltage	30	10
2.5	Twice rated voltage	45	15
5	Twice rated voltage	60	19
8.7	Twice rated voltage	75	26
15	Twice rated voltage	95	34
25	Twice rated voltage	125	40
34.5	Twice rated voltage	150	50

Table 6. Temperature rise ratings 0–3300 ft (0–1000 m)

	Standard	Optional
Unit rating (temperature rise winding)	65 °C	55 °C, 55/65 °C, 75 °C
Ambient temperature maximum	40 °C	50 °C
Ambient temperature 24-hour average	30 °C	40 °C
Temperature rise hotspot	80 °C	65 °C

**Figure 2. Transformer and pad dimensions**

① Add 9 inches for Bay-O-Net fusing.

Table 7. Fluid-filled—aluminum windings 55/65 °C rise ①**Dead-front—loop or radial feed—Bay-O-Net fusing oil-filled—aluminum windings**

65° rise kVA rating	Outline dimensions (inches)									Gallons of fluid	Approx. total weight (lb)
	A ②	B	C	D	E	F	G	H	I		
45	50	68	39	42	26	68	72	43	20	110	2,100
75	50	68	39	42	26	68	72	43	20	115	2,250
112.5	50	68	49	42	26	68	72	53	20	120	2,350
150	50	68	49	42	26	68	72	53	20	125	2,700
225	50	72	51	42	30	72	76	55	20	140	3,150
300	50	72	51	42	30	72	76	55	20	160	3,650
500	50	89	53	42	30	72	93	57	20	190	4,650
750	64	89	57	42	30	72	93	61	20	270	6,500
1000	64	89	59	42	30	72	93	63	20	350	8,200
1500	73	89	86	42	30	72	93	90	24	410	10,300
2000	73	72	87	42	30	72	76	91	24	490	12,500
2500	73	72	99	42	30	72	76	103	24	530	14,500
3000	73	84	99	46	37	84	88	103	24	620	16,700
3750	84	85	108	47	38	85	88	112	24	660	19,300
5000	84	96	108	48	48	96	100	112	24	930	25,000
7500	94	102	122	54	48	102	100	126	24	1,580	41,900

① Weights, gallons of fluid, and dimensions are for reference only and not for construction. Please contact Eaton for exact dimensions.

② Add 9 inches for Bay-O-Net fusing.

Table 8. Fluid-filled—copper windings 55/65 °C rise ①**Dead-front—loop or radial feed—Bay-O-Net fusing oil-filled—copper windings**

65° rise kVA rating	Outline dimensions (inches)									Gallons of fluid	Approx. total weight (lb)
	A ②	B	C	D	E	F	G	H	I		
45	50	64	39	34	30	64	69	43	20	110	2,100
75	50	64	39	34	30	64	69	43	20	115	2,350
112.5	50	64	49	34	30	64	69	53	20	115	2,500
150	50	64	49	34	30	64	69	53	20	120	2,700
225	50	64	51	34	30	64	73	55	20	140	3,250
300	50	64	51	34	30	64	75	55	20	160	3,800
500	50	81	53	34	30	64	85	57	20	200	4,800
750	64	89	57	42	30	72	93	61	20	255	6,500
1000	64	89	59	42	30	72	93	63	20	300	7,800
1500	73	89	86	42	30	72	93	90	24	410	10,300
2000	73	72	87	42	30	72	76	91	24	420	11,600
2500	73	72	99	42	30	72	76	103	24	500	14,000
3000	73	84	99	46	37	84	88	103	24	720	18,700
3750	84	85	108	47	38	85	88	112	24	800	20,500
5000	84	96	108	48	48	96	100	112	24	850	25,000
7500	94	102	122	54	48	102	100	126	24	1,620	46,900

① Weights, gallons of fluid, and dimensions are for reference only and not for construction. Please contact Eaton for exact dimensions.

② Add 9 inches for Bay-O-Net fusing.

Standard features

Connections and neutral configurations

- Delta-Wye: Low-voltage neutral will be a fully insulated X0 bushing with removable ground strap
- Grounded Wye-Wye: High-voltage neutral will be internally tied to the low-voltage neutral and brought out as the H0X0 bushing in the secondary compartment with a removable ground strap
- Delta-Delta: Transformer will be provided without a neutral bushing
- Wye-Wye: High-voltage neutral will be brought out as the H0 bushing in the primary compartment and the low-voltage neutral will be brought as the X0- bushing in the secondary compartment
- Wye-Delta: High-voltage neutral will be brought out as the H0 bushing in the primary compartment. No ground strap will be provided (line-to-line rated fusing is required)

High- and low-voltage bushings

- 200 A bushing wells (15 kV, 25 kV, and 35 kV)
- 200 A, 35 kV large interface
- 600 A (15 kV, 25 kV, and 35 kV) integral bushings (dead-front)
- Electrical-grade wet-process porcelain bushings (live-front)

Tank/cabinet features

- Bolted cover for tank access (45–2500 kVA)
- Welded cover with hand hole (>2500 kVA)
- Three-point latching door for security
- Removable sill for easy installation
- Lifting lugs (four)
- Stainless steel cabinet hinges and mounting studs
- Steel divider between high- and low-voltage compartment
- 20-inch-deep cabinet (45–1000 kVA)
- 24-inch-deep cabinet (1500–7500 kVA)
- 30-inch-deep cabinet (34.5/19.92 kV)
- Pentahead captive bolt
- Stainless steel one-hole ground pads (45–500 kVA)
- Stainless steel two-hole ground pads (750–10,000 kVA)
- Parking stands (dead-front)

Valves/plugs

- 1-inch upper filling plug
- 1-inch drain plug (45–500 kVA)
- 1-inch combination drain valve with sampling device in low-voltage compartment (750–10,000 kVA)
- Automatic pressure relief valve

Nameplate

- Laser-scribed anodized aluminum nameplate



Figure 3. Drain valve with sampler



Figure 4. Automatic pressure relief valve



Figure 5. Liquid level gauge



Figure 6. External gauges



Figure 7. External visible break with gauges

Optional features

High- and low-voltage bushings

- 200 A (15, 25 kV) bushing inserts
- 200 A (15, 25 kV) feed thru inserts
- 200 A (15, 25 kV) (HTN) bushing wells with removable studs
- High-voltage 600 A (15, 25, 35 kV) deadbreak one-piece bushings
- Low-voltage 6-, 8-holes spade
- Low-voltage 12-, 16-, 20-holes spade (750–2500 kVA)
- Low-voltage bushing supports

Tank/cabinet features

- Stainless steel tank base and cabinet
- Stainless steel tank base, cabinet sides and sill
- 100% stainless steel unit
- Service entrance (2-inch) in sill or cabinet side
- Touch-up paint (domestic)
- Copper ground bus bar
- Kirk-Key provisions
- Nitrogen blanket
- Bus duct cutout

Special designs

- Factory mutual (FM)
- UL classified
- Triplex
- High altitude
- K-Factor
- Step-up
- Critical application
- Modulation transformers
- Seismic applications (including OSHPD)

Switches

- One, two, or three On/Off loadbreak switches
- Four-position loadbreak V-blade switch or T-blade switch
- Delta-wye switch
- Three-position V-Blade selector switch
- 100 A, 150 A, 300 A tap changers
- Dual-voltage switch
- Visible disconnect with VFI / VFI-XD interlock
- External visible break (15 kV, 25 kV, and 35 kV, up to 3 MVA)
- External visible break with gauges (15 kV, 25 kV, and 35 kV, up to 3 MVA)

Gauges and devices

- Liquid-level gauge (optional contacts)
- Pressure vacuum gauge (optional contacts and bleeder)
- Dial-type thermometer (optional alarm contacts)
- Cover-mounted pressure relief device (optional alarm contacts)
- Ground connectors
- Hexhead captive bolt
- Molded case circuit breaker mounting provisions
- External gauges in padlockable box

Overcurrent protection

- Bay-O-Net fusing (current sensing, dual sensing, dual element, high amperage overload)
- Bay-O-Net expulsion fuse in series with a partial range under-oil ELSP current-limiting fuse (below 23 kV)
- Cartridge fusing in series with a partial range under-oil ELSP current-limiting fuse (above 23 kV)
- MagneX™ interrupter with ELSP current-limiting fuse
- Vacuum fault interrupter (VFI)—12.5 kA / 16 kA
- Vacuum fault interrupter extreme duty (VFI-XD)—25 kA
- Visible break window
- Fuse/switch interlock

Valves/plugs

- Drain/sampling valve in high-voltage compartment
- Globe type upper fill valve

Overvoltage protection

- Distribution-, intermediate-, or station-class surge arresters
- Elbow arresters (for dead-front connections)

Metering/fan/control

- Full metering package
- Current transformers (CTs)
- Metering socket
- NEMA 4 control box (optional stainless steel)
- NEMA 7 control box (explosion proof)
- Fan packages

Testing

- Customer test witness
- Customer final inspection
- Zero sequence impedance test
- Heat run test
- ANSI impulse test
- Audible sound level test
- RIV (Corona) test
- Dissolved Gas Analysis (DGA) test
- 8- or 24-hour leak test

Coatings (paint)

- ANSI Bell Green
- ANSI #61 Light Gray
- ANSI #70 Sky Gray
- Special paint available per request

Nameplate

- Stainless steel

Decals and labels

- High voltage warning signs
- Mr. Ouch
- Bi-lingual warning
- DOE compliant
- Customer stock code
- Customer stenciling
- Shock and arc flash warning decal
- Non-PCB decal

Construction

Core

The three-legged, step-lap mitered core construction is manufactured using a high-quality cutting machine. For maximum efficiency, cores are precisely stacked, virtually eliminating gaps in the corner joints.

Five-legged wound core or shell-type triplex designs are used for wye-wye connected transformers, and other special transformer designs.

Cores are manufactured with precision-cut, burr-free, grain-oriented silicon steel or amorphous metal, depending on customer preference or optimal material based upon performance requirements. Many grades of core steel are available for optimizing core loss efficiency.

Coils

Pad-mounted transformers feature a rectangular coil configuration with wire-wound, high-voltage primaries and sheet-wound secondaries. The design minimizes axial stress developed by short circuits and provides for magnetic balancing of tap connections.

Coils are wound using the highest quality winding machines providing exacting tension control and conductor placement for superior short-circuit strength and maximum efficiency.

Extra mechanical strength is provided by diamond pattern, epoxy-coated paper insulation, used throughout the coil, with additional epoxy at heavy stress points. The diamond pattern distribution of the epoxy and carefully arranged ducts, provide a network of passages through which cooling fluid can freely circulate.

Coil assemblies are heat-cured under calculated hydraulic pressure to ensure performance against short-circuit forces.

Core and coil assemblies

Pad-mounted transformer core and coil assemblies are braced with heavy steel ends to prevent the rectangular coil from distorting under short-circuit conditions. Plates are clamped in place using presses, and welded or bolted to form a solid core and coil assembly. Core and coil assemblies exceed ANSI and IEEE requirements for short-circuit performance. Due to the rigidity of the design, impedance shift after short-circuit is comparable to that of circular wound assemblies.

Tanks

Transformer tanks are designed for high strength and ease of handling, installation, and maintenance. Tanks are welded using precision-cut, hot rolled, pickled, and oiled steel. They are sealed to protect the insulating fluid and other internal components.

Transformer tanks are pressure-tested to withstand 7 psig without permanent distortion and 15 psig without rupture.

Tank finish

An advanced multi-stage finishing process exceeds IEEE Std C57.12.28™-2014. The eight-stage pre-treatment process ensures coating adhesion and slows corrosion. It converts tank surfaces to a nonmetallic, water-insoluble iron-phosphate coating.

The paint method consists of two distinct layers of paint. The first is an epoxy primer (E-coat) layer that provides a barrier against moisture, salt, and corrosives. The two-component urethane final coat seals and adds ultraviolet protection.

Vacuum processing

Transformers are dried and filled with filtered insulating fluid under vacuum, while secondary windings are energized. Coils are heated to drive out moisture, ensuring maximum penetration of fluid into the coil insulation system.

Insulating fluid

Eaton's Cooper Power series transformers are available with electrical-grade mineral insulating oil or Envirotemp™ FR3™ fluid. The highly refined fluids are tested and degassed to ensure a chemically inert product with minimal acid ions. Special additives minimize oxygen absorption and inhibit oxidation. To ensure high dielectric strength, the fluid is re-tested for dryness and dielectric strength, refiltered, heated, dried, and stored under vacuum before being added to the completed transformer.

Eaton's Cooper Power series transformers filled with Envirotemp™ FR3™ fluid feature unique fire safety, environmental, electrical, and chemical advantages, including insulation life extending properties.

A bio-based, sustainable, natural ester dielectric coolant, Envirotemp™ FR3™ fluid quickly and thoroughly biodegrades in the environment and is non-toxic per acute aquatic and oral toxicity tests.

Building for Environmental and Economic Sustainability (BEES) total life cycle assessment software, utilized by the US Dept. of Commerce, reports its overall environmental performance impact score at 1/4th that reported for mineral oil. Envirotemp™ FR3™ fluid has also earned the EPA Environmental Technology Verification of transformer materials.

With a fire point of 360 °C, Envirotemp™ FR3™ fluid is FM Approved® and UL® Classified "Less-Flammable" per NEC Article 450.23, fitting the definition of a Listed Product per NEC.



Figure 8. VFI-XD transformer with visible break

Pad-mounted VFI transformer

Eaton's Cooper Power series VFI transformer combines a conventional distribution transformer with the proven vacuum fault interrupter (VFI). This combination provides both voltage transformation and transformer overcurrent protection in one space saving and money saving package. The pad-mounted VFI protects the transformer and provides proper coordination with upstream protective devices. When a fault or overload condition occurs, the VFI trips and isolates the transformer or faulted section of the loop.

The three-phase VFI breaker has independent single-phase initiation, but is three-phase mechanically gang-tripped. A trip signal on any phase will open all three phases. This feature eliminates single-phasing of three-phase loads. It also enables the VFI breaker to be used as a three-phase loadbreak switch.

Due to the resettable characteristics of the VFI breaker, restoring three-phase service is faster and easier.

The sealed visible break window and switch is an option that can be installed to provide visible break contact. This feature provides enhanced safety and allows an operator to see if the loadbreak switch contacts are in an open or closed position before performing maintenance.

Envirotran™ FM Approved special protection transformer

Eaton's Cooper Power series Envirotran™ transformer is FM Approved and suitable for indoor locations. Factory Mutual Research Corporation's (FMRC) approval of the Envirotran transformer line makes it easy to comply with and verify compliance with Section 450.23, 2008 NEC, less-flammable liquid-filled transformer requirements for both indoor and outdoor locations.

Envirotran FM Approved transformers offer the user the benefit of a transformer that can be easily specified to comply with NEC, and makes FM Safety Data Sheet compliance simpler, while also providing maximum safety and flexibility for both indoor and outdoor installations.

Because the "FM Approved" logo is readily visible on the transformer and its nameplate, NEC compliance is now easily verifiable by the inspector.

Envirotran FM Approved transformers are manufactured under strict compliance with FMRC Standard 3990 and are filled with FM Approved Envirotemp™ FR3™ fluid, a fire-resistant dielectric coolant.

**Special application transformers****Data center transformer**

With focus rapidly shifting from simply maximizing uptime and supporting demand to improving energy utilization, the data center industry is continually looking for methods to increase its energy efficiency and reliability. A solution—Eaton's Cooper Power series Hardened Data Center (HDC) liquid-filled transformers are designed to provide surge protection and superior performance under the harshest electrical environments. Contrary to traditional dry-type units, HDC transformers provide unsurpassed reliability, overloadability, operational life, efficiency, thermal loading, and installed footprint. These units have reliably served more than 100 MW of critical data center capacity for a total of more than 6,000,000 hours without any reported downtime caused by a thermal or short-circuit coil failure.

The top priority in data center operations is uninterrupted service. Envirotran HDC transformers from Eaton, having substantially higher levels of insulation, are less susceptible to voltage surges. Eaton has experienced zero failures due to switching transients. The ANSI and IEEE standard impulse withstand ratings are higher for liquid-filled transformers, making them less susceptible to insulation failure. The Envirotran HDC transformer provides ultimate protection by increasing the BIL rating one level higher than standard liquid-filled transformer ratings. The cooling system of liquid-filled transformers provides better protection from severe overloads—overloads that can lead to significant loss of life or equipment failure.

Data center design typically includes multiple layers of redundancy, ensuring maximum uptime for the critical IT load. When best-in-class transformer manufacturing lead times are typically weeks, not days, an unexpected transformer failure can adversely affect the facility's reliability and profitability. Therefore, the ability to determine the electrical and mechanical health of a transformer can reduce the probability of costly, unplanned downtime. Routine diagnostic tests, including key fluid properties and dissolved gas analysis (DGA), can help determine the health of a liquid-filled transformer. Although sampling is not required for safe operation, it provides the user with valuable information, leading to scheduled repair or replacement, and minimizing the duration and expense of an outage. With a dry-type transformer, there is no reliable way to measure the health or likelihood of an impending failure.

Solar transformer

As a result of the increasing number of states that are adopting aggressive Renewable & Alternative Energy Portfolio Standards, the solar energy market is growing—nearly doubling year over year. Eaton, a key innovator and supplier in this expanding market, is proud to offer its Cooper Power series Envirotran transformers specifically designed for solar photovoltaic medium-voltage applications. Eaton is working with top solar photovoltaic developers, integrators, and inverter manufacturers to evolve the industry and change the way we distribute power.

In accordance with this progressive stance, every Envirotran Solar transformer is filled with non-toxic, biodegradable Envirotemp™ FR3™ dielectric fluid, made from renewable seed oils. On top of its biodegradability, Envirotemp™ FR3™ fluid substantially extends the life of the transformer insulation, saving valuable resources. What better way to distribute green power than to use a green transformer. In fact, delaying conversion to Envirotran transformers places the burden of today's environmental issues onto tomorrow's generations.

Eaton can help you create a customized transformer, based on site specific characteristics including: temperature profile, site altitude, solar profile, and required system life. The benefits gained from this custom rating include:

- Reduction in core losses
- Improved payback on investment
- Reduction in footprint
- Improved fire safety
- Reduced environmental impact

For the solar photovoltaic industry, Eaton offers standard step-up transformers and dual secondary designs, including 4-winding, 3-winding (Low-High-Low), and 3-winding (Low-Low-High) designs.

Wind transformer

Eaton offers custom designs for renewable energy power generation. Eaton manufactures its Cooper Power series Generator Step-Up (GSU) transformers for installation at the base of every wind turbine. Additionally, grounding transformers are available for wind power generation.

DOE efficiency

The United States Department of Energy (DOE) has mandated efficiency values for most liquid type, medium-voltage transformers. As a result, all applicable Eaton transformers 2500 kVA and below conform to efficiency levels as specified in the DOE ruling "10 CFR Part 431 Energy Conservation Program".

UL Listed and Labeled/Classified

The Envirotran transformer can be specified as UL Listed and Labeled, and/or UL Classified. UL listing is a verification of the design and construction of the transformer to ANSI and IEEE standards. UL listing generally is the most efficient, cost-effective solution for complying with relevant state and local electrical codes. UL Combination Classification/Listing is another way to comply with Section 450.23, 2008 NEC requirements. This combines the UL listed transformer with a UL Classified Less-Flammable Liquid and complies with the use restrictions found within the liquid classification.



K-Factor transformer

With a drastic increase in the use of ferromagnetic devices, arcing devices, and electric power converters, higher frequency loads have increased significantly. This harmonic loading has the potential to generate higher heat levels within a transformer's windings and leads by as much as 300%. Harmonic loading has the potential to induce premature failure in standard-design distribution transformers.

In addition to standard UL "K-Factor" ratings, transformers can be designed to customer-provided specifications detailing precise loading scenarios. Onsite measurements of magnitude and frequency, alongside harmonic analysis of the connected load can be performed by Eaton engineers or a third-party consultant. These field measurements are used to determine exact customer needs and outline the transformer specifications.

Eaton can design harmonic-resistant transformers that will be subjected to the unique harmonic loads. These units are designed to maintain normal temperature rise under harmonic, full-load conditions. Standard UL "K-Factor" designs can result in unnecessary costs when the "next-highest" K-Factor must be selected for a calculated design factor. To save the customer these unnecessary costs, Eaton can design the transformer to the specific harmonic spectrum used in the application. Eaton's Cooper Power series K-Factor transformers are filled with mineral oil or Envirotemp™ FR3™ fluid and have the added benefits of dielectric cooling such as higher efficiencies than dry-type transformers.

Modulation transformer

Bundled with an Outboard Modulation Unit (OMU) and a Control and Receiving Unit (CRU), a Modulation Transformer Unit (MTU) is designed to remotely achieve two-way communication.

The use of an MTU reduces travel time and expense versus traditional meter reading performed by high-voltage electricians. Additionally, with MTU it is possible to manage and evaluate energy consumption data, providing reduced metering costs and fewer tenant complaints.

An MTU uses the existing utility infrastructure, therefore eliminating the need to engineer and construct a dedicated communication network.



Figure 9. Modulation transformer

Inverter/rectifier bridge

Eaton complements its range of applications for transformers by offering dual winding designs intended for connection to 12-pulse rectifier bridges.

Product attributes

Eaton includes the following guarantees with every three-phase pad-mounted transformer.

Engineered to order (ETO)

Using customer specifications, Eaton will provide a well-developed, cost-effective solution to fit the customer's needs. Whether it is application specific, site specific, or a uniquely specified unit, Eaton will provide transformers with the best-in-class value and performance, saving the customer time and money.

Made in the U.S.A.

Eaton's three-phase pad-mounted transformers are produced in the U.S. with manufacturing facilities positioned strategically for rapid shipment of products. Furthermore, should the need arise, Eaton has a broad network of authorized service repair shops throughout the U.S.

Superior paint performance

Eaton's E-coat system protects transformers from nature's elements, provides unrivaled transformer paint life, and exceeds IEEE Std C57.12.28™-2014 and IEEE Std C57.12.29™-2005. In addition to the outside of the unit, each transformer receives a gray E-coat covering in the interior of the tank and cabinet, providing superior rust resistance and greater visibility during service.

If the wide range of standard paint selections does not suit the customer's needs, Eaton will customize the paint color to meet their requirements.

Rectangular coil design

Eaton utilizes a rectangular coil design. This winding technique results in a smaller overall unit footprint as well as reduced transformer weight without compromising the transformer's performance. Units have proven short circuit withstand capabilities up to 10 MVA.

Testing

Eaton performs routing testing on each transformer manufactured including the following:

- **Insulation power factor:** This test verifies that vacuum processing has thoroughly dried the insulation system to required limits
- **Ratio, polarity, and phase relation:** Assures correct winding ratios and tap voltages and confirms insulation of high-voltage and low-voltage circuits; checks entire insulation system to verify all live-to-ground clearances
- **Resistance:** This test verifies the integrity of internal high-voltage and low-voltage connections; provides data for loss upgrade calculations
- **Routine impulse:** The most severe test, simulating a lightning surge; applies one reduced wave and one full wave to verify the BIL rating
- **Applied potential:** Applied to both high-voltage and low-voltage windings, this test stresses the entire insulation system to verify all live-to-ground clearances
- **Induced potential:** 3.46 times normal plus 1000 V for reduced neutral designs
- **Loss test:** These design verification tests are conducted to assure that guaranteed loss values are met and that test values are within design tolerances; tests include no-load loss and excitation current along with impedance voltage and load loss
- **Leak test:** Pressurizing the tank to 7 psig ensures a complete seal, with no weld or gasket leaks, to eliminate the possibility of moisture infiltration or fluid oxidation

Design performance tests

The design performance tests include the following:

- **Temperature rise:** Our automated heat run facility ensures that any design changes meet ANSI and IEEE temperature rise criteria
- **Audible sound level:** Ensures compliance with NEMA requirements
- **Lightning impulse:** To assure superior dielectric performance, this test consists of one reduced wave, two chopped waves, and one full wave in sequence, precisely simulating the harshest conditions

Thomas A. Edison Research and Test Facility

We are constantly striving to introduce new innovations to the transformer industry, bringing you the highest quality transformer for the lowest cost. Eaton's Cooper Power series transformer products are ISO 9001 compliant, emphasizing process improvement in all phases of design, manufacture, and testing. We have invested millions of dollars in the Thomas A. Edison Technical Center, our premier research facility in Franksville, Wisconsin, affirming our dedication to introducing new innovations and technologies to the transformer industry. This research facility is fully available for use by our customers to utilize our advanced electrical and chemical testing labs.

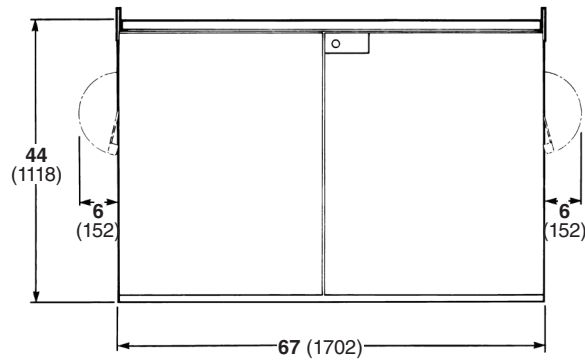
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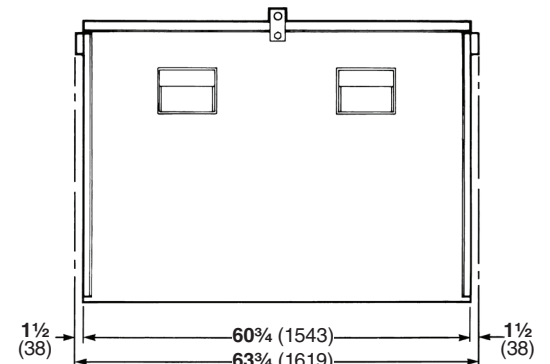
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Publication No. CA202003EN / Z29928
February 2025

Model PMH-19
14.4 kV Nominal

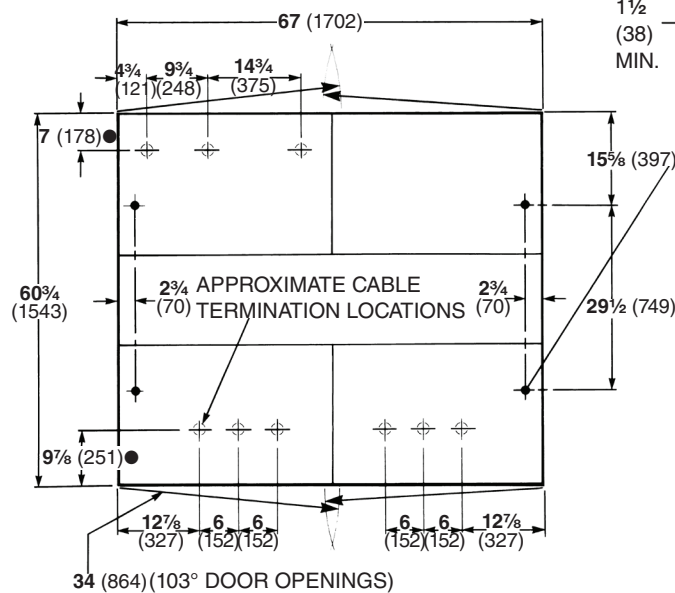
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FRONT VIEW

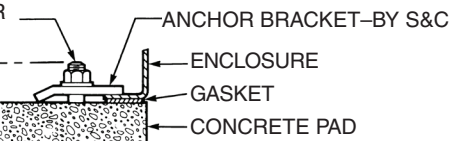


SIDE VIEW

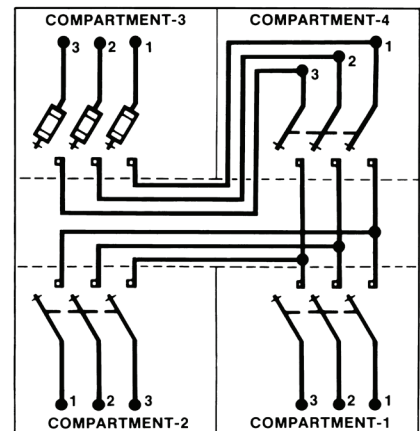


ANCHOR BOLT PLAN

FOUR 5/8 (16) DIA. ANCHOR BOLTS—BY USER



ANCHOR BOLT DETAIL



CONNECTION DIAGRAM

● When catalog number suffix “-M1,” “-U2,” or “-U3” is specified, cable-termination locations will be slightly affected. Consult the nearest S&C Sales Office for details.

TYPE PMDF PRIMARY METERING PAD-MOUNTED SWITCHGEAR 15KV • 25KV • 35KV



Federal Pacific three-phase primary-metering dead-front switchgear (Type PMDF) meet applicable industry standards IEEE 386 for elbow connections and IEEE C57.12.28 for enclosure security, and are available in ratings of 15kV through 35kV. The flexible PMDF design can accommodate several different types of current transformers (CTs) and voltage transformers (VTs), previously known as PTs (potential transformers), providing a convenient, weather protected, tamper-resistant enclosure for revenue metering at primary voltages on underground cable systems.

The PMDF termination compartment features a dead-front steel barrier with six (radial) or nine (loop) Federal Pacific 200 amp bushing wells accommodating load-break inserts and elbows. Optional 600 amp bushings are available. In addition, accessory parking stands and three 1/2" stainless-steel grounding nuts are included. Large door openings provide excellent accessibility for elbow operation. All doors are pad-lockable with rugged three-point latching.

The instrument-transformer compartment has provisions for mounting CTs (current transformers) and VTs (voltage transformers, formerly called PTs).

Instrument transformers may be customer installed. There are also options for Federal Pacific provided and installed instrument transformers or for customer provided, Federal Pacific installed, instrument transformers. A ground bus is provided and located for easy access to VTs. An insulated, hinged inner barrier with pentahead-bolt closures is standard.

PMDF enclosures, roofs, and doors are 11-gauge hot-rolled steel, all-welded construction. High-quality steel, corrosion-resistant hardware, chemical cleaning, and phosphatizing (or zirconization) corrosion-resistant epoxy-powder primer and a baked powder topcoat make the anti-corrosion coating system a leader in the industry. The standard finish color is pad-mount green, Munsell notation 7GY3.29/1.5. Optional colors are available. Special coatings are available for severe environments. The underside of the roof is coated with a "no-drip" anti-condensation compound.

Primary-metering requirements are also available in custom designs incorporating fusing and switching arrangements as well as optional externally mounted kWh meters and low-voltage compartments. Consult factory for dimensions, configurations, and optional features.



Elbow Compartment

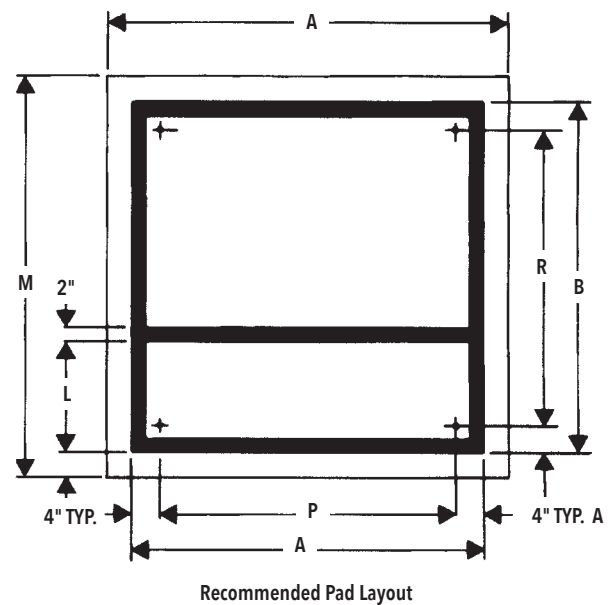
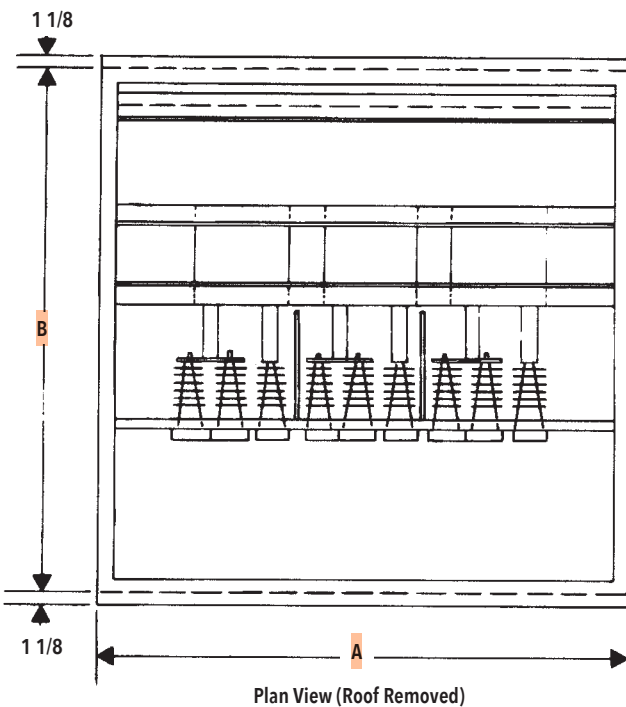
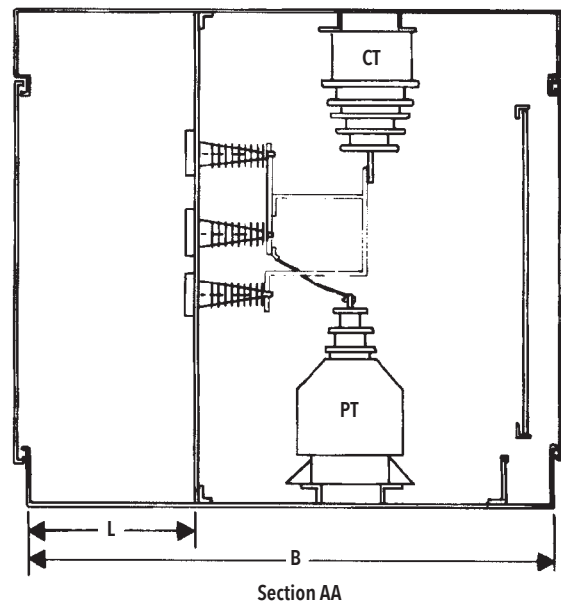
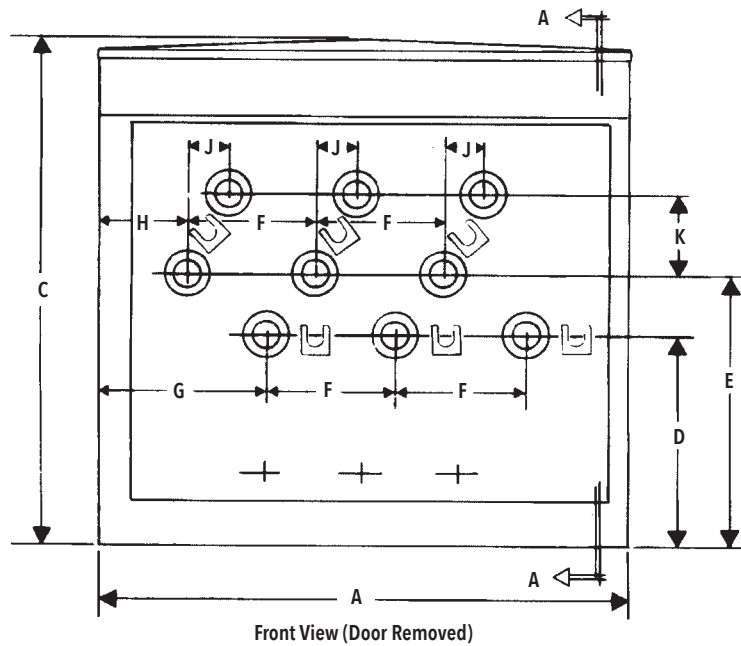


*Metering Transformer Compartment With
Hinged Barriers Bolted Closed*



*Metering Transformer Compartment With
Barriers Secured Open*

TYPE PMDF PRIMARY METERING PAD-MOUNTED SWITCHGEAR



Catalog Number	Volt Nom.	kV BIL	Typical Dimensions - Inches*														
			A	B	C	D	E	F	G	H	J	K	L	M	N	P	R
PMDF-315-R6-200	15	95	54	54	51	22	28	14	14	7	NA	NA	22	62	62	46	46
PMDF-315-L9-200	15	95	54	54	51	22	28	14	14	7	5	8-5/8	22	62	62	46	46
PMDF-325-R6-200	25	125	66	66	51	24-1/2	30-1/2	17-1/2	16	8-1/2	NA	NA	24	74	74	58	58
PMDF-325-L9-200	25	125	66	66	51	24-1/2	30-1/2	17-1/2	16	8-1/2	6	8-3/8	24	74	74	58	58
PMDF-335-R6-200	35	150	76	66	53	24-1/2	33	22-1/2	18-5/16	12-9/16	5-5/8	8-1/2	24	74	84	68	58

*Typical dimensions are provided for a sense of scale, not for construction purposes.

Federal Pacific



**Medium Voltage Grid
Connection Solutions for
Solar Farms, Battery Energy
Storage Systems and Other
Distributed Generation**

Why GridConnex?

GridConnex is an excellent alternative to traditional pole mount medium voltage service equipment for the solar, battery storage, or wind energy provider.

Gridconnex Advantages

Significantly reduces installation time while remaining aesthetically pleasing.

The GridConnex product offers a significant reduction in installation time. A single GridConnex is capable of replacing 4 to 5 poles! This allows for rapid deployment and ease of installation.



Before GridConnex



After GridConnex

Not only is the pad-mounted GridConnex product easier and quicker to install, gain the benefit of an aesthetically pleasing alternative to unsightly utility poles.

GridConnex Advantages

Exceptionally reliable, easy to service, and cost-effective.

GridConnex is exceptionally reliable because it is wired and tested in the factory. Also, the equipment is housed in a sturdy, environmentally controlled, 11-gauge steel enclosure. Assuring the components are not vulnerable to vandalism, vermin, lightning, or storms.

Since GridConnex is a pad-mounted product, serviceability is greatly improved. Bucket truck deployment is not needed to service equipment. Just open the door!



GridConnex is cost-effective because many required components are combined into a single enclosure. Simply stated, gang-operated air brake switches, reclosers, control power transformers, metering clusters, and fuse cutouts can be replaced with one prefigured product. The field labor savings are substantial.

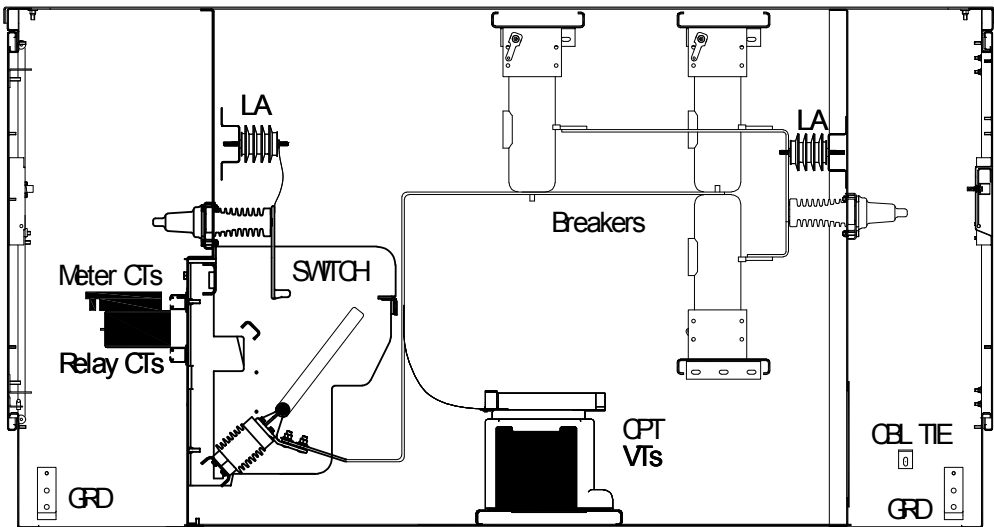
A fully loaded GridConnex product will include revenue grade metering, a visible disconnect for safe isolation and the ability to lockout, and circuit breakers replacing very expensive reclosers. (GridConnex comes standard with three independent circuit breakers. Tripping is three-phase, but open phase commissioning is possible with safe individual phase tripping).

How to Order: Select from the options below. If your requirements are not listed, please contact Federal Pacific at <https://www.federalpacific.com/contact/>

GridConnex Configured Number Designations

GC									
									Enclosure Color WH - White (Standard) GN - Green (Munsell 7GY3.29/1.5) GY - Grey (ANSI 61)
									Feeder Protection 0 - None 1 - Yes (50/51 Relay and Test Switch) 2 - Yes (50/51 Relay, Test Switch & Vsync LEA)
									Revenue Grade Metering 0 - None 1 - Yes (Current / Voltage Measuring, Meter, Test Switch)
									Uninterruptable Control Power C - Customer Supplied F - Factory Supplied
									Lightning Arrestors 0 - None 1 - Utility Side 2 - Solar Side 3 - Both Utility and Solar Side
									Visable Disconnect AJ - Autojet Switch XX - No Visable Disconnect
									Breaker Configuration 1 - Triple Single Phase Breakers 3 - Three Phase Breaker
									Bushings 2 - 200 Amp 6 - 600 Amp
									System Voltage A - 12,470 B - 13,200 C - 13,800 D - 14,400 E - 22,860 F - 24,940 G - 34,500 X - Other (Please Specify)
									Product Designation GC - GRIDCONNEX

The example below depicts a section view and one-line diagram of a typical configured GridConnex. See the configuration key located on page 4 for available options.



GridConnex with Switch [Typical, 15kV Shown] - Section View
Part Number GCA61AJ3F11WH

Position	0	1	2	3	4	5	6	7	8	9
Configured Part Number										

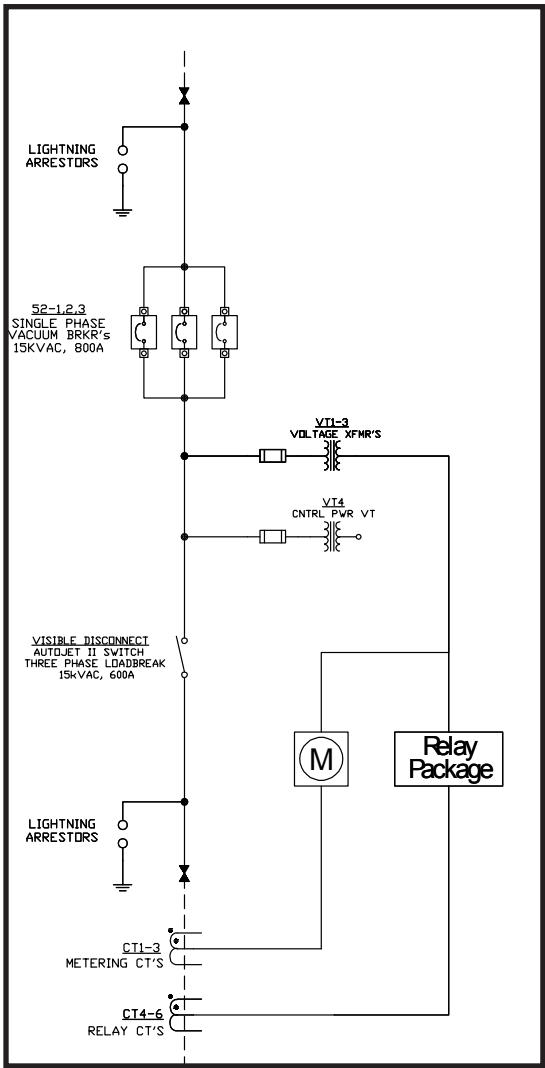
GridConnex™ Overall Equipment Ratings					
Rated Voltage	Continuous Current	Frequency	Basic Impulse Level (BIL)	Dielectric Strength	Rated Short-Circuit Current (SYM)
15kV	200/600A*	60Hz	95kV	36kV	20kA
25kV			125kV	60kV	16kA
35kV			150kV	80kV	

* Continuous current rating based on bushing or bushing well selection. Switchgear conforms to selected ANSI, NEMA, and IEEE standards.

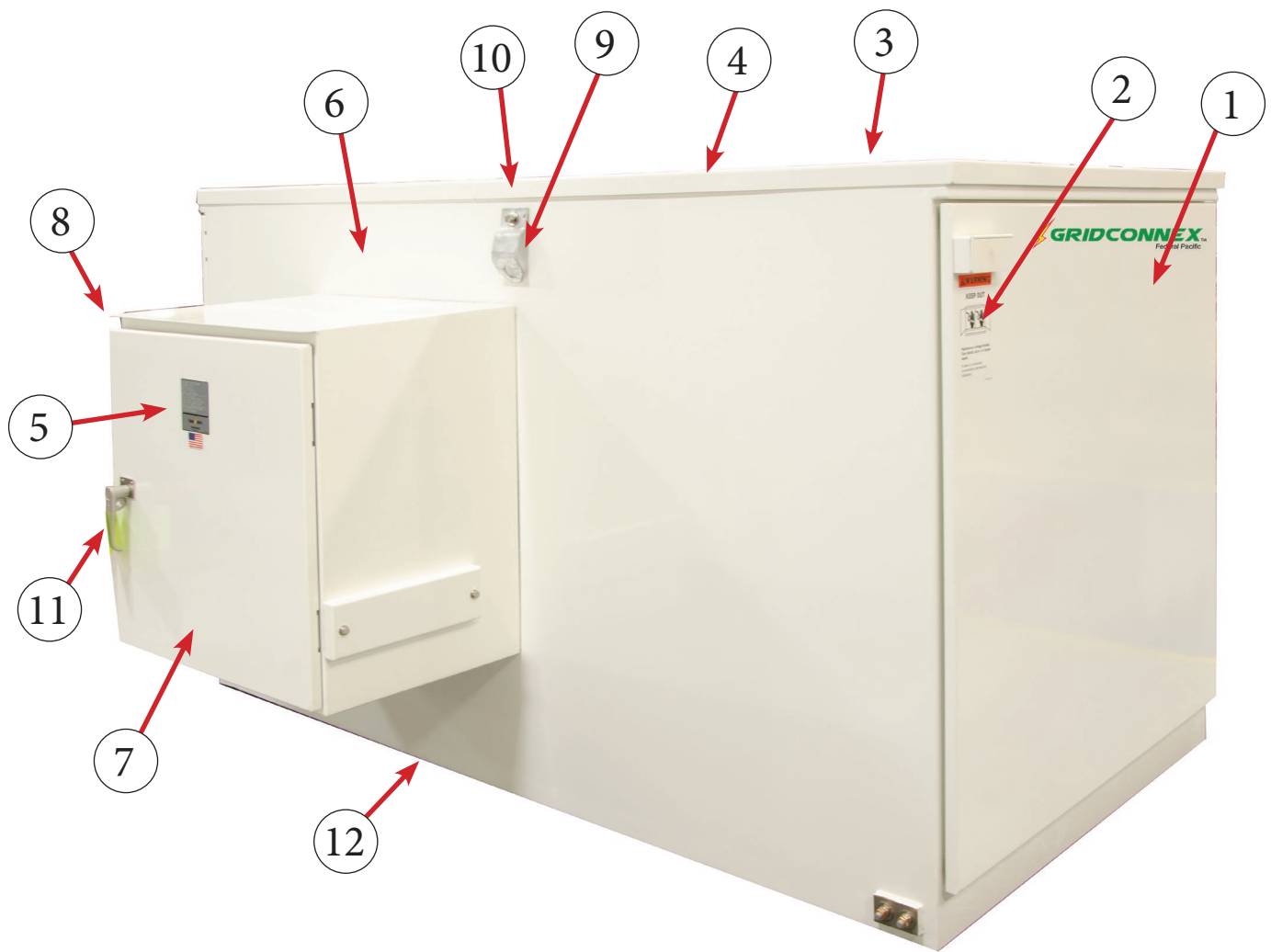
GridConnex Typical Dimensions - With AJ Switch			
Rated Voltage	Height	Width	Depth
15kV	56	48	104
25kV	72	60	116
35kV	85	57	132

GridConnex Typical Dimensions - Without AJ Switch			
Rated Voltage	Height	Width	Depth
15kV	56	48	82
25kV	72	60	106
35kV	85	57	122

NOTE - All dimensions in inches

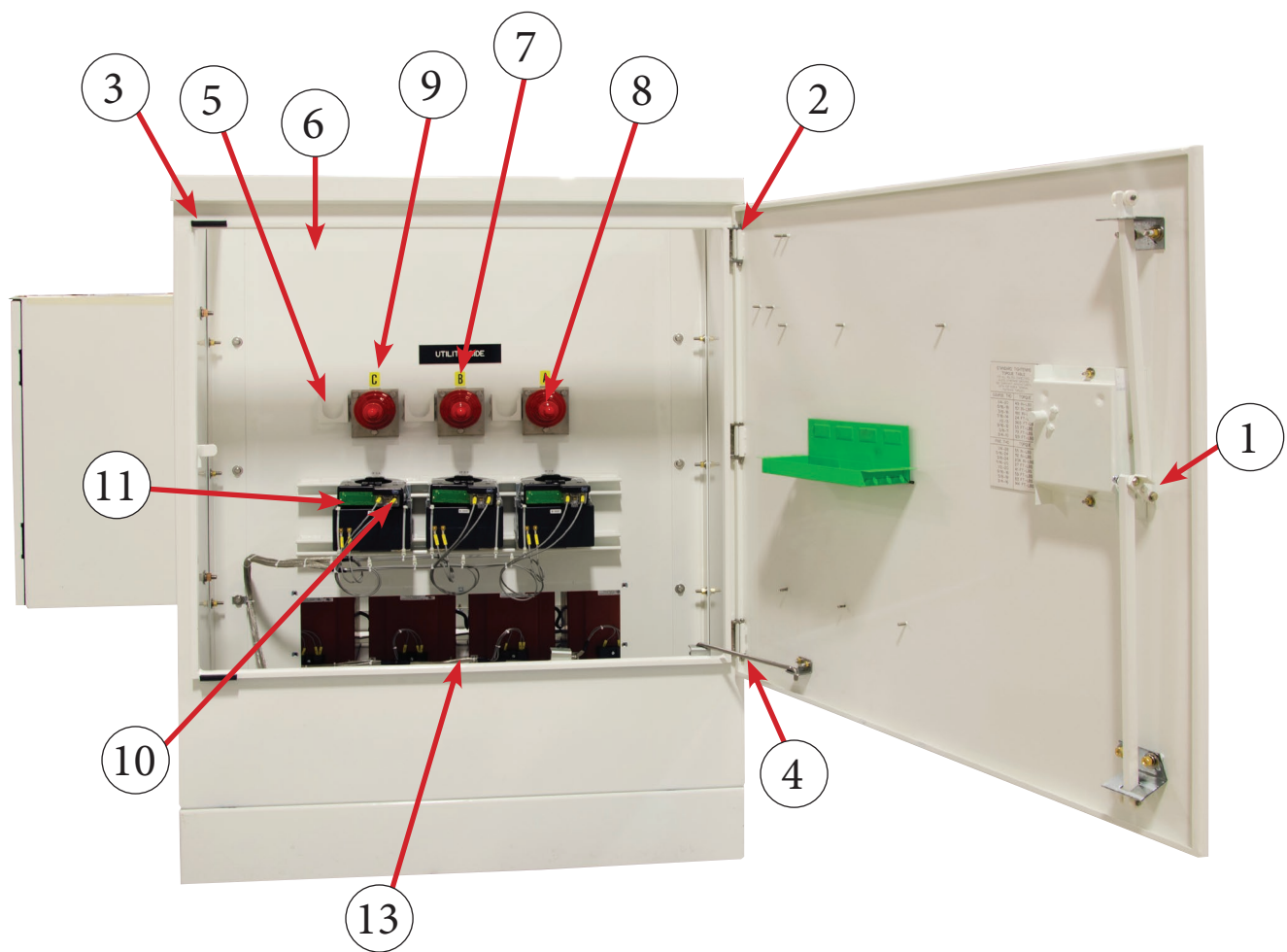


Typical One-Line Diagram



Enclosure Exterior of Federal Pacific Pad-Mounted GridConnex Solution.

- | | |
|---|---|
| 1. II-Gauge Steel Doors | 8. Drip-Shield over Control Compartments |
| 2. Hazard-Alerting Warning Signs on Exterior | 9. Galvanized-Steel Lifting Brackets |
| 3. One-Piece, Cross-Kinked II-Gauge Steel Roof | 10. Closed-Cell Cushions Isolate Enclosure from Lifting Bracket |
| 4. Insulating No-Drip Compound on Underside of Roof | 11. Stainless-Steel Handles on Control Compartment |
| 5. Silk-Screened, Aluminum Stamped Nameplate | 12. Closed-Cell Gasket at Bottom Isolates Enclosure from Mounting Surface |
| 6. II-Gauge Steel Welded Enclosure | |
| 7. Control Compartment Sealed to Enclosure | |



Customer Connection / Current Transformer Compartment.

- | | |
|---|--|
| <ul style="list-style-type: none"> 1. 11-Gauge Steel Doors with 3 point Latching System 2. Three Stainless Steel Hinges and Hinge Pins Per Enclosure Door 3. Bumper Gasket Cushions Door Interface, Prevents Metal to Metal Contact 4. Stainless Steel Wind brace 5. Stainless Steel Parking Stand for each Bushing 6. Formed Steel Equipment Mounting Panels Isolate Medium Voltage Components from Termination Compartment. | <ul style="list-style-type: none"> 7. 600 Amp Cycloaliphatic Epoxy Bushings with All-Copper Conductor on Stainless Steel Clamping Bracket (optional 200A Bushing Wells) 8. Removable Silver Plated All-Copper Stud on all Bushing with Red Protective Dust Covers. 9. Phase Identification Labels 10. Relay Current Transformers (when present) 11. Revenue Grade Current Transformers (when present) 13. Wide View Clear Polycarbonate Window for Volting Transformer Fuse Access. (when present) |
|---|--|

Construction

Enclosure Construction

Standard Enclosure features include heavy, 11-gauge hot-rolled pickled-and-oiled steel, all-welded construction, cross-kinked roof to eliminate potential for standing water, stainless steel hinges and switch operating pockets, deadfront compartment access doors with 3-point auto-latch door mechanisms and padlockable door handles with penta-head security bolts. These standard features, along with a rugged tamper-resistant design, provide a unit that meets the stringent security requirements of IEEE C57.12.28.

Enclosure Finish

The electrostatically deposited, baked-on powder epoxy finish provides a tough, durable high glass finish with protective qualities to ensure long-term enclosure protection. The standard color is white. Consult the factory for custom colors.

Bushings and Bushing Wells

Insulators of cycloaliphatic epoxy (CAE) polymers have been used in the power industry for over fifty years and have proven field experience globally in both indoor and outdoor applications. These polymers are light-weight, homogeneous, and readily molded by automatic pressure gelation (APG) process in both simple and complex contours. The formulation is balanced for high voltage, high strength, non-tracking, self-scouring, non-weathering applications in extremes of high temperature and sub-zero cold.

Federal Pacific's bushings and bushing wells are of cycloaliphatic epoxy and meet all the criteria set forth in ANSI/IEEE 386, which establishes ratings and design interface to accommodate industry-standard insulated separable elbow connectors. All bushings and bushing wells feature high conductivity copper rod contacts and include removable silver-plated copper studs. In addition, bushings and bushing wells all carry an engraved serial number for quality audit if the need should ever arise and are traceable to the particular switchgear assembly.



Federal Pacific cycloaliphatic bushings and bushing wells have all copper conductors and silverplated removable studs. Semi-conductive coating isolate bushings and dust covers protect high-voltage interfaces

Circuit Protection Devices

The Tavrida Circuit Breaker Modules contain the most advanced design elements of any MV breaker on the market. All components are assembled along a single axis, with three mono-stable magnetic actuators (one per pole). The actuators are mounted in a steel frame and are mechanically linked by a synchronizing shaft. The actuators drive a pulling insulator that, in turn, connects to the advanced Tavrida vacuum interrupters at the top of the breaker. This simple design results in the highest reliability available today. Tavrida delivers a maintenance-free breaker with a life expectancy of up to 150,000 close-open operations. The CM_I6 Control Module serves as the interface between the Circuit Breaker Module and the Schweitzer SEL-751 relay.

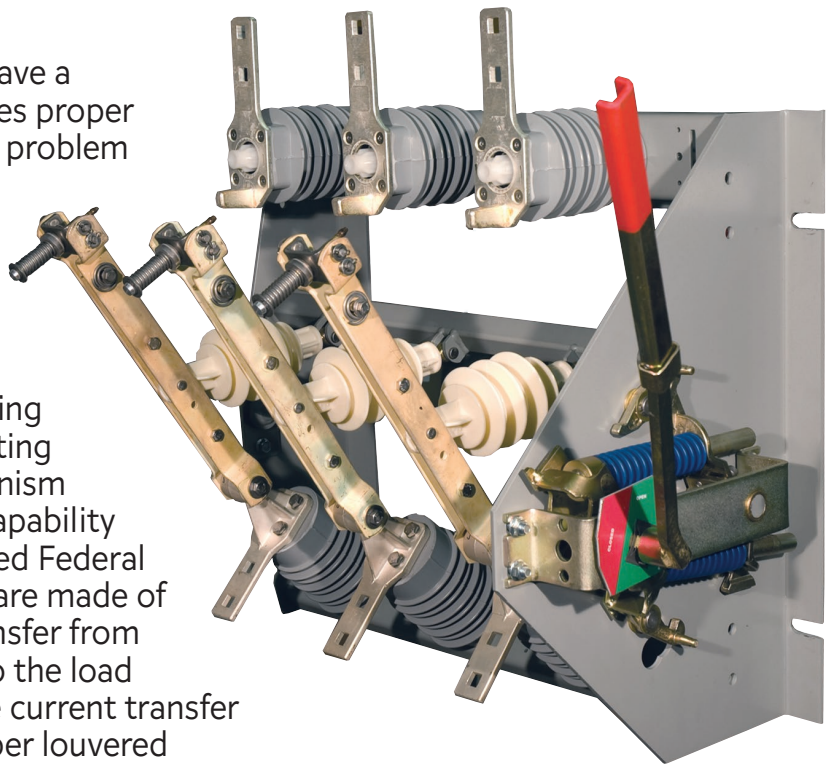


Meets or exceeds IEEE C34.04, C37.06,
C37.09, C37.09a and IEC 62271-100
ETL Recognized

Vacuum Circuit Breaker Ratings						
Rated Voltage	Rated Current	Short Circuit Current	BIL kV	Frequency (Hz)	Manufacturer	Breaker Type
5-15kV	800A	20kA	95	60	Tavrida	LD
27kV	800A	16kA	125	60		LD
35kV	1200A	16kA	150	60		OSM

Auto-Jet Switch

All Federal Pacific Auto-Jet switches have a heavy-gauge steel frame, which assures proper contact alignment and eliminates any problem of switch-to-enclosure alignment. An optional stainless-steel switch is available (current-carrying parts are not stainless-steel). A quick-make, quick-break stored-energy mechanism with heavy-duty, long-life die springs provides high-speed opening and closing independent of the operating handle speed. This high-speed mechanism assures the duty-cycle fault-closing capability and load interruption with the patented Federal Pacific interrupter. The switch blades are made of high conductivity copper. Current transfer from the switch-blade through the hinge to the load terminals is accomplished by a unique current transfer means, consisting of a beryllium-copper louvered contact band encircling a copper pin at the hinge point. Magnetic forces, due to a higher-than-normal current flow, tend to rotate the louvers on the contact band toward a vertical position, providing a higher contact pressure for fault-current duty.

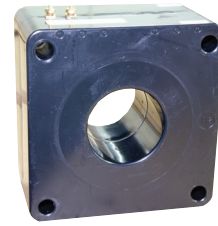


Switch Ratings						
kV		Amperes				60 Hz Withstand
Nom.	Max. Design	Continuous & Interrupting	Momentary RMS ASYM*	Fault-Closing RMS ASYM	BIL kV	
14.4	17	600	40,000	40,000	95	36
25	27	600	40,000	40,000	125	60
34.5	38	600	40,000	40,000	150	80

* The Auto-Jet switch has a three time fault close capability at 40kA and a single time fault close capability at 61kA.

Current and Voltage Sensing

Relay Class Current Transformers provide overcurrent sensing
Standard relay class of C50.
Manufactured to meet the requirements of IEEE C57.13
UL and CSA Recognized



Metering Class Extended range high accuracy current transformers
for revenue grade metering.
IEEE 0.15 accuracy class from 1% of rated current through rating factor.
Manufactured to meet the requirements of IEEE C57.13



Revenue grade voltage transformers for voltage sensing and
metering.
Accuracy class – 0.3% WXY at 100% rated voltage
Manufactured to meet the requirements of IEEE C57.13
UL and CSA Recognized



Uninterruptible Power Supply

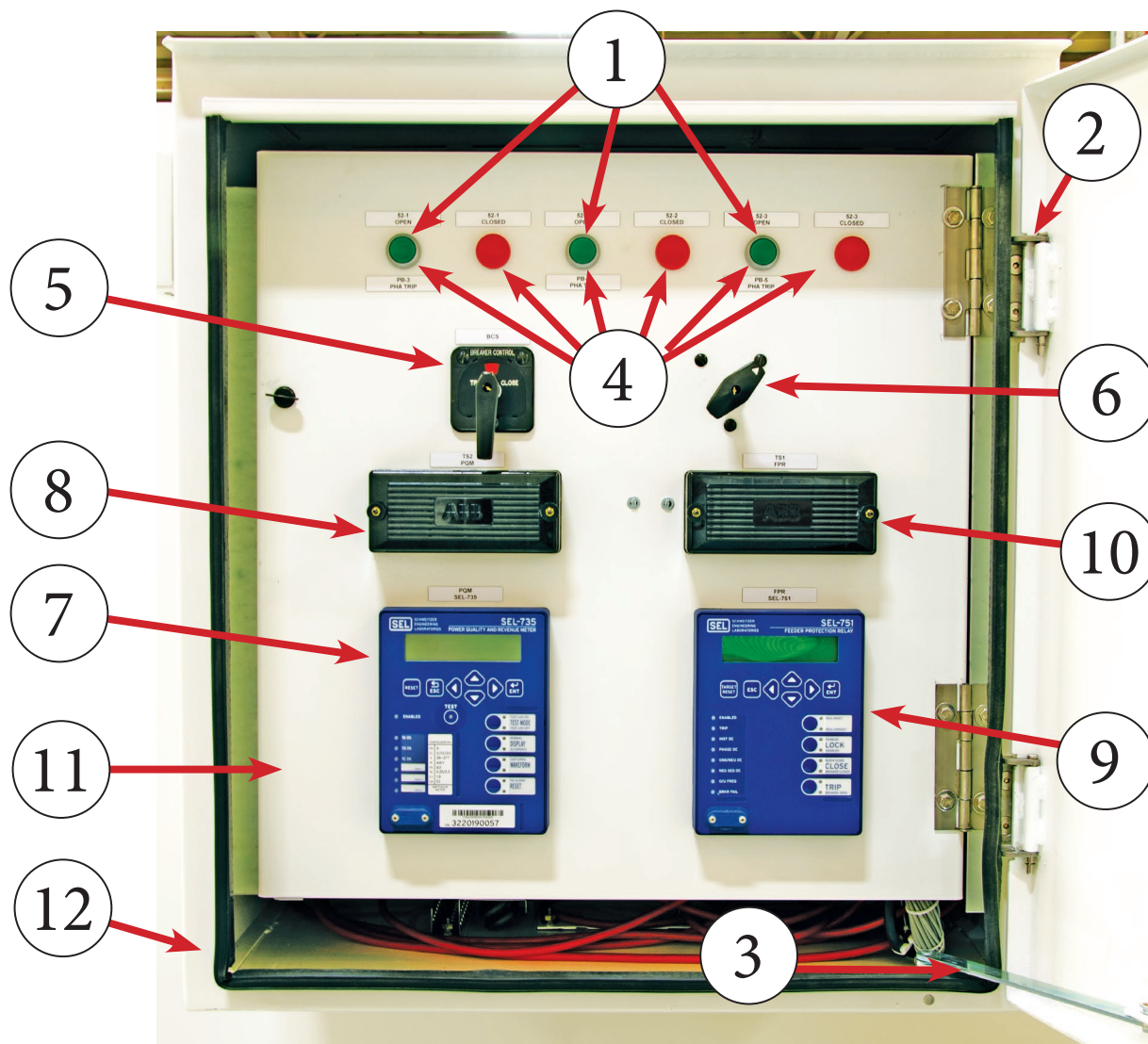
The supplied UPS provides adequate battery backup for the SEL-75I relay, SEL-735 meter, and vacuum circuit breakers when control power has been lost regardless of cause. The UPS ensures that the equipment is always capable of performing its intended function whether or not the normal control-power source, the voltage transformers, is available. The UPS also includes a battery charger and associated alarm circuits (I) in the event AC input to the battery charger is diminished or lost and (b) output from the battery is diminished below acceptable levels or lost.

Optional Accessories

Lightning Arrestors – Distribution class surge arrestors are used to limit the voltage due to lightning strikes and/or switching transients. Arrestors can be located at the Utility connection point, DG connection point, or at both locations.

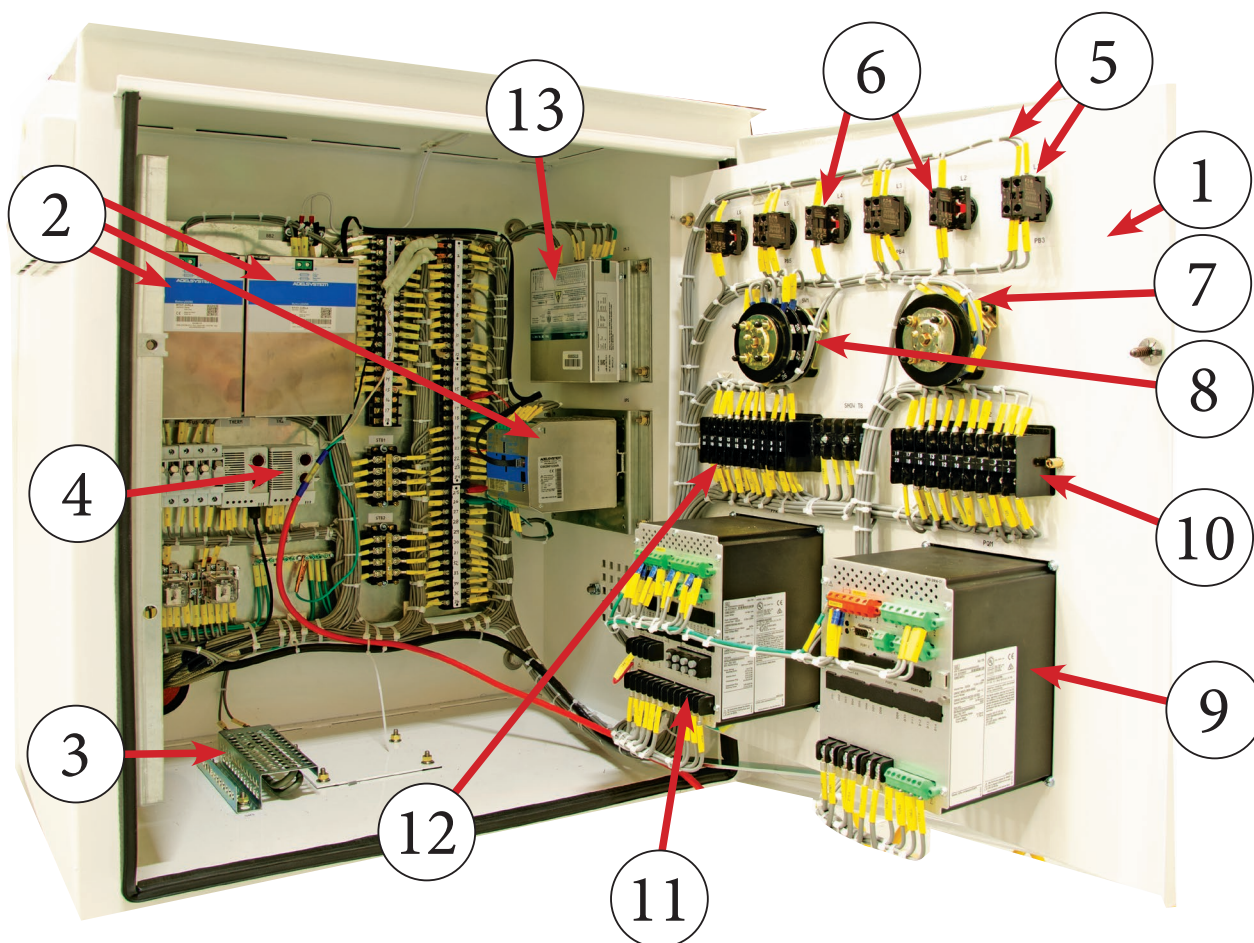
Low-Energy Analog Voltage Sensors (LEAs) – Sensor is used in conjunction with VTs and the SEL-75I relay to coordinate voltage sync between the Utility and Solar Farm / Battery Energy Storage Systems / Other DGs.





Low-Voltage Control Compartment (typical).

- | | |
|---|--|
| 1. Individual Phase Trip Pushbuttons for Commissioning. | 8. FT Style Test Switch (when present) |
| 2. Stainless Steel Hinges and Hinge Pins | 9. SEL-735 Power Quality and Revenue Meter (optional) |
| 3. Stainless Steel Wind brace | 10. FT Style Test Switch (when present) |
| 4. Breaker Open / Close Indication LED's | 11. Swing-Out Control Panel |
| 5. Breaker Control Switch | 12. Fully Gasketed Door Opening on Low Voltage Control Compartment |
| 6. Local / Remote Control Switch | |
| 7. SEL-75I Feeder Protection Relay (optional) | |



Low-Voltage Control Compartment (Interior, typical)

- | | |
|---|--|
| I. Swing-Out Control Panel. (Door-in-Door Construction) | 7. Breaker Control Switch |
| 2. UPS for Continuous Control Power. (optional) | 8. Local / Remote Control Switch |
| 3. Heater for Compartment Interior | 9. SEL-75I Feeder Protection Relay (optional) |
| 4. Humidistat / Thermostat | 10. FT Style Test Switch (when present) |
| 5. Individual Phase Trip Pushbuttons for Commissioning | 11. SEL-735 Power Quality and Revenue Meter (optional) |
| 6. Breaker Open / Close Indication LEDs | 12. FT Style Test Switch (optional) |
| | 13. Breaker Control Module |

Relays and Metering

The Federal Pacific GridConnex equipment uses the Schweitzer SEL-751 relay for feeder protection. Comprehensive protection capabilities, including time overcurrent, directional overcurrent, auto-reclosing, over-/undervoltage, frequency, cable/line thermal, and more.

Standard offering includes:

Directional Power Detection

2x16 LCD with 4 Push Buttons

Ethernet and EIA-485 communications with optional Multi-Mode Fiber ST

Current Inputs (Optional Voltage Inputs)

LEA Vsync / Vbat (300Vdc / 4 Arc-Flash Detection Inputs (Optional)

Meets IEC 60255-26:203, IEC 60255-27:2013, UL 508, CSA C22.2 No. 14-05

UL Listed to U.S. and Canadian Safety Standards.



Revenue Grade metering is accomplished by incorporating Metering class CTs and VTs with the Schweitzer SEL-735 meter. The SEL-735 ensures high-accuracy measurements with a ± 0.06 percent watt-hour (Wh) guarantee at unity power factor and a ± 0.02 percent typical rating.

Standard offering includes:

Basic PQ and recording 128MB, 16 Channels of LDP, 1 kHz waveform, 270 VSSI summary events, and up to 15th-order harmonics

Form 9 (Four-Wire Wye, 3Ps 3 CTs Meter Form)

Ethernet and EIA 485 Communications

Current and voltage inputs optimized for low-end accuracy

Various supported communication protocols including Standard SEL ASCII, SEL LMD, SEL FastMeter, SEL Compressed ASCII, MV-90 Transition, Modbus RTU/TCP, Mirrored Bits Communications, Telnet, DNP3 Level 2 Outstation and LAN/WAN, and Syncrophasors.

Meets ANSI C12.1-2014, IEC 62052-II:2013.

UL Listed to U.S. and Canadian Safety Standards.



Electro-Mechanical Overview

Electro-Mechanical is an American-owned company founded in 1958. It is headquartered in Bristol, Virginia (USA) and for more than 60 years has manufactured a wide variety of products used in the generation, transmission, distribution and control of electricity. These products, along with various electrical equipment repair and maintenance services, are used by a diverse mix of Energy (coal, oil, and gas), Electric Utility and Industrial customers worldwide. Federal Pacific medium-voltage metering, collector, and gird connection gear for the renewable markets is offered under the GridConnex® trade name.

Electro-Mechanical has earned a “customer oriented” reputation by keeping its focus on providing the best value to its customers through quality products and services. With six manufacturing companies and two repair and service companies, Electro-Mechanical has over 650,000 square feet of modern manufacturing facilities, located in Virginia and Mexico.

Electro-Mechanical consists of:

Federal Pacific - Dry-type transformers from .050 KVA through 10,000 KVA single and three phase, up to 25 kV, 110 kV BIL with UL® approval through 15 kV; Vacuum pressure impregnation and vacuum pressure encapsulation. Medium voltage switchgear including air-insulated live-front, dead-front, SCADA-controlled, automatic transfer, primary metering and wall-mounted pad-mounted and metal-enclosed switchgear. The quality systems of Federal Pacific have been certified by DQS Inc. to the ISO 9001:2015 Standard.

Line Power Manufacturing - Custom engineered electrical distribution and control apparatus including low and medium voltage metal-enclosed switchgear, power control centers, motor controls, and substations. Electrical power distribution systems and components used in mining. The quality systems of Line Power have been certified by DQS Inc. to the ISO 9001:2015 Standard.

MAFESA - Electro-Mechanical's manufacturing facility in Mexico for stock low-voltage transformers.

Engineered Solutions - Innovative engineered solutions are offered by Federal Pacific and Line Power meeting specific customer application needs. Products include custom medium voltage switchgear serving data centers and renewable energy, switchgear value propositions, and portable substations.

Line Power Parts & Rebuild - New parts, complete electrical equipment remanufacturing and onsite electrical equipment service. The parts service department provides replacement components manufactured by Electrical Group companies as well as commonly used OEM parts.

Mirus International, Inc. - Designs and develops world class power quality improvement products for mission critical operations. Our specialized product line includes highly efficient harmonic filters, transformers, autotransformers and Data Center power distribution equipment. Mirus' solutions minimize disruption to the power supply, improve reliability and adhere to the strictest of regulatory requirements while also saving energy and reducing operating costs.



Federal Pacific



Line Power Manufacturing



Mirus International

Federal Pacific Switchgear Products

Live-Front Pad-Mounted Switchgear - 15 kV • 27 kV
Manual, Automatic Transfer, Remote Supervisory Controlled Models
Live-Front/Dead-Front Pad-Mounted Switchgear - 15 kV • 27 kV
Manual, Automatic Transfer, Remote Supervisory Controlled Models
Dead-Front Pad-Mounted Switchgear - 15 kV • 27 kV
Manual, Automatic Transfer, Remote Supervisory Controlled Models
Pad-Mounted Capacitor Banks
Primary Metering Dead-Front Pad-Mounts - 15 kV • 27 kV • 38 kV
Fused Sectionalizer Dead-Front Pad-Mounts - 15 kV • 27 kV
Metal-Enclosed Switchgear - 5 to 38 kV
Manual, Automatic Source Transfer, Remote-Supervisory Control, Shunt Trip
Wall-Mounted Equipment - 15 kV • 27 kV
Wall-Mounted Switch Cabinets, Wall-Mounted Fuse Cabinets
Unit Substations - 5 to 38 kV
Vacuum Reclosers - 15 kV
Custom-Engineered Products - 5 to 121 kV
Portable Substations - Trailer, Skid and Track Mounted
Components
Micro-Processor and Stored-Energy Switch Operators, SCADA-Controlled Switch Operators

Federal Pacific Dry-Type Transformer Products

Industrial Control - 50 through 750 VA
Encapsulated 600 Volt Class
Three-Phase 3 through 15 kVA • Buck-Boost 50 VA through 5 kVA • Single-Phase 50 VA through 25 kVA
Ventilated 600 Volt Class
Single-Phase 15 through 167 kVA • Three-Phase 15 through 1000 kVA • K-Factor Rated
Three-Phase 15 through 500 kVA • Motor Drive Isolation Three-Phase 7.5 through 750 kVA
High Voltage General Purpose
Three-Phase 2.4 and 5 kV Class, 15 through 1500 kVA • Three-Phase 8.6 and 15 kV Class, 112.5 through 1500 kVA
Pad-Mounted
Single- and Three-Phase 2.4, 5 and 15 kV Class, 112.5 through 2500 kVA
Unit Substation and High Voltage Power
Three-Phase 2.4 through 25 kV Class, 112.5 through 10000 kVA High Voltage General Purpose
Three-Phase 2.4 and 5 kV Class, 15 through 1500 kVA • Three-Phase 8.6 and 15 kV Class, 112.5 through 1500 kVA
Vacuum Pressure Impregnated (VPI) and Vacuum Pressure Encapsulation (VPE)
600 Volt Class through 25 kV Class, 112.5 through 10000 kVA
Specialty Transformers
600 Volt Class through 25 kV Class, 50 VA through 10000 kVA
ABS Certified Marine Duty Transformers for Marine, Petro-Chem and Offshore Applications

