

TYPE PVE DEADFRONT VACUUM INTERRUPTER PAD-MOUNTED SWITCHGEAR 15kV • 25kV



Figure 1. Federal Pacific PVE Models Incorporate Vacuum Interrupters With Visible Disconnects Into a Rugged Heavy-Gauge Steel Enclosure Featuring Air-Insulated, Dead-Front Construction.

Featuring:

- Visible Disconnect on Each Vacuum Interrupter
- Vacuum Interrupter Switches – 200 amp and 600 amp
- Resettable Vacuum Fault Interrupters – 200 amp and 600 amp
- Electronic Trip Control of Vacuum Fault Interrupters
- Three-Phase Switching & Fault Protection
- Two-Way and Multi-Way Configurations
- Front Access or Front and Rear Access
- External Manual or Motor-Operation
- 200 amp Bushings Wells
- 600 amp Bushings
- Insulated Main Bus

Federal Pacific PVE Models of Pad-Mounted Switchgear combine air-insulated vacuum load-break interrupters for switching of primary feeders with air-insulated vacuum fault interrupters for protection of lateral load-feeder circuits. These vacuum switching and protection components are arranged in a variety of circuit configurations to provide the range of choices typically available in all other types of pad-mounted switchgear, including manual, supervisory-controlled, automatic-transfer and automatic sectionalizing (self-restoring) models. The vacuum interrupters are enveloped in a rugged 11-gauge steel enclosure with cable connections through 600 ampere bushings or 200 ampere bushing wells achieving a dead-front design with high-voltage components isolated from the environment by a galvanized-steel floor plate.

There is a choice of manual or electronically controlled tripping on all vacuum interrupters, which also feature an integral visible disconnect, providing the optimum arrangements for distribution system switching, protection and isolation applications.



Figure 2. Federal Pacific's 15kV, 600 ampere magnetically-actuated vacuum fault interrupter switch for use with a self-powered relay includes an integral visible disconnect. Disconnect shown closed.

Federal Pacific is the design innovator that has continued to develop and introduce superior medium-voltage switching and protection products for the electric power industry for over 50 years. Always pursuing functional configurations with operational considerations paramount, Federal Pacific is the industry leader that provides essential and exceptional features that keep competitors focused and following its lead.



Figure 3. Federal Pacific's 15kV, 600-ampere vacuum fault interrupter with visible disconnect for use with overcurrent relays that require external control power. Disconnect shown closed.

Vacuum Interrupters With Visible Disconnects, Both User Friendly and Environmentally Friendly

Federal Pacific's VIVD® (vacuum interrupters with visible disconnect) technology is the ultimate in environmentally secure switchgear incorporating air-insulated vacuum interrupters. The enclosure controls moisture, restricts entry of airborne contaminants, prevents penetration by animals and the curious while also ensuring security for operating personnel (by providing a visible gap after the vacuum interrupter opens) and the public (by eliminating exposure to hazardous materials or conditions).

VIVD's® revolutionary configuration solves the dilemmas not previously addressed by all other insulating mediums whether liquid-filled, gas-filled or solid-dielectric equipment... namely, providing an environmentally friendly insulating and isolating medium.

Liquid Insulation Mediums

Liquid dielectrics, whether-or-not they are biodegradable, have the propensity to ignite under the influence of an electrical arc, which reaches many thousands of degrees, creating an environmental and personnel hazard. In addition, liquid dielectrics consume resources that are best saved for use in other energy and food applications. Furthermore, the insulating property of liquid dielectric must be closely monitored to verify its quality and integrity and freedom from contamination by moisture and particulate material.

Liquid dielectrics are very heavy materials and, therefore, require high-capacity moving and handling equipment as well as substantially reinforced sub-structures on which to place them for installation or other mountings.

Gas (SF6) Insulation Mediums

Gas-filled units nearly always utilize sulphur hexafluoride (SF6), which is identified as the worst green-house gas that threatens the global environment. Equally detrimental as a severe health hazard, SF6 gas will form carcinogenic materials when it is exposed to an electrical arc. The high temperature of the electrical arc breaks down the SF6 gas into products that have been proven to cause cancer. The quality and quantity of SF6 gas within an interrupting chamber must be closely monitored and assured prior to performing any switching operation to avoid an eventful failure if insufficient gas is present or if it has become contaminated by moisture.

Equipment utilizing SF6 gas cannot be sealed to completely eliminate leakage of the gas, consequently refilling is inevitable and facility to remove and refill must be provided. Another concern and consideration is that reclamation equipment for housing SF6 when repair or replacement is necessary is expensive and cumbersome. The Federal government has implemented ever increasing stringent reporting requirements on the use and emissions of SF6 gas into the environment. Therefore, it is evident that the handling and disposal of equipment containing SF6 will gain increasing scrutiny in the future.

Solid-Dielectric Mediums

Units that incorporate solid materials, such as rubber and epoxies, as the insulating medium also present detrimental impact on the environment and may have a hidden potential to develop disruptive failures. These compounds, rubber and epoxies, do not biodegrade in any reasonable time frame and are therefore materials that are harmful to the environment. Furthermore, these compounds require considerable energy to manufacture, consuming resources that are better utilized for other applications.

Solid-dielectric material typically are employed to encapsulate vacuum interrupters. But, these encapsulated interrupters have not been successfully integrated with a visible disconnect that does not compromise the operational security and ease of operation afforded by insulation in air. Also, the additional space required to add a visible gap may compromise the smaller footprint afforded by the solid-dielectric design.

Air-Insulated Mediums

Air as an insulating medium is replenishable and self-renewing and thereby avoids the inherent hazards associated with every other insulating medium. Air is a naturally occurring compound that does not deplete or consume other energy resources in its production. An air-insulated electrical component does not require a refill valve, a pressure indicator or a volume level gauge. Air involved in an electrical arc does not develop any hazardous properties. Air is the most economical insulating medium. Air is the ultimate green-energy technology for switching and protection on electrical power distribution circuits.

Since air is an environmentally neutral medium, it is successfully used in the widest range of applications to provide insulating properties that are fully effective when combined with appropriate design controls. In-air insulation, manifested in the VIVID® technology, provides the visible open gap not offered by most other varieties of switchgear with vacuum interrupter technology. Each group-operated vacuum interrupter is integrated with a three-pole, group-operated visible disconnect. The integrated arrangement has the vacuum interrupter mechanically and electrically interlocked

with the visible disconnect such that the disconnect cannot be opened until after the vacuum interrupter has opened to interrupt the circuit. Furthermore, similar interlocking makes certain that the vacuum interrupter cannot be closed until after the visible disconnect is closed.

Eliminating reliance on liquid (oil), gas (sulphur hexafluoride—SF6), and solid materials (rubber and epoxy) as encapsulating and insulating materials, and utilizing air as a dielectric medium in a controlled environment, VIVID® Technology Switchgear is the leading-edge green technology revolutionizing distribution system reliability while providing unsurpassed operational flexibility.

VIVID® Technology Switchgear . . . Enhances Reliability with Air-Insulated Vacuum Interrupters

With over fifty years of design, development and manufacturing experience in the electric power industry, Federal Pacific brings its PVE line of switchgear products and components to enhance the security and reliability of underground distribution systems. The major components of Federal Pacific's VIVID® technology system include an air-insulated load-break vacuum interrupter switch for switching of main-primary feeders, air-insulated vacuum fault interrupters for switching and fault protection on distribution lateral load-feeder circuits, visible disconnects on all vacuum interrupters for confirming circuit isolation, trip-free operating mechanisms for instantaneous circuit interruption if closed onto a fault and an electronic sensing package for reliable tripping fault interrupters in response to overcurrent conditions.

Vacuum Interrupters

Since its first use in the 1920's, vacuum technology has become the interrupting medium of choice.

Vacuum circuit breakers have nearly 60 years of service in the severest of environments. Vacuum interrupters are efficient with a very low failure rate and are maintenance free. Vacuum technology issues no damaging ozone-depleting emissions. Vacuum interrupters contain all interrupting materials preventing any ionized gases from causing flashover of insulators to ground or phase-to-phase.



Figure 4. Federal Pacific's 15kV manually-operated vacuum interrupter with visible disconnect. Shown with disconnect open.



Figure 5. Federal Pacific's 27kV vacuum fault interrupter with motor operator.



Vacuum interrupters separate a set of contacts within an evacuated chamber. Vacuum interrupters are extremely compact and the circuit interruption process is virtually silent, with any noise associated with the operating mechanism. All of the materials used are benign to the environment. The vacuum chamber is of a ceramic material. Metals of various types comprise the contacts, shields and terminals. The interrupting capability of vacuum interrupters can exceed the mechanical capability of the operating mechanisms.

Contact technology enhancements have made vacuum interrupters the dependable preferred methodology for circuit interruption. With vacuum interrupters there are no gases discharged to contaminate adjacent components or the dielectric. Vacuum interrupters can be mechanically reset easily so there are no components to be replaced after an operation. Vacuum interrupters are capable of an exceptionally large number of mechanical and electrical operations before service may be necessary, if ever.

Vacuum Fault Interrupters

Federal Pacific's 15kV vacuum fault interrupters are available with continuous current ratings to 1200 amperes and short-circuit interrupting ratings to 18,000 amperes rms symmetrical, 28,800 amperes rms asymmetrical. And, Federal Pacific's 25kV vacuum fault interrupters are available with continuous current ratings to 600 amperes and short-circuit interrupting ratings to 12,500 amperes rms symmetrical, 20,000 amperes rms asymmetrical.

Federal Pacific combines three (3) vacuum interrupters with an operating mechanism to achieve three-phase load-break operation and avoid single phasing. With three-phase operation, vacuum interrupters virtually eliminate the possibility of ferro-resonance that may occur with single-

phase operation of lightly loaded circuits. In addition, the superior vacuum dielectric in the interrupter makes the possibility of restrikes and flashovers negligible. An operating mechanism combined with a reliable vacuum load-break interrupter insures the durability of the switching device over the anticipated life of the switchgear.

The vacuum fault interrupters are high-precision hermetically sealed contact systems that provide an effective, efficient means to interrupt rated fault currents. This capability has been proven in testing to ANSI/IEEE C37.60 which requires 116 fault interrupting operations over various percentages of the symmetrical short-circuit rating. All vacuum fault interrupters include an integral visible disconnect and an independent wear indicator on each phase, plus each phase has the capability to be independently adjusted to achieve proper contact pressure.

The exceptional switching and fault-closing capabilities of vacuum fault interrupters makes "fault hunting" more practical than ever before. And, the trip-free functionality of vacuum fault interrupters allows interrupters to immediately open when closed on a fault. That trip-free capability of vacuum fault interrupters minimizes exposure to excessive overcurrents and heating that shorten life-cycle operations due to insulation breakdown.

The vacuum interrupters are high-precision hermetically sealed contact systems that provide an effective, efficient means to interrupt load currents. These interrupters have the capability to interrupt the rated load current for up to 10,000 operations.

Visible Disconnects

Personal security is an important consideration in the development of all switches and fault interrupters. One of the primary advantages air-insulated equipment has over liquid-filled, SF6-filled and solid-dielectric equipment is the ability to provide a superior integral visible disconnect. Air-insulated switchgear avoids the necessity to compromise the visible disconnects. Liquid-filled designs either utilize a semaphore signal or an obscure arrangement viewed through a distorting liquid. Similarly, SF6-filled designs either utilize a semaphore or a less visible disconnect arrangement, which if in the gas medium has the potential to leak and create hazardous materials when an event occurs across the open gap – a real possibility for units that are known to leak and lose dielectric. A viable visible disconnect has not been developed for solid-dielectric designs, which if not imbedded in the dielectric material will either be expensive or compromise the advantage of solid dielectric if it remains in an air environment.



Figure 8. Federal Pacific's Visible Disconnect (shown open) is available on all Federal Pacific Vacuum Interrupter Switches and Vacuum Fault Interrupters.

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 lightweight, homogeneous and readily molded by the 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. To ensure the long-term survivability of Federal Pacific bushings and bushing wells, every individual unit is x-rayed in a 360° top-to-bottom examination to insure the integrity of the insulation. 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.



Figure 9. Federal Pacific cycloaliphatic bushings and bushing wells have all copper conductors and silver-plated removable studs. Semi-conductive coating isolate bushings and dust covers protect high-voltage interfaces.

Overcurrent Protection

Federal Pacific's vacuum fault interrupters response to overcurrents occurring on load-feeder circuits is controlled by either a self-powered relay (see Figure 10) that energizes a magnetic latch to trip the vacuum fault interrupter or by an SEL-501 Dual Universal OCR (see Figure 11) or similar overcurrent relay (OCR).

The self-powered relay in combination with the magnetic latch is utilized when vacuum fault interrupter operation is to be performed manually using the manual operating handle mounted on the side of the pad-mounted switchgear (or the manual trip-open button on the faceplate). Power for the relay is generated by the current transformers used for sensing the overcurrent.



Figure 10. The self-powered relay components include (1) the relay that provides all the settings and controls necessary to initiate vacuum circuit-breaker operations based on the programmed parameters, (2) the magnetic actuator pictured that provides mechanical trip-actuation of the vacuum circuit-breaker mechanism and (3) the current-sensing transformer that provides sensing and power input to the relay and trip circuit.

The SEL-501 relay (see Figure 11) requires that control power always be available and is used when the vacuum fault interrupter is to be motor-operated and also requires a UPS so that operations can be performed even when control power is lost. The relay and motor will then be powered by a control-power source, typically a voltage transformer. The SEL-501 relay provides overcurrent response for two vacuum fault interrupters in a single compact package. The relay is readily programmed to provide the specific relay curve that is desired for the particular application.

Current transformers provide overcurrent sensing as input to the relay. Reliability of the current transformers has been demonstrated over many years of service in all types of environments from the very hot to the very cold.

Federal Pacific vacuum fault interrupters are trip free. When closed on a fault, the vacuum fault interrupter will immediately open to clear the circuit.

Motor Operators

Federal Pacific vacuum interrupters can be optionally equipped with integral motor operators. When motor operated, the units are suitable for integration with additional appropriate control systems for application in automatic-source-transfer, automatic-sectionalizing, remote-supervisory-control and shut-trip schemes.

Federal Pacific motor operators are installed directly on the frame of the vacuum interrupter. The integrated compact arrangement of motor operators with vacuum interrupters means that very little additional space is required for applications requiring automation.

Optional controls are also available to permit motor operation and all tripping functions to be performed from a local but isolated location. By operating the unit by means of such a local, portable control station will eliminate concerns over exposure to arc-flash hazards.



Figure 11. Overcurrent Protection is provided using The SEL-501 Dual Universal OCR (see above left). Each OCR relay control can handle two vacuum fault interrupters. A UPS (at bottom in above left photo) is included to make certain control power is always available for operation of the relay to trip the vacuum fault interrupter in response to a fault a UPS is included. A current transformer (see above right) is used to sense the overcurrent condition and provide that input to the SEL-501 relay.

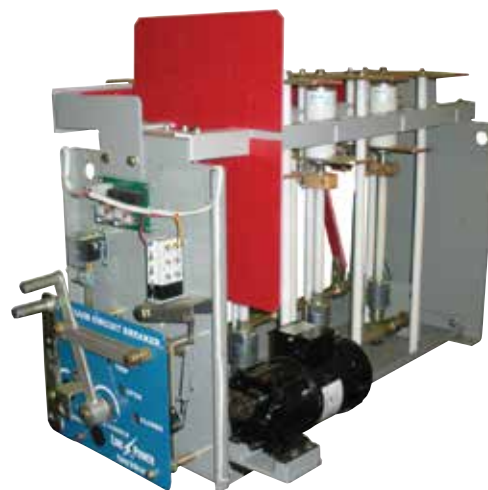


Figure 12. Motor Operators can be added to all federal pacific vacuum interrupters as pictured at the bottom right on the 15kv vacuum fault interrupter above.

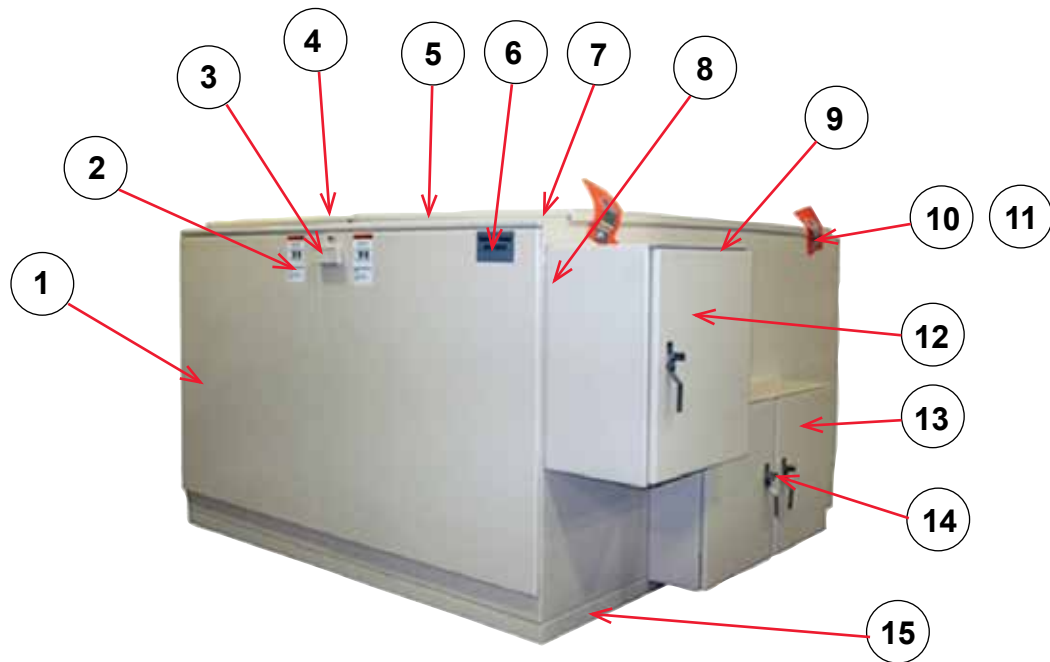


Figure 13. Enclosure Exterior of Federal Pacific PVE Vacuum Interrupter Pad-Mounted Switchgear.

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| 1. 11-Gauge Steel Doors | 10. Galvanized-Steel Lifting Brackets |
| 2. Hazard-Alerting Warning Signs on Exterior | 11. Closed-Cell Cushions Isolate Enclosure From Lifting Bracket |
| 3. Hinged, Stainless-Steel Door Lockbox | 12. Vacuum-Interrupter Electronic-Control Compartment |
| 4. One-Piece, Cross-Kinked 11-Gauge Steel Roof | 13. Vacuum-Interrupter Manual-Control Compartments |
| 5. Insulating No-Drip Compound on Underside of Roof | 14. Stainless-Steel Handles on Control Compartments |
| 6. Silk-Screened, Aluminum Stamped Nameplate | 15. Closed-Cell Gasket at Bottom Isolates Enclosure From Mounting Surface |
| 7. 11-Gauge Steel Welded Enclosure | |
| 8. Control Compartments Sealed to Enclosure | |
| 9. Drip-Shield Over Control Compartments | |

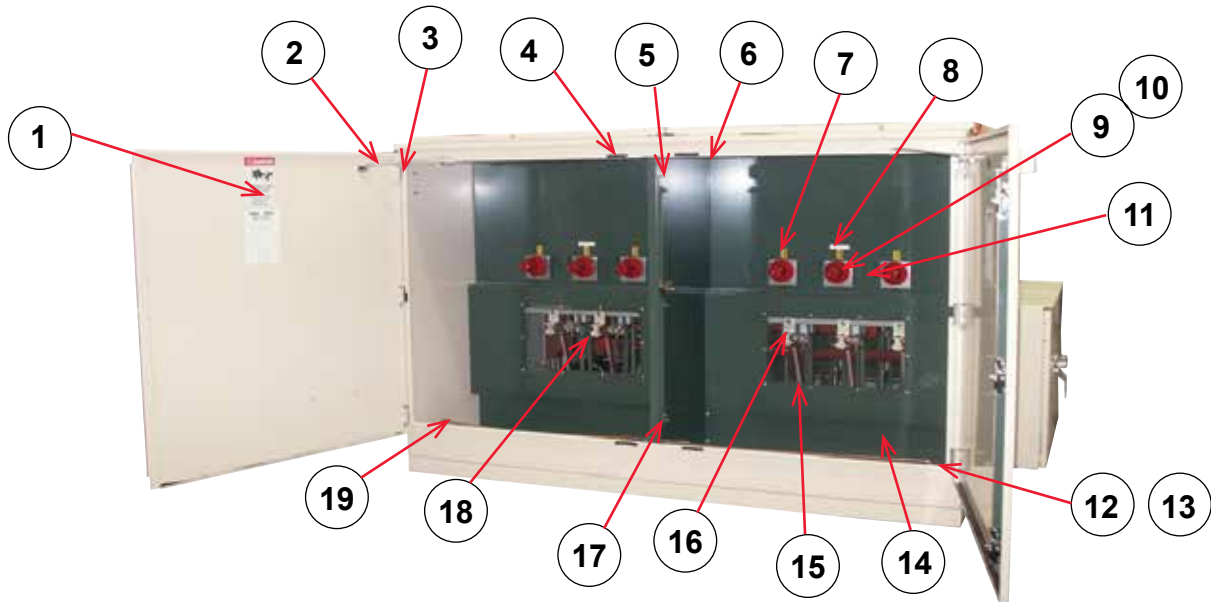


Figure 14. Incoming Termination Compartments of Vacuum Load-Break Switched Ways.

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| <ol style="list-style-type: none"> 1. Hazard-Alerting Danger Signs on Interior 2. Stainless-Steel Windbrace 3. Three (3) Stainless-Steel Hinges and Hinge Pins Per Enclosure Door 4. Bumper Gasket Cushions Door Interface, Prevents Metal-To-Metal Contact 5. Center Steel Divider Isolates Termination Compartments 6. Closed-Cell Gasket Seals Roof to Equipment-Mounting Panel 7. Phase Identification Labels 8. Compartment Identification Labels 9. 600 Ampere Cycloaliphatic Epoxy Bushings With All-Copper Conductor on Stainless-Steel Clamping Bracket 10. Removable Silver-Plated All-Copper Stud on All Bushings With Red Protective Dust Covers | <ol style="list-style-type: none"> 11. Stainless-Steel Parking Stand for Each Bushing 12. Cross-Kinked, Galvanized-Steel Floor Plate Isolates Vacuum Interrupters and Bus 13. Stainless-Steel Screened 1" Vent in Each Corner of Floor Plate Allows Any High Ground Water or Flooding to Drain Out 14. Formed-Steel Equipment-Mounting Panels Isolate High-Voltage Components From Termination Compartments 15. Wide-View Clear Polycarbonate Window for Viewing Visible Disconnect on Vacuum Load-Break Switches 16. Vacuum Load-Break Interrupter Switches 17. Stainless-Steel Door-Latch Pins 18. Visible Disconnects for Vacuum Load-Break Interrupter Switches 19. Continuous Ground Bus in Vacuum-Switch Termination Compartments |
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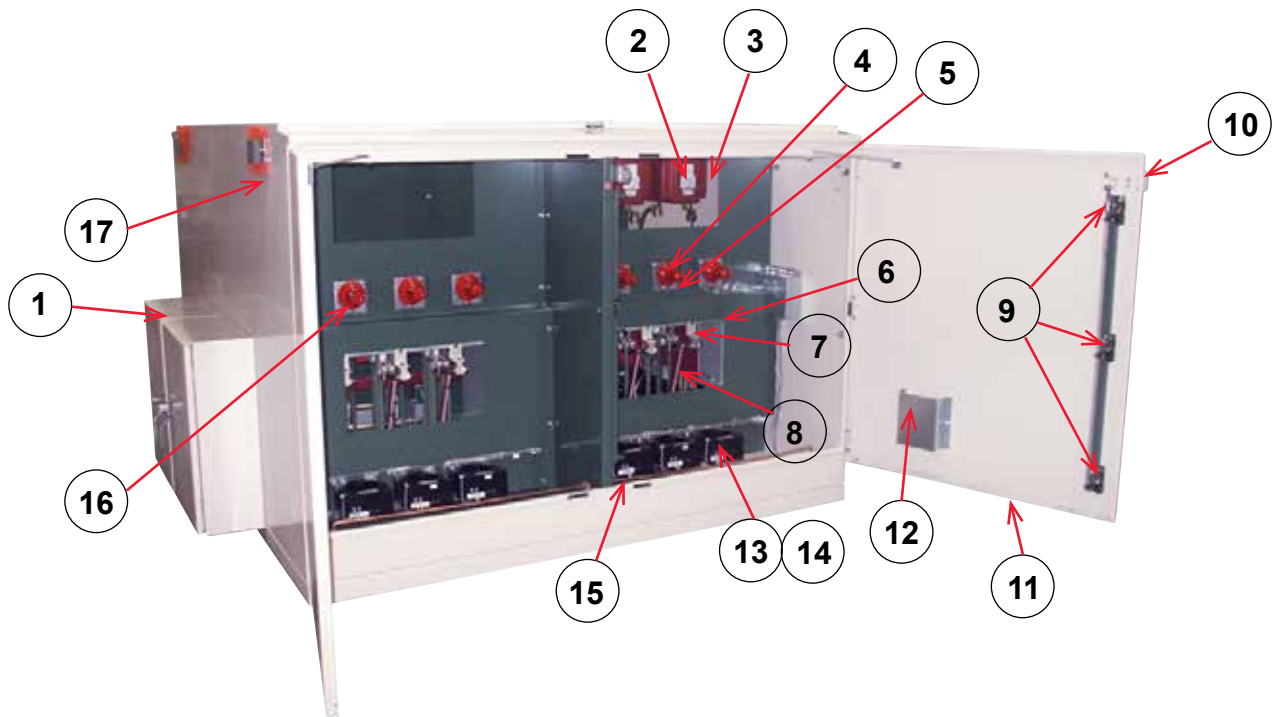


Figure 15. Load-Feeder Termination Compartments of Vacuum Fault-Interrupter Protected Ways.

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| <ol style="list-style-type: none"> 1. Compartments Provide Access to Manual-Operating Handles Of Vacuum Interrupters 2. Fused-Voltage Transformers for Sensing and Control Power for Relayed Vacuum Fault Interrupters 3. Viewing Window Provides Visibility and Access to Fused-Voltage Transformers 4. 600 Ampere Bushings for Fault Interrupters 5. Stainless-Steel Mounting Plate and Parking Stand For Each Bushing 6. Viewing Windows for Fault Interrupters 7. Vacuum Fault Interrupters 8. Visible Disconnect for Vacuum Fault Interrupters 9. Self-Latching and Resetting Three-Point Door Latches 10. Penta-Head Actuated Self-Latching Door Operating Mechanism | <ol style="list-style-type: none"> 11. Undercoating is Applied in Door-Flange Channel, Which Includes Drain Holes, to Provide Protection Against Accumulation of Contamination and Moisture 12. Storage Pocket 13. Current Transformers for Overcurrent Sensing on Vacuum Fault Interrupters (Optional Window-Type CTs Shown) 14. Optional Split-Core Current Transformers for Overcurrent Sensing 15. Continuous Copper Ground Bus Across Door Opening of Load-Feeder Termination Compartments 16. Optional 200 Ampere Bushing Wells to Replace 600 Ampere Bushings 17. Optional Mounting Provisions for Fault Indicators |
|--|---|

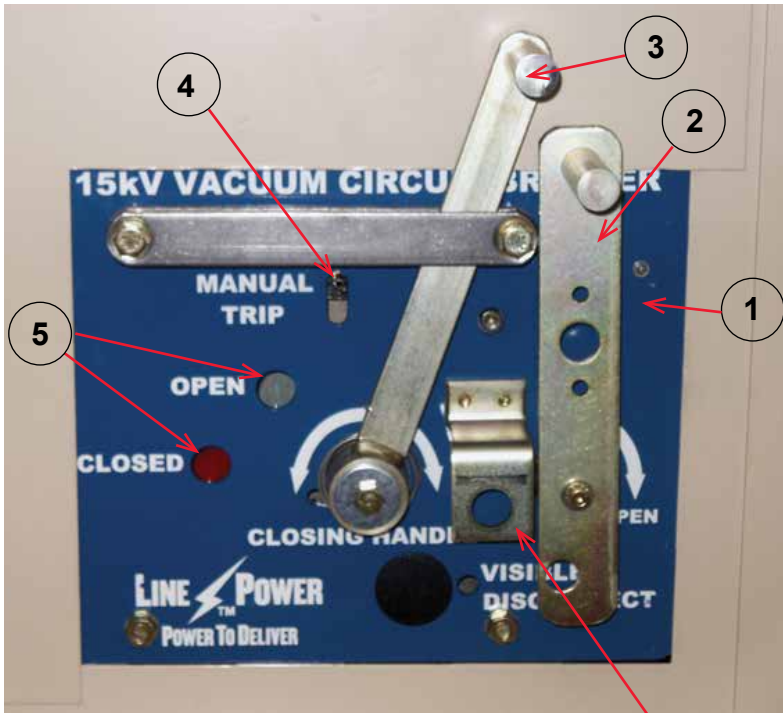


Figure 16. Faceplate of Vacuum Fault Interrupter.

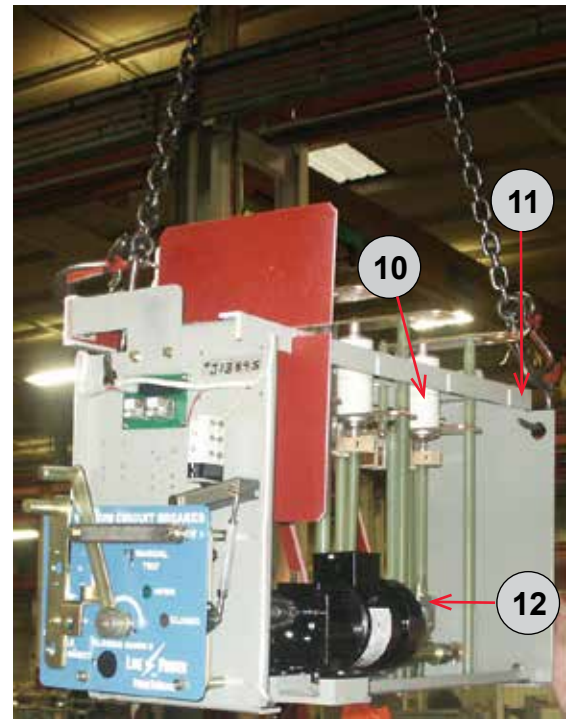


Figure 17. 15kV Vacuum Fault Interrupter with optional motor operator.

1. Faceplate is Silk Screened for Permanent Labeling (See Figure 13)
2. Visible-Disconnect Manual-Operating Handle
3. Vacuum Fault-Interrupter Manual-Operating Handle
4. Manual-Trip Open Operating Button
5. Vacuum Fault-Interrupter Open/Closed Position Indicators
6. Padlock Tab for Visible-Disconnect Manual-Operating Handle
7. Overcurrent Relay
8. Optional Motor Operator
9. Isolating Fiberglass Barrier
10. Vacuum Fault Interrupter
11. Insulated Phase Supports
12. Contact-Pressure Counter-Weight
13. Steel Mounting Frame
14. Undervoltage Relay
15. Shunt-Trip Relay

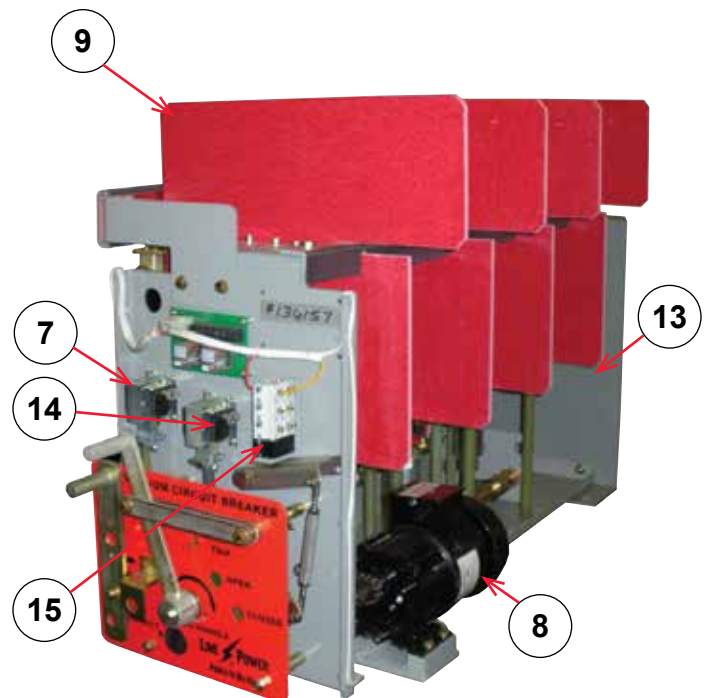
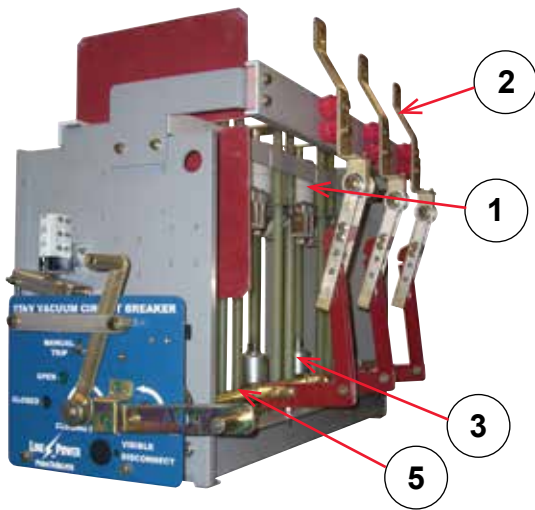


Figure 18. 27kV Vacuum Fault Interrupter with optional motor operator.



1. Load-Break Vacuum Interrupter
2. Outgoing (Load-Side) Contacts
3. Contact Pressure Counterweight
4. Visible-Disconnect Operating Link
5. Visible-Disconnect Operating Shaft
6. Stationary Contact For Visible Disconnect
7. Disconnect Blade Closed
8. Disconnect Blade Open

Figure 19. Vacuum Load-Break Interrupter Switch

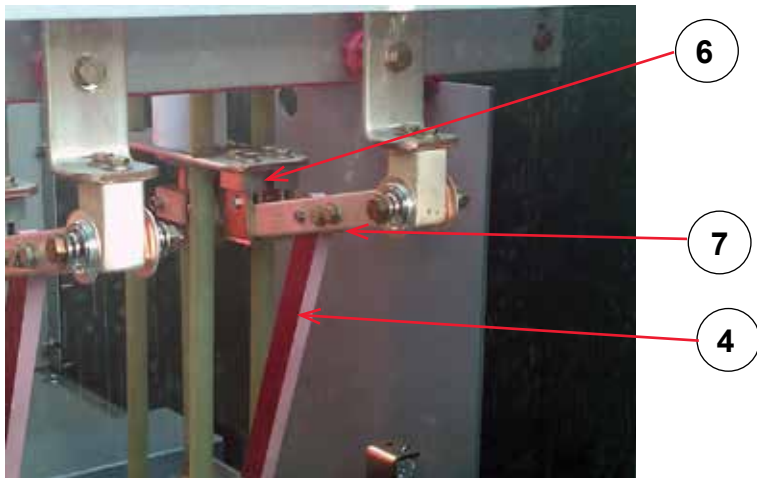


Figure 20. Integral Visible Disconnect – Disconnect Closed.



Figure 21. Integral Visible Disconnect — Disconnects Open.

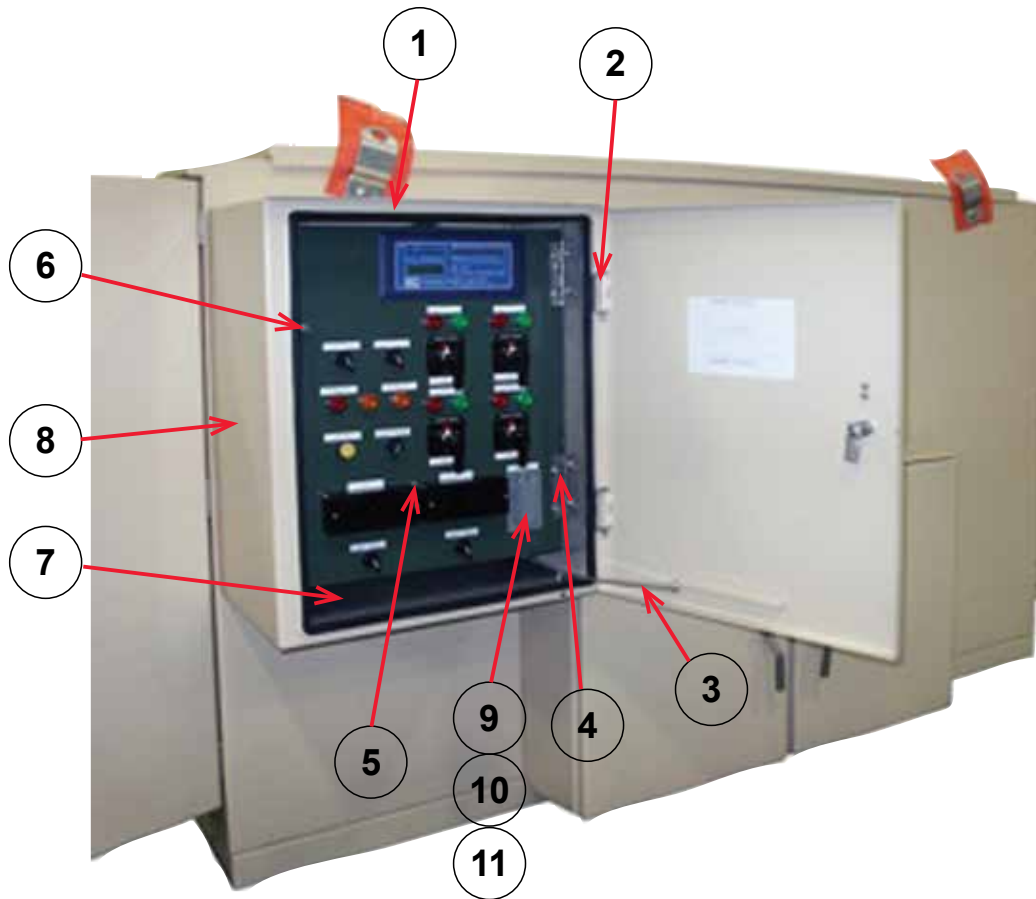


Figure 22. Features of Low-Voltage Enclosure for Relay and Controls. Configuration varies depending on specified requirements and relay used (shown with SEL-501 relay).

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| 1. Fully Gasketed Door Opening on Low-Voltage Control Compartments | 6. Captive Wing Nut Secures Relay Panel Closed |
| 2. Stainless-Steel Hinges and Hinge Pins on Control Compartment Doors | 7. Elevated Component Mounting Plate Eliminates any Contact with Moisture |
| 3. Self-Latching Wind Brace | 8. Heavy 11-gauge steel enclosure |
| 4. Stainless-Steel Hinges and Hinge Pins on Relay Panel | 9. Heater for Compartment Interior (not visible) |
| 5. Hinged Relay Panel Allows Easy Access to Internal Wiring and Components | 10. Internal Thermostat (not visible) |
| | 11. Internal Humidistat (not visible) |

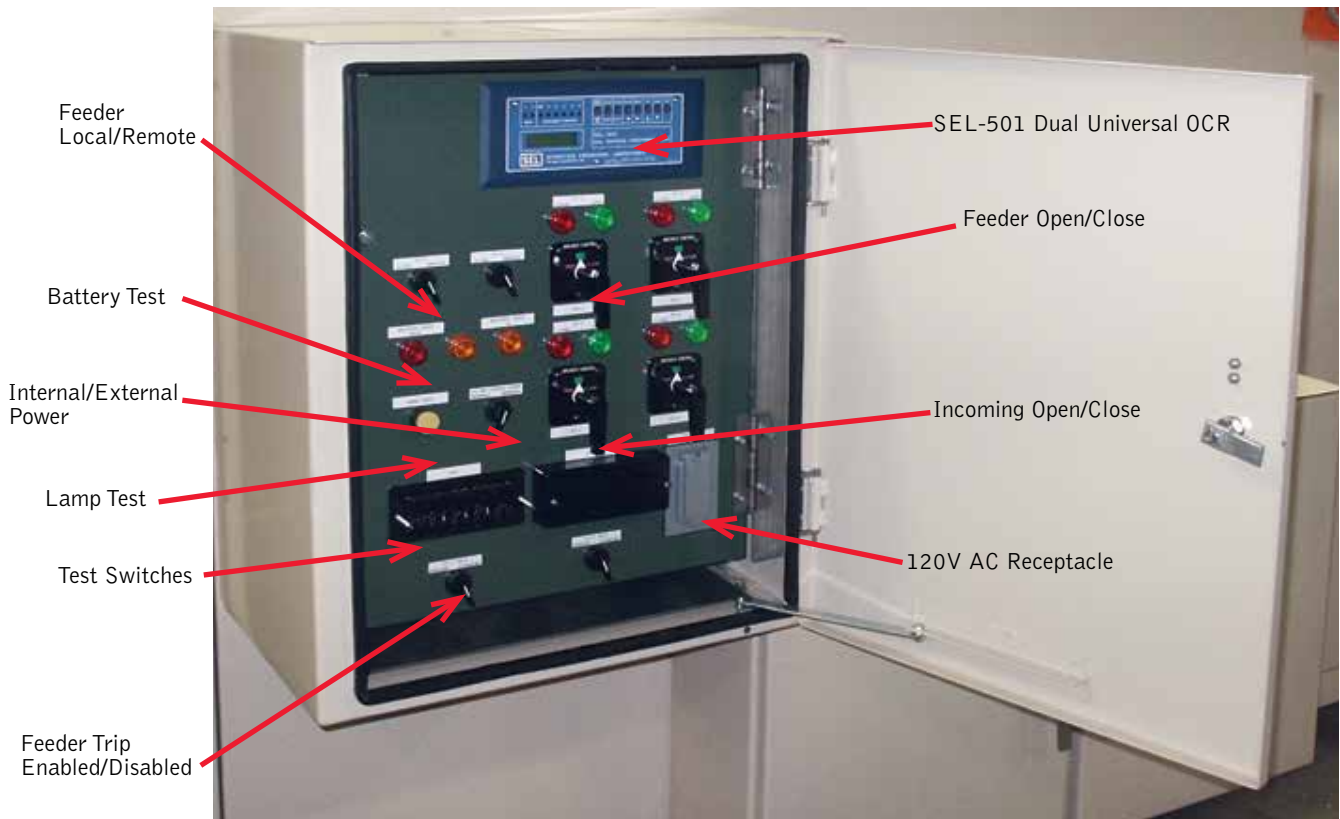


Figure 23. Relay and Control Compartment Component Identifications. Configuration varies depending on specified requirements and relay used (shown with SEL-501 relay).



SPECIFICATIONS

Applicable Standard	Maximum Voltage Class, kV	Frequency, Hertz	Lightning Impulse Withstand, (BIL) kV	AMPERES							
				Main Bus Continuous	Vacuum Fault Interrupter			Vacuum Load Interrupter Switch			1-Second Sym.
					Continuous Load Switching Loop Switching ①	Fault Closing, Sym.	Fault Interrupting, Sym.	Continuous Load Switching Loop Switching ①	Fault Closing, Sym.	Fault Interrupting, Sym.	
C37.60	15	50/60	95	600	600	12,500	12,500	200	12,500	12,500*	12,500
				600	600	12,500	12,500	600	12,500	12,500*	12,500
				1200	1200	18,000	18,000	1200	18,000	18,000	18,000
27	50/60	125	200	200	12,500	12,500	200	12,500	12,500	12,500	
			600	600	12,500	12,500	600	12,500	12,500	12,500	

① Units rated 200 amperes are furnished with 200-ampere bushing wells for connection of 200-ampere loadbreak inserts and separable insulated connectors. Vacuum Fault Interrupters and Vacuum Load Interrupters are rated 600 amperes.

* If integrated with relay control.

NOTE: For higher continuous current or fault current capabilities, contact the factory.

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