Type VFI, Fluid-insulated Switchgear; Installation, Operation and Maintenance Instructions

Powering Business Worldwide

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Safety for life

Eaton meets or exceeds all applicable industry standards relating to product safety in its Cooper Power™ series products. We actively promote safe practices in the use and maintenance of our products through our service literature, instructional training programs, and the continuous efforts of all Eaton employees involved in product design, manufacture, marketing, and service.

We strongly urge that you always follow all locally-approved safety procedures and safety instructions when working around high-voltage lines and equipment, and support our "Safety For Life" mission.

Safety information

The instructions in this manual are not intended as a substitute for proper training or adequate experience in the safe operation of the equipment described. Only competent technicians who are familiar with this equipment should install, operate, and service it.

A competent technician has these qualifications:

- Is thoroughly familiar with these instructions.
- Is trained in industry-accepted high- and low-voltage safe operating practices and procedures.
- Is trained and authorized to energize, de-energize, clear, and ground power distribution equipment.
- Is trained in the care and use of protective equipment such as arc flash clothing, safety glasses, face shield, hard hat, rubber gloves, clampstick, hotstick, etc.

Following is important safety information. For safe installation and operation of this equipment, be sure to read and understand all cautions and warnings.

Hazard Statement Definitions

This manual may contain four types of hazard statements:

DANGER

Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

NOTICE

Indicates a potentially hazardous situation which, if not avoided, may result in equipment damage only.

Safety instructions

Following are general caution and warning statements that apply to this equipment. Additional statements, related to specific tasks and procedures, are located throughout the manual.

DANGER

Hazardous voltage. Contact with hazardous voltage will cause death or severe personal injury. Follow all locally-approved safety procedures when working around high- and low-voltage lines and equipment. G103.3

WARNING

Before installing, operating, maintaining, or testing this equipment, carefully read and understand the contents of this manual. Improper operation, handling, or maintenance can result in death, severe personal injury, and equipment damage. G101.0

WARNING

This equipment is not intended to protect human life. Follow all locally-approved procedures and safety practices when installing or operating this equipment. Failure to comply can result in death, severe personal injury, and equipment damage. G102.1

WARNING

Power distribution and transmission equipment must be properly selected for the intended application. It must be installed and serviced by competent personnel who have been trained and understand proper safety procedures. These instructions are written for such personnel and are not a substitute for adequate training and experience in safety procedures. Failure to properly select, install, or maintain power distribution and transmission equipment can result in death, severe personal injury, and equipment damage. G122.2

Product information

Introduction

Service Information MN285006EN provides installation instructions, operation information, maintenance procedures, and limited testing information for Eaton's Cooper Power™ series Type VFI fluid-insulated underground distribution switchgear.

For in-depth testing information, refer to *Service Information MN285001EN VFI Tester Operating Instructions* for complete information regarding operation of the VFI tester and in-depth VFI underground distribution switchgear testing procedures.

Read this manual first

Read and understand the contents of this manual and follow all locally approved procedures and safety practices before installing or operating this equipment.

Additional information

These instructions do not claim to cover all details or variations in the equipment, procedures, or processes described, nor to provide directions for meeting every possible contingency during installation, operation, or maintenance. When additional information is desired to satisfy a problem not covered sufficiently for the user's purpose, please contact your Eaton representative.

Acceptance and initial inspection

VFI switchgear is completely assembled, tested, and inspected at the factory. The switchgear is filled to the correct level with insulating fluid. It is in good condition when accepted by the freight carrier for shipment.

1. Upon receipt, inspect the unit thoroughly for damage and loss of parts or fluid incurred during shipment. If damage or loss is discovered, file a claim with the carrier immediately.
2. Check for fluid leakage and tighten any bolts that may have loosened during shipment.

Handling and storage

The switchgear should remain on its shipping pallet until it is installed. When handling the switchgear, always use a fork truck that has adequate lifting capacity and forks that extend the entire length of the pallet. Improper handling can cause damage to the switchgear.

If the switchgear is to be stored for any appreciable time before installation, provide a clean, dry storage area. Be careful during handling and storage to minimize the possibility of mechanical damage. Do not stack other material on the switchgear.

Standards

Type VFI underground distribution switchgear products are designed and tested in accordance with IEEE Std C37.60™-2003, IEEE Std C37.74™-2003, IEEE Std C.57.12.28™-2005, and IEEE Std 386™-2006 standards.

Quality standards

ISO 9001 Certified Quality Management System

Product description

Type VFI switchgear provides fault interruption and convenient load switching for 15, 25, and 35 kV underground systems. VFI switchgear is designed for outdoor mounting on a concrete pad. Power is fed to and from the switchgear from underground through openings in the pad.

Deadfront construction minimizes the high-voltage safety hazards for both the operator and the general public.

Type VFI switchgear employs mineral oil, Envirotemp™ FR3™, or Envirotemp™ E200™ as the insulating medium to provide a compact, low profile installation.

NOTICE

The use of Envirotemp™ FR3™ dielectric fluid is limited to a minimum operating temperature of 0 °C (32 °F). Failure to comply can result in equipment misoperation.

T374.0

VFI switchgear can also be specified with a variety of control options to meet specific distribution system protection requirements

VFI switchgear operation

Type VFI switchgear utilizes vacuum interrupters to provide fault current interruption and load make/break switching capabilities. Hotstick-operable operating handles are located on the front plate of the unit. Vacuum fault interrupter operating mechanisms can be configured for either single- or ganged three-phase operation.

Current sensing transformers, located inside the switchgear tank, provide line current information to the control. When line current exceeds the minimum trip setting, the control initiates a signal which causes the vacuum fault interrupter to interrupt the circuit. Interruption may be single- or three-phase, depending upon the configuration of the control and vacuum fault interrupter.

Electronic control

Line current is sensed by internally mounted current sensing transformers. When current in excess of the minimum trip value is detected, the control initiates a signal which trips the faulted phase or phases, as applicable.

Refer to the applicable Installation and Operation manuals for control operation and setting procedures.

For Tri-Phase and TPG Controls:

- *MN285008EN: Tri-Phase, TPG and TPG with SCADA Electronic Control, Installation and Operation Instructions.*

For Edison Idea Relays:

- *CA165005EN: iTAP-265 Dual Overcurrent Relay*
- *Service Information S165-260-1, Use and Operations Manual for the iTAP-260 Underground Distribution VFI Switchgear Controller.*
- *CA165002EN: iDP-210 Feeder Protection Relay*

Loadbreak switch

In many configurations the Type RVAC switch is integrated within the VFI switchgear. Refer to the Operation section of *MN285005EN Type RVAC Fluid-Insulated Vacuum Switchgear; Installation, Operation, and Maintenance Instructions* for operation information for the RVAC switch.

Vacuum fault interrupters

Load and fault interruption takes place within sealed vacuum interrupters (**Figure 1**). Vacuum interrupters provide fast, low energy arc interruption and produce no arcing by-products to contaminate the insulating fluid.

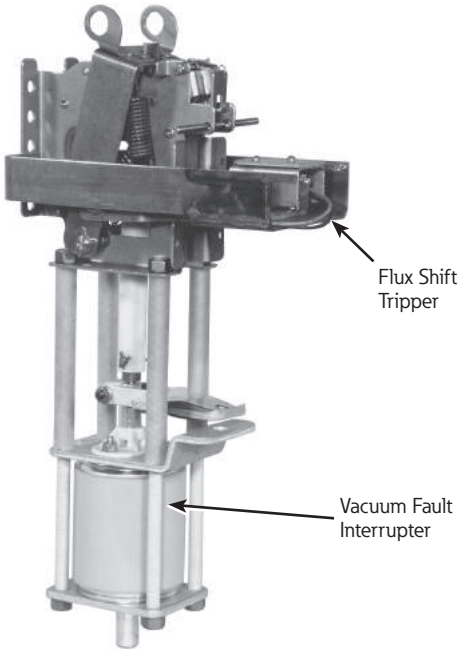

Figure 1. Vacuum fault interupter assembly

Bushings

600 A deadbreak aluminum type bushings, when furnished, conform to IEEE Std 386™-2006 standard. The standard 200 A interface for 15 and 25 kV class underground distribution switchgear is an Eaton's Cooper Power series 200 A bushing well. For 35 kV class, the standard 200 A interface is an Eaton's Cooper Power series 200 A one-piece loadbreak bushing. Both conform to IEEE Std 386™-2006 standard.

Bushings are mounted in-line and are located a minimum of 610 mm (24 inches) above the pad.

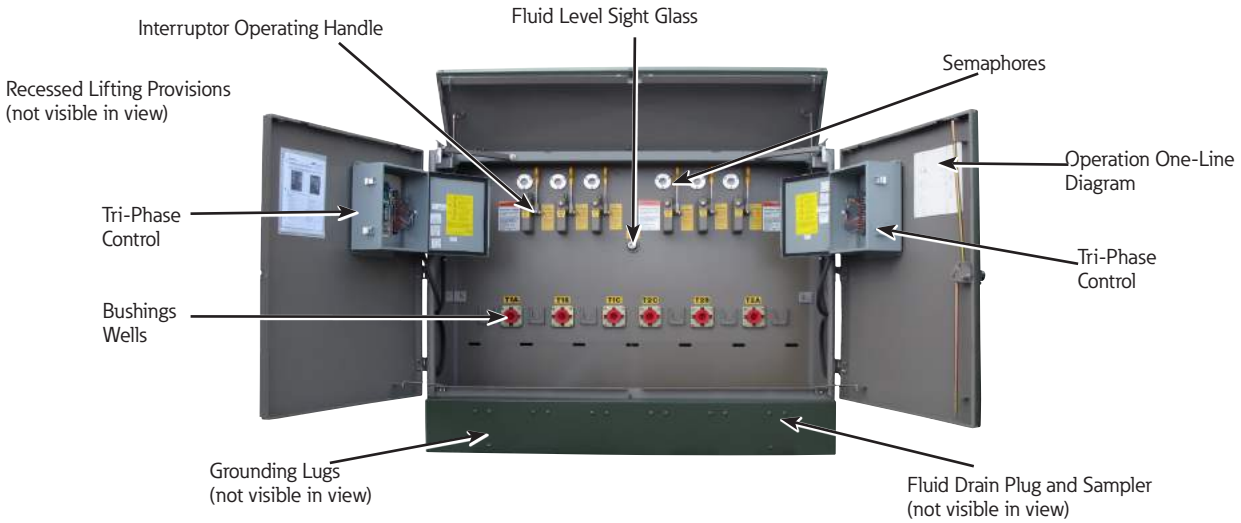

Figure 2. VFI switchgear components

Cabinet construction

Type VFI switchgear features deadfront, tamper-resistant, low-profile construction. It is suitable for operation in areas subject to excessive moisture, occasional flooding, and blowing snow. Cabinets meet the enclosure security requirements of IEEE Std C57.12.28™-2005 standard.

Top-hinged doors are provided with door stays and fitted with stainless steel hinges. On units wider than 1168 mm (46 in), split doors are provided to allow easy operation by one person. Side-hinged doors can also be provided as an option. Both source and tap doors can be fully open at the same time. Each door has a floating lock pocket with padlock provisions and a pentahead silicon bronze door bolt.

Tank construction is of 7- or 10-gauge steel and cabinets are made of 12 or 13-gauge steel. Recessed lifting provisions are provided at each corner of the tank for a balanced lift.

Table 1. Electrical ratings

Rating	5 kV	15 kV	25 kV	35 kV
Maximum Design Voltage, kV	15.5	15.5	27	38
BIL, kV	95	95	125	150
1-Minute Withstand (60 Hz) Interrupter* and Terminators, kV	35	35	60	70
Continuous Current (max), A	600	600	600	600
Interrupting Current (sym./asym.), kA	12/20	12/20	12/20	12/20
Momentary Current 10 cycles (asym.), kA	20	20	20	20
1-Second Withstand Current (sym.), kA	12	12	12	12
Making Current (sym.), kA	12	12	12	12
Transformer Magnetizing Interrupting Current, A	21	21	21	21
Cable Charging Interrupting Current, A	10	10	25	40

* The withstand rating of the switch is higher than that of the connectors per IEEE C37.74™ 2003 standard.

Padlocking provisions

Provisions are included for padlocking the cabinet in order to prevent unauthorized door opening. The cabinet must be locked at all times to prevent accidental contact with hazardous voltage.

Standard features

Standard features (refer to **Figure 2**) include a fluid level indicator, automatic pressure-relief valve, operation one-line diagrams on the doors, fluid fill plug, fluid drain and sampler and a standoff bracket for each bushing. Standard ground provisions include a 1/2-13 UNC stainless steel ground nut for each bushing.

Interrupter duty cycle

The vacuum fault interrupter mechanism conforms to the duty cycle requirements of IEEE Std C37.60™-2003 standard.

Switch test sequence

The vacuum fault interrupter operating mechanism conforms to the switch test sequence requirements of IEEE Std C37.74™-2003 standard.

Finish

VFI switchgear is finished in a green color which conforms to Munsell 7GY 3.29/1.5 Green. The coating conforms to the following specifications: IEEE Std C57.12.28™-2005 standard, ASTM B1117 1000- hour 5% salt spray corrosion test, ASTM D2247 1000- hour humidity test, ASTM G53 500-hour ultraviolet accelerated weathering test and ASTM D2794 impact test.

Nameplate

Prior to installation, be sure to check the switchgear nameplate on the tank front plate in the source side cabinet to verify that the voltage and current ratings are correct for the system on which the switchgear is to be installed.

Operating handles

⚠ DANGER

Hazardous voltage. Never rely on the open position of the operating handle or the contact position indicator; it does not ensure that the line is de-energized. Follow all locally approved safety practices. Failure to comply can result in contact with high voltage, which will cause death or severe personal injury. G123.1

⚠ WARNING

Hazardous voltage. Always use a hotstick when working with this equipment. Failure to do so could result in contact with high voltage, which will cause death or severe personal injury. G108A.0

The Type VFI switchgear is equipped with hotstick-operable handles that may be located on the tap- and/or source-side of the unit. The VFI switchgear can be configured for either single-phase or ganged three-phase operation (all three phases operated simultaneously with a single handle). The operating handle(s) (shown in **Figure 3** and **Figure 4**) provide convenient push-to-close and pull-to-open operation. The operating handle(s) may be padlocked in the open position. When configured for single-phase operation, each phase trips independently; however, the control may be configured to provide simultaneous tripping of all three phases.

Weight

The weight of the unit is shown on the nameplate. Make sure that lifting equipment used is rated sufficiently to safely handle the switchgear.

Special certifications

Units can be provided with a UL® listing and labeling depending on the features specified. Please ensure appropriate labeling is provided prior to installation for instances where a UL® listing is required.

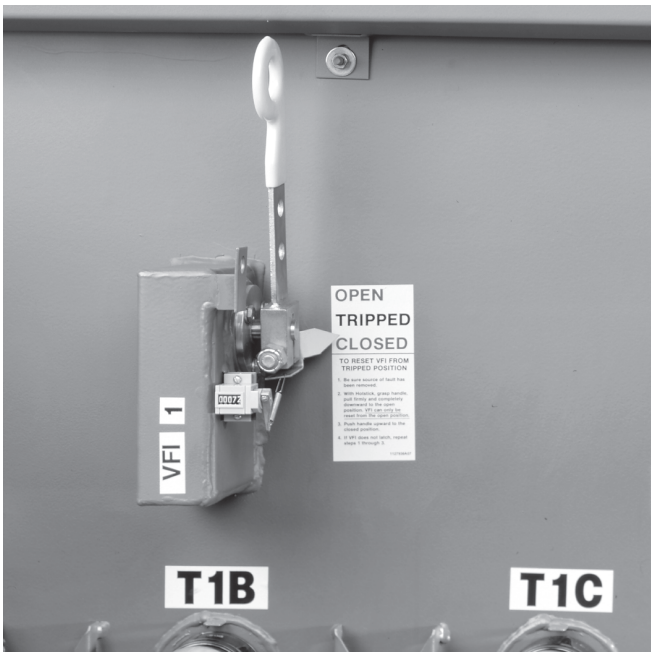

Figure 3. VFI switchgear operating handle, three-phase ganged operation

Figure 4. VFI switchgear operating handles, single-phase operation

Installation procedure

⚠ WARNING

This equipment is not intended to protect human life. Follow all locally approved procedures and safety practices when installing or operating this equipment. Failure to comply can result in death, severe personal injury, and equipment damage. G102.1

1. **Check fluid level.** Make sure the fluid in the switchgear tank is at the proper level by checking the fluid level indicator on the front plate(s). Some units have fluid level indicators on both source-side and tap-side front plates; both indicators should be at the proper level.

⚠ WARNING

This equipment relies on dielectric fluid to provide electrical insulation between components. The dielectric strength and moisture content of the fluid must be checked on a regular basis, as part of the routine maintenance inspection, to ensure that it is at or above minimum dielectric requirements and below the maximum moisture content. Use of this equipment with dielectric fluid that does not meet requirements can result in internal flashovers that will damage the equipment and can result in death or serious injury. G107.3

2. **Test fluid dielectric strength and moisture content.** If the switchgear has been stored for some time or is being relocated, perform these tests on the fluid in accordance with ASTM-approved testing procedures.

NOTICE

The use of Envirotemp™ FR3™ dielectric fluid is limited to a minimum operating temperature of 0 °C (32 °F). Failure to comply can result in equipment mis-operation. T374.0

A. In new equipment, the insulating fluid must have a minimum dielectric strength of 26 kV. If the dielectric strength of the fluid is less than 26 kV, process or replace the fluid to restore its dielectric strength to an acceptable minimum level.

B. Refer to the **Fluid testing** section of this manual for service recommendations based on the moisture content of the fluid.

C. For additional information on fluid specifications and tests, refer to Reference Data TD280022EN; Reclosers, Sectionalizers, Switches and to the **Fluid testing** procedures section of this manual.

3. **Check the nameplate ratings.** Make sure the ratings on the switchgear nameplate are correct for the planned installation.

⚠ WARNING

Falling equipment. Use the lifting lugs provided and follow all locally approved safety practices when lifting and mounting the equipment. Lift the unit smoothly and do not allow the unit to shift. Improper lifting can result in severe personal injury, death, and/or equipment damage. G106.3

NOTICE

Equipment damage. Never place jacks, tackle or other attachments under the unit for the purpose of lifting. Failure to comply will result in damage to the equipment. T240.0

4. **Mount switchgear on concrete pad.**

A. The switchgear must be installed on a level concrete pad or structure that has been designed to support the size and weight of the unit.

B. The switchgear must be hoisted only by the recessed lifting provisions provided at the four corners of the tank. Suitable lifting straps must be used to prevent damaging the switchgear housing.

⚠ WARNING

Hazardous voltage. Solidly ground all equipment. Failure to comply can result in death, severe personal injury, and equipment damage. T223.2

5. **Ground switchgear.** Switchgear must be adequately grounded. Install a permanent, low-resistance ground connection to the switchgear tank. Grounding provisions are provided near the bottom of the tank.

6. **Make high-voltage line connections.**

A. Prior to making connections, make sure that the source-side and tap-side cable elbows are correctly identified and that the switchgear unit is oriented correctly for the installation. The source leads must connect to the source bushings; tap leads must connect to the tap bushings of the unit.

B. Refer to the operation one-line diagram located inside the doors of the switchgear, and make only those elbow connections shown. The voltage and current ratings shown on the nameplate must be correct for the planned installation.

C. All cables not in use must be properly isolated from all other leads. Unused leads must be parked on standoff insulators or properly grounded using an elbow grounding kit.

IMPORTANT

Do not use the red shipping covers on unused bushings. They are not designed for permanent use on energized equipment.

D. All bushings not in use must be insulated with properly rated isolation cap. It is also recommended that bushing elbow studs be pre-installed for future use. The studs must be torqued into place, and this is best done before the equipment is energized.

⚠ WARNING

Hazardous voltage. Switchgear doors must be closed and padlocked at all times when unattended. Failure to comply can result in death, severe personal injury, and equipment damage. G168.1

7. **Close the door and apply a padlock to secure the switchgear from unauthorized access.**

Operation

⚠ DANGER

Hazardous voltage. Contact with hazardous voltage will cause death or severe personal injury. Follow all locally approved safety procedures when working around high and low voltage lines and equipment. G103.3

⚠ WARNING

Hazardous voltage. Never rely on the open position of the operating handle or the contact position indicator; it does not ensure that the line is de-energized. Follow all locally approved safety practices. Failure to comply can result in contact with high voltage, which will cause death or severe personal injury. G123.1

⚠ WARNING

Do not operate this equipment if energized parts are not immersed in dielectric fluid. Operation when parts are not properly immersed in dielectric fluid may result in internal flashovers that will damage the equipment and can cause death or severe personal injury. G104.4

Application

This switchgear must only be applied within its specified ratings. At no time should the continuous total load exceed the ratings shown on the nameplate.

This switchgear must always be filled to the correct level with mineral oil, Envirotemp™ E200 or Envirotemp™ FR3™ fluid.

Vacuum fault interrupters

The vacuum fault interrupter push/pull operating handles (shown in **Figure 3** and **Figure 4**) are located on the switchgear front plates. A hotstick must be used to operate the handles of the vacuum fault interrupters.

⚠ WARNING

Hazardous Voltage. Always use a shotgun stick when working with this equipment. Failure to do so could result in contact with high voltage, which will cause death or severe personal injury. G108.0

Opening interrupter

The vacuum fault interrupter is opened by pulling the operating handle down to the open position. The handle may be padlocked in the open position to prevent accidental closure.

Resetting the vacuum fault interrupter

After the vacuum fault interrupter mechanism has tripped, as the result of a fault condition, the mechanism must be reset before it can be closed. To reset the mechanism, firmly pull the operating handle down toward the ground until the latch resets. After the latch has been successfully reset, the vacuum fault interrupter mechanism can be closed normally.

Closing the interrupter

The vacuum fault interrupter is closed by briskly pushing the handle up, into the closed position.

Note: In many configurations, a Type RVAC switch is integrated within the VFI switchgear. Refer to the Operation section of *MN285005EN Type RVAC Fluid-Insulated Vacuum Switchgear; Installation, Operation, and Maintenance Instructions* for operation information for the RVAC switch.

Loadbreak switch

In most configurations, a Type RVAC loadbreak switch is integrated within the VFI switchgear. The switch's push-to-close/ pull-to-open handle is operated with a clampstick. The switch can be padlocked in either position, and a key interlock is available for added security.

Maintenance information

⚠ WARNING

This equipment relies on dielectric fluid to provide electrical insulation between components. The dielectric strength and moisture content of the fluid must be checked on a regular basis, as part of the routine maintenance inspection, to ensure that it is at or above minimum dielectric requirements and below the maximum moisture content. Use of this equipment with dielectric fluid that does not meet requirements can result in internal flashovers that will damage the equipment and can result in death or serious injury. G107.3

⚠ CAUTION

This equipment requires routine inspection and maintenance to ensure proper operation. If it is not maintained it can fail to operate properly. Improper operation can cause equipment damage and possible personal injury. G105.1

The Type VFI switchgear is a deadfront design. All live parts are contained within the sealed tank enclosure. A routine maintenance inspection program is required to ensure proper operation.

It is necessary to establish and maintain a regular schedule for sampling and testing the insulating fluid to ensure proper dielectric strength, moisture content and fluid levels in the switchgear.

Maintenance inspection procedure

The Type VFI switchgear must be de-energized, grounded, and removed from service before conducting any maintenance, fluid processing or fluid-filling procedures.

⚠ WARNING

Hazardous voltage. This equipment must be de-energized and grounded prior to conducting any maintenance, dielectric fluid processing or dielectric fluid filling procedures. Failure to comply can result in death or severe personal injury. T239.2

1. **De-energize and ground switchgear.**
2. **Reduce internal tank pressure to 0 PSIG.** The switchgear is equipped with a pressure relief valve that opens at 5 PSIG and closes at 3 PSIG. To relieve internal tank pressure, pull the ring on the pressure relief valve.

3. **Perform the following inspections:**

- **Check fluid level** – refer to the **Fuid fill guidelines** in this manual if fluid levels are low.

  Note: When the switchgear is installed on a level surface, the ball float in the fluid level indicator sight gauge on the front plate will be at the top of the site glass when fluid temperatures are 68 ºF (20 ºC) or higher. Colder temperatures and/or an uneven pad will result in the gauge indicating less than maximum fluid levels.

- **Inspect tank cover** – the tank cover should be free of chipped paint and corrosion. If a crack or hole is found, obtain a fluid sample and check moisture content and dielectric strength immediately. If a replacement cover or cover gasket is needed, refer to the **Replacement parts** section of this manual.
- **Inspect tank exterior for fluid leaks** – there should be no fluid staining on or near the tank seals at the bushings, visible break windows and other gasketed seals on the front plates. If fluid stains are present, check the fluid level, and see the **Fuid fill guidelines** if more fluid is required. Bushing leaks may be sealed by re-applying torque to the bushing clamp hardware (5 to 6 ft-lbs). Do NOT tighten visible break window hardware. First check for cracks in the window. If found, order replacement window kit. If no cracks, tighten hardware (95 to 105 in-lbs).
- **Check bushing and elbow conditions** – elbow connections should be secure and free from unusual wear. Record abnormalities and contact the manufacturer with any concerns.
- **Inspect tank and cabinets for corrosion or unusual signs of wear** – contact the manufacturer with any concerns.
- **Functionality check** – verify that cabinet doors close and lock properly. Verify manual operation of each switch and VFI. Contact the manufacturer with any concerns.
- **Record any other unusual wear/abnormalities** – contact the manufacturer with any concerns.

Internal inspection and repair

If internal damage is suspected or if the switchgear must be opened for inspection, the following procedure is recommended.

1. **De-energize and ground switchgear.**
2. **Draw a fluid sample.** Use the drain plug with sampler at the bottom of the tank. If moisture is found in the tank, refill with clean, dry insulating fluid.

⚠ WARNING

Hazardous voltage. This equipment must be de-energized and grounded prior to conducting any maintenance, dielectric fluid processing or dielectric fluid filling procedures. Failure to comply can result in death or severe personal injury. T239.2

3. **Clean off tank cover.** Take appropriate precautions to keep dirt, moisture, and other foreign matter from entering tank and contaminating the insulating fluid.
4. **Remove tank cover.**
5. **Inspect for internal damage.** Check inside the switchgear for broken leads or loose parts. If any bushings or interrupters are damaged, repair as required.
6. **Bushing repairs.** The bushings can be changed with the tank cover removed.

   A. Lower the fluid level as needed to make repairs. Store the drained fluid according to locally approved procedures and in a sealed, clean and dry container.

   B. Disconnect the internal cables and leads.

   C. Unbolt external steel clamps from the front plate and replace any damaged bushings or bushing wells with new parts and a new gasket. Be sure to position gasket so it will seal properly

7. **Interrupter repairs.** Contact your local Eaton representative for additional information and ordering procedures.
8. **Replace the tank cover.** New gaskets should be used when re-installing the cover. Refer to the section of this manual for further instructions.
9. **Refill with insulating fluid.** Refer to the **Fluid sampling guidelines** and **Fluid testing** sections of this manual, and make sure that the unit is properly filled to the 68 °F (20 °C) fluid fill level with clean, dry insulating fluid.
10. **Close and lock doors.** After repairs are completed, close and lock switchgear doors in order to prevent unauthorized access and accidental contact with high voltage lines.

Insulating fluid maintenance

⚠ WARNING

This equipment relies on dielectric fluid to provide electrical insulation between components. The dielectric strength and moisture content of the fluid must be checked on a regular basis, as part of the routine maintenance inspection, to ensure that it is at or above minimum dielectric requirements and below the maximum moisture content. Use of this equipment with dielectric fluid that does not meet requirements can result in internal flashovers that will damage the equipment and can result in death or serious injury. G107.3

To assure trouble-free operation of this equipment, a regular schedule of fluid testing and fluid maintenance is required. A routine fluid testing and maintenance schedule is necessary to monitor changes that occur in the fluid as a result of normal operation and to detect abnormal conditions that may occur.

Maintaining a record of this test data will help in assessing the condition of the fluid over time.

Frequency of maintenance

Fluid insulated units

The insulating fluid should be initially tested within two years after the installation of the equipment. That test will yield information required to establish a baseline reference for observing trends in the unit's normal operation and to diagnose any fault conditions that may be present.

After the initial fluid testing and inspection, vacuum switchgear should be maintained every two years.

Each scheduled maintenance of the switchgear should include a physical inspection of the unit, a fluid level check, and fluid testing as described in the **Fluid testing** section of this manual.

Types of fluid samples

The unit must be de-energized before withdrawing a fluid sample. Withdrawing a fluid sample from a unit that has critically low fluid level could result in flashover and unit failure when the unit is re-energized. Never energize this equipment without ensuring that it is filled to the proper fluid level with clean, dry insulating fluid.

The fluid sampling procedure requires that two types of fluid samples be taken:

1. **A bulk fluid sample** for general fluid tests. Approximately one quart (one liter), taken in accordance with ASTM D923 (latest revision), is required.
2. **A "gas-tight" fluid sample**, taken in accordance with ASTM D3613 (latest revision), for diagnosis and fault gas analysis

Fluid sampling guidelines

⚠ WARNING

Hazardous voltage. This equipment must be de-energized and grounded prior to conducting any maintenance, dielectric fluid processing or dielectric fluid filling procedures. Failure to comply can result in death or severe personal injury. T239.2

Use the following fluid sampling guidelines to prevent contamination and to safely extract fluid samples:

1. De-energize and ground the switchgear prior to sampling fluid.
2. Where local governing authorities allow access to energized equipment, the following precautions must be taken:

⚠ DANGER

Hazardous voltage. Contact with hazardous voltage will cause death or severe personal injury. Follow all locally approved safety procedures when working around high- and low-voltage lines and equipment. G103.3

⚠ WARNING

Hazardous voltage. Always use a shotgun stick when working with this equipment. Failure to do so could result in contact with high voltage, which will cause death or severe personal injury. G108.0

a. A hotstick tool capable of uncapping, opening and collecting fluid from the fluid sampling valve should be used to keep personnel away from the energized bushings.

⚠ WARNING

This equipment is not intended to protect human life. Follow all locally approved procedures and safety practices when installing or operating this equipment. Failure to comply can result in death, severe personal injury, and equipment damage. G102.1

b. Personnel authorized to access energized equipment must be properly trained in locally approved safety procedures and utilize locally approved personal protection equipment.

⚠ WARNING

Do not operate this equippment if energized parts are not immersed in dielectric fluid. Operation when parts are not properly immersed in dielectric fluid may result in internal flashovers that will damage the equipment and can cause death or severe personal injury. G104.4

c. Check switchgear fluid level prior to extracting a fluid sample. If the fluid level is low, do not attempt to extract a sample.

d. A means to plug the fluid sampling valve should be available in the event the valve is unable to close and fluid continues to flow.

⚠ WARNING

The switchgear tank must have neutral or positive internal pressure prior to extracting a fluid sample. Negative internal pressure may cause air to enter the tank during sampling which can reduce the fluid's dielectric strength. This may result in internal flashovers that will damage the equipment and can cause death or severe personal injury.

e. Neutralize internal tank pressure by pulling on the pressure relief device ring prior to opening the sampling valve.

3. Fluid samples should only be extracted when fluid temperatures are 59 ºF (15 ºC) or higher. Moisture analysis results may not accurately reflect the amount of moisture inside the switchgear if samples are extracted when the fluid is below this temperature.
4. The container temperature must be equal or greater than the ambient air temperature to prevent condensation after opening the container.
5. Never sample fluid during inclement weather (rain, sleet or snow). The fluid sample could be contaminated by moisture.
6. Always use the drain plug and sampler located near the bottom of the front plate of the tank to extract fluid samples.
7. Use only approved, new fluid-resistant tubing (nitrile or silicone rubber) for sampling the fluid. Use of previously used tubing or incompatible materials can result in contamination of the fluid sample. Tube ID required for the fluid sampling valve is 5/16 inch.
8. The fluid sampling valve and cap should be "finger tight". Use lineman's pliers or tongue and groove pliers to loosen the cap and/or valve if needed. Fluid should start to flow from the valve after 2 – 3 counterclockwise turns.

   Note: Do not attempt to turn the valve more than 5 full turns. The valve will completely uncouple after 8 turns and allow fluid to flow freely. If fluid does not flow from the valve after 5 turns and the tank has been de-pressurized, re-tighten the valve, and contact the manufacturer for further instructions.
9. Using a disposable container (not the container that will be sent to the lab), extract one quart of fluid from the sample valve and discard it as waste.
10. Use only glass or extruded metal (solderless) containers to store fluid for laboratory analysis. Plastic containers must not be used as water vapor can permeate through plastic and alter the results.
11. If dissolved gas analysis is required, the sample must be collected using a glass syringe designed for this purpose.
12. Label the sample container with the switchgear serial number, sample date and temperature at the time of extraction.
13. Rinse sample container with fluid before extracting a sample. Fill sample container with fluid to 1/3 of the container volume, rinse and discard rinse fluid.
14. Always fill sample containers to the top to prevent ambient air from altering the moisture content of the sample. Leave about one inch of air space in the container to account for thermal expansion.
15. Retighten sampling valve to "finger tight" plus a 1/4 turn. Reinstall cap, and leave it "finger tight".
16. Upon completion of sampling, recheck the switchgear fluid level, and add fluid if required.

Fuid fill guidelines

The fluid level indicator sight gauge on the front plate of the switchgear provides a convenient method to check fluid levels. The indicator provides the correct level for fluid at 68 °F (20 °C).

If the fluid level is low, use the following procedure to add dry insulating fluid to fill the unit to the correct level:

1. De-energize and ground the switchgear prior to fluid filling.
2. Use only insulating fluid that complies with ASTM D3487 (latest revision). The fluid must have a minimum dielectric strength of 30 kV when tested per ASTM D877. Never use fluid that contains PCBs (Polychlorinated Biphenyls).
3. Use only transfer equipment that uses insulating fluid resistant materials for hoses, seals, valves, pumps, etc. Failure to use proper transfer equipment can result in contamination of the fluid.
4. When adding fluid, use the fluid fill plug located on the front plate of the unit.
5. Avoid getting gas bubbles in the fluid during filling. Gas bubbles in the fluid can reduce the dielectric strength.
6. When filling is complete, check the fluid level gauge to verify that the fluid is filled to the correct level. Allow at least one hour for gas bubbles to dissipate prior to energizing the unit.
7. Install plug and energize the unit.
8. Record the date and the amount of fluid needed to re-fill the unit; retain information with the permanent maintenance record of the unit.

Fluid testing

The insulating fluid in this equipment has been tested to meet the requirements of ASTM D3487, and it has been processed to remove moisture and dissolved gases. It must be tested on a regular basis in order to ensure that it meets those requirements.

Two types of fluid tests are required to evaluate and maintain the quality of the insulating fluid. They are general fluid tests and dissolved gas analysis.

General fluid tests

The general fluid test requirements are taken from IEEE Std C57.106™-2002 *IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment*. The required fluid tests and acceptable limits for service-aged fluid are shown in **Table 2**.

Fluid test results that do not meet the requirements may indicate a problem with either the fluid or the unit. Contact your Eaton representative for technical assistance.

Dissolved gas analysis

Dissolved gas analysis is a useful technique for diagnosing abnormal conditions and assessing the "normal" condition of insulating fluid in fluid-filled equipment. The method employed is ASTM D3612, which is used in conjunction with IEEE Std C57.104™-2008 *IEEE Guide for the Detection and Determination of Generated Gases in Oil Immersed Transformers and their Relations to the Serviceability of the Equipment.* **Table 4** provides recommendations on dissolved gas levels in fluid insulated switchgear.

Table 2. Test limits for service-aged fluid

Fluid Test	Method	Requirement
Dielectric Strength	D877	26 kV minimum
Acid*	D974	0.20 mg KOH/g maximum
Dissipation*	D924	1.0% maximum
Interfacial*	D971	24 mN/m minimum
Water Content	D1533	See **Table 3**
*Requirements shown are for mineral oil only. Service-aged limits for ester fluids have not been established at the time of this publishing.		

Table 3. Service recommendations for insulating fluid moisture contents

Fluid Type	Water Content (ppm)	Service Recommendation
Mineral Oil	< 25	Continue with Eaton recommended maintenance schedule (inspection and sampling every 2 years).
	25 – 35	Obtain another fluid sample for moisture analysis in 6 months to determine if moisture levels are rising. Refer to the **Fluid sampling guidelines** section in this manual. If moisture levels increase, determine leak point and repair. Process or replace the fluid if water conent has exceeded 35 ppm.
	> 35	De-energize the equipment immediately. Take another sample and verify results. If verified, process or replace the fluid before returning to service.
FR3	< 400	Continue with Eaton recommended maintenance schedule (inspection and sampling every 2 years).
	400 – 600	Obtain another fluid sample for moisture analysis in 6 months to determine if moisture levels are rising. Refer to the **Fluid sampling guidelines** section in this manual. If moisture levels increase, determine leak point and repair. Process or replace the fluid if water conent has exceeded 600 ppm.
	> 600	De-energize the equipment immediately. Take another sample and verify results. If verified, process or replace the fluid before returning to service.
E200	< 800	Continue with Eaton recommended maintenance schedule (inspection and sampling every 2 years).
	800 – 1200	Obtain another fluid sample for moisture analysis in 6 months to determine if moisture levels are rising. Refer to the **Fluid sampling guidelines** section in this manual. If moisture levels increase, determine leak point and repair. Process or replace the fluid if water conent has exceeded 1200 ppm.
	> 1200	De-energize the equipment immediately. Take another sample and verify results. If verified, process or replace the fluid before returning to service.

Table 4. Dissolved gas in insulating fluid maintenance chart

Acetylene Level C2H2	Total Combustible Gas	Required Action
Less than 35 ppm	Less than 500 ppm	Normal Level - Resample per routine maintenance schedule
35-50 ppm	500-1000 ppm	Caution Level - Resample at 3-6 months to espablish trend; maintain fluid if gas levels increase to hazardous level.
More than 50 ppm	More than 1000 ppm	Hazardous Level - Remove unit from service and maintain the fluid.

Replacement parts

Only factory-authorized replacement parts are to be used for Eaton's Cooper Power series Distribution Switchgear products. Replacement parts are available through the factory Service Department. To order replacement parts, refer to the nameplate and provide the product type, serial number, catalog number, voltage rating, and a description of the part. Contact your Eaton representative for additional information and ordering procedures. The following documents are also available for common field repairs and procedures:

- MN285009EN – Cover gasket replacement, cover instalation, leak check procedures and fluid sampling porcedures.
- MN285007EN – Visible break window replacement procedure.

Testing

All underground distribution switchgear is carefully tested and adjusted at the factory to operate according to published data. Well-equipped test facilities, a detailed testing procedure and thoroughly trained personnel assure accurately calibrated equipment. Each unit leaves the factory ready for installation.

Pre-installation testing is not necessary. However, should verification of switchgear prior to installation be required, the vacuum interrupters can be tested using the following procedures.

High-potential withstand testing of vacuum interrupters

High-potential withstand tests can be performed to check the vacuum integrity of the interrupters used in VFI switchgear.

Safety Requirements

⚠ WARNING

Hazardous voltage. The switchgear (apparatus and control) and high-voltage transformer must be in a test cage or similar protected area to prevent accidental contact with the high-voltage parts. Solidly ground all equipment. Failure to comply can result in death, severe personal injury, and equipment damage. T221.5

⚠ CAUTION

Radiation. At voltages up to the specified test voltages, the radiation emitted by the vacuum interrupter is negligible. However, above these voltages, radiation injurious to personnel can be emitted. See Service Information MN280062EN, Vacuum Interrupter Withstand Test Voltage Ratings Information for further information. G109.2

To prevent accidental contact with high-voltage parts, the switchgear and high-voltage transformer must be placed in a suitable test cage and all proper grounding procedures must be observed.

With the vacuum interrupters open (manual operating handle(s) in the Open position), perform an AC high-potential test for one minute (or 15 minutes for DC) across each open vacuum interrupter assembly at the voltages shown in **Table 5**. The interrupter should withstand the test voltage and should not load down the source.

Table 5. High-Potential Withstand Test Voltages

VFI Voltage Rating (kV)	High-Potential* Test Voltages
15	25.5 kV AC RMS or 39.75 kV DC
25	30 kV AC RMS or 58.5 kV DC
35	37.50 kV AC RMS or 77.25 kV DC

* 75% of the production AC withstand test voltage, per IEEE Std C37.60™-2003 standard.

Trip and control testing

Eaton's Cooper Power series VFI Tester device (**Figure 5**) is used for testing VFI underground distribution units equipped with Tri-phase or TPG controls. It is self-contained and provides quick verification of the correct operation of VFI trip mechanisms, supervisory controls, and accessory SCADA boards.

Refer to *Service Information MN285001EN, VFI Tester Operating Instructions* for complete information regarding operation of the VFI tester and in-depth VFI underground distribution switchgear testing procedures.

For VFI switchgear provided with Edison Idea relays, please refer to the following service manuals for trip and control testing:

For iTAP-265 relay:

- *CA165005EN: iTAP-265 Dual Overcurrent Relay*

For iTAP-260 relay:

- *Service Information S165-260-1, Use and Operations Manual for the iTAP-260 Underground Distribution VFI Switchgear Controller*

For iDP-210 relay:

- *CA165002EN: iDP-210 Feeder Protection Relay*

Figure 5. VFI Tester Unit - Catalog Number KVFI TESTER

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