Switchgear
MN285004EN

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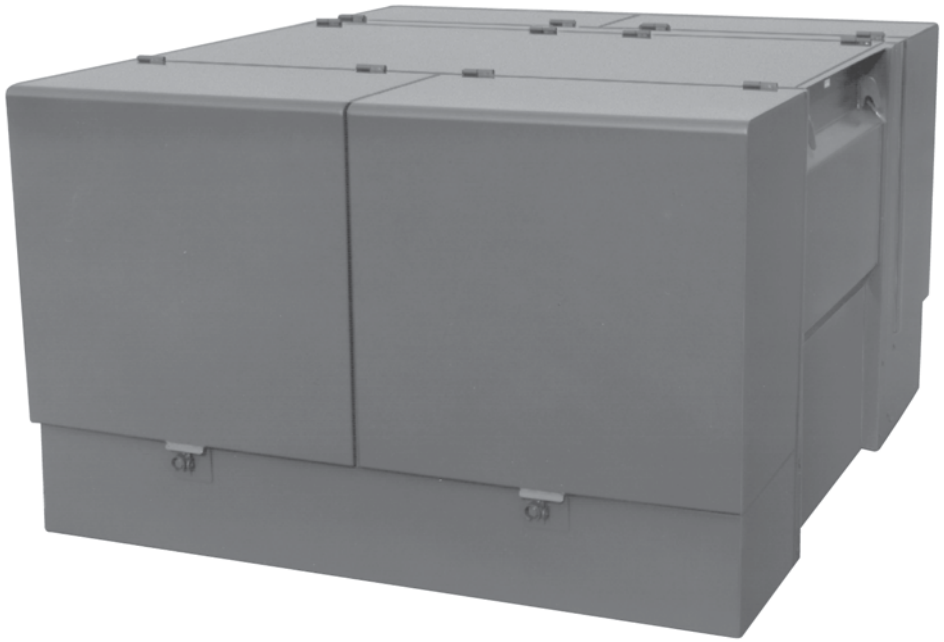
COOPER POWER SERIES

VFI SF_6-insulated vacuum fault interrupter installation, operation and maintenance instructions



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Contents

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.

CAUTION

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

Eaton's *Service Information MN285004EN* provides installation instructions, operation information, maintenance procedures and testing information for Cooper Power™ series VFI SF_6 insulated, pad-mounted vacuum switchgear.

The information contained in this manual is organized into the following major categories; *Safety Information,Product Information, Installation Procedure, Operation, Maintenance Information, and Testing*. Refer to the tableof contents for page numbers.

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 engineer.

Acceptance and initial inspection

VFI switchgear is completely assembled, tested, and inspected at the factory. The switchgear is filled with SF_6 to a pressure of 7 psig (± 0.5 psi), at an ambient temperature of approximately 70 to 75°F. 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 SF_6 incurred during shipment. If damage or loss is discovered, file a claim with the carrier immediately.
2. Check and tighten any bolts that may have loosened during shipment.
3. Check SF_6 pressure gauge; the pressure recorded should be approximately 7 psi at 70°F.

Note: The pressure of SF_6 will vary with temperature. Refer to Table 2 for acceptable pressure/temperature ranges. When possible, if the unit is cold, move it to a warm ventilated area, allow gas to warm and check pressure again. Units with a low reading should be checked for possible leaks.

4. Record the SF_6 pressure, date, ambient temperature in the SF_6 record log (Figure 7). A switchgear inspection and maintenance log should also be established and stored with the switchgear. It should be updated each time the unit is inspected.

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.

Product description

VFI vacuum 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. SF_6 insulation provides a compact, low-profile installation. 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.

VFI switchgear can be specified with a variety of control options to meet specific distribution system protectionrequirements.

Standards

VFI switchgear is designed and tested in accordance with ANSI standard C37.60 and C37.72.

Quality standards

ISO 9001 Certified Quality Management System

VFI operation

VFI switchgear utilizes vacuum interrupters to provide fault current interruption and load make/break switching capabilities. Shotgun stick operable operating handles are located on the front plate of the unit. VFI 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 VFI to interrupt the circuit. Interruption may be single-phase or three-phase, depending upon the configuration of the control and VFI 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.

- *S285-75-1, Tri-Phase Electronic Control, Installation and Operation Instructions.*

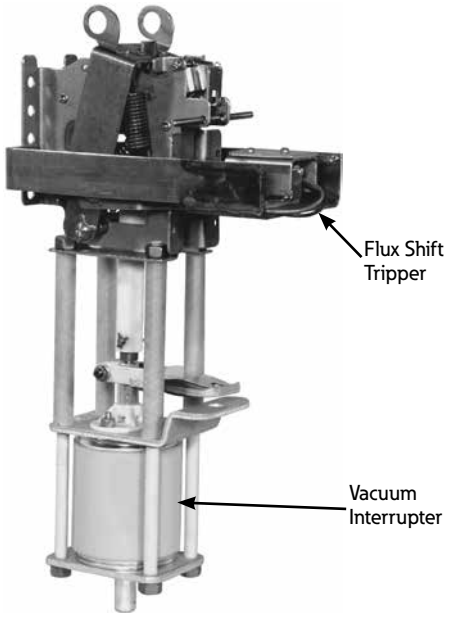

Figure 1. Vacuum Interrupter mechanism assembly.

Loadbreak switch

In many configurations Eaton's Cooper Power series RVAC switch is integrated within the VFI switchgear. Refer to *Service Information MN285003EN* for operation information for the RVAC switch.

Vacuum 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 medium.

Bushings

If 600-amp deadbreak aluminum type bushings are furnished, they conform to IEEE Std 386™ standard.

200-amp interfaces are provided as either 200-amp bushing wells or 200-amp one-piece 35 kV bushings; both conform to IEEE Std 386™ standard.

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

Cabinet construction

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 ANSI® standard C57.12.28.

Swing-up doors are provided with door stays and fitted with stainless steel hinges. On units wider than 46 inches, split doors are provided to allow easy operation by one person. Cabinet style 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 pentahead silicon bronze door bolt.

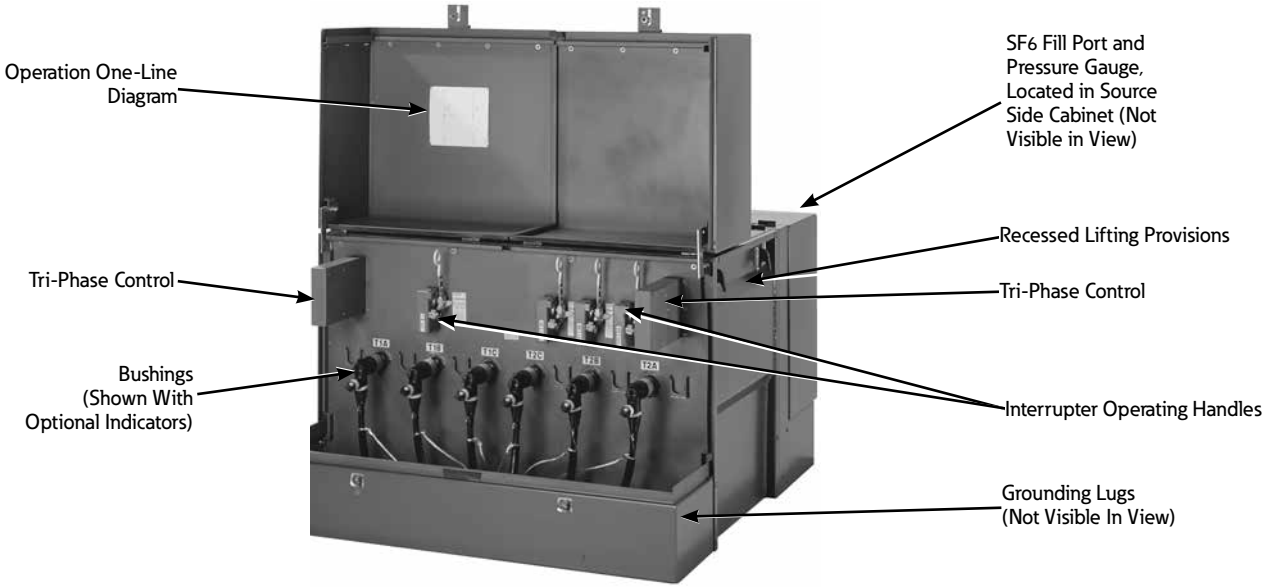

Figure 2. VFI fault interrupter components.

Table 1. Electrical ratings

Rating	5kV	15kV	25kV	35kV
Maximum Design Voltage, kV	15	15	27	38
BIL, kV	95	95	125	150
1-Minute Withstand (60 Hz) Interrupter and Terminators, kV	34	34	40	50
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	25
3 Sec. (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

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

Standard features

Standard features (Figure 2) include one-line diagrams on the doors, standoff brackets for each bushing, and SF_6 pressure gauge and fill port (Figure 3). Standard ground provisions include a 1/2-13 UNC stainless steel ground nut for each bushing.

SF_6 dielectric insulating system

Pressurized SF_6 dielectric is employed as an insulator in the central tank containing the Vacuum Fault interrupter assemblies. SF_6 fill valve, pressure gauge, and fill pressure chart (Figure 3) are provided for monitoring and adjustment of SF_6 pressure levels.

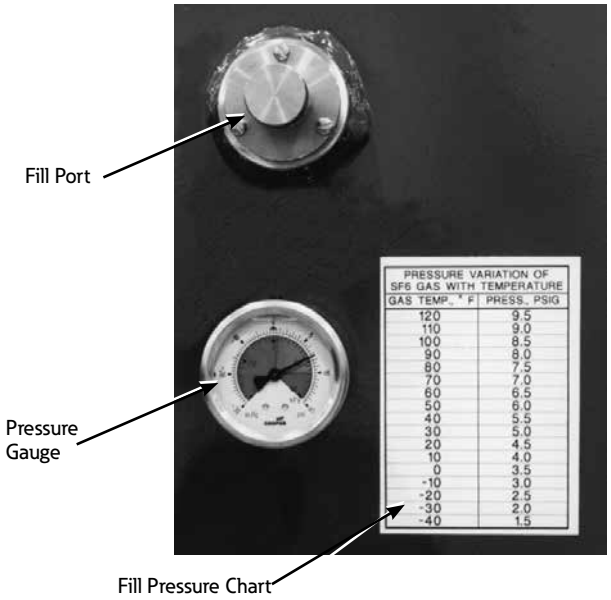

Figure 3. SF_6 Fill Port, Pressure Gauge, and Fill Pressure Chart.

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.

Interrupter duty cycle

The VFI interrupter mechanism conforms to the duty cycle requirements of ANSI® C37.60.

Switch test sequence

The VFI operating mechanism conforms to the switch test sequence requirements of ANSI® C37.72.

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: ANSI® standard C57.12.28, 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.

⚠ WARNING

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

Operating handles

The VFI interrupter is equipped with hotstick-operable handles that are typically mounted on the tap-side of the unit. The VFI 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 Figures 4 and 5) 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.

Figure 4. VFI operating handle, three-phase ganged operation.

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.

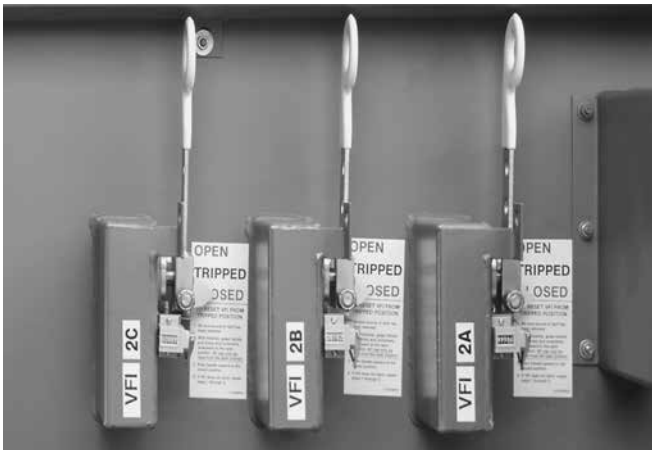

Figure 5. VFI operating handles, single-phase operation.

Installation

⚠ 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 and record the SF_6 pressure. Make sure the SF_6 gas within the switchgear tank is at proper pressure. Check the pressure gauge(s) on switchgear front plate(s). Refer to Figure 3. Some units have a pressure gauge on both the source and tap-side front plates; both gauges should indicate the same pressure. Record the pressure reading in the SF_6 record log (Figure 6) located on the inside panel of the source-side cabinet doors. Further record the pressure reading in the unit's inspection and maintenance record log.

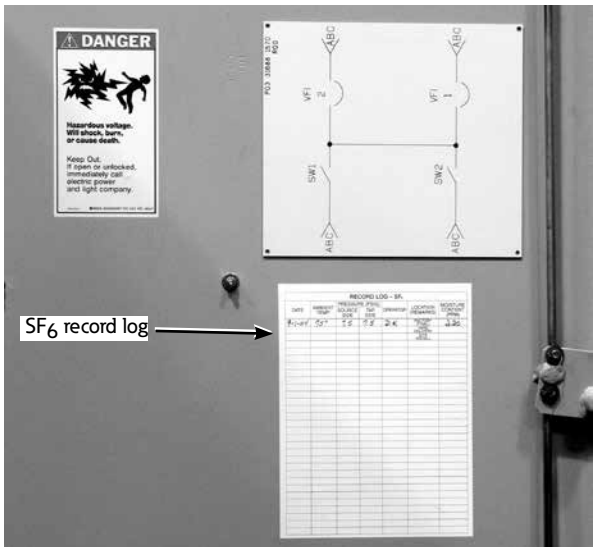

Figure 6. SF_6 record log affixed upon inside panel of source-side cabinet door.

SF_6 pressure within switchgear will generally vary from 3 to 10 psig, due to changes in ambient temperature. It is recommended that SF_6 gas be added when the pressure gauge reads 2 psig lower than the expected gas pressure. Refer to Table 2 to identify the approximate pressure that should be observed at different ambient temperatures.

Table 2. SF_6 Pressure Versus Ambient Temperature

Gas Temperature °F	Gas Pressure, psig
120	9.5
110	9.0
100	8.5
90	8.0
80	7.5
70	7.0
60	.5
50	6.0
40	5.5
30	5.0
20	4.5
10	4.0
0	3.5
-10	3.0
-20	2.5
-30	2.0
-40	1.5

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

⚠ CAUTION

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

CAUTION

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

CAUTION

Equipment damage. Improper lifting may cause equipment damage and may lead to premature failure. Recommend lifting with full length spreader beam. T375.0

3. Mount the 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

4. Ground the 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.

5. 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 or bushings 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.

   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.

IMPORTANT

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

6. Close and lock switchgear doors. Switchgear doors must be closed and locked in order to prevent unauthorized access and accidental contact with high voltage.

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

⚠ CAUTION

This equipment relies on SF_6 to provide electrical insulation between components. The pressure of the SF_6 within the unit must be checked on a regular basis, as part of the routine maintenance inspection, to assure that it is at or above minimum requirements. Use of this equipment with low SF_6 pressure can result in internal flashovers that will damage the equipment and can cause personal injury. G125.2

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 pressurized to the correct level with SF_6 gas.

VFI interrupters

The VFI push/pull operating handles (Figures 6 and 7) are typically located at the switchgear taps. A hotstick must always be used to operate the VFI operating handles.

⚠ 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

Note: In many configurations a RVAC switch is integrated within the VFI switchgear. Refer to *Service Information MN285003EN* for operation information for the RVAC switch.

Opening the interrupter

The VFI vacuum fault interrupter is opened by pulling the operating handle down to the open position (Figure 7). The handle may be padlocked in the open position to prevent accidental closure.

Resetting the interrupter

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

Closing the interrupter

The VFI vacuum fault interrupter is closed by using a hotstick to push the handle up, into the Closed position (Figure 8).

Figure 7. VFI operating handle in the open position.

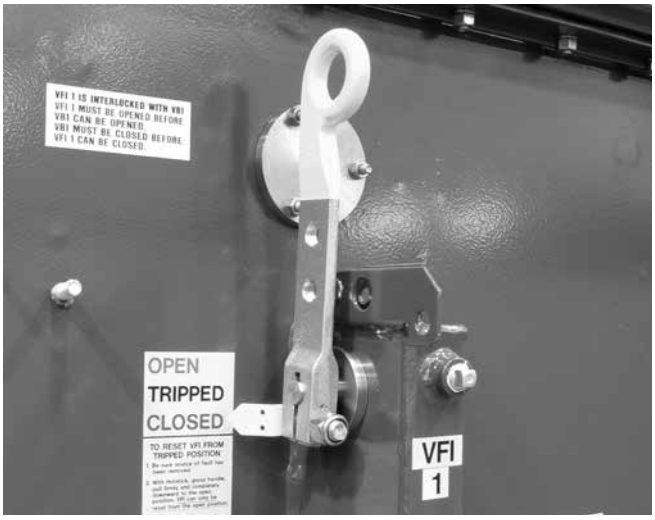

Figure 8. VFI operating handle in the closed position.

Testing

All pad-mounted 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 procedure.

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

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.

⚠ 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 S280-90-1, Vacuum Interrupter Withstand Test Voltage Ratings Information***, for further information.** G109.2

With the vacuum interrupters open (manual operating handle(s) in the Open position), perform a hi-pot test for one minute AC (or 15 minutes DC) across each open vacuum interrupter assembly at the voltages shown in Table 3. The interrupter should withstand the test voltage and should not load down the source.

Table 3. High Potential Withstand Test Voltages

VFI Voltage Rating (kV)	High Potential Test Voltages
15	26.2 kV AC rms or 37.1 kV DC
25	25 30 kV AC rms or 42.4 kV DC
35	35 37.5 kV AC rms or 53 kV DC

Trip and control testing

The VFI Tester device (Figure 9) is used for testing VFI pad-mounted units. 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 Bulletin S285-10-7, VFI Tester Operating Instructions* for complete information regarding operation of the VFI tester and in-depth VFI pad-mounted switchgear testing procedures.

Figure 9. VFI Tester Unit- Catalog Number KVFI TESTER.

Maintenance information

⚠ 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

⚠ CAUTION

This equipment relies on SF_6 to provide electrical insulation between components. The pressure of the SF_6 within the unit must be checked on a regular basis, as part of the routine maintenance inspection, to ensure that it is at or above minimum requirements. Use of this equipment with low SF_6 pressure can result in internal flashovers that will damage the equipment and can cause personal injury. G125.2

Maintenance program

A routine maintenance inspection program is required to ensure proper operation of the equipment. Detailed service records should be recorded in the unit's inspection and maintenance record log.

Routine inspection

It is necessary to establish and maintain a regular schedule for checking the pressure of the insulating SF_6 to ensure proper dielectric strength within the switchgear. Inspect the unit on 6 month intervals, whether in storage or in service, for the first year and annually afterwards. Check the gas pressure gauge and update the unit's inspection and maintenance log each time the switchgear is inspected.

Maintenance inspection procedure

The VFI switchgear must be de-energized, grounded and removed from service before conducting any maintenance, SF_6 sampling or filling procedures. VFI switchgear is a deadfront design. All live parts are contained within the sealed tank enclosure.

⚠ WARNING

Hazardous voltage. This equipment must be de-energized and grounded prior to conducting any maintenance, SF_6 sampling, or SF_6 filling procedures. Failure to comply can result in death or severe personal injury. T242.0

⚠ CAUTION

Toxic materials, skin irritant. Arcing in sulphur hexafluoride gas (SF_6) creates toxic by-products. Avoid breathing SF_6 that has been exposed to electrical arcing. Suitable protective clothingmust be worn to avoid contact with the powder residues that remain after electrical arcing in SF_6. Failure to use a suitable mask and protective clothing can result in skin irritation and illness. G121.1

1. De-energize and ground the switchgear. Always follow locally approved operating practice when working with this equipment.
2. Check SF_6 pressure. Make sure SF_6 within the switchgear tank is at the proper pressure by checking the pressure gauge(s) on the front plate(s) of the unit (Figure 10).
3. Inspect for damage. Check for any unusual wear to the paint finish. Check bushings and elbows to make sure connections are secure. Check for SF_6 leaks or other unusual or abnormal indications of wear or abuse. Make sure cabinet doors lock securely. Record any unusual conditions and make arrangements for immediate repair, if required.

Internal inspection and repair

If internal damage is suspected, or if the switchgear must be returned to the factory for service, contact your Eaton representative for shipping instructions and a return authorization number.

Adding gas

The SF_6 pressure in the unit will normally fluctuate due to changes in ambient temperature. SF_6 gas should be added when the pressure gauge reads 2 psig lower than the recommended gas pressure. Refer to Table 2 for a listing of the recommended gas at various ambient temperatures.

If SF_6 must be added, contact your Eaton representative for SF_6 Gas Top-Off Kit Catalog numbers KPA-1043-1/ KPA-1043-2 ordering information. Be prepared to provide a copy of the switchgear inspection and maintenance log, the serial number of the unit and a status report of its condition. Refer to *Service Bulletin S285-10-3, SF_6 Gas Top-Off Kit, KPA-1043-1/KPA-1043-2 Operation Instructions* for recommended SF_6 top-off procedures when using the KPA-1043-1/KPA-1043-2 Gas Top-Off Kit.

The recommended procedure for adding SF_6 gas is as follows.

IMPORTANT

Care should be exercised to avoid any introduction of moisture or air into the SF_6 gas chamber of the VFI unit during filling operations. Introduction of air or moisture can result in reduced dielectric performance of the SF_6 gas.

IMPORTANT

Filling apparatus used to introduce and transfer SF_6 gas into the pressurized SF_6 gas chamber of the VFI unit must contain an adjustable regulator for control of SF_6 flow during filling operations.

1. Verify the quality of SF_6 gas in the cylinder to be used during the transfer process.

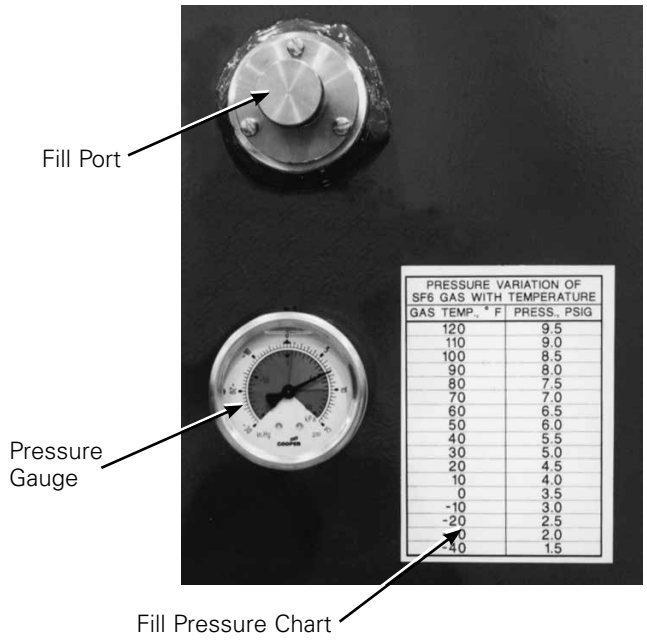

Figure 10. SF_6 Fill Port, Pressure Gauge, and Fill Pressure Chart.

2. Open the fill port of the pad-mount switchgear tank.
3. Connect the coupling valve of the SF_6 gas filling apparatus to the fill port of the pad-mount switchgear tank (Figure 10).
4. Slowly open the outlet valve of the regulated SF_6 source gas cylinder.
5. Refer to the chart on the switchgear tank to determine the maximum fill pressure for the current ambient temperature (Figure 10). When the pressure gauge of the switchgear tank indicates the targeted maximum pressure, close the outlet valve of the regulated filling apparatus.
6. Disconnect the coupling valve of the filling apparatus from the fill port of the pad-mount switchgear tank.
7. Close the fill port of the pad-mount switchgear tank.
8. Record the pressure reading in the SF_6 record log (Figure 6) located on the inside panel of the source-side cabinet doors. Further record the pressure reading in the unit's inspection and maintenance record log.

SF_6 gas analysis

SF_6 gas analysis is available for pad-mounted switchgear products. Contact your Eaton representative for details on where to obtain sample kits and on the specific tests available through the service.

Replacement parts

Replacement parts for pad-mounted switchgear units are available through the factory Service Department. To order replacement parts, refer to the nameplate and provide the product type, serial number, catalog number and voltage rating and a description of the part. Contact your Eaton representative for additional information and ordering procedure.

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