

## Type VFI, Oil-Insulated, Vacuum Fault Interrupter; Installation, Operation, and Maintenance Instructions

# S285-10-1



Figure 1.  
Kyle® Type VFI oil-insulated, vacuum fault interrupter.

921114KMA

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## SAFETY FOR LIFE



Cooper Power Systems products meet or exceed all applicable industry standards relating to product safety. 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 Cooper Power Systems 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 flash clothing, safety glasses, face shield, hard hat, rubber gloves, 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.

### 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 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 equipment can result in death, severe personal injury, and equipment damage.

G122.2

### 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.

## PRODUCT INFORMATION

### Introduction

Service Information S285-10-1 provides installation instructions, operation information, maintenance procedures, and limited testing information for Kyle® Type VFI oil-insulated padmounted vacuum switchgear.

For in-depth testing information, 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 padmounted 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, operating, or maintaining this equipment.

### Additional Information

These instructions do not claim to cover all details or variations in the equipment, procedures, or process 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, contact your Cooper Power Systems 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 oil. 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 oil incurred during shipment. If damage or loss is discovered, file a claim with the carrier immediately.
2. Check for oil 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 cabinet.

### ANSI Standards

Kyle® Type VFI Padmount Switchgear products are designed and tested in accordance with ANSI standards C37.60, C37.72, C37.85, C.57.12.28 and ANSI Standard 386.

### Quality Standards

ISO 9001:2000 Certified Quality Management System

### Product Description

Type 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. 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 oil as the insulation medium to provide a compact, low-profile installation.

R-TEMP® dielectric fluid may be provided instead of insulating oil, if specified at the time of order. Refer to the manufacturer's instructions for specifications and ASTM-approved testing procedures.

**CAUTION:** The use of R-TEMP® and Envirotemp® FR3™ dielectric fluid is limited to a minimum operating temperature of 0° C (32° F). Failure to comply can result in equipment misoperation.

T307.1

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

### VFI 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. 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- 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 that trips the faulted phase or phases, as applicable.

Refer to the applicable installation and operation manuals for control operation and setting procedures:

- *Service Information S285-75-1, Kyle® Tri-Phase, TPG, and TPG with SCADA Electronic Control; Installation and Operation Instructions*

## Loadbreak Switch

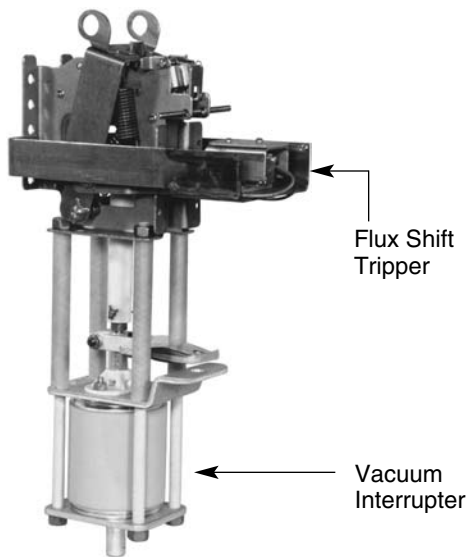
In many configurations the Type RVAC switch is integrated within the VFI switchgear. Refer to the Operation section of *S285-50-1 Type RVAC Oil-Insulated Vacuum Switchgear; Installation, Operation, and Maintenance Instructions* for operation information for the RVAC switch.

## Vacuum Interrupters

Load and fault interruption takes place within sealed vacuum interrupters (Figure 2). Vacuum interrupters provide fast, low-energy arc interruption and produce no arcing by-products to contaminate the insulating oil.

## Bushings

600 A deadbreak aluminum type bushings, when furnished, conform to ANSI standard 386.



**Figure 2.**  
Vacuum interrupter assembly.

911072KMA

The standard 200 A interface for 15 and 25 kV class padmounted switchgear is a Cooper Power Systems 200 A bushing well. For 35 kV class, the standard 200 A interface is a Cooper Power Systems 200 A one-piece load-break bushing. Both conform to ANSI standard 386.

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

## 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 ANSI standard C57.12.28.

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.

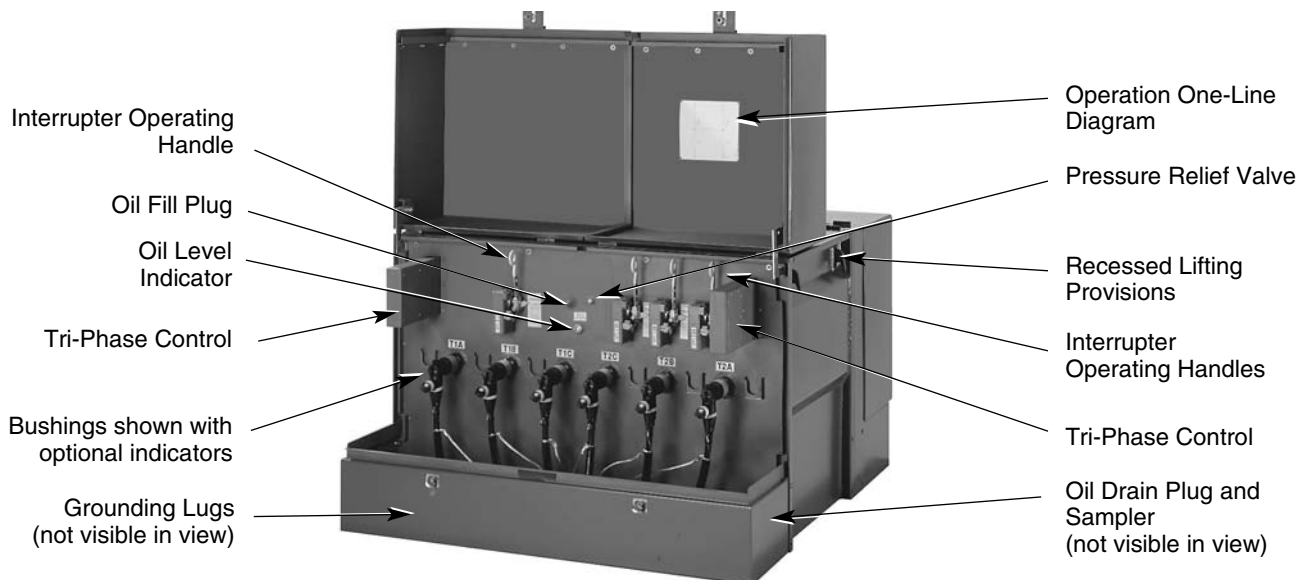
Tank construction is of 10-gauge steel and doors are made of 12-gauge steel. Recessed lifting provisions are provided at each corner of the tank for a balanced lift.

## 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 3) include an oil level indicator, automatic pressure-relief valve, operation one-line diagrams on the doors, oil fill plug, oil 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.



**Figure 3.**  
VFI fault interrupter components.

911074KMA

**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 Voltage (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	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

**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.

**Operating Handles**

**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:** 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. G108A.0

The Type VFI interrupter is equipped with hotstick-operable handles that may be located on the tap- and/or source-side of the unit. The VFI can be configured for either single-phase or ganged three-phase operation (all



**Figure 4.** VFI operating handle, three-phase ganged operation. 931158KMA



**Figure 5.** VFI operating handles, single-phase operation. 931157KMA

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.

## 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.

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

**CAUTION:** This equipment relies on oil to provide electrical insulation between components. The dielectric strength of the oil 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. Use of this equipment with insulating oil that does not meet minimum requirements can result in internal flashovers that will damage the equipment and can cause personal injury.

G107.2

2. **Test oil dielectric strength.** If the switchgear has been stored for some time, or is being relocated, perform a dielectric test on the oil in accordance with ASTM-approved testing procedures.

**Note:** R-TEMP® dielectric fluid may be provided instead of insulating oil, if specified at the time of order. Refer to manufacturer's instructions for specifications and ASTM-approved testing procedures.

**CAUTION:** The use of R-TEMP® and Envirotemp® FR3™ dielectric fluid is limited to a minimum operating temperature of 0° C (32° F). Failure to comply can result in equipment misoperation.

T307.1

- A. In new equipment, the oil must have a minimum dielectric strength of 26 kV, per ANSI C37.61. If the dielectric strength of the oil is less than 26 kV, filter the oil to restore its dielectric strength to acceptable minimum level.
- B. For additional information on oil specifications and tests, refer to *Reference Data R280-90-1*;

*Reclosers, Sectionalizers, Switches; Oil Specifications and Tests* and to the Oil 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.

**CAUTION:** Equipment damage. Follow all locally approved safety practices when lifting and mounting the equipment. Use the lifting lugs provided. Lift the unit smoothly and do not allow the unit to shift. Improper lifting can result in equipment damage.

G106.2

**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

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.


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


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## 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 out of oil. Oil is the electrical insulating medium within this equipment; operation out of oil will result in internal flashovers that will damage the equipment and can cause death or severe personal injury. G104.2


## 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 filled to the correct level with insulating oil or R-TEMP<sup>®</sup> dielectric fluid.

## VFI Interrupters

The VFI push/pull operating handles (shown in Figures 4 and 5) are located on the switchgear front plates. A shotgun stick must be used to operate the handles of the VFI 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. G108A.0

## Opening Interrupter

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

## Resetting 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, firmly 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 Interrupter

The VFI 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 *S285-50-1 Type RVAC Oil-Insulated Vacuum Switchgear; Installation, Operation, and Maintenance Instructions* for operation information for the RVAC switch.

## Loadbreak Switch

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

## 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 oil to provide electrical insulation between components. The dielectric strength of the oil 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. Use of this equipment with insulating oil that does not meet minimum requirements can result in internal flashovers that will damage the equipment and can cause personal injury. G107.2

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 oil to ensure proper dielectric strength and to maintain the proper oil level in the switchgear.

### Maintenance Inspection Procedure

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

**WARNING:** Hazardous voltage. This equipment must be de-energized and grounded prior to conducting any maintenance, oil sampling, or oil filling procedures. Failure to comply can result in death or severe personal injury. T239.1

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. **Check oil level.** Make sure the oil in the switchgear tank is at the proper level by checking the oil level indicator(s) on the front plate(s) of the unit.
 

**Note:** Refer to the **Insulating Oil Maintenance** section of this manual for additional information regarding oil maintenance and testing requirements.
4. **Inspect for damage.** Check for unusual wear to the paint finish. Check bushings and elbows. Make sure connections are secure. Check for oil leaks or other unusual or abnormal indications of wear or abuse. Make sure that cabinet doors will lock securely.

Record any unusual conditions.

### 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 an oil 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 oil.

**WARNING:** Hazardous voltage. This equipment must be de-energized and grounded prior to conducting any maintenance, oil sampling, or oil filling procedures. Failure to comply can result in death or severe personal injury. T239.1

3. **Clean off tank cover.** Take appropriate precautions to keep dirt, moisture, and other foreign matter from entering tank and contaminating the insulating oil.
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 oil level as needed to make repairs. Store the drained oil according to locally approved procedures.
  - 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 Cooper Power Systems representative for additional information and ordering procedures.
8. **Replace tank cover.** Secure with original hardware. The cover gasket may be reused if it is not damaged.
9. **Refill with insulating oil.** Refer to the *Oil Sampling and Testing Procedures* section of this manual, and make sure that the unit is properly filled to the 77° F (25° C) oil fill level with clean, dry insulating oil.
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 Oil Maintenance

 **CAUTION:** This equipment relies on oil to provide electrical insulation between components. The dielectric strength of the oil 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. Use of this equipment with insulating oil that does not meet minimum requirements can result in internal flashovers that will damage the equipment and can cause personal injury. G107.2

To assure trouble-free operation of this equipment, a regular schedule of oil testing and oil maintenance is required. A routine oil testing and maintenance schedule is necessary to monitor changes that occur in the oil 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 oil over time.

**Note:** R-Temp® dielectric fluid may be provided instead of oil, if specified at time of order. Refer to manufacturer's instructions for specifications and ASTM-approved testing procedures.

## Frequency of Maintenance

### Oil Insulated Units

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

After the initial oil testing and inspection, vacuum switchgear should be maintained every six years.

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

### Envirotemp® FR3™ Insulated Units

Periodic maintenance of Envirotemp® FR3™ fluid filled switchgear should be performed on the same schedule as would be performed for units of similar application filled with mineral oil. The basic recommended tests for Envirotemp® FR3™ fluid are dielectric strength, moisture content, and flash and fire points, using standard sampling techniques as described in the **Types of Oil Samples** section of this service bulletin.

## Types of Oil Samples


The unit must be de-energized before withdrawing an oil sample. Withdrawing an oil sample from a unit that has critically low oil 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 oil level with clean, dry insulating oil.

The oil sampling procedure requires that two types of oil

samples be taken:

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

## Oil Sampling Guidelines

 **WARNING:** Hazardous voltage. This equipment must be de-energized and grounded prior to conducting any maintenance, oil sampling, or oil filling procedures. Failure to comply can result in death or severe personal injury. T239.1

Use the following oil sampling guidelines in order to prevent contamination of the samples taken:

1. De-energize and ground the switchgear prior to sampling oil.
2. Never collect an oil sample immediately after oil has been added. A stabilization period of 96 hours is required prior to sampling.
3. Never sample oil during inclement weather (rain, sleet, or snow). The oil sample could be contaminated by moisture.
4. Always use the drain plug and sampler, located near the bottom of the front plate of the tank, to collect oil samples.
5. Use only approved oil-resistant materials, such as nitrile rubber or silicone tubing, for sampling the oil. Use of other materials can result in contamination of the oil sample.
6. Be careful to prevent contamination of the oil sample from foreign material such as dirt, dust, chemicals, etc., in oil carrying and holding apparatus such as oil cans, transfer tubes, syringes, etc.
7. Upon completion of the sampling, recheck the oil level, and add oil if required.

## Oil Fill Guidelines

**IMPORTANT:** Envirotemp® FR3™ fluid is fully miscible with mineral oil. There is no known detrimental performance impact when Envirotemp® FR3™ fluid is mixed with mineral oil. Conversely, except for some reduction in flash and fire points, the same is true for mineral oil mixed in with Envirotemp® FR3™ fluid. More than 7% mineral oil in Envirotemp® FR3™ fluid is required to drop the fire point to below 300°C. To maintain its exceptional environmental classification, combination of Envirotemp® FR3™ fluid with other fluids should be avoided. For this reason, it is recommended that mineral oil should not be used to “top-off” pad-mounted units containing Envirotemp® FR3™ fluid.

The oil level indicator sight gauge on the front plate of the switchgear provides a convenient method to check oil

level. The indicator provides the correct level for oil at 77° F (25° C).

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

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

## Oil Testing

The insulating oil 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 oil tests are required to evaluate and maintain the quality of the insulating oil. They are general oil tests and dissolved gas analysis.

### General Oil Tests

The general oil test requirements are taken from **IEEE Standard C57.106-1991™**, *IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment*. The required oil tests and acceptable limits for service-aged oil are shown in Table 2.

Oil test results that do not meet the requirements may indicate a problem with either the oil or the unit. Contact your Cooper Power Systems representative for technical assistance.

### Dissolved Gas Analysis

Dissolved gas analysis is a useful technique for diagnosing abnormal conditions and assessing the “normal” condition of oil in oil-filled equipment. The method employed is ASTM D3612, which is used in conjunction with **IEEE Standard C57.104-1987™**, *IEEE Guide for the Detection and Determination of Generated Gases in Oil-Immersed*

*Transformers and their Relations to the Serviceability of the Equipment*. Table 3 provides recommendations on dissolved gas levels in oil-insulated switchgear.

**TABLE 2**  
**Test Limits for Service-Aged Oil**

Oil Test	Method	Requirement
Dielectric Strength	D877	26 kV minimum
Acid Number	D974	0.20 mg KOH/g maximum
Dissipation Factor	D924	1.0% maximum
Interfacial Tension	D971	24 mN/m minimum
Moisture Content	D1533	35 ppm maximum

**TABLE 3**  
**Dissolved Gas in Insulating Oil Maintenance Chart**

Acetylene Level C <sub>2</sub> H <sub>2</sub>	Total Combustible Gas	Required Action
Less than 35 ppm	Less than 500 ppm	<i>Normal Level</i> Resample per routine maintenance schedule
35–50 ppm	500 – 1000 ppm	<i>Caution Level</i> Resample at 3–6 months to establish trend; maintain oil if gas levels increase to hazardous level.
More than 50 ppm	More than 1000 ppm	<i>Hazardous Level</i> Remove unit from service and maintain the oil.

## Replacement Parts

Only factory-authorized replacement parts are to be used for Kyle 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 Cooper Power Systems representative for additional information and ordering procedures.

## TESTING

All padmounted 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 and high voltage transformer must be in a test cage or similar protective device 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. T221.3

**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

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 a high-potential test for one minute/ac (or 15 minutes/dc) across each open vacuum interrupter assembly at the voltages shown in Table 4. The interrupter should withstand the test voltage and should not load down the source.

**TABLE 4**  
High-Potential Withstand Test Voltages

VFI Voltage Rating (kV)	High-Potential* Test Voltages
15	25.5 kV ac RMS or 37.1 kV dc
25	30 kV ac RMS or 42.4 kV dc
35	37.5 kV ac RMS or 74.2 kV dc

\*75% of rated low-frequency withstand test voltage, see Table 1.

### Trip and Control Testing

Cooper Power Systems VFI Tester device (Figure 6) is used for testing VFI padmounted 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.



**Figure 6.**  
VFI Tester Unit - Catalog Number KVFI TESTER.

030052KM

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 padmounted switchgear testing procedures.

