INSTRUCTIONS

For Operation and Adjustment

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INTRODUCTION

⚠ CAUTION

The equipment covered by this publication must be operated and maintained by qualified persons who are thoroughly trained and who understand any hazards that may be involved. This publication is written only for such qualified persons and is not intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

The S&C Open-Phase Detector—Type SPD is designed for grounded-system application in feeder bays of S&C Metal-Enclosed Switchgear where the load is switched and protected by a switch-operator-driven interrupter switch in combination with Type SM Power Fuses or Fault Fiter® Electronic Power Fuses. In such applications, the Type SPD Open-Phase Detector protects three-phase load circuits from open-phase conditions, including single-phasing resulting from blown feeder fuses. Also, in such applications, the Type SPD Open-Phase Detector can

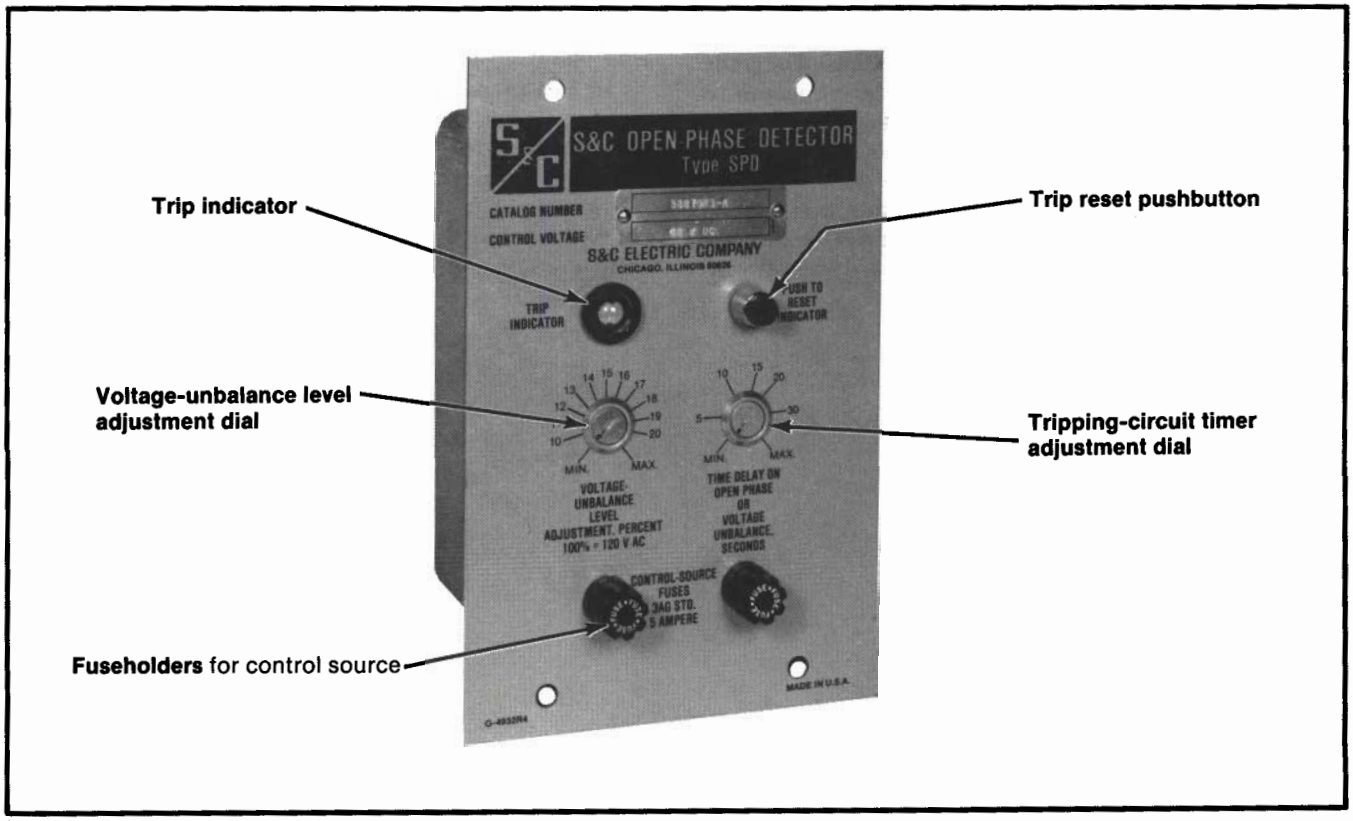

Figure 1. S&C Open-Phase Detector—Type SPD.

Supersedes Instruction Sheet 542-500 dated 8-14-89

INTRODUCTION — Continued

protect the three-phase load from source-side open-phase conditions caused by utility-line burndown, broken conductors, single-phase switching, equipment malfunctions, or single-phasing resulting from blown source-side fuses. When the switchgear assembly includes a source-transfer control which has the open-phase detection feature, the Type SPD Open-Phase Detector can be coordinated (by means of its time-delay adjustment) so that a source-side open-phase condition will initiate an automatic source transfer without opening the feeder switch.

The Type SPD Open-Phase Detector responds to all open-phase conditions (except those described under "Application Notes") through use of S&C's unique system of monitoring the phasor sum of the three-phase feeder's line-to-ground voltages to determine the degree of unbalance.

The Type SPD Open-Phase Detector does not require close coordination to match the time-current curves of feeder fuses to assure proper operation. And unlike some electromechanical relays, the reliable S&C Open-Phase Detector does not have hair-trigger contacts that can challenge dependable operation . . . nor is it affected by circuit load levels or unbalanced load current, as are protection schemes that depend upon current sensing.

One S&C Open-Phase Detector—Type SPD is employed for each three-phase load feeder to be protected. See Figure 2. The three-phase voltage-sensing input circuitry for the Type SPD Open-Phase Detector typically utilizes three S&C Indoor Voltage Sensors to derive sensing from the load side of each feeder fuse. (Alternately, three voltage transformers or other suitable voltage-sensing devices may be used.) Control voltage for the detector is typically supplied by the switch operator's power source, which must be derived from the source side of the feeder interrupter switch, or from an independent external source, to ensure that control power is available when one or more feeder fuses have blown.

The S&C Indoor Voltage Sensor, which has relay accuracy over an ambient temperature range of −40°F to +160°F, provides an output voltage that is directly proportional to line-to-ground voltage. It is a constant-current-output device like a current transformer and, therefore, primary fusing (required by voltage transformers) is eliminated. However, a secondary burden is required and is typically provided in the form of an S&C Adjustable Burden-Resistor Assembly. Each voltage sensor is also provided with an S&C Voltage Limiter—a protective device which prevents damage to the sensor's transformer in the event the secondary circuit is inadvertently opened or the burden is removed.

Application Notes

For systems where the metal-enclosed switchgear is fed from a delta grounded-wye connected transformer, the Type SPD Open-Phase Detector *will not* respond to a primary-side open-phase condition on that transformer, as the phasor sum of the primary-side (and hence secondary-side) winding voltages remains zero. If, however, the metal-enclosed switchgear is also furnished with a source-transfer control, that device *will* respond to the aforementioned open-phase condition, since it will detect the resulting reduction in magnitude of the phase-to-ground voltages.

In instances where the metal-enclosed switchgear feeder circuit serves a grounded-wye delta connected transformer, the Type SPD Detector similarly *will not* respond to a primary-side open-phase condition on that transformer when the transformer is subject to backfeed from the secondary side. For further information, consult the nearest S&C Sales Office.

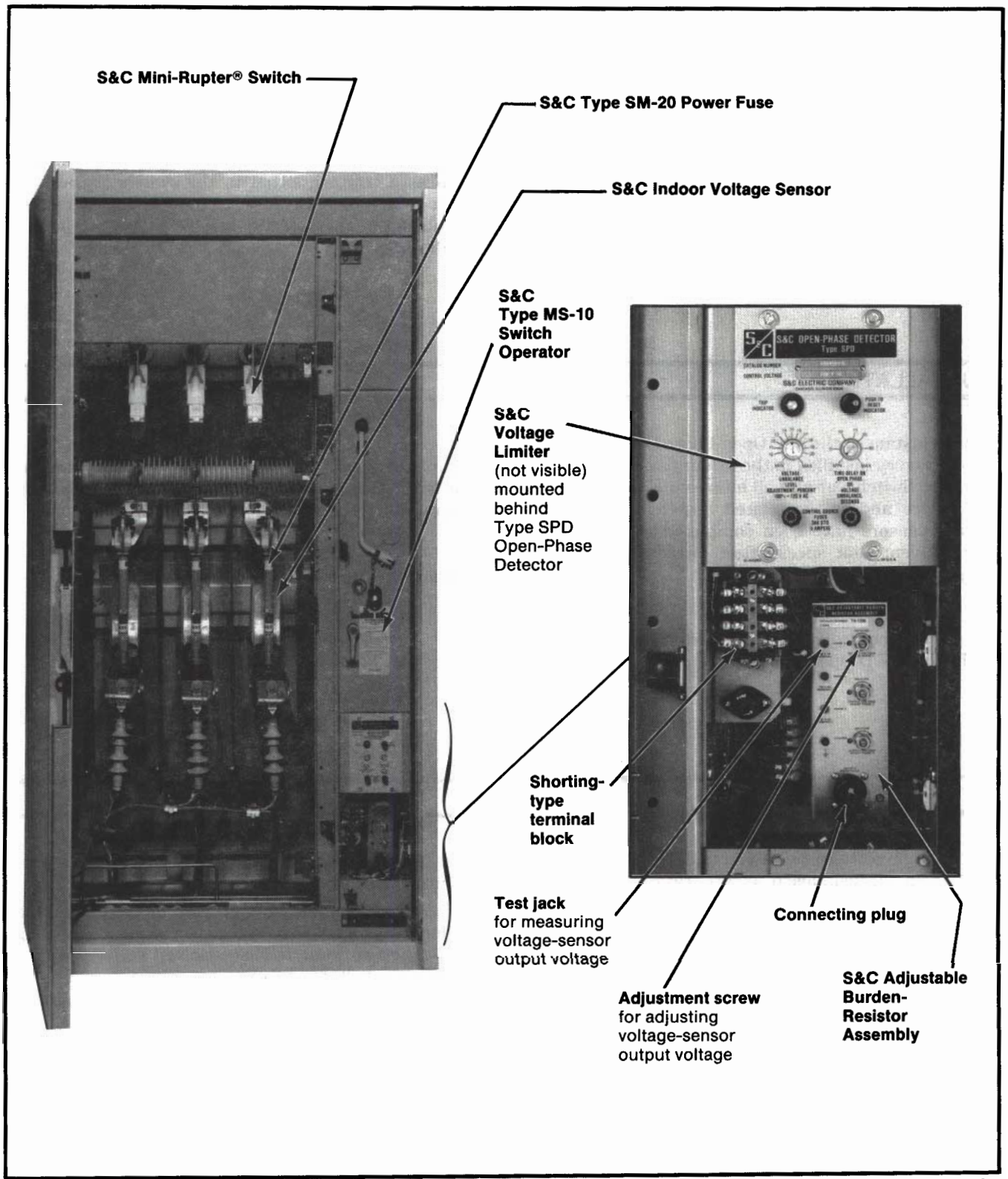

Figure 2. Typical feeder bay of an S&C Metal-Enclosed Switchgear lineup featuring Type SPD Open-Phase Detector. In some instances, the Type SPD Open-Phase Detector, Adjustable Burden-Resistor Assembly, and Voltage Limiter may be furnished on a drawout mounting panel.

FUNCTIONAL PERFORMANCE

Operation of one or two feeder fuses (or any other cause of single phasing) results in unbalance of the feeder line-to-ground voltages. A summing amplifier in the detector develops the phasor sum of the sensed voltages and produces a signal proportional to the degree of feeder voltage unbalance. This signal is filtered and compared to a preselected reference level (field adjustable for 10% to 20% voltage unbalance—sufficiently sensitive to detect open-phase conditions without nuisance tripping). Feeder voltage unbalance which causes the summing-amplifier output to exceed the reference level activates a built-in electronic timer.

The timer is adjustable for 5- to 30-second delay to permit coordination of the Type SPD Open-Phase Detector with source-transfer controls. If the unbalance decreases to a level lower than the reference before the timer times out, the timer resets and no action occurs. However, if the unbalance remains at or above the reference level (as in the case of a blown feeder fuse), the timer completes its cycle and an output relay supplies a tripping signal to the switch operator, to effect three-phase isolation of the feeder. Alternately, the output of the detector may be utilized to actuate an alarm.

INSTALLATION

In most instances, the S&C Open-Phase Detector—Type SPD is factory-installed in the feeder bay of S&C Metal-Enclosed Switchgear and all interconnections between the device and its associated switch operator and voltage sensors have been completed at the factory. In the event that special field interconnections are necessary, perform Steps 1 through 3.

Step 1
Remove the control-source fuses from the front panel of the Type SPD Open-Phase Detector.

Step 2
Complete the field interconnections in accordance with the system wiring diagram and interconnection wiring diagram furnished with the switchgear.

Step 3
Replace the fuses removed in Step 1.

DIELECTRIC TESTING

When high-voltage ac dielectric tests are to be performed on switchgear incorporating S&C Indoor Voltage Sensors, special precautions should be taken to prevent damage to the voltage sensor and the voltage limiter. These precautions include the following:

1. Jumper Terminal 1 and 2, Terminals 3 and 4, and Terminals 5 and 6 on the S&C Voltage Limiter or, if a shorting-type terminal block has been furnished, insert the shorting screws. See Figure 2.
2. In applications involving S&C Type AT Source-Transfer Controls, remove the plug from the input receptacle located at the rear of the source-transfer control and transfer the plug to the control's shorting receptacle; refer to the S&C instruction sheet furnished with the source-transfer control.

These precautions should also be followed when performing high-voltage dc dielectric tests, although application of rated dc dielectric test voltages will not damage the voltage sensors.

After the tests have been completed, remove the aforementioned jumpers or the shorting screws and transfer the plug from the shorting receptacle on the source-transfer control back to the input receptacle.

Test values which apply to S&C Indoor Voltage Sensors are given in the table on page 8.

Preliminary Tryout Before Switchgear is Energized—Optional

If it is going to be some time before high voltage is connected to the switchgear, the user may wish to perform a preliminary checkout so as to expedite full service once high voltage is available. For this reason an S&C Test Accessory, Catalog Number TA-1325, is offered; this device permits checking of the operation of the Type SPD Open-Phase Detector by means of an external single-phase signal input and a separate control source. See Figure 3. The test accessory consists of a receptacle interconnected to a terminal strip. When the test accessory is utilized, an unbalance (open-phase) condition can be simulated and precise adjustment-dial settings for voltage-unbalance level and time delay may be achieved. However, the burden resistor adjustments cannot be accomplished until high voltage has been applied to the switchgear. Proceed as follows.

1. Make sure that the switchgear-bay door is closed and securely latched. Also make sure that the high-voltage load-feeder switch is closed and (in the case of Type MS-2 or Type MS-10 Switch Operators) that the operator is charged.
2. Select the desired voltage-unbalance level and time delay by means of the adjustment dials on the Type SPD Open-Phase Detector as described on pages 6 and 7.
3. Remove the connecting plug from the output receptacle of the S&C Adjustable Burden-Resistor Assembly. See Figure 2. Transfer the plug to the receptacle of the test accessory. (This procedure isolates the S&C Indoor Voltage Sensors and eliminates the possibility of backfeed.)
4. Make up control-voltage and signal-voltage connections to the test-accessory terminal strip as shown in Figure 3.
5. Press the trip-reset pushbutton; the trip-indicator target should appear black.
6. Set the variable transformer for zero volts. Energize the isolation transformer. Slowly increase the signal voltage to a level somewhat higher than the unbalance-level setting. For example, if the unbalance-level setting is 15% ($0.15 \times 120 = 18$ volts◆), adjust the signal voltage to 20 volts.◆ After a time delay, the feeder interrupter switch should open and the target of the trip indicator should appear red.
7. Set the variable transformer for zero volts. Close the high-voltage load-feeder switch and recharge the operator (in the case of Type MS-2 and Type MS-10 Switch Operators). Press the trip-reset pushbutton. Now slowly increase the signal voltage to a level somewhat lower than the unbalance-level setting—16 volts◆ for the above example. Observe that, after the preset time period has elapsed, the load-feeder switch does not open.
8. Precise timer adjustment may be accomplished by applying a signal voltage of 20 volts◆ and measuring the time interval to switch opening.
9. When testing is completed, de-energize the control-voltage and signal-voltage circuits and remove the connections from the test-accessory terminal strip. Then transfer the connecting plug from the test accessory to the output receptacle of the S&C Adjustable Burden-Resistor Assembly.

◆ When 14.4-kv S&C Indoor Voltage Sensors are applied for sensing on systems rated 4.16 kv, the example for an unbalance-level setting of 15% becomes 10.4 volts (0.15×69.3). The "high" signal input then becomes 11.5 volts; the "low" signal input becomes 9.2 volts.

ADJUSTMENTS

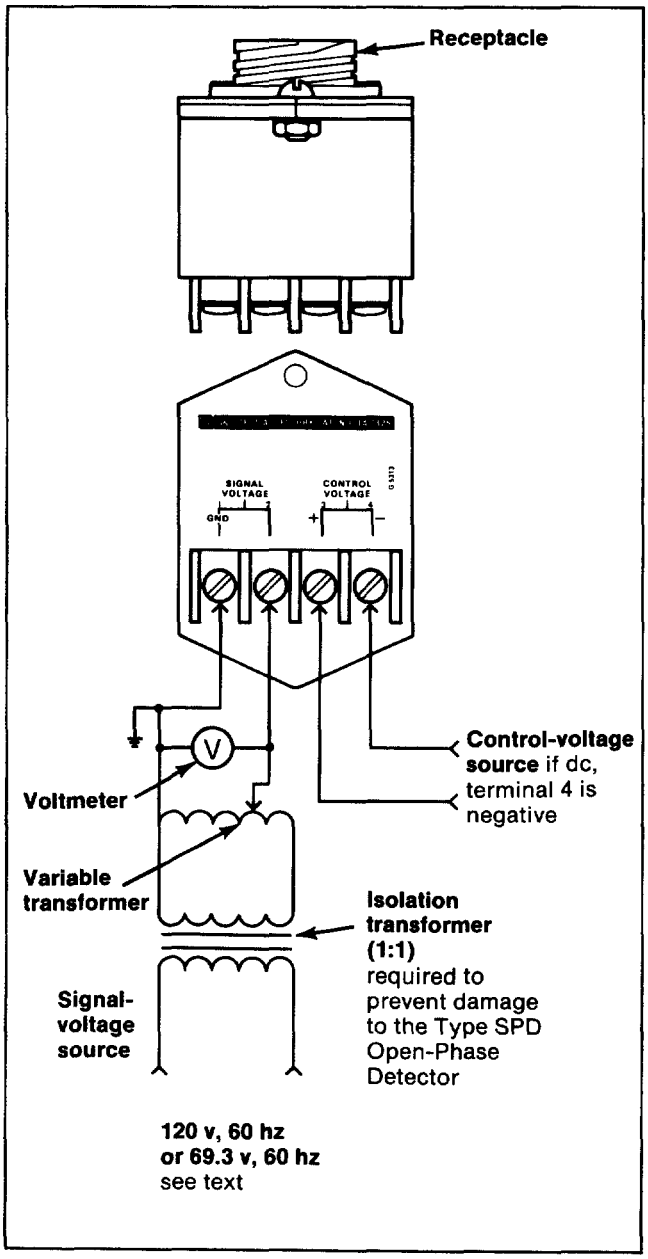

Figure 3. S&C Test Accessory Catalog Number TA-1325 and connection diagram.

The instructions which follow presuppose that the S&C Metal-Enclosed Switchgear has been installed in accordance with the applicable drawings, instruction sheets, and wiring diagrams, and is in all respects ready for operation, with the high-voltage circuits energized and carrying current.

Step 4

If the feeder interrupter switch is driven by an S&C Switch Operator—Type MS-2 or Type AS-30: Decouple the operator to prevent interruption of service to the load during the procedure which follows.

If the feeder interrupter switch is driven by an S&C Switch Operator—Type MS-10: Remove the control-source fuses from the front panel of the Type SPD Open-Phase Detector to prevent interruption of service to the load during the procedure which follows.

Step 5

If S&C Indoor Voltage Sensors are used for sensing: Adjust the magnitude of the phase 1 S&C Indoor Voltage Sensor output voltage as follows, using a voltmeter having a minimum input impedance of 5000 ohms per volt.

(a) Insert the probes in the test jacks labeled "PHASE 1" and "GROUND" on the front panel of the S&C Adjustable Burden-Resistor Assembly.

(b) Loosen the locking nut on the "OUTPUT VOLTAGE ADJUST PHASE 1" burden-resistor adjustment screw.

(c) Adjust the magnitude of the phase 1 voltage-sensor output for 120 volts ac.★

(d) Retighten the locking nut.

Step 6

Repeat Step 4 for the phase 2 and phase 3 S&C Indoor Voltage Sensors.

★ 69.3 volts ac when sensing is provided by 14.4-kv S&C Indoor Voltage Sensors applied on 4.16-kv systems.

Step 7

Adjust the 10- to 20-percent voltage-unbalance level detector for the unbalance level above which the Type SPD Open-Phase Detector is to respond. The unbalance voltage is the phasor sum of the line-to-ground voltages expressed in percent (100% = 120 volts ac▲). For example, 50% drop in voltage on one or two phases, with the remaining phase(s) at normal voltage, would result in a 50% unbalance.

The voltage-unbalance reference level is normally not a critical setting. In most applications a voltage-unbalance setting of 15% or 20% is sufficiently sensitive to detect an unbalance due to a source-side single-phasing condition and at the same time is not overly sensitive so as to result in nuisance tripping.

The level detector adjustment dial reads to within ±20% of the desired unbalance level. (For more precise setting, operational tests are required, utilizing the S&C Test Accessory, Catalog Number TA-1325. See "OPERATIONAL TESTING," on page 5.) The level detector will maintain its setting with a repetitive accuracy of ±3%.

Step 8

Adjust the 5- to 30-second time-delay timer for the desired period between detection of an open-phase condition and initiation of the tripping signal. This setting should be selected so that operation of the Type SPD Open-Phase Detector coordinates with operation of the feeder fuses and the source-side protective device. In most instances, a time delay of about 10 seconds is appropriate.

The timer adjustment dial reads to within ±20% of the desired time delay. (For more precise setting, operational tests are required, utilizing the S&C Test Accessory, Catalog Number TA-1325. See "OPERATIONAL TESTING," on page 5.) The timer will maintain its setting with a repetitive accuracy of ±5%.

Step 9

Simulate an open-phase condition by temporarily grounding the output of one of the voltage sensors, using a shorting jumper inserted in the test jacks on the S&C Adjustable Burden-Resistor Assembly or, alternately, if voltage transformers are furnished, by removing the secondary fuse from one transformer.

Step 10

If the feeder interrupter switch is driven by an S&C Switch Operator—Type MS-2 or Type AS-30: Recouple the operator to the interrupter switch.

If the feeder interrupter switch is driven by an S&C Switch Operator—Type MS-10: Replace the control-source fuses on the front panel of the Type SPD Open-Phase Detector.

Before Walking Away . . .

So that the switchgear is ready for normal operation, be sure that the following conditions exist:

- The high-voltage power fuses are closed and latched (disconnect style) or secured in their clips (non-disconnect style).
- The switchgear-bay door is closed and latched.
- The high-voltage load-feeder switch is closed.
- The switch operator is coupled to the high-voltage load-feeder switch (in the case of Type MS-2 or Type AS-30 Switch Operators).
- The switch operator is charged (in the case of Type MS-2 or Type MS-10 Switch Operators).
- The Type SPD Open-Phase Detector trip-indicator target appears black.

▲ 69.3 volts ac when sensing is provided by 14.4-kv S&C Indoor Voltage Sensors applied on 4.16-kv systems.

OPERATION

Under normal conditions, with the feeder interrupter switch closed, the trip-indicator target on the Type SPD Open-Phase Detector is black.

In the event one or two feeder fuses operate or a source-side open-phase condition occurs, an unbalance in the feeder line-to-ground voltages will result. Since this unbalance will exceed the voltage-unbalance level setting, the time-delay timer will start.

If the unbalance decreases to a level less than the voltage-unbalance level setting before the timer setting elapses, the timer will reset. But if the unbalance remains at or above the unbalance-level setting—as would be the case of a fault cleared by the feeder fuse(s)—the timer will complete its cycle. The output relay of the open-phase detector will pick up, thus tripping the switch operator, and the trip-indicator target will appear red.

MAINTENANCE

No routine maintenance is recommended for the S&C Open-Phase Detector—Type SPD other than an occasional functional checkout (about once per year) to verify that it is operational. This can be done by temporarily grounding the output of one of the voltage sensors, using a shorting jumper inserted in the test jacks on the S&C Adjustable Burden-Resistor Assembly or, alternately, if voltage transformers are furnished, by removing the secondary fuse from one transformer. Note: If the associated interrupter switch and switch operator can be decoupled, as is the case with an S&C Mini-Rupter Switch or Alduti-Rupter Switch power operated by an S&C Switch Operator—Type MS-2 or Type AS-30, this checkout can be accomplished at any convenient time without interrupting service to the load.

SPECIFICATIONS

S&C Open-Phase Detector—Type SPD

Base Catalog Number	Suffix	Control Circuit		
		Voltage		Current Requirement Milliamperes, Max
		Nominal	Operating Range	
38870R3 or 38871①	-A	48 v dc	39—56 v dc	250
	-B	125 v dc	100—140 v dc	250
	-D	120 v 60 hz	102—132 v 60 hz	75

① 38870R3 for applications using voltage-sensing devices having a nominal output of 120 volts, 60 hertz (typically obtained from three 14.4-kv or 25-kv S&C Indoor Voltage Sensors used in conjunction with S&C Adjustable Burden-Resistor Assembly Catalog Number TA-1335, three voltage transformers, or other suitable voltage-sensing devices). 38871 for applications using voltage-sensing devices having a nominal output of 69.3 volts, 60 hertz (typically obtained from three 14.4-kv S&C Indoor Voltage Sensors used in conjunction with S&C Adjustable Burden-Resistor Assembly Catalog Number TA-2232, applied on 4.16-kv systems).

Operating Temperature Range

Ambient Adjacent to Device .....−40° to +160°F

Dielectric Strength

1-Second .....1000 volts, 60 hz

Signal-Input Circuit

Nominal operating voltage .....120 volts, 60 hz■
Burden .....1 va maximum

Output-Relay Contact Ratings

Current Carrying
Continuous .....10 amperes
1-Second.....50 amperes
Interrupting.....1 ampere at 48 v dc;
0.5 ampere at 125 v dc;
10 amperes at 120 v 60 hz
100% PF

Fuses

Rating .....3 AG Std, 5 amperes

■ 69.3 volts, 60 hertz when sensing is provided by 14.4-kv S&C Indoor Voltage Sensors applied on 4.16-kv systems.

S&C Indoor Voltage Sensors

For the convenience of users who normally perform electrical tests on system components, appropriate withstand test values are given in the table below:

INDOOR VOLTAGE SENSOR RATINGS AND INSULATION TEST VALUES

Catalog Number	Rating, Kv				Withstand, Kv		
	System		Applied Line-to-Ground				
	Nom.	Max	Nom.	Max	60-Hertz, Rms①	Dc②③	Impulse (BIL)
81602R2	14 4	17.0	8.3	9.8	36	50	95
81603R2	25	29	14 4	16.7	60	70	125

① Ac withstand tests made on this equipment after shipment by S&C should be conducted at no more than 0.75 times the values shown. When making ac tests, the time duration for application of the test voltage should be limited to less than 10 seconds.

② The column headed "Dc" is given as a reference only for those making dc tests and represents values believed to be appropriate and approximately equivalent to the corresponding power-frequency withstand test values specified for components of this voltage class. The presence of this column in no way implies any requirement for a dc withstand test on these components

③ Dc withstand tests made on this equipment after shipment by S&C should be conducted at no more than 0.75 times the values shown. When making dc tests, the test voltage should be raised in discrete steps—one minute per step.