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To: FRCC Operating Entities:
Transmission Owners (TOs)
Transmission Operators (TOPs)

Date: March 05, 2009

From: FRCC Event Analysis Team (FEAT)
FRCC Operating Reliability Subcommittee (ORS)

Re: FEAT Notification of Switch Mechanism and Switch Semaphore Failure Modes

On October 30, 2008 the FEAT issued its report, entitled the “FRCC System Disturbance and Underfrequency Load Shedding Event Report” regarding the system disturbance that occurred on February 26, 2008. This report was reviewed by the FRCC Operating Reliability Subcommittee (ORS) on October 30, 2008, and approved by the FRCC Operating Committee (OC) on November 06, 2008. The OC has endorsed the 24 recommendations included in the report that was a result of the analysis.

Recommendation 2 states “It is recommended that FEAT notify all FRCC members of both the switch mechanism and the switch semaphore failure modes to increase situational awareness regarding the symptoms of these failures such that they can address any reliability issues that may occur in similar installations”.

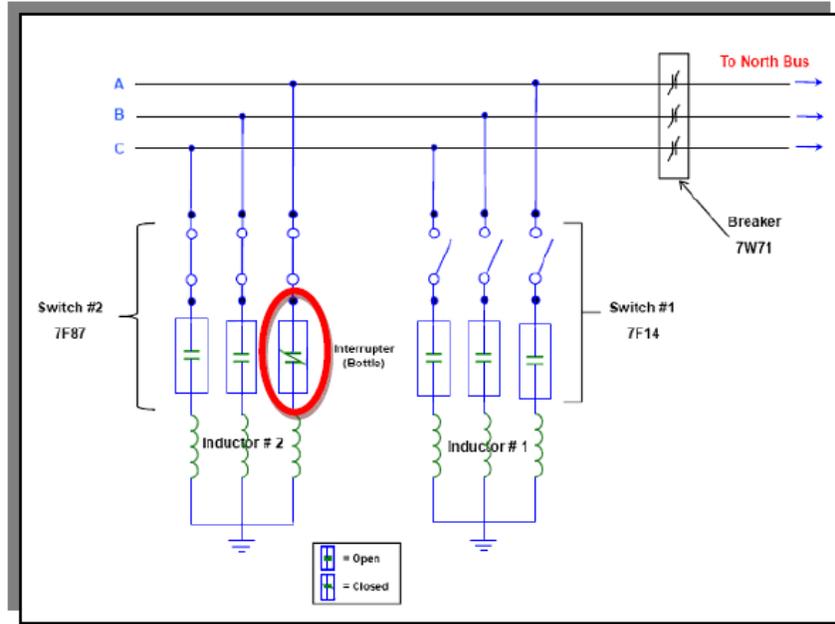
Two major contributing factors to the event were the component failure related to the 138-kV switch contact mechanism which failed internally in a mode which made detection of the condition difficult as well as the failed semaphore¹ mechanism that failed to actuate on loss of gas pressure and therefore provided false information during troubleshooting. Both of these items adversely contributed to the overall pre-event decision making process, which ultimately led to the removal of the protection from service during the troubleshooting activities. Post event analysis of the failed switch components found that a failed internal interrupting contact mechanism had caused one of the switch interrupters to fail in the closed position. There was also a coincidental failure of an internal pressure indicator (gas semaphore) identified. The failed semaphore had failed to actuate on loss of insulating gas pressure within the interrupter which if actuated would have likely halted all troubleshooting activities.

Although the manufacturer (S&C Electric Company) of the switch referenced above has already notified potentially affected customers within the FRCC, regarding the semaphore issue, we are making this notification in accordance with recommendation 2 of the FEAT report by notifying all FRCC Transmission Owners (TO) and Transmission Operators (TOP) of the potential switch mechanism failure mode and the potential semaphore failure mode.

¹ A “semaphore” in the context of this report is a red cylindrical indicator that protrudes on the side of the interrupter “bottle”. [The red cylinder is mechanically actuated to be visible externally and indicates if gas pressure within the interrupter is too low for normal interrupting action.]

Failed Switch Interrupter Mechanism

Post event analysis of the failed switch interrupter found that a failed internal interrupting contact mechanism had caused one of the switch interrupters to fail in the closed position. FRCC Transmission Owners (TOs) and Transmission Operators (TOPs) should be aware of the potential for the internal interrupter mechanism to fail in the “closed” position without causing an internal fault. This failure mode may allow a switch to remain energized and under load without tripping a series breaker such as in the installation illustrated below. Current imbalance and arcing occurs only upon opening the switch when the disconnecting set of contacts



Gas Semaphore

The following information was provided directly to potentially affected customers by the manufacturer regarding the potential semaphore failure mode:

S&C has become aware of issues involving the spring carrier in the gas pressure indicator assembly of early-production Series 2000 Circuit-Switcher interrupters. In a very small number of instances, a broken spring carrier resulted in the red target not actuating under a bona fide low gas pressure condition. Specifically affected are interrupters manufactured from the onset of production in 1986 through 1989 and, to a much lesser extent, interrupters manufactured from 1990 through 1995.

A red target that did not actuate can potentially be associated with an actual leak, the consequences of which vary by voltage and the winding configuration of the associated transformer. At 69, 115, and 161 kV and transformers with delta-configured primary windings, a Series 2000 Circuit-Switcher with a low-gas-pressure interrupter on one phase provides full-rated primary-side fault protection for faults that do not involve the ground, and full-rated secondary-side fault protection for all secondary faults. At 138 and 230 kV, however, a Series 2000 Circuit-Switcher with a low-gas-pressure interrupter on one phase *does not* provide full-rated primary-side or secondary-side fault protection on ungrounded or grounded systems.

S&C recommends that the following actions be taken:

- **Circuit-Switchers Manufactured From 1986 Through 1989:** Although red targets that did not actuate have only been observed in a very small number of cases, S&C recommends that *all* these interrupters be changed out. *Interrupters should be inspected as soon as possible for red targets that did not actuate, to prioritize the changeout.*
- **Circuit-Switchers Manufactured From 1990 Through 1995:** Interrupter changeout is probably *not* necessary. S&C believes that the likelihood of finding a red target that did not actuate is very low. *Interrupters can be inspected at your convenience.* If a red target that did not actuate is *not* found on any interrupter, the associated Circuit-Switcher can be returned to service; the Circuit-Switcher should be re-inspected at least once every five years.

S&C has developed an easy-to-use interrupter inspection tool to help in determining if the spring carrier in the gas pressure indicator assembly is broken as well as a detailed procedure to perform this inspection. The manufacturer has provided a copy of the inspection procedure that is attached to this letter (“RD-6933-lo-res.pdf”).

Because an outage is necessary to perform an inspection, you should consider having spare interrupters on hand to eliminate the need to take a second outage if a red target that did not actuate is found. Interrupters with broken spring carriers should be returned to S&C for evaluation.

If you believe that you may be a potentially affected customer but you were not notified by S&C please contact S&C directly for further information and/or to obtain an inspection tool.

Conclusion

FRCC TOs and TOPs should review these potential switch failure modes with field troubleshooting personnel as well as operations personnel to increase situational awareness regarding the symptoms of these failures and incorporate appropriate information into any relevant maintenance practices for any similar installations on their systems.

Furthermore, the FRCC requests that each entity provide an acknowledgment of this letter within 30 days. The acknowledgment should be sent to ocreports@FRCC.com. The response should identify any actions taken and/or anticipated to be taken along with actual or scheduled completion dates.

If you have any questions, please contact Hassan Hamdar at the FRCC. He can be reached at (813) 207-7989 or via email at hhamdar@FRCC.com

Sincerely,
FRCC Event Analysis Team/
FRCC Operating Reliability
Subcommittee

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Qualified Persons

⚠ WARNING

The equipment covered by this publication must be maintained by qualified persons who are thoroughly trained and who understand any hazards that may be involved. A qualified person is one who is trained and competent in:

- The skills and techniques necessary to distinguish exposed live parts from non-live parts of electrical equipment.
- The skills and techniques necessary to determine the proper approach distances corresponding to the voltages to which the qualified person will be exposed.
- The proper use of the special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools for working on or near exposed energized parts of electrical equipment.

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.

Following Safety Instructions

NOTICE

Thoroughly and carefully read this instruction sheet before inspecting red target indicators on Series 2000 Circuit-Switchers.



⚠ DANGER

De-energize and ground the Series 2000 Circuit-Switcher at all six terminals before performing this procedure.

Follow all applicable safety procedures.

Failure to do so could lead to injury or death.

PROPRIETARY STATEMENT

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Understanding Safety-Alert Messages

There are several types of safety-alert messages which may appear throughout this instruction sheet as well as on labels and tags attached to the Series 2000 Circuit-Switcher. Familiarize yourself with these types of messages and the importance of the various signal words:

DANGER

“DANGER” identifies the most serious and immediate hazards which will likely result in serious personal injury or death if instructions, including recommended precautions, are not followed.

WARNING

“WARNING” identifies hazards or unsafe practices which can result in serious personal injury or death if instructions, including recommended precautions, are not followed.

CAUTION

“CAUTION” identifies hazards or unsafe practices which can result in minor personal injury or product or property damage if instructions, including recommended precautions, are not followed.

NOTICE

“NOTICE” identifies important procedures or requirements that, if not followed, can result in product or property damage if instructions are not followed.

Documents Required

The following S&C Publications should be available at the job site to perform this procedure. Please contact your local S&C Sales Office for additional copies if needed, or download from www.sandc.com.

716-31	Specification Bulletin
716-501	Instructions for Field Assembly and Installation, Model 2010
716-504	Instructions for Field Assembly and Installation, Model 2020
716-500	Instructions for Field Assembly and Installation, Model 2030
716-502	Instructions for Field Assembly and Installation, Model 2040
716-600	Interrupter Replacement

Parts and Tools Required

Assemble all tools and parts required before starting. Also consider having spare interrupters on hand, in the event that a non-functioning indicator assembly is found through the inspection process.

Part numbers for replacement indicators can be found in Specification Bulletin 716-31.

SXA-4578	Target Inspection Kit*
SX-4982*	Inspection tool
SX-4983*	Cover bracket
Hardware*	1/2 -13 x 1” hex-head cap screw and washer. (Part No. 1323-315 and 1040-008)
Tools	3/4-inch wrench Handheld flashlight Needle-nose pliers (recommended)

*Included in inspection kit



Structure of the Series 2000 Gas Pressure Indicator

The gas pressure indicator is a mechanical device that signals low pressure within the interrupter by showing a “red target” or a red reflective coated cylinder when the 75 PSI nominal gas pressure drops below the low-pressure set point. See Figure 1.

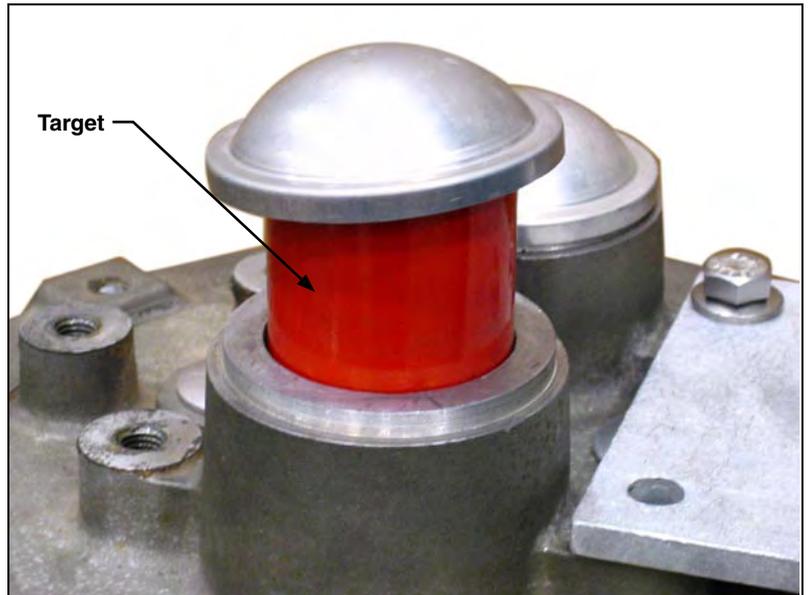


Figure 1. Gas pressure indicator in low-gas pressure position. The red target is visible.

Figure 2 provides a view inside the target assembly with the cap removed.

The target is held in position by two latch fingers that are spread apart by the trigger slide. See Figure 2.

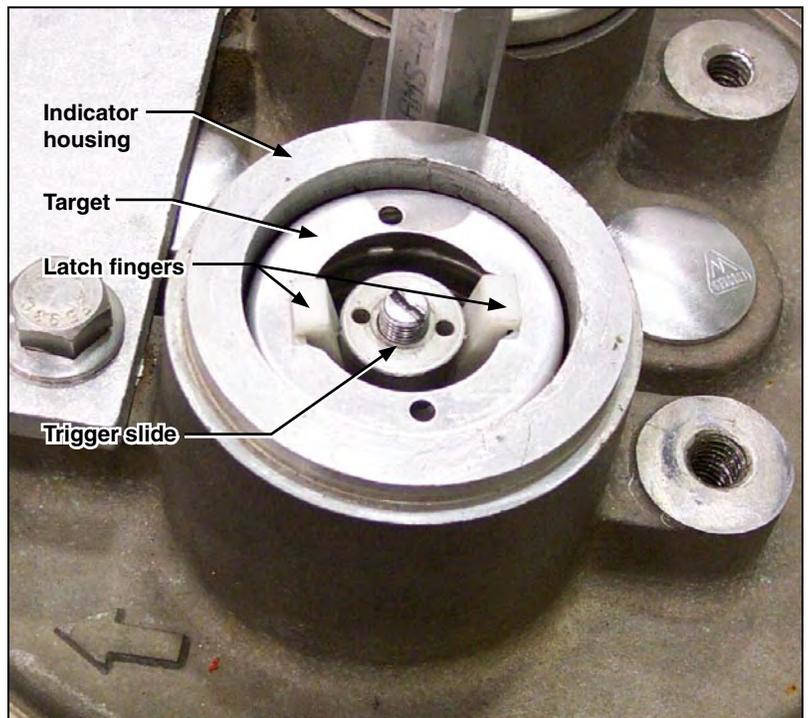


Figure 2. Indicator assembly top view. The fingers are holding the target inside the housing.



Positive pressure from the bellows spring holds the trigger slide in place between the latch fingers. The spring guide holds the bellows spring in place. See Figure 3.

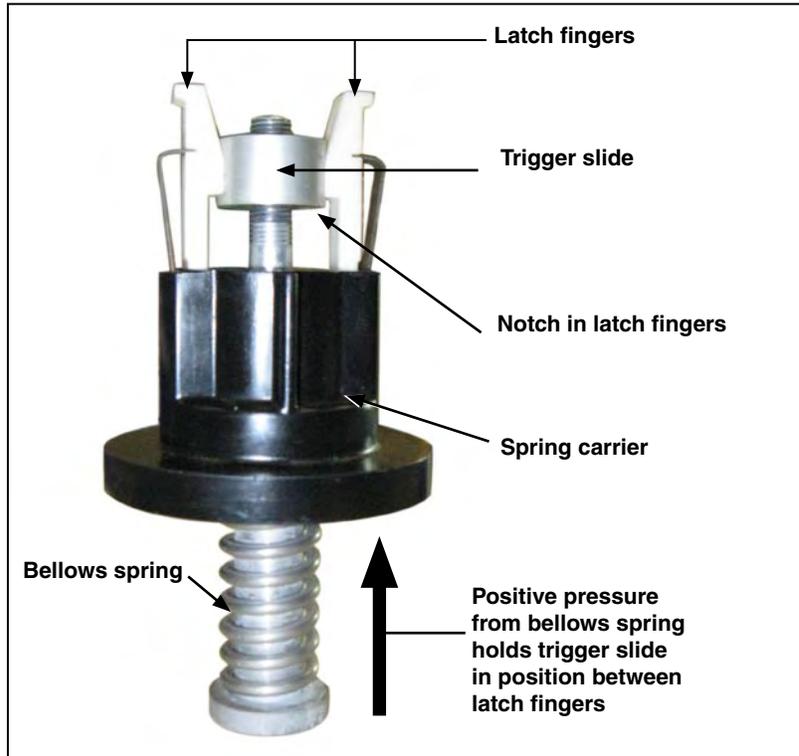


Figure 3. Interior of indicator assembly with red target indicator and target spring removed. Shows target under normal operating gas-pressure.

In the event an interrupter leaks, the lowering pressure draws the trigger slide down into a notch in the latch fingers. The latch springs on the outside of the fingers provide positive inward pressure which helps draw the latch fingers towards each other, releasing the reflective red target, which is under pressure from the target spring seated around the inside of the target indicator.

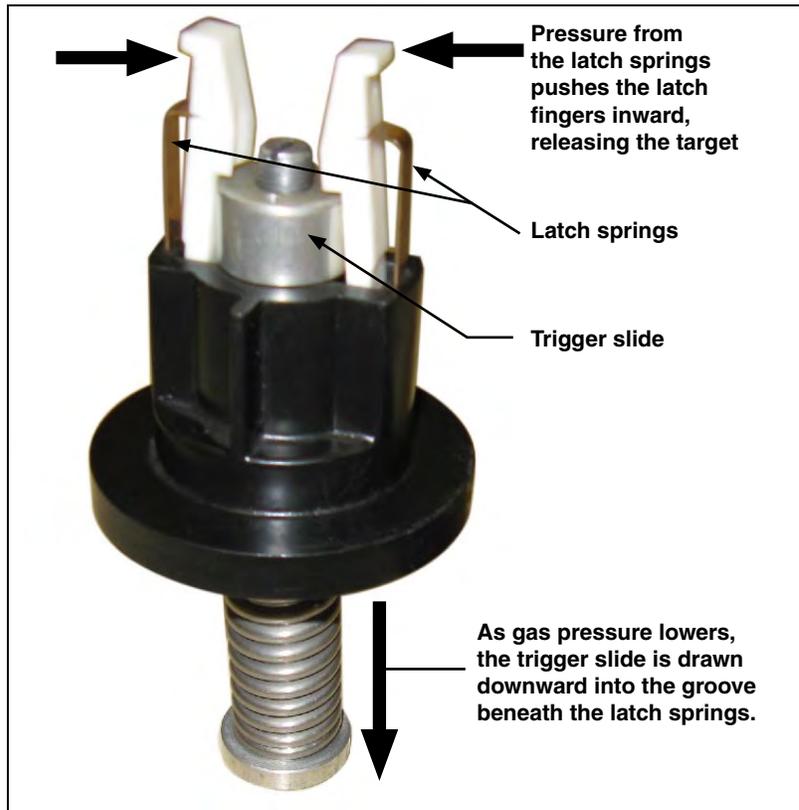


Figure 4. Interior of indicator assembly with red target and target spring removed. Shows indicator interior in low-gas pressure position

Figure 5 shows a broken spring carrier. The bellows spring has broken through the top of the spring carrier and is pressing against the trigger slide. In some cases, the top of the spring carrier may fragment, and pieces of the carrier, the latches, and latch springs may wedge underneath the trigger slide. In this condition, the gas pressure indicator will not actuate in the event the interrupter leaks.

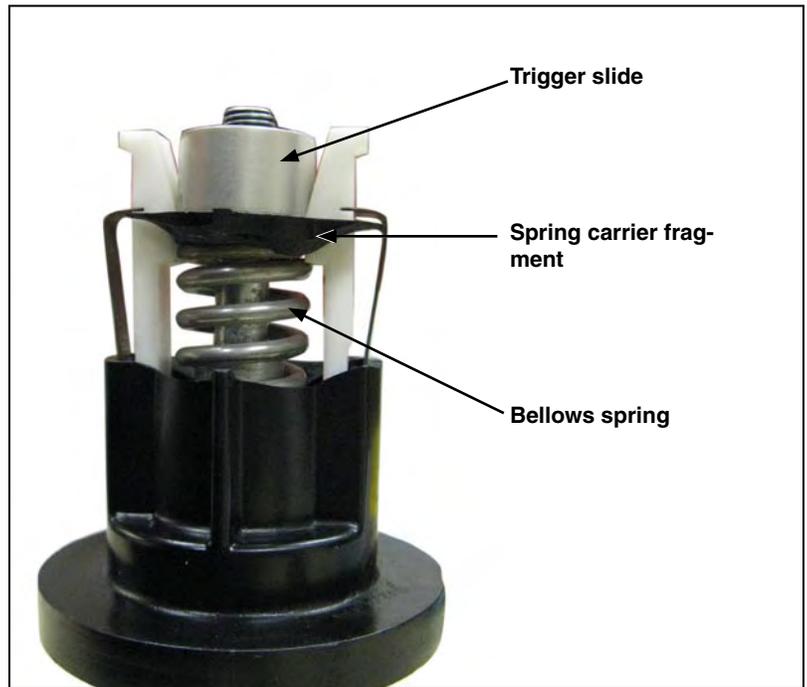


Figure 5. Interior of indicator assembly with broken spring carrier.

Figure 6 shows the way an indicator with a broken spring carrier may look from the outside. Note that the trigger slide is almost completely above the latch fingers. The top of the bellows spring is visible underneath the trigger slide.

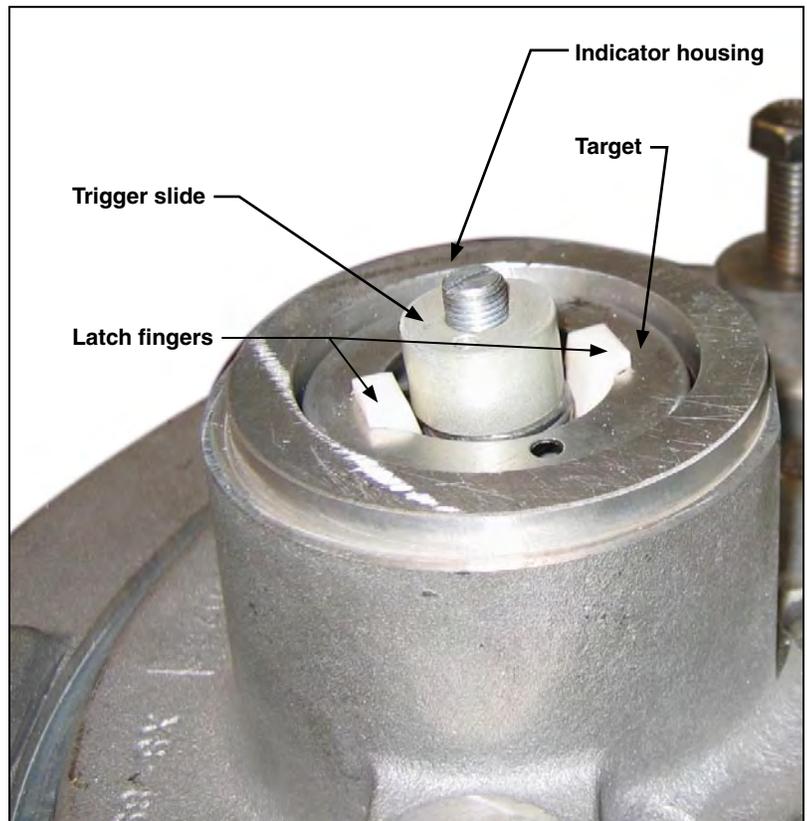


Figure 6. Indicator assembly with broken spring carrier. The trigger slide has been pushed above the surface of the indicator housing by the bellows spring.



Inspecting the Gas-Pressure Indicator

⚠ WARNING

Do not inspect the interrupter before installing the cover bracket.

Avoid placing hands or face over the pressure relief vent while installing cover bracket.

The pressure relief assembly is under 75 psig and could vent if the pressure seal is tampered with or broken.

Pieces of the rupture disc may eject causing personal injury.

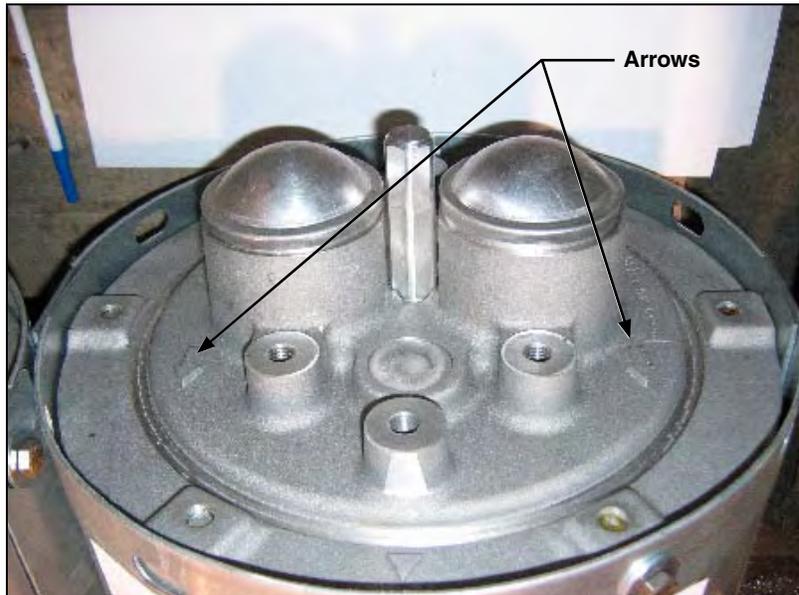


Figure 7. Arrows cast into interrupter.

Before Starting

Follow standard substation procedures for de-energize and tagging equipment on which work is to be performed.

Step 1

Identify the gas-pressure indicator. On a vertical interrupter, the gas-pressure indicator will be on the right when the arrows on the casting are pointing toward you. For a horizontal interrupter, the gas-pressure indicator will be on the right when the arrows are pointing down. See Figures 7 and 8.

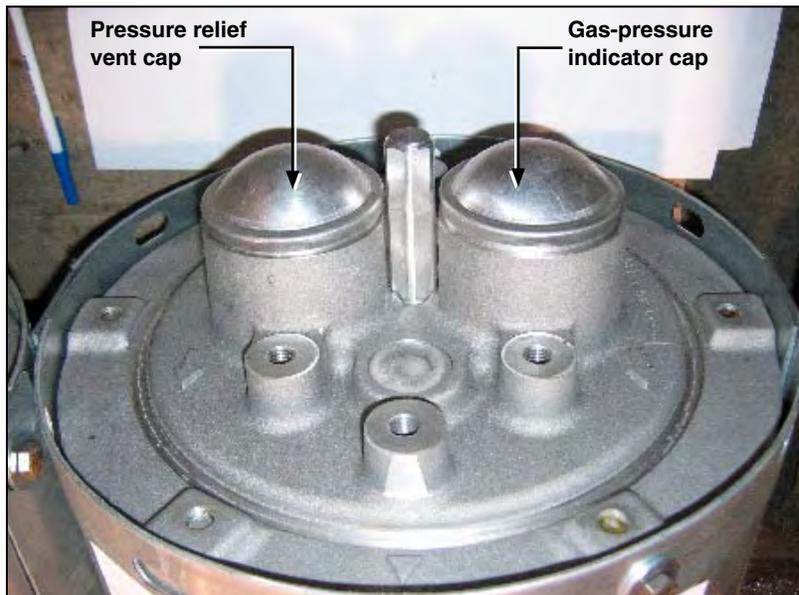


Figure 8. Gas-pressure indicator assembly is to the right when arrows are facing towards you. **DO NOT** tamper with pressure relief vent cap.

Step 2

The interrupter end-casting has two sets of terminal pad mounting holes. Install the cover bracket using the 1/2-13 x 1 hex head cap screw and washer as shown in Figure 9 in the unused hole. If two terminal pads are attached to the interrupter, temporarily remove one to allow for the installation of the cover bracket.

This bracket **MUST** be removed after the inspection procedure is completed.

⚠ WARNING

Do not place your fingers inside the indicator assembly to inspect for loose or broken parts.

The target assembly and trigger slide are under high pressure. If the spring carrier is broken, the trigger slide could quickly eject upwards creating a pinch hazard.

Injury to the fingers may result.

Step 3

The indicator cap is held to the indicator assembly with two springs.

Lift the cap to expose the indicator assembly and hold to one side.

Use a pair of pliers to remove the springs and cap if necessary. See Figure 10.

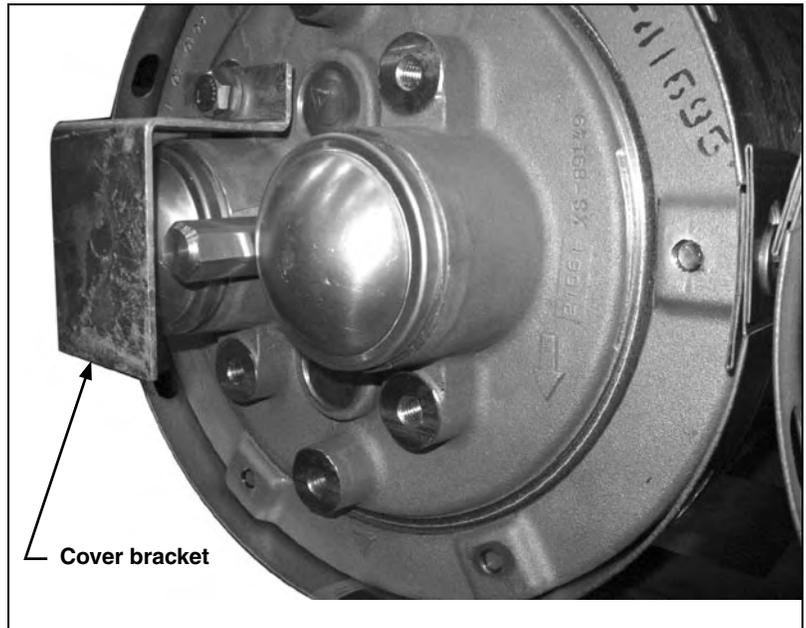


Figure 9. Install the cover bracket over the pressure relief vent cap.

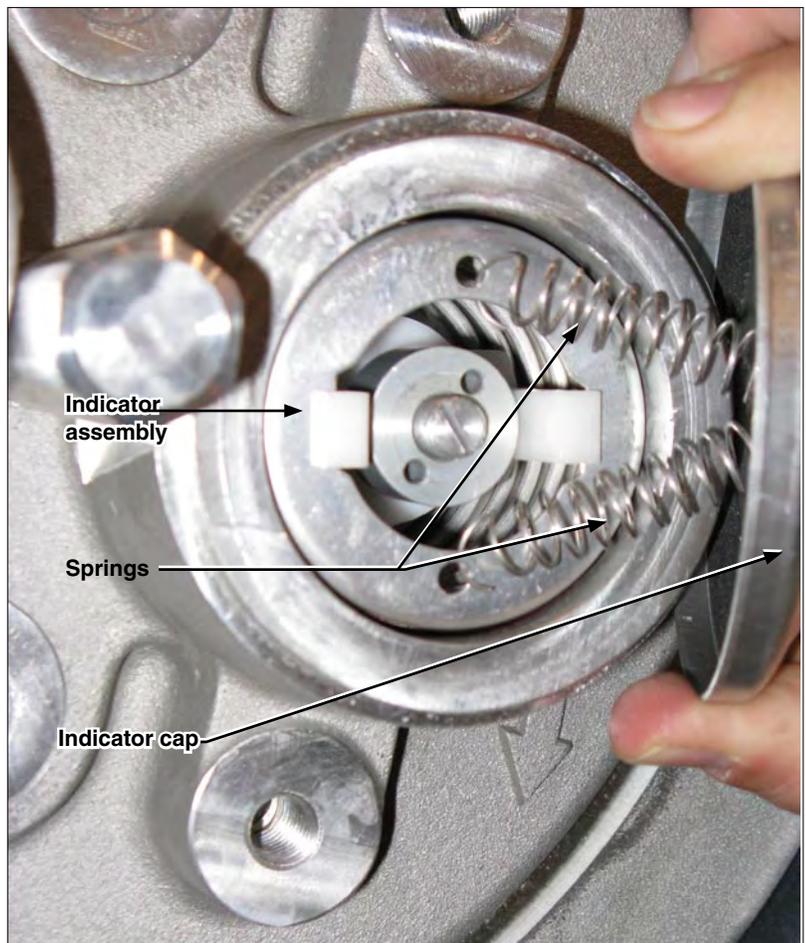


Figure 10. Gas pressure indicator with cap raised to show target assembly.



Visual Inspection

⚠ WARNING

Do not place your fingers inside the indicator assembly to inspect for loose or broken parts.

The indicator assembly and trigger slide are under pressure. If the spring carrier is broken, the trigger slide could quickly eject upwards creating a pinch hazard.

Injury to the fingers may result.

Step 4

Visually inspect the inside of the indicator assembly. An intact indicator will have the following characteristics:

- The trigger slide will be below the top of the latch fingers.
- The latch fingers will push firmly against the inside of the target.
- The spring carrier will be visible at the **BOTTOM** of the target indicator.
- The bellows spring will not be visible beneath the trigger slide.

If any broken or loose parts are found. Or the trigger slide is substantially above the indicator housing, the interrupter should be replaced.

If the indicator passes the initial visual inspection, continue with Step 5.

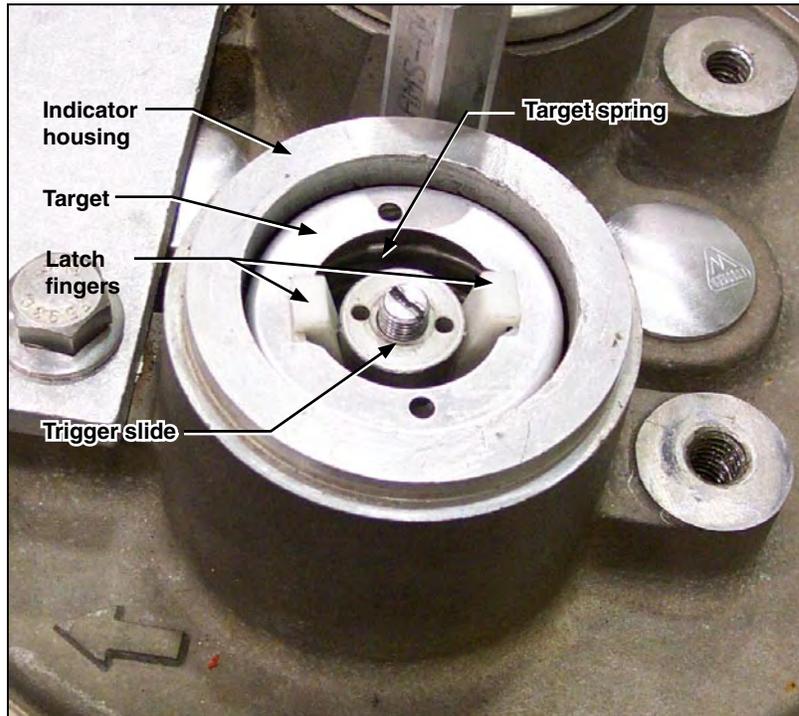


Figure 11. Indicator assembly. (Shown with cap removed.)

Using the Inspection Tool

Step 5

The inspection tool, SX-4982, is used to check for the proper clearance between the bottom of the trigger slide, and the spring carrier.

Insert the inspection tool into the indicator assembly. See Figure 12. Then rotate the tool so the top tooth is pointing towards the center of the trigger slide. The tool should fit easily around the trigger slide while being held vertically over the indicator assembly. See Figure 13. Do this to the trigger slide on both sides of the latch fingers.

If the tool does not easily fit around both sides of the trigger slide, the interrupter should be replaced.

If the trigger slide passes the inspection, the interrupter can be returned to service. Continue to Step 6.

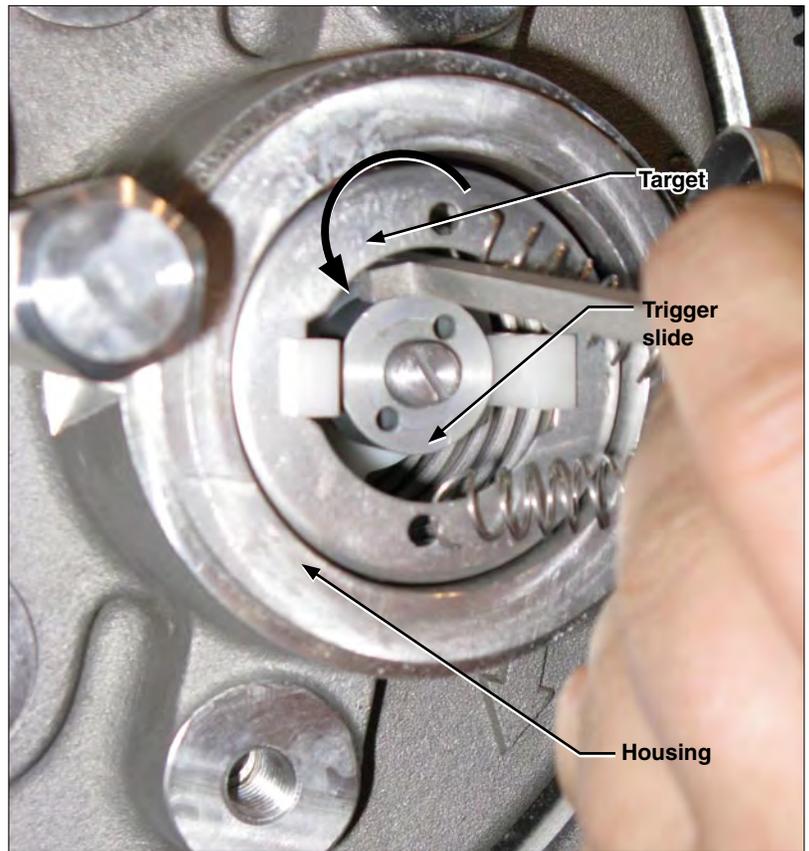


Figure 12. Carefully insert the inspection tool. Rotate the top tooth to the center of the trigger slide.

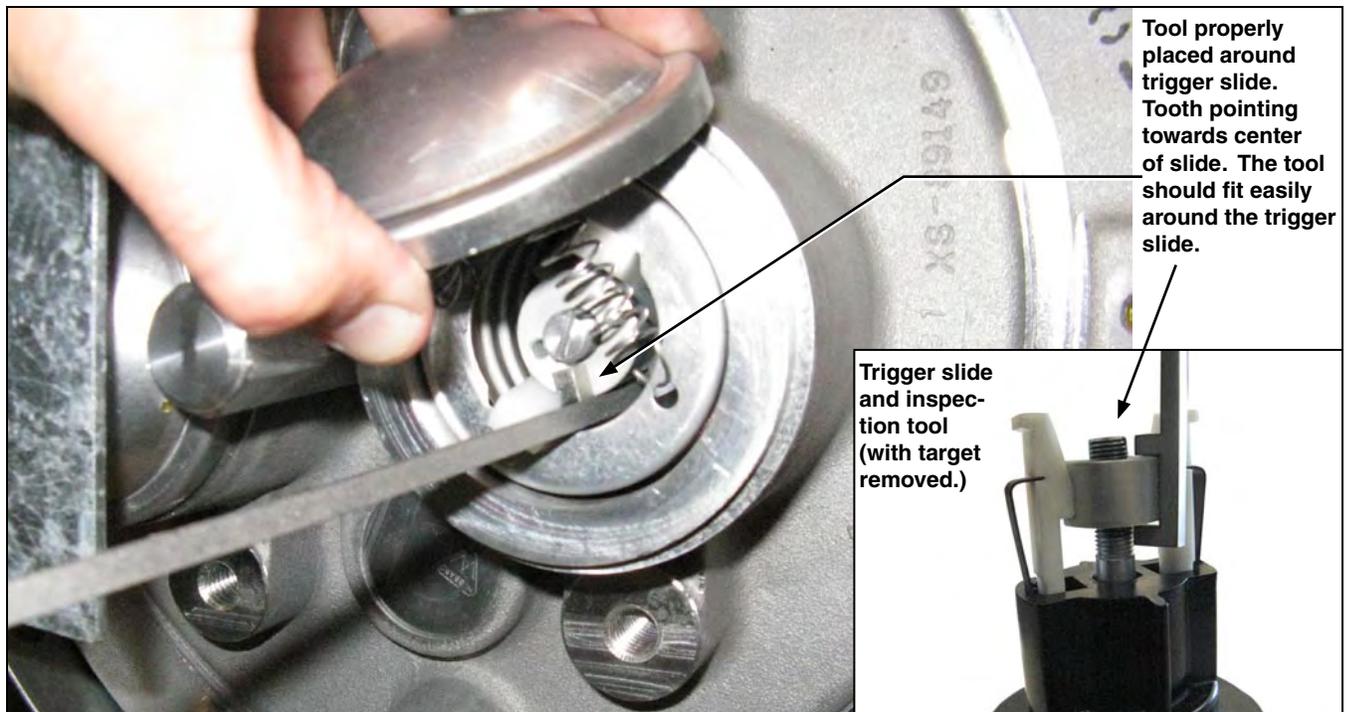


Figure 13. Rotate the tool until the top tooth is pointing inward. Inspect the trigger slide on both sides of the latch fingers. If the inspection tool can be inserted easily into the indicator housing, and fits around the trigger slide, the indicator assembly is in working condition and the interrupter can be returned to service.



⚠ WARNING

Remove the cover bracket after the inspection procedure is completed.

The pressure relief assembly is under 75 psig and is designed to vent in case of a severe overpressure inside the interrupter.

Personal injury or property damage may result.

Step 6

Replace the indicator cap and remove the cover bracket after the inspection is completed. Inspect the gas-pressure indicator again during the next Circuit-Switcher maintenance cycle. Refer to S&C Publication 716-90 for a suggested maintenance cycle.

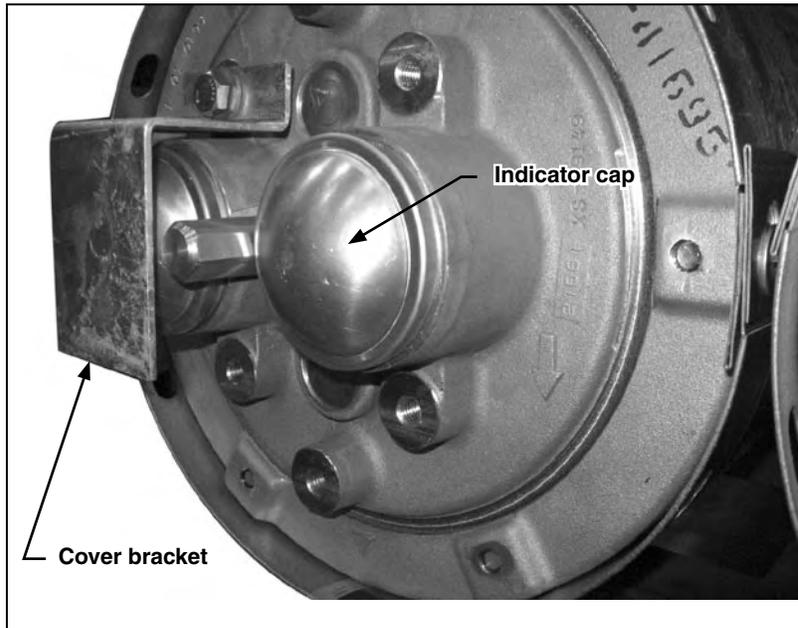


Figure 14. Replace the indicator cap. Remove the cover bracket over the pressure relief vent cap.