NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Lesson Learned

Breaker Failure due to Multiple Reclose Attempts

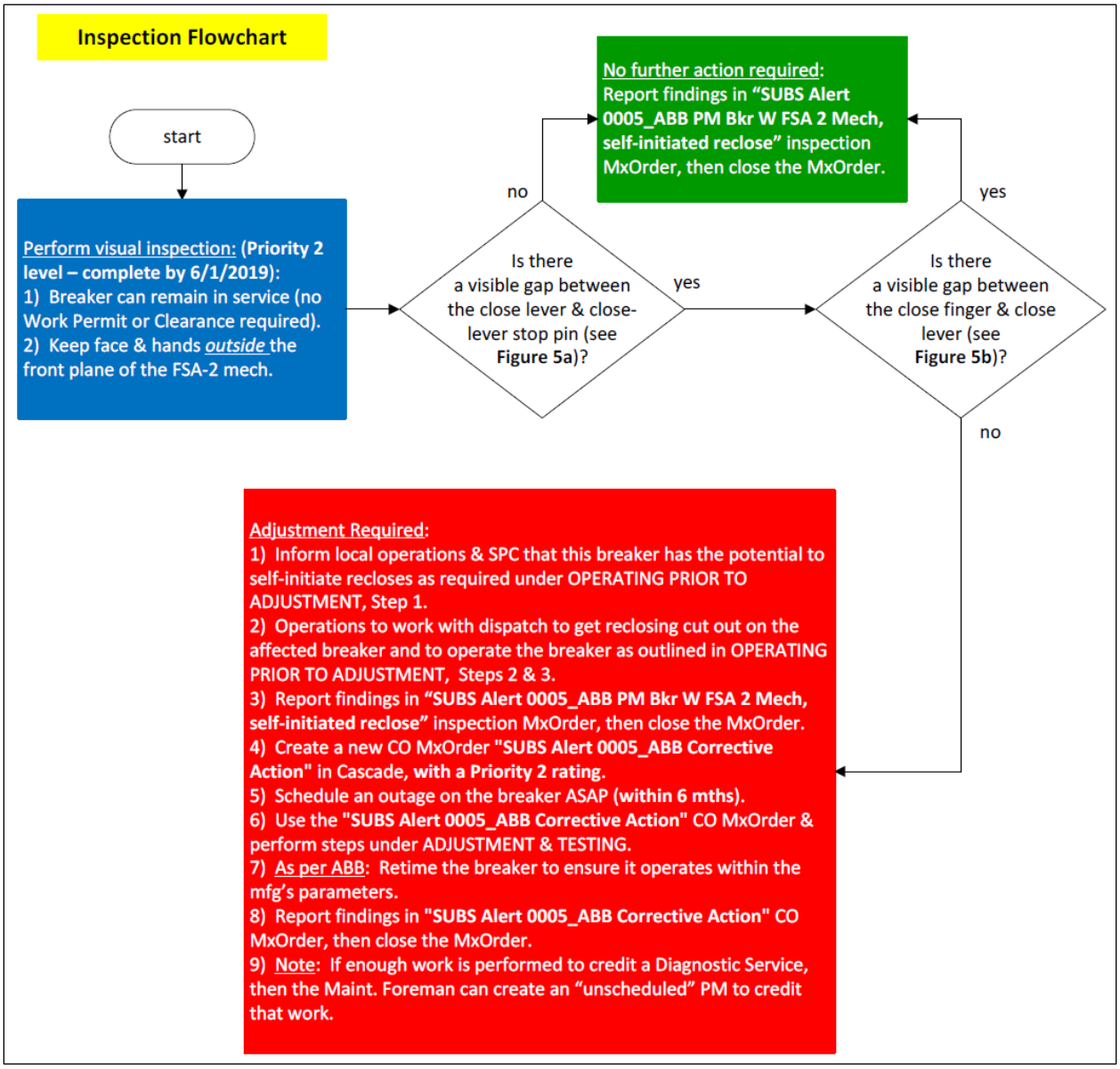
Primary Interest Groups
Transmission Operators (TOPs)
Transmission Owners (TOs)
Generation Owners (GOs)
Generation Operators (GOPs)

Problem Statement
During a 115 kV permanent line fault, a line breaker malfunctioned and reclosed into the fault eight times before failing internally, resulting in a bus differential lockout clearing all breakers on the 115 kV bus. After working with the manufacturer, it was determined that the issue was caused by maintenance being done on the breaker incorrectly.

Details
During a winter storm, a tree fell into a 115 kV line, breaking the C-phase conductor. The C-phase conductor fell and made permanent contact with the grounded transmission tower. The breakers at both ends of the line properly tripped to clear the fault. Both breakers then properly attempted a reclose and then tripped back open due to the permanent fault. After this second trip, one of the breakers malfunctioned and improperly self-initiated reclosures into the faulted line seven more times. During the final reclose attempt into the faulted line, the breaker failed to interrupt the fault and eventually faulted internally on the C-phase, causing the main bus differential lockout relay to properly operate and open all breakers on the 115 kV bus. All relaying operations worked properly for this event. The failed breaker was removed from service for further investigation and a replacement breaker was installed in its place.

Corrective Actions
The failed breaker was an ABB 121PM40-20 breaker and is a common breaker on this entity's system. The potential impact of future events with this type of breaker made this a high priority for the entity. The entity enlisted the manufacturer's help in troubleshooting the breaker. It was found that there was an insufficient gap between the top of the close-coil plunger and the close lever in the breaker's FSA-2 closing mechanism. The instructions for this breaker call for a 2–4 mm gap, but this breaker had a 0 mm gap. The troubleshooting team determined the issue could be visually identified without removing the breakers from service. They developed a procedure for field personnel to identify and correct this issue on other breakers on their system. Excerpts of the essential parts of that procedure can be found on the following pages.

Excerpts from the procedure manual developed to identify and correct issues:



Inspection Method:

1. Breaker can remain in service, no Work Permit or Clearance required.
2. Keep face & hands *outside the front plane* of the FSA-2 mechanism.
3. Inspect for visible gaps between:
    a. Close lever and the close-lever stop pin as shown in **Figure 5a**.
    b. Close finger and close lever as shown in **Figure 5b**.

Inspection Results:

1. **Figure 5a:**

    a. No Visible Gap exists:
        i. Close lever is correctly resting on the close-lever stop pin. No further action required.
        ii. Report findings in **"SUBS Alert 0005_ABB PM Bkr W FSA-2 Mech, self-initiated reclose"** inspection MxOrder, then close the MxOrder. **These are Priority 2 MxOrders and should be completed by 6/1/2019.**

    b. Visible Gap exists: Possible issue, more inspection required. Go to Inspection Results / Step 2.

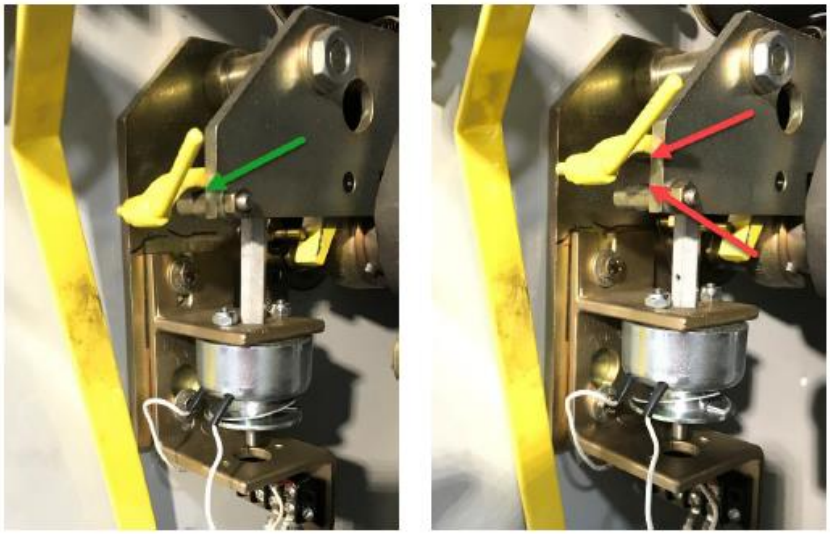


Figure 5a – Visible Gap Between Close Lever and The Close-Lever Stop Pin

2. **Figure 5b:**

   a. Visible Gap exists:
      i. No further action required.
      ii. Report findings in **"SUBS Alert 0005_ABB PM Bkr W FSA-2 Mech, self-initiated reclose"** inspection MxOrder, then close the MxOrder. **These are Priority 2 MxOrders and should be completed by 6/1/2019.**

   b. No Visible Gap exists:
      i. Inform local operations & SPC that this breaker has the potential to self-initiate recloses as required under **OPERATING PRIOR TO ADJUSTMENT**, Step 1.
      ii. Operations to work with dispatch to get reclosing cut out on the affected breaker and to operate the breaker as outlined in **OPERATING PRIOR TO ADJUSTMENT**, Steps 2 & 3.
      iii. Report findings in **"SUBS Alert 0005_ABB PM Bkr W FSA-2 Mech, self-initiated reclose"**, Priority 2 inspection MxOrder, then close the MxOrder.
      iv. Create a new CO MxOrder **"SUBS Alert 0005_ABB Corrective Action"** in Cascade, **with a Priority 2 rating.**
      v. Schedule an outage on the breaker as soon as possible (within 6 months).
      vi. Use the **"SUBS Alert 0005_ABB Corrective Action"** CO MxOrder, and perform the steps listed under **ADJUSTMENT** & **TESTING** below.
      vii. As per ABB: Retime the breaker to ensure that it operates within manufacturer's parameters.
      viii. Report findings in the **"SUBS Alert 0005_ABB Corrective Action"** CO MxOrder, then close the MxOrder.
      ix. Note: If enough work is performed to credit a Diagnostic Service, then the Maintenance Foreman can create an "unscheduled" PM to credit that work.

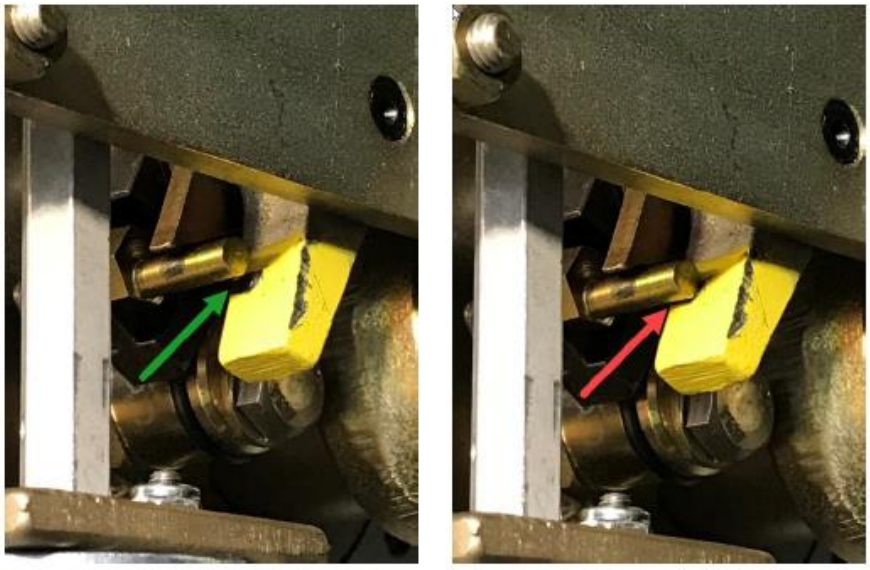


Figure 5b – Visible Gap Between Close Finger and Close Lever

OPERATING PRIOR TO ADJUSTMENT:

1. Inform local operations and SPC that this breaker has the ability to self-initiate recloses during permanent-fault conditions.
2. Local Operations to work with dispatch to get reclosing on the affected breaker cutout. A Caution tag will be placed locally at the substation by the operator, as well as in SCADA by the dispatcher.
3. With reclosing cutout, the breaker will never attempt a reclose and will not self-initiate reclosing. However, the following steps need to be taken into account if a fault occurs on the associated line:
    a. **SUSPECT BREAKER ON ONLY ONE END OF THE LINE** – If reclosing is cutout on one end of the line, that end will not reclose without manual intervention. In these steps the breaker with reclosing cutout is referred to as the "suspect breaker", and the breaker with reclosing cut-in is referred to as the "non-suspect" breaker. There are two plausible scenarios:
        i. If the non-suspect breaker has successfully reclosed, dispatch can feel confident in closing the suspect breaker since the fault was transient, as demonstrated by the successful reclosing.
        ii. If the non-suspect breaker did not successfully reclose, that is an indication that a permanent fault may be present. In this case dispatch should attempt to close only the non-suspect breaker. If the non-suspect breaker remains closed, dispatch can feel confident that the faulted condition no longer exists, and the suspect breaker can also be remotely closed. If the non-suspect breaker trips again after dispatch attempts to close it, TLM should patrol the line to determine if there is still a faulted section of the line. Dispatch should not attempt to close the suspect breaker before the non-suspect breaker closes successfully, which would demonstrate that the faulted condition is no longer present.
    b. **SUSPECT BREAKERS ON BOTH ENDS OF THE LINE** – If reclosing is cutout on both ends of the line, the line will remain de-energized and neither breaker will attempt a reclose. In this case TLM should patrol the line to determine if there is still a faulted section of the line. Dispatch ***shall not*** attempt to close breakers on either end until there is assurance the fault is no longer present. If either breaker is closed and the permanent fault condition still exists, the breaker could begin self-initiating recloses into the faulted line with no way to stop the self-initiated reclose / relay trip cycles.

ADJUSTMENT:

1. Remove breaker from service.
2. Remove all stored energy from the close & trip springs as follows:
    a. Operate the breaker into the closed position, wait for the charging motor to completely charge the close springs and shut off.
    b. Turn OFF power to the AC & DC motor bus.
    c. Press & release the trip button, followed by an immediate press & release of the close button, followed by an immediate press & release of the trip button.
3. Loosen bolts holding the close-coil mounting bracket to the close-latch assembly. Drop & adjust the close-coil mounting bracket. Attain the mfg's recommended gap between the top of the close-coil plunger and the close lever (with the lever lifted to touch the release finger) as outlined in the instruction book.
4. Tighten bolts holding the close-coil mounting bracket to the close-latch assembly.
5. Turn ON power to the AC & DC motor bus.
6. Perform steps listed under **TESTING** to ensure that issue is resolved.

TESTING:

1. **Perform an O-C-O test simulating a relay-initiated response to a permanent fault:**
   a. Operate the breaker into the closed position, wait for the charging motor to completely charge the close springs and shut off.
   b. Press & release the trip button. Press & release of the close button, followed by an immediate press & release of the trip button. Wait for the charging motor to completely charge the close springs and shut off.
   c. Repeat steps 1a & 1b two more times (for a total of three O-C-O tests).
2. Results:
   a. Breaker trips/closes/trips, charging motor runs & charges the close springs, breaker stays open for *all* of the three O-C-O tests without any self-initiated recloses. No further adjustment required. Retime the breaker to ensure that it operates within manufacturer's parameters. Work with local operations to have reclosing cut-in when the breaker is returned to service.
   b. Breaker trips/closes/trips, charging motor runs & charges the close springs, close cam does not stay on latch, breaker self-initiates a reclose on *any* of the 3 tests.
      i. Perform steps listed under **ADJUSTMENT**, using a different gapping that is still within the manufacturer's limits. Then, repeat **TESTING** to ensure that issue is resolved.
      ii. Install a new close-latch assembly. Perform steps listed under **ADJUSTMENT**. Then, repeat **TESTING** to ensure that issue is resolved.

Lesson Learned

The failed breaker was an ABB 121PM40-20 breaker and the entity engaged in a contract to have an ABB representative assist in troubleshooting the breaker. It was found that there was an insufficient gap between the top of the close-coil plunger and the close lever in the breaker's FSA-2 mechanism. The instructions for this breaker call for a 2–4 mm gap but this breaker had a 0 mm gap. There were felt-pen markings near the close-coil brackets that indicated the close-latch assembly, close coil, or both had been worked on in the past. It is likely that this gap insufficiency was introduced during the time of work rather than during the manufacturing process. The troubleshooting team was able to replicate the breaker self-initiated reclose issue and once the gap adjustment was made the self-initiated reclosing no longer occurred.

It is important to note that the self-reclosing only occurs when there is a "trip-reclose-trip" sequence of operations like there would be during a permanent fault on a position that utilizes automatic reclosing. Therefore, this problem does not pose a safety hazard for hold orders or cutting out reclosing on breakers with this FSA-2 mechanism type. The entity has a large number of these breakers and issued a substation maintenance alert to all districts with ABB 72PM, 121PM, and 145PM breakers equipped with FSA-2 mechanisms.

In addition to the alert that was issued, the entity included a step to verify the gap parameters in their breaker diagnostic checklists that are used during maintenance activities.

The entity wants to clarify that breakers with this type of mechanism *do not* come from the factory with this issue. The issue can only be introduced when the close-latch assembly is replaced, when a close-coil is replaced, or when both components are replaced. If maintenance crews check and adjust the gap between the top of the close-coil plunger and the close-lever using the parameters listed in the

instruction book after parts replacement, then the self-reclosing issue *cannot* occur.

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For more Information please contact:

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