ALSTOM/AREVA HGT DASHPOT REBUILD PROCESS

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ABSTRACT

This paper summarizes Tri-State G&T's experiences with a service advisory from GE related to the dashpot in Alstom/Areva HGF circuit breakers and associated equipment failures, evaluation, and maintenance responses. The prioritization and decision-making process is summarized, as well.

INTRODUCTION

Alstom issued a service advisory in 2018 related to the dashpot of HGF type circuit breakers, both live and dead tank designs. If the dashpot leaks out and operates below the stated oil level, mechanical damage to the breaker can occur. The service advisory describes inspecting, correcting, and repairing if necessary. Tri-State suffered a breaker failure that was related to this concern on a high-operations breaker.

INITIAL BREAKER FAILURE

Tri-State had a breaker fail in service upon an opening operation in which an HGF breaker operated with an empty dashpot, potentially many times based on physical damage indications. Breaker details are as follows:

Areva HGF 1014

245kV, 2000A, 40kA

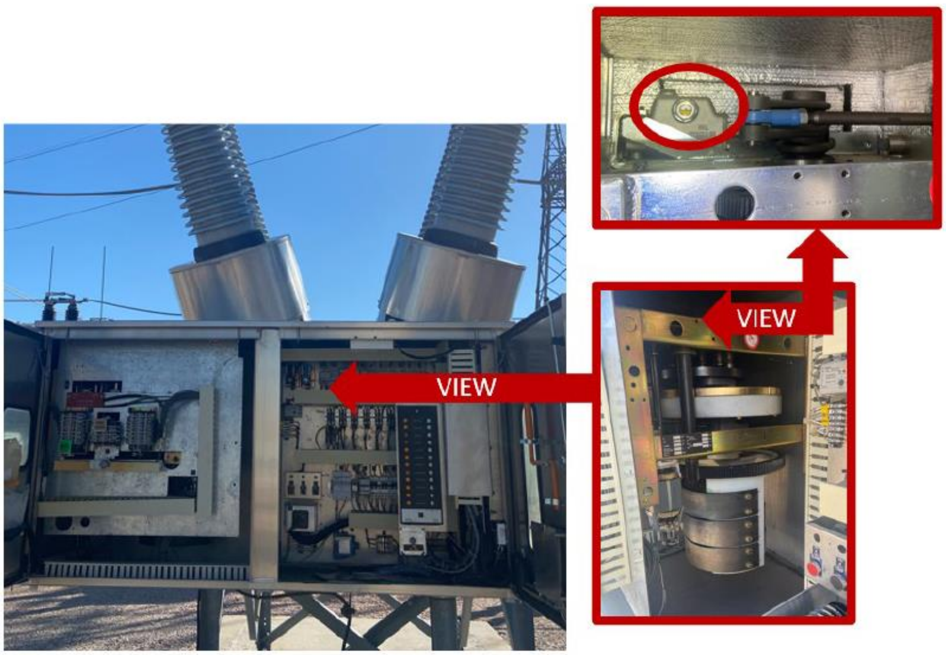
FKF 2-9 spring mechanism

At some point prior to the failure, the Pole 1 drive rod had broken in service during a closing operation. When the trip command was issued that lead to the failure, the contacts of Pole 1 did not open but the crank was in the open position. The stuck pole led to significant system impacts at Tri-State, which will not be discussed.

Upon inspection and evaluation of the relay records, the point of failure inside Pole 1 was obvious to the responding technicians. Main circuit resistance showed the closed position while the Pole 1 crank, interphase operating linkage, and other two poles were in the open position. The breaker in question is shown below in Figure 1.

Failed HGF 1014 Breaker
Figure 1

The dashpot oil level was inspected and found to be not visible in the sight glass. The dashpot oil level is found by viewing the top-left edge of the inside of the control cabinet from the right side. Details are shown below in Figure 2.

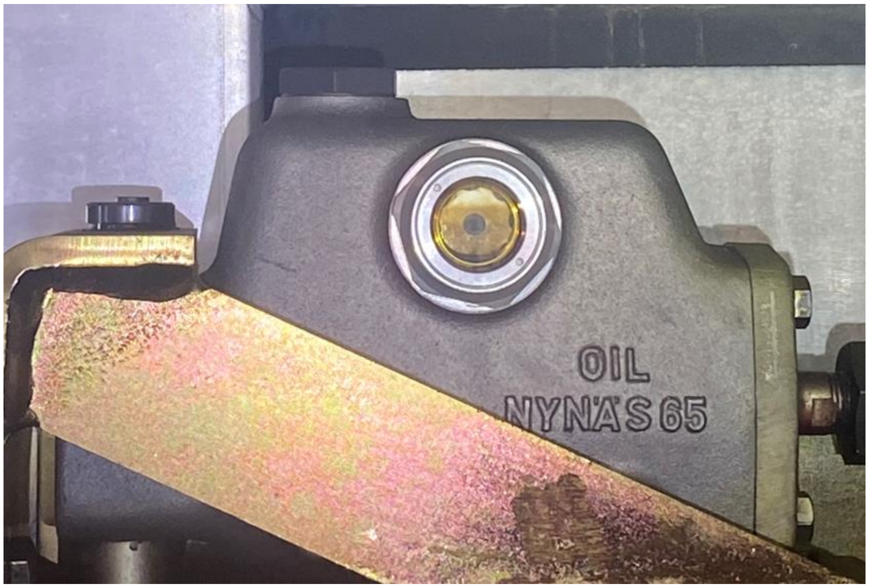


Finding Dashpot Oil Level
Figure 2

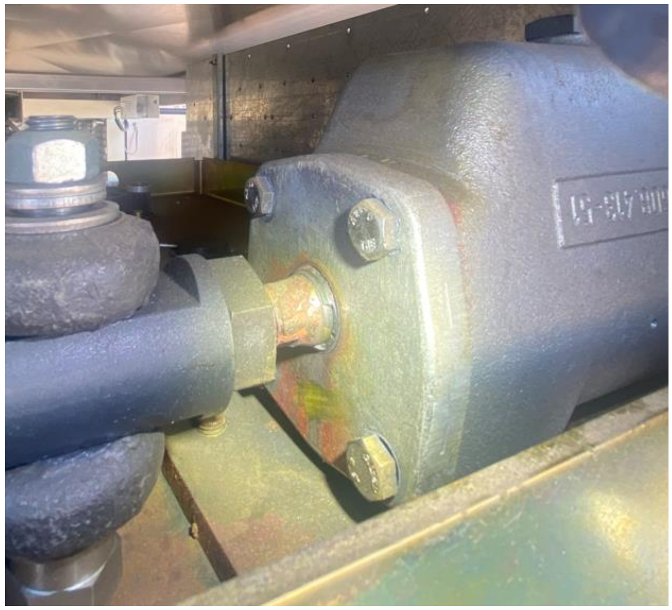
The dashpot oil level indication from the service advisory is shown below in Figure 3.

Acceptable Dashpot Oil Level from Service Advisory
Figure 3

The dashpot of the impacted breaker is shown below in Figures 4 and 5. Note that there is no oil in the sight glass, however it is discolored. It is suspected that this is from oxidation – with the compromised shaft seal, oil was leaking out and oxygen and moisture were leaking in. There was extensive dried up oil residue below an obviously deteriorated and non-functioning shaft seal.



Dashpot with No Oil Level Visible in Sight Glass
Figure 4



Compromised Shaft Seal
Figure 5

During physical inspection of the bell crank on Pole 1, the crank stop was found to be buried into the casting stop up to 0.25 inches when in the open position. This indicates that there was damage to the insulating drive rod inside the tank. A photo of the damaged stop is shown in Figure 6.

Crank Over travelled into Open Stop
Figure 6

The interphase operating linkage was also found to be bent between Pole 1 and Pole 2. The linkage had been scraping the housing and causing significant metal shavings inside the crank box on Pole 1. Photos of this are shown below in Figure 7. The bent linkage is another indication of damage related to the empty dashpot.

Damage to the Interphase Operating Linkage Seen from Pole 1 Crank Box
Figure 7

The breaker was determined to be a total failure. Due to its age there was no consideration made to pursue repairs or refurbishment. The breaker was scrapped.

IMMEDIATE CHECKS

Tri-State utilizes a formal memorandum called a Substation Maintenance Bulletin, or SMB, to convey important substation maintenance tasks or inspections related to potential equipment failure/damage. An SMB was issued for this potential failure mode and all remaining HGFs were visually inspected within three weeks. Information was relayed back to the Substation Maintenance Engineer to work with the local foremen on prioritization and follow-up work. This is discussed in a later section.

The SMB process is used for both short and long-term benefits. It quickly conveys important information in a formal manner but also can be posted in all affected equipment for future reference during later maintenance activities. Once the SMB was issued, progress inspecting the remaining HGFs was tracked and monitored to make sure none were left out. An example of the SMB inside the impacted equipment is shown below in Figure 8.

Substation Maintenance Bulletin Posted Inside of Impacted Equipment for Future Reference
Figure 8

Upon initial discovery of the failed breaker's empty dashpot, rebuild kits and make-up oil were purchased from GE. These are both long lead-time items. It is advisable to have these on-hand in a warehouse if any HGFs exist at a utility.

Most dashpots that were inspected had acceptable oil levels and no indications of oil leakage. In that instance, the SMB was posted inside the breaker cabinet, and the oil level was inspected during routine bi-monthly patrol inspections. The status was relayed to engineering and tracking was updated. No other actions were taken for acceptable oil levels.

Overall, 10% of dashpots inspected had some sort of deficiency:

Low Oil or Signs of Leakage

In the event that the oil level was found low or there were signs of leakage, the following response was taken:

- Crank open stops inspected for signs of impact or damage
- Inspect crank housings for unacceptable levels of metal particles/shavings
- Inspect interphase operating linkage for visible issues

If no concerns were found during the detailed visual inspection, oil was added to the dashpot to bring it to an acceptable level. This was done with the dashpot in place via a DGA syringe and Tygon tubing. The oil level was inspected biweekly and the rebuild was to occur as soon as practical. An example of low oil level and signs of oil leakage is shown below in Figure 9.

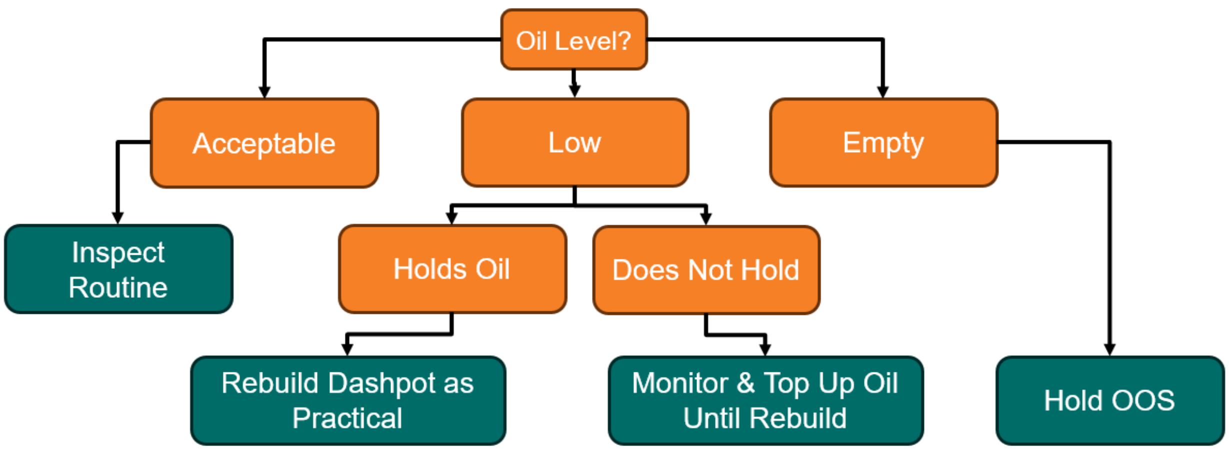
Example of Low Oil and Signs of Leakage
Figure 9

No Oil Visible in Dashpot

A single breaker was found with no oil in the dashpot. In that instance, given the age of the breaker, its operations count, and similar operating conditions to the failed breaker, the decision was made to replace the breaker proactively. It was kept out of service and replaced.

DECISION MAKING AND PRIORITIZATION

A decision tree was created to maintain consistent actions on different possible scenarios during the dashpot inspections. That decision tree is shown below in Figure 10



Decision Tree for Managing Follow-Up Process
Figure 10

The initial approach was devised in the field after adequate information had been gathered and the first non-failed breaker was inspected. It is beneficial to make decisions on the various scenarios that might occur before they do occur; hard decisions need to be made and it becomes easy to bend rules and make one-off exceptions when pressured by system operations, when countering resource constraints, or when disappointing product lead times hinder plans.

It took Tri-State months to get adequate parts on-hand to perform all of the required dashpot rebuilds. The kit from GE provides all materials and dashpot oil. The rebuild kit was set up as an inventory item in the warehouse inventory control system. Had parts been available initially, the entire decision making process and prioritizing work process would have been significantly easier.

REPAIRS PERFORMED

GE had provided instructions to rebuild the dashpot with the service kits, however the instructions were cryptic in a few areas. Upon inquiry, GE modified the instructions to be clearer and more easily understood. The repairs require the use of a slow-close (maintenance operating) device, which had no instructions available. GE provided detailed instructions on the use of the maintenance operating device. Working with GE to understand the full process helped to instill confidence and gain knowledge on the specific details of the rebuild. It is helpful to request from GE the most current versions of Document Number PRO-006 (Dashpot Rebuild Procedure) and Document Number PRO-018 Revision 0 (Slow Movement Device Procedure) for specific details and procedures on rebuilding the dashpot.

As it was a new maintenance task for the Apparatus Technicians at Tri-State, training for reach region was performed prior to removing the dashpot and rebuilding it. These steps were incorporated into the Annual Equipment Training that all three regions receive every year. These are specialized trainings on topics of interest or with heightened relevance, often performed by outside consultant experts.

Much time was spent on ensuring full understanding of the slow-close device prior to use, getting an appropriate bottle jack, and making custom adapters to ensure the jack stays aligned during the slow-close operation. The alignment of the slow-close device and its linkage connection is shown below in Figure 11.

Slow-Close Device Mounting
Figure 11

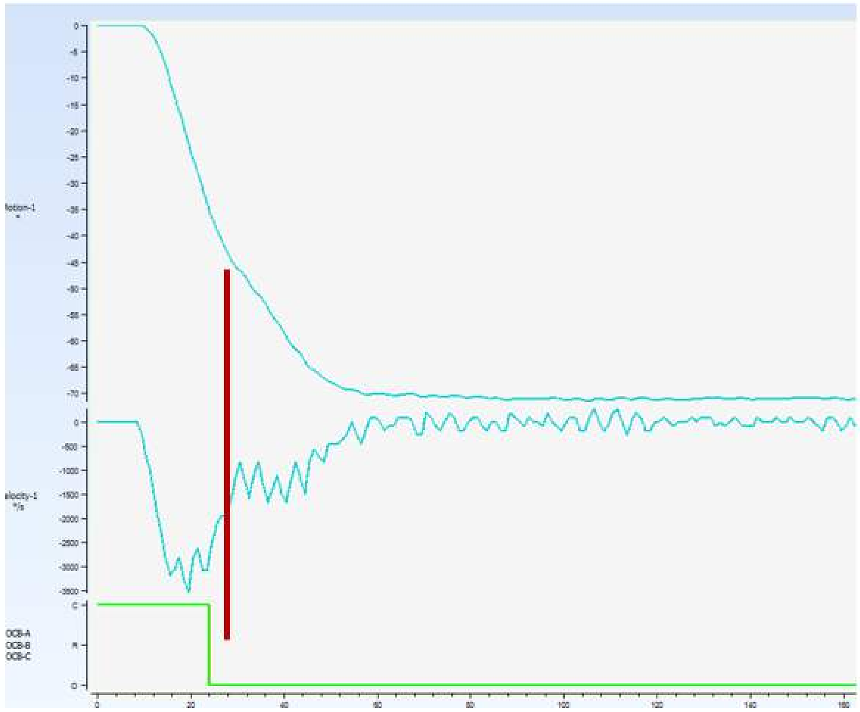
The jack could potentially slip off the device, making the process dangerous without adequate controls put in place. An example including the jack head saddle and the base strap of the device are shown in Figure 12.

Slow-Close Device Safety Provisions
Figure 12

Following GE's provided instructions for the repair, the process moves very easily. The kit from GE has clearly labelled components to fully re-gasket the dashpot and replace the piston rings and other wear components. The biggest concern when fitting the linkages to the dashpot during installation, is ensuring the dashpot is positioned where it does not bottom out at the end of a trip stroke. This step is clearly listed in the instructions and should be followed exactly. Due to the location of the lock-nut on the piston rod, getting a large enough torque wrench into the space to attain the 185 ft-lb specification is also challenging, but do-able.

TESTING

Each breaker was fully tested after the dashpot rebuild to confirm workmanship and validate the dashpot action. A complete diagnostic maintenance was performed per Tri-State standards, given the amount of required work. While performing timing and travel testing, special attention should be paid to the action of the dashpot on the open stroke. An example of acceptable dashpot action is shown below in Figure 13. The opening motion of the breaker begins to be retarded by the action of the dashpot catching the linkage.



Correct Dashpot Action in Travel Traces after Rebuild
Figure 13

Since the breaker will have undergone a significant change, it is logical to perform full maintenance in order to reset any triggers in the computerized maintenance management system (CMMS). Full testing after the repair, including timing and travel, main circuit resistance, and controls verification can help to uncover any other issues that need to be addressed while the breaker is out of service.

CONCLUSION

Ultimately, it is important to stay current with service advisories to avoid having a piece of equipment fail in service due to a known issue. Once a known issue is identified, it is important to maintain an adequate spare parts inventory – cataloged and managed in a warehouse – to address the issues as they arise. Given the very long lead times and logistic/supply chain concerns at present, an inventory of on-hand spare parts is even more critical to address issues and avoid keeping equipment out of service for undue periods of time. When new tasks are expected of maintenance crews, detailed training and preparation will set them and the program up for success. Lastly, a decision tree will help shape the repair program with a consistent angle on various scenarios that may be encountered.

BIOGRAPHY

Michael D. Wolf, PE is a Principle Engineer of Substation Maintenance at Tri-State Generation and Transmission Association, a G&T cooperative in Colorado, Wyoming, New Mexico, and Nebraska. Mike has been working with the operation, maintenance, testing, and commissioning of substation power equipment since 2008. He has a Bachelor's Degree in electrical engineering from Clarkson University, a Masters Degree in power engineering from Worcester Polytechnic Institute, and is a licensed electrical engineer in five states.