North American Transmission FORUM

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NATF Redacted Operating Experience Report

Safety – Transformer Electrical Shock Incident

About NATF Redacted Operating Experience (OE) Reports

North American Transmission Forum (NATF) operating experience reports highlight positive or negative transmission (reliability or resiliency) experiences worth sharing for learning opportunities or potential trending. The overall goal is to help each other learn without experiencing the same issues first-hand. This sharing originates confidentially within the NATF membership.

Redacted operating experience reports are posted on the NATF public website to allow the NATF and its members to more broadly share information, especially safety-related alerts and learnings, with contractors and other utilities to benefit the industry at large.

The NATF member company that submitted the initial restricted distribution OE report for this topic/event has approved the NATF to issue this redacted OE report.

Open Distribution

Disclaimer

Topic

Transformer Electrical Shock Incident

Description

During normal maintenance activities on a generator step up (GSU) transformer, a substation electrician sustained an electrical shock when removing the last flexible link between the X2 bushing and the isophase bus.

To facilitate maintenance on the GSU and plant station service transformers (SST), clearance had been provided by the plant. Tags had been installed; testing to ensure that the clearance zone was deenergized had been conducted; and personal protective grounds had been installed on the high side of the GSU, isophase bus, SST low side breakers, and the generator neutral. At the time of the event, all three GSU high-side leads were disconnected and pulled back from the H1 bushings. The lifted high-side leads were connected to the ground mat via personal protective grounds.

GSU low-side leads were in the process of being disconnected when the event occurred. Low-side X1 bushing connects to "B" phase of the isophase bus and X2 bushing connects to "C" phase of the isophase bus. All X1 bushing links had been removed without incident. As the last link connecting the X2 bushing to the isophase bus was pushed away and separated from the X2 bushing by the substation electrician, he felt a shock. At the time of the event, the Electrician was positioned with one hand on top of the X2 bushing and the other hand touching the isophase bus link that was still connected to the grounded isophase bus. In addition, the following transformer lead configurations existed:

- GSU "A" low-side leads were disconnected. Low side X1 bushing connects to "A" phase of the isophase bus and X2 bushing connects to "B" phase of the isophase bus. No shock issues occurred while removing these links.
- GSU "C" low-side leads were still connected to the isophase. Low side X1 bushing connects to "C" phase of the isophase bus and X2 bushing connects to "A" phase of the isophase bus.
- SST "A" was still connected to high- and low-side equipment.
- SST "B" was still connected to high- and low-side equipment.
- SST "C" high- and low-side leads had been disconnected without incident.

Impact to Safety

Anytime an employee is subject to an electrical shock or discharge, significant personal injury and or death can result. In this case, we were very fortunate in that the employee suffered only minor discomfort and was released to return to work after being seen by plant medical staff.

Lessons Learned

1. Ensure that transformers are grounded at all times during the removal and installation of primary and secondary leads.

Reference: NATF-OER-303

2. Substation and plant ground mat integrity should be verified via a preventive maintenance policy with a defined periodicity. Whenever personal protective grounds are installed and attached to a ground that is not in a defined testing program, a "clamp-on" ground resistance tester must be used to ensure an adequate ground exists so the personal protective grounds will serve their intended function.

3. The use of tested personal protective grounds is needed to ensure capacitive and induced charges are bled to ground. This also ensures that if a circuit is re-energized that a good connection to earth exists to protect workers that may be working between grounds.

Apparent Cause

The apparent cause of the shock was determined to be an induced voltage from within the transformer. There were no identified transformer failures that caused the induced voltage. The pumps and fans were off at the time of the incident and therefore forced convection of the oil was eliminated as a cause for the voltage generation. It is concluded through a process of elimination, testing, and research into operating experience data that the most probable cause of the shock incident was induced/static voltage that developed on the ungrounded and floating H1 bushing on GSU "B" based on wind and on the insulating paper in the transformer due to natural convection of oil. The induced/static voltage discharged momentarily through the individual with one hand on the X2 bushing and one hand on the grounded isophase bus link. This apparent cause agrees with the magnitude of the shock and the situation at which the event occurred.

Contributing Cause

Throughout the transformer maintenance activities, the substation electrician had been wearing his leather gloves, but removed them temporarily to improve manual dexterity as he was picking up fallen washers. Without putting the leather gloves back on, the Substation Electrician removed the last link from the X2 bushing and sustained the shock. If the substation electrician had been wearing leather gloves, the resistive properties of the gloves may have been enough to prevent the "shock" from occurring or at least minimized the current flow from the shock. Leather gloves are normally worn while removing leads, and there has never been a shock incident during this step in the past. On that same day, the leads were removed from GSU "A" while leather gloves were worn, and there was no shock incident.

Actions Taken

All power transformers at the 230 kV and 500 kV voltage levels will have their procedures enhanced to include additional steps when performing transformer maintenance activities.

- The grounded H1 connections to the main transformers will be last off and first on.

- Before reconnecting high-side leads after being disconnected, there will be a Doble ground stick applied to the H1 bushing pad to discharge any potential static charge buildup.

- All main and station service transformers must be completely disconnected prior to any Doble testing being performed.

- The use of leather gloves will be required when removing or reconnecting leads.

Reference: NATF-OER-303

- Need to test all installed protective grounds with the earth ground clamp meter to ensure or verify there is a path to ground.

Extent of Condition

N/A