NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Lessons Learned

Inadequate Battery Configuration Management Damaged a Generating Station and Tripped an HVDC Conversion Station

Primary Interest Groups

Generator Owners (GOs)
Generator Operators (GOPs)
Transmission Owners (TOs)
Transmission Operators (TOPs)

Problem Statement

Progressive voltage drops occurred on three-phase transmission lines between a multiunit generating station and an AC-DC conversion station for a major intertie. At the same time, all units at the generating station were without monitoring and half of the units were running without control and protection due to the loss of DC supply.

Details

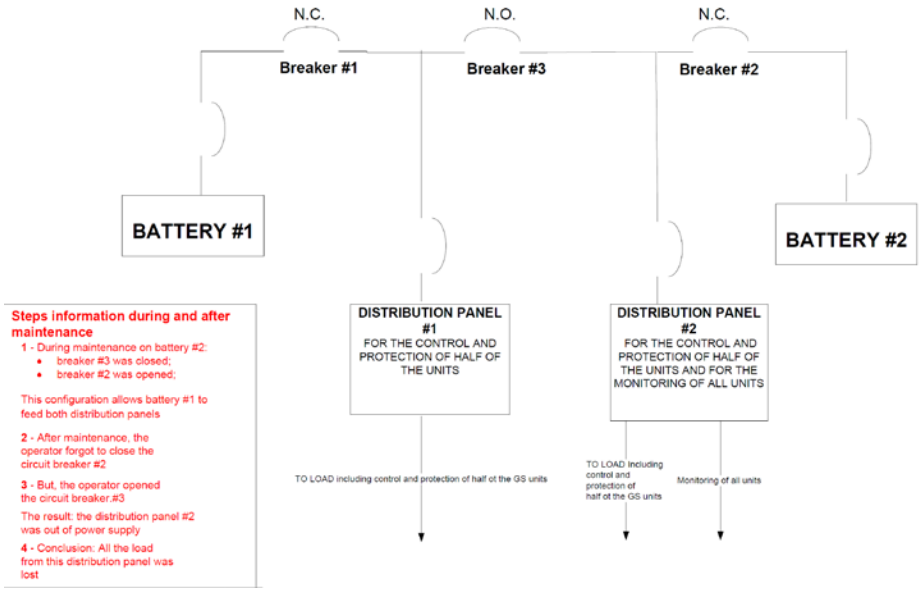
At the generating station, two main batteries are installed to supply the control and protection of the units. In the normal configuration, each of the batteries supply the protection and control of half of the units. However, it is possible for one battery to supply the protection and control for all the units when the other battery is out-of-service for maintenance.

In the configuration shown in the figure on the right, Distribution Panel #2 for monitoring all the units, and the control and protection of half the units, is normally supplied by battery #2.

<u>The Event</u>

The different personnel involved in the event are the:

- Switchgear technicians (referred to as “technicians” after this point) responsible for doing maintenance on the batteries
- Generating station operators responsible for commissioning the battery
- Generating station desk operators who execute instructions from the control center at the generating station desk



- Control center operators who give instructions to the generating station desk operator and exercises the GOP function

Just prior to the event, the technicians were doing maintenance on the batteries. After the technicians completed their maintenance on Battery #2, the generating station operator did not close Circuit Breaker #2 that supplies Distribution Panel #2 from Battery #2 before opening Circuit Breaker #3, which had been supplying the panel from the Battery #1. Consequently, Distribution Panel #2, which feeds the monitoring of all units and the control and protection of half of the units, was not supplied with power.

Monitoring for the entire generating station was lost. Consequently, no alarms were seen by the generating station desk operator nor at the control center. The panel remained out of service for about an hour and a half.

Approximately an hour after the loss of the panel, progressive voltage drops started to occur on the transmission lines connecting the generating station to the AC-DC conversion station. Due to the loss of generating station monitoring, diagnosis during the event and later investigation into the cause of the event were difficult to conduct. Eventually, it was determined that the most probable cause for the progressive voltage drops was a cascade effect due to the response of the AC-DC substation to the initial voltage drop (in/out service of filters) and the lack of regulation at the generating station due to of the loss of the DC supply.

The event resulted in damage to the generating units that were left without protection due to the loss of DC power. The power transfer for the DC interconnection was also lost for more than three hours.

Discussion

When the generating station operator failed to close Circuit Breaker #2, he had his technical instructions in-hand but did not have the switching plan with him. The technical instructions included actions to perform on specific equipment; the switching plan contained all actions to be performed, including confirmation steps (e.g., to check if alarms are still present on the control panel). Following the event, it was noted that many operators have been only following the technical instructions.

A contributing factor to the duration of the event was the lack of communication from the generating station desk operator to the control center operator. When the batteries were (supposedly) returned to service, the generating station desk operator should have notified the control center operator. The operator at the control center only discovered hours later that the maintenance was completed. Because of this lack of notification, the control center operator did not make a connection between the loss of monitoring and the maintenance on the batteries.

General considerations

- Organizations develop internal controls for any process that is critical to the success of that organization. The more critical the need to “get it right,” the tighter the controls need to be.

- Losing DC power at a generating station can have severe consequences. Therefore, maintenance that can impact DC power supplies requires a commensurate degree of planning, a checklist with detailed instructions, peer-checks, monitoring, and supervision as well as workers' communication and status updates to control center operations to avoid such consequences.

Corrective Actions

Following the analysis and investigations, the entity developed the following corrective actions:

1. Ensure that generating station operators have all necessary procedures and technical documentation in-hand when performing switching operations.
2. Confirm that actual engineering practices that apply to maintenance of any power that supplies protection, regulation, control, monitoring, or telecontrol systems are suitable.
3. Evaluate the power supply of the control and protection systems of all strategic generating stations and, if necessary, modify the power supply systems.
4. Improve generating station operator awareness regarding the risks encountered by the loss of DC supply in generating stations and stress the importance of communication with the control center operators (specifically by adding it into written procedures if not already included). The communication shall emphasize the importance of communicating changes in equipment status and availability promptly.
5. Establish clear procedures for when the DC supply of some or all units are lost (for example: stop the units).

Lessons Learned

- Establish internal controls on maintenance activities that are commensurate with the criticality of the work. Ensure that the criticality of the work, including the configuration of the network at the time of the work, is understood.
- Emphasize the importance of clear and prompt communication between generation station operators and control centers, specifically when there is a change in critical equipment status and availability.
- Improve generating station operator awareness regarding the risks posed by the loss of DC supply in generating stations and further stress the importance of communication by specifically adding it into written procedures.

If there is no battery back-up, the following recommendation might be applicable. When in-service battery maintenance is performed, ensure that redundant supplies (such as mobile battery carts or permanently installed "swing batteries" connected in parallel) exist to supply power to essential protection and controls plus monitoring tools. If those methods are not feasible, consider delaying maintenance on the batteries until units are off-line.

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