UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

June 16, 2011

NRC INFORMATION NOTICE 2011-12: REACTOR TRIPS RESULTING FROM WATER INTRUSION INTO ELECTRICAL EQUIPMENT

ADDRESSEES

All holders of operating licenses or construction permits for a nuclear power reactor issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees about recent events involving water intrusion into electrical equipment that resulted in reactor trips. The NRC expects recipients to review the information for applicability to their facilities and to consider actions, as appropriate, to avoid similar problems. The suggestions contained within this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

<u>Calvert Cliffs Nuclear Power Plant, Units 1 and 2</u>

On February 18, 2010, Calvert Cliffs Nuclear Power Plant experienced a dual-unit reactor trip with complications in Unit 2. The event started in Unit 1 when water leakage through the roof of the auxiliary building caused an electrical ground on a 13-kilovolt (kV) bus that tripped one of the four reactor coolant pumps (RCPs), resulting in an automatic reactor trip of Unit 1 on reactor coolant system low-flow. This electrical ground was not isolated close to the source because of a failed ground protection relay in the feeder breaker from a 500-kV/13-kV service transformer in Unit 2 that provides an alternate source of power to the RCP buses in Unit 1. This incident resulted in the actuation of upstream protective relays and the subsequent deenergizing of a 500-kV/13-kV service transformer in Unit 2, resulting in the loss of power to all Unit 2 RCPs and an automatic reactor trip of Unit 2 on reactor coolant low-flow.

A subsequent review found that the licensee had previously recognized the degraded condition of the auxiliary building roof but left it unresolved for approximately 7 years before the dual-unit trip. The degraded condition of the roof led to a failure of the auxiliary building to protect safety-related switchgear from environmental conditions. After the trip, the licensee's corrective actions to prevent recurrence included (1) improving processes for the categorization, prioritization, and management of roofing issues, (2) revising the relay calibration procedures to

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perform a final as-left pickup verification to ensure that a relay was not damaged during maintenance, and (3) revising the procedure to keep both breakers normally open in the alternate source of power to the Unit 1 RCP buses from a 500-kV/13-kV service transformer in Unit 2 and to the Unit 2 RCP buses from a 500-kV/13-kV service transformer in Unit 1.

More information is available in “Calvert Cliffs Nuclear Power Plant—NRC Special Inspection Report 05000317/2010006 and 05000318/2010006; Preliminary White Finding,” dated June 14, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML101650723); Licensee Event Report (LER) 317-2010-001, “Reactor Trip due to Water Intrusion into Switchgear Protective Circuitry,” dated May 27, 2010 (ADAMS Accession No. ML101530461); and LER 318-2010-001, “Reactor Trip due to Failure of Protective Relay Circuitry,” dated May 27, 2010 (ADAMS Accession No. ML101530459). In addition to the previously discussed issues, these documents provide details on (1) the failure of the emergency diesel generator in Unit 2 to power a safety-related 4-kV bus because an Agastat relay in the starting circuit of the emergency diesel generator timed out early, thus introducing the trip signal for the low lube oil pressure before the lube oil pressure increased sufficiently to clear this signal, (2) the licensee’s failure to adequately evaluate and correct a history of degraded CO-8-type ground fault and overcurrent relays, and (3) the licensee’s failure to set the actual relay settings for phase overcurrent protection to the values specified in design-basis calculations.

Braidwood Station, Units 1 and 2

On August 16, 2010, Braidwood Station experienced a dual-unit reactor trip. Unit 2 tripped first, and Unit 1 tripped approximately 13 minutes later. In the main generator isophase bus framework of Unit 2, a deionizer fin detached from a section of the crossover damper assembly, which caused a ground fault that resulted in a generator lockout and reactor trip. Following the reactor trip, the Unit 2 condenser hotwell level began to rise, thus requiring the redirection of condensate from the hotwell to the condensate storage tank. A design deficiency caused the redirection of the condensate to the auxiliary feedwater (AFW) suction header, resulting in the discharge of approximately 12,000 gallons of water from the AFW suction header standpipes in Unit 2 to the turbine deck floor of the turbine building. This volume of water flowed down through floor openings to the lower elevations of the turbine building that is shared between both units at Braidwood Station.

The water leaked into the 4-kV switchgear in Unit 1 and caused a ground fault that tripped a 4-kV breaker, deenergizing downstream 480-V switchgear and motor control centers. Circulating water pumps A and C in Unit 1 tripped because of a loss of power, resulting in a low condenser vacuum that caused a turbine trip and a reactor trip in Unit 1. In addition, a loss of power to the motor control centers resulted in a loss of power to the condenser steam dump valves, which then could not be opened for the normal removal of decay heat. Operators used the power-operated relief valves of the steam generator to remove decay heat and to maintain temperature and pressure in Unit 1.

The licensee installed AFW system suction header standpipes in 1986 to provide a standing head of water to address a low net positive suction head problem when the motor-driven AFW pumps were started. However, this design change introduced the potential for water spills from the standpipes because the AFW suction header is also used as the flowpath of condenser hotwell reject water from the hotwell to the condensate storage tank. At certain flow rates, large amounts of water can be drawn up into the standpipes and could spill onto the turbine deck because the standpipes are open to the atmosphere on the common turbine building. The licensee observed water overflowing from the AFW standpipes onto the floor of the turbine building on multiple occasions; however, it did not correct the condition because it had assessed that the overflow of the water did not have a significant impact on plant operations.

The licensee’s corrective actions included (1) limiting the condensate storage tank level to prevent another AFW standpipe siphon event, (2) implementing an operating configuration change to valves controlling a condensate hotwell rejection, (3) developing a plan to identify long-term water leaks, spills, other uncontrolled fluid conditions or any degraded or abnormal conditions. In addition, the licensee planned to install a design feature on the AFW suction standpipe to prevent recurrence of water spill events via that pathway.

More information is available in “Braidwood Station, Units 1 and 2, NRC Special Inspection Team (SIT) Report 05000456/2010010; 05000457/2010010,” dated November 12, 2010 (ADAMS Accession No. ML103190505); Braidwood Station, Unit 2, LER 457-2010-003, “Reactor Trip Caused by Phase to Ground Fault of a Failed Crossover Damper/Deionizer Assembly due to an Inadequate Inspection Acceptance Criteria and Preventive Maintenance Inspection Frequency,” dated October 15, 2010 (ADAMS Accession No. ML102880320); and Braidwood Station, Unit 1, LER 456-2010-001-01, “Reactor Trip due to Water Intrusion in Breakers Causing Circulating Water Pump Trips and Resulting in Loss of Condenser Vacuum,” dated March 2, 2011 (ADAMS Accession No. ML110620091).

Grand Gulf Nuclear Station, Unit 1

On March 8, 2010, Grand Gulf Nuclear Station, Unit 1, experienced an automatic reactor scram caused by low reactor water level. An erroneous signal caused the minimum flow valve on reactor feedwater pump B (RFP B) to fail open. The erroneous signal was generated as a result of an electrical short that was caused by condensation in a junction box that contained feedwater suction flow transmitter cables. As RFPs A and B attempted to increase speed to restore normal feedwater flow, the RFP A turbine control valve experienced mechanical binding, which caused RFP A to trip. The reduction in feed flow caused the reactor water level to decrease to the reactor protection system actuation setpoint level.

The licensee found that the junction box where the feedwater suction flow transmitter fault originated was full of condensed water from a steam leak from valve packing in the feedwater heater room. An inadequate splice assembly allowed water to penetrate the cable jacket at the spliced connection, thus causing a short that affected the signal from the flow transmitter and driving the minimum flow valve open. The licensee discovered the steam leak approximately 1 month before the reactor scram event. However, the licensee had not thoroughly evaluated the potential effects of the leak and, as a result, did not immediately correct the condition.

Before restarting the unit, the licensee inspected electrical boxes in the turbine building and drained several boxes where water had accumulated. The licensee identified boxes that contained water and inadequate cable splices and repaired the splices as necessary.

More information is available in “Grand Gulf—NRC Integrated Inspection Report 05000416/2010002,” dated May 4, 2010 (ADAMS Accession No. ML101250383), and Grand Gulf Nuclear Station, Unit 1, LER 416-2010-001, “Automatic Reactor Scram on Decreasing Reactor Water Level due to Inadvertent Reactor Feed Pump Trip,” dated May 5, 2010 (ADAMS Accession No. ML101250552).

DISCUSSION

In each event described in this IN, an electrical fault occurred as a result of water intrusion into electrical equipment. In each case, the licensee had previously recognized the source of the water but had not corrected it. For systems within the scope of Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” to 10 CFR Part 50, Criterion XVI, “Corrective Action,” requires licensees to establish measures to “assure that conditions adverse to quality” be “promptly identified and corrected.”

The timely corrective actions to assess and prevent water intrusion into electrical equipment can help prevent significant events and ensure nuclear plant safety.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below or to the appropriate NRC Office of Nuclear Reactor Regulation project manager.

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Note: NRC generic communications may be found on the NRC public Web site, http://www.nrc.gov, under NRC Library.

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