April 25, 2013

MEMORADUM TO: Michele G. Evans, Director
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

FROM: Richard P. Correia, Director ***/RA/***
Division of Risk Analysis
Office of Nuclear Regulatory Research

SUBJECT: TRANSMITTAL OF FINAL BYRON STATION UNIT 2 ACCIDENT SEQUENCE PRECURSOR ANALYSIS

This memorandum transmits the final results of an accident sequence precursor (ASP) analysis of an operational event that occurred at Byron Station, Unit 2 on January 30, 2012. The Office of Nuclear Regulatory Research (RES) requested a formal analysis review from the licensee in accordance with U.S. Nuclear Regulatory Commission Regulatory Issue Summary 2006-24, "Revised Review and Transmittal Process for Accident Sequence Precursor Analyses," because the analysis had a preliminary conditional core damage probability (CCDP) greater than 1×10^{-4}. Comments from the licensee, the Office of Nuclear Reactor Regulation (NRR), and Region III staff were reviewed by RES and incorporated into the analysis, when appropriate.

The ASP Program continues to systematically review licensee event reports (LERs) and all other event reporting information [e.g., inspection reports (IRs)] for potential precursors, and to analyze those events which have the potential to be precursors. The complete summary of FY 2012 ASP events will be provided in the upcoming Commission paper on the status of the ASP Program and Standardized Plant Analysis Risk (SPAR) Models due to be issued in October 2012.

Transmittal to Licensee Requested. We are requesting NRR to send the enclosed final ASP analysis to the licensee for their information. The ASP analysis will be made publically available after the analysis has been transmitted to the licensee. Please inform us when the ASP analysis has been sent to the licensee.

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Final ASP Analysis Summary. A brief summary of the final ASP analysis, including the results, is provided below.

Transformer and Breaker Failures Cause Loss of Offsite Power, Reactor Trip, and De-Energized Safety Buses (January 2012) at Byron Station, Unit 2. This event is documented in LER 454/12-001-01 and IR 05000455/2012008.

Event Summary. At 10:01 on January 30, 2012, Byron Station, Unit 2 experienced an event, in which the 4.16 kV engineered safety feature (ESF) buses were not energized by an operable power source for eight minutes. A failed insulator in the 345 kV switchyard caused the loss of one of three electrical phases (Phase "C") supplying 345 kV offsite power to the Unit 2 station auxiliary transformers (SATs). Following the insulator failure, the reactor automatically tripped from full power due to an under-voltage condition on 6.9 kV buses that supply power to two of four reactor coolant pumps (RCPs). The loss of Phase C, however, did not result in an automatic under-voltage protection signal for either 4 kV ESF buses, because the under-voltage protection scheme did not provide adequate protection from a single phase loss of either Phase "A" or "C". As a result, all running safety equipment powered by the ESF buses had tripped. This included the charging pumps which supply RCP seal injection, the component cooling water pumps, system which supply thermal barrier heat exchanger cooling to the RCP seals, and the essential service water pumps. These conditions existed until operators manually opened (from the main control room) the SAT feeder breakers about eight minutes after the event had initiated. Following the opening of the SAT feeder breakers, both emergency diesel generators started and loaded supplying power to Buses 241 and 242, as designed.

No significant degradation to the RCP seals occurred based on the manual action occurring within the time it would have taken for the RCP seal water volume to deplete (about 13 minutes). Reactor decay heat was removed utilizing the diesel-driven auxiliary feedwater (AFW) pump and steam generator power operated relief valves while the primary system cooled down in the natural circulation mode of operation. On January 31, 2012, Unit 2 entered Mode 5 (i.e., Cold Shutdown). Repairs were completed and the Unit 2 SATs were returned to their normal alignment on January 31, 2012.

Summary of Analysis Results. This operational event resulted in a best estimate CCDP of 1×10^{-4}. This CCDP is strongly dependent on the human error probability for recovery (operators opening the SAT feeder breakers); and it is expected that this recovery event would have large uncertainties because (1) the recovery event modeled in this analysis is a previously unanalyzed event in plant probabilistic risk assessments, (2) the normal uncertainties associated with using human reliability analysis (HRA) methods can be significant, and (3) current HRA methods were not designed with recovery actions in mind. Sensitivity studies performed using additional HRA methods were performed; the CCDPs for these analyses ranged from 2×10^{-5} to 3×10^{-3}. The detailed description of these analyses can be found in the ASP analysis report provided in the Enclosure.

Risk Insights. The dominant risk for this event involves the failure of operators to open the SAT feeder breakers within 13 minutes, thus causing a loss of seal injection and cooling to the RCPs. The Westinghouse Owners Group 2000 RCP Seal Model used in the SPAR models assumes that if both seal cooling and injection are lost, the RCP seals will experience voiding conditions in approximately 13 minutes. When voiding conditions occur in the RCPs, the Stage 2 seals have a 20-percent chance of failing. At Byron Station, if the diesel-driven AFW

pump is successful in maintaining steam generator water inventory, operators would have approximately 4 hours to open the Unit 2 SAT feeder breakers to restore power to the ESF buses (thus restoring power to safety systems) to prevent core uncovery and subsequent core damage. For most of the important risk scenarios, actual core damage occurs long after the battery has depleted. However, our current PRA practice is not to give probabilistic credit for the possibility of restoring power and safety equipment after the batteries have depleted.

Sensitive Information. The detailed ASP analysis has been reviewed in accordance with current guidance for sensitive unclassified non-safeguards information, and it has been determined that it may be released to the public.

Enclosure: as stated.

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