UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 21, 2020

MEMORANDUM TO: Eric Benner, Director
Division of Engineering and External Hazards
Office of Nuclear Reactor Regulation

FROM: Brett Titus, Chief
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Division of Engineering and External Hazards
Office of Nuclear Reactor Regulation

SUBJECT: BACKFIT SCREENING ANALYSIS—INDUSTRY INITIATIVE TO RESOLVE OPEN PHASE CONDITION IN OPERATING REACTORS—UNITED STATES NUCLEAR REGULATORY COMMISSION BULLETIN 2012-01, "DESIGN VULNERABILITY IN ELECTRIC POWER SYSTEM"

The purpose of this memorandum is to document the conclusions of the staff's backfit screening analysis results associated with the industry's efforts to address open phase conditions (OPCs).

An OPC, as discussed in this memo, is defined as an open phase, with or without a ground fault, which is located on the high voltage side of a transformer connecting a general design criterion (GDC) 17 off-site power circuit to the on-site power distribution system. An OPC may also occur because of various faults such as one or two out of three circuit breaker poles not fully opening or closing, or the failure of transformer bushings or line insulators, leading to a loss of circuit continuity. This type of fault creates voltage and current imbalances in electrical power systems that may be detrimental to operating equipment. An OPC, if not detected and disconnected in a timely manner, represents a design vulnerability for many nuclear power plants (NPPs). If unrecognized or untended, it may lead to a condition in which neither the off-site power system nor the on-site power system is able to support the design safety functions. The electrical power systems of NPPs have been adversely impacted from such OPC design vulnerability as discussed in NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12074A115)."

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The electric power system design at most NPPs did not include provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss or degradation of power from the transmission network caused by an OPC. Therefore, the staff notes that modifications are not necessary to bring a facility into compliance with a license or the rules or orders of the Commission. In response to Bulletin 2012-01, most licensees have opted to implement the voluntary industry initiative (VII) developed by the Nuclear Energy Institute (NEI) (ADAMS Package Accession No. ML15075A454). The goal of the VII is to ensure that an OPC will not prevent functioning of important-to-safety systems and components. To achieve this goal, the engineered safeguard buses should be transferred to an alternate source if an OPC prevents the functioning of important-to-safety systems or components. The VII provides criteria in areas related to monitoring equipment, automatic protection features, alarms, periodic tests, calibrations, setpoint verifications, and inspections. In response to the VII, members of the nuclear industry developed plans for installing systems, called Open Phase Isolation Systems (OPIS), which would detect and alarm in the main control room and automatically actuate to protect against OPCs.

On March 9, 2017, the U.S. Nuclear Regulatory Commission (NRC) issued Staff Requirements Memorandum (SRM) SECY-16-0068, "Interim Enforcement Policy for Open Phase Conditions [OPCs] in Electric Power Systems for Operating Reactors (ADAMS Accession No. ML17068A297)." The SRM directed the staff to verify that licensees have appropriately implemented the VII, including updating the licensing basis to reflect the need to protect against OPCs. Accordingly, on October 31, 2017, the staff issued Temporary Instruction (TI) 2515-194, "Inspection of the Licensees' Implementation of Industry Initiative Associated with the Open Phase Condition Design Vulnerabilities in Electric Power Systems (NRC Bulletin 2012-01), Revision 0, (ADAMS Accession No. ML17137A416)," to verify the implementation of the VII (Section 03.01 of the TI) at all currently operating power plants and to gather information (Section 03.02) to determine whether the modifications implemented by the licensees adequately address potential OPCs.

Inspections were conducted at four pilot plants (River Bend, Palo Verde, Byron, and St. Lucie), which encompassed the fundamental designs licensees chose to implement the VII and address an OPC. The results of these inspections are documented in individual inspection reports (ADAMS Accession Nos. ML18085B197, ML18103A157, ML18138A136, and ML18208A328, respectively). Two public meetings were held with industry representatives (meeting summaries available at ADAMS Accession Nos. ML18268A346 and ML18309A227) to discuss the staff's observations and concerns based on a preliminary assessment from the information gathered by the TI. The preliminary assessment performed by the EEOB staff revealed the potential need to perform a backfit regulatory analysis and, depending upon the result, provide a notation vote paper in accordance with Commission direction in SRM SECY-16-0068 on additional requirements such as the following:

- Scoping of OPIS components within the maintenance rule (10 CFR 50.65);
- Adding a Limiting Condition for Operation into the plant's Technical Requirements Manual (TRM), or equivalent document, to establish equipment unavailability limits; and
- Associated Surveillance Requirements in the TRM.

This assessment, once complete, will be used to support the staff's closure of Bulletin 2012-01.

By letter dated June 6, 2019, (ADAMS Accession No. ML19163A176), NEI submitted Revision 3 to the voluntary industry initiative. This revision incorporates an option for plants to perform a

risk evaluation to support manual response to an OPC as an alternative to enabling automatic isolation upon an OPC. The letter further indicates that the industry's chief nuclear officers have voted to approve this revision to the NEI OPC initiative and that the initiative is a formal commitment by NEI member companies that operate nuclear power plants to follow a specific policy or plan of action.

The staff received a copy of the risk guidance document for implementing the risk option, NEI 19-02, "Guidance for Assessing Open Phase Condition Implementation Using Risk Insights," on June 20, 2019 (ADAMS Accession No. ML19172A086). At a public meeting on July 16, 2019, NEI indicated that approximately 60 percent of plants are planning to implement the risk-informed approach discussed above.

In response to the licensees' proposed modifications to their facilities to address potential OPCs and the preliminary assessment performed by the EEOB staff on industry's VII implementation, NRC staff performed a risk assessment (ADAMS Accession No. ML20021A271) to evaluate the potential change in Core Damage Frequency (CDF) resulting from these modifications per the guidance in NUREG/BR-0058, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission." The purpose of these evaluations was to determine whether the addition of an automatic OPIS resulted in a substantial safety increase compared to a configuration with no OPIS installed. Specifically, evaluations were conducted to assess the CDF associated with: (1) an OPC occurring and no OPIS installed; and (2) an OPC occurring and an installed OPIS with automatic initiation enabled. (Note: Performing the backfit analysis with OPIS in automatic actuation mode is the scenario that represents the greatest potential increase in safety, thus bounds other scenarios such as operating OPIS in alarm-only mode with corresponding manual actions.). Retrospectively, the staff determined that the analysis completed in January 2020 met the intent of NRR ADM 405, Revision 3, "NRR Technical Work Product Quality and Consistency," issued on March 18, 2020.

The risk assessment analyzed the impact of an OPC for a sampling of plants with two different electrical configurations. The first configuration was for a plant in which: (1) the safety buses are fed directly by offsite power full-time; and, (2) an OPC causes a loss of offsite power with failure of the emergency power source to automatically restore power due to the OPC. The second configuration was for a plant in which: (1) the safety-related loads are fed full-time from non-safety buses fed by a main generator; and upon a generator trip, a fast transfer is made to offsite power feeds; and, (2) an OPC occurs on the offsite power source, such that there is no immediate impact to the plant; but if an initiating event occurs that trips the main generator, there is a possibility of propagating the phase imbalance down to the safety-related buses thus rendering them unavailable.

For the first configuration, no additional initiating event was assumed beyond the OPC. For the second configuration, the risk assessment assumes a generic initiating event frequency of a plant trip of one per year, which represents the sum of all internal initiating events from transients, special initiators, and LOCAs. For both configurations, the assessment assumes a station blackout as a worst-case condition surrogate if the OPC is not identified and isolated within 13 minutes. This operator response time is based on demonstrating no significant degradation to the Reactor Coolant Pump (RCP) seals resulting from the loss of charging pumps, which supply RCP seal injection. The staff also included several conservative assumptions (e.g., 1000x increase in all running, motor-driven pumps' nominal failure probability, no credit for FLEX) in the risk assessment.

The staff's conclusion, based on the bounding and conservative risk assessment described above, is that the OPIS implementation in automatic yielded an average reduction in CDF of 7.08E-6 per reactor-year. This result does not represent a potential risk reduction that constitutes a substantial increase to safety (i.e., CDF of 10E-4 per reactor year). Furthermore, its implementation does not reach the safety goal screening criterion[1] of 10E-5 per reactor-year discussed in NUREG/BR-0058 for proceeding with the backfit regulatory analysis process. Thus, based on the above results, the OPIS implementation in automatic does not result in a substantial increase in the overall protection of the public health and safety. The cost-benefit portion of the backfit regulatory analysis process is not warranted.

1 Regulatory initiatives involving new requirements to prevent core damage should result in a reduction of at least 10E-5 in the estimated mean value CDF (i.e., the CDF before the proposed regulatory change should exceed the CDF after the change by at least 10E-5) to justify proceeding with further backfit regulatory analyses.

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ADAMS Accession Number: ML19198A304 ***via email** **NRR-106**

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