
POLICY ISSUE

Notation Vote

May 31, 2016

SECY-16-0068

FOR: The Commissioners

FROM: Victor M. McCree
Executive Director for Operations

SUBJECT: INTERIM ENFORCEMENT POLICY FOR OPEN PHASE CONDITIONS
IN ELECTRIC POWER SYSTEMS FOR OPERATING REACTORS

PURPOSE:

To request Commission approval of an interim Enforcement Policy (IEP), applicable to all operating reactors, that allows the U.S. Nuclear Regulatory Commission (NRC) to exercise enforcement discretion for certain noncompliances with the requirements specified in the technical specifications (TSs) for "Electrical Power Systems" (typically TS Section 3.8) and action statement(s) associated with "AC Sources-Operating" and "AC Sources-Shutdown," and with Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 17, "Electric Power Systems." This IEP may also be applicable to certain nonconformances with the principal design criteria specified in the updated final safety analysis report (UFSAR), as well as noncompliances with the design criteria for the protection and safety systems (onsite power system) under 10 CFR 50.55a(h)(2) or 10 CFR 50.55a(h)(3), and 10 CFR 50.36, "Technical Specifications." This paper does not address any new commitments or resource implications.

SUMMARY:

The NRC staff is proposing a revision to the Enforcement Policy to permit the staff to exercise enforcement discretion for certain noncompliances with TSs or GDC 17, and certain nonconformances with the analogous principal design criteria specified in the UFSAR, as well as noncompliances with 10 CFR 50.55a(h)(2) or 10 CFR 50.55a(h)(3), and 10 CFR 50.36. These potential violations are associated with inoperable electrical power systems (offsite and onsite) caused by an open phase condition (OPC) design vulnerability in the offsite electric

CONTACTS: Robert Fretz, OE/EB
301 415-1980

Roy Mathew, NRR/DE/EEEB
301-415-8324

power system that would require a reactor shutdown or prevent a reactor startup if a licensee could not come into conformance within the TS-required completion times.

If approved, the proposed IEP would apply to all operating power reactor licensees resolving OPC design vulnerabilities that have been identified as not conforming to the requirements mentioned above.

BACKGROUND:

On January 30, 2012, Byron Station, Unit 2, experienced an automatic reactor trip from full power because the 6.9-kilovolt (kV) reactor coolant pump (RCP) B and C buses detected an undervoltage condition (two of four RCPs trip logic initiates a reactor trip). The undervoltage condition was caused by a broken inverted insulator stack of the phase C conductor for the 345-kV power circuit that supplies both station auxiliary transformers (SAT). The insulator failure resulted in a high-impedance fault through the dropped phase C conductor and a sustained OPC on the high voltage side of the SAT. The open circuit created an unbalanced voltage condition on the two 6.9-kV nonsafety-related RCP buses and the two 4.16-kV engineered safety features (ESF) buses. ESF loads remained energized momentarily, relying on equipment protective devices to prevent damage from an unbalanced overcurrent condition. The overload condition caused several ESF loads to trip.

About 8 minutes after the reactor trip, the control room operators diagnosed the loss of phase C condition and manually tripped breakers to separate the unit buses from the offsite power source, because there were no design features provided in the electrical power system to detect OPCs and automatically transfer the ESF buses to the onsite power sources. When the operators opened the SAT feeder breakers to the two 4.16-kV ESF buses, the loss of ESF bus voltage resulted in the emergency diesel generators automatically starting and restoring power to the ESF buses. The loss of RCP seal cooling due to the charging pumps tripping could have resulted in a loss-of-coolant event within minutes had the operators failed to diagnose the condition in a timely manner. The accident sequence precursor analyses conducted by the staff calculated a conditional core damage probability of 1×10^{-4} . Additional information may be found in NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System."

On February 28, 2012, a second event occurred at Byron Station, Unit 1. This event was also initiated by a failed inverted porcelain insulator, and resulted in an open phase as well as a phase-to-ground fault on the switchyard side of the offsite power circuit to the SAT.

The Byron Station events led the staff to identify several past operating experiences that were also caused by design vulnerabilities associated with single phase OPCs, including: South Texas, Unit 2 (2001); Beaver Valley Power Station, Unit 1 (2007); James A. Fitzpatrick Nuclear Power Plant (2005); and Nine Mile Point, Unit 1 (2005). Although not recognized at the time, these events involved offsite power circuits that were rendered inoperable by an open-circuited phase.

Based on the first Byron Station operating event, the staff issued NRC Information Notice 2012-03, "Design Vulnerability in Electric Power System," dated March 1, 2012 (Agencywide Document Access and Management System (ADAMS) Accession No. ML120480170), to inform licensees of the issues uncovered at Byron Station as well as describe the events at other

plants involving a similar offsite power OPC design vulnerability. On July 27, 2012, the staff issued NRC Bulletin 2012-01, requiring licensees to confirm whether they are in compliance with 10 CFR 50.55a(h)(2), 10 CFR 50.55a(h)(3), and GDC 17 or the principal design criteria specified in each unit's UFSAR. The Committee to Review Generic Requirements reviewed NRC Bulletin 2012-01 and determined at that time that the staff's approach did not constitute a backfit. Specifically, the NRC requested licensees to provide information to address the following:

- the protection scheme to detect and automatically respond to a single phase open circuit condition or high impedance ground fault condition on GDC 17 power circuits; and
- the operating configuration of ESF buses at power.

The staff reviewed the responses provided by the NRC licensees in accordance with 10 CFR 50.54(f). This review is documented in a summary report dated February 26, 2013 (ADAMS Accession No. ML13052A711).

Staff Interactions with Stakeholders

In addition to these generic communications, the NRC staff has been working with nuclear industry representatives, and licensees for operating and new reactors, to resolve the OPC issue. These outreach activities have included 14 public meetings held between March 2012 and January 2015.

Key stakeholder outreach activities have included:

- The staff visited Byron Station in January 2014 to understand more about the corrective actions taken to date to address the OPC issue.
- On March 12, 2014, the staff conducted a technical session at the 2014 Regulatory Information Conference regarding the OPC. The session was titled, "Loss of Safety Functions—Undetected Open Phase(s) in Balanced Three Phase Offsite Power System." This session was well attended by the U.S. industry, as well as international participants.
- The staff and industry representatives briefed the Advisory Committee on Reactor Safeguards subcommittee on digital instrumentation and control systems on November 17, 2014, and the full committee on December 4, 2014, concerning regulatory requirements and the path forward for resolving the OPC issue.
- The staff has been coordinating with the international community to ensure that the staff considers all relevant information and operating experience in the development of staff guidance for the proposed regulatory action.

Additionally, on October 9, 2013, the Nuclear Energy Institute (NEI) notified the NRC (ADAMS Accession No. ML13333A147) that the industry's Chief Nuclear Officers approved a formal initiative to address OPCs, and that the initiative represented a formal commitment among nuclear power plant licensees to address the OPC design vulnerability for operating reactors

and new reactor active plant designs. The current schedule to complete actions to resolve the OPC design vulnerability under this initiative is December 31, 2018 (see NEI letter dated March 16, 2015, ADAMS Accession Nos. ML15075A456 and ML15075A455).

The NRC staff provided a response to the industry's initiative, including its planned open phase isolation system (OPIS), in a letter to NEI dated November 25, 2014 (ADAMS Accession No. ML14120A203). The staff noted that the capability of the onsite power system to permit functioning of structures, systems, and components (SSCs) may depend on successful operation of OPIS, and that the proposed solution needs to fully address GDC 17 or the principal design criteria specified in each plant's UFSAR. The staff also communicated functional criteria for demonstrating compliance with existing regulatory requirements.

The staff also developed draft Branch Technical Position (BTP) 8-9, "Open Phase Condition Protection," (ADAMS Accession No. ML14057A433) to provide design criteria and staff guidance consistent with applicable regulations and existing guidance found in Chapter 8 of the Standard Review Plan, "Electric Power Systems." Public comments requested through a *Federal Register* notice (79 FR 32580) were addressed when finalizing the BTP. The final BTP 8-9 was published in July 2015 (ADAMS Accession No. ML15057A085), and the staff plans to use this guidance for future licensing actions to verify compliance with applicable regulations related to electric power systems.

DISCUSSION:

The January 2012 operating event at Byron Station, Unit 2, revealed a significant design vulnerability where an OPC in the plant's offsite power supply caused a loss of certain safety functions powered by the site's AC electric power system. The loss of these safety functions occurred because the ESF electric power system's protection scheme was unable to detect and isolate the loss of a single phase between the transmission network and the onsite power distribution system. The resulting degraded and unbalanced voltage conditions on redundant ESF buses led to the tripping of equipment required for normal plant operations and safe shutdown. The inability of the protection scheme to detect an OPC and automatically transfer power from the affected electric power system allowed the degraded offsite power system to remain connected to ESF buses, and prevented other onsite AC sources (e.g., emergency diesel generators) from starting and powering these buses. As a result, certain equipment required for safe operations remained powered by the degraded AC source and were put in jeopardy to either rely on internal safety features to lock-out and protect the vulnerable components or risk damage from overheating. Furthermore, equipment relied on for safe shutdown was also at risk of being unavailable for a period of time outside the plant's accident analysis, even after restoration of an operable power source.

GDC 17 establishes requirements for the design of nuclear power plant electric power systems for which a construction permit application was submitted after the Commission published the GDC in 1971. For current operating power plants designed before the promulgation of GDC 17, the UFSAR sets forth criteria similar to GDC 17¹ which requires, in part, that plants have an offsite and an onsite electric power system with adequate capacity and capability to ensure the

¹ Additional information can be found in NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System": Summary Report (ADAMS Accession No. ML13052A711)

functioning of SSCs important to safety in the event of anticipated operational occurrences and postulated accidents. The staff has determined that the potential for OPCs occurring in offsite power sources must be considered in the electric power system design to comply with GDC 17, or conform to the analogous principal design criteria in the UFSAR, as well as comply with the design criteria for protection systems under 10 CFR 50.55a(h)(2) or 10 CFR 50.55a(h)(3).

The NRC and licensees at all nuclear plants have understood that electrical faults, in general, are credible failure mechanisms and that open-circuit faults (i.e., OPCs), in particular, can occur on one, two, or all three phases of an electrical power system. However, because the design vulnerability involving certain offsite power OPCs was not previously recognized, licensees may not have considered all potential OPC scenarios in complying with GDC 17, or conforming to the analogous principal design criteria in the UFSAR, and complying with 10 CFR 50.55a(h)(2) or 10 CFR 50.55a(h)(3). As a result, the potential for offsite power OPCs and their associated design vulnerabilities were not specifically identified as an issue during the licensing reviews of the current operating nuclear power plants.

In fact, all operating reactor licensees stated in their responses to Bulletin 2012-01 that the OPC design vulnerability exists at their facilities, except for the Seabrook Nuclear Power Plant because of its unique switchyard design configuration. The licensees further noted that the protection system relays were not designed specifically to detect a single-phase OPC in a three-phase AC power system because this vulnerability was not considered in the original plant design. The staff noted from the bulletin responses that most licensees have not performed a formal analysis for this OPC design vulnerability scenario. Therefore, these plants may not have been designed to detect and mitigate the consequence of an OPC in its electric power systems and, thus, may not be in compliance with GDC 17, or in conformance with the applicable principal design criteria in the UFSAR, or in compliance with 10 CFR 50.55a(h)(2) or 10 CFR 50.55a(h)(3). When an operability assessment is performed, these potential noncompliances would likely result in a determination of inoperability, resulting in the need to enter the applicable TS action statements.

The NRC staff believes that compliance with regulatory requirements may be established if each licensee addresses the design issue based on the plant-specific electric power system design, design basis loading conditions, and electrical system operating configuration for normal, abnormal, and accident conditions.

For new reactors that are under construction (Vogtle Units 3 and 4, and Summer Units 2 and 3), the staff will use the appropriate regulatory tool² to bring the new reactor plants into compliance with all applicable requirements in light of the OPC design vulnerability.

The NRC staff also recognizes that, for some licensees, compliance with the current licensing basis (CLB) does not require that the design of the electric power system consider all potential OPCs in offsite power sources, and that these licensees have nevertheless committed to implementing interim compensatory measures and plant modifications under the industry initiative. In the event that the actions taken by a licensee to correct the OPC design vulnerability do not adequately address potential OPCs that might occur in offsite power sources

² Southern Nuclear Operating Company committed to complete plant modifications before fuel load at Vogtle Units 3 and 4, (ADAMS Accession No. ML15226A058). Similarly, South Carolina Electric & Gas Company committed to complete plant modifications before fuel load at Summer Units 2 and 3 (ADAMS Accession No. ML15343A117).

by the date committed to under the industry's initiative (December 31, 2018), the NRC staff may consider implementing plant-specific backfits in accordance with 10 CFR 50.109, "Backfitting." The staff has reviewed the backfitting issue and has prepared a Documented Evaluation (ADAMS Accession No. ML15254A208) that supports the conclusion that the consideration of potential OPCs in offsite power sources is necessary to bring a facility into conformance with the licensee's written commitments. This evaluation further supports updating the CLB for operating nuclear reactors, on a plant-specific basis, to require that the electric power systems meet GDC 17 or the analogous principal design criteria specified in the UFSAR, and other applicable regulatory requirements, assuming all potential OPCs in offsite power.

The staff has developed the enclosed proposed IEP authorizing the use of enforcement discretion to refrain from taking action for noncompliances associated with the GDC 17, or nonconformances with the analogous principal design criteria in the UFSAR, 10 CFR 50.55a(h)(2) or 10 CFR 50.55a(h)(3), and 10 CFR 50.36, while licensees address design vulnerabilities associated with OPCs within their respective electrical power systems. Licensees are expected to be in full compliance by December 31, 2018, under the industry initiative. In accordance with the proposed IEP, the staff will normally exercise discretion and not pursue enforcement action related to a failure to comply with the associated TSs due to inoperable power sources, and other violations associated with the OPC design vulnerability. The proposed policy does not provide enforcement discretion for noncompliances with any other aspects of the requirements mentioned above. Enforcement discretion would only apply if the licensee completes the actions outlined in the IEP.

Based on its review of the responses to NRC Bulletin 2012-01 and to requests for additional information, the NRC staff has determined that the corrective actions and compensatory measures implemented by licensees have sufficiently reduced the risk associated with an offsite power OPC, and provide reasonable assurance of adequate protection of public health and safety. The interim compensatory measures include, but are not limited to, operator awareness and procedure modifications.

The staff is proposing that the IEP remain in place until January 30, 2019, unless otherwise modified for a specific facility. Licensees must also comply with all other requirements, as applicable, unless explicitly replaced or amended in the Enforcement Policy.

RECOMMENDATIONS:

Approve for publication the enclosed *Federal Register* notice which includes the IEP.

The Commissioners

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COORDINATION:

The Office of the General Counsel has reviewed this paper and has no legal objection.

/RA/

Victor M. McCree
Executive Director
for Operations

Enclosure:
Federal Register Notice

The Commissioners

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/RA/

Victor M. McCree
Executive Director
for Operations

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