

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

December 2, 2010

NRC INFORMATION NOTICE 2010-26: SUBMERGED ELECTRICAL CABLES

ADDRESSEES

All holders of an operating license or construction permit 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 who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All current and potential applicants for a combined license or standard design certification for a nuclear power plant under the provisions of 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." All current and potential applicants for a construction permit under the provisions of 10 CFR Part 50.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of observations of protracted cable submergence in water, recent NRC inspection findings, and the results of licensees' responses to Generic Letter (GL) 2007-01, "Inaccessible or Underground Power Cable Failures That Disable Accident Mitigation Systems or Cause Plant Transients," dated February 7, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML070360665). Furthermore, this IN provides additional clarification to IN 2002-12, "Submerged Safety-Related Electrical Cables," dated March 21, 2002 (ADAMS Accession No. ML020790238), through the NRC's observations of the submergence in water of electrical cables that feed safety-related equipment at certain facilities. The NRC expects recipients to review the information for applicability to their facilities and consider taking action, as appropriate, to avoid similar problems. The suggestions that appear in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

Monticello Nuclear Generating Plant

On September 11, 2008, a double phase-to-ground fault occurred on the underground feeder cables (offsite power) routed from the 2RS (345-kilovolt (kV)/34.5-kV) transformer to the 2R (34.5-kV/4.16-kV) transformer at the Monticello Nuclear Generating Plant. On December 16, 2008, the NRC issued Inspection Report 05000263/2008-009 (ADAMS Accession No. ML083510254), which documented the results of a special inspection that it performed at the plant. The special inspection evaluated the facts and circumstances surrounding the loss of normal offsite power and resultant reactor trip and other complications that occurred on September 11, 2008. The inspectors identified a violation for the licensee's failure to establish an effective monitoring and corrective action plan that included the 34.5-kV underground feeder cables in the scope of a monitoring program that met the requirements of

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10 CFR 50.65(a)(1). This cable was found submerged, as the manhole was full of water above the level of the conduits. The licensee's evaluation of the cable failure determined that the faults did not occur in the section of cable that was found submerged.

The inspectors determined that the licensee's preventive maintenance and testing methodology for the 34.5-kV cables was not sufficient to establish the condition of the cables, and, therefore, the exemption of 10 CFR 50.65(a)(2) was not applicable. Additionally, the preventive maintenance and testing methodology implemented by the licensee for the 34.5-kV cables did not provide the information necessary to ensure that the 2R transformer was capable of fulfilling its intended function. Therefore, the licensee had not effectively assessed the performance goal before the failure. Thus, the exemption of 10 CFR 50.65(a)(2) was not applicable. Following the cable failure, the licensee performed tan-delta and partial discharge (PD) cable performance monitoring tests to identify the extent of the cable degradation. The tan-delta testing indicated that the A2 phase conductor (which failed on September 11, 2008) had a severe fault at a second splice location, and, therefore, the licensee needed to replace the splice. The PD testing identified termination problems in the B2 and C2 cable conductor splices and at the stress cones. To address these deficiencies, the licensee repaired or replaced the faulted cable. The licensee is implementing a cable monitoring and testing program to monitor the performance of the cables.

Fermi Power Plant, Unit 2

On September 11, 2007, the NRC issued Inspection Report 05000341/2007-003 (DRS) (ADAMS Accession No. ML072540412), which documented the results of a component design bases inspection that it performed at the Fermi Power Plant, Unit 2. The emergency diesel generator cables installed between the residual heat removal complex and the reactor building, which were located below the maximum ground water level, were not designed for continuous underwater service. The inspectors identified a violation of Criterion III, "Design Control," of Appendix B to 10 CFR Part 50, for the licensee's failure to implement licensing and design-basis requirements when the licensee specified and purchased safety-related and nonsafety-related cables. The inspectors noted that the licensee failed to ensure that the cables were designed for continuous underwater service, which is contrary to statements made in the licensee's updated final safety analysis report. The licensee entered the finding into its corrective action program to investigate the design of the cables and to institute a cable management program.

Point Beach Nuclear Plant

On April 21, 2008, the NRC issued Inspection Reports 05000266/2008-007 and 05000301/2008-007 (ADAMS Accession No. ML081130194), which documented the results of the agency's special inspection. The purpose of the special inspection was to review the circumstances surrounding the loss of the Point Beach Nuclear Plant, Unit 1, 1X-04 transformer that resulted in the loss of safety bus 1B-04 at the plant. One of three violations identified during the inspection dealt with the licensee's failure to establish a test program that would adequately demonstrate that medium-voltage cables subjected to submergence in water would perform satisfactorily in service. Specifically, the online, energized PD testing methodology that the licensee had adopted in approximately 2001 to periodically assess the condition of submerged power cables failed to provide any indication of declining cable performance or an indication of an imminent failure of the transformer cables before the actual failure on January 15, 2008.

On May 11, 2010, the NRC issued Inspection Reports 05000266/2010-002 and 05000301/2010-002 (ADAMS Accession No. ML101310428), which documented a violation of the requirements in Criterion XVI, "Corrective Action," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 because of the licensee's failure to implement timely corrective actions to address the longstanding issue of submerged, medium-voltage underground cables at the Point Beach Nuclear Plant. Specifically, the NRC first identified this issue in 1997, with numerous condition reports written by the licensee since that time. The licensee entered this issue into its corrective action program. The licensee's corrective actions included the increased monitoring and pumping of manholes, and its proposed actions include design changes to support the automatic monitoring and removal of water from the manholes.

The medium-voltage cable condition monitoring program at the Point Beach Nuclear Plant was subsequently inspected during the Post-Approval Phase 2 License Renewal inspection. The inspection was documented in NRC Inspection Report 05000266/2010-011 (ADAMS Accession No. ML102850469). Inspections of commitments associated with the cable condition monitoring program were concluded to be acceptable.

Beaver Valley Power Station, Units 1 and 2

On August 4, 2009, the NRC issued Inspection Reports 05000334/2009-003 and 5000412/2009-003 (ADAMS Accession No. ML092160021), which documented the results of an inspection at the Beaver Valley Power Station, Units 1 and 2. The inspectors identified a violation of Criterion III, "Design Control," of Appendix B to 10 CFR Part 50, whereby First Energy Nuclear Operating Company (FENOC), the licensee for the Beaver Valley Power Station, Units 1 and 2, failed to maintain safety-related cables in an environment for which these cables were designed. Since the NRC issued IN 2002-12, FENOC has had several opportunities to trend as-found data, implement effective maintenance programs, and identify and thoroughly evaluate long-term adverse conditions for underground safety-related cables exposed to continuous submerged environments. The cables affected include those for Unit 1 river water and Unit 2 service water. FENOC entered the issue into its corrective action program to initiate a review of the current manhole and cable monitoring programs, as well as long-term corrective actions.

Wolf Creek Generating Station

On November 7, 2008, the NRC issued Inspection Report 05000482/2008-004 (ADAMS Accession No. ML083120336), which documented the results of an inspection at the Wolf Creek Generating Station. The inspectors identified a violation of Criterion III, "Design Control," of Appendix B to 10 CFR Part 50 because the licensee failed to adequately demonstrate that submerged 4,160-volt cables are designed or qualified for such service and that they would continue to remain operable. These cables include those of residual heat removal, containment spray, and essential service water. The licensee has subsequently written a condition report and work orders to inspect cables and dewater cable vaults and has conducted tests to monitor the performance of the cables.

Callaway Plant

On October 21, 2009, the NRC issued Inspection Report 05000483/2009-004 (ADAMS Accession No. ML092940774), which documented the results of an inspection at the Callaway Plant. The inspectors identified a violation of Criterion XVI, "Corrective Action," of Appendix B to 10 CFR Part 50 because the licensee failed to take prompt corrective actions to prevent continuous submergence of essential service water pump power cables. The licensee initially identified this submergence issue in its corrective action program (action request) in 2002, but it did not complete the corrective actions. The continuously submerged environment for these cables existed because the two vaults containing these cables (MH-01N and MH-01S) had inadequate seals that are needed to protect the vaults from incoming surface water. These cables were not designed to be continuously submerged and could fail over time based on the operating experience examples in GL 2007-01 and IN 2002-12. The licensee failed to correct an inadequate and degraded seal design for underground cable vaults MH-01N and MH-01S and failed to adequately demonstrate operability for the 4.16-kV essential service water pump cables through adequate testing and analysis for a continuously submerged condition. This violation was determined to be of very low safety significance because the degraded seals were a design or qualification deficiency confirmed not to result in loss of operability. The licensee has subsequently taken measures to improve the seals and has created a Callaway corrective action document to further evaluate and correct this issue.

Peach Bottom Atomic Power Station, Units 2 and 3

On February 8, 2010, the NRC issued Inspection Reports 05000277/2009-005 and 05000278/2009-005 (ADAMS Accession No. ML100390108), which documented the results of a routine inspection at the Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3. The inspectors identified a violation of Criterion III, "Design Control," of Appendix B to 10 CFR Part 50 because the licensee failed to maintain safety-related power cables (including low-voltage cables) in an environment for which they were designed and tested. Specifically, the licensee did not adequately select and review a 480-volt alternating current power cable for suitability of application of materials. The cable feeds a safety-related motor control center that has been in a submerged environment in a manhole for an extended period of time (at least since 2002). Additionally, PBAPS personnel did not take actions to properly evaluate and mitigate the effects of long-term submergence of these safety-related electrical power cables. To address this issue, the licensee entered it into its corrective action program.

Three Mile Island Nuclear Station

On July 31, 2009, the NRC issued Inspection Report 5000289/2009-003 (ADAMS Accession No. ML092120364), which documented the results of a routine inspection at the Three Mile Island (TMI) Nuclear Station, Unit 1. The inspectors identified a violation of Criterion V, "Instructions, Procedures, and Drawings," of Appendix B to 10 CFR Part 50 because the licensee failed to establish and accomplish appropriate work instructions and procedures to inspect underground electrical cables, vaults, and supports for degradation or adverse effects caused by long-term repetitive submergence in water. TMI personnel had not entered the cable vaults, and TMI procedures did not require the actual visual inspection of the cables, supports, or vaults sufficient to determine operability. Furthermore, the licensee did not take action to identify or remediate the cause of the repetitive flooding and to restore the function of the designed cable vault drain systems. The inspectors observed corroded cable tray supports, damaged galvanized armor protective sleeves on cables, and indications of repetitive long-term cable submergence in water. The licensee entered, inspected, and dewatered all affected

vaults. The licensee initiated work orders to correct all identified discrepancies. Some of the licensee's proposed corrective actions included the implementation of a cable vault improvement initiative such as preventing rainwater intrusion, lid repair, installing lid gaskets, applying sealant to the lids, concrete repair, cable support repair, improving the grading/surrounding environment to prevent water runoff into the vaults, and restoring and maintaining French drains and other drains between vaults.

Vermont Yankee Nuclear Power Station

On May 10, 2010, the NRC issued Inspection Report 05000271/2010-002 (ADAMS Accession No. ML101300363), which documented the results of an inspection at the Vermont Yankee Nuclear Power Station. The inspectors identified a violation of Criterion III, "Design Control," of Appendix B to 10 CFR Part 50 because Entergy (the licensee for the Vermont Yankee Nuclear Power Station) did not select and review safety-related cables suitable for application in the environment in which they were found. Specifically, Entergy allowed the continuous submergence of safety-related cables that were not designed or qualified for continuous submergence and failed to demonstrate that the cables would remain operable. Entergy initiated condition reports to address the issues, commenced the dewatering of the affected manholes, and initiated a preventive maintenance plan to ensure proper design conditions. The finding was determined to be of very low safety significance because it was a design or qualification deficiency which was confirmed to have not resulted in a loss of operability or functionality. Specifically, the continuously submerged cables were not designed or qualified for that environment but were still fully capable of performing their design functions.

BACKGROUND

Cable failures have a variety of causes, including manufacturing defects, damage caused by shipping and installation, and exposure to electrical transients or abnormal environmental conditions during operation. Latent shield or insulation damage could result from errors during cable installation, which could be caused by cable jamming, cable pull-bys, cable sidewall bearing pressure, pulling cables through conduits and flexible conduit, or computerized cable routing system software routing cables through the wrong raceway. The likelihood of failure from any of these factors increases over time as the cable insulation degrades and/or is exposed to water.

During the license renewal and routine baseline inspections, NRC inspectors identified numerous inspection findings that indicate that some licensees are not maintaining cables important to safety in an environment for which they were designed.

On March 21, 2002, the NRC staff issued IN 2002-12, which described medium-voltage cable failures at the Oyster Creek Nuclear Generating Station and the Davis-Besse Nuclear Power Station. The cable failures resulted from submerged safety-related cables in manholes and duct banks that were subjected to long-term flooding problems. Based on the operating experience described in IN 2002-12, several licensees began manhole restoration projects, replaced faulty dewatering equipment and cable supports, and made other modifications.

During a meeting on the license renewal application for the St. Lucie Plant in April 2003, members of the Advisory Committee on Reactor Safeguards questioned whether cable issues were also applicable in accordance with 10 CFR Part 50. The NRC staff responded that the staff of the Office of Nuclear Reactor Regulation (NRR) would evaluate the Committee's concerns. The NRR staff reviewed the available operating experience of cable failures and

observed that some cables at nuclear power plants, which were qualified for 40 years through licensees' equipment qualification programs, were failing before the end of the qualified life of the cables. The staff identified 23 licensee event reports and two morning reports from 1988 to 2004 that described failures of buried medium-voltage alternating current and low-voltage direct current power cables that resulted from insulation failure. In most of the reported cases, the failed cables had been in service for 10 years or more. The NRR staff confirmed that the subject issue was applicable in accordance with 10 CFR Part 50 for operating reactors.

In 2006, the NRC began a detailed review of underground electrical power cables after moisture-induced cable failures were identified at some plants. The cables were exposed to submergence in water, condensation, wetting, and other environmental stresses. Because these cables are not designed or qualified for submerged or moist environments, the possibility that more than one cable could fail has increased; this failure could disable safety-related accident mitigation systems. On February 7, 2007, the NRC issued GL 2007-01 to gather information on inaccessible or underground power cable failures for all cables that are within the scope of the Maintenance Rule (10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants").

DISCUSSION

Based on the above, the NRC expects licensees to identify conditions that are adverse to quality for cables, such as long-term submergence in water. Upon discovery of a submerged condition, the licensee should take prompt corrective actions to restore the environment to within the cable's design specifications, immediately determine the operability of the cable(s) to perform its intended design function, and determine the impact of the adverse environment on the design life of the cable. These corrective actions typically involve the removal of water, the installation of a sump pump or the repair of the drainage conditions, and evaluation of the operability of the cable(s) including testing where appropriate. The long-term corrective actions could involve establishment of a condition monitoring program for all cables which are inaccessible and underground and under the maintenance rule, including testing of cables to verify the cables are not degraded and visual inspection of manholes for water accumulation to ensure continued operability.

Cables are not typically designed or qualified for submergence unless they are procured as submarine cables. Demonstration that a cable is designed or qualified for long-term submergence (i.e., submerged in water continuously or for extended periods of time) requires a qualification test report or certification from the cable vendor. The industry's previously conducted post-loss-of-coolant accident cable submergence tests do not demonstrate qualification for long-term cable submergence, and the use of the Arrhenius methodology by some licensees to demonstrate qualification for long-term cable submergence is invalid. For areas in which cables could be submerged, the licensee should identify and demonstrate that these cables are designed or qualified by documented testing for the required duration.

While the initial NRC inspection findings discussed in IN 2002-12 at Beaver Valley Power Station, Oyster Creek Nuclear Power Plant, Pilgrim Nuclear Power Station, Brunswick Steam Electric Plant, Davis-Besse Nuclear Power Station, and Millstone Power Station, Unit 2, did not identify any specific violations of NRC requirements, the NRC staff will evaluate future cable submergence issues to determine whether NRC regulations are being met.

The NRC issued GL 2007-01 to gather information on inaccessible or underground power cable failures for all cables within the scope of the Maintenance Rule. The NRC staff identified 269 cable failures based on its review of responses from all licensees (65 sites and 104 reactor units). These failure data indicated an increasing trend in underground cable failures, and the predominant contributing factor was submergence or moisture intrusion that degraded the insulation. The staff noted that the cables are failing within the plants' 40-year licensing periods. Some of the cable failures have resulted in plant transients and shutdowns, loss of safety redundancy, entries into limiting conditions for operation, and challenges to plant operators. The NRC staff published the summary report that captured the review of responses from all licensees on November 12, 2008 (ADAMS Accession No. ML082760385).

The NRC regulations require licensees to assess the condition of their components; monitor the performance or condition of structures, systems, and components in a manner sufficient to provide reasonable assurance that they are capable of fulfilling their intended functions; and establish a suitable test program to ensure that all testing necessary to demonstrate that components will perform satisfactorily in service is identified and performed. To date, NRC inspectors have identified various violations of NRC requirements at several facilities. Appendix A to this IN lists NRC inspection reports from 2008–2010 that identified inspection findings related to cable submergence.

Cables not designed or qualified for, but exposed to, wet or submerged environments have the potential to degrade. Cable degradation increases the probability that more than one cable will fail on demand because of a cable fault, lightning surge, or a switching transient. Although a single failure is within the plant design basis, multiple failures of this kind would be challenging for plant operators. Also, an increased potential exists for a common-mode failure of accident-mitigating system cables if they are subjected to the same environment and degradation mechanism for which they are not designed or qualified for. Some licensees have attempted to periodically drain the accumulated water from the cable surroundings to avoid cable failures. In some cases, the water quickly refilled the cavity in areas in which the water table was above the base level of a cable trench or underground vault. In other cases, water accumulated seasonally (e.g., because of snowfall or rain), filling the conduit or raceways. In both cases, periodic draining could slow the rate of insulation degradation, but it may not prevent cable degradation. Licensees should ensure that cables that could become submerged are adequately monitored.

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 NRR project manager.

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Note: NRC generic communications may be found on the NRC public Web site,
<http://www.nrc.gov>, under Electronic Reading Room/Document Collections.

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APPENDIX A

LIST OF U.S. NUCLEAR REGULATORY COMMISSION INSPECTION REPORTS ON CABLE SUBMERGENCE ISSUES

1. Inspection Report 05000263/2008-009, December 16, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML083510254)
2. Inspection Reports 05000266/2008-007 and 05000301/2008-007, April 21, 2008 (ADAMS Accession No. ML081130194)
3. Inspection Report 05000416/2009-006, April 30, 2009 (ADAMS Accession No. ML091200372)
4. Inspection Reports 05000335/2008-004 and 05000389/2008-004, November 12, 2008 (ADAMS Accession No. ML083170830)
5. Inspection Report 05000482/2008-004, November 7, 2008 (ADAMS Accession No. ML083120336)
6. Inspection Report 05000331/2009-005, February 3, 2010 (ADAMS Accession No. ML100341068)
7. Inspection Reports 05000334/2009-003 and 05000412/2009-003, August 4, 2009 (ADAMS Accession No. ML092160021)
8. Inspection Report 05000483/2009-004, October 21, 2009 (ADAMS Accession No. ML092940774)
9. Inspection Reports 05000315/2009-005 and 05000316/2009-005, January 26, 2010 (ADAMS Accession No. ML100271609)
10. Inspection Report 05000285/2009-006, December 30, 2009 (ADAMS Accession No. ML093641134)
11. Inspection Report 05000354/2009-004, November 12, 2009 (ADAMS Accession No. ML093160532)
12. Inspection Report 05000219/2009-003, July 30, 2009 (ADAMS Accession No. ML092110491)
13. Inspection Reports 05000528/2009-008, 05000529/2009-008, and 05000530/2009-008, November 19, 2009 (ADAMS Accession No. ML093240524)
14. Inspection Report 05000289/2009-003, July 31, 2009 (ADAMS Accession No. ML092120364)
15. Inspection Report 05000271/2010-002, May 10, 2010 (ADAMS Accession No. ML101300363)

16. Inspection Report 05000346/2010-002, April 27, 2010 (ADAMS Accession No. ML101170741)
17. Inspection Reports 05000266/2010-002 and 05000301/2010-002, May 11, 2010 (ADAMS Accession No. ML101310428)
18. Inspection Reports 05000315/2010-002 and 05000316/2010-002, May 5, 2010 (ADAMS Accession No. ML101250243)
19. Inspection Reports 05000237/2010-002 and 05000249/2010-002, May 10, 2010 (ADAMS Accession No. ML101300436)
20. Inspection Report 05000400/2010-002, April 30, 2010 (ADAMS Accession No. ML101200174)
21. Inspection Report 05000261/2010-002, April 30, 2010 (ADAMS Accession No. ML101200497)
22. Inspection Reports 05000277/2009-005 and 05000278/2009-005, February 8, 2010 (ADAMS Accession No. ML100390108)