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

February 7, 2007

NRC GENERIC LETTER 2007-01: INACCESSIBLE OR UNDERGROUND POWER CABLE  
FAILURES THAT DISABLE ACCIDENT MITIGATION  
SYSTEMS OR CAUSE PLANT TRANSIENTS

**ADDRESSEES**

All holders of operating licenses for nuclear power reactors, except those who 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 generic letter to:

- (1) Inform licensees that the failure of certain power cables can affect the functionality of multiple accident mitigation systems or cause plant transients.
- (2) Inform licensees that in the absence of adequate monitoring of cable insulation, equipment could fail abruptly during service, causing plant transients or disabling accident mitigation systems.
- (3) Ask licensees to provide information on the monitoring of inaccessible or underground electrical cables.

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.54(f), addressees are required to submit a written response to this generic letter.

**BACKGROUND**

Cable failures have a variety of causes: manufacturing defects, damage caused by shipping and installation, and exposure to electrical transients or abnormal environmental conditions during operation. The likelihood of failure from any of these causes increases over time as the cable insulation degrades.

Electrical cables in nuclear power plants are usually located in dry environments, but some cables are exposed to moisture from condensation and wetting in inaccessible locations such

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as buried conduits, cable trenches, cable troughs, above ground and underground duct banks, underground vaults, and direct-buried installations. The cable insulation goes through gradual degradation due to a variety of reasons.

In Information Notice (IN) 2002-12, "Submerged Safety-Related Electrical Cables," NRC described medium-voltage cable failures at Oyster Creek, Davis-Besse, and several other plants as a result of safety-related cables submerged in manholes and duct banks subject to long-term flooding problems. In response to IN 2002-12, several licensees began manhole restoration projects, replaced faulty dewatering equipment and cable supports, and made other modifications. Several other licensees reported water removal problems, but have not begun a program for the early detection of potential failures.

The NRC began a detailed review after observing that some of the cables qualified for 40 years, through the equipment qualification program, were failing at several nuclear stations prior to the end of qualified life. At each nuclear station, there may be only a dozen or so power cables installed in locations susceptible to moisture-induced damage. The low number of cables notwithstanding, the staff identified 23 licensee event reports and 2 morning reports since 1988 regarding failures of buried medium-voltage, alternating current (AC) and direct current (DC) low voltage cables from insulation failure. The staff has knowledge of several other cable failures that were not required to be reported and therefore, these reported events are only a fraction of all failures. In most of the reported cases, the failed cables had been in service for 10 years or more. The rugged design of the electrical cables may prevent early failure even after extended immersion in water.

#### **APPLICABLE REGULATORY REQUIREMENTS**

NRC regulations in 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 4, state that "[s]tructures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation."

NRC regulations in 10 CFR Part 50, Appendix A, GDC 17, state that "[p]rovisions shall be included to minimize the probability of losing electric power from any of the remaining [power] supplies...[a] loss of power from the transmission network, or the loss of power from the onsite electric power supplies."

NRC regulations in 10 CFR Part 50, Appendix A, GDC 18, state that "[e]lectric power systems important to safety shall be designed to permit appropriate periodic inspection and testing of important...features, such as wiring, insulation" and "to assess the continuity of the systems and the condition of their components," "the operability of the systems as a whole," and "the transfer of power among the nuclear power unit, the offsite power system, and the onsite power system."

NRC regulations in 10 CFR 50.65(a)(1) state that "[e]ach holder of a license to operate a nuclear power plant...shall monitor the performance or condition of structures, systems, or components...in a manner sufficient to provide reasonable assurance that such structures, systems, and components...are capable of fulfilling their intended functions."

NRC regulations in 10 CFR Part 50, Appendix B, Criterion XI, state that “[a] test program shall be established to assure that all testing required to demonstrate that...components will perform satisfactorily in service is identified and performed.”

These design criteria require that cables, which are routed underground, be capable of performing their function when subjected to anticipated environmental conditions such as moisture or flooding. Further, the design should minimize the probability of power interruption when transferring power between sources. The cable failures that could disable risk-significant equipment are expected to have monitoring programs to demonstrate that the cables can perform their safety function when called on. However, the recent industry cable failure data indicates a trend in unanticipated failures of underground/inaccessible cables that are important to safety.

## **DISCUSSION**

Cables susceptible to moisture-induced failures may vary from plant to plant, and these cables are generally routed through underground conduits, concrete duct banks, cable trenches, cable troughs, underground vaults or directly buried. Although nuclear plant electrical systems are designed to be single-failure-proof, undetected degradation of cables due to preexisting manufacturing defects or other causes in wetted environments can result in multiple equipment failures:

- The failure of power cables that connect the offsite power to the safety bus can prevent offsite power recovery for far longer than the coping time originally considered for station blackout conditions. A licensee may not detect the incipient failure of these cables because in some plants these cables generally remain deenergized during power generation and are not periodically energized for testing.
- The failure of the power cables from an emergency diesel generator (EDG) to the safety bus (where the EDGs are in separate buildings) can prevent recovery of standby power from the EDG and result in the unavailability of a full train of accident mitigation systems during a loss-of-offsite-power event.
- The failure of the power cables to an emergency service water (ESW) or component cooling water pump can disable one train of emergency core cooling systems for long-term service unless the headers can be cross connected and the redundant pump(s) are capable and lined up to supply sufficient cooling for both trains. If the EDGs are cooled by ESW or service water, the cable failure can disable the EDG and cause the loss of one train of emergency standby power.

As an example of a reportable event, when Oyster Creek, Unit 1, was shutdown, the station lost power to a 4160-VAC bus due to a ground fault on an underground cable between the EDG and the safety bus. The loss of power led to a trip of reactor protection system channel 2, a full reactor scram signal, and main steam line isolation (Agencywide Documents Access and Management System (ADAMS) Accession No. 9612020214, LER 05000219/96-09).

As an example of multiple equipment failures, the Davis-Besse Nuclear Power Station had an underground cable insulation failure that resulted in the trip of the 13.8-kV circulating water pump breaker and a loss of power to two 4-kV substations affecting non-safety related loads.

The cable showed signs of insulation degradation caused by moisture intrusion (Inspection Report No: 05000346/2004017, ADAMS Accession No. ML050310426, issued on January 30, 2005).

Generally, these types of cable failure results in fault currents several orders of magnitude larger than the normal current. Until isolated by a breaker, the fault current or transient voltages would propagate on the immediate power systems and potentially fail other systems with degraded insulation systems.

Cables not qualified for but exposed to wet 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 or a switching transient. While a single failure is within the plant design basis, multiple failures of this kind would be challenging for the plant operators.

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 where the water table was above the base level of a cable trench or underground vault. In other cases, the water accumulated seasonally during snowfall or rain, filling the conduit or raceways, with potential for the cables to dry out whenever the humidity drops. In both cases, periodic draining may decrease the rate of insulation degradation, but would not prevent cable failures.

Some licensees have detected cable degradation prior to failures through techniques for measuring and trending the condition of cable insulation. Licensees can assess the condition of cable insulation with reasonable confidence using one or more of the following testing techniques: partial discharge testing, time domain reflectometry, dissipation factor testing, and very low frequency AC testing. Licensees can replace faulty cables during scheduled refueling outages prior to cable failure that would challenge plant safety. The Oconee Nuclear Station relied on the partial discharge test to monitor the condition of the emergency power supply cable insulation and replaced the cable during a scheduled outage (Inspection Report No. 50-269/99-12, 50-270/99-12, ADAMS Accession No. ML003676749, issued on September 21, 1999).

## **REQUESTED INFORMATION**

Addressees are requested to submit the following information to NRC within 90 days of the date of this generic letter:

- (1) Provide a history of inaccessible or underground power cable failures for all cables that are within the scope of 10 CFR 50.65 (the Maintenance Rule) and for all voltage levels. Indicate the type, manufacturer, date of failure, type of service, voltage class, years of service, and the root causes for the failure.
- (2) Describe inspection, testing and monitoring programs to detect the degradation of inaccessible or underground power cables that support EDGs, offsite power, ESW, service water, component cooling water and other systems that are within the scope of 10 CFR 50.65 (the Maintenance Rule).

## **REQUIRED RESPONSE**

In accordance with 10 CFR 50.54(f), the addressees are required to submit written responses to this generic letter. This information is sought to verify licensees' compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. The addressees have two options:

- (1) Addressees may choose to submit written response providing the information requested above within the requested time period.
- (2) Addressees who choose not to provide information requested or cannot meet the requested completion dates are required to submit written responses within 30 days of the date of this generic letter. The responses must address any alternative course of action proposed, including the basis for the acceptability of the proposed alternative course of action.

The addressee should address the required written response to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, 11555 Rockville Pike, Rockville, MD 20852, under oath or affirmation under the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f). In addition, the addressee should send a copy of the response to the appropriate regional administrator.

## **REASONS FOR INFORMATION REQUEST**

The requested information will enable the staff to determine whether the requirements in the Applicable Regulatory Requirements section are being met in regard to the operational readiness of critical systems that could cause a plant transient or mitigate accidents. The reported licensee events and regional reports have established an operating experience history that requires further information on cable failures be obtained.

## **RELATED GENERIC COMMUNICATIONS**

Information Notice 2002-12: Submerged Safety-Related Electrical Cables (ADAMS Accession No. ML020790238).

## **BACKFIT DISCUSSION**

Under the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f), this generic letter transmits an information request for the purpose of verifying compliance with applicable, existing requirements. Specifically, the requested information will enable the NRC staff to determine whether the applicable requirements are being met in regard to the operation readiness of the critical systems that could cause plant transient or mitigate accidents power system. No backfit is either intended or approved in the context of issuance of this generic letter. Therefore, the staff has not performed a backfit analysis.

## **FEDERAL REGISTER NOTIFICATION**

The staff published a notice of opportunity for public comment on this generic letter in the *Federal Register* on August 1, 2005 (70 FR44127). Comments were received from four nuclear electric utilities and one industry group (Nuclear Energy Institute), and two sets of cable-testing information were received from Imcorpotech, a cable-testing vendor. The staff received a total of 198 comments. The staff considered all comments. The staff's evaluation of the comments is publicly available through the NRC's ADAMS under Accession No. ML060440150.

## **CONGRESSIONAL REVIEW ACT**

This generic letter is not a rule as designated by the Congressional Review Act (5 U.S.C. §§801-888) and, therefore, is not subject to the Act.

## **PAPERWORK REDUCTION ACT STATEMENT**

This generic letter contains information collection requirements that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.). These information collections were approved by the Office of Management and Budget (OMB), approval No: 3150-0011, which expires on February 28, 2007.

The burden to the public for these mandatory information collections is estimated to average 60 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the information collection.

Send comments regarding this burden estimate or any other aspect of these information collections, including suggestions for reducing the burden, to the Records and FOIA/Privacy Services Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by Internet electronic mail to [INFOCOLLECTS@NRC.GOV](mailto:INFOCOLLECTS@NRC.GOV); and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0011), Office of Management and Budget, Washington, DC 20503.

## **Public Protection Notification**

NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

## CONTACTS

Please direct any questions about this matter to the technical contact listed below.

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