

August 29, 2007

Mr. James H. Riley
Nuclear Energy Institute
1776 I Street, NW, Suite 400
Washington, DC 20006-3708

SUBJECT: PROPOSED LICENSE RENEWAL INTERIM STAFF GUIDANCE
LR-ISG-2007-02: CHANGES TO GENERIC AGING LESSON LEARNED
(GALL) REPORT AGING MANAGEMENT PROGRAM (AMP) XI.E6,
"ELECTRICAL CABLE CONNECTIONS NOT SUBJECT TO 10 CFR 50.49
ENVIRONMENTAL QUALIFICATION REQUIREMENTS"

Dear Mr. Riley:

The purpose of this letter is to provide you with the opportunity to comment on the proposed License Renewal Interim Staff Guidance LR-ISG-2007-02, which clarifies GALL AMP XI.E6, "Electrical Cable Connections Not Subject to 10 CFR 50.49 Environment Qualification Requirements."

In September 2005, the U.S. Nuclear Regulatory Commission (NRC) staff added to its license renewal guidance documents GALL AMP XI.E6 to address the aging management of metallic portion of electrical cable connections. By letter dated September 5, 2006, Nuclear Energy Institute (NEI) expressed concerns with GALL AMP XI.E6 and provided an NEI White Paper that discussed its position regarding GALL AMP XI.E6. On November 30, 2006, the NRC staff met with NEI representatives to discuss the white paper. In a letter dated March 16, 2007, the NRC staff provided responses to each of the industry's concerns identified in the white paper. By letter dated May 25, 2007, NEI submitted comments on the staff's responses.

The NRC staff has considered NEI's comments and revised GALL AMP XI.E6 as appropriate. Enclosed is the proposed revision of GALL AMP XI.E6 for your review and comment. This LR-ISG provides clarification of existing guidance with no additional requirements.

A notice relating to this proposed LR-ISG is being sent to the Office of the *Federal Register* for publication. The staff is requesting your comments on the proposed LR-ISG as indicated in the *Federal Register* Notice. If you have any questions regarding this matter, please contact Ms. Linh Tran, by telephone at 301-415-4103 or via e-mail at Int@nrc.gov.

-2-

An identical letter was sent to Mr. David Lochbaum at the Union of Concerned Scientists.

Sincerely,

/RA/

Pao-Tsin Kuo, Director
Division of License Renewal
Office of Nuclear Reactor Regulation

Project No. 690

Enclosure:
Proposed LR-ISG-2007-02

cc w/encl: See next page

August 29, 2007

Mr. David Lochbaum
Union of Concerned Scientists
1707 H Street, NW, Suite 600
Washington, DC 20006-3919

SUBJECT: PROPOSED LICENSE RENEWAL INTERIM STAFF GUIDANCE
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ADAMS Accession Nos.: ML072420437 (Package); ML071770376 (Letter); ML071770376 (FRN)

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Letter to: James Riley, David Lochbaum, from: PTKuo, Dated, August 29, 2007

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Project No. 690

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PROPOSED LICENSE RENEWAL INTERIM STAFF GUIDANCE LR-ISG-2007-02:
CHANGES TO GENERIC AGING LESSON LEARNED (GALL) REPORT
AGING MANAGEMENT PROGRAM (AMP) XI.E6, "ELECTRICAL CABLE CONNECTIONS
NOT SUBJECT TO 10 CFR 50.49 ENVIRONMENTAL QUALIFICATION REQUIREMENTS"

Introduction

Consistent with the requirements specified in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 54, Section 54.4(a), electrical cable connections support safety-related and non-safety-related functions in that the failure of the electrical cable connections precludes a function from being accomplished (10 CFR 54.4(a)(1), (a)(2), and (a)(3)).

Electrical cable connections exposed to appreciable ohmic or ambient heating during operation may experience loosening caused by repeated cycling of connected loads or of the ambient temperature environment. Different materials used in various cable system components can produce situations where stresses between these components change with repeated thermal cycling. For example, under loaded conditions, ohmic heating may raise the temperature of a compression terminal and cable conductor well above the ambient temperature, thereby causing thermal expansion of both components. Thermal expansion coefficients of different materials may alter mechanical stresses between the components so that the termination may be impacted. When the current is reduced, the affected components cool and contract. Repeated cycling in this fashion can cause loosening of the termination, and may lead to high electrical resistance or eventual separation of compression-type terminations. Threaded connectors may loosen if subjected to significant thermally induced stress and cycling. Because of the potential loosening of bolted cable connections, the staff included, in its updated license renewal guidance documents, AMP XI.E6, "Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements," to manage the potential aging of electrical cable connections not subject to 10 CFR 50.49 environmental qualification requirements.

Background and Discussion

The staff included AMP XI.E6, "Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements," in Chapter XI of GALL Report, Revision 1, dated September 2005. By letter dated September 5, 2006, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML062770105), Nuclear Energy Institute (NEI) submitted a white paper regarding GALL AMP XI.E6 (ADAMS Accession No. ML062770111). NEI stated that there was not enough operating experience to support a conclusion that cable connections are a significant aging concern and that the recommended program elements of GALL AMP XI.E6 duplicate aging management activities already defined and accepted in other AMPs. NEI also stated that the expanded scope of the program includes all voltage ranges regardless of the amount of evidence from operating experience. In addition, NEI identified wording in GALL AMP XI.E6 that included connections in active components. NEI asked the staff to review its white paper to eliminate GALL AMP XI.E6 or minimize its scope and redundancy so that the plant would not be burdened with activities that have no actual aging management benefit.

On November 30, 2006, the staff met with NEI representatives to discuss the white paper. In a letter dated March 16, 2007, (ADAMS Accession No. ML070400349), the staff provided responses to each of the industry's concerns identified in the white paper. By letter dated

May 25, 2007, (ADAMS Accession Nos. ML071590175 and ML071590182), NEI submitted comments on the staff's responses.

In reviewing the industry's white paper and comments, the staff determined that although GALL AMP XI.E6 was based on the technical bases of Electric Power Research Institute documents, and Sandia National Laboratories Report, SAND 96-0344, little operating experience related to failed connections due to aging had been identified. Most of the operating experience related to failed connections were due to human errors or maintenance practices. The operating experience cannot support the periodic inspection recommended in AMP XI.E6 in GALL Report, Revision 1, dated September 2005. However, because there have been limited number of age related failures of cable connections, a one-time inspection of the metallic portion of electrical cable connections is warranted. On this basis, the staff is revising GALL AMP XI.E6 to clarify and recommend a one-time inspection, on a representative sampling, to ensure that either aging of metallic cable connections is not occurring or an existing preventive maintenance program is effective, such that a periodic inspection is not required.

Proposed Action

The staff is proposing to revise GALL AMP XI.E6 to recommend a one-time inspection prior to the period of extended operation for electrical cable connections not subject to 10 CFR 50.49 EQ requirement instead of the periodic inspection currently stated in GALL AMP XI.E6. The staff determined that this one-time inspection, on a representative sample basis, is adequate to ensure that either aging of metallic cable connections is not occurring and/or the existing preventive maintenance program is effective so that a periodic inspection program is not required. The one-time inspection verifies that loosening and/or high resistance of cable connections due to thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, and oxidation are not happening and periodic inspections are not required. The one-time inspection should include testing of a representative sample of the electrical cable connection population subject to an aging effect. The sample should include each type of electrical cable connection. The following factors shall be considered for sampling: voltage level (medium and low voltage), circuit loading (high load), and location (high temperature, high humidity, vibration, etc.). The technical basis for the sample selection should be documented. The one-time inspection will confirm that there are no aging effects that require management during the period of extended operation.

The applicant will take corrective actions when acceptance criteria are not met. Corrective actions may include, but are not limited to sample expansion, increase inspection frequency, and replacement or repair of the affected cable connection components.

When an applicant performs periodic preventive maintenance that includes inspection and testing of cable connections, the applicant can credit this maintenance activity toward GALL AMP XI.E6. The applicant may also revise its preventive maintenance procedures to cover the inspection of cable connections to take credit for GALL AMP XI.E6.

Attached is the proposed revision to GALL AMP XI.E6. Although this proposed revision does not convey a change in the regulations or how they are being interpreted, it is being provided to facilitate preparation of future submittals in support of applications for license renewal. This LR-ISG provides a clarification of existing guidance with no additional requirements.

XI.E6 ELECTRICAL CABLE CONNECTIONS NOT SUBJECT TO 10 CFR 50.49 ENVIRONMENTAL QUALIFICATION REQUIREMENTS (REVISED)

Program Description

Cable connections are used to connect cable conductors to other cable conductors or electrical devices. Connections associated with cables within the scope of license renewal are part of this program. The most common types of connections used in nuclear power plants are splices (butt or bolted), crimp-type ring lugs, connectors, and terminal blocks. Most connections involve insulating material and metallic parts. This aging management program (AMP) focuses on the metallic parts of the electrical cable connections. This program provides a one-time inspection, on a sampling basis, to confirm the absence of age-related degradation of cable connections due to thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, and oxidation.

Generic Aging Lesson Learned (GALL) XI.E1, "Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements," manages the aging of insulating material but not the metallic parts of the electrical connections. GALL XI.E1 is based on only a visual inspection of accessible cables and connections. Visual inspection may not be sufficient to detect the aging effects from thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, and oxidation on the metallic parts of cable connections.

Electrical cable connections exposed to appreciable ohmic or ambient heating during operation may experience loosening caused by repeated cycling of connected loads or of the ambient temperature environment. Different materials used in various cable system components can produce situations where stresses between these components change with repeated thermal cycling. For example, under loaded conditions, ohmic heating may raise the temperature of a compression terminal and cable conductor well above the ambient temperature, thereby causing thermal expansion of both components. Thermal expansion coefficients of different materials may alter mechanical stresses between the components so that the termination may be impacted. When the current is reduced, the affected components cool and contract. Repeated cycling in this fashion can cause loosening of the termination, and may lead to high electrical resistance or eventual separation of compression-type terminations. Threaded connectors may loosen if subjected to significant thermally induced stress and cycling.

Cable connections within the scope of license renewal should be tested at least once prior to the period of extended operation to provide an indication of the integrity of the cable connections. The specific type of test to be performed and is to be a proven test for detecting loose connections, such as thermography, contact resistance testing, or another appropriate test justified in the application.

This program, as described, can be thought of as a sampling program. The following factors shall be considered for sampling: voltage level (medium and low voltage), circuit loading (high loading), and location (high temperature, high humidity, vibration, etc.). The technical basis for the sample selections should be documented. If an unacceptable condition or situation is identified in the selected sample, corrective action program will be used to evaluate the condition and determine appropriate corrective action.

SAND 96-0344, "Aging Management Guidelines for Electrical Cable and Terminations," indicated loose terminations were identified by several plants. The major concern is that the failures of a deteriorated cable system (cables, connections including fuse holders, and penetrations) that could prevent it from performing its intended function. This program is not applicable to cable connections in harsh environment since they are already addressed by the requirements of 10 CFR 50.49. Even though cable connections may not be exposed to harsh environments, loosening or high resistance of connection is a concern due to aging mechanisms discussed above.

Evaluation and Technical Basis

1. **Scope of Program:** External connections terminating at an active or passive devices are in the scope of this program. Wiring connections internal to an active assembly are considered a part of the active assembly and therefore are not within the scope of this program. This program does not include high-voltage (>35 kV) switchyard connections. The cable connections covered under the EQ program are not included in the scope of this program.
2. **Preventive Actions:** No actions are taken as part of this program to prevent or mitigate aging degradation.
3. **Parameters Monitored/Inspected:** This program will focus on the metallic parts of the connection. The monitoring includes loosening of bolted connections or high resistance of cable connections due to thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, and oxidation. A representative sample of electrical cable connections is tested. The following factors shall be considered for sampling: voltage level (medium and low voltage), circuit loading (high load), and location (high temperature, high humidity, vibration, etc.). The technical basis for the sample selection is to be documented.
4. **Detection of Aging Effects:** A representative sample of electrical connections within the scope of license renewal will be tested at least once prior to the period of extended operation to confirm that there are no aging effects requiring management during the period of extended operation. Testing may include thermography, contact resistance testing, or other appropriate testing methods without removing the connection insulation such as heat shrink tape, sleeving, insulating boots, etc. The one-time inspection provides additional confirmation to support industry operating experience that shows electrical connections have not experienced a high degree of failures, and that existing installation and maintenance practices are effective.
5. **Monitoring and Trending:** Trending actions are not included as part of this program because it is a one-time inspection program.
6. **Acceptance Criteria:** The acceptance criteria for each test are to be defined for the specific type of test performed and the specific type of cable connections tested.
7. **Corrective Actions:** If test acceptance criteria are not met, the corrective action program will be used to perform an evaluation that will consider the extent of the condition, the

indications of aging effect, and changes to the one-time inspection program. Corrective actions may include, but are not limited to sample expansion, increase inspection frequency, and replacement or repair of the affected cable connection components. As discussed in the appendix to this report, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the corrective actions.

8. **Confirmation Process:** As discussed in the appendix to this report, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the confirmation process.
9. **Administrative Controls:** As discussed in the appendix to this report, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the administrative controls.
10. **Operating Experience:** Electrical cable connections exposed to appreciable ohmic or ambient heating during operation may experience loosening caused by repeated cycling of connected loads or of the ambient temperature environment. There have been limited number of age related failures of cable connections reported. This one-time inspection confirms the absence of aging degradation of metallic cable connections.

References

EPRI TR-109619, *Guideline for the Management of Adverse Localized Equipment Environments*, Electric Power Research Institute, Palo Alto, CA, June 1999.

IEEE Std. P1205-2000, *IEEE Guide for Assessing, Monitoring and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations*.

NUREG/CR-5643, *Insights Gained From Aging Research*, U.S. Nuclear Regulatory Commission, March 1992.

SAND96-0344, *Aging Management Guideline for Commercial Nuclear Power Plants – Electrical Cable and Terminations*, prepared by Sandia National Laboratories for the U.S. Department of Energy, September 1996.

EPRI TR - 104213, *Bolted Joint Maintenance & Application Guide*, Electric Power Research Institute, Palo Alto, CA, December 1995.

Staff's Response to the NEI White Paper on Generic Aging Lessons Learned (GALL) Report Aging Management Program (AMP) XI.E6, "Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements," dated March 16, 2007 (ADAMS Accession Number ML070400349)