

March 16, 2007

Mr. Alexander Marion
Nuclear Energy Institute
1776 I Street, NW, Suite 400
Washington, DC 20006-3708

SUBJECT: STAFF RESPONSE TO THE NUCLEAR ENERGY INSTITUTE (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 REQUIREMENT"

Dear Mr. Marion:

By letter dated September 5, 2006, NEI submitted a white paper associated with the GALL Report AMP XI.E6. In its letter, NEI stated that there is not enough operating experience to support a conclusion that cable connections are a significant aging management concern. NEI is concerned that some of the recommended program elements of GALL AMP XI.E6 duplicate already defined and accepted aging management activities. NEI is also concerned that the expanded scope of the program includes all voltage ranges. In addition, NEI identified wording in GALL AMP XI.E6 that appeared to include connections in active equipment. Finally, NEI is asking the staff to review the white paper to eliminate GALL AMP XI.E6 or to minimize its scope and redundancy so that plants will not be burdened with activities that have no actual aging management benefits.

On November 30, 2006, the staff met with NEI representatives to discuss NEI's white paper. A summary of this meeting is available via the Agencywide Documents Access and Management Systems (ADAMS) under Accession No. ML063600004.

The staff completed its review and Enclosure 1 provides its response to NEI's white paper. The staff determined that GALL AMP XI.E6 was based on technical information contained in Electric Power Research Institute documents, SAND 96-0344 report, and industry wide use of thermography. However, only few operating experiences of failed connections due to aging have been identified and these operating experiences cannot support periodic inspections as currently recommended in GALL AMP XI.E6. The staff intends to revise GALL AMP XI.E6, using the License Renewal Interim Staff Guidance process, to recommend a one time inspection on a representative basis to ensure that either aging of metallic cable connections is not occurring or an AMP credited for renewal is effective such that periodic inspections are not needed.

A. Marion

-2-

If you have any questions regarding this matter, please contact Ms. Linh Tran of my staff at 301-415-4103 or via e-mail at lint@nrc.gov.

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

Sincerely,

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

Enclosure:
As stated

cc w/encl: See next page

March 16, 2007

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

SUBJECT: STAFF RESPONSE TO THE NUCLEAR ENERGY INSTITUTE (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 REQUIREMENT"

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D. Lochbaum

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An identical letter was sent to Mr. Alexander Marion at the Nuclear Energy Institute.

Sincerely,

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

Enclosure:
As stated

cc w/encl: See next page

D. Lochbaum

-2-

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An identical letter was sent to Mr. Alexander Marion at the Nuclear Energy Institute.

Sincerely,

/RA/

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

Enclosure:
As stated

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ADAMS Accession No: **ML070400349**

OFFICE	LA:DLR	DLR	PM:DLR	OGC	BC:RLRC	BC:RLRB	D:DLR
NAME	YEdmonds	DNguyen	LTran	MBarkman nlo w/edits	KChang	RAuluck	PTKuo
DATE	2/20 /07	2/21/07	2/21/07	3/09/07	3/09/07	3/14/07	3/ 16 /07

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Letter to A. Marion, D. Lochbaum, from PTKuo, dated March 16, 2007

SUBJECT: STAFF RESPONSE TO NEI WHITE PATER ON GALL AMP XI.E6
(ELECTRICAL CABLE)

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NUCLEAR ENERGY INSTITUTE

Project No. 690

cc:

Ms. Christine S. Salembier, Commissioner
State Liaison Officer
Department of Public Service
112 State St., Drawer 20
Montpelier, VT 05620-2601

Mr. James Ross
Nuclear Energy Institute
1776 I St., NW, Suite 400
Washington, DC 20006-3708

Mr. Frederick W. Polaski
Manager License Renewal
Exelon Corporation
200 Exelon Way
Kennett Square, PA 19348

Mr. Clifford I. Custer
Project Manager, License Renewal
FirstEnergy Nuclear Operating Company
P.O. Box 4
Route 168 (Mail Stop SIM-2)
Shippingport, PA 15077

Mr. Paul Gunter, Director
Reactor Watchdog Project
Nuclear Information & Resource Service
6930 Carroll Avenue, Suite 340
Takoma Park, MD 20912

Mr. Hugh Jackson
Public Citizen's Critical Mass Energy &
Environment Program
215 Pennsylvania Ave., SE
Washington, DC 20003

Mary Olson
Nuclear Information & Resource Service
Southeast Office
P.O. Box 7586
Asheville, NC 28802

Mr. Garry G. Young
Manager, License Renewal Services
1448 SR 333, N-GSB-45
Russellville, AR 72802

Robert A. Vincent
Licensing Lead - License Renewal Project
Palisades Nuclear Plant
27780 Blue Star Memorial Highway
Covert, MI 49043

Lorrie Bell, Project Manager
Wolf Creek Nuclear Operating Corporation
P.O. Box 411
Burlington, KS 66839

Roger Stewart
Progress Energy Carolinas, Inc.
3581 West Entrance Road
RNP A9
Hartsville, SC 29550

Michael H. Crowthers, Supervisor Nuclear
Regulatory Affairs
PPL Susquehanna, LLC
Two North Ninth Street (GENPL4)
Allentown, PA 18101-1179

Staff Response to the Nuclear Energy Institute (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 Requirement"

Comment 1. 1.1 Statement of Industry Concerns. Subsequent to the receipt of comments on the proposed E6 program, the NRC expanded the scope of the program to include active components, contrary to Part 54. The E6 program had the following scope added "... regardless of their association with active or passive components," after the final publication and public comment period was closed and final public comments received (Reference 4). This expanded the program to include connections in or related to active equipment, contrary to the 10 CFR 54 Statements of Consideration (SOC) and as the SOC is implemented in other XI Aging Management Programs (AMPs), such as XI.E5 Fuse Holders.

Response:

The phrase "regardless of their association with active or passive components" refers to a cable connection to a device regardless of whether this device is an active or passive component. The staff considers motor terminals and switchgear terminals for external cable connections to be the interface between the passive cable connection and the active device. These cable connections are considered in-scope of GALL AMP XI.E6 since these cable connections are installed in the field by the applicant. The staff will revise GALL AMP XI.E6 to clarify the scope of this program to include only external cable connections terminating at an active device such as motor, motor control center, switchgear or of a passive device such as a fuse cabinet. Wiring connections internal to an active assembly installed by manufacturers are considered a part of the active assembly and therefore are not within the scope of GALL AMP XI.E6.

Comment 2. 1.2 Statement of Industry Concerns. The proposed E6 program is premised on a concern with effects in post-accident conditions, yet it would impose aging management for connections in post-accident conditions when they are not required to operate after the initiation of an accident or in the harsh post-accident environment. This approach conflicts with, and inappropriately expands, without rulemaking, the established regulatory scheme in 10 CFR 50.49 scoping electrical equipment required to operate in post-accident harsh environments.

Response:

Aging management for cable connections not subject to the requirements of 10 CFR 50.49, "Environment Qualification of Electric Equipment Important to Safety for Nuclear Power Plants," is not required in post-accident conditions, and are not subject to GALL AMP XI.E6. Even though cable connections subject to AMP XI.E6 are not subject to harsh environments, they are required to perform the intended function that is the basis for their inclusion in the scope of license renewal. The aging management requirements of XI.E6 are not applicable to cable connections in harsh environment which are already addressed by the requirements of

Enclosure

10 CFR 50.49. However, cable connections within the scope of license renewal subject to the identified aging effects are required to be managed to ensure that their intended function will be maintained. The staff will revise GALL AMP XI.E6 to clarify this concern.

Comment 3. 1.3 Statement of Industry Concerns. The asserted technical justification for the proposed program is based on a missapplication [sic] of operating experience data in that the scope of the program applies all aging effects to all voltage ranges (i.e., high, medium and low voltage) regardless of the operating experience evidence that shows connections not to be a significant aging management concern and previously identified aging effects by voltage level to be covered in the XI.E1 through XI.E3 AMPs and specific NRC concerns with specific metallic connections to be covered in the XI.E4 and XI.E5 AMPs.

Response:

The operating experience cited in the GALL AMP XI.E6 can be viewed as applicable aging effects of cable termination that may require aging management. The staff understands that the industry widely uses thermography to detect loose connections associated with all voltage levels (high, medium, and low).

Furthermore, industry operating experiences described in SAND 96-0344, "Aging Management Guideline (AMG) for Electrical Cable and Termination," September 1996, support GALL AMP XI.E6. SAND 96-0344 used six primary sources of information to characterize the historical performance of electrical terminations: NRC Information Notices, Bulletins, Circulars, Generic Letters, Nuclear Plant Reliability Data System (NPRDS) data, and Licensee Event Report (LER) data. It also used industry information provided by previous analyses and reports, information obtained from operating nuclear plants acting as host utilities, and plant surveys. The following were observed:

- a. Mechanical stresses (including vibrations) were frequently cited as a cause for connection failure. As evidenced from discussions with utilities, aging occurs predominantly near the end device or load connections.
- b. Connector failures constitute a large percentage of all failures noted for low voltage cables (30% for NPRDS, 58% for LERs). A large percentage of these failures can be attributed to oxidized, corroded, or dirty contact surfaces.
- c. Loosening and breakage of lugs are the most frequent compression fitting failures, based on both NPRDS and LERs data.
- d. Instances of termination loosening due to thermal cycling were identified by several plants contacted during the preparation of SAND 96-0344, and summarized in the empirical data presented in Section 3 of SAND 96-0344.

In addition, operating experience at Kewaunee regarding reactor trip due to loss of power on instrument bus IV (LER Number 3051984014) has shown that aging effects of connections at low voltage could be a concern. The Electric Power Research Institute (EPRI)-1007933,

“Aging Assessment Field Guide,” recommends field inspection of low voltage cable connections due to corrosion. However, in its search for operating experience, the staff has found that the majority of loose connections were due to human errors or design deficiencies. Operating experience has not shown that failed connections due to aging are a significant cause of loss of safety-related equipment and few connection failures were related to aging. However, because of the limited number of aging related failures of low voltage connections, a one-time inspection as described in the letter is warranted. Please refer to staff’s response to Comment 5 below regarding industry comment about the previously identified aging effects covered in GALL AMPs XI.E1 through XI.E5.

Comment 4. 1.4 Statement of Industry Concerns. The asserted technical justification for the proposed program is based on a misapplication of operating experience data in that the E6 AMP basis incorrectly interprets and uses the information from its referenced LERs to inappropriately support the requirement for this program.

Response:

See the staff’s response to Comment 3 above.

Comment 5. 1.5 Statement of Industry Concerns. A comprehensive license renewal scheme already exists to address non-Section 50.49 electrical system conditions important to license renewal. The proposed E6 program elements would also duplicate those already defined and accepted as aging management activities under 1) the GALL AMP XI.E1 Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements, 2) XI.E2 Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Used in Instrumentation Circuits, 3) XI.E3 Inaccessible Medium-Voltage Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements and other AMPS in the GALL, Revision 1, 4) the XI.E4 AMP which provides for aging management of electrical connections in metal enclosed buses, and 5) the XI.E5 AMP which provides for aging management of electrical connections to fuse holders outside of active equipment.

Response:

The staff disagrees with industry’s comment regarding the overlapping of GALL AMP XI.E6 with previously identified aging effects covered by GALL AMPs XI.E1 through XI.E5. The staff concluded that the environments, scopes, aging effects, and materials of GALL AMP XI.E6 are different from those of GALL AMPs XI.E1 through XI.E5. The following provides the staff’s rationale:

- GALL AMP XI.E1 addresses aging management for cable and connection insulation materials in adverse localized environments. The aging effects of these materials are cracking, discoloration, or melting of insulation due to high heat, radiation, and moisture. Not many connections are installed in those locations. As a result, very few connections will be inspected for aging degradation under AMP XI.E1.

- GALL AMP XI.E2 addressed the same aging effects, materials, and environments as GALL AMP XI.E1 but is different in scope. It is only applicable to high voltage, low level signal cables such as high-range radiation monitors and neutron monitors. GALL AMP XI.E2 covers a very limited number of connections associated with high-range radiation monitors and neutron monitors.
- GALL AMP XI.E3 addresses degradations of cable insulation due to water entry into inaccessible medium voltage cables installed in duct banks, or in direct buried cables. A limited number of connections are involved in GALL AMP XI.E3. GALL AMP XI.E4 addresses degradation of bus bar insulation of metal enclosed bus work and loosening of bolted connections of bus bars. GALL AMP XI.E4 does not address cable connections.
- GALL AMP XI.E6 addresses the same aging effects of metallic portions for fuse holders as GALL AMP XI.E5. However, the scope of GALL AMP XI.E5 is much smaller and involves low voltage circuits such as 125 V dc. Typically, fuse holders are inside an active assembly and very few fuse holders are outside of an active assembly and therefore very few fuse holders are in scope of GALL AMP XI.E5.
- GALL AMP XI.E6 addresses the metallic portions of non-EQ cable connections exposed to inside and outside air environments. These cable connections are subject to aging effects of loosening of bolted connections or high resistance due to thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, and oxidation.

Therefore, GALL AMP XI.E6 is not an overlap of GALL AMPs XI.E1 through XI.E5.

Comment 6. 1.6 Statement of Industry Concerns. The proposed E6 program is not premised on new experience and should be evaluated on its merits (or lack thereof) outside the context of the license renewal arena. In the license renewal context, it is well established that when a new program is proposed it is based on some new industry experience that comes up associated with aging that needs to be addressed by an AMP. All the references of the E6 program were in existence when the Calvert Cliffs license renewal application was approved in March of 2000. No justification has been provided to impose this new program on operating licensed reactors, and certainly not to employ the license renewal context to impose new requirements.

Response:

See the staff's response to Comment 3 above.

Comment 7. 3 Connections in Active Equipment. Therefore the inclusion of connections in or directly associated with active equipment is duplication of, and/or an unjustified burden and safety reduction of the Maintenance Rule activities and contrary to 10 CFR 54, the License Renewal Rule, and the Statement of Considerations (SOC) published with the Rule.

Response:

The Maintenance Rule (10 CFR 50.65) may not monitor/inspect the condition of cable connections and only requires the licensees to monitor the performance or condition of structures, systems, or components (SSCs) important to safety against licensee-established goals. When performance or condition of an SSC does not meet the established goals, then appropriate corrective actions are taken. However, GALL AMP XI.E6 is used to manage the aging effects of cable connections before degradation occurs and not after it fails. Also, when an applicant performs periodic preventive maintenance and if the preventive maintenance includes inspection/monitoring 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. Regarding industry's comment about connections associated with active equipment, see staff response to Comment 1.

Comment 8. **4 Environmental Conditions.** The environmental conditions applied to the proposed XI.E6 program exceed the License Renewal Rule. From the Program Descriptions of the XI.E1, XI.E2, and XI.E3 AMPs which state: "As stated in NUREG/CR-5643, The major concern with cables is the performance of aged cable when it is exposed to accident conditions." The statement of considerations for the final license renewal rule (60 Fed. Reg. 22477) states, "The major concern is that failures of deteriorated cable systems (cables, connections, and penetrations) might be induced during accident conditions." Since they are not subject to the environmental qualification requirements of 10 CFR 50.49, the electrical cables and connections covered by this program are either not exposed to harsh accident conditions or are not required to remain functional during or following an accident to which they are exposed." ...It is apparent that this proposed program would impose an assumption of harsh environment exposure on equipment not required to operate after the initiation of an accident or not otherwise exposed to harsh accident conditions in the first place. Such an assumption is contrary to the already established scoping regulations defining electrical equipment required to operate in post-accident harsh environments. Electrical connections required to operate after the initiation of an accident or in harsh accident conditions are already included in 10 CFR 50.49, the Environmental Qualification AMP in accordance with 10 CFR 54.4(a)(3).

Response:

GALL AMP XI.E6 was not intended to impose harsh environment requirements. The staff will modify the program description to state:

The major concern is the failure of a deteriorated cable system (cables, connection including fuse holders and penetrations) to perform its intended function that is the basis for including it in the scope of license renewal. Even though cable connections may not be exposed to harsh environments, loosening or high resistance of connections are of concern due to aging effects as identified in GALL AMP XI.E6.

Comment 9. 5 Benefit-Cost Consideration. The proposed XI.E6 program states that a “representative sample of electrical cable connections” is to be tested. Assuming a percentage as small as 1% was determined to be representative, which would mean that a sample of 2,500 connections would have to be tested.

The sample of 200 power cables possibly by thermography, leaving the remaining 2,300 control and instrumentation connections to be taken out of service and tested. The stated purpose of the proposed XI.E6 program is to test non-EQ cable connections that are within the scope of license renewal to provide an indication of their integrity. Looking at the benefits and costs, the XI.E6 program is proposing to manage a group of electrical components that have been found by documented research NOT to have any major aging concerns and is very costly. In addition it would result in inoperability of safety related equipment for considerable periods of time.

Response:

When SCs are determined to be within scope of the license renewal and are subject to aging effects, 10 CFR Part 54 requires aging management of these SCs during the period of extended operation. GALL AMP XI.E6 recommended testing of cable connections on a sample basis. The applicant can define sampling criteria for testing. The staff feels that these recommendations are not an undue burden to the applicants.

Regarding taking safety-related equipment out of service for considerable periods of time, the staff feels that testing methods such as thermography are available which do not require equipment to be out of service because it is performed when equipment is energized and conducted from a safe distance. Resistance measurements can also be performed during scheduled preventive maintenance, and this activity is not complicated or excessively difficult.

Comment 10. 6 Determination of Electrical Circuit Operability Already Addressed by Existing Programs. Independent of environmental conditions, the determination of operability of an electrical circuit can be made by several methods depending on the normal condition and function of the circuit. The two normal conditions are energized and not energized. Periodic or intermittent energization can be considered as a subset of either, but will be conservatively considered here as normally not energized. The normal functions can be to provide power, control, or indication.

... Therefore, there are adequate methods for the plant operators to determine the operability of electrical connections independent of an XI.E6 program.

Response:

When an SC is subject to an aging mechanism, it may not perform its intended function when needed. Loss of function due to an aging mechanism would likely take a long period of time. Sometimes, the aging effects would not be revealed as an immediate indication of a problem with the equipment or circuit. The staff is concerned that an SC may fail to function when it is

required to be functional. Specifically, periodically/intermittently energized circuits that do not have continuous determination of operability and scheduled testing may not detect aging of the equipment unless it specifically calls for inspection or testing of cable connections.

Comment 11. 7 Observable Characteristics of Field Connections. The assurance that there are no adverse material-environment-aging effects requiring aging management is typically verified by observing some basic characteristic(s) of the component in question. For the types of connections described (bolted, ring tongue, butt splice, fused) the readily observable characteristic of these connection in the field is the condition of the electrical insulation material that covers them. This observation is readily achieved by the implementation of the GALL AMP XI.E1 when applied to all cables and connection in scope for license renewal. The typical characteristics of a challenged cable or connection are discoloration, embrittlement, and cracking of the exterior insulation. Likewise, there are visual indications for uninsulated connections as discussed in EPRI TR 104213 Section 8.2.

All of these indications precede any level of degradation of the insulation or the underlying metallic connection that would lead to loss of operability and failure.

Response:

The staff disagrees with industry's comments. As mentioned earlier in the response for Comment 5 above, the environment, materials, and aging effects for GALL AMPs XI.E1 and XI.E6 are different. Observation of insulation materials of cable and connections in adverse localized environments as recommended by XI.E1 may not cover or may not represent all connections in-scope of GALL AMP XI.E6 installed outside or inside air environments.

EPRI TR 104213, "Bolted Joint Maintenance & Application Guide," December 1995, indicates that an electrical connections must be designed to remain tight and maintain good conductivity through a large temperature range. Meeting this requirement is difficult if the materials specified for the bolt and the conductor lug are different, having different coefficients of thermal expansion. For example, copper and aluminum material expand more than most bolting materials. If thermal stress is added to stresses inherent at assembly, the joint members of fasteners can yield. If plastic deformation occurs during thermal loading (i.e., heat up), the joint will be loose when the connection cools down. Increased temperature difference in electrical bolted joints is due to increased current duration. The temperature of an electrical bolted joint will rise and the stress will increase with increasing current duration. If this temperature increase is not taken into consideration, loose, failure prone joints will result. EPRI TR 104213 recommends that joint resistance of bolted joints be checked using a low range ohm meter.

Comment 12. 8 Operating Experience (OE). Operating experience has not shown that failed connections are a significant cause of loss of safety related equipment, beyond the initial (debug or break-in) period of operation after construction. As stated in both SAND 96-0344 (Reference 6) and EPRI TR-1003471 (Reference 9), some connection failures will occur randomly during plant life. These are mainly due to specific events, such as maintenance activities, that

challenge the circuit or have caused some direct physical damage to the connection. These can be minimized or avoided by good procedures, better work planning and coordination, and improved maintenance practices. These physical damage failures are not related to aging. Further, the operating experience in fact provides strong evidence that reliable processes are already in place to address these conditions in that with the thousands of connections and hundreds of years of operating experience there have been very few failures.

Response:

The staff disagrees with the conclusions reached through the logic offered by NEI's comment on the basis of operating experience, and views that industry operating experience actually supports the need for the one time inspection requirements. Also see the staff's response to Comment 3.

Comment 13. 9 Duplication of Other GALL AMP Requirements. Since the five electrical AMPs, XI.E1 through XI.E5, and EQ program cover all of the electrical connections within the scope of the proposed E6 program for license renewal, and the proposed XI.E6 program would directly conflict with the hazardous environment electrical equipment scoping already established by 10 CFR 50.49, the proposed program is neither justified nor consistent with existing regulatory requirements.

Response:

The staff disagrees that GALL AMP XI.E6 is a duplication of GALL AMPs XI.E1 through XI.E5. See the staff's response to Comment 5.