NEI E6 Electrical Connections Program White Paper

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Nuclear Energy Institute

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NEI would like to acknowledge the contributions to this White Paper of Mr. Steven Schellin, PE, of the Nuclear Management Company's Point Beach Nuclear Plant and former Chairman of the NEI License Renewal Electrical Working Group (LREWG). Mr. Schellin has multiple degrees in Nuclear Engineering from the University of Wisconsin, taught there, and done basic research there and at the Argonne National Laboratory. He has over 40 years of nuclear power plant design and operational experience. He is currently the Project Manager of the Point Beach Nuclear Plant license renewal project. Mr. Larry Seamans, PE, NMC Palisades Nuclear Plant, current NEI LREWG Chairman and other members of the LREWG and other interested parties have also provided technical comments that have been incorporated therein.

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NOTICE

EXECUTIVE SUMMARY

The NRC has required aging management for the metallic portion of electrical connections in the proposed XI.E6 Program as stated in the Generic Aging Lessons Learned Report (GALL), Revision 1. The industry concerns with this program are multiple and include the extension of aging management to active components, which is contrary to 10 CFR 54, the Licensing Renewal Rule, and Statement of Considerations as provided by the NRC Commissioners. This white paper provides a discussion of the bases and operating experience used by the NRC staff to justify the proposed XI.E6 Program. It notes that no new aging affects requiring management are identified for electrical connections that are not already adequately covered by other aging management programs (AMPs). The connections in active equipment are adequately covered with the aging management of that active equipment under the Maintenance Rule. The environmental conditions imposed by the proposed XI.E6 program do not apply under 10 CFR 54 to electrical connections outside of 10 CFR 50.49. Other previously existing AMPs manage the aging of cables and connections at all voltage levels. The XI.E3 AMP provides coverage where there is any appreciable ohmic heating. The operating experience and reports referenced all existed prior to the beginning of the license renewal process and do not show the failure of electrical connections are caused by aging, rather that they are random, typically caused by an outside event, and of minor significance in number and frequency relative to plant operation and safety. This aging concern was not identified in or required for any of the plants re-licensed prior to the issuance of the GALL revision. The white paper provides documentation to show that the NRC has not demonstrated the need for the XI.E6 program.

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1 STATEMENT OF INDUSTRY CONCERNS

The industry concerns with the proposed XI.E6 Program as stated in the Generic Aging Lessons Learned Report (GALL) (Reference 5) (Attachment 1) are:

The Proposed E6 Program is Contrary to Regulation

1. 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.

2. 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.

The Proposed E6 Program is Not Technically Justified

3. The asserted technical justification for the proposed program is based on a missapplication 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.

4. The asserted technical justification for the proposed program is based on a missapplication 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.

The Proposed E6 Program is Duplicative of Existing Processes and Programs and Not Justified for License Renewal

5. 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 busses, and 5) the XI.E5 AMP which provides for aging management of electrical connections to fuse holders outside of active equipment.

6. 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.

Because of these concerns the industry has thoroughly examined a number of topics associated with electrical connections including the types and functions of connections, connections in active equipment, environmental conditions, determination of operability, observable field characteristics, operating experience of electrical connections (including LERs) and the need for a separate electrical connections program. We have also reviewed the NRC stated bases (Reference 3) for each of the above. This white paper presents the results of this review and forms a comprehensive framework for further technical and licensing discussion of the proposed XI.E6 program. We believe that this paper demonstrates that the NRC should either eliminate the program or justify and properly define its scope and eliminate redundancy with existing programs; including current operational and specific license renewal premised programs, so that plants will not be burdened with activities that have no actual aging management benefit.

2 TYPES AND FUNCTIONS OF ELECTRICAL CONNECTIONS

To better define the potential conditions at operating plants regarding aging of electrical connections, one must first understand the configurations and construction of the connections and what possible aging mechanisms exist for each type.

Compression connectors are the most popular connector type, where a metal connector is physically crimped or mechanically swaged to conductors. There are several different types of connections that can be made with compression connectors.

Bolted Connections - Bolted electrical connections are typically used for medium and higher voltage power circuits and consist of either (a) one cable terminated in an appropriately sized metal (usually copper) lug and bolted to the electrical power output connection of a transformer, motor control center(MCC) breaker, or the input connection of a piece of operating equipment, such as a motor driving a pump or valve operator, or at a penetration, or (b) two cables terminated in appropriately sized metal lugs with the lugs bolted together to form a continuous circuit. Bolted connections at a MCC or at the powered equipment are typically interior to the MCC cabinet or termination junction box on the equipment and may or may not be insulated by tape, heat shrink, or boot. If they are not insulated they must not be exposed for reasons of personnel safety per the National Electrical Code (NEC). In either case the connections are not accessible when powered. When not powered, insulated connections will only have the insulation visible and uninsulated connections will require that the protective cabinet or terminal box be opened for access to the termination. In both cases the connection is considered and managed as part of the active equipment. Bolted connections at a transformer may be external and will be fully insulated. Where two cables are joined by a bolted connection the connection is either taped or covered by an insulating heat shrink kit. In none of the bolted connection configurations is the metallic portion of the electrical connection visible or accessible when powered and only for the connection made inside active equipment may the connection be visible when not powered. When bolted connections are installed correctly and enclosed or covered by insulation, they are not exposed to adverse conditions which would cause aging.

Ring Tongue and Screw Connections - Ring tongue and screw connections (referred to as “crimp-type ring lugs” in the GALL) are typically used for low power, control, and instrumentation circuits and consist of an appropriately sized ring tongue that has been compressed onto the stripped, exposed end of a conductor using a calibrated crimping tool. This ensures consistency of the connection between the conductor and the ring tongue connector for QA purposes as typically required for the circuits within the scope of license renewal (i.e., safety related, non-safety related affecting safety, and regulated event circuits). The ring tongue connector is then terminated at a terminal block or other component with a screw of compatible material (usually copper). These connections are usually not insulated but internal to terminal junction boxes or the active equipment to which they interconnect. Ring tongue connectors for terminations at fuse holders are already covered for aging management under GALL AMP XI.E5. Terminations at terminal blocks are also already covered for aging management under GALL AMP XI.E1. Some of the instrumentation connections covered under GALL AMP XI.E2 may also be made using ring tongue connectors. The exposed ring tongue and screw connection are not exposed when powered for reasons of personnel safety per the National Electrical Code (NEC). For personnel safety equipment enclosures, cabinets, or junction boxes are not opened when the equipment is energized, to be able to examine these connections. Since they are enclosed, they are not exposed to adverse conditions which would cause aging.

Butt Spliced Connections - Butt spliced connections are typically used for low power, control, and instrumentation circuits and used at connections to equipment pigtails or pigtails of containment penetrations. They consist of the stripped, exposed ends of two conductors being inserted into a metallic (copper) butt splice compression connector, the connector being compressed onto the conductors using a calibrated crimping tool, and the connector and ends of the conductors being enclosed in an insulating heat shrink splice kit (which may enclose all of the conductors individually and then together for a multi-conductor cable). The heat shrink splice kits are specially manufactured for specific cable, conductor, and connector sizes and have unique application procedures that must be followed by qualified personnel using calibrated crimping equipment. The types of heat shrink splice kits used in a nuclear power plant are qualified for the plant normal and accident environment in which they are installed.

Fusion connectors may be fitted to (typically) medium or high voltage power cables or grounding conductors and consist of a metal connection fitting that is welded, brazed, or soldered to the conductors. Their use and insulation after being fused to the conductor is the same as a crimped connector. The connection is either taped or covered by an insulating heat shrink kit. When covered by insulation, they are not exposed to adverse conditions which would cause aging.

Splice insulation systems (heat-shrink or tape) are used to environmentally seal cable or splice terminations or junctions. They are generally applied over a compression or fusion connection. The types of connections included in the scope of the proposed XI.E6 program are constructed in a manner which does not expose them to adverse environmental conditions. The metallic portions of the connections are not visible, except inside active equipment. The visible portion of these connections is the insulation covering the metallic electrical conductors and this insulation is adequately aging managed by the XI.E1 AMP.

3 CONNECTIONS IN ACTIVE EQUIPMENT

Connections that are within active equipment are maintained as part of that equipment per the Maintenance Rule. In the License Renewal Rule, 10 CFR 54 (Reference 1), Statements of Consideration (Reference 2) there are several statements that explain and exempt active equipment from being required to also be covered by aging management programs directed toward passive components as follows:

> *"considerable experience has demonstrated that its regulatory process, including the performance-based requirements of the maintenance rule, provide adequate assurance that degradation due to aging of components that perform active functions will be appropriately managed"*
>
> *"components that perform active functions can be generically excluded from an aging management review on the basis of performance or condition-monitoring programs."*
>
> *"Functional degradation resulting from the effects of aging on active functions is more readily determinable, and existing programs and requirements are expected to directly detect the effects of aging."*

> *"many licensee programs that ensure compliance with technical specifications are based on surveillance activities that monitor performance of systems, structures, and components that perform active functions."*

For personnel safety accessibility to the connections in active equipment is only possible when that equipment is de-energized for maintenance and testing or refurbishment, therefore it is not appropriate to require a separate AMP that takes this equipment out of service separately to maintain connections that are internal to the equipment just because the connections are made by cables and conductors from outside the active equipment. This would force the License Renewal Rule to cause an unnecessary increase in the equipment unavailability time for the Maintenance Rule equipment and directly decrease the safety of the plant without any gain in reliability of the equipment or system.

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.

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.**"

The rationale for these programs is properly focused on "the electrical cables and connections …either not exposed to harsh accident conditions or are not required to remain functional during or following an accident to which they are exposed." This rationale is well-founded because functional loss of non-EQ, important to safety circuits due to exposure to accident conditions is expected, indicating that the only concern regarding the effects of aging on non-EQ important to safety electrical connections should be the loss of operability of a circuit prior to initiation of an accident. In contrast, the proposed XI.E6 program description would impose harsh environment condition assumptions on equipment not expected to see harsh environments or not required to operate in the post-accident harsh environments, when it states *"The major concern is that failures of a deteriorated cable system (cables, connections including fuse holders, and penetrations) might be induced during accident conditions. Since the connections are not subject to the environmental qualification requirements of 10 CFR 50.49, an aging management program is required to manage the aging effects."* 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).

Evaluation of the specific aging mechanisms and environments for the metallic portion of electrical connections provides multiple reasons why it can be justified that no aging occurs as shown by the table in Attachment 11, Connection Aging Evaluation.

5 BENEFIT- COST CONSIDERATION

The proposed XI.E6 references SAND 96-0344 as the source of information on *"loose terminations…identified by several plants"* ; however the conclusion reached in the Sandia report, following its exhaustive and documented research, is that the area of concern is only related to the operation of accident mitigation equipment that is subject to harsh accident conditions. By its own statement, then, the proposed XI.E6 program is really only trying to manage a group of electrical components that have been found by documented research NOT to have any major aging concerns.

Now, let's put the proposed XI.E6 program in perspective. A minority of electrical connections are associated with power circuits and most are associated with control circuits and instrumentation circuits. There are literally tens of thousands of electrical connections in a typical nuclear power plant that are within license renewal scope because each in-scope cable has at least four connections (as a minimum there are connections at the bus, on both the input and output sides of a remote starter/breaker near the component, and the power connections directly on the component) and most control and instrumentation circuits have several intermediate connections through terminal cabinets. Therefore, if there are 50,000 cables within license renewal scope at a plant, there might be 5,000 power cables (with approx. 20,000 connections) and 45,000 control and instrumentation cables (with possibly 270,000 connections); the total number of connections could easily be on the order of 250-300,000.

The power circuit connections are normally the only circuits with enough current flow to make thermography feasible. Since the proposed XI.E6 program discredits visual inspection as a detection method**,** this leaves only physical circuit testing techniques, such as contact resistance, for the vast majority of the connections. With recent personnel safety concerns related to arc-flash, exposure of energized connections to be able to perform thermography on energized medium voltage and high voltage electrical power equipment is very difficult. In order to perform contact resistance or other tests on control and instrumentation connections, each associated circuit must be taken out of service, insulation removed, and depending on the circuit disconnection and reconnection may be required.

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.

In summary, the proposed XI.E6 program contradicts the SOC, as related to active components by including all non-EQ plant connections in the population set and makes the program unrealistic as related to any stated benefit.

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.

Normally energized circuits have a continuous determination of operability by the performance of their normal functions, regardless of which function they perform. Loss of function is an immediate indication of a problem with the equipment or circuit and considered an event. Diagnosis would determine the cause and during restoration of the function a performance test would likely be performed to ensure operability before return to service is permitted. Therefore plant personnel performing observations of equipment operating as expected as a normal part of the plant operation ensures operability of normally energized circuits. This is achieved in the control room by both the automatic alarm circuits of the plant systems and the operator normal functions or by auxiliary operators during shift rounds. Connected instrumentation may also measure voltage and amperage in the circuits of concern, providing quantitative verification of circuit operability and capability.

Not normally energized or periodically/intermittently energized circuits do not have continuous determination of operability. These circuits must rely on the use of the circuit to perform either periodically required plant functions or scheduled testing and the knowledge that the plant conditions between uses or tests are not adversely affecting the circuits or equipment. This is equivalent to a determination that the materials and environments of normal operation are not causing any aging or that the aging is so minimal and slow that the integrity of the circuit is not affected between tests. When these circuits are periodically operated the determination of operability is achieved in the control room by operator observation of their performance, which may be aided by the automatic alarm circuits of the plant systems or by auxiliary operator observation of the operation in the plant. Connected instrumentation may also measure voltage and amperage in the circuits of concern, providing quantitative verification of circuit operability and capability. Scheduled testing may be to meet Technical Specifications, code requirements, or any other commitment. The initial plant design and maintenance of the plant environmental conditions within the design parameters provides assurance that there will be no adverse material-environment-aging effects requiring aging management.

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

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. (Attachment 3)

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.

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 SAND96-0344 (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.

A review of the OE and LERs discussed in the proposed XI. E6 program resulted in no recent industry experience that would support the imposition of a wholly new program in the first instance. From a license renewal perspective, all of the referenced conditions on which the new proposed XI. E6 program are supposed to be based were in existence prior to the issuance of the first renewed license - the Calvert Cliffs license renewal application was approved in March of 2000. Thus, even were a new program justified, the use of current license renewal review processes to impose such a program is unjustified.

The seven Licensee Event Reports (LERs) referenced by the NRC in NUREG-1833 as operating experience in support of the proposed XI.E6 program are shown in Attachments 4 through 10. An abstracted description, evaluation, and conclusions regarding each of these LERs follows:

LER-2541987023 dated 11/11/1987 at Quad Cities 1 - Corrosion - Conditions found were corrosion of the diesel engine fire pump start relay contacts and a loose connection at the voltage regulator. Low fire protection header auto start signal to the diesel did not work (first time) but later an Electrical Maintenance Department second and third auto start worked, apparently cutting through the relay contact corrosion. On the fourth EMD auto start, the starter motor failed. The likely cause was too many demand starts in such a short time. The motor failure caused smoke and a small fire. A loose connection to the voltage regulator was found. The voltage regulator loose connection would not cause the starter motor to fail. This would be an **in-scope LR** system and components under Category 3 (Appendix R). The cause of the contact corrosion and loose connection were not identified. **The failures were self-identifying in active components covered by the Maintenance Rule.** The redundant App. R systems worked as designed.

LER-2651998003 dated 6/28/1998 at Quad Cities 2 - Vibration - Generator trip causing a reactor trip due to offsite failure of a static line (345KV 9-10 miles from plant due to severe weather) and a loose connection in a junction box off a CT under the main generator (likely cause was vibration, but no other loose connections noted). The report stated that "a method of verifying the integrity of the generator circuits in high vibration areas will be developed." The loose connections in this event are **out-of-scope for LR** and **would not be covered by the proposed XI.E6 program**. All ESF systems worked as designed.

LER-2751985015 dated 5/20/1985 at Diablo Canyon 1 - Vibration - Reactor trip and SI due to loss of flow from a reactor coolant pump. The RCP tripped because the instrument inverter power output breaker opened caused by a loose connection in the breaker. The connections were reterminated, were to "be rechecked in 30 days and again quarterly until the connections are replaced with an improved method of making terminations." No determination as to the cause was noted and an inverter is not a high vibration component. This is likely an **in-scope LR** system and component. The failure was **self-identifying in active components** covered by the Maintenance Rule. The Emergency Core Cooling System actuation worked as designed.

LER-3741988008 dated 6/17/1988 at LaSalle 2 - Thermal Cycling - Low pressure core spray (LPCS) operating in the full test mode and the LPCS/RCIC equipment cubicle cooler fan breaker tripped, resulting in a declaration of the LPCS and RCIC inoperable (even though building ventilation was available) per TS. The load side terminations at the feed breaker for the fan were loose. After tightening the systems were restored to service. The breaker is not in the fan cubicle and no cause for the loose connections was noted. The NRC conclusion of thermal cycling as a cause is not supported by the information. This is an **in-scope LR** system and components. The failure was **self-identifying in active components** covered by the Maintenance Rule.

LER-3211994005 dated 5/1/1994 at Hatch 1 & 2 - Not human error - While Unit 1 was at 100% power the output breaker for the "B" RPS motor-generator set opened and RPS logic created an automatic reactor shutdown signal. Three loose connections were found in the RPS Bus power distribution panel 1C71. Tightening them restored the bus power. The cause of the loose connections cannot be determined. Connections on the "B" RPS bus were checked and tightened and the "A" bus and Unit 2 RPS busses will be checked at next outage. This is an **in-scope LR** system and components. The failure was **self-identifying in active components** covered by the Maintenance Rule.

LER-3681999002 dated 2/2/1999 at ANO-2 - Not human error - During a scheduled refueling outage ANO-2 discovered that Station Battery cell-to-cell and terminal connection tightness had not been **verified** each 18 months as required by TS. The connection tightness was verified and there were no indication that either Station Battery was actually inoperable due to connections not being checked. This is an **in-scope LR** system and components. This was a **procedure failure** where the tightness check had been omitted during procedure revisions in prior years. **No loose connections were found**. The check had been done during 60-month test procedures.

LER-3731991016 dated 10/24/1991 at LaSalle 1 - Not human error - While Unit 1 was at 98% power the Division 3 125 VDC battery (supplies emergency power to HPCS) was declared inoperable when a loose cable connection on cell #1 was reported. The connection was retorqued and resistance check verified acceptable. The cause of the loose connection is unknown. Unit 1 and 2 Division 3 battery connections were inspected to verify tightness. No other loose connections were noted in the description. This is an **in-scope LR** system and components. Batteries are **active components** and connections are inspected and verified on periodic basis independent of LR.

Reviewing these LER reminds one of the wisdom that the Commissioners imbedded in the Statement of Consideration published with the License Renewal Rule when they wrote:

> *"considerable experience has demonstrated that its regulatory process, including the performance-based requirements of the maintenance rule, provide adequate assurance that degradation due to aging of components that perform active functions will be appropriately managed"*

To summarize, each of the cited operational examples actually demonstrate that existing programs are effective, a basic procedural deficiency easily corrected, or not even relevant to the proposed E6 justification as follows:

- LER-3681999002 was related to a procedure not checking connections as required by TS.

- LER-2651998003 involves components outside the scope of the proposed XI.E6 program. The proposed XI.E6 program would have no affect on preventing this failure in the future.

- LER-2541987023, LER-2751985015, LER-3741988008, LER-3211994005 and LER-3731991016 report on failures associated with active components with performance-based requirements as noted in the SOC.

Per NEI 95-10, Appendix B, as adopted by the NRC, the following items noted in the above LERs are active components for LR per 10 CFR 54.21(a)(1)(i):

- Batteries - Item 76
- Chargers, Converters, Inverters (includes M-G sets) - Item 78
- Circuit Breakers - Item 79
- Electrical Controls and Panel Internal Component Assemblies - Item 83
- Generators, Motors - Item 86
- Power Supplies - Item 94
- Regulators (e.g., voltage regulators) - Item 97
- Relays - Item 98
- Switchgear, Load Centers, MCC, etc. - Item 103

9 DUPLICATION OF OTHER GALL AMP REQUIREMENTS

The XI.E1 AMP provides for periodic, visual inspection of all accessible cables and connection in a plant for indication of aging or deterioration and implements all ten (10) elements of an aging management program as stated in the GALL. This would include the connections that are taped or sleeved with heat shrink insulation over field connections. Terminal blocks not in active equipment require visual inspection for aging as a connection under XI.E1. Further aging management of connections is provided by both the XI.E2 and XI.E3 AMPs. The XI.E2 AMP covers important cables and connections where the impedance of the insulation may be important to the signal, such as in nuclear instrumentation or radiation monitoring instrumentation. The XI.E3 AMP provides both a determination of the operable status of inaccessible medium-voltage cable and well as providing direct testing of the cables. The XI.E4 AMP provides for aging management of electrical connections in metal enclosed busses. The XI.E5 AMP provides for aging management of electrical connections to fuse holders outside of active equipment. Further, the imposition of post accident harsh environment assumptions to equipment either not exposed to such environments or not required to operate following an accident, as the proposed E6 program would do, is directly at odds with the long-established regulatory scheme scoping electrical equipment that is required to operate in post-accident harsh environments, pursuant to 10 CFR 50.49.

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.

10 CONCLUSION

The proposed E6 program has not been justified for several reasons. First, connections in active equipment are adequately covered with the aging management of that active equipment under the Maintenance Rule. Second, by its own definition the post-accident environmental conditions presumed by the proposed license renewal XI.E6 program apply only to electrical connections outside of 10 CFR 50.49, in direct conflict to the harsh environment scoping criteria well-established by the 10 CFR 50.49 regulatory scheme. Third, previously existing AMPS manage both the aging of cables and connections at all voltage levels and where there is any appreciable ohmic heating, the XI.E3 AMP provides coverage. Forth, the operating experience and reports referenced in support of this program in fact do not show the failure of electrical connections are caused by aging, rather that they are random conditions, typically caused by an outside event, are very infrequent and of minor significance when viewed relative to plant operation and safety. Thus, no new aging affects requiring management are identified for electrical connections that are not already adequately covered by other AMPs. Accordingly, as demonstrated above not only has the proposed E6 program not been demonstrated to be necessary to provide reasonable assurance of safety, but there is substantial technical justification demonstrating that the proposed XI.E6 program should not be required.

11 REFERENCES

1. 10 CFR 54, The License Renewal Rule.
2. The statement of considerations for the final license renewal rule, 60 Fed. Reg. 22477.
3. NUREG-1833, "Technical Bases for Revision to the License Renewal Guidance Documents," October 2005.
4. NUREG-1832, "Analysis of Public Comments on the Revised License Renewal Guidance Documents," September 2005.
5. NUREG-1801, "Generic Aging Lessons Learned (GALL) Report," Volume 2, September 2005.
6. 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.
7. NUREG/CR-6834 SAND2002-1942P, "Circuit Analysis – Failure Mode and Likelihood Analysis," September 2003.
8. Not used.
9. EPRI-1003471, "Electrical Connection Application Guidelines," Electric Power Research Institute, Palo Alto, CA, December 2002.
10. EPRI TR-104213, "Bolted Joint Maintenance & Applications Guide," Electric Power Research Institute, Palo Alto, CA, December 1995.
11. NEI 95-10, revision 6, June 2005.

ATTACHMENTS

1. NUREG-1801 GALL AMP XI.E6
2. NUREG-1832 NEI Comments on the GALL XI.E6 AMP
3. Electrical Excerpts from EPRI TR 104213
4. LER-2541987023
5. LER-2651998003
6. LER-2751985015
7. LER-3741988008
8. LER-3211994005
9. LER-3681999002
10. LER-3731991016
11. Connection Aging Evaluation

ATTACHMENT 1 – NUREG 1801 GALL AMP XI.E6

XI.E6 Electrical Cable Connections Not Subject to 10 CFR 50.49 Environment Qualification Requirements

PROGRAM DESCRIPTION

Cable connections are used to connect cable conductors to other cables 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 for electrical cable connections (metallic parts) account for the following aging stressors: thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, and oxidation.

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 is not 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.

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

Cable connections within the scope of license renewal should be tested to provide an indication of the integrity of the cable connections. The specific type of test performed will be determined prior to the initial test, and is to be a proven test for detecting loose connections, such as thermography, contact resistance testing, or other appropriate testing justified in the application.

This program, as described, can be thought of as a sampling program. The following factors are considered for sampling: application (high, medium and low voltage), circuit loading, and location (high temperature, high humidity, vibration, etc.). The technical basis for the sample selections is documented. If an unacceptable condition or situation is identified in the selected sample, a determination is made as to whether the same condition or situation is applicable to other connections not tested.

SAND 96-0344, "Aging Management Guidelines for Electrical Cable and Terminations," indicated loose terminations were identified by several plants. The major concern is that failures of a deteriorated cable system (cables, connections including fuse holders, and penetrations) might be induced during accident conditions. Since the connections are not subject to the environmental qualification requirements of 10 CFR 50.49, an aging management program is required to manage the aging effects. This program will ensure that electrical cable connections will perform their intended function for the period of extended operation.

EVALUATION AND TECHNICAL BASIS

1. ***Scope of Program:*** Connections associated with cables in scope of license renewal are part of this program, regardless of their association with active or passive components.

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 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 are to be considered for sampling: application (high, medium and low voltage), circuit loading, and location (high temperature, high humidity, vibration, etc.). The technical basis for the sample selected is to be documented.

4. ***Detection of Aging Effects*:** Electrical connections within the scope of license renewal will be tested at least once every 10 years. Testing may include thermography, contact resistance testing, or other appropriate testing methods. This is an adequate period to preclude failures of the electrical connections since experience has shown that aging degradation is a slow process. A 10-year testing interval will provide two data points during a 20-year period, which can be used to characterize the degradation rate. The first tests for license renewal are to be completed before the period of extended operation.

5. ***Monitoring and Trending*:** Trending actions are not included as part of this program because the ability to trend test results is dependent on the specific type of test chosen. However, test results that are trendable provide additional information on the rate of degradation.

6. ***Acceptance Criteria*:** The acceptance criteria for each test are defined by the specific type of test performed and the specific type of cable connections tested.

7. ***Corrective Actions*****:** An engineering evaluation is performed when the test acceptance criteria are not met in order to ensure that the intended functions of the cable connections can be maintained consistent with the current licensing basis. Such an evaluation is to consider the significance of the test results, the operability of the component, the reportability of the event, the extent of the concern, the potential root causes for not meeting the test acceptance criteria, the corrective action necessary, and the likelihood of recurrence. When an unacceptable condition or situation is identified, a determination is made on whether the same condition or situation is applicable to other in-scope cable connections not tested. 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*****:** Operating experience has shown that loosening of connections and corrosion of connections are aging mechanisms that, if left unmanaged, could lead to a loss of electrical continuity and potential arcing or fire.

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.

ATTACHMENT 2 – NUREG 1832 NEI COMMENTS ON THE GALL XI.E6 AMP

Table A.2.5: Disposition of NEI Comments on Chapter VI of the GALL Report

Comment Number	Item Number	Comment/Proposed Change	Basis for Comment	NRC Disposition
G.VI-A-5	LP-12	Cable connection metallic parts – NEI recommends deleting the AMP XI.E6, "Electrical Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements"	This is a proposed AMP that has not been published previously, has not been proposed in a draft or final ISG, and has not been required for any previously approved license renewal application. This AMP should be eliminated as these items either have no aging effects requiring management or are adequately covered by other AMPs. Operating experience does not indicate a need for this proposed program.	The staff did not agree with this comment because SAND 96-0344, "Aging Management Guidelines For Electrical Cable and Terminations," identified loosened terminations at several plants. Additionally, EPRI TR -104213 recommends inspection of bolted joints for evidence of overheating, signs of burning or discoloration and indication of loose bolts. It recommends checking the joint resistance of bolted joints using a low range ohmmeter. GALL AMP XI.E1 manages the aging of insulating materials but not the metallic parts of the electrical connections, which is the subject of this new AMP. The GALL Report was not revised to address this proposed change.

ATTACHMENT 3 – ELECTRICAL EXCERPTS FROM EPRI TR 104213

6.12 Electrical Connections

An electrical connection must be designed to remain tight and maintain good conductivity through a large temperature range. Meeting this design requirement is difficult if the materials specified for the bolt and the conductor are different and have different rates of thermal expansion. For example, copper and aluminum bus materials expand faster than most bolting materials. If thermal stress is added to stresses inherent at assembly, the joint members or fasteners can yield. If plastic deformation occurs during thermal loading (i.e., heatup) when the connection cools, the joint will be loose. The following sections provide material recommendations and installation techniques for copper and aluminum bus installations.

6.12.1 Copper Bus Bars

Copper bus is typically hard temper (ASTM B187, Standard Temper HO4) and has a minimum tensile strength of 40 ksi. Because hard copper has no detectable yield point, the tensile strength is used in all calculations. The coefficient of thermal expansion for copper bus is 9.3 x 10-6 inches/inches/°F and Young's modulus is 17.5 x 106 psi.

6.12.2 Aluminum Bus Bars

Aluminum bus is typically medium hard temper (ASTM B2317 6061-T61). The material has a tensile strength of 20 ksi and a yield strength of 15.0 ksi. Softer tempers are seldom used because they have low yield strength (8 ksi), which would permit excessive cold flow. The coefficient of thermal expansion for aluminum bus is 12.8 x 10-6 inches/inches/°F and Young's Modulus is 10 x 106 psi.

Special cleaning and coating requirements for aluminum prevent the formation of a highly resistant aluminum oxide film on the exposed metal.

6.12.3 Aluminum Bolts

Aluminum bolts are recommended for use with aluminum bus in order to achieve the same coefficients of thermal expansion, 12.8 x 10 -6 inches/inches/°F. The tensile strength (62 ksi) and yield strength (40 ksi) of aluminum bolts (2024-T4) are comparable to those of Grade 2 low carbon steel bolts of the same size. Aluminum bolts are often lubricated to prevent galling during assembly.

6.12.4 Bronze Bolts

Bronze bolts (ASTM F-486 No. 651) are ideal for use with copper bus. The two materials have nearly the same coefficients of thermal expansion. The tensile strength of bronze bolts is 75 ksi, and the yield strength is 35 ksi.

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6.12.5 Low Carbon Steel Bolts

Low carbon steel bolts (ASTM A-307 Grade A) are not recommended for power connections. However, the bolts may be acceptable for low power or instrument connections in which no significant thermal heating is produced. Low carbon steel bolts have a tensile strength of 60 ksi and a yield strength of 36 ksi. During installation, these bolts could be stressed to the yield point, with additional thermal stress resulting in the plastic deformation.

6.12.6 High Strength Steel Bolts

High strength steel bolts (ASTM A-325, ASTM A-490, and SAE Grade 5) are recommended for use with copper bus or aluminum bus because of the bolts' low cost. Coating these bolts with zinc reduces corrosion. Because high strength steel bolts have a relatively low coefficient of thermal expansion (6.5 x 10-6 inches/inches/°F), Belleville washers may be used in conjunction with the bolts. The tensile strength of these bolts is 120 ksi, and the yield strength is between 80 ksi and 92 ksi.

6.12.7 Stainless Steel Bolts

The coefficient of thermal expansion for austenitic stainless steel bolts (ASTM A-193 Classes 1 and 2) is comparable to that of copper bus (9.3 x 10-6 inches/inches/°F). These bolts are suitable for corrosive environments. Class 1 bolts have a yield strength of 30 ksi and a tensile strength of 75 ksi. Thus, the bolts will approach or enter the plastic region due to installation stress. Class 1 bolts are not recommended for use with aluminum bus.
Class 2 bolts have a yield strength of 80 ksi and a tensile strength of 125 ksi. These bolts are appropriate for any application. However, Class 2 bolts are more expensive than Class 1 bolts.

8.2 Inspection of Electrical Bolted Joints

Inspect bolted joints for evidence of overheating, signs of burning or discoloration, and indications of loose bolts. The bolts should not be retorqued unless the joint requires service or the bolts are clearly loose. Verifying the torque is not recommended. The torque required to turn the fastener in the tightening direction (restart torque) is not a good indicator of the preload once the fastener is in service. Due to relaxation of the parts of the joint, the final loads are likely to be lower than the installed loads. However, this load reduction has little effect on electrical conductivity or joint performance. Check the joint resistance of bolted joints using a low range ohm meter.

ATTACHMENT 4 – LER 2541987023

Unit Name: QUAD CITIES 1
LER Number: 1987-023
Revision: 0
Event Date: 11/11/1987
CFR Section(s): 50.73(a)(2)(v)(D) - Event or Condition That Alone Could Prevent Mitigation of Accident Consequences
Operating Mode: 1
Operating Level: 100
ACN Number: 8803290290
LER Title: Elevated HPCI Discharge Piping Temperature Due to Reactor Feedwater System Back Leakage
Power Level – 000%.

On November 11, 1987, Quad Cities Unit One was in the refuel mode at 0 percent power and Unit Two was in the run mode at 95 percent thermal power. At 0528 hours a low fire protection header pressure automatic start signal should have started the 1/2B diesel fire pump. The 1/2A pump was unavailable for maintenance reasons (see LER 254/87-032 Revision 00). The 1/2B pump subsequently did autostart at 0540 hours and the electrical maintenance department (EMD) initiated an inspection of the 1/2B pump to determine why it did not start upon low suction pressure. The EMD observed two successful auto starts, but a third autostart resulted in the failure of the diesel engine starter motor. This occurred at 1335 hours. The motor failure caused a lot of smoke and a small fire which was quickly extinguished. The 1/2B fire pump as declared inoperable. A backup fire suppression water system was established to promptly with specification 3.12.B.3. The initial failure to start when expected was due to corrosion on some of the engine start relay contacts. The starter motor failure was caused by a loose connection at the voltage regulator. The 1/2B fire pump fire damaged components where replaced and the loose wire was retightened. The 1/2B fire pump was tested and seemed operable on November 21, 1987 at 0345 hours. This report is submitted per specification 3.12.B3.

ATTACHMENT 5 – LER 2651998003

Unit Name: QUAD CITIES 2
LER Number: 1998-003
Revision: 00
Event Date: 06/28/1998
CFR Section(s): 50.73(a)(2)(iv)(A) - Actuation of an Engineered Safety Feature or the RPS
Operating Mode: 1
Operating Level: 100
ACN Number: 9808040294
LER Title: A Unit Two Main Generator Trip and Subseuqent Reactor Scram Occurred Due to a Loose Electrical Connection in a Current Transformer That was Caused by Vibration

On 06281998, at 0223, Unit 2 was in Power Operation at 100% power. A Unit 2 Main Generator trip and subsequent Reactor Scram occurred. A walkdown of the relay targets associated with the Unit 2 Main Generator was performed. A differential protective relay on the "C" phase for the Main Generator was found actuated. Simultaneously, a 345 KV line tripped on a "B to C" phase fault. The fault was indicated on the line protective relays and the digital fault recorder located in the 345 KV switchyard. A line crew found a static line that had fallen down 9-10 miles outside of Quad Cities Station caused by severe weather related conditions in the area. The Operational Analysis Department (OAD). System Engineering and Electrical Maintenance were called to investigate the cause for the Unit 2 Main Generator trip. A loose electrical connection was found in a junction box on a lead off a Current Transformer under the Main Generator. The lose connection along with the indicated line fault caused the protective relay to trip which in turn tripped the Main Generator. Immediate corrective actions included stabilizing Unit 2, placing the Unit in Hot Shutdown and initiation Work Request's to troubleshoot and repair problems found. Also, a method of verifying the integrity of the generator circuits in high vibration areas will be developed. The safety significance to the health and safety of the onsite personnel and to the public was minimal. All expected ESF actuations occurred as designed to bring the reactor to a safe shutdown condition.

ATTACHMENT 6 – LER 2751985015

Unit Name: DIABLO CANYON 1
LER Number: 1985-015
Revision: 0
Event Date: 05/20/1985
CFR Section(s): 50.73(a)(2)(i)
Operating Mode: 1
Operating Level: 90
ACN Number: 8507010102
LER Title: Containment Purge Valves Opened Without Valid Current Slave Relay Test
POWER LEVEL - 055%.

At 0520 PDT, 5-20-85, with Unit 1 in mode 1 (Power Operation), a reactor trip followed by a safety injection occurred. All automatic equipment responded as designed. The plant was stabilized in mode 3 (Hot Standby) in accordance with procedures. All systems and equipment affected by this event were returned to normal operation. This event was caused by a loose connection to the output circuit breaker for instrument inverter IY-1-2. This resulted in the breaker tripping open producing a reactor coolant pump breaker position trip signal. Since the unit was above P-8 (Loss of Flow Permissive), only 1 breaker open signal was required to initiate a reactor trip signal. The connections were reterminated and the inverter was returned to normal operation. To prevent recurrence, the output circuit breaker connections will be rechecked in 30 days and again quarterly until connections are replaced with an improved method of making terminations. This was the 7th emergency core cooling system (ECCS) actuation cycle to date that has resulted in the discharge of water into RCS.

ATTACHMENT 7 – LER 3741988008

Unit Name: LASALLE 2
LER Number: 1988-008
Revision: 1
Event Date: 06/17/1988
CFR Section(s): 50.73(a)(2)(v)(D) - Event or Condition That Alone Could Prevent Mitigation of Accident
Consequences
Operating Mode: 1
Operating Level: 100
ACN Number: 8810180211
LER Title: Elevated HPCI Discharge Piping Temperature Due to Reactor Feedwater System Back Leakage
POWER LEVEL - 091%.

On June 17, 1988, at 1815 hours with Unit 2 in operational condition 1 (RUN) at 91% power, while the Unit 2 low pressure core spray (LPCS) was operating in the full flow test mode, the LPCS/Reactor Core isolation cooling (RCIC) equipment cubicle cooler fan 2VY04C breaker tripped due to thermal overload. At this time, the LPCS and RCIC systems were declared inoperable in accordance with Tech Specs 3/4.5.1 and 3/4.5.2 respectively. Work request L81404 was initiated to troubleshoot and repair the feed breaker for the fan. Upon inspection of the breaker, it was discovered that the load side terminations of the breaker were loose. The connections were tightened and the fan was restarted by 0243 hours on June 18, 1988. Following a successful 2 hours fan run, at 0500 hours on June 18, 1988, the LPCS and RCIC systems were declared operable. Normal reactor building ventilation was available to support the operation of the LPCS and RCIC systems during the event, had the system been required. This event is being reported pursuant to the requirements of 10CFR50.73(A)(2)(V) due to the loss of safety system functions.

ATTACHMENT 8 – LER 3211994005

Unit Name: HATCH 1
LER Number: 1994-005
Revision: 0
Event Date: 05/01/1994
CFR Section(s): 50.73(a)(2)(i), 50.73(a)(2)(v)(A) - Event or Condition That Alone Could Prevent Reactor Safe Shutdown
Operating Mode: 1
Operating Level: 100
ACN Number: 9406010003
LER Title: Update to Completion of TS Required Reactor Shutdown Due to Jet Pump Inoper.
POWER LEVEL - 100%

On 5/1/94 at 2102 EDT, Unit 1 was in the Run mode at 100% of rated thermal power. At that time, the output breaker for the "B" Reactor Protection System (RPS) motor-generator (MG) set opened. This caused a loss of power to the "B" channels of the RPS, Offgas Radiation Monitoring System, Process Radiation Monitors, Neutron Monitoring System, and Primary Containment Isolation System (PCIS). These systems actuated on loss of power resulting in an automatic reactor shutdown signal in RPS logic system "B," closure of various PCIS valves, actuation of the pressurization mode of the Main Control Room Environmental Control System, and the "B" trains of the Unit 1 and Unit 2 Standby Gas Treatment Systems. After three loose connections in RPS bus power distribution panel 1C71-P001 were tightened, power was restored to the bus from the RPS MG set, its normal power supply. All affected equipment was then returned to its normal configuration. The cause of this event was loose connections in panel 1C71-P001. The connections apparently loosened, causing bus voltage and/or frequency limits to be exceeded, protection relay actuation, and bus de-energization. No activities were in progress that would have caused the connections to come loose; therefore, it cannot be determined why the connections were loose. The connections on the "B" RPS bus were checked and tightened; the connections on the "A" bus and the Unit 2 RPS busses will be checked during the next refueling outage for each unit.

ATTACHMENT 9 – LER 3681999002

Unit Name: ANO 2
LER Number: 1999-002
Revision: 00
Event Date: 02/02/1999
CFR Section(s): 50.73(a)(2)(i)
Operating Mode: 6
Operating Level: 000
ACN Number: 9903160032
LER Title: Station Battery Cell-To-Cell and Terminal Connection Tightness Was Not Verified As Required By Technical Specifications Due To Requirements Being Inadvertently Omitted During Procedure Revisions

During a scheduled refueling outage, ANO-2 discovered that Station Battery cell-to-cell and terminal connection tightness had not been verified each 18 months as required by Technical Specifications (TS). The requirements for verification of connector tightness had been inadvertently omitted during procedure revisions in 1989 and 1990. The surveillance had not been verified during four previous refueling outages for each battery but had been done during performance of 60-month test procedures. Service Test procedures were revised. Connector tightness was satisfactorily verified for both batteries during the outage in which the condition was discovered. A review of other battery surveillance requirements determined that they were adequately included in existing procedures. Standard Technical Specifications do not require this surveillance for the ANO-2 battery type. There are no indications that either Station Battery was actually inoperable due to connections not being tight. Voltage tests and resistance readings are believed to have been capable of detecting loose connections.

ATTACHMENT 10 – LER 3731991016

Unit Name: LASALLE 1
LER Number: 1991-016
Revision: 0
Event Date: 10/24/1991
CFR Section(s): 50.73(a)(2)(i)
Operating Mode: 5
Operating Level: 0
ACN Number: 9112020346
LER Title: Unit 1 Scram Due to a Feedwater Signal Spike
POWER LEVEL - 098%.

On October 24, 1991, with Unit 1 in operational condition 1 (RUN) at 98% power, the division 3 125 volt DC battery was declared inoperable at 1045 hours when a loose cable connection on cell #1 was reported. Since the division 3 battery is the emergency DC power supply for the high pressure core spray (HPCS, HP)(BG) system, the HPCS system was declared inoperable. The reactor core isolation cooling (RCIC, RI) (BN) system was already inoperable due to a failed operability surveillance. The battery cable connection was quickly retorqued to the proper value and resistance measurements verified acceptable. The division 3 battery was declared operable at 1143 hours on October 24, 1991. The cause of this event is unknown. The consequences of this event were minimal, since division 1 and division 2 emergency core cooling systems were fully operable during this event. The Unit 1 and Unit 2 division 3 batteries were inspected to verify the battery connections were tight. Technical Specifications require the unit to be shutdown with both HPCS and RCIC system inoperable. This event is reportable to the Nuclear Regulatory Commission as a Licensee Event Report in accordance with 10CFR50.73(A)(2)(V)(A) due to a decrease in safe shut down capability.

ATTACHMENT 11 – CONNECTION AGING EVALUATION

Aging Mechanism	Environment	Reasons Why No Aging Occurs
Loosening of connections	Vibration	No vibration associated with in-scope equipment/areas and proper design and use of connection locking mechanisms (lock washers, Belleville washers).
Loosening of connections	Thermal cycling	Compatible metals so no differential expansion. No overheating due to electrical overloading or transients is ensured by adequate engineering design or coordinated overload protection.
Fatigue	Bending	No bending, restrained cables at connections. Cables ends held in place at connections by connector (butt end or bolted) and splice kit heat shrink or taped connections, proper materials. Protected from bending by design or in static trays, conduits, and cabinets/ junction boxes (JBs)
Corrosion	Moisture	No moisture present or protected from water by atmosphere control (air conditioning (A/C) prevents condensation) or covered by splice heat shrink or tape or protected in cabinets / JBs
Corrosion	Contamination	Protected from contamination by atmosphere control (A/C and/or filters) or covered by splice heat shrink or tape or protected in cabinets / JBs
Corrosion	Galvanic	Compatible metals and/or silver or tin plated connecting surfaces
Oxidation	Exposure to air	Connections covered by splice heat shrink or tape and in-scope connectors have seals to keep out air/moisture required for oxidation.