ADDENDUM
to
MEMORANDUM OF UNDERSTANDING
between
U.S. NUCLEAR REGULATORY COMMISSION
and
ELECTRIC POWER RESEARCH INSTITUTE
on
COOPERATIVE NUCLEAR SAFETY RESEARCH

Aging, Qualification, and Condition Monitoring of Electrical Cables

I. Introduction

This Addendum to the Memorandum of Understanding (the Addendum) is entered into by and between the Office of Nuclear Regulatory Research (RES) of the U.S. Nuclear Regulatory Commission (NRC) and the Electric Power Research Institute (EPRI), effective as of the date of signature of the last of the parties to execute this Addendum (the effective date). The NRC and EPRI are parties to the Memorandum of Understanding on Cooperative Nuclear Safety Research (the MOU, found under Enclosure 1). The MOU allows and encourages cooperation in nuclear safety research that benefits both the NRC, EPRI, and the nuclear power industry. These benefits include the ability to exchange technical expertise and information whenever such sharing can be accomplished in a mutually beneficial manner.

This Addendum to the MOU is authorized pursuant to either or both Section 31, “Research Assistance,” of the Atomic Energy Act of 1954, as amended, and Section 205, “Office of Nuclear Regulatory Research,” of the Energy Reorganization Act of 1974. The roles, responsibilities, terms, and conditions of this Addendum to the MOU should not be interpreted in a manner inconsistent with, and shall not supersede, applicable Federal laws and regulations.

This Addendum describes a cooperative research program between the NRC and EPRI in the area of the aging and condition monitoring of electrical cables and will also establish the overall work scope, roles, and responsibilities of the parties involved in this research program.

II. Background

Electrical cables are important to nuclear safety because they are used to (1) mitigate the effects of an accident, (2) monitor critical parameters to ensure safety, (3) monitor emergency core cooling, and (4) monitor, gauge, and prevent the potential for a containment breach and offsite release of radiation. In addition, cables are significant from an equipment and plant reliability perspective because cable failures can cause equipment and plant trips.

A variety of environmental stressors in nuclear power plants can influence the aging of electrical cables such as temperature, radiation, moisture/humidity, vibration, chemical spray, and mechanical stress. Exposure to these stressors over time can lead to degradation that may go undetected unless the aging mechanisms are identified and electrical, mechanical, or physical properties of the cable are monitored.

The NRC confirmed in its review of Generic Letter (GL) 2007-01, "Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients," that electrical cables historically were often not included in aging analyses and condition-monitoring evaluations. Cables are passive components and have been considered to require no inspection or maintenance. However, electrical cables are important safety components because they provide power to safety-related equipment and are used for instrumentation and controls.

Review of data submitted in response to GL 2007-01 showed that cable failures are occurring under normal service conditions within the service interval of 20-30 years, which is before the end of the expected life span of the cables. The NRC staff's evaluation of the licensee responses to GL 2007-01 concluded that licensees should have a program for using available diagnostic cable-testing methods to assess cable condition. Condition monitoring is essential for assessing the health and aging degradation of electrical cables to ensure reliable operation of safety-related equipment, instruments, and controls during normal operations and design basis events.

Specifically, this research will assess and evaluate condition-monitoring methods on electrical cables subjected to aging under normal operating conditions and design basis event (accident) conditions. EPRI has issued reports that, when used in conjunction with other published EPRI guidance, provide the industry with methods for assessing cable aging. Research completed under this MOU will assist in evaluating the adequacy or effectiveness of the EPRI recommendations contained in EPRI Report 1022969, "Electrical Cable Test Applicability Matrix for Nuclear Power Plants" [2011] (Proprietary), as well as other methods and techniques put forward by other industry groups in monitoring electrical cable infrastructure health.

III. Objectives

The overall objectives of this cooperative research program are as follows:

- To confirm the adequacy of condition monitoring methods for cables in a harsh and mild (submerged) environment and validate service life predictions.

- Confirm the condition-based qualification methodology as discussed in IEEE standard 323 "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations."

- Confirm acceleration factors for the accelerated aging process as argued in IEEE standard 323, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," and JNES report, "Assessment of Cable Aging for Nuclear Power Plants SS-0903."

- Evaluate current test methods and aging factors for cables in a submerged environment as well as conduct research to identify and evaluate new methodologies.

This Addendum will serve as a vehicle to facilitate cooperation on research programs between EPRI and the NRC on the aging of cables exposed to adverse environmental conditions. Specifically, EPRI and the NRC will cooperate on developing test plans and evaluating test data.

This Addendum is intended to fulfill the following specific objectives:

- Ensure the timely exchange of information (e.g., progress, milestones, and amendments) on planned and ongoing activities conducted under this research program.

- Ensure the timely sharing of the results of this research program.

- Ensure effective programmatic review and oversight of this research program.

- Evaluate further the test data and refine equipment qualification and condition-monitoring methodology.

For the benefit of both parties, EPRI's participation in this project permits the NRC to leverage EPRI researchers' nuclear plant electrical engineering and cable system aging management knowledge and experience. Specifically, EPRI's knowledge on the design, operation, testing, and aging management of cable systems will enhance the project through its expert review and comments on proposed testing methodologies. EPRI's review and comments will be helpful to facilitate the development of accelerated aging methods that will yield results that more closely represent the natural aging of cable systems as well as better condition-monitoring practices and data.

As a result of participation in this project, EPRI will both contribute to and develop an improved understanding of cable aging and condition monitoring. The parties in this Addendum will make the results of the research available to the nuclear power industry so that power plants can conduct evaluations to better manage cable aging. EPRI research reports will be distributed to EPRI's membership based on its internal policies.

Final evaluation and conclusions drawn from research results may result in the following actions and results:

- Better information on cable aging.
- Improvements in condition-monitoring methodology.
- Better information for making decisions pertaining to cable systems.

The NRC staff may use the results of this program to refine guidance for reviewing licensee submittals and to support the staff's reevaluation of environmental qualification requirements, subsequent incorporation into 10 CFR 50.49, "Environmental qualification of electric equipment important to safety for nuclear power plants," and revision of Regulatory Guides 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants", 1.218, "Condition Monitoring Program for Electric Cables Used In Nuclear Power Plants," and NUREG-1801, "Generic Aging Lessons Learned (GALL) Report."

Although the NRC and EPRI will jointly evaluate the results developed under this research program, both parties will independently determine the implications of the results for the intended use by each party.

IV. Scope

The scope of this Addendum includes the following:

- EPRI and the NRC will participate in assessing condition-monitoring methods and testing

cables that are representative of those used in commercial nuclear power plants. Specifically, the NRC will subject cables to accelerated aging (or pre-aging) and at periodic intervals to a series of condition-monitoring tests. Each test will be performed in accordance with the test plan and procedures. Following testing, the data will be analyzed to draw conclusions on condition-monitoring methods for particular insulation materials.

- For cables in mild and harsh environments, the NRC will evaluate the cables under normal operating conditions and accident conditions. The first phase of the project will focus on assessing condition-monitoring techniques during normal operational aging. Thus, cables should be subjected to normal operating conditions (temperature, radiation, humidity) in both mild and harsh environments to simulate 40, 60, and 80 years of operation. The second phase will focus on cables subject to accident conditions and located in harsh environments. These cables should be exposed to a simulated accident (temperature, pressure, humidity, radiation, chemical/steam spray). The condition-monitoring techniques should be evaluated for the capability to predict proper operation of cables during and after the accident (post-accident period).

- For cables in a submerged environment, the NRC and EPRI will collaborate to develop an effective methodology to perform accelerated aging on such cables. These cables will be subjected to stressors such as elevated frequencies, voltage cycling, temperature, and wet-dry cycling to induce aging (water tree and moisture intrusion). Moreover, the NRC and EPRI will also work together to determine an aging coefficient that correlates cables that have been subjected to accelerated aging to those that have aged naturally. The condition monitoring techniques will be evaluated to determine the techniques ability to track degradation as a function of time.

In support of the items in the scope, at least one yearly face-to-face meeting should take place between the NRC, EPRI, and personnel from the Governmental or Private Research Institutions. The parties should also engage in several rounds of written correspondence.

V. Project Direction and Coordination

- The period of performance of the Addendum to the MOU is been amended to reflect a period of performing lasting from the date of signature of the last of the parties to execute this Addendum through September 30, 2021. Going forward, this Addendum may be amended only through the written concurrence of both the NRC and EPRI.

- Overall project direction and coordination will be conducted through project managers, who will be the single points of contact representing the NRC and EPRI. These managers may arrange meetings to coordinate the effort and assess project progress within the scope set forth in this Addendum. The project managers are the following:

EPRI
Andrew Mantey
Senior Project Manager
Plant Engineering
Electric Power Research Institute
Charlotte, NC 28262-8550

NRC
Darrell Murdock
Project Manager
Instrumentation, Controls, and Electrical Engineering Branch
Office of Nuclear Regulatory Research
MS T10A12
Washington, DC 20555-0001

To maintain consistent project direction, the project managers will discuss matters related to project direction prior to the start of any major activities.

The NRC project manager will provide direction to the Research Institution. The NRC project manager is responsible for coordinating the direction of the project with the EPRI project manager.

- The organizational participants in this program are the following:

    - EPRI will provide project management, electrical engineering, and cable system aging management knowledge and experience. EPRI will provide funding for projects under its responsibility.

    - The NRC's Office of Nuclear Regulatory Research will provide project management and funding for projects under its responsibility.

    - Other sponsoring organizations, such as DOE, may participate subject to the approval of the NRC and EPRI.

VI. Schedule

The project managers will provide the participating organizations with periodic progress reports that will include updated schedules.

The NRC and EPRI project managers will discuss technical modifications to the research program that affect the scope or the parties' responsibilities within this Addendum. Modifications that affect the scope or responsibilities of the parties within this Addendum will require either a new agreement or a revision to this Addendum that would need to be approved and signed by authorized representatives of the parties.

VII. Deliverables

The NRC's final program deliverables resulting from this cooperative research program will be a set of NUREG/CR reports that summarize the results of the research projects. The NUREG/CR reports will be made available to the public in accordance with the NRC's policies and procedures on publication. EPRI research results falling within the scope of this memorandum will be made available to the public in accordance with EPRI's standard policies and procedures.

The research institutions or laboratories under contract to the NRC will provide technical assistance to NRC staff for the report deliverables, which consist of: (1) monthly status reports documenting the test results, (2) a summary of cables to be used for testing, (3) test plan and procedures, (4) a summary of the methodology to perform accelerated aging and coefficient in a submerged environment, (5) a summary of the assessment of condition-monitoring methods for normal operational aging, (6) a summary of the assessment of condition-monitoring methods under accident conditions, (7) a draft final report to be delivered upon its completion, and (8) a final report to be published as a NUREG/CR report that summarizes the data and provides an assessment of condition-monitoring techniques. The final report will not assess the impact to the environmental qualification regulation.

VIII. Disputes

If a dispute arises out of or relating to this Addendum or any breach thereof, the parties will first attempt to settle the dispute through direct negotiation between the project managers. If the project managers cannot settle such a dispute, the dispute shall be submitted to the Director of Nuclear Regulatory Research at the NRC and the Vice President and the Chief Nuclear Officer at EPRI.

AGREEMENT

/RA/	**9/28/16**
Michael F. Weber	Date
Director of Nuclear Regulatory Research	
U.S. Nuclear Regulatory Commission	

/RA/	**9/30/16**
Neil Wilmshurst	Date
Vice President and Chief Nuclear Officer	
Electric Power Research Institute	