July 30, 2013

Mr. Keith Waldrop, Senior Project Manager
Electric Power Research Institute
1300 West WT Harris Boulevard
Charlotte, NC 28262

SUBJECT: RESPONSE TO ELECTRIC POWER RESEARCH INSTITUTE REGARDING RESEARCH & DEVELOPMENT ROADMAP TO ADDRESS POTENTIAL STRESS-CORROSION CRACKING OF WELDED STAINLESS STEEL USED NUCLEAR FUEL DRY STORAGE CANISTERS

Dear Mr. Waldrop:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to the Electric Power Research Institute (EPRI) letter[1] dated January 31, 2013, requesting the NRC to review and comment on EPRI's Research and Development (R&D) Roadmap (the Roadmap) to address the issue of potential stress-corrosion cracking (SCC) of welded stainless steel used nuclear fuel dry storage canisters.

The NRC staff has reviewed the information contained in the Roadmap and considered the discussion of the April 4, 2013 public meeting[2]. The staff recommends additional qualified inspections and further development of planned specific tasks. A detailed discussion consistent with the Roadmap labeling and formatting is as follows:

1) Introduction: A limited number of successful in-situ inspections, as proposed, may not be sufficient, even when combined with additional laboratory and literature data, "to determine the conditions and time frames for which SCC may be possible." This data, however, is expected to assist in predicting the time frames required to reach the window of environmental conditions necessary to support SCC susceptibility. The addition of a qualified inspection method sufficient to detect SCC would be required to benchmark a proposed SCC initiation procedure.
2) Purpose: While the Roadmap is "focused on acquiring sufficient data to understand the phenomenon of SCC in the context of dry cask storage," the scope of the proposed actions goes beyond this purpose. The failure modes and effects analysis (FMEA) considers and assesses the consequences of failure mechanisms, particularly those associated with SCC. These items generally appear to be helpful in understanding and prioritizing tasks associated with final resolution. NRC staff agrees that the additional effort will be valuable, as long as those efforts do not delay progress in resolving the chloride-induced SCC (CISCC) issue.

[1] EPRI's letter to David Pstrak, "Transmission of EPRI's R&D Roadmap to Address Potential Stress-Corrosion Cracking of Welded Stainless Steel Used Nuclear Fuel Dry Storage Canisters," dated January 31, 2013, Agencywide Documents Access and Management Systems (ADAMS) Accession Number ML13042A140.
[2] S. Ruffin, NRC, "Summary Of April 12, 2012, Meeting With The Nuclear Energy Institute And Industry Regarding Marine Atmosphere Stress Corrosion Cracking," May 4, 2012 (ML12128A133).

3) Background: Corrosion Mechanisms and Types: Based on the content of the Roadmap, the scope of the associated efforts is unclear. For example, microbiologically influence corrosion (MIC) is introduced in the background section, but is not addressed in the subsequent sections.
4) Current State of Knowledge: While many of the details needed to finalize the susceptibility assessment are not known at this time, progress has been made regarding understanding the conditions required for CISCC to occur in austenitic stainless steels. NRC staff finds that a draft "Susceptibility Assessment" identifying the specific parameters that are either adequately defined or requiring refinement to support resolution of this issue would be useful. NEI presented such a draft document at an NRC public meeting with EPRI and industry representatives on April 12, 2012[3].
    (a) SCC of Stainless Steel (SS) Dry Storage Canisters: Necessary Conditions: Other sources of chlorides may include salts on roads near the Independent Spent Fuel Storage Installation (ISFSI), or chloride from nearby condenser water. Even when the chloride levels in condenser water are not considered sufficient; the vapor can contact the canister surface and evaporate. Repeated cycles can result in sufficient levels of chloride on the surface.
    (b) SCC of SS Dry Storage Canisters: Limitations in the Current State of Knowledge: Section 4.2.1 of the roadmap states that the Center for Nuclear Waste Regulatory Analyses (CNWRA) experiments indicate that SCC will not occur above 45ºC. This seems to be an interpretation of the results in NUREG/CR-7030. In the subsequent testing in the current research program, SCC was observed at temperatures up to 80ºC because the relative humidity (RH) was higher than in the previous NUREG-CR-7030 tests. The current testing[4] indicates that SCC could occur provided that the RH is at least close to the deliquescence relative humidity (DRH) for magnesium chloride pure salt, around 25-30 % RH at 80ºC.
5) Proposed Susceptibility Assessment R&D: This section requires further development to clearly identify the specific tasks that are planned, the need that each will fulfill, and the associated schedule. NRC staff recommends that the tasks be tied to the draft "Susceptibility Assessment" referenced in bullet (4), above. For example, based on the Roadmap, it appears that additional laboratory testing is planned. However, it is unclear which laboratory experiments, as discussed in Section 5.1.4.2, are being proposed to refine the current state of knowledge in regard to chloride threshold, initiation time, crack growth rate, or a combination of these, given the associated stress state and other environmental conditions. Additionally, it is unclear how iron contamination, weld repairs, and de-icing salts will be addressed. It would be advantageous if the needed information and planned activities to acquire it are more clearly communicated to all stakeholders. The voluntary inspections are valuable and, while the process can, and should be, developed and refined with each subsequent inspection, the goals and limitations of the inspections should be more clearly communicated. For example, remote visual examination will provide useful information about the state of the canister surface, but may be unable to definitively confirm the absence of CISCC, especially in the early stages of SCC. It is noted that some of the data that will be acquired during the voluntary inspections is

[3] G. Oberson, D. Dunn, T. Mintz, X. He, R. Pabalan, and L. Miller. "US NRC-Sponsored Research on Stress Corrosion Cracking Susceptibility of Dry Storage Canister Materials in Marine Environments." Proceedings of the 2013 Waste Management Conference. (ML13029A490)

intended to inform analytical models. However, there are many variables at play and a success path with this approach given the three proposed inspections is not evident.

The NRC recognizes that additional work is needed to address this issue. For existing canisters, a consequence assessment would help determine the safety significance of this potential degradation mechanism and aid in determining the appropriate level of effort. Consideration of monitoring methods that could detect precursors of SCC (e.g., incipient pitting) may also be important going forward.

A different approach may be considered for newly fabricated canisters. One possibility is to investigate ways to reduce the propensity for CISCC during the design and fabrication process, such as reducing the stresses in the canister, or using more corrosion resistant material. In addition, design changes that allow better inspection and monitoring of the canister surface could help in early detection and mitigation of conditions that favor chloride-induced SCC.

We appreciate your commitment to work closely with other stakeholders in developing the technical basis for safe storage of spent nuclear fuel at ISFSIs. We believe that the timeframe proposed for addressing this problem is appropriate given the potential consequences of the issue and the scope of activities to bring about its resolution.

If you have any questions regarding this response, please contact me or David Tarantino of my staff at (301) 287-9164.

Sincerely,

/RA/

David Tang, Acting Chief
Structural Mechanics and Materials Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

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