UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 11, 2023

Mr. Brett Titus
Director Regulatory Affairs
Nuclear Energy Institute
1201 F Street, NW, Suite 1100
Washington, DC 20004

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION REPORT OF THE REGULATORY AUDIT OF THE NUCLEAR ENERGY INSTITUTE - PROPOSED AGING MANAGEMENT PROGRAM REVISION TO SELECTIVE LEACHING PROGRAM (XI.M33)

Dear Mr. Titus:

On January 12, 2022, Nuclear Energy Institute (NEI) submitted proposed revisions to the Selective Leaching aging management program (AMP) of the Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report (Agencywide Documents Access and Management System Accession No. ML22019A285).

The NRC staff acknowledges that risk informing aging management related to selective leaching is an innovative approach and welcomed the opportunity to explore this option. Like other innovation approaches, the NRC wants to understand the effects of the process. The NRC staff conducted an audit to review the supporting documentation to the pilot implementation of Limerick's Selective Leaching program. The purpose of the audit was: 1) to establish an understanding of technical basis of all proposed changes, whether related to risk or not, in order to conclude the adequacy of the proposed revised AMP and 2), if applicable, identify any gaps in information that may be needed in order to support the conclusion.

The NRC staff completed its aging management audit from September 15, 2022 to October 13, 2022, in accordance with the audit plan (ML22244A083). The audit report is enclosed.

If you have any questions, please contact me by email at Lauren.Gibson@nrc.gov.

Sincerely,

/RA/

Lauren Gibson, Chief
License Renewal Projects Branch
Division of New and Renewed Licenses
Office of Nuclear Reactor Regulation

Project No. 689

Enclosure:
Audit Report

cc w/encl.: Listserv

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION REPORT OF THE REGULATORY AUDIT OF THE NUCLEAR ENERGY INSTITUE - PROPOSED AGING MANAGEMENT PROGRAM REVISION TO SELECTIVE LEACHING PROGRAM (XI.M33) DATED: JANUARY 11, 2023

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U.S. NUCLEAR REGULATORY COMMISSION

SUMMARY AUDIT REPORT OF THE NUCLEAR ENERGY INSTITUE - PROPOSED AGING MANAGEMENT PROGRAM

REVISION TO SELECTIVE LEACHING PROGRAM (XI.M33)

September 15, 2022 – October 13, 2022

List of Participants

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- Jonathan Evans, Reliability and Risk Analyst
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Enclosure

I. BACKGROUND

On January 12, 2022, NEI submitted proposed revisions to GALL-SLR AMP for Selective Leaching and Inaccessible Power Cables (ML22019A291). A public meeting was held on June 2, 2022, with NEI, EPRI, & industry to discuss the NEI-proposed revisions. The staff's initial thoughts were that more detailed explanations (and technical basis) within the AMPs are needed to support this transformative approach, as communicated during industry presentations. This audit focused on Limerick's pilot program to adopt the proposed revisions to the Selective Leaching AMP.

II. DOCUMENTS REVIEWED

- 3002020832 - Electromagnetic NDE Techniques for Detection of Selective Leaching in Gray Cast Iron Piping, Electric Power Research Institute (EPRI)
- 3002020830 - Ultrasonic NDE Techniques for Detection of Selective Leaching in Complex Shaped Gray Cast Iron Components, EPRI
- 3002020822 - Accelerated Testing and Evaluation of Factors Affecting Selective Leaching Susceptibility, EPRI
- 3002020713 - Leveraging Risk Insights for Aging Management Program Implementation, EPRI
- 3002016057 - Selective Leaching - State-of-the-Art Technical Update, EPRI

III. INFORMATION REQUESTED

As further described in Appendix A, the technical basis for the following topics was initially requested in the audit plan:

1. Aging Mechanism Uncertainties
2. Malleable Iron
3. Inspection Sample Size Reduction
4. Re-Introduction of Hardness Testing
5. Credit for Undefined Future NDE Techniques
6. Reliance on One Inspection Technique
7. Samples Based on Consequence
8. Removal of Prescriptive Corrective Actions

Additional questions were asked during the audit. See Appendix B.

IV. AUDIT OBSERVATIONS

The NRC staff considered both the general process being used to risk inform an aging management program as well as the specific application of it to the Selective Leaching AMP.

Other proposed changes to the AMP not related to risk informing were also provided by NEI and audited by the NRC. Specific observations from the audit are detailed below.

Probabilistic Risk Assessment

The NRC staff reviewed the information provided in EPRI 3002020713 regarding how consequence would be evaluated using the proposed risk-informed (RI) methodology for the Selective Leaching AMP. EPRI 3002020713 states that data from probabilistic risk assessment (PRA) basic events, internal events PRA, internal fire PRA, internal flooding PRA, 50.69 categorizations, and RI inservice inspection (ISI) will be used to inform the consequence evaluation. The plant used to pilot the RI Selective Leaching AMP (Limerick) in EPRI 3002020713 had a previously NRC-approved license amendment to adopt 10 CFR 50.69, "Risk-informed categorization and treatment of structures, systems and components for nuclear power reactors," and had previously categorized several systems using the 50.69 process. Some of the SSCs within the scope of the Selective Leaching AMP at the pilot plant had not been previously categorized using the 50.69 process. EPRI 3002020713 states that, if the SSC was not categorized a part of 50.69, the 50.69 process was reproduced by extracting importance measures from PRA model results. Contrary to the previous statement, EPRI 3002020713 also states that fire model importance measures were not used in the consequence evaluation and that the fire protection system importance measures used (from the internal events model) only represent the importance of using fire protection system SSCs for reactor pressure vessel injection and do not address the impact on the fire model.

It is unclear to the staff why the fire model importance measures were not used. The process used to determine consequence for fire protection system SSCs does not appear to evaluate the contribution to consequence from external hazards consistent with the 50.69 categorization process outlined in NEI 00-04, "10 CFR 50.69 SSC Categorization Guideline." Additional information should be provided explaining how consequence from external hazards will be considered as part of the proposed RI methodology.

EPRI 3002020713 states that the available guidance for 50.69 in NEI 00-04 and Regulatory Guide (RG) 1.201, "Guidelines for Categorizing Structures, Systems, and Components in Nuclear Power Plants According to Their Safety Significance," allows for leveraging the process for addressing passive SSCs that is based on the methodology for RI ISI outlined in EPRI TR 112657, "Revised Risk-Informed Inservice Inspection Evaluation Procedure." The NRC staff notes that RG 1.201 specifically references American Society of Mechanical Engineers Code Case N-660, "Risk-Informed Safety Classification for Use in Risk-Informed Repair/Replacement Activities," as an acceptable approach for addressing the passive function of active components and states that alternatives to this code case may be submitted to the NRC for review as part of a 50.69 application. The NRC staff also notes that there are numerous code cases and modified code cases that have been approved by the NRC for use in RI ISI and repair/replacement activities (RRA). The NRC staff further notes that RI RRA code cases generally exclude requirements to evaluate the contribution from external hazards, but that RG 1.201 includes evaluation of external hazards for all SSCs, including those evaluated using code case N-660.

It is unclear to the staff specifically how consequence will be evaluated for passive components categorized as part of the proposed RI methodology. Additional information should be provided describing the process that will be used to evaluate consequences for passive components, including specific code cases that may be used, whether those code cases have been NRC-approved, and how external hazards will be considered.

EPRI 3002020713 describes the process used to implement the RI methodology for the Selective Leaching AMP at a pilot plant that has a previously approved 50.69 license amendment. EPRI 3002020713 does not describe a generic process for how consequence should be evaluated at other plants that want to adopt the proposed RI methodology, including those that do not have a previously approved 50.69 license amendment.

It is unclear to the staff what process will be used to evaluate consequence for any licensee that wants to use the proposed RI methodology. Additional information should be provided describing a generic process that can be used to evaluate consequence at plants that want to adopt the proposed RI methodology.

EPRI 3002020713 does not describe how PRA technical adequacy will be ensured for licensees that want to use the proposed RI methodology. The NRC has reviewed the technical adequacy of the PRA for plants that have approved 10 CFR 50.69 license amendments. The scope of these reviews included internal events PRA, including internal flooding and internal fire risk.

It is unclear to the staff how PRA technical adequacy will be ensured for plants that wish to use the proposed RI methodology, including those that do not have a previously NRC-approved license amendment to adopt 50.69. Additional information should be provided explaining how PRA technical adequacy will be ensured for plants that want to adopt the proposed RI methodology.

EPRI 3002020713 bins consequence results into three categories – high, medium, and low – based on conditional core damage probability (CCDP) and conditional large early release probability (CLERP) values.

It is unclear to the staff how the CCDP and CLERP values for the consequence categories (high, medium, and low) were developed. Additional information should be provided explaining the basis for the values used to define the consequence categories and why the values are appropriate for SSCs within the scope of the Selective Leaching AMP.

Specific to Selective Leaching AMP

Although not explicitly associated with the proposed changes to the Selective Leaching AMP, the NRC staff notes that EPRI 3002020713, “Leveraging Risk Insights for Aging Management Program Implementation (Leveraging Risk document), Section 3.6, “Pilot Insights and Lessons Learned,” states that some components scoped-in under 10 CFR 54.21(a)(2) could potentially be removed from aging management requirements, based on information from internal flooding probabilistic risk assessments. The NRC staff cautions that the current regulations in 10 CFR Part 54 do not allow removal of components from an aging management review based on probabilistic risk assessments. The statement of considerations for the revised license renewal rule in 1995 (60FR22461) states:

> “Probabilistic arguments may assist in developing an approach for aging management adequacy. However, probabilistic arguments alone will not be an acceptable basis for concluding that, for those structures and components subject to an aging management review, the effects of aging will be adequately managed in the period of extended operation.”

During the audit, the staff reviewed the NEI-proposed revision to GALL-SLR Report AMP XI.M33, “Selective Leaching,” and noted the following technical gaps:

- In addressing aging management program selection considerations, Section 3.4 of the Leveraging Risk document notes that programs associated with well understood aging mechanisms would be appropriate for application of a risk-informed approach. The Leveraging Risk document states, “The greater the knowledge of the aging mechanism and, in particular, its likelihood of occurrence, the easier it will be to set likelihood thresholds that achieve the high level of granularity of risk rankings for that mechanism.” According to EPRI Report 3002016057, “Selective Leaching State-of-the-Art Technical Update,” (Selective Leaching State-of-the-Art report) there were notable technical gaps associated with the susceptibility to this aging effect including:
    - impact of different environmental chemistry parameters (e.g., pH, soil resistivity / conductivity, halide concentrations, oxygen content),
    - corrosion behavior of different iron matrix structures (ferrite, pearlite, martensite) resulting from manufacturing processes (e.g., cooldown rate),
    - effects of alloying elements in cast iron,
    - effects of trace metals, which may be present from the casting process, on susceptibility,
    - conflicting studies regarding the effects of the flake graphite network in gray cast iron as it relates to susceptibility

    Given the potentially large uncertainties associated with the susceptibility of gray cast iron to selective leaching, it is unclear to the staff that the high level of granularity, noted in the Leveraging Risk document, can be achieved in the likelihood rankings for this material. While likelihood variations may be sufficiently quantified to focus inspections into more likely general populations, the current uncertainties due to environmental variations and material composition do not allow sufficient susceptibility refinement for the staff to concur with the industry’s proposed reductions to the overall inspection activities for selective leaching of gray cast iron.

    The Selective Leaching State-of-the-Art report notes that additional research into the selective leaching susceptibility, for various environmental parameters (e.g., pH, resistivity / conductivity, halide concentrations, oxygen content, etc.) as well as material alloying compositions, could provide improved guidance and instruction for identifying and selecting the most susceptible locations to selective leaching.

    The Selective Leaching State-of-the-Art report also identifies a need for “fitness-for-service” rules for the evaluation of selective leaching defects in gray cast iron as well as copper alloy components. It further notes the need for evaluation guidance of selective leaching defects in complex geometries. The State-of-the-Art report also notes that selective leaching may produce defects that are precursors to stress corrosion cracking in susceptible copper alloy components. Due to the brittle nature of gray cast iron, if selective leaching is detected, considerations for crack initiation resulting from selective leaching may need to be included for gray cast iron components. The potential cracking aspects introduce additional uncertainties due to variations in fracture mechanics properties that complicates considerations for the industry’s proposed reductions to the overall inspection activities.

- The staff recently became aware of operating experience identifying graphitic corrosion on the internal surfaces of malleable iron fittings exposed to closed -cycle cooling water (ML21327A279 and ML22010A129). The staff reached out to individuals on the EPRI Selective Leaching Task Force in early October 2021 with this information. In addition,

several other historical examples of selective leaching in malleable iron were subsequently identified by the staff in the industry operating experience database. Malleable iron is currently not within the scope of GALL-SLR Report AMP XI.M33, "Selective Leaching," and was not included in the proposed revision to the AMP. Not including all susceptible materials in the proposed revision to the AMP introduces another aging management uncertainty associated with this degradation mechanism and tends to demonstrate that aspects of the selective leaching aging mechanism may not be well understood. The technical basis for not including malleable iron in the proposed AMP revision should be provided.

- NEI's proposed AMP revision introduced an option of using risk-informed inspection sample selection, using the risk-framework described in the Leveraging Risk document, or the currently specified inspection sampling methodology in the GALL-SLR Report guidance (i.e., 3 percent with a maximum of 10 components). The proposed AMP revised the sample size to 2 or 3 components per population, depending on whether surrogate components are inspected. For large populations, the sample size in the proposed AMP revision is significantly reduced when compared to GALL--SLR Report guidance. The staff notes that the potentially large uncertainties associated with the various environmental variations and material composition makes it difficult to see how the smaller sample sizes can adequately represent a larger population of components. The technical basis for the risk -informed sampling methodology and the sample sizes should be provided as part of the technical basis for the proposed AMP revision.

- NEI's proposed AMP revision re-introduces hardness testing as one of several acceptable inspection and examination methods. The GALL-SLR Report had replaced hardness testing with mechanical examination techniques and destructive examinations. The technical basis for the change is documented in NUREG–2221, "Technical Bases for Changes in the Subsequent License Renewal Guidance Documents NUREG–2191 and NUREG–2192," and states "hardness testing was deleted based on the staff's review of license renewal applications (LRAs) and determining that conducting hardness testing of as found conditions of components was not viewed as practical." The proposed AMP revision re-introduces hardness testing without a technical basis. Hardness testing can theoretically identify the presence of selective leaching. However, the Selective Leaching State-of-the-Art report notes for field measurements, parameters such as surface preparation and the orientation of the indenter may affect the measurement and introduce uncertainty. The report states that further work to understand the reliability and essential parameters of field hardness testing as a means to identify selective leaching may be warranted. Based on the reasons provide above, the technical basis for re-introducing hardness testing should be provided, including a description of any further work that addresses the noted uncertainties and essential parameters.

- The proposed AMP revision introduces "[n]ondestructive examination techniques demonstrated to be capable of detecting the presence and/or extent of selective leaching on the component" as an inspection method. The staff notes NDE for selective leaching has not achieved widespread acceptance. In addition, EPRI Reports 3002020832, "Electromagnetic NDE Techniques for Detection of Selective Leaching in Gray Cast Iron Piping," and 3002020830, "Ultrasonic NDE Techniques for Detection of Selective Leaching in Complex Shaped Gray Cast Iron Components," note this effort is an ongoing research project (i.e., not a proven practice) and is applicable to gray cast iron (i.e., only one of the four materials within the scope of GALL--SLR Report AMP XI.M33). Furthermore, the staff reviewed EPRI Report 3002020832 and noted nondestructive

examination techniques can be non-conservative (i.e., estimates greater remaining wall thickness) when compared to pit gauges and laser profilometry. The staff notes that Footnote 3 of the proposed revisions to GALL-SLR- Report Table XI.M33-1 equates volumetric NDE (capable of detecting selective leaching) with a destructive examination. It is not clear that NDE that is only capable of detecting selective leaching can also be used to evaluate fitness-for-service comparable to a destructive examination. Based on the reasons provided above, the technical basis for introducing NDE techniques in the proposed AMP revision should be provided.

- GALL-SLR Report AMP XI.M33 currently recommends two inspection techniques (i.e., visual/mechanical inspections and destructive examinations) for each population. The proposed AMP revision states "[i]nspections and examinations may consist of any [of] the following methods" (referring to either visual/mechanical, hardness, nondestructive, or destructive examinations). During the audit, industry participants noted that the wording of the proposed revisions may not have been consistent with the industry intent. Revised wording consistent with the intent of the industry (if appropriate) should be provided or the technical basis for relying on one inspection technique in the proposed AMP revision should be provided.
- The "corrective actions" program element of AMP XI.M33 (with the issuance of GALL--SLR) was revised to include specific recommendations for conducting extent of condition examinations when acceptance criteria are not met. NUREG-2222, "Disposition of Public Comments on the Draft Subsequent License Renewal Guidance Documents NUREG-2191 and NUREG-2192," includes a discussion about the specific number of additional inspections in the corrective action program element as part of the basis for the reduced sample size in the GALL-SLR AMP (vs. that in GALL, Revision 2). The technical basis for the proposed AMP revision deleting these prescriptive corrective actions should be provided.

- The current "corrective actions" program element of AMP XI.M33 notes that components meet system design requirements, such as minimum wall thickness, when extended to the end of the extend operation period. As discussed during the audit, additional guidance may be warranted to account for the brittle nature of gray cast iron piping. The Selective Leaching State-of-the-Art report notes guidance for evaluating the extent of selective leaching in degraded components would better support engineering fitness-for-service evaluations and extent of condition determinations. The report also questions whether leached areas can simply be treated as typical wall loss or whether the selective leaching process introduces other variables into consideration of the failure modes (i.e., crack initiation points). The industry should provide additional guidance for fitness-for-service evaluations and extent of condition determinations in order to justify the removal of the current prescriptive corrective actions in the proposed AMP revision.

<u>Specific to the Limerick Pilot of the Proposed Selective Leaching AMP</u>

Because the Leveraging Risk document only provides general guidance regarding the development of a risk-informed AMP, the NRC staff reviewed Appendix A, "Selective Leaching AMP Pilot Results – Limerick," of the subject document to determine if the general guidance was sufficient to establish reasonably sound aging management activities. During the audit the NRC staff noted several technical gaps in the pilot program implementation. The staff also noted that NEI's presentation, during the August 4, 2022, Risk-Informed License Renewal meeting (ML22216A115), discussed the development and submittal by the end of the year, for NRC

endorsement of NEI Technical Report on Risk Insights for Aging Management. It is not clear whether resolution of the gaps discussed below will be addressed in the new NEI technical report or whether these gaps will be addressed separately on the docket:

- For a buried environment, the following soil specific likelihood inputs were considered in the pilot: external coatings, soil corrosivity, and whether the cathodic protection system is operating and maintained. In addition to the above factors, GALL-SLR Report AMP XI.M41, "Buried and Underground Piping and Tanks," considers backfill quality and cathodic protection system effectiveness (i.e., if cathodic protection acceptance criteria, such as -850 mV instant-off, are being met) when determining the extent of inspections for steel piping. Although AMP XI.M41 is focused predominately on managing loss of material due to other corrosion mechanisms (e.g., general corrosion), these preventive actions can also be effective in mitigating loss of material due to selective leaching in buried cast irons and copper alloys. The technical basis for not including backfill quality and cathodic protection system effectiveness as likelihood inputs for a buried environment should be provided.
- For internal environments, the flow rate input into the likelihood ranking categorizes “stagnant flow” with the lowest susceptibility score. A literature review performed by the staff (e.g., "NRC Information Notice 94-59, “Accelerated Dealloying of Cast Aluminum-Bronze Valves Caused by Microbiologically Induced Corrosion") indicated stagnant conditions are most prone to selective leaching. In addition, EPRI Report 3002020822, “Accelerated Testing and Evaluation of Factors Affecting Selective Leaching Methodology,” states that stagnant conditions are often more detrimental than flowing conditions for dezincification.

  During the audit, industry representatives said the pilot program considered “intermittent flow,” which consists of periods of stagnant flow and consistent flow, as the worst environment. The discussion in the pilot program documentation appeared to correlate microbiological influenced corrosion with the occurrence of selective leaching. The pilot program ranked “stagnant” flow as the lowest susceptibility score due to the self-limiting oxygen supply in stagnant conditions. Either a clearer definition of the flow regimes is warranted or the technical basis for ranking "stagnant flow" with the lowest susceptibility score for flow rate should be provided.
- Although coatings are considered as an input into the likelihood ranking for an external buried environment in the pilot program, coatings were not included for the internal environment. The staff notes that internal coatings are extensively used in some systems (e.g., fire protection piping) and the lack of internal coatings consideration may adversely skew the likelihood rankings. Either internal coatings should be included in the likelihood rankings or the technical basis for not including coatings for internal environment should be provided.
- Pilot program Table A-5 “Risk-Informed Inspection Scope” shows that one excavation (typically a 10-foot length) would be performed by the risk-informed approach to look for selective leaching on the external surface of more than 16,000 feet of fire protection piping. The information from the likelihood ranking spreadsheets shows a single value for the entire fire piping system by only considering a single soil corrosivity value and a single cathodic protection effectiveness rating. The reduced sample size being given in the pilot does not appear to account for the uncertainties of these parameters, as well as potential variations in gray cast iron material properties. Details on how location of the one excavation will be determined and information for how one 10-foot section can be considered as representative of the entire 16,000 feet should be provided.

- The pilot program risk matrix spreadsheet showed that all of the components in a soil environment, except for the fire protection piping, were ranked with a value of 14 out of a possible 18. The buried fire protection piping (more than 16,000 feet) was ranked with a value of 15 out of 18. The staff noted that the ranking associated with cathodic protection was the same for all the buried piping systems, even though the original specification for the plant drain system did not specify that cathodic protection was required for that system. Although an extensive amount of work may have been expended to provide likelihood rankings, if almost every system has an identical ranking, then the value of the likelihood ranking process is not clear.

  As initially noted by the staff, while likelihood variations may be sufficiently quantified to focus inspections into more likely general populations, the current uncertainties due to environmental variations (e.g., soil corrosivity, cathodic protection effectiveness) and material composition do not allow sufficient susceptibility refinement for the staff to concur with the industry's proposed reductions to the overall inspection activities for selective leaching. Additional refinements to the likelihood ranking process should be provided that will allow a greater differentiation than a single point (i.e., 14 versus 15) currently shown in the pilot program.

V. AUDIT RESULTS

For NRC to reach a determination on the extent to which the proposed AMP revisions can be incorporated into the GALL-SLR Report, the NRC would need additional information as discussed in Section III.

In addition, the NRC is considering whether any of the changes not addressed in the audit observations above may be separated out and incorporated independently.

Although the forthcoming NEI generic guidance for risk informing aging management was not provided for review, the NRC is conceptually supportive of it and looks forward to further engagement, including a more thorough and formal review.

VI. EXIT MEETING

On October 13, 2022, the NRC staff presented the audit results and observations during an exit meeting with NEI, EPRI, and industry members supporting the audit.

APPENDIX A

The following information was initially requested in the audit plan:

1. Technical Basis for Aging Mechanism Uncertainties. EPRI 3002016057, "Selective Leaching State-of-the-Art Technical Update," cites "notable technical gaps" regarding:

    - Impact of different environmental chemistry parameters (e.g., pH, resistivity / conductivity, halide concentrations, oxygen content) on selective leaching rates and overall susceptibility

    - effects that alloying elements may have on cast iron susceptibility

    - corrosion behavior of different iron matrix structures (ferrite, pearlite, martensite) and effects of trace metals, which may be present from the casting process, on susceptibility

    - conflicting studies regarding the effects of the flake graphite network in gray cast iron as it relates to susceptibility

    - introduction of additional failure modes (e.g., crack initiation points) resulting from selective leaching

    - likelihood impact for flow rates on copper alloy differ between EPRI 3002016057 and EPRI 3002020623, Appendix A

2. Technical Basis for Malleable Iron. Operating experience involving a recent SLRA applicant in 2020 identified graphitic corrosion on the internal surfaces of malleable iron fittings exposed to closed cycle cooling water (ML21327A279 and ML22010A129). Based on this new operating experience, the staff is considering including malleable iron as a material type susceptible to selective leaching in the next revision to the GALL-SLR Report. The staff requests a technical basis for why the proposed NEI revision to GALL-SLR AMP XI.M33, "Selective Leaching," does not include malleable iron as a material type susceptible to selective leaching.

3. Technical Basis for Inspection Sample Size Reduction. The extent of inspections for selective leaching during the subsequent period of extended operation (i.e., 3 percent with a maximum of 10 components per GALL-SLR guidance) was reduced when compared to the extent of inspections for selective leaching during the initial period of extended operation. The NEI document proposes a further reduction down to 2-3 components per population without a technical basis.

4. Technical Basis for Re-Introduction of Hardness Testing. Hardness testing was replaced with mechanical examination techniques and destructive examinations with the issuance of GALL-SLR. The NEI document proposes re-introducing hardness testing without a technical basis. Hardness testing can theoretically identify the presence of selective leaching but is unable to characterize the extent of selective leaching.

5. Technical Basis for Credit for Undefined Future NDE Techniques. The NEI document introduces "[n]ondestructive examination techniques demonstrated to be capable of detecting

the presence and/or extent of selective leaching on the component" as an inspection method. The AMP should identify specific NDE techniques which are capable of detecting selective leaching in cast irons and copper alloys. The staff noted that NDE for selective leaching has not achieved widespread acceptance.

6. Technical Basis for Reliance on One Inspection Technique. GALL-SLR Report AMP XI.M33 recommends visual/mechanical and destructive examinations for each population. The NEI proposal states "[i]nspections and examinations may consist of any [of] the following methods" (referring to either visual/mechanical, hardness, nondestructive, or destructive examinations). A basis is needed for going from two inspections techniques in our current guidance down to one inspection technique.

7. Technical Basis for Samples Based on Consequence. When using the risk-informed sampling methodology, inspections focus on consequence, not likelihood (see second bullet in Section A.7 of EPRI 3002020713 or the sampling requirements in the proposed revision to AMP XI.M33).

    a) How is susceptibility to selective leaching considered while using this methodology?

    b) Provide the technical basis for the likelihood values used and the exclusion of likelihood from the minimum samples.

    c) The methodology used to determine risk/consequence appears to be a new method, especially when the components being reviewed have not been categorized in accordance with 10 CFR 50.69. Has this methodology been peer reviewed or accepted? Will this methodology be applied if the licensee does not have an approved 50.69 license amendment or the majority of components have not been categorized?

    d) Provide the technical basis for using the PRA results to quantify the consequences associated with passive components (such as piping, valve bodies, and heat exchangers).

8. Technical Basis for Removal of Prescriptive Corrective Actions. The "corrective actions" program element of AMP XI.M33 (with the issuance of GALL-SLR) was revised to include specific recommendations for conducting extent of condition examinations when acceptance criteria are not met. This is consistent with several other GALL-SLR Report AMPs. The NEI document proposes deleting this language; therefore, a technical basis is needed for this change.

Additional questions were asked during the audit. See Appendix B.

APPENDIX B

The following information needs were communicated to NEI during the audit. They have not been edited from how they appeared as communicated to the licensee. The numbering continues from the information needs (# 1-8) discussed in the audit plan.

9. Make available the SLRA program basis documentation and drawings.

10. Explain how consequence was determined for fire protection components. Is this consistent with the process in NEI 00-04 when non-PRA methods are used?

11. Section 3.6 of the Leveraging Risk document (p64/126) states that information was organized in large spreadsheets to consolidate information (e.g., system name, component type, safety class, intended function, quantitative & qualitative risk information), which allowed for easier application of likelihood and consequence information. Without seeing the spreadsheets, it's unclear whether they would provide useful insights to the staff during our review of the pilot AMP.

    Request: Provide the spreadsheets discussed in Section 3.6 along with any accompanying explanations to help understand the information.

12. Section 3.6 final bullet (p67/120) notes that a final insight from the pilots indicates that some SSCs scoped-in under 54.4(a)(2) could potentially be removed from aging management review, based on information gathered from existing analyses (such as internal flooding PRA).

    Request: Provide additional information and a more detailed discussion about this insight.

13. Figure A-4, Risk Matrix Binning (p96/126) shows boxes with SSC designations (e.g., NSR GCI/Soil x3). For the soil environment, there are four boxes shown: NSR GCI/Soil x3, NSR GCI/Soil x1, SR GCI/Soil x1, and NSR GCI/Soil x1.

    Request: Provide information about what each SSC box represents and information showing how the consequence and likelihood rankings were determined (specifically for the soil environment, but generally for each SSC box).

14. Tables A-4 and A-5 (p99/126) show original inspection scopes and risk-informed inspection scopes. The first column is for component type, and except for fire hydrants, it is not clear how the components are distributed with the various populations (material/environment combinations) in the program. The pilot program was performed at a site where the Selective Leaching program was based on GALL Rev 2, which provided for a 20 percent sample (up to a maximum of 25 components) for each population.

    Request: Provide information explaining how the inspection scope (i.e., numbers of inspections) was originally determined in Table A-4 and the specific bases for how the inspection scope was determined for the risk-informed approach in Table A-5. Include information about which populations contain which component types.

15. Questions based on review of EPRI Report 3002020713 (Leveraging Risk Insights Document):

    a) Soil corrosivity, cathodic protection, and coatings are used as likelihood inputs for a buried/soil environment (page 85). Why is backfill quality (demonstrated by plant records or by examining the backfill while conducting inspections) not considered

    b) Given that stagnant conditions promote selective leaching (example reference provided below), it is unclear why “stagnant flow” results in the lowest susceptibility score for flow rate (page 85).

        i. NRC Information Notice No. 94-59, “Accelerated Dealloying of Cast Aluminum-Bronze Valves Caused by Microbiologically Induced Corrosion,” states “[f]low below approximately 1.5 meters [5 feet] per second lends to the system the potential for fouling which can promote the formation of microbiologically induced corrosion nodules as found in the subject valves.”

    c) Scoring with respect to cathodic protection considers whether the system is operating, monitored, or maintained (page 85). It does not appear that effectiveness of the cathodic protection system (i.e., if cathodic protection acceptance criteria, such as -850 mV instant-off, are being met) is considered when performing this ranking.

    d) The subject EPRI Report states “[u]nder passive SCC categorization, the risk of catastrophic ruptures, this is, loss of pressure retaining function of plant components, is considered” (page 89). There is a recognition in some of the EPRI documents that dealloying in brittle material (e.g., gray cast iron) can lead to structural failures whereas dealloying in ductile material (e.g., copper alloy) can lead to leakage. Does the risk-informed framework consider brittleness of the material with respect to likelihood of failure?

    e) One of the fundamental questions for this audit is understanding the basis for two inspections per population. Section A.7 of EPRI Report 3002020713 discusses the topic but does not provide a basis for the number. If the basis for two inspections per population is addressed in any of the EPRI documents, please provide specific direction to the staff.

16. The marked-up AMP proposed by NEI includes the following acceptance criterion: “[f]or copper alloys with >15% zinc, a white/gray meringue deposit may develop on the surface.” Meringue dezincification is discussed in EPRI Report 3003030822 (page 44) and in the source I pulled below. The issue I have is that “may develop on the surface” is not an acceptance criterion.

    a) Francis, Roger. (2010). Corrosion of Copper and its Alloys - A Practical Guide for Engineers - 9.1 Dezincification. NACE International.

        i. “Dezincification can lead to a number of problems…[t]hey [referring to brass fittings] become filled with a voluminous, but hollow, white corrosion product, not unlike meringue.

17. The 1st and 2nd bullets discuss SCCs where consequence or likelihood cannot be evaluated. It is not clear why the risk-framework approach should be used if either of these factors cannot be quantified. The deterministic sampling approach prescribed in GALL-SLR Report AMP XI.M33 may be more appropriate in these instances.

18. The 3rd bullet discusses establishing a periodic program if any inspection results reveal the aging effect may cause a loss of intended function for the component during the period of extended operation. This statement is confusing because the GALL-SLR version of the Selective Leaching program is already a periodic inspection program (whereas the GALL Revision 2 version is a one-time inspection program).

19. I recognize that the proposed sample size is loosely based on GALL-SLR requirements (i.e., (3 x 1%) + (3 x 3 components) = 3% or 9 components ≈ SLR sample size). However, for populations where only one likelihood category is used, the inspection sample size would be one component (for populations less than 150 components).

20. For populations less than 150 components, the 4th bullets states perform one inspection in the high likelihood category with a 2nd confirmatory inspection in the medium likelihood category. It isn't clear why the confirmatory sample would not be performed in the high likelihood category. This comment is also applicable to the 5th bullet where low likelihood is sampled if aging is identified in the medium likelihood category.

21. For the gray cast iron fire water piping with an internal environment of raw water, does the piping have internal mortar lining and, if so, should the likelihood ranking account for the internal mortar lining? Will this change location selections?

    Plant Drainage piping exposed to soil: The likelihood ranking for cathodic protection shows a ranking of 1: "cathodic protection was operating and maintained." According to the Limerick response to RAI B.2.1.29-1 (ML120470084) the plant drainage piping is not cathodically protected and the design specification for cathodic protection does not require these lines to be cathodically protected. Please clarify whether the plant drainage piping is or is not cathodically protected. Has consideration of stray current been considered for non-cathodically piping? (State-of-the-art Report notes that accelerated selective leaching has been attributed to stray current and discusses "a potential contribution from stray currents in the proximity to an impressed current cathodic protection system utilizing an anode bed."