SLR-M32
SLR Technical Issues Input Form

Section 1: General
Technical Issue: X
Regulatory Issue:
Author: NEI
Source: (Title; Date; Type) NUREG -1801, Rev 2: XI.M33 and XI.M41
NUREG-1800, Rev 2, Table 3.0-1 item XI.M33
NUREG-1800, Rev. 2, Tables 3.1-1, 3.2-1, 3.3-1, and 3.4-1

Section 2: Issue
2.1 Describe the issue in one or two sentences:

One-time inspections during the first forty years of plant operation identified loss of material due to selective leaching in components with susceptible alloys in aggressive environments (e.g., gray cast iron in fire water systems) that required corrective actions or plant-specific programs. However, loss of material due to selective leaching in susceptible alloys in non-aggressive environments (e.g., treated water, closed cooling water, or water contaminated fuel/lube oil environments) did not require plant-specific programs during the period of extended operation (40 to 60 years). Periodic visual inspections supplemented with destructive examinations for metallurgical properties are recommended to manage loss of material due to selective leaching for the subsequent license renewal period.

2.2 Provide further Information or describe recommended research in one or two sentences:

Revision of the Selective Leaching Program for the subsequent license renewal period is recommended to:

- Limit the scope of the program to components fabricated with susceptible materials in aggressive environments (i.e., raw water, groundwater, and waste water)
- Remove materials in chemically controlled and non-aggressive environments (i.e., closed cooling water, treated water, condensation, and water contaminated fuel oil or lube oil) from the scope of the program.
- Require periodic visual inspections supplemented with destructive examinations (i.e., degree of dealloying, depth of dealloying through wall thickness, and chemical composition).
- Exclude components included in AMP XI.M42, Aging Management of loss of Coating Integrity for Internal Service Level III (Augmented) Coatings, from the scope of the Selective Leaching Program.
- Exclude buried components from the Selective Leaching Program that do not require external corrosion control consistent with AMP XI.M41 Table 4a Category D preventive actions or are cathodically protected consistent with AMP XI.M41, Buried and Underground Piping and Tanks, Element 4.b.xi.A.

Although the Selective Leaching Program does not provide guidance on preventive actions, it is noted that monitoring of water chemistry consistent with AMP XI.M2, Water Chemistry, or AMP XI.M21A, Closed Treated Water Systems, to control pH and concentration of corrosive contaminants in treated water or closed cooling water environments is effective in minimizing selective leaching. One-Time Inspections for the initial license renewal confirmed that managing water chemistry consistent with AMP XI.M2 or AMP XI.M21A will minimize selective leaching

to the extent that it will not cause loss of intended function during the period of extended operation. One-Time Inspections performed by AMP XI.M33 during the first forty years of plant operation also confirmed that a plant-specific program was not required to manage selective leaching in non-aggressive environments during the period of extended operation.

2.3 Describe ongoing research in one or two sentences

None

2.4 Link the research to one or more AMPs

None

Section 3: Recommended Change

3.1 Describe the proposed change in detail

Revise the SRP Table 1's, GALL AMR line items, and AMP XI.M33 to require periodic visual inspections supplemented with destructive examinations for susceptible materials in aggressive environments.

3.2 Provide a markup of the SRP Rev 2 text that would change

The following GALL changes are recommended:
SRP Table 3.0-1 item XI.M33 (See Attachment 1 markup)
SRP Table 3.1-1 ID 93 (delete item 93 and associated GALL lines)
SRP Table 3.2-1 ID's 34 through 37 (delete items 34 through 36 & revise item 37 consistent with Attachment 4 example)
SRP Table 3.3-1 ID 72 (revise consistent with Attachment 4 example)
SRP Table 3.4-1 ID's 32 and 33 (See Attachment 4 example)

3.3 Provide a markup of the GALL Rev 2 text that would change

The following GALL changes are recommended:
GALL AMP XI.M33 (See Attachment 2 markup)
GALL AMP XI M41 Element 4.b.xi.A. (See Attachment 3 markup)
AMR line items associated with the SRP Table 1 line items identified in 3.2 above.

3.4 Provide a Technical Basis for the proposed change:

One-time inspections conducted during the first forty years of plant operation identified loss of material due to selective leaching in components with susceptible alloys in aggressive environments (e.g., gray cast iron in fire water systems) that required corrective actions or plant-specific programs. However, loss of material due to selective leaching in susceptible alloys in chemically controlled or non-aggressive environments (e.g., treated water, closed cooling water, or water contaminated fuel/lube oil environments) did not require plant-specific programs during the period of extended operation (40 to 60 years).

Although the Selective Leaching Program does not provide guidance on preventive actions, it is noted that monitoring of water chemistry consistent with AMP XI.M2, Water Chemistry, or AMP XI.M21A, Closed Treated Water Systems, to control pH and concentration of corrosive contaminants in treated water or closed cooling water environments is effective in minimizing

selective leaching. One-Time Inspections for the initial license renewal confirmed that managing water chemistry consistent with AMP XI.M2 or AMP XI.M21A will minimize selective leaching to the extent that it will not cause loss of intended function during the period of extended operation. One-Time Inspections performed by AMP XI.M33 during the first forty years of plant operation also confirmed that a plant-specific program was not required to manage selective leaching in non-aggressive environments during the period of extended operation.

3.5 Describe any eventual guidance in one or two sentences

None required

3.6 Describe the location of the change and indicate new line items or AMPs

See 3.2 and 3.3 above

3.7 For AMPs, Identify which GALL Elements will change

GALL AMP XI.M33, Element 1 through Element 7 (See Attachment 2 markup)
GALL AMP XI M41 Element 4.b.xi.A. (See Attachment 3 markup)

Section 4 Affected GALL / SRP Items (Identify GALL/SRP Section)

See 3.2 and 3.3 above

Section 5 References (Identifier; Title; Location in Reference)

M. G. Fontana, Corrosion Engineering, John Wiley and Sons, New York, 1982.

ATTACHMENT 1

Mark-up Showing Changes To SRP-LR Table 3.0-1

Table 3.0-1 FSAR Supplement for Aging Management of Applicable Systems				
GALL Chapter	**GALL Program**	**Description of Program**	**Implementation Schedule***	**Applicable GALL Report and SRP Chapter References**
XI.M33	Selective Leaching	The program includes a ~~one-time~~ periodic visual inspection coupled with ~~either hardness measurement or other~~ mechanical examination techniques such as ~~destructive testing,~~ scraping, or chipping of selected components that may be susceptible to selective leaching. Destructive examinations of components for metallurgical properties are also conducted. This is to determine whether loss of materials ~~is occurring and whether the process~~ will affect the ability of the components to perform their intended function for the period of extended operation.	Program should be implemented prior to period of extended operation	GALL IV / SRP 3.1 GALL V / SRP 3.2 GALL VII / SRP 3.3 GALL VIII / SRP 3.4

ATTACHMENT 2

XI.M33 SELECTIVE LEACHING

Program Description

~~This program demonstrates the absence of selective leaching.~~ The program for selective leaching of materials ensures the integrity of the components made of gray cast iron and copper alloys (except for inhibited brass) that contain greater than 15 percent zinc (> 15% Zn) or greater than 8 percent aluminum (>8% Al in the case of aluminum-bronze) exposed to a raw water, ~~closed cooling water, treated water,~~ waste water, or ground water environment that may lead to selective leaching of one of the metal components. ~~where there has not been previous experience of selective leaching.~~ The AMP includes a ~~one-time~~ periodic visual inspection of selected components that may be susceptible to selective leaching, coupled with ~~either hardness measurements (where feasible, based on form and configuration) or~~ mechanical examination techniques (e.g., chipping and scraping). Destructive examinations of components for metallurgical properties (i.e., degree of dealloying, depth of dealloying through wall thickness, and chemical composition) are also conducted. These techniques can determine whether loss of materials due to selective leaching is occurring and whether selective leaching will affect the ability of the components to perform their intended function for the period of extended operation.

The selective leaching process involves the preferential removal of one of the alloying elements from the material, which leads to the enrichment of the remaining alloying elements. Dezincification (loss of zinc from brass) and graphitization (removal of iron from cast iron) are examples of such a process. Susceptible materials, high temperatures, stagnant-flow conditions, and a corrosive environment, such as acidic solutions for brasses with high zinc content and dissolved oxygen, are conducive to selective leaching.

Although the program does not provide guidance on preventive action, it is noted that monitoring of water chemistry consistent with AMP XI.M2, Water Chemistry, or AMP XI.M21A, Closed Treated Water Systems, to control pH and concentration of corrosive contaminants ~~and treatment to minimize dissolved oxygen~~ in treated water or closed cooling water environments ~~are~~ is effective in minimizing ~~reducing~~ selective leaching. ~~Water chemistry is managed by the Water Chemistry program (AMP XI.M2).~~ One-time inspections during initial license renewal inspections confirmed that managing water chemistry consistent with AMP XI.M2 or AMP XI.M21A will minimize selective leaching to the extent that it will not cause loss of intended function during the period of extended operation. One-time inspections performed by AMP XI.M33 during initial license renewal activities also confirmed that a plant specific program was not required to manage selective leaching in non-aggressive environments.

Evaluation and Technical Basis

1. *Scope of Program:* ~~This program demonstrates the absence of selective leaching. For materials and environments where selective leaching is currently occurring or for materials in environments where the component has been repaired with the same material, a plant-specific program is required.~~ This program monitors for loss of material due to selective leaching in susceptible alloys in aggressive environments. Components include piping, valve bodies and bonnets, pump casings, and heat exchanger components that are susceptible to selective leaching. The materials of construction for these components may include gray cast iron and uninhibited brass containing greater than 15% zinc or greater

than 8% aluminum. These components may be exposed to aggressive environments such as raw water, ~~treated water, closed cooling water,~~ waste water, or ground water~~, water contaminated fuel oil, or water-contaminated lube oil~~.

Service Level III coatings prevent unanticipated or accelerated corrosion of base metals on the surfaces of components in aggressive water environments. AMP XI.M42, Aging Management of loss of Coating Integrity for Internal Service Level III (Augmented) Coatings manages degradation of these coatings which are not included in the scope of this program. Buried components in a groundwater environment that do not require external corrosion control consistent with Table 4a Category D preventive actions or buried components that are cathodically protected consistent with Element 4.b.xi.A of XI.M41, Buried and Underground Piping and Tanks, are not included in the scope of this program.

2. *Preventive Actions:* This program is a condition monitoring program and it contains no preventive actions.

3. *Parameters Monitored/Inspected:* This program monitors ~~selective leaching through the monitoring of surface hardness~~ metallurgical properties and visual appearance (color, porosity, abnormal surface conditions).

4. *Detection of Aging Effects:* ~~The visual inspection and hardness measurement or other mechanical examination techniques, such as destructive testing (when the opportunity arises), chipping, or scraping, is a one-time inspection conducted within the last 5 years prior to entering the period of extended operation. Because selective leaching is a slow acting corrosion process, this measurement is performed just prior to the period of extended operation. Follow-up of unacceptable inspection findings includes an evaluation using the corrective action program and a possible expansion of the inspection sample size and location.~~

~~Where practical, the inspection includes a representative sample of the system population and focuses on the bounding or lead components most susceptible to aging due to time in service, severity of operating conditions, and lowest design margin. Twenty percent of the population with a maximum sample of 25 constitutes a representative sample size. Otherwise, a technical justification of the methodology and sample size used for selecting components for one-time inspection should be included as part of the program's documentation. Each group of components with different material/environment combinations is considered a separate population.~~

~~Selective leaching generally does not cause changes in dimensions and is difficult to detect by visual inspection. However, in certain brasses, it causes plug-type dezincification, which can be detected by visual inspection. One acceptable procedure is to visually inspect the susceptible components closely and conduct Brinell hardness testing (where feasible, based on form and configuration or other industry-accepted mechanical inspection techniques) on the inside surfaces of the selected set of components to determine if selective leaching has occurred. If selective leaching is apparent, an engineering evaluation is initiated to determine acceptability of the affected components for further service.~~

Visual inspections and mechanical examination techniques (e.g., involving chipping or scraping) conducted under this program are opportunistic in nature. At a minimum, in the 10-year period prior to the period of extended operation, and in each 10-year period during the period of extended operation, a sample of 3 percent of the population (defined as

components having the same material) or a maximum of 10 components per population are inspected. Where practical, the visual inspection focuses on the bounding or lead components most susceptible to aging because of time in service and severity of operating conditions. This minimum sample size does not override the opportunistic inspection basis of this AMP. Opportunistic inspections would still be conducted even though in a given 10-year period, 3 percent or 10 components might have already been visually inspected.

Visual inspections include all accessible surfaces. In certain brasses, selective leaching causes plug-type dezincification, which can be detected by visual inspection. Selective leaching of gray iron usually shows rusting and in some cases a surface layer with the appearance of graphite, which can be detected by visual inspection. Mechanical examination techniques such as chipping and scraping should augment visual inspections for gray iron components. Unless otherwise required (e.g., by the ASME code), all inspections are carried out using plant-specific procedures by inspectors qualified through plant-specific programs.

A destructive examination provides more information than a visual inspection. At a minimum, two destructive examinations shall be performed in each material group population. The applicant may take credit for each component destructively examined as being equivalent to visually inspecting two components. Destructive examinations will be used to determine the metallurgical properties (i.e., degree of dealloying, depth of dealloying through wall thickness, and chemical composition).

5. *Monitoring and Trending:* ~~This is a one-time inspection to determine if selective leaching is an issue. Monitoring and trending is not required.~~ Trending of destructive examination results to indicate the progression of dealloying is performed. Mechanical properties (e.g., minimum wall thickness) are projected until the next inspection period to confirm structural integrity is maintained.

6. *Acceptance Criteria:* The ~~acceptance criteria are~~ criterion is no visible evidence of selective leaching. ~~or no more than a 20 percent decrease in hardness.~~ The criterion for uninhibited copper alloys with greater than 15 percent zinc, ~~the criteria~~ is no noticeable change in color from the normal yellow color to the reddish copper color. The criterion for grey cast iron is the absence of a surface layer with the appearance of graphite that can be easily removed by cutting or scraping. System components shall meet system design requirements such as minimum wall thickness.

7. *Corrective Actions:* Engineering evaluations are performed for ~~test or~~ inspection results that do not satisfy ~~established~~ acceptance criteria or trending that does not confirm structural integrity will be maintained until the next inspection period. The corrective actions program ensures that conditions adverse to quality are ~~promptly~~ corrected. If the deficiency is assessed to be ~~significantly~~ a significant condition adverse to quality, the cause of the condition is determined and an action plan is developed to preclude repetition. As discussed in the Appendix for GALL, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the corrective actions. Unacceptable inspection findings result in additional inspection(s) being performed, which may be on a periodic basis, or in component repair or replacement.

8. *Confirmation Process:* Site quality assurance (QA) procedures, review and approval processes, and administrative controls are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B. As discussed in the Appendix for GALL, the

staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the confirmation process and administrative controls.

9. *Administrative Controls:* The administrative controls for this program provide for a formal review and approval of corrective actions. The administrative controls for this program are implemented through the site's QA program in accordance with the requirements of 10 CFR Part 50, Appendix B.

10. *Operating Experience:* The elements that comprise these inspections (e.g., the scope of the inspections and inspection techniques) are consistent with industry practice and staff expectations. Selective leaching has been detected in components constructed from cast iron, brass, bronze, and aluminum bronze. Components affected have included valve bodies, pump casings, piping, and cast iron fire protection piping buried in soil.

References

10 CFR Part 50, Appendix B, *Quality Assurance Criteria for Nuclear Power Plants*, Office of the Federal Register, National Archives and Records Administration, 2009.

EPRI TR-107514, *Age Related Degradation Inspection Method and Demonstration*, Electric Power Research Institute, April 1998.

Fontana, M. G., *Corrosion Engineering*, McGraw Hill, p 86-90, 1986.

NUREG-1705, *Safety Evaluation Report Related to the License Renewal of Calvert Cliffs Nuclear Power Plant, Units 1 and 2*, U.S. Nuclear Regulatory Commission, December 1999.

NUREG-1723, *Safety Evaluation Report Related to the License Renewal of Oconee Nuclear Station, Units 1, 2, and 3*, U.S. Nuclear Regulatory Commission, March 2000.

NUREG-1930, *Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Units 2 and 3*, U.S. Nuclear Regulatory Commission, November 2009.

Schweitzer, P. A., *Encyclopedia of Corrosion Technology 2nd Ed*, Marcel Dekker, p 201-202. March 17, 2004.

NRC Information Notice 84-71, Graphitic Corrosion of Cast Iron in Salt Water, September 06, 1984.

NRC Information Notice 94-59, Accelerated Dealloying of Cast Aluminum-Bronze Valves Caused by Microbiologically Induced Corrosion, August 17, 1994.

ATTACHMENT 3

XI.M41 BURIED AND UNDERGROUND PIPING AND TANKS

Element 4.b.xi.A (as modified by LR-ISG-2011-03)

xi. Dependent on plant-specific operating experience and implementation of preventive actions, the number of one-time selective leaching inspections for the external surfaces of buried components which are susceptible to selective leaching, as recommended in AMP XI.M33, may be adjusted as follows:

A. No selective leaching inspections are required of the external surface of gray cast iron buried components which meet the following: (a) the components have been cathodically protected since installation, (b) ~~for the 10-year period prior to~~ during the period of extended operation the cathodic protection system has had 80 percent availability, and (c) the as-found measured soil-to-pipe potential readings during periodic cathodic protection surveys meets the acceptance criteria of program element 6,“acceptance criteria,” of this AMP. Where only portions of the population of components have met this criterion, those portions may be deducted from the population size for purposes of determining the number of inspections; however, the maximum sample size of AMP XI.M33 is still applicable. The same adjustments may be utilized for copper alloy based components; however, technical justification must be provided that demonstrates the effectiveness of cathodic protection in the prevention of selective leaching for those alloys. Absent such a justification, the AMPXI.M33 sample size recommendations cannot be adjusted.

ATTACHMENT 4

Mark-up Showing Changes To SRP-LR Table 3.4-1 items 32 and 33

Table 3.4-1 Summary of Aging Management Programs for Steam and Power Conversion System Evaluated in Chapter VIII of the GALL Report							
ID	Type	Component	Aging Effect/ Mechanism	Aging Management Programs	Further Evaluation Recommended	Rev 2 Item	Rev 1 Item
32	BWR/PWR	Gray cast iron piping, piping components, and piping elements exposed to soil and not cathodically protected or exempt from external corrosion control	Loss of material due to selective leaching	Chapter XI.M33, "Selective Leaching"	No	VIII.E.SP-26 VIII.G.SP-26	VIII.E-22(SP-26) VIII.G-25(SP-26)
33	BWR/PWR	Gray cast iron, Copper alloy (>15% Zn or >8% Al) Piping, piping components, and piping elements exposed to ~~Treated water,~~ Raw water, ~~Closed-cycle cooling water~~	Loss of material due to selective leaching	Chapter XI.M33, "Selective Leaching"	No	~~VIII.A.SP-27~~ VIII.A.SP-28 VIII.A.SP-30 ~~VIII.E.SP-27~~ ~~VIII.E.SP-29~~ VIII.E.SP-30 ~~VIII.E.SP-55~~ ~~VIII.F.SP-27~~ ~~VIII.F.SP-29~~ VIII.F.SP-30 ~~VIII.F.SP-55~~ ~~VIII.G.SP-27~~ VIII.G.SP-28 ~~VIII.G.SP-29~~ VIII.G.SP-30 ~~VIII.G.SP-55~~	~~VIII.A-8(SP-27)~~ VIII.A-7(SP-28) VIII.A-6(SP-30) ~~VIII.E-23(SP-27)~~ ~~VIII.E-19(SP-29)~~ VIII.E-20(SP-30) ~~VIII.E-21(SP-55)~~ ~~VIII.F-19(SP-27)~~ ~~VIII.F-16(SP-29)~~ VIII.F-17(SP-30) ~~VIII.F-18(SP-55)~~ ~~VIII.G-26(SP-27)~~ VIII.G-24(SP-28) ~~VIII.G-21(SP-29)~~ VIII.G-22(SP-30) ~~VIII.G-23(SP-55)~~