FINAL LICENSE RENEWAL INTERIM STAFF GUIDANCE
LR-ISG-2011-01

AGING MANAGEMENT OF STAINLESS STEEL STRUCTURES AND COMPONENTS IN TREATED BORATED WATER

INTRODUCTION

This final license renewal interim staff guidance (LR-ISG) LR-ISG-2011-01, "Aging Management of Stainless Steel Structures and Components in Treated Borated Water," provides guidance as to one acceptable approach for managing the effects of aging during the period of extended operation for stainless steel structures and components exposed to treated borated water within the scope of the License Renewal Rule (Title 10 of the *Code of Federal Regulations*, Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants" (10 CFR Part 54)). This LR-ISG revises the U.S. Nuclear Regulatory Commission (NRC) staff's aging management recommendations in the Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants (SRP-LR) and Generic Aging Lessons Learned (GALL) Report.

DISCUSSION

The staff has determined that existing guidance in the SRP-LR and GALL Report may not adequately address aging management in treated borated water environments. Specifically, for pressurized water reactors (PWRs), the guidance inappropriately credits boron as a corrosion inhibitor in place of other aging management activities. As a result, aging effects such as loss of material, cracking, and reduction of heat transfer may not be adequately managed using the existing guidance.

The GALL Report recommends that stainless steel components exposed to treated borated water be managed for aging effects such as loss of material and cracking by the Water Chemistry program, while both the Water Chemistry and One-Time Inspection programs are recommended for managing these aging effects in treated (i.e., non-borated) water. Additionally, the GALL Report does not include reduction of heat transfer as an aging effect for PWR stainless steel heat exchanger components exposed to treated borated water, while boiling water reactor (BWR) stainless steel heat exchanger components exposed to treated water are managed for reduction of heat transfer due to fouling (e.g., the collection of corrosion products) by the Water Chemistry and One-Time Inspection programs. In each of these cases, the corrosion inhibiting properties of boron were thought to be a sufficient alternative to performing an aging management activity.

In Revision 1 of the GALL Report, the staff attributed the low corrosiveness of PWR reactor coolant relative to that of BWR reactor coolant, in part, to the presence of boron:

> "Unlike the PWR reactor coolant environment (treated borated water), the BWR reactor coolant environment (i.e., treated water) does not contain boron, a recognized corrosion inhibitor." (NRC, 2005)

However, the staff has concluded that the relatively low incidence of corrosion issues in stainless steel components exposed to PWR primary water is likely not due to the presence of

boron, but rather is due to reactor coolant chemistry controls that result in dissolved oxygen levels that are normally less than 5 parts per billion (ppb) (ASM, 2006; EPRI, 2006). Oxygen is a well-known contributor to metal corrosion in water. Corrosion literature often cites a critical dissolved oxygen threshold of approximately 100 ppb where pitting and crevice corrosion become a concern for a variety of materials (EPRI, 2001, 2006; NACE, 1984; DePaul, 1957). Stress corrosion cracking of stainless steel has been observed at oxygen levels in excess of 10 ppb in low-chloride water environments (EPRI, 2004).

The Effect of Boron on Corrosion

Although Revision 1 of the GALL Report recognized boron as a corrosion inhibitor, specific borates (compounds containing boron-oxygen ions), distinct from the boron atom, are used to inhibit corrosion. Borates must be present in sufficient concentrations to be effective. If not added in adequate quantity, borates can cause pitting and increase corrosion rates (Rosenfeld, 1981; Jones, 1996).

PWR primary water has been termed “borated,” which may incorrectly suggest that the water chemistry is controlled to contain the proper amounts of the specific borate ions that inhibit corrosion. Rather, PWR primary water contains boric acid. Boric acid weakly dissociates to form hydrogen and borate ions; however, there is little evidence of beneficial effects of the added borate on stainless steel corrosion. Stainless steels are equally resistant to loss of material in high purity water and dilute solutions of boric acid (EPRI, 2001; NACE, 1985; De Renzo). The effect of boric acid on stress corrosion cracking of stainless steel is mixed. Laboratory stress corrosion cracking tests have shown that boric acid additions to high purity water have been both beneficial (Tsuruta, 1992) and detrimental (ANL, 1985).

The staff removed the reference to boron as a corrosion inhibitor in Revision 2 of the GALL Report, but did not update all the guidance for treated borated water to include additional aging management activities to account for this change.

Revised SRP-LR and GALL Report Guidance

The staff has determined that aging management for loss of material due to pitting and crevice corrosion and cracking due to stress corrosion cracking in treated borated water should be consistent with that for treated water. As a result, the staff recommends an additional one-time inspection to verify the effectiveness of the Water Chemistry program to manage these aging effects. The revised guidance applies to stainless steel structures and components exposed to treated borated water environments that are not actively controlled to oxygen levels less than 5 ppb. The affected PWR systems include, but are not limited to, the containment spray system, emergency core cooling system, spent fuel pool storage system, spent fuel pool cooling and cleanup system, and chemical and volume control system. The spent fuel pool systems are exposed to indoor air and are considered saturated with oxygen, at a concentration of approximately 6,000 ppb (Rooney, 1998). The containment spray system and portions of the emergency core cooling systems take suction from the refueling water storage tank, which is not typically deoxygenated. Also, while the main portion of the chemical and volume control system is continuously maintained to oxygen levels less than 5 ppb, other portions of this system are not.

The staff has also determined that stainless steel heat exchanger tubes exposed to treated borated water should be age managed for reduction of heat transfer due to fouling. Fouling can occur from the deposition of corrosion products and other particulates as well as the precipitation of dissolved ions, such as borates, on heat transfer surfaces. As a result, the staff recommends that stainless steel heat exchanger tubes be managed for reduction of heat transfer due to fouling with the Water Chemistry and One-Time Inspection programs, consistent with the current guidance for BWR heat exchangers exposed to treated water environments. The affected PWR systems include the containment spray system, emergency core cooling system, spent fuel pool cooling and cleanup system, and chemical and volume control system.

ACTION

The staff has determined that boron should not be credited as a corrosion inhibitor for stainless steel components in treated borated water. Thus, the staff has revised the SRP-LR and GALL Report to include the following additional aging management activities to align the guidance for treated borated water with that for treated water:

- Add the One-Time Inspection program to verify the effectiveness of the Water Chemistry program to manage loss of material due to pitting and crevice corrosion and cracking due to stress corrosion cracking in treated borated water. This revised guidance applies to stainless steel structures and components exposed to treated borated water environments that are not actively controlled to oxygen levels less than 5 ppb.

- Add reduction of heat transfer due to fouling as an aging effect for stainless steel heat exchanger tubes exposed to treated borated water, and manage this aging effect with the Water Chemistry and One-Time Inspection programs.

The staff has revised entries in SRP-LR Tables 3.2-1 and 3.3-1, and the associated items in the GALL Report, in Appendix A, “Revised SRP-LR” and Appendix B, “Revised GALL Report.” The extent and locations of changes are clarified in Appendix C, “Mark-Up Showing Changes to the SRP-LR” and Appendix D, “Mark-Up Showing Changes to the GALL Report.” An overview of these changes is discussed below.

The staff added the One-Time Inspection program to verify the effectiveness of the Water Chemistry program for managing loss of material due to pitting and crevice corrosion and cracking due to stress corrosion cracking in the GALL Report Table V.A, Containment Spray System (PWR); V.D1, Emergency Core Cooling System (PWR); VII.A2, Spent Fuel Storage; VII.A3, Spent Fuel Pool Cooling and Cleanup (PWR); and portions of VII.E1, Chemical and Volume Control System (PWR). The staff notes that the new guidance also applies to BWR and PWR spent fuel storage racks, for which there is currently no specific guidance in the GALL Report for the loss of material aging effect. The staff also added items to SRP-LR Table 3.3-1 to account for the new guidance for portions of the chemical and volume control system where oxygen is not controlled to low levels.

The staff added reduction of heat transfer due to fouling as an aging effect requiring management with the Water Chemistry and One-Time Inspection programs for stainless steel heat exchanger tubes in the GALL Report Table V.A, Containment Spray System (PWR); V.D1, Emergency Core Cooling System (PWR); VII.A3, Spent Fuel Pool Cooling and Cleanup (PWR); and VII.E1, Chemical and Volume Control System (PWR). The staff noted that the current

GALL Report guidance for the containment spray system already includes a reduction of heat transfer item; however, the cited environment is treated water. As a result, the application of this guidance has been inconsistent. Some PWR applicants have applied the items to the treated borated water environments, while others have considered the items as not applicable. Thus, the staff revised the environment for this item to treated borated water. Finally, the staff revised items in SRP-LR Tables 3.2 and 3.3 to account for the added guidance for heat exchanger tubes.

The guidance in this final LR-ISG is approved for use by the staff and stakeholders and will be incorporated into the NRC's next formal license renewal document revision. On November 8, 2011, the staff issued a *Federal Register* notice (NRC, 2011) to request public comments on draft LR-ISG-2011-01, "Aging Management of Stainless Steel Structures and Components in Treated Borated Water." In response, the NRC received comments from the Nuclear Energy Institute by letter dated December 13, 2011 (NEI, 2011) and Exelon Generation Company, LLC by letter dated December 14, 2011 (Exelon, 2011). The NRC staff considered these comments in developing the final LR-ISG-2011-01. The staff's responses to these comments are in Appendix E, "Resolution of Public Comments on Draft LR-ISG-2011-01."

NEWLY IDENTIFIED SYSTEMS, STRUCTURES, AND COMPONENTS UNDER 10 CFR 54.37(b)

The NRC is not proposing to treat the heat exchangers in the PWR systems as "newly identified" systems, structures, and components (SSCs) under 10 CFR 54.37(b). Therefore, any additional action on such materials which the NRC may impose upon current holders of renewed operating licenses under 10 CFR Part 54 would not fall within the scope of 10 CFR 54.37(b). The NRC would have to address compliance with the requirements of 10 CFR 50.109 before it may impose any new aging management requirements on current holders of renewed operating licenses (see discussion below).

BACKFITTING DISCUSSION

This LR-ISG contains guidance as to one acceptable approach for managing the effects of aging during the period of extended operation for stainless steel structures and components exposed to treated borated water within the scope of license renewal. Set forth below is the staff's discussion on compliance with the requirements of the Backfit Rule, 10 CFR 50.109.

Compliance with the Backfit Rule

Issuance of this LR-ISG does not constitute backfitting as defined in 10 CFR 50.109(a)(1), and the NRC staff did not prepare a backfit analysis for issuing this LR-ISG. There are several rationales for this conclusion, depending upon the status of the nuclear power plant licensee.

Licensees who are currently in the license renewal process – This LR-ISG is directed to current applicants for license renewal. However, this LR-ISG is not backfitting as defined in 10 CFR 50.109(a)(1). This guidance is non-binding and provides one approach acceptable to the NRC staff for managing the effects of aging in treated borated water environments in accordance with the requirements of 10 CFR Part 54. License renewal applicants are not required to use this guidance. Applicants may elect to propose an alternative approach for managing the aging of stainless steel structures and components in treated borated water

environments during the period of extended operation. In addition, the Backfit Rule does not protect license renewal applicants voluntarily requesting renewed licenses from changes in NRC requirements or guidance on license renewal prior to or during the pendency of their renewal application (NRC, 2008). Therefore, issuance of this LR-ISG does not constitute backfitting as applied to current applicants for license renewal.

Licensees who already hold a renewed license – This guidance is non-binding and the LR-ISG does not require current holders of renewed licenses to take any action (i.e., programmatic or plant hardware changes for managing the aging in treated borated water environments). However, current holders of renewed licenses should treat this guidance as operating experience and take actions as appropriate to ensure that applicable aging management programs are, and will remain, effective. If, in the future, the NRC decides to take additional action and impose requirements for management in treated borated water environments, then the NRC will follow the requirements of the Backfit Rule.

Current operating license or combined license holders who have not yet applied for renewed licenses – This LR-ISG is not directed at holders of (original) operating licenses or combined licenses until they apply for license renewal. As such, this LR-ISG does not constitute backfitting as applied to holders of (original) operating licenses and is not otherwise inconsistent with the applicable issue finality provisions in 10 CFR Part 52 as applied to holders of combined licenses.

CONGRESSIONAL REVIEW ACT

This interim staff guidance is a rule as designated in the Congressional Review Act (Title 5 of the United States Code, Part I, Chapter 8 (5 USC, Sec. 801)). However, the Office of Management and Budget (OMB) has not found it to be a major rule as designated in the Congressional Review Act.

REFERENCES

5 USC, Sec. 801, Congressional Review of Agency Rulemaking, Office of the Law Revision Counsel of the House of Representatives, 2012.

10 CFR Part 50, Domestic Licensing of Production and Utilization Facilities, Office of the Federal Register, National Archives and Records Administration, 2012.

10 CFR Part 54, Requirements for Renewal of Operating Licenses for Nuclear Power Plants, Office of the Federal Register, National Archives and Records Administration, 2012.

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APPENDIX A

REVISED SRP-LR

Table 3.2-1 Summary of Aging Management Programs for Engineered Safety Features Evaluated in Chapter V of the GALL Report

ID	Type	Component	Aging Effect/Mechanism	Aging Management Programs	Further Evaluation Recommended	Rev2 Item	Rev1 Item
19	BWR/PWR	Stainless steel Heat exchanger tubes exposed to Treated water, Treated water (borated)	Reduction of heat transfer due to fouling	Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"	No	V.D2.EP-74 V.A.EP-74 V.D1.E-20	V.D2-13(EP-34) V.A-16 (EP-34) N/A
20	PWR	Stainless steel Piping, piping components, and piping elements; tanks exposed to Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"	No	V.A.E-12 V.D1.E-12	V.A-28(E-12) V.D1-31(E-12)
21	PWR	Steel (with stainless steel or nickel-alloy cladding) Safety injection tank (accumulator) exposed to Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"	No	V.D1.E-38	V.D1-33(E-38)
22	PWR	Stainless steel Piping, piping components, and piping elements; tanks exposed to Treated water (borated)	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"	No	V.A.EP-41 V.D1.EP-41	V.A-27(EP-41) V.D1-30(EP-41)

Table 3.3-1 Summary of Aging Management Programs for Auxiliary Systems Evaluated in Chapter VII of the GALL Report

ID	Type	Component	Aging Effect/ Mechanism	Aging Management Programs	Further Evaluation Recommended	Rev2 Item	Rev1 Item
17	BWR/ PWR	Stainless steel Heat exchanger tubes exposed to Treated water, Treated borated water	Reduction of heat transfer due to fouling	Chapter XI.M2, “Water Chemistry,” and Chapter XI.M32, “One-Time Inspection"	No	VII.A4.AP-139 VII.A3.A-101 VII.E1.A-101	VII.A4-4(AP-62) N/A N/A
28	PWR	Stainless steel Piping, piping components, and piping elements; tanks exposed to Treated borated water (Primary, oxygen levels controlled) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, “Water Chemistry”	No	VII.E1.AP-82	VII.E1-20(AP-82)
29	PWR	Steel (with stainless steel cladding); stainless steel Piping, piping components, and piping elements exposed to Treated borated water (Primary, oxygen levels controlled)	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, “Water Chemistry”	No	VII.E1.AP-79	VII.E1-17(AP-79)

Table 3.3-1 Summary of Aging Management Programs for Auxiliary Systems Evaluated in Chapter VII of the GALL Report							
ID	**Type**	**Component**	**Aging Effect/ Mechanism**	**Aging Management Programs**	**Further Evaluation Recommended**	**Rev2 Item**	**Rev1 Item**
124	BWR/ PWR	Stainless steel, Steel (with stainless steel or nickel-alloy cladding) Spent fuel storage racks (BWR), Spent fuel storage racks (PWR), Piping, piping components, and piping elements; exposed to Treated water >60°C (>140°F), Treated borated water >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"	No	VII.A2.A-96 VII.A2.A-97 VII.A3.A-56 VII.E1.A-103	VII.A2-6(A-96) VII.A2-7(A-97) VII.A3-10(A-56) N/A
125	BWR/ PWR	Steel (with stainless steel cladding); stainless steel Spent fuel storage racks (BWR), Spent fuel storage racks (PWR), Piping, piping components, and piping elements exposed to Treated water, Treated borated water	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"	No	VII.A2.AP-79 VII.A2.A-98 VII.A2.A-99 VII.A3.AP-79 VII.E1.A-102	VII.A2-1(AP-79) N/A N/A VII.A3-8(AP-79) N/A

APPENDIX B

REVISED GALL REPORT

V A	ENGINEERED SAFETY FEATURES Containment Spray System (PWR)						
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
V.A.EP-74	V.A-16(EP-34)	Heat exchanger tubes	Stainless steel	Treated water (borated)	Reduction of heat transfer due to fouling	Chapter XI.M2, “Water Chemistry,” and Chapter XI.M32, “One-Time Inspection”	No
V.A.EP-41	V.A-27(EP-41)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated water (borated)	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
V.A.E-12	V.A-28(E-12)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No

V	ENGINEERED SAFETY FEATURES						
D1	Emergency Core Cooling System (PWR)						
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
V.D1.EP-41	V.D1-30(EP-41)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated water (borated)	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
V.D1.E-12	V.D1-31(E-12)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
V.D1.E-38	V.D1-33(E-38)	Safety injection tank (accumulator)	Steel (with stainless steel or nickel-alloy cladding)	Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
V.D1.E-20		Heat exchanger tubes	Stainless steel	Treated water (borated)	Reduction of heat transfer due to fouling	Chapter XI.M2, “Water Chemistry,” and Chapter XI.M32, “One-Time Inspection"	No

VII AUXILIARY SYSTEMS A2 Spent Fuel Storage							
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
VII.A2.AP-79	VII.A2-1(AP-79)	Piping, piping components, and piping elements	Steel (with stainless steel cladding); stainless steel	Treated borated water	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
VII.A2.A-96	VII.A2-6(A-96)	Spent fuel storage racks (BWR)	Stainless steel	Treated water >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
VII.A2.A-97	VII.A2-7(A-97)	Spent fuel storage racks (PWR)	Stainless steel	Treated borated water >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
VII.A2.A-98		Spent fuel storage racks (BWR)	Stainless steel	Treated water	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
VII.A2.A-99		Spent fuel storage racks (PWR)	Stainless steel	Treated borated water	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No

VII AUXILIARY SYSTEMS A3 Spent Fuel Pool Cooling and Cleanup (PWR)							
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
VII.A3.A-56	VII.A3-10(A-56)	Piping, piping components, and piping elements	Steel (with stainless steel or nickel-alloy cladding)	Treated borated water >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
VII.A3.AP-79	VII.A3-8(AP-79)	Piping, piping components, and piping elements	Steel (with stainless steel cladding); stainless steel	Treated borated water	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, “Water Chemistry” and Chapter XI.M32, “One-Time Inspection”	No
VII.A3.A-101		Heat exchanger tubes	Stainless steel	Treated borated water	Reduction of heat transfer due to fouling	Chapter XI.M2, “Water Chemistry,” and Chapter XI.M32, “One-Time Inspection"	No

VII AUXILIARY SYSTEMS E1 Chemical and Volume Control System (PWR)							
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
VII.E1.AP-79	VII.E1-17(AP-79)	Piping, piping components, and piping elements	Steel (with stainless steel cladding); stainless steel	Treated borated water (Primary, oxygen levels controlled)	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry"	No
VII.E1.AP-82	VII.E1-20(AP-82)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated borated water (Primary, oxygen levels controlled) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry"	No
VII.E1.A-101		Heat exchanger tubes	Stainless Steel	Treated borated water	Reduction of heat transfer due to fouling	Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"	No
VII.E1.A-102		Piping, piping components, and piping elements	Steel (with stainless steel cladding); stainless steel	Treated borated water	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"	No
VII.E1.A-103		Piping, piping components, and piping elements	Stainless steel	Treated borated water >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"	No

APPENDIX C

MARK-UP SHOWING CHANGES TO THE SRP-LR

Additions shown in underline, bold
Deletions marked with strikethrough

Table 3.2-1 Summary of Aging Management Programs for Engineered Safety Features Evaluated in Chapter V of the GALL Report							
ID	**Type**	**Component**	**Aging Effect/Mechanism**	**Aging Management Programs**	**Further Evaluation Recommended**	**Rev2 Item**	**Rev1 Item**
19	BWR/PWR	Stainless steel Heat exchanger tubes exposed to Treated water, **Treated water (borated)**	Reduction of heat transfer due to fouling	Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"	No	V.A.EP-74 V.D2.EP-74 **V.D1.E-20**	V.A-16(EP-34) V.D2-13(EP-34) **N/A**
20	PWR	Stainless steel Piping, piping components, and piping elements; tanks exposed to Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No	V.A.E-12 V.D1.E-12	V.A-28(E-12) V.D1-31(E-12)
21	PWR	Steel (with stainless steel or nickel-alloy cladding) Safety injection tank (accumulator) exposed to Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No	V.D1.E-38	V.D1-33(E-38)
22	PWR	Stainless steel Piping, piping components, and piping elements; tanks exposed to Treated water (borated)	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No	V.A.EP-41 V.D1.EP-41	V.A-27(EP-41) V.D1-30(EP-41)

Table 3.3-1 Summary of Aging Management Programs for Auxiliary Systems Evaluated in Chapter VII of the GALL Report

ID	Type	Component	Aging Effect/ Mechanism	Aging Management Programs	Further Evaluation Recommended	Rev2 Item	Rev1 Item
17	BWR/ PWR	Stainless steel Heat exchanger tubes exposed to Treated water, **Treated borated water**	Reduction of heat transfer due to fouling	Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"	No	VII.A4.AP-139 **VII.A3.A-101** **VII.E1.A-101**	VII.A4-4(AP-62) **N/A** **N/A**
28	~~BWR/~~ PWR	Stainless steel~~, Steel (with stainless steel or nickel-alloy cladding) Spent fuel storage racks (BWR), Spent fuel storage racks (PWR), Piping, piping components, and piping elements,~~ Piping, piping components, and piping elements; tanks exposed to ~~Treated water >60°C (>140°F),~~ Treated borated water **(Primary, oxygen levels controlled)** >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry"	No	~~VII.A2.A-96~~ ~~VII.A2.A-97~~ ~~VII.A3.A-56~~ VII.E1.AP-82	~~VII.A2-6(A-96)~~ ~~VII.A2-7(A-97)~~ ~~VII.A3-10(A-56)~~ VII.E1-20(AP-82)

Table 3.3-1 Summary of Aging Management Programs for Auxiliary Systems Evaluated in Chapter VII of the GALL Report							
ID	**Type**	**Component**	**Aging Effect/ Mechanism**	**Aging Management Programs**	**Further Evaluation Recommended**	**Rev2 Item**	**Rev1 Item**
29	~~BWR/~~ PWR	Steel (with stainless steel cladding); stainless steel Piping, piping components, and piping elements exposed to Treated borated water **(Primary, oxygen levels controlled)**	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry"	No	~~VII.A2.AP-79~~ ~~VII.A3.AP-79~~ VII.E1.AP-79	~~VII.A2-1(AP-79)~~ ~~VII.A3-8(AP-79)~~ VII.E1-17(AP-79)
124	**BWR/ PWR**	**Stainless steel, Steel (with stainless steel or nickel-alloy cladding) Spent fuel storage racks (BWR), Spent fuel storage racks (PWR), Piping, piping components, and piping elements; exposed to Treated water >60°C (>140°F), Treated borated water >60°C (>140°F)**	**Cracking due to stress corrosion cracking**	**Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"**	**No**	**VII.A2.A-96 VII.A2.A-97 VII.A3.A-56 VII.E1.A-103**	**VII.A2-6(A-96) VII.A2-7(A-97) VII.A3-10(A-56) N/A**

Table 3.3-1 Summary of Aging Management Programs for Auxiliary Systems Evaluated in Chapter VII of the GALL Report							
ID	**Type**	**Component**	**Aging Effect/ Mechanism**	**Aging Management Programs**	**Further Evaluation Recommended**	**Rev2 Item**	**Rev1 Item**
125	**BWR/ PWR**	**Steel (with stainless steel cladding); stainless steel Spent fuel storage racks (BWR), Spent fuel storage racks (PWR), Piping, piping components, and piping elements exposed to Treated Water, Treated borated water**	**Loss of material due to pitting and crevice corrosion**	**Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"**	**No**	**VII.A2.AP-79 VII.A2.A-98 VII.A2.A-99 VII.A3.AP-79 VII.E1.A-102**	**VII.A2-1(AP-79) N/A N/A VII.A3-8(AP-79) N/A**

APPENDIX D

MARK-UP SHOWING CHANGES TO THE GALL REPORT

Additions shown in underline, bold
Deletions marked with strikethrough

V ENGINEERED SAFETY FEATURES A Containment Spray System (PWR)							
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
V.A.EP-74	V.A-16(EP-34)	Heat exchanger tubes	Stainless steel	Treated water **(borated)**	Reduction of heat transfer due to fouling	Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"	No
V.A.EP-41	V.A-27(EP-41)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated water (borated)	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No
V.A.E-12	V.A-28(E-12)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No

V ENGINEERED SAFETY FEATURES D1 Emergency Core Cooling System (PWR)							
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
V.D1.EP-41	V.D1-30(EP-41)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated water (borated)	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No
V.D1.E-12	V.D1-31(E-12)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No
V.D1.E-38	V.D1-33(E-38)	Safety injection tank (accumulator)	Steel (with stainless steel or nickel-alloy cladding)	Treated water (borated) >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No
V.D1.E-20		**Heat exchanger tubes**	**Stainless steel**	**Treated water (borated)**	**Reduction of heat transfer due to fouling**	**Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"**	**No**

VII AUXILIARY SYSTEMS A2 Spent Fuel Storage							
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
VII.A2.AP-79	VII.A2-1(AP-79)	Piping, piping components, and piping elements	Steel (with stainless steel cladding); stainless steel	Treated borated water	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No
VII.A2.A-96	VII.A2-6(A-96)	Spent fuel storage racks (BWR)	Stainless steel	Treated water >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No
VII.A2.A-97	VII.A2-7(A-97)	Spent fuel storage racks (PWR)	Stainless steel	Treated borated water >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No
VII.A2.A-98		**Spent fuel storage racks (BWR)**	**Stainless steel**	**Treated water**	**Loss of material due to pitting and crevice corrosion**	**Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"**	**No**
VII.A2.A-99		**Spent fuel storage racks (PWR)**	**Stainless steel**	**Treated borated water**	**Loss of material due to pitting and crevice corrosion**	**Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"**	**No**

VII AUXILIARY SYSTEMS A3 Spent Fuel Pool Cooling and Cleanup (PWR)							
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
VII.A3.A-56	VII.A3-10(A-56)	Piping, piping components, and piping elements	Steel (with stainless steel or nickel-alloy cladding)	Treated borated water >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No
VII.A3.AP-79	VII.A3-8(AP-79)	Piping, piping components, and piping elements	Steel (with stainless steel cladding); stainless steel	Treated borated water	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry" **and Chapter XI.M32, "One-Time Inspection"**	No
VII.A3.A-101		**Heat exchanger tubes**	**Stainless steel**	**Treated borated water**	**Reduction of heat transfer due to fouling**	**Chapter XI.M2, "Water Chemistry," and Chapter XI.M32, "One-Time Inspection"**	**No**

VII AUXILIARY SYSTEMS E1 Chemical and Volume Control System (PWR)							
Item	**Link**	**Structure and/or Component**	**Material**	**Environment**	**Aging Effect/ Mechanism**	**Aging Management Program (AMP)**	**Further Evaluation**
VII.E1.AP-79	VII.E1-17(AP-79)	Piping, piping components, and piping elements	Steel (with stainless steel cladding); stainless steel	Treated borated water **(Primary, oxygen levels controlled)**	Loss of material due to pitting and crevice corrosion	Chapter XI.M2, "Water Chemistry"	No
VII.E1.AP-82	VII.E1-20(AP-82)	Piping, piping components, and piping elements; tanks	Stainless steel	Treated borated water **(Primary, oxygen levels controlled)** >60°C (>140°F)	Cracking due to stress corrosion cracking	Chapter XI.M2, "Water Chemistry"	No
VII.E1.A-101		**Heat exchanger tubes**	**Stainless Steel**	**Treated borated water**	**Reduction of heat transfer due to fouling**	**Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"**	**No**
VII.E1.A-102		**Piping, piping components, and piping elements**	**Steel (with stainless steel cladding); stainless steel**	**Treated borated water**	**Loss of material due to pitting and crevice corrosion**	**Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"**	**No**
VII.E1.A-103		**Piping, piping components, and piping elements**	**Stainless steel**	**Treated borated water >60°C (>140°F)**	**Cracking due to stress corrosion cracking**	**Chapter XI.M2, "Water Chemistry" and Chapter XI.M32, "One-Time Inspection"**	**No**

APPENDIX E

RESOLUTION OF PUBLIC COMMENTS ON DRAFT LR-ISG-2011-01

Comment No.	Comment Source (ADAMS Accession No.)	Comment on Draft LR-ISG-2011-01	NRC Staff Response
1	Nuclear Energy Institute letter dated December 13, 2011 (ML11350A112)	1. Add line items to address loss of material and cracking of CVCS piping exposed to borated water that is not oxygen-controlled. Manage by the Water Chemistry and One-Time Inspection programs. 2. Eliminate the proposed one-time inspection requirement for fouling of CVCS heat exchanger tubes. Operational experience does not support the additional burden and visual inspections would result in significant dose to personnel. 3. Add line items to clarify management of spent fuel pool storage racks for loss of material with the Water Chemistry and One-Time Inspection programs.	1. Comment incorporated 2. No changes to the LR-ISG have been incorporated. The One-Time Inspection program is intended to confirm the insignificance of the reduction of heat transfer aging effect. This guidance does not preclude a license renewal applicant from proposing and justifying other approaches to minimize dosage. 3. Comment incorporated
2	Exelon Generation Company, LLC letter dated December 14, 2011 (ML11353A424)	1. Add line items to address loss of material and cracking of CVCS piping exposed to borated water that is not oxygen-controlled. Manage by the Water Chemistry and One-Time Inspection programs. 2. Eliminate the proposed one-time inspection requirement for fouling of heat exchanger tubes. Rather, recommend performance testing or inspection of different heat exchangers with similar materials and environment that would result in lower radiation dose rates. 3. Add line items to clarify management of spent fuel pool storage racks for loss of material with the Water Chemistry and One-Time Inspection programs.	1. Comment incorporated 2. No changes to the LR-ISG have been incorporated. The LR-ISG provides guidance as to one acceptable approach for managing the effects of aging during the period of extended operation; however, this guidance does not preclude a license renewal applicant from proposing and justifying other approaches. Also, the inspection of comparable heat exchangers to verify that reduction of heat transfer is being adequately managed is consistent with the guidance in the One-Time Inspection program. 3. Comment incorporated