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Light Water Reactor Sustainability Program

Simplified Cost-Benefit Analysis of Subsequent License Renewal

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U.S. Department of Energy

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Simplified Cost-Benefit Analysis of Subsequent License Renewal

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ABSTRACT

The license renewal and subsequent license renewal processes, defined in 10 CFR 54, provide a framework for U.S. nuclear plants to extend their operating licenses, but that process can ultimately result in costly, timely, resource-intensive efforts to satisfy the requirements for license extension. This report provides areas where the cost, time, and resource efforts may be reduced with additional analytical evaluation, model changes, inspection technique changes, and a review of past inspection results.

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EXECUTIVE SUMMARY

The license renewal (LR) and subsequent license renewal (SLR) processes, defined in 10 CFR 54, provide a framework for U.S. nuclear plants to extend their operating licenses, but that process can ultimately result in costly, timely, resource-intensive efforts to satisfy the requirements for license extension. This report provides areas where the cost, time, and resource efforts may be reduced with additional analytical evaluation, model changes, inspection technique changes, and a review of past inspection results.

In order to properly analyze each of the aging management programs (AMPs) that implement LR and SLR requirements for U.S. plants, an overview of the LR/SLR application process, which is submitted to the Nuclear Regulatory Commission, is described. Next, based on experience implementing requirements and commitments at many operating nuclear plants after application approval is received, each of the 56 AMPs in the SLR process were individually reviewed and classified in two ways: first, the AMP was screened as high, medium, or low with respect to the burden to implement; next, the AMP was screened as high, medium, or low with respect to the likelihood of successfully reducing burden. In addition, a summary of each AMP is also presented within this screening context: description, scope, evaluation, and conclusion. Typically, almost all SLR commitments that are made in an SLR application are tied directly to an AMP, which is why a majority of this report focuses on AMPs.

This two-part screening evaluation resulted in dividing the AMPs into three tiers from the highest value to pursue additional efforts to minimize licensee burden to the lowest value to pursue additional efforts to minimize licensee burden. Those tiers are presented below.

Tier 1 AMPs:

- XI.M27: Fire Water System
- XI.M29: Outdoor and Large Atmospheric Metallic Storage Tanks
- XI.M30: Fuel Oil Chemistry
- XI.M32: One-Time Inspection
- XI.M41: Buried and Underground Piping and Tanks
- XI.M42: Internal Coatings/Linings for In-Scope Piping, Piping Components, Heat Exchangers, and Tanks.

Tier 2 AMPs:

- XI.E3A: Electrical Insulation for Inaccessible Medium-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
- XI.E3B: Electrical Insulation for Inaccessible Instrument and Control Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
- XI.E3C: Electrical Insulation for Inaccessible Low-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
- XI.E4: Metal Enclosed Bus

- XI.M16A PWR Vessel Internals
- XI.M33: Selective Leaching
- XI.M35: ASME Code Class 1 Small-Bore Piping.

Tier 3 AMPs:

- All AMPs that are not included in Tier 1 or Tier 2.

Finally, a discussion is included to identify additional opportunities to reduce burden using plant risk information, both within the framework of the AMP exercise presented above and generically. The candidates for risk-informed benefits are discussed in detail in Appendix C, and they include:

- Risk-informed performance-based approaches.
- Experimental capabilities to model degradation mechanisms and methods to accelerate degradation in a laboratory setting.
- Advanced detection and examination methods.
- Modern modeling techniques (e.g., finite element modeling) to predict degradation progression in the next 10, 20, or 40 years. A progression of how future research could be used is included in support of this project.

CONTENTS

TABLES

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ACRONYMS

AISC	American Institute of Steel Construction
AMP	Aging management program
AMR	Aging management review
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American wire gauge
B&W	Babcock & Wilcox
BWR	Boiling-water reactor
BWRVIP	Boiling Water Reactor Vessel and Internals Project
CAD	Computer-aided design
CASS	Case Austenitic Stainless Steel
CCCW	Closed-cycle cooling water
CE	Combustion Engineering
CFD	Computational fluid dynamics
CLB	Current licensing basis
CRD	Control rod drive
CUF	Cumulative usage factor
ECCS	Emergency Core Cooling System
ECT	Eddy current testing
EPRI	Electric Power Research Institute
EQ	Environmental Qualification
FAC	Flow-accelerated corrosion
FOST	Fuel oil storage tanks
GALL	Generic Aging Lessons Learned
GALLSLR	Generic Aging Lessons Learned for Subsequent License Renewal
GL	Generic Letter
HVAC	Heating, ventilation, and air conditioning
IASCC	Irradiation-assisted stress corrosion cracking
ID	Inside diameter
IPA	Integrated plant assessment
LAR	License amendment request
LOCA	Loss-of-coolant accident
LR	License renewal

LRA	License renewal application
LRT	Leak rate test
MC	Metal Containment
MEB	Metal enclosed buses
MIC	Microbiologically influenced corrosion
MRV	Minimum required value
MT	Magnetic-particle testing
NDE	Non-destructive examination
NDT	Non-destructive testing
NEI	Nuclear Energy Institute
NPP	Nuclear power plant
NPS	Nominal pipe size
NRC	Nuclear Regulatory Commission
NSR	Non-safety related
OCCW	Open-cycle cooling water
OE	Operating experience
PEO	Period of extended operation
PLL	Predicted lower limit
PRA	Probabilistic risk analysis
PT	Penetration testing
PWR	Pressurized-water reactor
PWSCC	Primary water stress corrosion cracking
RCS	Reactor coolant system
RI	Risk-informed
RIAM	Risk-informed aging management
RPV	Reactor pressure vessel
RT	Radiography testing
RV	Reactor vessel
RVI	Reactor vessel internal
SC	Structures and components
SCC	Stress corrosion cracking
SLC	Standby liquid control
SLR	Subsequent license renewal
SME	Subject-matter expert
SPEO	Subsequent period of extended operation

SR	Safety-related
SSC	system, structure, and component
TLAA	Time-limited aging analyses
TS	Technical Specification
UT	Ultrasonic testing

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SIMPLIFIED COST-BENEFIT ANALYSIS OF SUBSEQUENT LICENSE RENEWAL

1. INTRODUCTION

The purpose of this report is to identify areas of burden and areas in which the relaxation of subsequent license renewal (SLR) application commitments are both possible and can be achieved while adhering to all regulatory requirements. These burdens include cost, time, labor, radiological protection, and risk to plant personnel or equipment. Commitments that incorporate risk insights would allow flexibility in plant operations and long-term cost savings. A general assessment of the SLR commitments that must be fulfilled by a typical nuclear power plant (NPP) in order for the SLR application to be approved are considered in this report.

Currently, an SLR application is largely a deterministic process, and benefits can be gained by supplementing deterministic analyses with risk insights. U.S. NPPs are extending their lifespan to 80 years, and SLR commitments add up to significant costs over the approximately 30-year subsequent period of extended operation (SPEO) (10 years prior to the SPEO and the remaining 20 years of operation). Commitments that incorporate risk insights would allow flexibility in plant operations and long-term cost savings.

Additionally, there are other potential opportunities for research in the area of aging management reviews and AMPs. These may include experimental capabilities, system/plant modeling, and advanced detection and examination methods. Each of these areas could result in relief for both individual plants submitting SLR applications (SLRAs) and regulatory guidance changes for the U.S. nuclear industry. The integrated plant assessment (IPA) that is used to develop a license renewal (LR) application (LRA, 40–60 years) or subsequent LRA (SLRA, 60–80 years) has multiple steps defined in 10 CFR 54.21. Each of these has Nuclear Regulatory Commission (NRC)-accepted methodologies with the Nuclear Energy Institute (NEI) [1–3] and Electric Power Research Institute Lab (EPRI) [4–8] guidance documents to assist in industry best practices. These steps have now been established and rigorously reviewed through 69 applications to date, eight of which are SLRAs.

2. METHODOLOGY

This report provides insights based on actual examples or subject-matter expert (SME) input on innovations for each step through a simplified "cost-benefit analysis." These steps include:

- Scoping: 10 CFR 54.4 contains requirements for plant systems, structures, and components that are required to be in scope of an LR.
- Screening: Only passive long-lived components are required to be managed for aging in the period of extended operation or SPEO. This step removes active components (or subcomponents) and those that are routinely replaced.
- Aging Management Review: This process breaks down the plant systems into component types, materials, environments, and applicable aging effects that require management. The guidance for this comes from the NRC but has a basis in EPRI technical reports (the "EPRI tools") [4–8] for defining how and where aging mechanisms can occur.
- Aging Management Programs (AMPs): Ultimately, a plant will form commitments to individual AMPs and potentially stand-alone commitments (component replacements, one-time inspections of specific equipment, etc.). Much of what a licensee commits to is based on a plant-specific operating experience, but there are general expectations the NRC has for all applicants.

Each step in the IPA has potential areas to reduce burden to plants through risk applications, experimental capabilities, system/plant modeling, and advanced detection and examination methods.

The following opportunities were evaluated to reduce burden using the following methodology:

1. Identify the scope of AMPs that are applicable to the LRA and SLRA scope. There is some variation in AMPs depending on reactor type (i.e., boiling-water reactor [BWR] or pressurized-water reactor [PWR]). NRC guidance for AMPs is applicable for any large light-water reactor.
2. Identify a particular AMP's scope. Licensees develop the AMP scope for a particular plant based on the equipment matching the 10 CFR 54.4 definitions and the current licensing basis (CLB). Note: a typical AMP scope is used herein.
3. Evaluate the scope of review, monitoring, inspection, and frequency of monitoring/inspection actions required for the equipment under a given AMP.
4. Identify additional NRC regulatory requirements. In many cases, there are additional NRC regulatory requirements associated with the AMP. This includes any regulations that already contain an aging management component (e.g., equipment qualification in 10 CFR 50.49).
5. Review conclusion of the factors described above. The review focuses on the cumulative impact of the AMP on plant resources and the ability to reduce the burden.

Appendix D describes the areas and opportunities to reduce burden to the plant. Specifically for risk applications, probabilistic risk analysis (PRA) concepts and expertise were used to provide context for successful risk applications in other regulatory areas as part of the simplified cost-benefit. A literature review of ongoing initiatives currently being pursued by other organizations (e.g., EPRI and NEI) and successful risk applications in other areas of the nuclear industry proved useful in understanding the existing industry landscape.

3. ANALYSIS

Listed in Table 1 are each AMP and title. Below are a description, scope, and evaluation of what each AMP provides in the LRA process. LR AMPs are directly applicable to SLR AMPs, so a duplicate list was not required.

Table 1. AMPs associated with SLRA.

AMP #	Title
X.E1	Environmental Qualification (EQ) of Electrical Components
X.M1	Fatigue Monitoring
X.M2	Neutron Fluence Monitoring
X.S1	Concrete Containment Unbonded Tendon Prestress
XI.E1	Electrical Insulation for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
XI.E2	Electrical Insulation for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Used in Instrumentation Circuits
XI.E3A	Electrical Insulation for Inaccessible Medium-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
XI.E3B	Electrical Insulation for Inaccessible Instrument and Control Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements

Table 1. (continued).

AMP #	Title
XI.E3C	Electrical Insulation for Inaccessible Low-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
XI.E4	Metal-Enclosed Bus
XI.E5	Fuse Holders
XI.E6	Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
XI.E7	High-Voltage Insulators
XI.M1	ASME Section XI Inservice Inspection, Subsection IWB, IWC, and IWD
XI.M2	Water Chemistry
XI.M3	Reactor Head Closure Stud Bolting
XI.M4	BWR Vessel ID Attachment Welds
XI.M7	BWR Stress Corrosion Cracking
XI.M8	BWR Penetrations
XI.M9	BWR Vessel Internals
XI.M10	Boric Acid Corrosion
XI.M11B	Cracking of Nickel-Alloy Components and Loss of Material Due to Boric Acid-Induced Corrosion in Reactor Coolant Pressure Boundary Components (PWR Only)
XI.M12	Thermal Aging Embrittlement of Case Austenitic Stainless Steel (CASS)
XI.M16A	PWR Vessel Internals
XI.M17	Flow-Accelerated Corrosion
XI.M18	Bolting Integrity
XI.M19	Steam Generators
XI.M20	Open-Cycle Cooling Water System
XI.M21A	Closed Treated Water Systems
XI.M22	Boraflex Monitoring
XI.M23	Inspection of Overhead Heavy Load and Light Load (Related to Refueling) Handling Systems
XI.M24	Compress Air Monitoring
XI.M25	BWR Reactor Water Cleanup System
XI.M26	Fire Protection
XI.M27	Fire Water System
XI.M29	Outdoor and Large Atmospheric Metallic Storage Tanks
XI.M30	Fuel Oil Chemistry
XI.M31	Reactor Vessel Material Surveillance
XI.M32	One-Time Inspection
XI.M33	Selective Leaching

Table 1. (continued).

AMP #	Title
XI.M35	ASME Code Class 1 Small-Bore Piping
XI.M36	External Surfaces Monitoring of Mechanical Components
XI.M37	Flux Thimble Tube Inspection
XI.M38	Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components
XI.M39	Lubricating Oil Analysis
XI.M40	Monitoring of Neutron-Absorbing Materials Other Than Boraflex
XI.M41	Buried and Underground Piping and Tanks
XI.M42	Internal Coatings/Linings for In-Scope Piping, Piping Components, Heat Exchangers, and Tanks
XI.S1	ASME Section XI, Subsection IWE
XI.S2	ASME Section XI, Subsection IWL
XI.S3	ASME Section XI, Subsection IWF
XI.S4	10 CFR 50, Appendix J
XI.S5	Masonry Walls
XI.S6	Structures Monitoring
XI.S7	Inspection of Water-Control Structures Associated with Nuclear Power Plants
XI.S8	Protective Coating Monitoring and Maintenance

A discussion of each AMP is provided in Appendix A. The details of each AMP are provided in a description, scope, and evaluation.

4. RESULTS

The results of each AMP as a candidate for further study in the cost/benefit analysis are provided in Table 2. A summary of the basis for concluding that continued Cost/Benefit Analysis research is also provided in this section.

Table 2. AMP Determination for Continued Cost/Benefit Analysis.

AMP #	Title
Analysis Conclusion	
X.E1	Environmental Qualification (EQ) of Electrical Components
This is an existing program that does not place undue burden on the site resources. The 10 CFR 50.49 (risk-informed [RI] engineering programs) is applicable to EQ; therefore, the station has a path to RI EQ. This program would not benefit from further evaluation to reduce inspection labor or cost.	
X.M1	Fatigue Monitoring
This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.	
X.M2	Neutron Fluence Monitoring
This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.	
X.S1	Concrete Containment Unbonded Tendon Prestress

Table 2. (continued).

AMP #	Title
Analysis Conclusion	
This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.	
XI.E1	Electrical Insulation for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.E2	Electrical Insulation for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Used in Instrumentation Circuits
This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.E3A	Electrical Insulation for Inaccessible Medium-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
This program may benefit from further evaluation to reduce inspection labor or cost.	
XI.E3B	Electrical Insulation for Inaccessible Instrument and Control Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
This program may benefit from further evaluation to reduce inspection labor or cost.	
XI.E3C	Electrical Insulation for Inaccessible Low-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
This program may benefit from further evaluation to reduce inspection labor or cost.	
XI.E4	Metal-Enclosed Bus
Based on plant-specific LR inspection results, an evaluation could provide justification for performing a one-time inspection in the SPEO. This program may benefit from further evaluation to reduce the frequency of inspections and cost.	
XI.E5	Fuse Holders
This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce labor or cost.	
XI.E6	Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce labor or cost.	
XI.E7	High-Voltage Insulators
This program would not benefit from further evaluation to reduce labor or cost.	
XI.M1	ASME Section XI Inservice Inspection, Subsection IWB, IWC, and IWD
This is an existing station program (required by station technical specifications [TSs]) and generally does not have further LR-related enhancements. This program has benefited from numerous RI options, which stations have incorporated. Review additional RI options to determine whether these, or additional options, may be beneficial.	
XI.M2	Water Chemistry

Table 2. (continued).

<table>
<tr><th>AMP #</th><th>Title</th></tr>
<tr><th colspan="2">Analysis Conclusion</th></tr>
<tr><td colspan="2">This is an existing program that does not place undue burden on the site resources. This is a program the station implements to preserve the integrity of components in contact with treated water. This program would not benefit from further evaluation to reduce inspection labor or cost.</td></tr>
<tr><td>XI.M3</td><td>Reactor Head Closure Stud Bolting</td></tr>
<tr><td colspan="2">This is an existing LR AMP. With a favorable review of plant-specific and industry operating experience (OE), the frequency of inspections in the SPEO may be increased. This program may benefit from further evaluation to reduce inspection labor or cost.</td></tr>
<tr><td>XI.M4</td><td>BWR Vessel ID Attachment Welds</td></tr>
<tr><td colspan="2">This is an existing LR AMP. This program is required by ASME Section XI code and prescribed by the NRC-accepted Boiling Water Reactor Vessel and Internals Project (BWRVIP)-48-A report. This program would not benefit from further evaluation to reduce inspection labor or cost.</td></tr>
<tr><td>XI.M7</td><td>BWR Stress Corrosion Cracking</td></tr>
<tr><td colspan="2">This is an existing LR AMP. This program is required by NUREG-0313 and the licensees’ response to generic letter (GL) 88-01. This program would not benefit from further evaluation to reduce inspection labor or cost.</td></tr>
<tr><td>XI.M8</td><td>BWR Penetrations</td></tr>
<tr><td colspan="2">This is an existing LR AMP. NRC approved BWRVIP guidance documents for SLR inspections. The reduction of the type, number, and frequency of BWR vessel internal inspections would require extensive testing and investigation to justify any changes. This program would not benefit from further evaluation to reduce inspection labor or cost.</td></tr>
<tr><td>XI.M9</td><td>BWR Vessel Internals</td></tr>
<tr><td colspan="2">This is an existing LR AMP. NRC approved the BWRVIP guidance documents for SLR inspections. The reduction of the type, number, and frequency of BWR vessel internal inspections would require extensive testing and investigation to justify any changes. This program would not benefit from further evaluation to reduce inspection labor or cost.</td></tr>
<tr><td>XI.M10</td><td>Boric Acid Corrosion</td></tr>
<tr><td colspan="2">This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.</td></tr>
<tr><td>XI.M11B</td><td>Cracking of Nickel-Alloy Components and Loss of Material Due to Boric Acid-Induced Corrosion in Reactor Coolant Pressure Boundary Components (PWR Only)</td></tr>
<tr><td colspan="2">This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.</td></tr>
<tr><td>XI.M12</td><td>Thermal Aging Embrittlement of Case Austenitic Stainless Steel (CASS)</td></tr>
<tr><td colspan="2">This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.</td></tr>
<tr><td>XI.M16A</td><td>PWR Vessel Internals</td></tr>
<tr><td colspan="2">This is an existing LR AMP. NRC approved the guidance document MRP-227-A (as supplemented) for SLR inspections. The licensee may submit a generic AMP for approval which would require extensive support work for approval. It should be noted that industry events have impacted the reactor</td></tr>
</table>

Table 2. (continued).

AMP #	Title
Analysis Conclusion	
vessel internal (RVI) program and may change the RVI program requirements. This program should be monitored for any evolving changes in scope.	
XI.M17	Flow-Accelerated Corrosion
This is an existing LR AMP required by NUREG-1344 and GL 89-08 response. This program may benefit from further evaluation to reduce inspection labor or cost by implementing RI criteria.	
XI.M18	Bolting Integrity
This is an existing LR AMP. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M19	Steam Generators
This is an existing LR AMP that is a TS-required program. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M20	Open-Cycle Cooling Water System
This is an existing LR AMP that is based on the licensee's response to GL 89-13. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M21A	Closed Treated Water Systems
This is an existing LR AMP that has a low impact on labor and a high value for preventing loss of material and cracking due to corrosion and stress corrosion cracking (SCC). This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M22	Boraflex Monitoring
This is an existing LR AMP that has a low impact on labor. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M23	Inspection of Overhead Heavy Load and Light Load (Related to Refueling) Handling Systems
This is an existing LR AMP that has a low impact on labor and high value on safety. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M24	Compressed Air Monitoring
This is an existing LR AMP. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M25	BWR Reactor Water Cleanup System
This is an existing LR AMP that is required by NRC NUREG and GL. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M26	Fire Protection
This is an existing LR AMP. Most inspections for this AMP are required by the National Fire Protection Association (NFPA) code and the fire protection insurer. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M27	Fire Water System
This is an existing LR AMP. Many of the inspections for this AMP are required by the NFPA code and the fire protection insurer. If the fire water system has been on treated water from installation, evaluation of previous inspections for blockage data could provide justification for extending the	

Table 2. (continued).

AMP #	Title
Analysis Conclusion	
normally dry piping inspection frequency. There are also options to modify the plant in lieu of certain inspections/testing (e.g., sprinkler and non-draining sections). This program could benefit from further evaluation to reduce inspection labor or cost.	
XI.M29	Outdoor and Large Atmospheric Metallic Storage Tanks
This is an existing LR AMP. This program may benefit from further evaluation to reduce inspection labor or cost. Specifically, further evaluation into performing volumetric tank bottom inspections without requiring the draining of the respective tank could reduce cost.	
XI.M30	Fuel Oil Chemistry
This is an existing LR AMP. May be able to justify increasing the inspection frequency based on plant OE and environmental conditions. (e.g., at least one utility will inspect their fuel oil storage tanks [FOST] on a 20-year frequency). This program may benefit from further evaluation to reduce inspection labor or cost.	
XI.M31	Reactor Vessel Material Surveillance
This is an existing AMP required by 10 CFR Part 50, Appendix H. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M32	One-Time Inspection
This is an existing program that will require review of plant history of one-time inspections or periodic inspections from the LR program. Experimental testing of specific materials could provide data for justification for reduced testing of components. Review of industry OE from the LR programs may provide data for justification for reduced testing of certain material-environment combinations. A RI program could reduce the number of inspections based on those material/environment combinations that have resulted in increased aging effects. This program would benefit from further evaluation to reduce inspection labor or cost.	
XI.M33	Selective Leaching
This is an existing program that will require reviewing the plant history of selective leaching to determine whether one-time inspections or periodic inspections are required. Experimental testing of specific materials could provide data for justification to reduce component testing. This program would benefit from further evaluation to reduce inspection labor or cost, including timing the inspections and test concurrently with other AMP's respective inspections and tests (e.g., perform selective leaching opportunistic inspections when the buried and underground piping and tanks AMP performs excavations).	
XI.M35	ASME Code Class 1 Small-Bore Piping
This is an existing LR AMP that will require reviewing the plant history of cracking on in-scope small-bore piping. This program would benefit from further evaluation to reduce inspection labor or cost.	
XI.M36	External Surfaces Monitoring of Mechanical Components
This is an existing LR AMP that is incorporated into the system owner's system walkdown program. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M37	Flux Thimble Tube Inspection
This is an existing program that is required by the licensee's response to NRC Bulletin 88-09. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M38	Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components

Table 2. (continued).

AMP #	Title
Analysis Conclusion	
This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M39	Lubricating Oil Analysis
This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M40	Monitoring of Neutron-Absorbing Materials Other Than Boraflex
This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.M41	Buried and Underground Piping and Tanks
This program may benefit from further evaluation to reduce inspection manpower or cost. The most beneficial factor in the reduction of buried piping inspections is to meet the acceptance criteria for an installed, induced-current, cathodic protection system. This reduces the number of required buried piping inspections which are very costly. It may also be beneficial to review site specific buried piping inspection results to determine if the preventative measure, coatings, backfill and cathodic protection, have been effective in controlling aging. If the results of the review are favorable, an argument could be developed to justify reduction of the number of inspections.	
XI.M42	Internal Coatings/Linings for In-Scope Piping, Piping Components, Heat Exchangers, and Tanks
This LR AMP may benefit from further evaluation to reduce inspection labor or cost. Identifying ways of examining internal coatings without draining the components (e.g., tanks) could reduce the licensee burden. Experimental testing of existing coatings, operating in an in-service environment, could provide justification for the extension of the inspection frequency.	
XI.S1	ASME Section XI, Subsection IWE
This program that is required by 10 CFR 50.55a would not benefit from further evaluation to reduce inspection labor or cost.	
XI.S2	ASME Section XI, Subsection IWL
This program that is required by 10 CFR 50.55a would not benefit from further evaluation to reduce inspection labor or cost.	
XI.S3	ASME Section XI, Subsection IWF
This program that is required by 10 CFR 50.55a would not benefit from further evaluation to reduce inspection labor or cost.	
XI.S4	10 CFR 50, Appendix J
This LR AMP that is required by 10 CFR 50, Appendix J would not benefit from further evaluation to reduce inspection labor or cost.	
XI.S5	Masonry Walls
This is an existing program that does not place undue burden on the site resources, consists of visual inspections by qualified inspectors every 5 years, and would not benefit from further evaluation to reduce inspection labor or cost.	
XI.S6	Structures Monitoring

Table 2. (continued).

AMP #	Title
Analysis Conclusion	
This is an existing program that does not place undue burden on the site resources, is monitored under 10 CFR 50.65, and consists of visual inspections by qualified inspectors every 5 years. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.S7	Inspection of Water-Control Structures Associated with Nuclear Power Plants
This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost.	
XI.S8	Protective Coating Monitoring and Maintenance
This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection labor or cost. Inspection frequency has been extended to every 6 years, based on emergency core cooling system (ECCS) suction strainers debris margin.	

4.1 Basis for AMPs Identified as Beneficial

The basis for the AMPs identified as benefiting from continued cost/benefit analysis are provided below.

4.1.1 XI.E3 (Series)

XI.E3A – Electrical Insulation for Inaccessible Medium-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements

XI.E3B – Electrical Insulation for Inaccessible Instrument and Control Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements

XI.E3C – Electrical Insulation for Inaccessible Low-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements

These programs are grouped together in this discussion as the licensee burden associated with them is similar across all 3 programs. The location of many of these cables (i.e., underground vaults or manholes) is problematic for allowing of access to perform inspections. In most cases, large cranes must be employed to remove concrete shields to allow access to the cables. This represents a high hazard lift which must be carefully planned in each instance to maintain personnel safety. In cases where a site has several manholes, the frequency of inspection may be such that a high hazard lift takes place almost every week which elevates overall plant risk.

4.1.2 XI.E4 - Metal-Enclosed Bus

The metal-enclosed bus program is listed because of the risk associated with accessing and inspecting the in-scope components. Clearance order development must be carefully controlled as the associated voltages are deadly from a personnel safety standpoint. Also, removal from service and restoration, if not done correctly, will cause operational impacts and challenge plant operation. In addition, defense in depth is reduced as inspections take place, so the plant risk profile is challenged when these activities take place. It is advantageous to complete the inspections quickly or perform them less often to restore the affected metal-enclosed bus to service.

4.1.3 XI.M16A - PWR Vessel Internals

The PWR internals program challenges are significant financially. Highly specialized tooling must be developed, qualified, demonstrated, and sometimes reserved years ahead of its use to do these inspections. They can obviously only be done during periods when the core is offloaded (i.e., the most demanding period during a refueling outage) and impacts from possible discovery present enterprise level risk. Therefore, contingency planning must start years ahead of time and must be as robust as any planning for the outage. For the reasons above, the cost associated with these exams is very significant.

4.1.4 XI.M27 - Fire Water System

The Fire Water System program is a burden for licensees to implement due to a number of factors including the volumetric inspection of tanks and visual inspection of non-draining piping sections. The volumetric tank inspection requires special tools, equipment, certifications, and personnel. In addition, those tanks are infrequently inspected so planning and execution of the inspections are non-routine activities. Also, the inspection of non-draining piping sections has the potential to be a very large scope based on plant configuration. With a large volume of piping sections, clearance writing for isolation must be carefully controlled and coordinated with fire watches and/or compensatory measures to ensure safety from a fire standpoint in the affected areas. Identification of significant blockage triggers an immediate need to correct the condition due to those fire watches and/or compensatory measures in order to restore the system to its design function. Therefore, contingency planning ahead of these inspections must be very robust. In summary, the depth of contingency planning, coordination among work groups, and careful attention to detail required for isolating parts of the system make this effort a burden for the licensee.

4.1.5 XI.M29 - Outdoor and Large Atmospheric Metallic Storage Tanks

The XI.M29 program carries a significant cost associated with the volumetric inspection of the large tank bottoms as well as a large operational impact if those tanks must be drained to facilitate inspection. Many of these tanks are safety related and hold significant water volume that must be orchestrated and controlled during refueling outages. So, removing the water for inspection (and any possible repairs) for any length of time presents a challenge for water inventory and storage. Careful planning must be employed to ensure proper water inventory at various points during the refueling outage. If the tank is inspected with the water not drained (i.e., underwater robot technology), there are very strict controls that must be maintained from a foreign material perspective so important plant equipment is not rendered inoperable due to loss of control of the robot. In addition, this type of technology is often very costly and when it has to be employed for multiple tanks on a plant site, it becomes even more costly.

4.1.6 XI.M30 - Fuel Oil Chemistry

The primary burden associated with the Fuel Oil Chemistry program is the inspection of diesel fuel tanks. This evolution must take place when the associated emergency diesel generator(s) is(are) out of service for maintenance (i.e., 'diesel outage'). These outages are carefully planned and scripted like a mini-refueling outage since many utilities have short timeframes that the diesel can be out of service. With only a 7 day window in many cases, the duration to drain, clean, inspect, potentially repair, and restore the system (all while other diesel work activities are in progress) is a significant burden. Contingency plans, parts, personnel, etc. all must be on standby in the event any degradation is detected requiring a repair.

4.1.7 XI.M32 - One-Time Inspection

The One-Time Inspection program carries a burden to implement due to the large number of required inspections and the complexities associated with many of those inspections. Clearances, work order planning, scaffold build/removal, insulation removal/reinstallation, inspection with qualified individuals, post maintenance testing, etc. all must take place for each individual inspection. Since the premise for the program is a wide range, sample-based approach, there is a limited ability to combine a cluster of components under one clearance or work order. In addition, many of the unique material/environment combinations that require inspection exist in systems that may not routinely be inspected, so operational alignments for taking some of these components out of service present unique, sometimes first-of-a-kind (FOAK) challenges to licensees from an operational standpoint.

4.1.8 XI.M33 – Selective Leaching

The licensee burden associated with selective leaching is somewhat new and still evolving. Many plants have very little experience with selective leaching, but it has a few aspects that represent the burden. First, many in scope components are buried and exposed to soil (see discussion on XI.M41 for difficulties inspecting buried components). Also, the unknowns associated with potential extent of condition, future periodicity of inspections, etc. when selective leaching is found pose problems for many plants. Finally, the methods for inspection have not historically yielded highly reliable results. Visual inspection remains the most reliable method to detect selective leaching and it is not accurate with respect to the prediction of the rate of degradation. For these reasons, licensees sometimes struggle with the implementation aspects of selective leaching.

4.1.9 XI.M35 – ASME Code Class 1 Small-Bore Piping

Since the small-bore socket weld program applies only to ASME Class 1, the inspection of those components usually represents very high-risk locations. Any findings that compromise the reactor coolant pressure boundary will result in NRC notifications. Also, any repairs or replacements will have to meet ASME Code Class 1 requirements so parts, equipment, procedures, etc. must be prepared well in advance of inspections or plant staff will be responding to an emergent issue that possibly threatens outage duration. While destructive testing can be performed to reduce the number of UT exams, it is likewise a major evolution to remove ASME Code Class 1 welds from service for destructive exams. In some rare cases, opportunistic destructive exams present themselves for non-LR work and those can be credited for this program. Aside from those opportunities, this program poses hardships to the licensee.

4.1.10 XI. M41 - Buried and Underground Piping and Tanks

The buried piping program challenges are typically the most well-known challenges in LR/SLR implementation. Excavation of in scope piping presents personnel safety challenges associated with entering the trench and site excavation, operational challenges where safety related piping is exposed for days, and financial challenges for external vendors, specialized equipment, etc. Also, in cases where the piping must be exposed to bare metal to facilitate inspection (removal of all protective coatings), there is risk in reapplying the coating and restoring backfill that may create degradation sites where none existed previously. While buried piping must remain in good health to support safe operation of the plant, there are significant challenges as discussed above associated with these inspections.

4.1.11 XI.M42 - Internal Coatings/Linings for In-Scope Piping, Piping Components, Heat Exchangers, and Tanks

Similar to XI.M29, the same challenges exist in this program for inspection of tanks (i.e., draining, water inventory, equipment). In addition, some of the other components within the scope of this program may not be routinely taken out of service or inspected so making those components accessible is sometimes a new evolution (or rarely performed). Finally, this program presents difficulty in personnel qualifications to perform the inspections. The certifications required to meet the criteria are quite rare so in many cases, there may only be one or two qualified personnel within a utility's organization that can perform the coatings inspections at a plant site. This poses problems from a resource management standpoint.

5. REFERENCES

1. NEI. 2005. “Industry Guideline for Implementing the Requirements of 10 CFR Part 54 The License Renewal Rule.” NEI 95-10, Rev. 6, *Nuclear Energy Institute*, Jun. 2005. https://www.nrc.gov/docs/ML0518/ML051860406.pdf.

2. NEI. 2017. “Industry Guideline for Implementing the Requirements of 10 CFR Part 54 for Subsequent License Renewal.” NEI 17-01, Rev. 0, *Nuclear Energy Institute*, Mar. 2017. https://www.nrc.gov/docs/ML1733/ML17339A599.pdf.

3. NEI. 2020. “Aging Management Program Effectiveness.” NEI 14-12, Revision 1, *Nuclear Energy Institute,* Sep. 2020. https://www.nrc.gov/docs/ML1509/ML15090A665.pdf.

4. EPRI. 2006. “Non-Class 1 Mechanical Implementation Guideline and Mechanical Tools, Revision 4.” Technical Report, *Electric Power Research Institute*, Palo Alto, CA: No. 1010639, Jan. 23, 2006: pp. 462. https://www.epri.com/research/products/000000000001010639.

5. EPRI. n.d. “Plant Support Engineering: Aging Effects for Structures and Structural Components (Structural Tools).” No. 1015078, Technical Report, *Electric Power Research Institute*, Palo Alto, CA: Dec. 21, 2007: pp. 272. https://www.epri.com/research/products/1015078.

6. EPRI. 2018. “Long-Term Operations: Subsequent License Renewal Non-Class 1 Mechanical Implementation Guideline and Mechanical Tools.” No. 3002011822, Final Technical Report, *Electric Power Research Institute*, Palo Alto, CA: Apr. 30, 2018: pp. 346. https://www.epri.com/research/products/3002011822.

7. EPRI. 2018. “Long-Term Operations: Subsequent License Renewal Aging Effects for Structures and Structural Components (Structural Tools).” No. 3002013084, Final Technical Report, *Electric Power Research Institute*, Palo Alto, CA: Nov. 2018.

8. EPRI. 2018. “Long-Term Operations: Subsequent License Renewal Electrical Handbook.” No. 3002010401, Final Technical Report, *Electric Power Research Institute*, Palo Alto, CA: Apr. 27, 2018: pp. 350. https://www.epri.com/research/products/3002010402.

9. U.S. NRC. 2017. “Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report.” NUREG-2191, vol. 2, Rev. 0, United States Nuclear Regulatory Commission, Office of Nuclear Regulation, May 2017. https://www.nrc.gov/docs/ML1718/ML17187A204.pdf.

10. U.S. NRC. 2010. “Generic Aging Lessons Learned (GALL) Report.” Final NUREG-1801, Rev. 2, United States Nuclear Regulatory Commission, Office of Nuclear Regulation, Dec. 2010. https://www.nrc.gov/docs/ML1034/ML103490041.pdf.

11. EPRI. 2022. “Leveraging Risk Insights for Aging Management Program Implementation.” No. 3002020713, Technical Report, *Electric Power Research Institute*, Palo Alto, CA: Apr. 2022.

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Appendix A
AMP Evaluations

This appendix contains reports of each of the AMPs required in NUREG-1801, Revision 2.

A-1. AMPs

A-1.1 Section X AMPs

- **X.E1: Environmental Qualification (EQ) of Electrical Components**
  - Description:

    The NRC has established nuclear station EQ requirements in 10 CFR Part 50, Appendix A, Criterion 4, and 10 CFR 50.49. 10 CFR 50.49 specifically requires that an EQ program be established to demonstrate that certain electrical equipment located in harsh plant environments [that is, those areas of the plant that could be subject to the harsh environmental effects of a loss-of-coolant accident (LOCA), high energy line break and post-LOCA environment] are qualified to perform their safety function in those harsh environments after the effects of in service (operational) aging. 10 CFR 50.49 requires that the effects of significant aging mechanisms be addressed as part of EQ.

    For equipment located in a harsh environment, the objective of EQ is to demonstrate with reasonable assurance that electric equipment important to safety, for which a qualified life has been established, can perform its safety function(s) without experiencing common cause failures before, during or after applicable design basis events.

    For equipment located in a mild environment (an environment that at no time would be significantly more severe than the environment occurring during normal operation, including anticipated operational occurrences as defined in 10 CFR 50.49), the demonstration that the equipment meets its functional requirements during normal environmental conditions and anticipated operational occurrences is in accordance with the plant design and licensing basis. Equipment important to safety located in a mild environment is not part of an EQ program per 10 CFR 50.49(c). Documents that demonstrate that a component is qualified or designed for a mild environment include design/purchase specifications, seismic test qualification reports, an evaluation, or certificate of conformance.
  - Scope:

    EQ programs apply to certain electrical equipment that are important to safety and could be exposed to harsh environment accident conditions, as defined in 10 CFR 50.49 and RG 1.89, Revision 1. Plant EQ programs along with Generic Aging Lessons Learned (GALL)-SLR Report AMP X.E1 demonstrate acceptability of the EQ electrical equipment time-limited aging analyses (TLAA) analysis under 10 CFR 54.21(c)(1).
  - Evaluation:

    10 CFR 50.49 does not require the detection of aging effects for in service EQ equipment. EQ program actions that could be viewed as detection of aging effects include (a) inspecting EQ equipment periodically with particular emphasis on monitoring or condition assessment and (b) monitoring of plant environmental conditions or component parameters used to verify that the equipment is within the bounds of its EQ basis including attributes, assumptions, and conservatisms for equipment/environmental conditions and other factors. Monitoring or

inspection of certain environmental conditions or component parameters may provide a means to maintain equipment qualified life.

Visual inspection of accessible, passive EQ equipment is performed at least once every 10 years. The purpose of the visual inspection is to identify adverse localized environments that may impact qualified life. Potential adverse localized environments are evaluated through the applicant's corrective action program. The first periodic visual inspection is to be performed prior to the SPEO.

- Conclusion:

  This is an existing program that does not place undue burden on the site resources. 10 CFR 50.49 (Risk-Informed Engineering Programs) is applicable to EQ, therefore the station has a path to risk-inform EQ. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **X.M1: Fatigue Monitoring**

  - Description:

    This AMP provides an acceptable basis for managing structures and components (SCs) that are the subject of fatigue or cycle-based TLAAs or other analyses that assess fatigue or cyclical loading, in accordance with the requirements in 10 CFR 54.21(c)(1)(iii). Examples of cycle-based fatigue analyses for which this AMP may be used include, but are not limited to: (a) cumulative usage factor (CUF) analyses or their equivalent that are performed in accordance with American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements for specific mechanical or structural components; (b) fatigue analysis calculations for assessing environmentally-assisted fatigue; (c) implicit fatigue analyses, as defined in the United States of America Standards (USAS) B31.1 design code or ASME Code Section III rules for Class 2 and Class 3 components; (d) fatigue flaw growth analyses that are based on cyclical loading assumptions; (e) fracture mechanics analyses that are based on cycle-based loading assumptions; and (f) fatigue waiver or exemption analyses that are based on cycle-based loading assumptions. This program may be used for fatigue analyses that apply to mechanical or structural components.

    Fatigue of components is managed by monitoring one or more relevant fatigue parameters, which include, but are not limited to, the CUF factors, the environmentally adjusted (CUFen), transient cycle limits, and the predicted flaw size (for a fatigue crack growth analysis). The limit of the fatigue parameter is established by the applicable fatigue analysis and may be a design limit, for example, from an ASME Code fatigue evaluation; an analysis-specific value, for example, based on the number of cyclic load occurrences assumed in a fatigue exemption evaluation; or the acceptable size of a flaw identified during an in-service inspection.

  - Scope:

    The scope includes those mechanical or structural components with a fatigue TLAA or other analysis that depends on the number of occurrences and severity of transient cycles. The program monitors and tracks the number of occurrences and severity of thermal and pressure transients for the selected components, to ensure that they remain within the plant-specific limits. The program ensures that the fatigue analyses remain within their allowable limits, thus minimizing the likelihood of failures from fatigue-induced cracking of the components caused by cyclic strains in the component's material. In addition, the program can be used to monitor actual plant operating conditions for component locations with stress-based fatigue calculations (i.e., stress-based CUF calculations) to perform updated evaluations of the fatigue analyses to ensure they continue to meet the design limits.

For the purposes of ascertaining the effects of the reactor water environment on fatigue, applicants include CUFen calculations for a set of sample reactor coolant system components. This sample set includes the locations identified in NUREG/CR–6260 and additional plant-specific component locations in the reactor coolant pressure boundary if they may be more limiting than those considered in NUREG/CR–6260. Plant-specific justification can be provided to demonstrate that calculations for the NUREG/CR–6260 locations do not need to be included. Component locations within the scope of this program are updated based on OE, plant modifications, and inspection findings.

- Evaluation:

  The program uses applicant defined activities or methods to track the number of occurrences and severity of design basis transient conditions, and any applicable plant operating conditions used to inform updated evaluations of the fatigue analyses. Monitoring of water chemistry parameters that are inputs to environmentally assisted fatigue calculations may be performed in accordance with the implementation of this AMP or an applicant's Water Chemistry Program. TS requirements may apply to these activities.

- Conclusion:

  This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

• **X.M2: Neutron Fluence Monitoring**

- Description:

  This AMP provides a means to ensure the validity of the neutron fluence analysis and related neutron fluence-based, TLAAs. In so doing, this AMP also provides an acceptable basis for managing aging effects attributable to neutron fluence in accordance with requirements in 10 CFR 54.21(c)(1)(iii). This program monitors neutron fluence for reactor pressure vessel (RPV) components and RVI components and is used in conjunction with the GALL-SLR [9] AMP XI.M31, "Reactor Vessel Material Surveillance." Neutron fluence is a time-dependent input parameter for evaluating the loss of fracture toughness due to neutron irradiation embrittlement. Accurate neutron fluence values are also necessary to identify the RPV beltline region, for which neutron fluence is projected to exceed 1 × 1017 n/cm2 (E > 1 MeV) during the SPEO.

- Scope:

  The scope of the program includes RPV and RVI components that are subject to a neutron embrittlement TLAA or other analysis involving time-dependent neutron irradiation. The program monitors neutron fluence throughout the SPEO to determine the susceptibility of the components to initiating events (IEs), irradiation-assisted stress corrosion cracking (IASCC), IESRC, and void swelling or distortion. The use of this program also continues to ensure the adequacy of the neutron fluence estimates by: (a) monitoring plant and core operating conditions relative to the assumptions used in the neutron fluence calculations, and (b) continuously updating the qualification database associated with the neutron fluence method as new calculational and measurement data become available for benchmarking.

  This program is used in conjunction with GALL-SLR Report AMP XI.M31, "Reactor Vessel Material Surveillance." Updated neutron fluence calculations, plant modifications, and RPV surveillance program data are used to identify component locations within the scope of this program, including the beltline region of the RPV. Applicable requirements in 10 CFR Part 50, and if appropriate, plant TS, related to calculating neutron fluence estimates and incorporating those calculations into neutron irradiation analyses for the RPVs and RVIs must be met.

- Evaluation:

  The program monitors component neutron fluence as determined by the neutron fluence analyses, and appropriate plant and core operating parameters that affect the calculated neutron fluence. The calculational methods, benchmarking, qualification, and surveillance data are monitored to maintain the adequacy of neutron fluence calculations. Neutron fluence levels in specific components are monitored to verify component locations within the scope of this program are identified.

  Neutron fluence is estimated using a computational method that incorporates the following major elements: (1) determination of the geometrical and material input data for the reactor core, vessel and internals, and cavity; (2) determination of the characteristics of the neutron flux emitting from the core; (3) transport of the neutrons from the core to the vessel, and into the cavity; and (4) qualification of the calculational procedure. X.M2-3 Guidance on acceptable methods and assumptions for determining RPV neutron fluence is described in NRC RG 1.190. The use of RG 1.190-adherent methods to estimate neutron fluence for the RPV beltline regions significantly above and below the active fuel region of the core, and RVI components may require additional justification, even if those methods were approved by the NRC for RPV neutron fluence calculations.

- Conclusion:

  This is an existing program that used to be part of the XI.M31, Reactor Vessel Material Surveillance AMP, that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **X.S1: Concrete Containment Unbonded Tendon Prestress**

  - Description:

    This TLAA AMP provides reasonable assurance of the adequacy of prestressing forces in unbonded tendons of prestressed concrete containments, during the SPEO, under 10 CFR 54.21(c)(1)(iii). The program consists of an assessment of measured tendon prestress forces from required examinations performed in accordance with Subsection IWL of the ASME Code, Section XI, as incorporated by reference in 10 CFR 50.55a, and as further supplemented herein. The assessment related to the adequacy of the prestressing force for each tendon group based on type (i.e., hoop, vertical, dome, inverted-U, helical) and other considerations (e.g., geometric dimensions, whether affected by repair/replacement, etc.) establishes (a) acceptance criteria in accordance with ASME Code Section XI, Subsection IWL and (b) trend lines constructed based on the guidance provided in the NRC Information Notice (IN) 99-10, “Degradation of Prestressing Tendon Systems in Prestressed Concrete Containments.” The NRC Regulatory Guide (RG)1.35.1, “Determining Prestressing Forces for Inspection of Prestressed Concrete Containments,” may be used for guidance related to calculation of prestressing losses and predicted forces.

  - Scope:

    The program addresses the assessment of unbonded tendon prestressing forces measured in accordance with ASME Code Section XI, Subsection IWL, when an applicant performs the concrete containment prestressing force TLAA using 10 CFR 54.21(c)(1)(iii).

  - Evaluation:

    This is primarily a condition monitoring program, which periodically measures and evaluates tendon forces such that corrective action can be taken, if required, prior to tendon forces falling below minimum required values established in the design. Maintaining the prestressing above the minimum required value (MRV) [prestressing force], as described under the acceptance criteria below, provides reasonable assurance that the structural and functional adequacy of the concrete containment is maintained.

In addition to Subsection IWL examination requirements, the estimated and all measured prestressing forces up to the current examination are plotted against time. The predicted lower limit (PLL) line, MRV, and trend line are developed for each tendon group examined for the SPEO. The trend line represents the general variation of prestressing forces with time based on the actual X.S1-2 measured forces in individual tendons of the specific tendon group. The trend line for each tendon group is constructed by regression analysis of all measured prestressing forces in individual tendons of that group obtained from all previous examinations. The PLL line, MRV, and trend line for each tendon group are projected to the end of the SPEO. The trend lines are updated at each scheduled examination.

- Conclusion:

  This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

A-1.2 Section XI Electrical AMPs

- **XI.E1: Electrical Insulation for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements**

  - Description:

    The purpose of this AMP is to provide reasonable assurance that the intended functions of electrical cable insulating material (e.g., power, control, and instrumentation) and connection insulating material that are not subject to the EQ requirements of 10 CFR 50.49 are maintained consistent with the CLB through the SPEO.

  - Scope:

    This AMP applies to accessible cable and connection electrical insulation within the scope of SLR including in-scope cables and connections subjected to an adverse localized environment.

  - Evaluation:

    This is an existing LR AMP. Cable and connection electrical insulation are inspected to identify cable and connection insulation installed in an adverse localized environment. Accessible electrical cables and connections are visually inspected for cable jacket and connection electrical insulation surface anomalies such as embrittlement, discoloration, cracking, melting, swelling, or surface contamination. Plant-specific OE is also evaluated to identify in-scope cable and connection insulation previously subjected to adverse localized environment during the period of extended operation. Cable and connection insulation are evaluated to confirm that the dispositioned corrective actions continue to support in-scope cable and connections intended functions during the SPEO.

    Accessible electrical cables and connections subjected to an adverse localized environment found in the performance of this AMP are visually inspected at least once every 10 years. If visual inspections identify degraded or damaged conditions, then testing may be performed for evaluation. For a large number of cables and connections identified as potentially degraded, a sample population is tested. A sample of 20 percent of each cable and connection type with a maximum sample size of 25 is tested. Testing may include thermography and other proven condition monitoring test methods applicable to the cable and connection insulation. Testing as part of an existing maintenance, calibration or surveillance program may be credited for testing. The first inspection for SLR is to be completed prior to the SPEO.

- Conclusion:

  This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.E2: Electrical Insulation for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Used in Instrumentation Circuits**

  - Description:

    The purpose of this AMP is to provide reasonable assurance that the intended functions of electrical cables and connections (that are not subject to the EQ requirements of 10 CFR 50.49 and are used in instrumentation circuits with sensitive, high voltage, low-level current signals) are maintained consistent with the CLB through the SPEO.

  - Scope:

    This AMP applies to electrical cables and connections (cable system) electrical insulation used in circuits with sensitive, high-voltage, low-level current signals. Examples of these circuits include radiation monitoring and nuclear instrumentation that are subject to aging management review and subjected to adverse localized environments caused by temperature, radiation, or moisture.

  - Evaluation:

    This is an existing LR AMP. Review of calibration results or findings of surveillance programs can provide an indication of the existence of aging effects based on acceptance criteria related to instrumentation circuit performance. The first reviews are completed prior to the SPEO and at least every 10 years thereafter.

    Cable system testing is conducted when the calibration or surveillance program does not include the cabling system in the testing circuit, or as an alternative to the review of calibration results described above. A cable system test for detecting deterioration of the electrical insulation system is performed. This can be one or more of the following tests: insulation resistance tests, time domain reflectometry tests, or other testing judged to be effective in determining cable system insulation physical, mechanical, and chemical properties, as applicable. The test frequency of the cable system is determined by the applicant based on engineering evaluation, but the test frequency is at least once every 10 years. The first test is to be completed prior to the SPEO.

  - Conclusion:

    This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.E3A: Electrical Insulation for Inaccessible Medium-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements**

  - Description:

    The purpose of the AMP is to provide reasonable assurance that the intended functions of inaccessible medium-voltage power cables (operating voltages of 2 kV to 35 kV) that are not subject to the EQ requirements of 10 CFR 50.49 are maintained consistent with the CLB through the SPEO. This AMP applies to all inaccessible or underground (e.g., installed in buried conduit, embedded raceway, cable trenches, cable troughs, duct banks, vaults, manholes, or direct buried installations) medium-voltage cables that are within the scope of SLR and potentially exposed to wetting or submergence (i.e., significant moisture). Inaccessible medium-voltage cables designed for continuous wetting or submergence are also included in this AMP for a one-time inspection and test.

- Scope:

  This AMP applies to inaccessible or underground medium-voltage (2kV to 35kV) power cable installations (e.g., direct buried, buried conduit, duct bank, embedded raceway, cable trench, vaults, or manholes) that are within the scope of SLR and potentially exposed to significant moisture. Significant moisture is defined as exposure to moisture that lasts more than three 3 days (that, if left unmanaged, could potentially lead to a loss of intended function. Cable wetting or submergence that results from event driven occurrences and is mitigated by either automatic or passive drains is not considered significant moisture for this AMP.

- Evaluation:

  This is an existing AMP. For inaccessible medium-voltage power cables exposed to significant moisture, test frequencies are adjusted based on test results (including trending of aging degradation where applicable) and plant-specific OE. Cable testing occurs at least once every 6 years. The first tests for LR are to be completed prior to the SPEO with additional tests performed at least once every 6 years thereafter.

  The inspection frequency for water accumulation is established and performed based on plant-specific OE with cable wetting or submergence. The inspections are performed periodically based on water accumulation over time. The periodic inspection occurs at least once annually with the first inspection for SLR completed prior to the SPEO. Inspection of manholes equipped with water level monitoring and alarms that result in consistent and subsequent pump out of accumulated water prior to wetting or submergence of cables can be performed at least once every five years, if supported by plant operating experience

  With the evaluation of past plant-specific inaccessible medium-voltage power cable inspections for manhole water accumulation data, it may be possible to reduce the manhole inspections to those that only accumulate water. Existing maintenance and surveillance programs may be credited for testing the in-scope inaccessible medium-voltage power cables.

- Conclusion:

  This program may benefit from further evaluation to reduce inspection workforce or cost.

- **XI.E3B: Electrical Insulation for Inaccessible Instrument and Control Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements**

  - Description:

    The purpose of the AMP is to provide reasonable assurance that the intended functions of inaccessible or underground instrument and control cables that are not subject to the EQ requirements of 10 CFR 50.49 are maintained consistent with the CLB through the SPEO.

  - Scope:

    This AMP applies to inaccessible and underground (e.g., installed in buried conduit, embedded raceway, cable trenches, cable troughs, duct banks, vaults, manholes, or direct buried installations) instrumentation and control cables that are within the scope of SLR, and potentially exposed to significant moisture. Significant moisture is defined as exposure to moisture that lasts more than 3 days that if left unmanaged, could potentially lead to a loss of intended function.

    Instrumentation cables are cables carrying either analog or digital signals such as coaxial cable, or cable comprised of twisted 16 or 18 American wire gauge (AWG) conductor shielded pairs rated 300V with an overall shield. Examples of control cables included in this AMP are multiconductor 600V 12 or 14 AWG cables used to monitor or initiate control functions through indication, switches, limit switches, relays, contacts, etc.

- Evaluation:

  This is a new AMP. For inaccessible instruments and control cables exposed to significant moisture, visual inspection frequency is determined based on inspection and test results as well as plant-specific and industry OE. For inaccessible and underground instruments and control cables exposed to significant moisture where testing is required, a one-time test is performed. Visual inspection occurs at least once every 6 years and may be coordinated with the periodic inspection for water accumulation. The inspection frequency for water accumulation in manholes/vaults is established and performed based on plant-specific OE with cable wetting or submergence. The inspections are performed periodically based on water accumulation over time. The periodic inspection occurs at least once annually with the first inspection for SLR completed prior to the SPEO. Inspection of manholes equipped with water level monitoring and alarms that result in consistent and subsequent pump out of accumulated water prior to wetting or submergence of cables can be performed at least once every five years, if supported by plant operating experience.

  With the evaluation of past plant-specific inaccessible instrument and control cable testing and manhole water accumulation data, it may be possible to reduce the manhole inspections to those that only accumulate water. Further experimental testing of instrument and control cable insulation may reveal that submerged instrument and control cable insulation degradation does not occur as expected. The data could be used to justify reducing the frequency of or eliminating instrumentation and control cable inspections. Existing maintenance, calibration and surveillance programs may be credited for testing the in-scope inaccessible instrument and control cables.

- Conclusion:

  This program may benefit from further evaluation to reduce inspection workforce or cost.

- **XI.E3C: Electrical Insulation for Inaccessible Low-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements**

  - Description:

    The purpose of the AMP is to provide reasonable assurance that the intended functions of inaccessible or underground low-voltage ac and dc power cables (i.e., typical operating voltage of less than 1,000 V, but no greater than 2 kV) that are not subject to the EQ requirements of 10 CFR 50.49 are maintained consistent with the CLB through the SPEO.

    This AMP applies to all underground (e.g., installed in buried conduit, embedded raceway, cable trenches, cable troughs, duct banks, vaults, manholes, or direct buried installations) low-voltage power cables, including those designed for continuous wetting or submergence, within the scope of SLR exposed to significant moisture. Significant moisture is defined as exposure to moisture that lasts more than three days that if left unmanaged, could potentially lead to a loss of intended function. Cable wetting or submergence that results from event driven occurrences and is mitigated by either automatic or passive drains is not considered significant moisture for the purposes of this AMP.

  - Scope:

    This AMP applies to underground (e.g., installed in buried conduit, embedded raceway, cable trenches, cable troughs, duct banks, vaults, manholes, or direct buried installations) low-voltage power cables that are within the scope of SLR and potentially exposed to significant moisture. For this AMP, low-voltage ac and dc power cables are considered in-scope cables with typical operating voltage of less than 1,000 V, but no greater than 2 kV.

In-scope inaccessible and underground low-voltage power cable splices subjected to wetting or submergence are included within the scope of this program. Cables designed for continuous wetting or submergence are also included in this AMP. Additional tests and periodic visual inspections are determined by the test/inspection results and industry and plant-specific aging degradation OE with the applicable cable electrical insulation.

- Evaluation:

  This is an existing AMP. For inaccessible low-voltage power cables exposed to significant moisture, visual inspection frequency is determined based on inspection and test results as well as plant-specific and industry OE. For inaccessible and underground low-voltage power cables exposed to significant moisture where testing is required, a one-time test is performed. Visual inspection occurs at least once every 6 years and may be coordinated with the periodic inspection for water accumulation. The inspection frequency for water accumulation in manholes/vaults is established and performed based on plant-specific OE with cable wetting or submergence. The inspections are performed periodically based on water accumulation over time. The periodic inspection occurs at least once annually with the first inspection for SLR completed prior to the SPEO. Inspection of manholes equipped with water level monitoring and alarms that result in consistent and subsequent pump out of accumulated water prior to wetting or submergence of cables can be performed at least once every five years, if supported by plant operating experience.

  With the evaluation of past plant-specific inaccessible low-voltage cable testing and manhole water accumulation data, it may be possible to reduce the manhole inspections to those that only accumulate water. Further experimental testing of low voltage cable insulation may reveal that submerged low voltage cable insulation degradation does not occur as expected. The data could be used to justify reducing the frequency of or eliminating low-voltage cable inspections.

- Conclusion:

  This program may benefit from further evaluation to reduce inspection workforce or cost.

- **XI.E4: Metal-Enclosed Bus**

  - Description:

    The purpose of this AMP is to provide an internal and external inspection of metal enclosed buses (MEBs) within the scope of SLR to identify age-related degradation of electrical insulating material (i.e., porcelain, xenoy, thermoplastic organic polymers), and metallic and elastomer components (e.g., gaskets, boots, and sealants). This AMP provides reasonable assurance that in-scope MEBs will be maintained consistent with the CLB through the SPEO.

  - Scope:

    This AMP manages the age-related degradation effects for electrical bus bar bolted connections, bus bar electrical insulation, bus bar insulating supports, bus enclosure assemblies (internal and external), and elastomers. This program does not manage the aging effects on external bus structural supports, which are managed under NUREG-2191 AMP XI.S6, "Structures Monitoring."

  - Evaluation:

    This is an existing LR AMP. This SLR program requires that MEB internal surfaces are visually inspected for aging degradation including cracks, corrosion, foreign materials debris, excessive dust buildup, and evidence of moisture intrusion. MEB insulating material is visually inspected for signs of embrittlement, cracking, chipping, melting, discoloration, swelling, or surface contamination. Internal bus insulating supports are visually inspected for structural integrity and signs of cracks. MEB external surfaces are visually inspected for loss of material due to general, pitting, and crevice corrosion. Accessible elastomers (e.g., gaskets, boots, and sealants) are inspected for degradation including surface cracking, crazing, scuffing, dimensional change (e.g., “ballooning” and “necking”), shrinkage, discoloration, hardening or loss of strength.

These inspections require a sample of accessible bolted connections be inspected for increased resistance of connection by using thermography or by measuring connection resistance using a micro-ohmmeter. Twenty percent of the population with a maximum sample size of 25 constitutes a representative sample size. The first inspection for measuring connection resistance or thermography is completed prior to the SPEO and every 10 years thereafter. As an alternative to thermography or measuring connection resistance of bolted connections, for accessible bolted connections covered with heat shrink tape, sleeving, insulating boots, etc., the applicant may use visual inspection of insulation material to detect surface anomalies, such as embrittlement, cracking, chipping, melting, discoloration, swelling, or surface contamination. When an alternative visual inspection is used to check MEB bolted connections, the first inspection is completed prior to the SPEO and every 5 years thereafter.

Based on the plant specific number of inspections and the results of the LR required inspections, an evaluation of current inspection results may provide justification for relief of the frequency of inspections.

- Conclusion:

  Based on plant specific LR inspection results, an evaluation could provide justification for performing a One-Time inspection in the SPEO. This program may benefit from further evaluation to reduce the frequency of inspections and cost.

- **XI.E5: Fuse Holders**

  - Description:

    The purpose of this AMP is to provide reasonable assurance that the intended functions of fuse holders within the scope of SLR and subject to aging management are maintained consistent with the CLB. The fuse holder program was developed specifically to address aging management of fuse holder insulation material and fuse holder metallic clamp aging mechanisms and effects. This AMP utilizes visual inspection and testing to identify age-related degradation for both fuse holder electrical insulation material and fuse holder metallic clamps. Visual inspection and testing provide reasonable assurance that the applicable aging effects are identified, and fuse holder insulators and metallic clamps are age managed.

  - Scope:

    This AMP manages in-scope fuse holders outside of active devices that are considered susceptible to the following aging effects: increased resistance of connection due to chemical contamination, corrosion, and oxidation or fatigue caused by ohmic heating, thermal cycling, electrical transients, frequent removal and replacement, or vibration. It also manages degradation of electrical insulation for the fuse holders with metallic clamps susceptible to the aging effects identified. Fuse holders inside an active device (e.g., switchgears, power supplies, inverters, battery chargers, and circuit boards) and not subject to the aging effects identified, are not within the scope of this AMP.

  - Evaluation:

    This is an existing LR AMP. Fuse holders within the scope of this AMP are visually inspected and tested at least once every 10 years to provide an indication of the condition of the metallic clamp of the fuse holder. Testing may include thermography, contact resistance testing, or other appropriate testing methods. Visual inspection includes inspection for electrical insulation surface anomalies indicating signs of reduced insulation resistance due to thermal/ thermoxidative degradation of organics, radiolysis, and photolysis (UV sensitive materials only) of organics, radiation-induced oxidation, and moisture intrusion as indicated by signs of embrittlement, discoloration, cracking, melting, swelling, or surface contamination.

Depending on the plant specific number of in-scope fuse holders, usually a low quantity, an evaluation to reduce the number of inspections or increase the frequency of a 10-year inspection cycle would not be cost beneficial. However, there are very few plants that have needed to credit this program for and LRA and therefore it may be worthwhile to justify having no fuse holders in the scope of the program that require aging management. This is typically because any fuses that would be in scope are contained in an active enclosure which allows for screening out of the AMP.

- Conclusion:

  This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce manpower or cost.

- **XI.E6: Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements**

  - Description:

    The purpose of this AMP is to provide reasonable assurance that the intended functions of the metallic parts of electrical cable connections that are not subject to the EQ requirements of 10 CFR 50.49 and susceptible to age-related degradation resulting in increased resistance of the connection are maintained consistent with the CLB through the SPEO. This AMP manages the aging mechanisms and effects associated with the metallic portion of electrical connections that result in increased resistance of connection due to thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, or oxidation such that the metallic portions of the electrical cable connections are maintained consistent with the CLB through the SPEO.

    Cable connections are used to connect cable conductors to other cable conductors or electrical devices. Connections associated with cables within the scope of LR are part of this AMP. Examples of connections used in NPPs include bolted connectors, coaxial/triaxial connections, compression/crimped connectors, splices (butt or bolted), stress cones, and terminal blocks. Most connections involve insulating material and metallic parts. This AMP focuses on the metallic parts of the electrical cable connections. This AMP provides testing, on a sampling basis, to demonstrate that either aging of metallic cable connections is not occurring and/or that the existing preventive maintenance program is effective. Testing confirms the absence of age-related degradation of cable connections resulting in increased resistance of connection due to thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, or oxidation.

  - Scope:

    Cable connections associated with cables within the scope of LR that are external connections terminating at active or passive devices, are in the scope of this AMP. Wiring connections internal to an active assembly are considered part of the active assembly and, therefore, are not within the scope of this AMP. This AMP does not include high voltage (>35 kV) switchyard connections. The cable connections covered under the EQ program are not included in the scope of this program.

- Evaluation:

  This is an existing AMP. This SLR program requires a one-time test of a representative sample of each type of electrical cable connections for indication of increase resistance of connection due to thermal cycling, ohmic heating, electrical transients, vibration, chemical contamination, corrosion, or oxidation. This testing is performed to determine whether a periodic testing program of cable connections is warranted. Based on the existing AMP, the applicant would perform a plant-specific OE review to determine the extent of any age-related degradation.

  The One-Time testing may include thermography, contact resistance testing, or other appropriate testing methods without removing the connection insulation. This testing requires 20 percent of a connector type population with a maximum sample of 25 representative connector sample size. Thermography testing would occur while the in-scope components are in service and would not impact plant operations. Contact resistance testing would occur as part of existing planned maintenance activities. Neither of these testing methods would be considered manpower of cost prohibitive.

- Conclusion:

  This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce manpower or cost.

• **XI.E7: High-Voltage Insulators**

- Description:

  The purpose of the AMP is to provide reasonable assurance that the intended functions of high-voltage insulators within the scope of SLR are maintained consistent with the CLB through the SPEO. The high-voltage insulator program was developed specifically to age manage high-voltage insulators susceptible to aging degradation due to local environmental conditions.

  The high-voltage insulators program includes visual inspections to identify degradation of high-voltage insulator sub-component parts, namely insulation and metallic elements. Visual inspection provides reasonable assurance that the applicable aging effects are identified, and high-voltage insulator age degradation is managed. Insulation materials used in high-voltage insulators may degrade more rapidly than expected when installed in an environment conducive to accelerated aging. The insulation and metallic elements of high-voltage insulators are made of porcelain, cement, malleable iron, aluminum, and galvanized steel. Significant loss of metallic material can occur due to mechanical wear caused by oscillating movement of insulators due to wind. Surface corrosion in metallic parts may appear due to contamination or where galvanized or other protective coatings are worn. With substantial airborne contamination such as salt, surface corrosion in metallic parts may become significant such that the insulator no longer will support the conductor. Various airborne contaminates such as dust, salt, fog, cooling tower plume, or industrial effluent can contaminate the insulator surface leading to reduced insulation resistance. Excessive surface contaminants or loss of material can lead to insulator flashover and failure.

- Scope:

  This AMP manages the age-related degradation effects of high-voltage insulators (operating at nominal system voltages greater than 1 kV and equal to or less than 765 kV) within the scope of SLR, susceptible to wind and airborne contaminants including dust, salt, fog, cooling tower plume, industrial effluent, or loss of material. Different categories of high-voltage insulators such as porcelain high-voltage insulators, polymer high-voltage insulators and toughened glass high-voltage insulators are considered and covered in this AMP.

- Evaluation:

  This is a new AMP. Inspection frequency for this program is based on the results of a plant-specific OE review with respect to the particular type of insulator. If the results of the plant-specific OE review are favorable, then it is suggested a one-time inspection, prior to the SPEO, to determine if any in-scope components show signs of (a) loss of material in metallic parts by corrosion and/or frequent movement, and (b) reduced insulation resistance by surface contamination or weakening of sheathing due to a variety of stressors. If the results of the One-Time inspection revels aging issues, then a frequency of inspection would be determined based on the type of insulator, component's time is service and plant-specific environmental conditions.

  If the results of the plant-specific OE review revels aging management issues exist, then an inspection frequency of in-scope components would be developed based on the type of insulator, component's time is service and plant-specific environmental conditions.

- Conclusion:

  This program would not benefit from further evaluation to reduce manpower or cost.

A-1.3 Section XI Mechanical AMPs

- **XI.M1: ASME Section XI Inservice Inspection, Subsection IWB, IWC, and IWD**

  - Description:

    10 CFR 50.55a, imposes the in-service inspection (ISI) requirements of the ASME Code, Section XI, Rules for ISI of Nuclear Power Plant Components for Class 1, 2, and 3 pressure-retaining components and their integral attachments in light-water cooled power plants. The rules of Section XI require a mandatory program of examinations, testing and inspections to demonstrate adequate safety and to manage deterioration and aging effects. Inspection of these components is covered in Subsections IWB, IWC, and IWD, respectively, in accordance with the applicable plant ASME Code Section XI edition(s) and addenda as required by 10 CFR 50.55a(g)(4).1 The program generally includes periodic visual, surface, and/or volumetric examination and leakage test of Class 1, 2, and 3 pressure-retaining components and their integral attachments. Repair/replacement activities for these components are covered in Subsection IWA of the ASME Code. The ASME Code Section XI ISI program, in accordance with Subsections IWA, IWB, IWC, and IWD, has been shown to be generally effective in managing aging effects in Class 1, 2, and 3 components and their integral attachments in light-water cooled power plants.
    10 CFR 50.55a imposes additional conditions and augmentations of ISI requirements specified in the ASME Code, Section XI, and those conditions or augmentations described in 10 CFR 50.55a are included as part of this program. In certain cases, the ASME Code Section XI ISI program is augmented to manage effects of aging for LR and is so identified in the GALL-SLR) [9].

  - Scope:

    The ASME Code Section XI program provides the requirements for ISI, repair, and replacement of Class 1, 2, and 3 pressure-retaining components and their integral attachments in light-water cooled NPPs. The components within the scope of the program are specified in ASME Code, Section XI, Subsections IWB-1100, IWC-1100, and IWD-1100 for Class 1, 2, and 3 components, respectively. The components described in Subsections IWB-1220, IWC-1220, and IWD-1220 are exempt from the volumetric and surface examination requirements, but not exempt from VT-2 visual examination and pressure testing requirements of Subsections IWB-2500, IWC-2500, and IWD-2500

- Evaluation:

  The ASME Code, Section XI ISI program detects degradation of components by using the examination and inspection requirements specified in ASME Code, Section XI Tables IWB-2500-1, IWC-2500-1, and IWD-2500-1 for Class 1, 2, and 3 components, respectively.

  The program uses three types of examination—visual, surface, and volumetric—in accordance with the requirements of Subsection IWA-2000. Surface examination uses magnetic particle, liquid penetrant, or eddy current examinations to indicate the presence of surface discontinuities and flaws. Volumetric examination uses radiographic, ultrasonic, or eddy current examinations to indicate the presence of discontinuities or flaws throughout the volume of material included in the inspection program.

  The extent and schedule of the inspection and test techniques prescribed by the program are designed to maintain structural integrity and to detect and repair or replace components before the loss of intended function of the component. Inspection can reveal cracking, loss of material due to corrosion, leakage of coolant, and indications of degradation due to wear or stress relaxation (such as changes in clearances, settings, physical displacements, loose or missing parts, debris, wear, erosion, or loss of integrity at bolted or welded connections). Class 1, 2, and 3 components are examined and tested as specified in Tables IWB-2500-1, IWC-2500-1, and IWD-2500-1, respectively. The tables specify the extent and schedule of the inspection and examination methods for the components of the pressure-retaining boundaries.

- Conclusion:

  This is an existing station program (required by station TSs) and generally does not have further LR-related enhancements. This program has benefited from numerous RI options, which stations have incorporated. Review additional RI options to determine whether these, or additional options, may be beneficial.

- **XI.M2: Water Chemistry**

  - Description:

    The main objective of this program is to mitigate loss of material due to corrosion, cracking due to SCC and related mechanisms, and reduction of heat transfer due to fouling in components exposed to a treated water environment. The program includes periodic monitoring of the treated water in order to minimize loss of material or cracking.

    The water chemistry program for BWRs relies on monitoring and control of reactor water chemistry based on industry guidelines contained in the BWRVIP-190 EPRI 3002002623, "BWR Vessel and Internals Project? BWR Water Chemistry Guidelines," Revision 1. The BWRVIP-190 has three sets of guidelines: (i) one for reactor water, (ii) one for condensate and feedwater, and (iii) one for control rod drive mechanism cooling water. The water chemistry program for PWRs relies on monitoring and control of reactor water chemistry based on industry guidelines contained in EPRI 3002000505, "PWR Primary Water Chemistry Guidelines," Revision 7 and EPRI 3002010645, "PWR Secondary Water Chemistry Guidelines," Revision 8.

    The water chemistry programs are generally effective in removing impurities from intermediate and high flow areas. The GALL-SLR [9] identifies those circumstances in which the water chemistry program is to be augmented to manage the effects of aging for LR. For example, the water chemistry program may not be effective in low flow or stagnant flow areas. Accordingly, in certain cases as identified in the GALL-SLR Report, verification of the effectiveness of the chemistry control program is undertaken to provide reasonable assurance that significant degradation is not occurring, and the component's intended function is maintained during the

SPEO. For these specific cases, an acceptable verification program is a one-time inspection of selected components at susceptible locations in the system.

- Scope:

  The program includes components in the reactor coolant system, the engineered safety features, the auxiliary systems, and the steam and power conversion system. This program addresses the metallic components subject to aging management review that are exposed to a treated water environment controlled by the water chemistry program.

  The monitoring methods and frequency of water chemistry sampling and testing is performed in accordance with the EPRI water chemistry guidelines and based on plant operating conditions. The main objective of this program is to mitigate loss of material due to corrosion and cracking due to SCC in components exposed to a treated water environment.

- Evaluation:

  This is a mitigation program and does not provide for detection of any aging effects of concern for the components within its scope. The monitoring methods and frequency of water chemistry sampling and testing is performed in accordance with the EPRI water chemistry guidelines and based on plant operating conditions. The main objective of this program is to mitigate loss of material due to corrosion and cracking due to SCC in components exposed to a treated water environment.

  The program includes specifications for chemical species, impurities and additives, sampling and analysis frequencies, and corrective actions for control of reactor water chemistry. System water chemistry is controlled to minimize contaminant concentration and mitigate loss of material due to general, crevice, and pitting corrosion and cracking caused by SCC. For BWRs, maintaining high water purity reduces susceptibility to SCC, and chemical additive programs such as hydrogen water chemistry or noble metal chemical application also may be used. For PWRs, additives are used for reactivity control, to control pH and dose rates, and inhibit corrosion.

- Conclusion:

  This is an existing program that does not place undue burden on the site resources. This is a program the station implements to preserve the integrity of components in contact with treated water. This program would not benefit from further evaluation to reduce inspection workforce or cost.

• **XI.M3: Reactor Head Closure Stud Bolting**

- Description:

  This program includes (a) ISI in accordance with the requirements of the ASME Code Section XI, Subsection IWB, Table IWB 2500-1; and (b) preventive measures to mitigate cracking. The program also relies on recommendations delineated in the NRC RG 1.65, Revision 1.

- Scope:

  The program manages the aging effects of cracking due to SCC or intergranular stress corrosion cracking (IGSCC) and loss of material due to wear or corrosion for reactor vessel closure stud bolting (studs, washers, bushings, nuts, and threads in flange) for both BWRs and PWRs.

- Evaluation:

  The ASME Code Section XI ISI program detects and sizes cracks, detects loss of material, and detects coolant leakage by following the examination and inspection requirements specified in Table IWB-2500-1.

  The extent and schedule of the inspection and test techniques prescribed by the program are designed to maintain structural integrity, to detect aging effects and to repair or replace components before the loss of intended function of the component. Inspection can reveal cracking, loss of material due to corrosion or wear, and leakage of coolant.

  The program uses visual, surface, and volumetric examinations in accordance with the general requirements of Subsection IWA-2000. Surface examination uses magnetic particle or liquid penetrant examinations to indicate the presence of surface discontinuities and flaws. Volumetric examination uses radiographic or ultrasonic examinations to indicate the presence of discontinuities or flaws throughout the volume of material. Visual VT-2 examination detects evidence of leakage from pressure-retaining components, as required during the system pressure test.

  Components are examined and tested in accordance with ASME Code, Section XI, Table IWB-2500-1, Examination Category B-G-1, for pressure-retaining bolting greater than 2 inches in diameter. Examination Category B-P for all pressure-retaining components specifies visual VT-2 examination of all pressure-retaining boundary components during the system leakage test. Table IWB-2500-1 specifies the extent and frequency of the inspection and examination methods, and IWB-2400 specifies the schedule of the inspection.

- Conclusion:

  This is an existing LR AMP. With a favorable review of plant specific and industry OE, the frequency of inspections in the SPEO may be increased. This program may benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M4: BWR Vessel ID Attachment Welds**

  - Description:

    This program is a condition monitoring program for detecting cracking due to SCC, IGSCC, and cyclical loading mechanisms in the reactor vessel inside diameter (ID) attachment welds of BWRs. The program includes inspection and flaw evaluation in accordance with the requirements of the ASME Code, Section XI, and the guidance in "BWR Vessel and Internals Project, Vessel ID Attachment Weld Inspection and Flaw Evaluation Guidelines" [Boiling Water Reactor Vessel and Internals Project (BWRVIP)-48-A] to provide reasonable assurance of the long-term integrity and safe operation of BWR vessel ID attachment welds.

    The guidance in BWRVIP-48-A includes inspection recommendations and evaluation methodologies for certain attachment welds between the vessel wall and the brackets that attach components to the vessel. In some cases, the attachment is a weld attached directly to the vessel wall; in other cases, the attachment includes a weld build-up pad on the vessel wall. The BWRVIP-48-A report includes information on the geometry of the vessel ID attachments; evaluates susceptible locations and the safety consequence of failure; provides recommendations regarding the method, extent, and frequency of augmented examinations; and discusses acceptable methods for evaluating the structural integrity significance of indications detected during examinations.

- Scope:

  This program manages the effects of cracking caused by SCC, IGSCC, or cyclical loading mechanisms for those BWR vessel ID attachment welds that are covered by BWRVIP-48-A. The program is an augmented ISI program that uses the inspection and flaw evaluation criteria in BWRVIP-48-A to detect cracking and monitor the effects of cracking on the intended functions of these components.

- Evaluation:

  The extent and schedule of the inspections prescribed by BWRVIP-48-A and ASME Code, Section XI, are designed to maintain structural integrity, to discover aging effects, and to repair or replace the component before a loss of intended function. The vessel ID attachment welds are visually examined in accordance with the requirements of ASME Code, Section XI, Table IWB-2500-1, Examination Category B-N-2. The inspection and evaluation guidelines of BWRVIP-48-A recommend more stringent inspections for certain attachment welds. The nondestructive examination techniques that are appropriate for the augmented examinations, including the uncertainties inherent in delivering and executing these techniques and applicable for inclusion in flaw evaluations, are included in BWRVIP-03.

- Conclusion:

  This is an existing LR AMP. This program is required by ASME Section XI code and prescribed by NRC accepted BWRVIP-48-A report. This program would not benefit from further evaluation to reduce inspection workforce or cost. XI.M3: Reactor Head Closure Stud Bolting

- **XI.M7: BWR Stress Corrosion Cracking**

  - Description:

    The program to manage IGSCC in BWR coolant pressure boundary piping made of stainless steel (SS) and nickel-based alloy components is delineated in NUREG–0313, Revision 2, and the NRC GL 88-01 and its Supplement 1. The material includes base metal and welds. The comprehensive program outlined in NUREG–0313, Revision 2 and NRC GL 88-01 describes improvements that, in combination, will reduce the susceptibility to IGSCC. The program includes (a) preventive measures to mitigate IGSCC and (b) inspection and flaw evaluation to monitor IGSCC and its effects. The staff-approved Boiling Water Reactor Vessel and Internals Project (BWRVIP)-75-A report allows for modifications to the inspection extent and schedule described in the NRC GL 88-01 program.

  - Scope:

    The program focuses on (a) managing and implementing countermeasures to mitigate IGSCC and (b) performing ISI to monitor IGSCC and its effects on the intended function of BWR piping components within the scope of LR. The program is applicable to all BWR piping and piping welds made of austenitic–SS and nickel alloy that are 4 inches or larger in nominal diameter containing reactor coolant at a temperature above 93°C (Celsius) [200°F (Fahrenheit)] during power operation, regardless of code classification. The program also applies to pump casings, valve bodies, and reactor vessel attachments and appurtenances, such as head spray and vent components. Control rod drive return line nozzle caps and associated welds (previously addressed in GALL Report, Revision 2, [10] AMP XI.M6, “BWR Control Rod Drive Return Line Nozzle”) may be included in the scope of the program. NUREG-0313, Revision 2 and NRC GL 88-01, respectively, describe the technical basis and staff guidance regarding mitigation of IGSCC in BWRs. Attachment A of NRC GL 88-01 delineates the staff-approved positions regarding materials, processes, water chemistry, weld overlay reinforcement, partial replacement, stress improvement of cracked welds, clamping devices, crack characterization and repair criteria, inspection methods and personnel, inspection schedules, sample expansion, leakage detection, and reporting requirements.

- Evaluation:

  The extent, method, and schedule of the inspection and test techniques delineated in NRC GL 88-01 are designed to maintain structural integrity, to detect and mitigate degradation, and to repair or replace components before the loss of intended function of the component. Modifications to the extent and schedule of inspection in NRC GL 88-01 are allowed in accordance with the inspection guidance in approved BWRVIP-75-A. The potential for stagnant flow conditions such as dead legs is considered when selecting inspection locations. The program identifies these locations. Prior to crediting hydrogen water chemistry to modify extent and frequency of inspections in accordance with BWRVIP-75-A, the applicant should meet conditions described in the staff's safety evaluations regarding BWRVIP-62-A. The program uses volumetric examinations to detect IGSCC. Inspection can reveal cracking and leakage of coolant. The extent and frequency of inspection recommended by the program are based on the condition of each weld (e.g., whether the weldments were made from IGSCC-resistant material, whether a stress improvement process was applied to a weldment to reduce residual stresses, and how the weld was repaired, if it had been cracked).

- Conclusion:

  This is an existing LR AMP. This program is required by NUREG-0313 and the licensees' response to GL 88-01. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M8: BWR Penetrations**

  - Description:

    The program for BWR vessel instrumentation penetrations, control rod drive (CRD) housing and incore-monitoring housing (ICMH) penetrations and standby liquid control (SLC) nozzles/Core ΔP nozzles includes inspection and flaw evaluation in conformance with the guidelines of staff-approved Boiling Water Reactor Vessel and Internals Project (BWRVIP) Topical Reports BWRVIP-49-A, BWRVIP-47-A and BWRVIP-27-A. The program manages cracking due to cyclic loading, SCC and IGSCC for these BWR vessel penetrations and nozzles. The inspection and evaluation guidelines of BWRVIP-49-A, BWRVIP-47-A, and BWRVIP-27-A contain generic guidelines intended to present appropriate inspection recommendations to assure safety function integrity. The guidelines of BWRVIP-49-A provide information on the type of instrument penetration, evaluate their susceptibility and consequences of failure, and define the inspection strategy to assure safe operation. The guidelines of BWRVIP-47-A provide information on components located in the lower plenum region of BWRs, evaluate their susceptibility and consequences of failure, and define the inspection strategy to assure safe operation. The guidelines of BWRVIP-27-A are applicable to plants in which the SLC system injects sodium pentaborate into the bottom head region of the vessel (in most plants, as a pipe within a pipe of the core plate ΔP monitoring system).

  - Scope:

    The scope of this program is applicable to BWR instrumentation penetrations, CRD housing and ICMH penetrations and BWR SLC nozzles/Core ΔP nozzles. The program manages cracking due to cyclic loading or SCC and IGSCC using inspection and flaw evaluation in accordance with the guidelines of NRC staff-approved BWRVIP-49-A, BWRVIP-47-A and BWRVIP-27-A.

- Evaluation:

  The inspection guidelines of BWRVIP-49-A, BWRVIP-47-A, and BWRVIP-27-A, along with the existing inspection requirements in ASME Code, Section XI, Table IWB-2500-1, are sufficient to monitor for indications of cracking in BWR instrumentation nozzles, CRD housing and ICMH penetrations and BWR SLC nozzles/Core ΔP nozzles and should continue to be followed for the SPEO. The extent and schedule of the inspection and test techniques prescribed by the NRC staff approved BWRVIP inspection guidelines and the ASME Code, Section XI program are designed to maintain structural integrity, to detect aging effects, and to perform repair or replacement before the loss of intended function of the component.

  Instrument penetrations, CRD housing and ICMH penetrations and SLC system nozzles or housings are inspected in accordance with the NRC staff approved BWRVIP inspection guidelines and the requirements in the ASME Code, Section XI. These examination categories include volumetric examination methods (UT or radiography testing), surface examination methods (liquid penetrant testing or magnetic particle testing), and VT-2 visual examination methods.).

- Conclusion:

  This is an existing LR AMP. NRC approved BWRVIP guidance documents for SLR inspections. The reduction of the type, number, and frequency of BWR Reactor Vessel Internal inspections would require extensive testing and investigation to justify any changes. This program would not benefit from further evaluation to reduce inspection workforce or cost.

• **XI.M9: BWR Vessel Internals**

- Description:

  The program includes inspection and flaw evaluations in conformance with the guidelines of applicable and staff-approved Boiling Water Reactor Vessel and Internals Project (BWRVIP) documents to provide reasonable assurance of the long-term integrity and safe operation of BWR vessel internal components. The program manages the effects of cracking due to SCC, IGSCC, or IASCC, cracking due to cyclic loading (including flow-induced vibration), loss of material due to wear, loss of fracture toughness due to neutron or thermal embrittlement, and loss of preload due to thermal or irradiation-enhanced stress relaxation.

- Scope:

  The program is focused on managing the effects of cracking due to SCC, IGSCC, or IASCC, cracking due to cyclic loading (including flow-induced vibration) and loss of material due to wear. This program also manages loss of fracture toughness due to neutron or thermal embrittlement and loss of preload due to thermal or irradiation enhanced stress relaxation. The program contains ISI to monitor the effects of cracking on the intended function of the components, uses NRC approved BWRVIP reports as the basis for inspection, evaluation, repair and/or replacement, as needed, and evaluates the susceptibility of nickel alloy, CASS, PH martensitic SS (e.g., 15-5 and 17-4 PH steel), martensitic SS (e.g., 403, 410, 431 steel) and other SS (e.g., 304 steel) components to neutron or thermal embrittlement.

  The scope of the program includes the following BWR reactor vessel (RV) and RV internal components as subject to the following staff-approved applicable BWRVIP guidelines: Core shroud: BWRVIP-76-A and BWRVIP-02-A. Core plate: BWRVIP-25 and BWRVIP-50-A. Core spray: BWRVIP-18, BWRVIP-16-A and BWRVIP-19-A. Shroud support: BWRVIP-38 and BWRVIP-52-A. Jet pump assembly: BWRVIP-41, BWRVIP-138 and BWRVIP-51-A. Low-pressure coolant injection coupling: BWRVIP-42-A and BWRVIP-56-A. Top guide: BWRVIP-26-A, BWRVIP-183 and BWRVIP-50-A. Control rod drive housing and lower plenum components (reactor vessel internal components): BWRVIP-47-A and BWRVIP-55-A. Steam dryer: BWRVIP-139-A and BWRVIP-18, Revision 1-A.

- Evaluation:

  The extent and schedule of the inspection and test techniques prescribed by the applicable and NRC staff approved BWRVIP guidelines are designed to maintain structural integrity, to detect aging effects, and to perform repair or replacement before the loss of intended function of BWR vessel internals. Vessel internal components are inspected in accordance with the requirements of ASME Code Section XI, Subsection IWB, Table IWB-2500-1, Examination Category B-N-2 for core support structures, and Examination Category B-N-1 for reactor vessel internal components. This inspection specifies visual VT-3 examination to determine the general mechanical and structural condition of the component supports by (a) verifying parameters, such as clearances, settings, and physical displacements and (b) detecting discontinuities and imperfections, such as loss of integrity at bolted or welded connections, loose or missing parts, debris, corrosion, wear, or erosion. BWRVIP program requirements provide for inspection of BWR internals to manage loss of material and cracking using appropriate examination techniques such as visual examinations (e.g., EVT-1, VT-1) and volumetric examinations (e.g., ultrasonic testing).

- Conclusion:

  This is an existing LR AMP. NRC approved BWRVIP guidance documents for SLR inspections. The reduction of the type, number, and frequency of BWR Reactor Vessel Internal inspections would require extensive testing and investigation to justify any changes. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M10: Boric Acid Corrosion**

  - Description:

    The Boric Acid Corrosion program relies, in part, on implementation of recommendations in the NRC GL 88-05 to identify, evaluate, and correct borated water leaks that could cause corrosion damage to reactor coolant pressure boundary components in PWRs. Potential improvements to boric acid corrosion programs have been identified because of OE with cracking of certain nickel alloy pressure boundary components (NRC Regulatory Issue Summary 2003-013 and NUREG–1823).

    Borated water leakage from piping and components that are outside the scope of the program established in response to NRC GL 88-05 may affect SCs that are subject to aging management review (AMR). Therefore, the scope of the monitoring and inspections of this program includes all components subject to an AMR that may be adversely affected by some form of borated water leakage. The scope of the evaluations, assessments, and corrective actions include all observed leakage sources and the affected SCs.

    Borated water leakage may be discovered through activities other than those established specifically to detect such leakage. Therefore, the program includes provisions for triggering evaluations and assessments when leakage is discovered by other activities. The effects of boric acid corrosion on reactor coolant pressure boundary materials in the vicinity of nickel alloy components are managed by GALL-SLR [9] AMP XI.M11B, “Cracking of Nickel-Alloy Components and Loss of Material Due to Boric Acid-Induced Corrosion in Reactor Coolant Pressure Boundary Components (PWRs Only).”

  - Scope:

    The program covers any SCs on which boric acid corrosion may occur (e.g., steel and copper alloy) and electrical components onto which borated reactor water may leak. The program includes provisions in response to the recommendations of NRC GL 88-05. NRC GL 88-05 elicits a program consisting of systematic measures to provide reasonable assurance that corrosion caused by leaking borated water does not lead to degradation of the leakage source or adjacent SCs, to provide assurance that the reactor coolant pressure boundary will have an extremely low probability of abnormal leakage, rapidly propagating failure, or gross rupture. Such a program provides for (a) determination of the principal location of leakage, (b) examinations and procedures for locating small leaks, and (c) engineering evaluations and corrective actions to provide reasonable assurance that boric acid corrosion does not lead to degradation of the leakage source or adjacent structures or components. Although NRC GL 88-05 addresses boric acid corrosion of reactor coolant pressure boundary components, the recommendations in NRC GL 88-05 are also effective in managing the aging of other in-scope components.

- Evaluation:

  The AMP monitors the aging effects of loss of material due to boric acid corrosion on the intended function of an affected SC by detection of borated water leakage. Borated water leakage results in deposits of white boric acid crystals and the presence of moisture. Discolored boric acid crystals are an indication of corrosion. Boric acid deposits, borated water leakage, or the presence of moisture that could lead to the identification of loss of material can be monitored through visual examination. In order to identify potential borated water leaks inside containment that have not been detected during walkdowns and maintenance, the program tracks airborne radioactivity monitors, humidity monitors, temperature monitors, reactor coolant system water inventory balancing, and containment air cooler thermal performance. The program also looks for evidence of boric acid deposits on control rod drive mechanism shroud fans, containment air recirculation fan coils, containment fan cooler units, and airborne filters.

- Conclusion:

  This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M11B: Cracking of Nickel-Alloy Components and Loss of Material Due to Boric Acid-Induced Corrosion in Reactor Coolant Pressure Boundary Components (PWR Only)**

  - Description:

    This program addresses OE of degradation due to primary water stress corrosion cracking (PWSCC) of components or welds constructed from certain nickel alloys (e.g., Alloy 600/82/182) and exposed to PWR primary coolant at elevated temperature. The initiation and growth of PWSCC cracks have been shown to be a function of several variables, including but not limited to: (i) temperature, (ii) stress, (iii) microstructure, (iv) time, and (v) water chemistry. As a result, this program is informed by GALL-SLR [9] AMP XI.M2, "Water Chemistry."

    In addition to inspections designed to identify cracking of nickel alloy components, this program also contains inspections designed to potentially identify the presence of boric acid residues, which has been demonstrated by OE to lead to loss of material in susceptible carbon and low alloy steel components. Thus, this program is used in conjunction with GALL-SLR Report AMP XI.M10, "Boric Acid Corrosion." Except as required in 10 CFR 50.55a, it is not the general intent of this program to manage the aging of components and welds constructed from PWSCC-resistant nickel alloys (e.g., Alloy 690/52/152).

    Plants have implemented and maintained existing programs to manage cracking due to PWSCC for nickel alloy components and welds, consistent with EPRI Materials Reliability Program

(MRP)-126. The scope of SLR may identify additional nickel alloy components or welds to be included in the applicant's AMP.

- Scope:

  The scope of this program includes three basic groups of components and materials: (i) all nickel alloy components and welds which are identified at the plant in accordance with the guidelines of EPRI MRP-126; (ii) nickel alloy components and welds identified in ASME Code Cases N-770, N-729 and N-722, as incorporated by reference in 10 CFR 50.55a; and (iii) components that are susceptible to corrosion by boric acid and may be impacted by leakage of boric acid from nearby or adjacent nickel alloy components previously described. This program manages cracking due to PWSCC and loss of material due to boric acid corrosion.

- Evaluation:

  Components and welds within the scope of this program are inspected for evidence of PWSCC by volumetric, surface, or visual testing. In the event boric acid residues or corrosion products are discovered during these inspections, the potential for, or extent of, loss of material is evaluated by visual and quantitative methods.

  For nickel alloy components and welds addressed by regulatory requirements contained in 10 CFR 50.55a, inspections are conducted in accordance with 10 CFR 50.55a. Other nickel alloy components and welds within the scope of this program are inspected in accordance with the guidance in the EPRI MRP-126 report.

  The program also performs a baseline volumetric or inner-diameter surface inspection of all susceptible nickel alloy branch line connections and associated welds as identified in Table 4-1 of EPRI MRP-126 if such components or welds are of a sufficient size to create a loss of coolant accident through a complete failure (guillotine break) or ejection of the component and the normal operating temperature of the components is 274°C (Celsius) [525°F (Fahrenheit)] or greater. The baseline inspection is performed prior to the SPEO using a qualified method in accordance with Appendix IV or VIII of ASME Code Section XI as incorporated by reference in 10 CFR 50.55a, or equivalent. Existing periodic inspections using volumetric, or surface examination methods may be credited for the baseline inspection. If the baseline inspection indicates the occurrence of PWSCC, periodic volumetric or inner-diameter surface inspections are performed with adequate periodicity.

- Conclusion:

  This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M12: Thermal Aging Embrittlement of Cast Austenitic Stainless Steel (CASS)**

  - Description:

    The reactor coolant system components are inspected in accordance with the ASME Code, Section XI. This inspection is augmented to detect the effects of loss of fracture toughness due to thermal aging embrittlement of cast austenitic stainless steel (CASS) piping components except for valve bodies. This AMP includes determination of the potential significance of thermal aging embrittlement of CASS components based on casting method, molybdenum content, and percent ferrite. For components for which thermal aging embrittlement is "potentially significant," aging management is accomplished through either (a) qualified visual inspections, such as enhanced visual examination (EVT-1); (b) a qualified UT methodology; or (c) a component-specific flaw tolerance evaluation in accordance with the ASME Code, Section XI. Additional inspection or evaluations to demonstrate that the material has adequate fracture toughness are not required for components for which thermal aging embrittlement is not significant. The scope of the program includes ASME Code Class 1 piping constructed from CASS with service conditions above 250°C (Celsius) [482°F (Fahrenheit)].

- Scope:

  This program manages loss of fracture toughness in ASME Code Class 1 piping components made from CASS. The program includes screening criteria to determine which CASS components have the potential for significant loss of fracture toughness due to thermal aging embrittlement and require augmented inspection. The screening criteria are applicable to all primary pressure boundary components constructed from CASS with service conditions above 250°C [482°F]. The screening criteria for the significance of thermal aging embrittlement are not applicable to niobium-containing steels; such steels require evaluation on a case-by-case basis.

- Evaluation:

  The program monitors the effects of loss of fracture toughness on the intended function of the component by identifying the CASS materials that are susceptible to thermal aging embrittlement. The program does not directly monitor for loss of fracture toughness that is induced by thermal aging; instead, the impact of loss of fracture toughness on component integrity is indirectly managed by using visual or volumetric examination techniques to monitor for cracking in the components.

  For valve bodies, and other "not susceptible" CASS piping components, no additional inspection or evaluations are needed to demonstrate that the material has adequate fracture toughness. For piping components for which thermal aging embrittlement is "potentially significant," the AMP provides for qualified inspections of the base metal, such as EVT-1 or a qualified UT methodology, with the scope of the inspection covering the portions determined to be limiting from the standpoint of applied stress, operating time, and environmental considerations. Examination methods that meet the criteria of the ASME Code, Section XI, Appendix VIII are acceptable.

  Alternatively, a plant-specific or component-specific flaw tolerance evaluation, using specific geometry, stress information, material properties, and ASME Code, Section XI can be used to demonstrate that the thermally-embrittled material has adequate toughness. For CASS piping, UT may be performed in accordance with the methodology of Code Case N-824, as conditioned by 10 CFR 50.55a

- Conclusion:

  Flaw tolerance evaluations are much more beneficial to the site. Performing an EVT-1 or surface examination can be burdensome, at minimum for radiological protection considerations. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M16A: PWR Vessel Internals**

  - Description:

    This program is used to manage the effects of age-related degradation mechanisms that are applicable to the PWR RVI components. In the absence of an acceptable generic methodology such as an approved revision of Materials Reliability Program (MRP)-227 that considers an operating period of 80 years, this program may be based on an existing plant program that is consistent with EPRI Technical Report No. 1022863, "Materials Reliability Program: Pressurized Water Reactor (PWR) Internals Inspection and Evaluation Guidelines," (MRP-227-A), which is implemented in accordance with NEI 03-08, "Guideline for the Management of Materials Issues." Because the guidelines of MRP-227-A are based on an analysis of the RVI that considers the operating conditions up to a 60-year operating period, these guidelines are supplemented through a gap analysis that identifies enhancements to the program that are needed to address an 80-year operating period. In this program, the term "MRP-227-A (as supplemented)" is used to describe either MRP-227-A as supplemented by this gap analysis, or an acceptable generic methodology such as an approved revision of MRP-227 that considers an operating period of 80 years.

- Scope:

  The scope of the program includes all RVI components based on the plant's applicable nuclear steam supply system design. The scope of the program applies the methodology and guidance in MRP-227-A (as supplemented), which provides an augmented inspection and flaw evaluation methodology for assuring the functional integrity of safety-related internals in commercial operating U.S. PWR NPPs designed by Babcock & Wilcox (B&W), Combustion Engineering (CE), and Westinghouse. The scope of components includes core support structures, those RVI components that serve an intended LR safety function pursuant to criteria in 10 CFR 54.4(a)(1), and other RVI components whose failure could prevent satisfactory accomplishment of any of the functions identified in 10 CFR 54.4(a)(1)(i), (ii), or (iii). In addition, ASME Code, Section XI includes inspection requirements for PWR removable core support structures in Table IWB-2500-1, Examination Category B-N-3, which are in addition to any inspections that are implemented in accordance with MRP-227-A (as supplemented).

- Evaluation:

  This is an existing AMP. The program manages the following age-related degradation effects and mechanisms that are applicable in general to RVI components at the facility: (a) cracking induced by SCC, PWSCC, IASCC, or fatigue/cyclic loading; (b) loss of material induced by wear; (c) loss of fracture toughness induced by thermal aging and neutron irradiation embrittlement; (d) changes in dimensions due to void swelling or distortion; and (e) loss of preload due to thermal and irradiation-enhanced stress relaxation or creep.

  The inspection methods are defined and established in MRP-227-A (as supplemented). Standards for implementing the inspection methods are defined and established in MRP-228. In all cases, well-established inspection methods are selected. These methods include volumetric UT examination methods for detecting flaws in bolting and various visual (VT-3, VT-1, and EVT-1) examinations for detecting effects ranging from general conditions to detection and sizing of surface-breaking discontinuities.

- Conclusion:

  This is an existing LR AMP. NRC approved guidance document MRP-227-A (as supplemented) for SLR inspections. The licensee may submit a generic AMP for approval which would require extensive support work for approval. It should be noted that industry events have impacted the RVI program and may change the RVI program requirements. This program should be monitored for any evolving changes in scope.

• **XI.M17: Flow-Accelerated Corrosion**

- Description:

  This program manages wall thinning caused by flow-accelerated corrosion (FAC) and may also be used to manage wall thinning due to erosion mechanisms, if present, that are not being managed by another program. The program is based on commitments made in response to the NRC GL 89-08 and relies on implementation of the EPRI guidelines in the Nuclear Safety Analysis Center (NSAC)-202L for an effective FAC program. The program includes (a) identifying all susceptible piping systems and components; (b) developing FAC predictive models to reflect component geometries, materials, and operating parameters; (c) performing analyses of FAC models and, with consideration of OE, selecting a sample of components for inspections; (d) inspecting components; (e) evaluating inspection data to determine the need for inspection sample expansion, repairs, or replacements, and to schedule future inspections; and (f) incorporating inspection data to refine FAC models. This program may also manage wall thinning caused by mechanisms other than FAC, in situations where periodic monitoring is used in lieu of eliminating the cause of various erosion mechanisms.

- Scope:

  The FAC program, described by the EPRI guidelines in NSAC-202L, includes procedures or administrative controls to assure that structural integrity is maintained for carbon steel piping components containing single- and two-phase flow conditions. This program also includes the pressure retaining portions of pump and valve bodies within these systems. The FAC program was originally outlined in NUREG–1344 and was further described through the NRC GL 89-08. The program may also include components that are subject to wall thinning due to erosion mechanisms such as cavitation, flashing, droplet impingement, or solid particle impingement in various water systems. Since there are no materials that are known to be totally resistant to wall thinning due to erosion mechanisms, susceptible components of any material may be included in the erosion portion of the program.

- Evaluation:

  Generally, this is an existing LR AMP. For FAC, the inspection program delineated in NSAC-202L includes identification of susceptible locations. For periods of extended operation beyond 60 years, piping systems that have been excluded from wall thickness monitoring due to operation less than 2 percent of plant operating time (as allowed by NSAC-202L) will be reassessed to ensure adequate bases exist to justify this exclusion. If actual wall thickness information is not available for use in this assessment, a representative sampling approach can be used. This program specifies nondestructive examination methods, such as ultrasonic testing (UT) and/or radiographic testing, to quantify the extent of wall thinning. Opportunistic visual inspections of up-stream and down-stream piping and components are performed during periodic pump and valve maintenance or during pipe replacements to assess internal surface conditions. A representative sample of components is selected based on the most susceptible locations for wall thickness measurements at a frequency in accordance with NSAC-202L guidelines to identify and mitigate degradation before the component integrity is challenged.

  For erosion mechanisms, the program includes the identification of susceptible locations based on the extent-of-condition reviews from corrective actions in response to plant-specific and industry OE.

- Conclusion:

  This is an existing LR AMP required by NUREG-1344 and GL 89-08 response. This program may benefit from further evaluation to reduce inspection workforce or cost by implementing RI criteria.

- **XI.M18: Bolting Integrity**

  - Description:

    The program manages aging of closure bolting for pressure retaining components. The program includes periodic visual inspection of closure bolting for indications of loss of preload, cracking, and loss of material due to general, pitting, and crevice corrosion, microbiologically influenced corrosion (MIC), and wear as evidenced by leakage. Closure bolting that is submerged or located in piping systems that contain air or gas for which leakage is difficult to detect, is inspected or tested by alternative means. The program also includes sampling-based volumetric examinations of high-strength closure bolting to detect indications of cracking. The program also includes preventive measures to preclude or minimize loss of preload and cracking.

- Scope:

  This program manages the effects of aging of closure bolting for pressure retaining components (aging effects associated with heating, ventilation, and air conditioning (HVAC) closure bolting are managed by GALL-SLR Report AMP XI.M36) within the scope of LR. This program does not manage aging of reactor head closure stud bolting (GALL-SLR Report AMP XI.M3) or structural bolting (GALL-SLR Report AMPs XI.S1, XI.S3, XI.S6, XI.S7, and XI.M23).

- Evaluation:

  Generally, this is an existing LR AMP. Degradation of pressure boundary closure bolting due to crack initiation, loss of preload, or loss of material may result in leakage from the mating surfaces or joint connections of pressure boundary components. Periodic inspections of ASME Code class and non-ASME Code class bolted joints for signs of leakage are conducted at least once per refueling cycle. The inspections may be performed as part of ASME Code Section XI leakage tests or as part of other periodic inspection activities, such as system walkdowns or GALL-SLR Report AMP XI.M36 inspections. Bolted joints that are not readily visible during plant operations and refueling outages are inspected when they are made accessible and at such intervals that would provide reasonable assurance the components' intended functions are maintained.

  High strength closure bolting [actual measured yield strength greater than or equal to 150 ksi (1,034 MPa)] may be subject to SCC. For all closure bolting greater than 2 inches in diameter (regardless of code classification) with actual yield strength greater than or equal to 150 ksi (1,034 MPa) and closure bolting for which yield strength is unknown, volumetric examination in accordance with ASME Code Section XI, Table IWB-2500-1, Examination Category B-G-1, is performed.

  In each 10-year period during the SPEO, a representative sample of bolt heads and threads is inspected. The inspection includes a representative sample of 20 percent of the population of bolt heads and threads (defined as bolts with the same material and environment combination) or a maximum of 25 bolts per population at each unit.

- Conclusion:

  This is an existing LR AMP. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M19: Steam Generators**

  - Description:

    The program is applicable to managing the aging of steam generator tubes, plugs, sleeves, divider plate assemblies, tube-to-tubesheet welds, heads (interior surfaces of channel or lower/upper heads), tubesheet(s) (primary side), and secondary side components that are contained within the steam generator (i.e., secondary side internals). The aging of steam generator pressure vessel welds is managed by other programs such as NUREG-2191 AMP XI.M1, "ASME Section XI Inservice Inspection, Subsections IWB, IWC, and IWD," and AMP XI.M2, "Water Chemistry." The establishment of a steam generator program for ensuring steam generator tube integrity is required by plant TSs. The TS require tube integrity to be maintained and specify performance criteria, condition monitoring requirements, inspection scope and frequency, acceptance criteria for the plugging or repair of flawed tubes, acceptable tube repair methods, and leakage monitoring requirements.

- Scope:

  This program addresses degradation associated with steam generator tubes, plugs, sleeves, divider plate assemblies, tube-to-tubesheet welds, heads (interior surfaces of channel or lower/upper heads), tubesheet(s) (primary side), and secondary side components that are contained within the steam generator (i.e., secondary side internals). The program does not cover the steam generator secondary side shell, any nozzles attached to the secondary side shell or steam generator head, or the welds associated with these components. In addition, the program does not cover steam generator head welds (other than general corrosion of these welds caused as a result of degradation (defects/flaws) in the primary side cladding).

- Evaluation:

  Generally, this is an existing LR AMP. The TS require that a Steam Generator program be established and implemented to maintain the integrity of the steam generator tubes. In accordance with this requirement, components that could compromise tube integrity are evaluated or monitored (e.g., degradation of a secondary side component that could result in a loss of tube integrity is managed by this program). The inspection requirements in the TS are intended to detect degradation (i.e., aging effects), if they should occur.

  The TS are performance-based, and the actual scope of the inspection and the expansion of sample inspections are justified based on the results of the inspections. The goal is to perform inspections at a frequency sufficient to provide reasonable assurance of steam generator tube integrity for the period of time between inspections.

  The general condition of some components (e.g., plugs, secondary side components, divider plates, and primary side cladding of channel heads and tubesheets) is monitored. It may be monitored visually, and, subsequently, more detailed inspections may be performed if degradation is detected.

  NEI 97-06 provides additional guidance on inspection programs to detect degradation of tubes, sleeves, plugs, and secondary side internals. The frequencies of the inspections are based on technical assessments. Guidance on performing these technical assessments is contained in NEI 97-06 and the associated industry guidelines.

- Conclusion:

  This is an existing LR AMP that is a TS required program. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M20: Open-Cycle Cooling Water System**

  - Description:

    This program relies, in part, on implementing portions of the recommendations for the NRC GL 89-13 to provide reasonable assurance that the effects of aging on the open-cycle cooling water (OCCW) (or service water) system will be managed for the SPEO.

    The OCCW system program manages aging effects of components in raw water systems, such as service water, by using a combination of preventive, condition monitoring, and performance monitoring activities. These include:

    a. surveillance and control techniques to manage aging effects caused by biofouling, corrosion, erosion, and fouling in the OCCW system or SCs serviced by the OCCW system;

    b. inspection of components for signs of loss of material, corrosion, erosion, cracking, fouling, and biofouling; and

c. testing of the heat transfer capability of heat exchangers that remove heat from components important to safety.

- Scope:

  This program addresses piping, piping components, piping elements, and heat exchanger components exposed to raw water in the OCCW system. The program applies to components constructed of various materials including steel, stainless steel (SS), aluminum, copper alloys, titanium, nickel alloy, fiberglass, polymeric materials, and concrete. The program may manage loss of coating integrity as provided in the XI.M20-2 recommendations of NUREG-2191 AMP XI.M42. This program references NRC GL 89-13; plant activities in response to NRC GL 89-13 may be credited for this program, as appropriate.

- Evaluation:

  This is an existing LR AMP. Inspection scope, methods (e.g., visual, or volumetric inspections, performance testing), and frequencies are in accordance with the applicant's docketed response to NRC GL 89-13. As noted in NRC GL 89-13, testing frequencies can be adjusted to provide assurance that equipment will perform the intended function between test intervals but should not exceed 5 years. Visual inspections are used to identify fouling, and loss of coating or lining integrity and provide a qualitative assessment for loss of material due to various forms of corrosion and erosion. Examinations of polymeric and concrete materials should be consistent with the examinations described in AMP XI.M38. Volumetric examinations, such as ultrasonic testing, eddy current testing, and radiography are used to quantify the extent of wall thinning or loss of material.

- Conclusion:

  This is an existing LR AMP that is based on the licensee's response to GL 89-13. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M21A: Closed Treated Water Systems**
  - Description:
  - NPPs contain many closed, treated water systems. These systems undergo water treatment to control water chemistry and prevent corrosion (i.e., treated water systems). These systems are also recirculating systems in which the rate of recirculation is much higher than the rate of addition of makeup water (i.e., closed systems). This is a mitigation program that also includes condition monitoring to verify the effectiveness of the mitigation activities. The program includes: (a) water treatment, including the use of corrosion inhibitors, to modify the chemical composition of the water such that the function of the equipment is maintained and such that the effects of corrosion are minimized; (b) chemical testing of the water to demonstrate that the water treatment program maintains the water chemistry within acceptable guidelines; and (c) inspections to determine the presence or extent of degradation. Depending on the water treatment program selected for use in association with this AMP and/or plant OE, this program also may include corrosion monitoring (e.g., corrosion coupon testing) and microbiological testing. NUREG-2191 XI.M21A Closed Treated Water System AMP was amended by SLR-ISG-2021-02-MECHANICAL.
  - Scope:

    This program manages the aging effects of loss of material due to corrosion, cracking due to SCC, and reduction of heat transfer due to fouling of the internal surfaces of piping, piping components, piping elements and heat exchanger components fabricated from any material and exposed to treated water.

- Evaluation:

  Generally, this is an existing LR AMP. This program monitors water chemistry parameters (preventive monitoring) and the condition of surfaces exposed to the water (condition monitoring). Depending on the water treatment program selected for use in association with this AMP and/or plant OE, this program may also include corrosion monitoring (e.g., corrosion coupon testing) and microbiological testing.

  Water chemistry parameters (such as the concentration of iron, copper, silica, oxygen, and hardness, alkalinity, specific conductivity, and pH) are monitored because maintenance of optimal water chemistry prevents loss of material and cracking due to corrosion and SCC. The specific water chemistry parameters monitored and the acceptable range of values for these parameters are in accordance with the EPRI 3002000590 “Closed Cooling Water Chemistry Guideline,” which is used in its entirety for the water chemistry control or guidance.

- Conclusion:

  This is an existing LR AMP that has a low impact on manpower and a high value for preventing loss of material and cracking due to corrosion and SCC. This program would not benefit from further evaluation to reduce inspection workforce or cost.

• **XI.M22: Boraflex Monitoring**

- Description:

  Many neutron-absorbing materials, such as Boraflex, Boral, Metamic, boron steel, and carborundum, are used in spent fuel pools. This AMP addresses aging management of spent fuel pools using Boraflex as the neutron-absorbing material. GALL-SLR [9] AMP XI.M40, “Monitoring of Neutron-Absorbing Material Other Than Boraflex,” addresses aging management of spent fuel pools using neutron-absorbing materials other than Boraflex, such as Boral, Metamic, boron steel, and carborundum. When a spent fuel pool criticality analysis credits Boraflex and materials other than Boraflex, the guidance in both GALL-SLR Report AMPs XI.M22 and XI.M40 applies.

  For Boraflex panels in spent fuel storage racks, gamma irradiation and long-term exposure to the wet fuel pool environment causes shrinkage resulting in gap formation, gradual degradation of the polymer matrix, and the release of silica to the spent fuel storage pool water. This results in the loss of boron carbide in the neutron absorber sheets. A monitoring program for the Boraflex panels in the spent fuel storage racks is implemented to assure that no unexpected degradation of the Boraflex material compromises the criticality analysis in support of the design of spent fuel storage racks.

- Scope:

  This program manages the effect of reduction in neutron-absorbing capacity due to degradation in sheets of neutron-absorbing material made of Boraflex affixed to spent fuel racks.

- Evaluation:

  This is an existing LR AMP. Aging effects on Boraflex panels are detected by monitoring silica levels in the spent fuel storage pool on a regular basis, such as monthly, quarterly, or annually (depending on Boraflex panel condition); by measuring boron-10 areal density on a frequency determined by the material condition of the Boraflex panels, with a minimum frequency of once every 5 years; and by applying predictive methods to the measured results. The amount of boron-10 carbide present in the Boraflex panels is determined through direct measurement of boron-10 areal density by periodic verification of boron-10 loss through areal density measurement techniques, such as the BADGER device. Frequent Boraflex testing is sufficient to verify that Boraflex panel degradation does not compromise criticality analysis for the spent fuel pool storage racks. Additionally, changes in the level of silica present in the spent fuel pool water provide an indication of changes in the rate of degradation of Boraflex panels.

- Conclusion:

  This is an existing LR AMP that has a low impact on manpower. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M23: Inspection of Overhead Heavy Load and Light Load (Related to Refueling) Handling Systems**

  - Description:

    The Inspection of Overhead Heavy Load and Light Load (Related to Refueling) Handling Systems AMP evaluates the effectiveness of maintenance monitoring activities for cranes and hoists that are within the scope of SLR. This program addresses the inspection and monitoring of crane-related structures and components to provide reasonable assurance that the handling system does not affect the intended function of nearby safety-related equipment. Many crane systems and components are not within the scope of this program because they perform an intended function with moving parts or with a change in configuration, or they are subject to replacement based on qualified life.

  - Scope:

    This program manages the aging effects associated with handling systems that are within the scope of 10 CFR 54.4. Portions of the handling system that are within the scope of this program include the bridges, structural members, and structural components.

  - Evaluation:

    This is an existing LR AMP. Load handling systems are visually inspected at a frequency in accordance ASME B30.2, “Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist),” or other appropriate standard in the ASME B30 series. ASME B30.2 establishes inspection frequencies based on the severity of service, as defined by the number and magnitude of lifts. For systems that are infrequently in service, such as containment polar cranes, periodic inspections are performed once every refueling cycle just prior to use. Visual inspections consist of the following:

    – Bridges, structural members, and structural components are visually inspected for loss of material due to general corrosion, deformation, cracking, and wear.
    – Bolted connections are visually inspected for loss of material due to general corrosion; cracking; and loose or missing bolts or nuts, and other conditions indicative of loss of preload.

    Visual inspection activities are performed by personnel qualified in accordance with plant-specific procedures and processes.

  - Conclusion:

    This is an existing LR AMP that has a low impact on manpower and high value on safety. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M24: Compressed Air Monitoring**
  - Description:

    The purpose of the compressed air monitoring program is to provide reasonable assurance of the integrity of the compressed air system downstream of the instrument air dryers. The program consists of monitoring moisture content, corrosion, and performance of the compressed air system. This includes (a) preventive monitoring of water (moisture) and other potentially corrosive contaminants to keep within the specified limits; and (b) opportunistic inspection of components for indications of loss of material due to corrosion. This program is based on relevant aspects of the respective Utility's response to NRC GL 88-14.
  - Scope:

    This program manages the aging effects of loss of material due to corrosion in compressed air system components located downstream of the compressed air system air dryers, or for components exposed to an internal gas environment (e.g., nitrogen-filled accumulators). Aging effects associated with components located upstream of the air dryers, or those exposed to an air environment that is not subject to the preventive actions of this program, are managed by NUREG-2191 AMP XI.M38, "Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components."
  - Evaluation:

    This is an existing LR AMP. The program periodically samples and tests the air in the compressed system in accordance with industry standards (i.e., ANSI/ISA-7.0.01-1996). Compressed air systems have in-line dew point instrumentation that either continuously monitors using an automatic alarm system or is checked at least daily to determine whether moisture content is within the recommended range. Additionally, opportunistic visual inspections of component internal surfaces exposed to an air-dry environment are performed for signs of loss of material due to corrosion. Guidance for inspection frequency and inspection methods of these components is provided in standards or documents such as ASME OM-2012, Division 2, Part 28.

    Inspections and tests are performed by personnel qualified in accordance with site procedures and programs to perform the specified task.
  - Conclusion:

    This is an existing LR AMP. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M25: BWR Reactor Water Cleanup System**
  - Description:

    This program is a condition monitoring program that provides inspections to manage cracking due to SCC or IGSCC on the intended function of certain austenitic stainless steel (SS) piping in the reactor water cleanup (RWCU) system of BWRs. Based on the NRC criteria related to inspection guidelines for RWCU piping welds outboard of the second isolation valve, the program includes the measures delineated in NUREG–0313, Revision 2, and NRC GL 88-01 and its Supplement 1.
  - Scope:

    This program provides ISI to manage cracking due to SCC or IGSCC in austenitic SS piping outboard of the second containment isolation valves in the RWCU system.

The components included in this program are the welds in piping that have a nominal diameter of 4 inches or larger and that contain reactor coolant at a temperature above 93°C (Celsius) [200°F (Fahrenheit)] during power operation, regardless of ASME Code classification.

- Evaluation:

  This is an existing AMP. The extent, method, and schedule of the inspections delineated in the NRC inspection criteria for RWCU piping and NRC GL 88-01 are designed to maintain structural integrity and to detect aging effects before the loss of intended function of austenitic SS piping and fittings. Guidelines for the inspection schedule, methods, personnel, and sample expansion are based on NRC GL 88-01 and GL 88-01, Supplement 1, and any applicable alternatives to these inspections that were subsequently approved by the NRC. These alternative inspections are implemented in accordance with the CLB for the plant. Typically, if all of the GL 89-10 actions had not been satisfactorily completed, then one alternative inspection would include 10 percent of the welds every refueling outage. Another alternative inspection would typically include at least 2 percent of the welds or 2 welds every refueling outage, whichever sample is larger, if: (a) all of the GL 89-10 actions had been satisfactorily completed, (b) no IGSCC had been detected in RWCU piping welds inboard of the second containment isolation valves, and (c) no IGSCC had been detected in RWCU piping welds outboard of the second containment isolation valves after a minimum of 10 percent of the susceptible welds were inspected.

- Conclusion:

  This is an existing LR AMP that is required by NRC NUREG and GL. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M26: Fire Protection**

  - Description:

    The Fire Protection AMP includes a fire barrier inspection program. The fire barrier inspection program requires periodic visual inspection of fire barrier penetration seals; fire barrier walls, ceilings, and floors; fire damper assemblies; and periodic visual inspection and functional tests of fire-rated doors to provide reasonable assurance that their operability is maintained. The AMP also includes periodic inspection and testing of the halon/carbon dioxide (CO_2) or clean agent fire suppression system. Additionally, this AMP is complemented by the NUREG-2191 AMP XI.S6, “Structures Monitoring,” which consists of periodic visual inspections by personnel qualified to monitor SCs for applicable aging effects.

  - Scope:

    This program manages the effects of loss of material and cracking, increased hardness, shrinkage, and loss of strength on the intended function of the penetration seals; fire barrier walls, ceilings, and floors; fire damper assemblies; and other fire resistance materials (e.g., Flamemastic, 3M fire wrapping, spray-on fire proofing material, intumescent coating, etc.) that serve a fire barrier function; and all fire-rated doors (automatic or manual) that perform a fire barrier function. It also manages the aging effects on the intended function of the halon/CO_2 or clean agent fire suppression system.

  - Evaluation:

    This is an existing LR AMP. Visual inspection of penetration seals detects cracking, seal separation from walls and components, and rupture and puncture of seals. Visual inspection by fire protection qualified personnel of not less than 10 percent of each type of seal in walkdowns is performed at a frequency in accordance with an NRC-approved fire protection program (e.g., Technical Requirements Manual, Appendix R program) or at least once every refueling outage.

Visual inspection to detect cracking and loss of material are conducted by fire protection qualified personnel of the fire barrier walls, ceilings, floors, and doors (e.g., wear, missing parts); fire damper assemblies; and other fire barrier materials including structural steel fire proofing during walkdowns at a frequency in accordance with an NRC-approved fire protection program. Periodic functional tests are conducted on fire doors.

Visual inspections of the halon/CO2 or clean agent fire suppression system are performed to detect any sign of corrosion before the loss of the component intended function. Periodic testing of the halon/carbon dioxide (CO2) or clean agent fire suppression systems is conducted on a schedule in accordance with an NRC-approved fire protection program.

- Conclusion:

  This is an existing LR AMP. Most inspections for this AMP are required by the NFPA code and the Fire Protection Insurer. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M27: Fire Water System**

  - Description:

    This AMP applies to water-based fire protection system components. Full-flow testing and visual inspections are conducted in order to ensure that loss of material, cracking, and flow blockage are adequately managed. The portions of the water-based fire protection system that are: (a) normally dry but periodically are subject to flow (e.g., dry-pipe or preaction sprinkler system piping and valves) and (b) that cannot be drained or allow water to collect, are subjected to augmented testing or inspections. Also, portions of the system (e.g., fire service main, standpipe) are normally maintained at required operating pressure and monitored such that loss of system pressure is immediately detected and corrective actions are initiated. This AMP also replaces sprinklers before reaching 50 years in service or tests a representative sample of sprinklers using the guidance of National Fire Protection Association (NFPS) 25, “Inspection, Testing and Maintenance of Water-Based Fire Protection Systems.”

  - Scope:

    Components within the scope of water-based fire protection systems include items such as sprinklers, nozzles, fittings, valve bodies, fire pump casings, hydrants, hose stations, fire water storage tanks, fire service mains, and standpipes, water storage tanks; and aboveground, buried, and underground piping and components that are tested in accordance with the applicable NFPA codes and standards. The internal surfaces of water-based fire protection system piping that is normally drained, such as dry-pipe sprinkler system piping, are included within the scope of the AMP. Fire hose stations and standpipes are considered piping in the AMP.

  - Evaluation:

    This is an existing LR AMP. Periodic flow tests, flushes, internal and external visual inspections, and testing of sprinklers are performed. Visual inspection of yard fire hydrants, fire hydrant hose hydrostatic tests, gasket inspections, and fire hydrant flow tests are conducted to provide opportunities to detect degradation before a loss of intended function can occur.

    In each 5-year interval, beginning 5 years prior to the SPEO, the program either conduct a flow test or flush sufficient to detect potential flow blockage, or conduct a visual inspection of 100 percent of the internal surface of piping segments that cannot be drained or piping segments that allow water to collect. In each 5-year interval of the SPEO, 20 percent of the length of piping segments that cannot be drained or piping segments that allow water to collect is subject to volumetric wall thickness inspections. If the results of a 100-percent internal visual inspection are acceptable, and the segment is not subsequently wetted, no further augmented tests or inspections are necessary. In lieu of recurring inspections on non-draining piping, such piping segments can be modified so that the water does not collect and can be drained.

The inspections and tests of all water-based fire protection components occur at the intervals specified in NFPA 25, or as modified by Table XI.M27-1. Of these inspections and tests, the fire water storage tanks interior and exterior inspections are volumetric testing have the potential to add great amounts of burden to the respective Utility. The water-based fire protection systems are normally maintained at required operating pressure and monitored in such a way that loss of system pressure is immediately detected and corrected when acceptance criteria are exceeded. Continuous system pressure monitoring or equivalent methods (e.g., number of jockey fire pump starts or run time) are conducted.

- Conclusion:

  This is an existing LR AMP. Many of the inspections for this AMP are required by the NFPA code and the Fire Protection Insurer. If the Fire Water System has been on treated water from installation, evaluation of previous inspections for blockage data could provide justification for extending the normally dry piping inspection frequency. There are also options to modify the plant in lieu of certain inspections/testing (e.g., sprinkler and non-draining sections). This program could benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M29: Outdoor and Large Atmospheric Metallic Storage Tanks**

  - Description:

    The Outdoor and Large Atmospheric Metallic Storage Tanks AMP manages the effects of loss of material and cracking on the outside and inside surfaces of metallic aboveground tanks constructed on concrete or soil. All metallic outdoor tanks (except fire water storage tank interior surfaces and exterior surfaces not exposed to soil or concrete) and certain indoor metallic tanks are included. If the tank exterior is fully accessible, tank outside surfaces may be inspected under the program for inspection of external surfaces NUREG-2191 AMP XI.M36 for visual inspections of external surfaces recommended in this AMP; surface examinations are conducted in accordance with the recommendations of this AMP. This program credits the standard industry practice of coating or painting the external surfaces of steel tanks as a preventive measure to mitigate corrosion. The program relies on periodic inspections to monitor degradation of the protective paint or coating. Tank inside surfaces are inspected by visual or surface examinations as required to detect applicable aging effects.

  - Scope:

    Tanks within the scope of this program include: (a) all metallic outdoor tanks (except fire water storage tank interior surfaces and exterior surfaces not exposed to soil or concrete) constructed on soil or concrete; (b) indoor large volume metallic storage tanks (i.e., those with a capacity greater than 100,000 gallons) designed to internal pressures approximating atmospheric pressure and exposed internally to water; and (c) other indoor metallic tanks that sit on, or are embedded in concrete where plant specific operating experience reveals that the tank bottom (or sides for embedded tanks) to concrete interface is periodically exposed to moisture. Visual inspections are conducted on tank insulation and jacketing when these are installed.

  - Evaluation:

    This program consists of periodic inspections of metallic tanks (with or without coatings) to manage the effects of corrosion and cracking on the intended function of these tanks. Inspections cover all surfaces of the tank (i.e., outside uninsulated surfaces, outside insulated surfaces, bottom, interior surfaces). The AMP uses periodic plant inspections to monitor degradation of coatings, sealants, and caulking because it is a condition directly related to the potential loss of material or cracking. Thickness measurements of the bottoms of the tanks are conducted periodically. Periodic internal visual inspections and surface examinations, as required to detect applicable aging effects, are performed to detect degradation that could be occurring on the inside of the tank. Frequency of tank inspections depends on an internal or external tank inspection and the tank material-environment-aging effects-inspection technique.

- Conclusion:

  This is an existing LR AMP. This program may benefit from further evaluation to reduce inspection workforce or cost. Specifically, further evaluation into performing volumetric tank bottom inspections without requiring the draining of the respective tank could reduce cost.

- **XI.M30: Fuel Oil Chemistry**

  - Description:

    This AMP includes (a) surveillance and maintenance procedures to mitigate corrosion and (b) measures to verify the effectiveness of the mitigative actions and confirm the insignificance of an aging effect. Fuel oil quality is maintained by monitoring and controlling fuel oil contamination in accordance with the plant's TS. Guidelines of the American Society for Testing and Materials (ASTM) Standards, such as ASTM D 0975, D 1796, D 2276, D 2709, D 6217, and D 4057, also may be used. Exposure to fuel oil contaminants, such as water and microbiological organisms, is minimized by periodic draining or cleaning of tanks and by verifying the quality of new oil before its introduction into the storage tanks. However, corrosion may occur at locations in which contaminants may accumulate, such as tank bottoms. Accordingly, the effectiveness of the program is verified to provide reasonable assurance that significant degradation is not occurring, and that the component's intended function is maintained during the SPEO. The thickness measurement of the tank bottom is an acceptable verification program.

  - Scope:

    Components within the scope of the program are the diesel fuel oil storage tanks, piping, and other metal components subject to aging management review that are exposed to an environment of diesel fuel oil.

  - Evaluation:

    Loss of material due to corrosion of the diesel fuel oil tank or other components exposed to diesel fuel oil cannot occur without exposure of the tank's internal surfaces to contaminants in the fuel oil, such as water and microbiological organisms. Periodic multilevel sampling provides assurance that fuel oil contaminants are below unacceptable levels. If tank design features do not allow for multilevel sampling, a sampling methodology that includes a representative sample from the lowest point in the tank may be used.

    At least once during the 10-year period prior to the SPEO, each diesel fuel tank is drained and cleaned, the internal surfaces are visually inspected (if physically possible) and volumetrically inspected if evidence of degradation is observed during visual inspection, or if visual inspection is not possible. During the SPEO, at least once every 10 years, each diesel fuel tank is drained and cleaned, the internal surfaces are visually inspected (if physically possible), and, if evidence of degradation is observed during inspections, or if visual inspection is not possible, these diesel fuel tanks are volumetrically inspected. The external surfaces of tank bottoms for outdoor tanks exposed to soil or concrete and indoor tanks exposed to periodically wetted concrete or exposed to soil are volumetrically inspected. The tank draining, cleaning, and corresponding inspection/testing can be a significant burden on the utility.

- Conclusion:

  This is an existing LR AMP. May be able to justify increasing the inspection frequency based on plant OE and environmental conditions. (e.g., at least one utility will inspect their FOST on a 20-year frequency). This program may benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M31: Reactor Vessel Material Surveillance**

  - Description:

    10 CFR Part 50, Appendix H, requires implementation of a Reactor Vessel Material Surveillance program when the peak neutron fluence at the end of the design life of the vessel exceeds 1017 n/cm2 (E > 1 MeV). The purpose of the material surveillance program is to monitor the changes in fracture toughness to the ferritic reactor vessel beltline materials. As described in Regulatory Issue Summary 2014-11, beltline materials are those ferritic reactor vessel materials with a projected neutron fluence greater than 1017 n/cm2 (E > 1 MeV) at the end of the license period (for example, the SPEO), which are evaluated to identify the extent of neutron radiation embrittlement for the material. The surveillance capsules contain reactor vessel material specimens and are located near the inside vessel wall in the beltline region so that the specimens duplicate, as closely as possible, the neutron spectrum, temperature history, and maximum neutron fluence experienced at the reactor vessel's inner surface. Because of the location of the capsules between the reactor core and the reactor vessel wall, surveillance capsules typically receive neutron fluence exposures that are higher than the inner surface of the reactor vessel. This allows surveillance capsules to be withdrawn and tested prior to the inner surface receiving an equivalent neutron fluence so that the surveillance test results bound the conditions at the end of the SPEO.

  - Scope:

    The program addresses neutron embrittlement of all ferritic reactor vessel beltline materials as defined by 10 CFR Part 50, Appendix G, as the region of the reactor vessel that directly surrounds the effective height of the active core and the adjacent regions of the reactor vessel that are predicted to experience sufficient neutron damage to be considered in the selection of the limiting material with regard to radiation damage. Materials with a projected neutron fluence greater than 1017 n/cm2 (E > 1 MeV) at the end of the license period (for example, the SPEO), are considered to experience sufficient neutron damage to be included in the beltline. Materials monitored within the licensee's existing, materials surveillance program typically continue to serve as the basis for the reactor vessel surveillance AMP.

  - Evaluation:

    Reactor vessel materials are monitored by a surveillance program in which surveillance capsules are withdrawn from the reactor vessel and tested consistent with 10 CFR Part 50, Appendix H. The ASTM standards referenced in Appendix H describe the methods used to monitor irradiation embrittlement (as described in Element 3, above), selection of materials, and the withdrawal schedule for surveillance capsules. Because the withdrawal schedule in Table 1 of ASTM E185-82 is based on plant operation during the original 40-year license term, standby capsules may need to be incorporated into the program as capsules to be tested within a withdrawal schedule that covers the SPEO. Alternatively, this program can propose implementation of in-vessel irradiation of capsule(s) with reconstituted specimens from previously tested capsules and appropriate neutron fluence monitoring.

- Conclusion:

  This is an existing AMP required by 10 CFR Part 50, Appendix H. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M32: One-Time Inspection**
  - Description:

    A one-time inspection of selected components is conducted just prior to the beginning of a SPEO (e.g., prior to the second period of extended operation) in order to verify the system-wide effectiveness of an AMP that is designed to prevent or minimize aging to the extent that it will not cause the loss of intended function during the SPEO. For example, effective control of water chemistry under the GALL-SLR [9] AMP XI.M2, "Water Chemistry," program can prevent some aging effects and minimize others. However, there may be locations that are isolated from the flow stream for extended periods and are susceptible to the gradual accumulation or concentration of agents that promote certain aging effects. This program provides inspections that verify that unacceptable degradation is not occurring.

  - Scope:

    The scope of this program includes systems and components that are subject to aging management using GALL-SLR Report AMPs XI.M2, "Water Chemistry;" XI.M30, "Fuel Oil Chemistry;" and XI.M39, "Lubricating Oil Analysis;" and for which no aging effects have been observed or for which the aging effect is occurring very slowly and will not affect the component's or structure's intended function during the SPEO based on prior OE data. The scope of this program also may include other components and materials where the environment in the SPEO is expected to be equivalent to that in the prior operating period and for which no aging effects have been observed. The scope of this program includes managing long-term loss of material due to general corrosion for steel components.

  - Evaluation:

    This is an existing LR AMP. Elements of the program include (a) determination of the sample size of components to be inspected based on an assessment of materials of fabrication, environment, plausible aging effects, and OE; (b) identification of the inspection locations in the system or component based on the potential for the aging effect to occur; and (c) determination of the examination technique, including acceptance criteria that would be effective in managing the aging effect for which the component is examined. The inspection includes a representative sample of each population (defined as components having the same material, environment, and aging effect combination) and, where practical, focuses on the bounding or lead components most susceptible to aging due to time in service, and severity of operating conditions. A representative sample size is 20 percent of the population or a maximum of 25 components at each unit. This results in approximately 200-300 total inspections per unit.

    The sample of components are inspected before the end of the current operating term to provide reasonable assurance that the aging effect will not compromise any intended function during the SPEO. Inspections need to be timed to allow the inspected components to attain sufficient age such that the aging effects with long incubation periods (i.e., those that may affect intended functions near the end of the SPEO) are identified. Within these constraints, the applicant schedules the inspection no earlier than 10 years prior to the SPEO.

  - Conclusion:

    This is an existing program that will require review of plant history of One-Time inspections or periodic inspections from the LR program. Experimental testing of specific materials could provide data for justification for reduced testing of components. Review of industry OE from the LR programs may provide data for justification for reduced testing of certain material-environment combinations. A Risk Informed program could reduce the number of inspections based on those material/environment combinations that have resulted in increased aging effects. This program would benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M33: Selective Leaching**
  - Description:

    The program for selective leaching (dealloying) of materials includes components made of gray cast iron, ductile iron, and copper alloys (except for inhibited brass) that contain greater than 15 percent zinc or greater than 8 percent aluminum exposed to a raw water, closed-cycle cooling water (CCCW), treated water, wastewater, or soil environment. Depending on the environment, the AMP includes one-time, or opportunistic or periodic visual inspections of selected components that are susceptible to selective leaching, coupled with mechanical examination techniques (e.g., chipping, scraping). Destructive examinations of components to determine the presence of and depth of dealloying through-wall thickness are also conducted. These techniques can determine whether loss of material due to selective leaching is occurring and whether selective leaching will affect the ability of the components to perform their intended function for the SPEO.
  - Scope:

    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, ductile iron, and copper alloys (except for inhibited brass) containing greater than 15 percent zinc or greater than 8 percent aluminum. These components may be exposed to raw water, CCCW, treated water, wastewater, or soil. Depending on plant-specific OE and implementation of preventive actions, certain components may be excluded from the scope of this program.
  - Evaluation:

    Generally, this is an existing LR AMP. One-time and periodic inspections are conducted of a representative sample of each population. A population is defined as the same material and environment combination. Opportunistic inspections are conducted whenever components are opened, or buried or submerged surfaces are exposed.

    One-time inspections are only conducted for components exposed to CCCW or treated water when no plant-specific OE of selective leaching exists in these environments. In the 10 year period prior to a SOEO, a sample of 3 percent of the population or a maximum of 10 components per population at each unit are visually and mechanically (for gray cast iron and ductile iron components) inspected.

    Opportunistic and periodic inspections are conducted for components exposed to raw water, wastewater, or soil, and for components in CCCW or treated water where XI.M33-3 plant-specific OE includes selective leaching in these environments. Opportunistic inspections are conducted whenever components are opened, or buried or submerged surfaces are exposed. Periodic inspections are conducted in the 10-year period prior to a SPEO and in each 10-year period during a SPEO. If the inspection conducted for ductile iron in the 10-year period prior to a SPEO (i.e., the initial inspection) meets acceptance criteria, periodic inspections do not need to be conducted during the SPEO for ductile iron. In these periodic inspections, a sample of 3 percent of the population or a maximum of 10 components per population are visually and mechanically (for gray cast iron and ductile iron components) inspected at each unit.

- Conclusion:

  This is an existing program that will require review of plant history of Selective Leaching to determine if One-Time inspections or periodic inspections are required. Experimental testing of specific materials could provide data for justification for reduced testing of components. This program would benefit from further evaluation to reduce inspection workforce or cost, including timing the inspections and test concurrently with other AMP's respective inspections and tests (e.g., perform selective leaching opportunistic inspections when the Buried and Underground Piping and Tanks AMP performs excavations).

- **XI.M35: ASME Code Class 1 Small-Bore Piping**

  - Description:

    This program is a condition monitoring program for detecting cracking in small-bore, ASME Code Class 1 piping. The program augments the ISI specified by ASME Code, Section XI, for certain ASME Code Class 1 piping that is less than 4 inches nominal pipe size (NPS) and greater than or equal to 1-inch NPS.

    This program supplements the ASME Code, Section XI, examinations with volumetric examinations, or alternatively, destructive examinations, to detect cracks that may originate from the inside diameter of butt welds, socket welds, and their base metal materials. The examination schedule and extent are based on plant-specific OE and whether actions have been implemented that would successfully mitigate the causes of any past cracking. The program relies on a sample size as specified in NUREG-2191, Table XI.M35 1 as the means to determine whether cracking is occurring in the total population of ASME Code Class 1 small-bore piping in the plant.

  - Scope:

    This program manages the effects of SCC and cracking due to thermal or vibratory fatigue loading for certain ASME Code Class 1 small-bore piping. For the purposes of this program, small-bore piping includes piping that is less than 4 inches NPS and greater than or equal to 1-inch NPS.

  - Evaluation:

    This is an existing LR AMP. Depending on the results of the LR program exams, this was a One-Time inspection or a continuing inspection program. For SLR, a sample of ASME Code Class 1 small-bore piping welds is examined in accordance with the categories specified in NUREG-2191, Table XI.M35-1. The initial schedule of examinations, either one-time for Categories A and B or periodic for Category C, is based on plant-specific OE and whether actions that would successfully mitigate the causes of any past cracking have been implemented. Periodic examinations are implemented as per Category C if the one-time examinations detect any unacceptable flaws or relevant conditions. The scope of the examinations includes both full penetration (butt) welds and partial penetration (socket) welds.

    Category A is based on the plant not recording any cracks in in-scope small bore piping. A One-Time inspection of 3% of the total population up to 10 inspections of full penetration (butt) welds and partial penetration (socket) welds, each. Inspections are completed within 6 years of SPEO.

    Category B and C are based on the plant history of cracks in in-scope small bore piping. Category B would be a One-Time inspection of 10% of the total population up to 25 inspections of full penetration (butt) welds and partial penetration (socket) welds, each. Actions must be taken to mitigate the cause of the cracking. Inspections are completed within 6 years of SPEO. Category C would be a continuing inspection program that would inspect 10% of the total population up to 25 inspections of full penetration (butt) welds and partial penetration (socket) welds, each. No actions have been taken to mitigate the cause of the cracking. Initial inspections are completed within 6 years of SPEO, with subsequent examinations every 10 years thereafter.

- Conclusion:

  This is an existing LR AMP that will require review of plant history of cracking on in-scope small bore piping. This program would benefit from further evaluation to reduce inspection workforce or cost.

• **XI.M36: External Surfaces Monitoring of Mechanical Components**

- Description:

  The External Surfaces Monitoring of Mechanical Components program is based on system inspections and walkdowns. This program consists of periodic visual inspections of metallic, polymeric, and cementitious components, such as piping, piping components, ducting, ducting components; HVAC closure bolting; heat exchanger components, and seals. The program manages aging effects through visual inspection of external surfaces for evidence of loss of material, cracking, hardening or loss of strength, reduced thermal insulation resistance, loss of preload for HVAC closure bolting, and reduction of heat transfer due to fouling. When appropriate for the component and material (e.g., elastomers, flexible polymers, polyvinyl chloride), physical manipulation is used to augment visual inspection to confirm the absence of hardening or loss of strength, or reduction in impact strength. This program may also be used to manage cracking due to SCC in aluminum and stainless steel (SS) components exposed to aqueous solutions and air environments containing halides.

- Scope:

  This program visually inspects the external surfaces of mechanical components (but not buried or inaccessible underground components' external surfaces). The program also inspects heat exchanger surfaces exposed to air for evidence of reduction of heat transfer due to fouling.

- Evaluation:

  This is an existing LR AMP. This program manages the aging effects of loss of material, cracking, hardening or loss of strength, reduced thermal insulation resistance, loss of preload for HVAC closure bolting, and reduction of heat transfer due to fouling using visual inspections. In addition, physical manipulation is used to manage hardening or loss of strength and reduction in impact strength.

  Inspections are performed by personnel qualified in accordance with site procedures and programs to perform the specified task. When required by the ASME Code, inspections are conducted in accordance with the applicable code requirements. Non-ASME Code inspections and tests follow site procedures that include inspection parameters for items such as lighting, distance, offset, surface coverage, and presence of protective coatings. The inspections are capable of detecting age-related degradation and, with the exception of examinations to detect cracking in SS or aluminum components, are performed at a frequency not to exceed one refueling cycle. This frequency accommodates inspections of components that may be in locations normally accessible only during outages (e.g., high dose areas). Surfaces that are not readily visible during plant operations and refueling outages are inspected when they are made accessible and at such intervals that would ensure the components' intended functions are maintained.

  Periodic visual inspections or surface examinations are conducted on SS and aluminum components to manage cracking every 10 years during the SPEO when applicable. Surface examinations or VT-1 examinations are conducted on 20 percent of the surface area unless the component is measured in linear feet, such as piping. Alternatively, any combination of 1-foot length sections and components can be used to meet the recommended extent of 25-inspections. In some instances, thermal insulation has been included in-scope to reduce heat transfer from components because absent the insulation, the thermal effects could affect a function described in 10 CFR 54.4(a). When metallic jacketing has been used, it is acceptable to conduct external visual inspections of the jacketing in order to detect damage to the jacketing that would permit in leakage of moisture as long as the jacketing has been installed in accordance with plant-specific procedures that include configuration features such as minimum overlap, location of seams, etc. If plant-specific procedures do not include these features, an alternative inspection methodology should be proposed. Component surfaces that are insulated and exposed to condensation and insulated outdoor components are periodically inspected every 10 years during the SPEO.

Visual inspection will identify indirect indicators of elastomer and flexible polymer hardening or loss of strength, including the presence of surface cracking, crazing, discoloration, and, for elastomers with internal reinforcement, the exposure of reinforcing fibers, mesh, or underlying metal. Visual inspections cover 100 percent of accessible component surfaces. Visual inspection will identify direct indicators of loss of material due to wear to include dimension change, scuffing, and, for flexible polymeric materials with internal reinforcement, the exposure of reinforcing fibers, mesh, or underlying metal. Manual or physical manipulation can be used to augment visual inspection to confirm the absence of hardening or loss of strength for elastomers and flexible polymeric materials (e.g., heating, ventilation, and air conditioning flexible connectors) where appropriate. The sample size for manipulation is at least 10 percent of the available surface area.

- Conclusion:

  This is an existing LR AMP that is incorporated into the System Owner’s system walkdown program. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M37: Flux Thimble Tube Inspection**
  - Description:

    The Flux Thimble Tube Inspection is a condition monitoring program used to inspect for thinning of the flux thimble tube wall, which provides a path for the incore neutron flux monitoring system detectors and forms part of the reactor coolant system (RCS) pressure boundary. Flux thimble tubes are subject to loss of material at certain locations in the reactor vessel where flow-induced fretting causes wear at discontinuities in the path from the reactor vessel instrument nozzle to the fuel assembly instrument guide tube. A periodic nondestructive examination methodology, such as eddy current testing (ECT) or other applicant-justified and the NRC-accepted inspection method, is used to monitor for wear of the flux thimble tubes. This program implements the recommendations of NRC Bulletin 88-09, as described below.

  - Scope:

    The flux thimble tube inspection encompasses all of the flux thimble tubes that form part of the RCS pressure boundary. The instrument guide tubes are not in the scope of this program. Within scope are the licensee responses to NRC Bulletin 88-09, as accepted by the staff in its closure letters on the bulletin, and any amendments to the licensee responses as approved by the staff.

  - Evaluation:

    This is an existing AMP. An inspection methodology (such as ECT) that has been demonstrated to be capable of adequately detecting wear of the flux thimble tubes is used to detect loss of material during the SPEO. Justification for methods other than ECT should be provided unless use of the alternative method has been previously accepted by the NRC.

Examination frequency is based upon actual plant-specific wear data and wear predictions that have been technically justified as providing conservative estimates of flux thimble tube wear. The interval between inspections is established such that no flux thimble tube is predicted to incur wear that exceeds the established acceptance criteria before the next inspection. The examination frequency may be adjusted based on plant-specific wear projections. Rebaselining of the examination frequency should be justified using plant-specific wear-rate data unless prior plant-specific NRC acceptance for the rebaselining is received outside the LR process. If design changes are made to use more wear-resistant thimble tube materials [e.g., chrome-plated stainless steel (SS)], sufficient inspections are conducted at an adequate inspection frequency, as described above, for the new materials.

- Conclusion:

  This is an existing program that is required by the licensee's response to NRC Bulletin 88-09. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M38: Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components**

  - Description:

    This program consists of inspections of the internal surfaces of piping, piping components, ducting, heat exchanger components, and other components exposed to potentially aggressive environments. These environments include air, air with borated water leakage, condensation, gas, diesel exhaust, fuel oil, lubricating oil, and any water-filled systems. In addition, aging effects associated with fire water system components with only a leakage boundary (spatial) or structural integrity (attached) intended function may be managed by this program. These internal inspections are performed during the periodic system and component surveillances or during the performance of maintenance activities when the surfaces are made accessible for visual inspection. The program includes visual inspections and when appropriate, surface examinations. For certain materials, such as flexible polymers, physical manipulation, or pressurization to detect hardening or loss of strength is used to augment the visual examinations conducted under this program. This program may also be used to manage cracking due to SCC in aluminum and SS components exposed to aqueous solutions and air environments containing halides.

  - Scope:

    This program includes the internal surfaces of piping, piping components, ducting, heat exchanger components, and other components. Inspections are performed when the internal surfaces are accessible during the performance of periodic surveillances or during maintenance activities or scheduled outages. This program is not intended for components where loss of intended function has occurred due to age-related degradation.

  - Evaluation:

    This is an existing LR AMP. This program manages loss of material, cracking, reduction of heat transfer due to fouling, hardening or loss of strength of elastomeric components, and flow blockage. Visual and mechanical (e.g., involving manipulation or pressurization of elastomers and flexible polymeric components) inspections conducted under this program are opportunistic in nature; they are conducted whenever piping, heat exchangers, or ducting are opened for any reason. At a minimum, in each 10-year period during the SPEO, a representative sample of 20 percent of the population (defined as components having the same material, environment, and aging effect combination) or a maximum of 25 components per population (the maximum is dependent on the number of plant Units) is inspected at each unit. The minimum sample size does not override the opportunistic inspection basis of this AMP. Opportunistic inspections continue even though in a given 10-year period, 20 percent or 25 components might have already been inspected. Periodic visual inspections or surface examinations are conducted on SS and aluminum to manage cracking every 10 years during the SPEO when applicable. Surface examinations or VT-1 examinations are conducted on 20 percent of the surface area inspected unless the component is measured in linear feet, such as piping. Alternatively, any combination of 1-foot length sections and components can be used to meet the recommended extent of 25 inspections.

Visual inspections include all accessible surfaces. Inspections and tests are performed by qualified personnel in accordance with site procedures and programs to perform the specified task. Unless otherwise required, inspections follow site procedures that include inspection parameters for items such as lighting, distance, offset, surface coverage, presence of protective coatings, and cleaning processes. The inspection procedures must be capable of detecting the aging effect(s) under consideration. These inspections provide for the detection of aging effects before the loss of component function. Visual inspection of flexible polymeric components is performed whenever the component surface is accessible. Visual and tactile inspections are performed when the internal surfaces become accessible during the performance of periodic surveillances or during maintenance activities or scheduled outages. Manual or physical manipulation or pressurization of flexible polymeric components is used to augment visual inspection, where appropriate, to assess loss of material or strength. The sample size for manipulation is at least 10 percent of accessible surface area, including visually identified suspect areas. For flexible polymeric materials, hardening, loss of strength, or loss of material due to wear is expected to be detectable before any loss of intended function.

- Conclusion:

  This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M39: Lubricating Oil Analysis**

  - Description:

    The purpose of the Lubricating Oil Analysis program is to provide reasonable assurance that the oil environment in the mechanical systems is maintained to the required quality to prevent or mitigate age-related degradation of components within the scope of this program. This program maintains oil systems (lubricating and hydraulic) contaminants (primarily water and particulates) within acceptable limits, thereby preserving an environment that is not conducive to loss of material or reduction of heat transfer. Oil testing activities include sampling and analysis of lubricating oil for detrimental contaminants. The presence of water or particulates may also be indicative of in-leakage and corrosion product buildup.

  - Scope:

    Components within the scope of the program include piping, piping components; heat exchanger tubes; reactor coolant pump elements; and any other plant components subject to AMR that are exposed to an environment of lubricating oil (including non-water-based hydraulic oils).

  - Evaluation:

    This is an existing LR AMP. Moisture or corrosion products increase the potential for, or may be indicative of, loss of material due to corrosion and reduction of heat transfer due to fouling. The program performs periodic sampling and testing of lubricating oil for moisture and corrosion particles in accordance with industry standards. The program recommends sampling and testing of the old oil following periodic oil changes or on a schedule consistent with equipment manufacturer's recommendations or industry standards [e.g., ASTM D 6224-02]. Plant-specific

OE also may be used to adjust manufacturer's recommendations or industry standards in determining the schedule for periodic sampling and testing when justified by prior sampling results. For hydraulic fluids, if the fluid is replaced based on a periodicity recommended by the fluid manufacturer, equipment vendor, or plant-specific documents, testing need not be conducted for in-service oils.

- Conclusion:

  This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M40: Monitoring of Neutron-Absorbing Materials Other Than Boraflex**

  - Description:

    Many neutron-absorbing materials are used in spent fuel pools. This AMP addresses aging management of spent fuel pools that use materials other than Boraflex, such as Boral, Metamic, boron steel, and Carborundum. GALL-SLR [9] AMP XI.M22, "Boraflex Monitoring," addresses aging management of spent fuel pools that use Boraflex as the neutron-absorbing material. When a spent fuel pool criticality analysis credits both Boraflex and materials other than Boraflex, the guidance in both AMPs XI.M22 and XI.M40 applies.

    A monitoring program is implemented to assure that degradation of the neutron-absorbing material used in spent fuel pools that could compromise the criticality analysis will be detected. The AMP relies on periodic inspection, testing, monitoring, and analysis of the criticality design to assure that the required 5 percent subcriticality margin is maintained during the period of SLR.

  - Scope:

    The AMP manages the effects of aging on neutron-absorbing components/materials other than Boraflex used in spent fuel racks.

  - Evaluation:

    This is an existing AMP. The loss of material and the degradation of neutron absorbing material capacity are determined through coupon and/or direct in-situ testing. Such testing should include periodic verification of boron loss through boron-10 areal density measurement of coupons or through direct in-situ techniques. In addition to measuring boron content, testing should also be capable of identifying indications of geometric changes in the material (blistering, pitting, and bulging). The frequency of the inspection and testing depends on the condition of the neutron-absorbing material and is determined and justified with plant-specific OE by the licensee. The maximum interval between inspections for polymer-based materials (e.g., Carborundum, Tetrabor), regardless of OE, should not exceed 5 years. The maximum interval between inspections for nonpolymer-based materials (e.g., Boral, Metamic, Boralcan, borated stainless steel), regardless of OE, should not exceed 10 years.

  - Conclusion:

    This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.M41: Buried and Underground Piping and Tanks**

  - Description:

    This AMP manages the aging of the external surfaces of buried and underground piping and tanks. It addresses piping and tanks composed of any material, including metallic, polymeric, and cementitious materials. This program manages aging through preventive, mitigative, inspection, and in some cases, performance monitoring activities. It manages applicable aging effects such as loss of material and cracking.

- Scope:

  This program manages the effects of aging of the external surfaces of buried and underground piping and tanks constructed of any material including metallic, polymeric, and cementitious materials. The term "polymeric" material refers to plastics or other polymers that comprise the pressure boundary of the component. The program addresses aging effects such as loss of material and cracking. The program also manages loss of material due to corrosion of piping system bolting within the scope of this program.

- Evaluation:

  This is an existing LR AMP. Visual inspections consist of: (a) the external surface condition of buried or underground piping or tanks; (b) the external surface condition of associated coatings; or (c) external surfaces of controlled low strength material backfill are performed. Inspections of buried and underground piping and tanks are conducted during each 10-year period, commencing 10 years prior to the SPEO. Piping inspections are typically conducted by visual examination of the external surfaces of pipe or coatings. Tank inspections are conducted externally by visual examination of the surfaces of the tank or coating or internally by volumetric methods. Opportunistic inspections are conducted for in-scope piping whenever they become accessible.

  The number or length of buried piping inspections is determined by the type of piping material, and cathodic protection categorization. The number or length of underground piping inspections is determined by piping material. When the inspections are based on the number of inspections in lieu of percentage of piping length, 10 feet of piping is exposed for each inspection. All buried or underground tanks are inspected, except underground Polymeric or Cementitious tanks.

- Conclusion:

  This LR AMP may benefit from further evaluation to reduce inspection workforce or cost. The most beneficial factor in the reduction of buried piping inspections is to meet the piping material acceptance criteria for cathodic protection. This can radically reduce the number of required buried piping inspections.

  It may also be beneficial to review site specific buried piping inspection results to determine if the preventative measure, coatings, backfill and cathodic protection, have been effective in controlling aging. If the results of the review are favorable, an argument could be developed to justify reduction of the number of inspections.

- **XI.M42: Internal Coatings/Linings for In-Scope Piping, Piping Components, Heat Exchangers, and Tanks**

  - Description:

    Proper maintenance of internal coatings/linings is essential to provide reasonable assurance that the intended functions of in-scope components are met. Degradation of coatings/linings can lead to loss of material or cracking of base materials and downstream effects such as reduction in flow, reduction in pressure, or reduction of heat transfer when coatings/linings become debris. The program consists of periodic visual inspections of internal coatings/linings exposed to closed-cycle cooling water (CCCW), raw water, treated water, treated borated water, waste water, fuel oil, and lubricating oil, air, and condensation. Where the visual inspection of the coated/lined surfaces determines that the coating/lining is deficient or degraded, physical tests are performed, where physically possible, in conjunction with the visual inspection.

- Scope:

  The scope of the program is internal coatings/linings for in-scope piping, piping components, heat exchangers, and tanks exposed to CCCW, raw water, treated water, treated borated water, waste water, fuel oil, and lubricating oil, air, and condensation, where loss of coating or lining integrity could prevent satisfactory accomplishment of any of the component's or downstream component's CLB intended functions identified under 10 CFR 54.4(a)(1), (a)(2), or (a)(3).

- Evaluation:

  This is an existing LR AMP. Visual inspections are intended to identify coatings/linings that do not meet acceptance criteria, such as peeling and delamination. Aging mechanisms associated with coatings/linings are described as follows: Blistering, Cracking, Flaking, Peeling, Delamination and Rusting. Loss of material and cracking is managed for cementitious materials. Physical damage consists of removal or reduction of the thickness of coating/lining by mechanical damage. Physical testing is intended to identify the extent of potential degradation of the coating/lining.

  The extent of baseline and periodic inspections is based on an evaluation of the effect of a coating/lining failure on the in-scope component's intended function(s), potential problems identified during prior inspections, and known service life history; however, the extent of inspection is not any less than the following for each coating/lining material and environment combination.

  – All tanks–all accessible internal surfaces (and external surfaces when credited to isolate the external surfaces of a component from the environment).
  – All heat exchangers–all accessible internal surfaces (and external surfaces when credited to isolate the external surfaces of a component from the environment.)
  – Piping–either inspect a representative sample of seventy-three 1-foot axial length circumferential segments of piping or 50 percent of the total length of each coating/lining material and environment combination, whichever is less at each unit.

  Inspection frequency is every 6 years for coatings that meet acceptance criteria. Inspection frequency is 4 years otherwise. The 6-year frequency may be extended to 12 years for trained equipment as long as one train is inspected every 6 years (alternating train inspections).

  In addition, where loss of internal coating or lining integrity cannot result in downstream effects such as reduction in flow, drop in pressure, or reduction of heat transfer for in-scope components, a representative sample of external wall thickness measurements can be performed every 10 years commencing 10 years prior to the SPEO to confirm the acceptability of the corrosion rate of the base metal in lieu of visual inspections of the coatings/linings. For heat exchangers and tanks, a representative sample includes 25 percent coverage of the accessible external surfaces. For piping, a representative sample size is described above.

- Conclusion:

  This LR AMP may benefit from further evaluation to reduce inspection workforce or cost. Identifying ways of examining internal coatings without draining the components (e.g., tanks) could reduce the licensee burden. Experimental testing of existing coatings, operating in an in-service environment, could provide justification for the extension of the inspection frequency.

A-1.4 Section XI Structural AMPs

- **XI.S1: ASME Section XI, Subsection IWE**
  - Description:

    10 CFR 50.55a imposes the ISI requirements of the ASME Code, Section XI, Subsection IWE, for steel containments (Class Metal Containment [MC]) and steel liners for concrete containments (Class CC). The scope of Subsection IWE includes steel containment shells and their integral attachments, steel liners for concrete containments and their integral attachments, containment penetrations, hatches, airlocks, moisture barriers, and pressure-retaining bolting. The requirements of ASME Code, Section XI, Subsection IWE, with the additional requirements specified in 10 CFR 50.55a(b)(2), are supplemented herein to augment an existing program applicable to managing aging of steel containments, steel liners of concrete containments, and other containment components for the SPEO.
  - Scope:

    The scope of this program addresses the pressure-retaining components of steel containments and steel liners of concrete containments specified in Subsection IWE-1000 and are supplemented to address aging management of potential corrosion in inaccessible areas of the drywell shell exterior of BWR Mark I steel containments. The components within the scope of Subsection IWE are Class MC pressure-retaining components (steel containments) and their integral attachments, metallic shell and penetration liners of Class CC containments and their integral attachments, containment moisture barriers, containment pressure-retaining bolting, and metal containment surface areas, including welds and base metal. The concrete portions of containments are inspected in accordance with Subsection IWL. Subsection IWE requires examination of coatings that are intended to prevent corrosion, including those inside BWR suppression chambers. The GALL-SLR Report AMP XI.S8 is a protective coating monitoring and maintenance program that is recommended to provide reasonable assurance of ECCS operability, whether or not the GALL-SLR Report AMP XI.S8 is credited in GALL-SLR Report AMP XI.S1.
  - Evaluation:

    This is an existing AMP. The examination methods, frequency, and scope of examination specified in 10 CFR 50.55a and Subsection IWE provide reasonable assurance that aging effects are detected before they compromise the design-basis requirements. IWE-2500-1 and the requirements of 10 CFR 50.55a provide information regarding the examination categories, parts examined, and examination methods to be used to detect aging. Regarding the extent of examination, all accessible surfaces receive at least a general visual examination as specified in Table IWE-2500-1 and the requirements of 10 CFR 50.55a with results evaluated in accordance with IWE-3100.
  - Conclusion:

    This is a program is required by 10 CFR 50.55a. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.S2: ASME Section XI, Subsection IWL**
  - Description:

    10 CFR 50.55a imposes the examination requirements of the ASME Code, Section XI, Subsection IWL, for reinforced and prestressed concrete containments (Class CC). The scope of IWL includes reinforced concrete and unbonded post-tensioning systems. ASME Code, Section XI, Subsection IWL and the additional requirements specified in 10 CFR 50.55a(b)(2)

constitute an existing mandated program applicable to managing aging of containment reinforced concrete and unbonded post-tensioning systems, and supplemented herein, for SLR. Containments with grouted tendons may require an additional plant-specific AMP), based on the guidance in NRC RG 1.90, "Inservice Inspection of Prestressed Concrete Containment Structures with Grouted Tendons," to address the adequacy of prestressing forces.

- Scope:

  Subsection IWL-1000 specifies the components of concrete containments within its scope. The components within the scope of Subsection IWL are reinforced concrete and unbonded post-tensioning systems of Class CC containments, as defined by CC-1000. The program also includes testing of the tendon corrosion protection medium and the pH of free water. Subsection IWL exempts from examination portions of the concrete containment that are inaccessible (e.g., concrete covered by liner, foundation material, or backfill or obstructed by adjacent structures or other components).

- Evaluation:

  This is an existing AMP. The frequency and scope of examinations specified in 10 CFR 50.55a and Subsection IWL provide reasonable assurance that aging effects would be detected before they would compromise the design-basis requirements. The frequency of inspection is specified in IWL-2400. Concrete inspections are performed in accordance with Examination Category L-A. Under Subsection IWL, ISI of concrete and unbonded post-tensioning systems is required at 1, 3, and 5 years following the initial structural integrity test. Thereafter, inspections are performed at 5-year intervals. For sites with multiple plants, the schedule for ISI is provided in IWL-2421. In the case of tendons, only a sample of the tendons of each tendon type requires examination during each inspection.

- Conclusion:

  This is a program is required by 10 CFR 50.55a. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.S3: ASME Section XI, Subsection IWF**

  - Description:

    10 CFR 50.55a, imposes the ISI requirements of the ASME Code, Section XI, for Class 1, 2, 3, and MC piping and components and their associated supports. The ISI of supports for ASME piping and components is addressed in Section XI, Subsection IWF. This program supplements ASME Code, Section XI, Subsection IWF, which constitutes an existing mandated program applicable to managing aging of ASME Class 1, 2, 3, and MC component supports for SLR.

  - Scope:

    This program addresses ASME Class 1, 2, 3, and MC component supports. The scope of the program includes support members, structural bolting, high-strength structural bolting [actual measured yield strength greater than or equal to 150 ksi (1,034 MPa)], anchor bolts, welds, support anchorage to the building structure, accessible sliding surfaces, constant and variable load spring hangers, guides, stops, and vibration isolation elements. The acceptability of inaccessible areas (e.g., portions of supports encased in concrete, buried underground, or encapsulated by guard pipe) is evaluated when conditions exist in accessible areas that could indicate the presence of, or result in, degradation to such inaccessible areas.

- Evaluation:

  This is an existing AMP. The program requires that a sample of ASME Class 1, 2, and 3 piping supports that are not exempt from examination and 100 percent of supports other than piping supports (Class 1, 2, 3, and MC), be examined as specified in Table IWF2500-1. The sample size examined for ASME Class 1, 2, and 3 component supports is as specified in Table IWF-2500-1. The provisions of ASME Code Section XI, Subsection IWF are supplemented to include a one-time inspection of an additional 5 percent of the sample size specified in Table IWF-2500-1 for Class 1, 2, and 3 piping supports. The one-time inspection is conducted within 5 years prior to entering the SPEO. The VT-3 examination method specified by the program can reveal loss of material due to corrosion and wear, cracks, verification of clearances, settings, physical displacements, loose or missing parts, debris, or dirt in accessible areas of the sliding surfaces, or loss of integrity at bolted connections.

  For all high-strength bolting [actual measured yield strength greater than or equal to 150 ksi (1,034 MPa)] in sizes greater than 1-inch nominal diameter (including ASTM A490 and equivalent ASTM F2280), volumetric examination comparable to that of ASME Code Section XI, Table IWB-2500-1, Examination Category B-G-1 should be performed at least once per interval to detect cracking in addition to the VT-3 examination.

- Conclusion:

  This is a program is required by 10 CFR 50.55a. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.S4: 10 CFR 50, Appendix J**

  - Description:

    A typical primary reactor containment system consists of a containment structure (containment), and a number of electrical, mechanical, equipment hatch, and personnel air lock penetrations. As described in 10 CFR Part 50, Appendix J, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors," (Appendix J) periodic containment leak rate tests are required to assure that (a) leakage through these containments or systems and components penetrating these containments does not exceed allowable leakage rates specified in the TS and (b) integrity of the containment structure is maintained during its service life.

    This AMP credits the existing program required by 10 CFR Part 50 Appendix J and augments it to ensure that all containment pressure-retaining components are managed for age-related degradation.

  - Scope:

    The scope of the containment leak rate test (LRT) program includes the containment system and related systems and components penetrating the containment pressure-retaining or leakage-limiting boundary. The aging effects associated with containment pressure-retaining boundary components within the scope of SLR and excluded from Type B or C Appendix J testing must still be managed. Other programs may be credited for managing the aging effects associated with these components; however, the component and the proposed AMP should be clearly identified.

  - Evaluation:

    This is an existing LR AMP. A containment LRT program is effective in detecting leakage rates of the containment pressure boundary components, including seals and gaskets, and in identifying and correcting sources of leakage. While the calculation of leakage rates and satisfactory performance of containment leak rate testing demonstrates the leakage integrity of the containment, it does not by itself provide information that would indicate that age-related degradation has initiated or that the capacity of the containment may have been reduced for other types of loading conditions. This would be achieved with the implementation of acceptable containment ISI programs such as ASME Code Section XI, Subsection IWE and IWL, (NUREG-2191 AMP XI.S1 and AMP XI.S2).

- Conclusion:

  This existing LR AMP is required by 10 CFR 50, Appendix J. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.S5: Masonry Walls**

  - Description:

    The NRC Inspection and Enforcement Bulletin (IEB) 80-11, “Masonry Wall Design,” and NRC Information Notice (IN) 87-67, “Lessons Learned from Regional Inspections of Licensee Actions in Response to IE Bulletin 80-11,” constitute an acceptable basis for a masonry wall AMP. NRC IEB 80-11 required (a) the identification of masonry walls in close proximity to or having attachments from safety-related systems or components and (b) the evaluation of design adequacy and construction practice. NRC IN 87-67 recommended plant-specific condition monitoring of masonry walls and administrative controls to ensure that the evaluation basis developed in response to NRC IEB 80-11 is not invalidated by: (a) deterioration of the masonry walls (e.g., new cracks not considered in the reevaluation), (b) physical plant changes such as installation of new safety related systems or components in close proximity to masonry walls, or (c) reclassification of systems or components from non-safety-related to safety-related, provided appropriate evaluation is performed to account for such occurrences.

  - Scope:

    The scope includes all masonry walls identified as performing intended functions in accordance with 10 CFR 54.4. Masonry walls consist of solid or hollow concrete block, mortar, grout, steel bracing, reinforcing and supports. The aging effects on masonry walls that are considered fire barriers are also managed by GALL-SLR Report AMP XI.M26, Fire Protection, as well as being managed by this program. Aging effects on the steel elements of masonry walls are managed by GALL-SLR Report AMP XI.S6.

  - Evaluation:

    This is an existing AMP. Visual examination of the masonry walls by qualified inspection personnel is sufficient. In general, masonry walls are inspected every 5 years. Provisions exist for more frequent inspections in areas where significant loss of material, cracking, or other signs of degradation are observed to provide reasonable assurance that there is no loss of intended function between inspections. In addition, masonry walls that are fire barriers are visually inspected in accordance with GALL-SLR Report AMP XI.M26. Steel elements of masonry walls are visually inspected under the scope of GALL-SLR Report AMP XI.S6.

  - Conclusion:

    This is an existing program that does not place undue burden on the site resources. This is a program which consists of visual inspections by qualified inspectors every 5 years. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.S6: Structures Monitoring**
  - Description:

    Implementation of structures monitoring under (10 CFR 50.65 (the Maintenance Rule) is addressed in NRC RG 1.160, and Nuclear Management and Resources Council 93-01. These two documents and supplemental guidance herein provide guidance for development of licensee-specific programs to monitor the condition of structures and structural components within the scope of the LR rule, such that there is no loss of structure or structural component intended function.

    Identified aging effects are evaluated by qualified personnel using criteria derived from industry codes and standards contained in the plant current licensing bases, including ACI 349.3R, ACI 318, SEI/ASCE 11, and the American Institute of Steel Construction (AISC) specifications, as applicable.

    The program includes preventive actions to ensure structural bolting integrity. The program also includes periodic sampling and testing of groundwater and the need to assess the impact of any changes in its chemistry on below grade concrete structures.
  - Scope:

    The scope of the program includes all SCs, component supports, and structural commodities in the scope of LR that are not covered by other structural AMPs (i.e., “ASME Section XI, Subsection IWE” GALL-SLR AMP XI.S1]; “ASME Section XI, Subsection IWL” (GALL-SLR Report AMP XI.S2); “ASME Section XI, Subsection IWF” (GALL-SLR Report AMP XI.S3); “Masonry Walls” (GALL-SLR Report AMP XI.S5); and NRC RG 1.127, “Inspection of Water-Control Structures Associated with Nuclear Power Plants” (GALL-SLR Report AMP XI.S7).
  - Evaluation:

    This is an existing AMP. Structures are monitored under this program using periodic visual inspection of each structure/aging effect combination by a qualified inspector to ensure that aging degradation will be detected and quantified before there is loss of intended function. It may be necessary to enhance or supplement visual inspections with nondestructive examination, destructive testing and/or analytical methods, based on the conditions observed or the parameter being monitored. Visual inspection of elastomeric elements is supplemented by tactile inspection to detect hardening if the intended function is suspect. The inspection frequency depends on safety significance and the condition of the structure as specified in NRC RG 1.160. In general, all structures are monitored at an interval not to exceed 5 years. The program includes provisions for more frequent inspections based on an evaluation of the observed degradation.
  - Conclusion:

    This is an existing program that does not place undue burden on the site resources. This is a program monitored under 10 CFR 50.65 and consists of visual inspections by qualified inspectors every 5 years. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.S7: Inspection of Water-Control Structures Associated with Nuclear Power Plants**
  - Description:

    This program describes an acceptable basis for developing an inspection and surveillance program for dams, slopes, canals, and other raw water-control structures associated with emergency cooling water systems or flood protection of NPPs. The program addresses age-related deterioration, degradation due to environmental conditions, and the effects of natural phenomena that may affect water-control structures. The program recognizes the importance of periodic monitoring and maintenance of water-control structures so that the consequences of age-related deterioration and degradation can be prevented or mitigated in a timely manner.

An AMP addressing water-control structures is expected regardless of whether a plant is committed to NRC RG 1.127. Aging management of water-control SCs may be included in “Structures Monitoring” GALL-SLR AMP XI.S6]; however, details pertaining to water-control structures should be explicitly incorporated and identified in GALL-SLR Report AMP XI.S6 program attributes if this approach is taken.

- Scope:

  The scope includes raw water-control structures associated with emergency cooling water systems or flood protection of NPPs. The water-control structures included in the program are concrete structures, embankment structures, spillway structures and outlet works, reservoirs, cooling water channels and canals, flood protection walls and gates, and intake and discharge structures. The scope of the program also includes structural steel, and structural bolting associated with water-control structures, steel or wood piles and sheeting required for the stability of embankments and channel slopes, and miscellaneous steel, such as sluice gates and trash racks.

- Evaluation:

  This is an existing AMP. NRC RG 1.127 identifies parameters to be monitored and inspected for water-control structures. Inspection of water-control structures is conducted under the direction of qualified engineers experienced in the investigation, design, construction, and operation of these types of facilities. Visual inspections are primarily used to detect degradation of water-control structures. Periodic inspections are to be performed at least once every 5 years. The program includes provisions for increased inspection frequency based on an evaluation of the observed degradation. The program also includes provisions for special inspections immediately following the occurrence of significant natural phenomena, such as large floods, earthquakes, hurricanes, tornadoes, or intense local rainfalls.

- Conclusion:

  This is an existing program that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost.

- **XI.S8: Protective Coating Monitoring and Maintenance**

  - Description:

    Proper maintenance of protective coatings inside containment (defined as Service Level I in NRC RG 1.54, Revision 1, or latest version) is essential to the operability of post-accident safety systems that rely on water recycled through the containment sump/drain system. Degradation of coatings can lead to clogging of ECCS suction strainers, which reduces flow through the system and could cause unacceptable head loss for the pumps.

    Maintenance of Service Level I coatings applied to carbon steel and concrete surfaces inside containment (e.g., steel liner, steel containment shell, structural steel, supports, penetrations, and concrete walls and floors) also serve to prevent or minimize loss of material due to corrosion of carbon steel components and aids in decontamination. Regulatory Position C4 in NRC RG 1.54, Revision 23, describes an acceptable technical basis for a Service Level I coatings monitoring and maintenance program that can be credited for managing the effects of corrosion for carbon steel elements inside containment. ASTM International (formerly American Society for Testing and Materials) standard (ASTM) D5163-08 and endorsed years of the standard in NRC RG 1.54 are acceptable and considered consistent with SLR-ISG-2021-03-STRUCTURES: Appendix B Page 3 of 6 NUREG-2191 the Generic Aging Lessons Learned for Subsequent License Renewal (GALLSLR) Report. In addition, Electric Power Research Institute Report 1019157, "Guideline on Nuclear Safety-Related Coatings," (December 2009) provides additional information on the ASTM standard guidelines.

A comparable program for monitoring and maintaining protective coatings inside containment, developed in accordance with NRC RG 1.54, Revision 23, is acceptable as an AMP for SLR.

Service Level I coatings credited for preventing corrosion of steel containments and steel liners for concrete containments are subject to requirements specified by the ASME Code, Section XI, Subsection IWE (GALL-SLR Report AMP XI.S1). However, this program (GALL-SLR Report AMP XI.S8) reviews Service Level I coatings to ensure that the protective coating monitoring and maintenance program is adequate for SLR.

- Scope:

  The minimum scope of the program is Service Level I coatings applied to steel and concrete surfaces inside containment (e.g., steel liner, steel containment shell, structural steel, supports, penetrations, and concrete walls and floors), defined in NRC RG 1.54, Revision 23, as follows: "Service Level I coatings are used in areas inside the reactor containment where the coating failure could adversely affect the operation of post-accident fluid systems and thereby impair safe shutdown." The scope of the program also should include any Service Level I coatings that are credited by the licensee for preventing loss of material due to corrosion in accordance with NUREG-2191 AMP XI.S1.

- Evaluation:

  This is an existing LR AMP. ASTM D-5163-08 provides guidelines that are acceptable to the NRC staff for establishing an in-service coatings monitoring program for Service Level I coating systems in operating NPPs, and identifies the parameters monitored or inspected to be "any visible defects, such as blistering, cracking, flaking, peeling, rusting, and physical damage."

  General visual inspections, as per ASTM D5163-08, will be performed at an interval not to exceed six years. The inspection interval will be based on station operating experience and trending of the total amount of degraded and unqualified coatings allowed in containment that demonstrates acceptable coating performance with respect to the ECCS sump strainer debris limits. An applicant that proposes to extend the inspection interval to greater than every refueling outage will need to provide information regarding the available margin for its ECCS suction strainers to accommodate coatings debris. ASTM D5163-08 discusses the qualifications for inspection personnel, the inspection coordinator, and the inspection results evaluator. ASTM D 5163-08 also discusses development of the inspection plan and the inspection methods to be used. It states that a general visual inspection shall be conducted on all readily accessible coated surfaces during a walk-through.

- Conclusion:

  This is an existing LR AMP that does not place undue burden on the site resources. This program would not benefit from further evaluation to reduce inspection workforce or cost. Inspection frequency can be extended to every 6 years, based on ECCS suction strainers debris margin.

Appendix B
Assessment of SLR Commitments

B-1. APPROACH

The intent of this appendix was to look at SLR commitments and identify the most burdensome obligations for an NPP in terms of costs, labor, time, risk, interruption to plant operation, etc.

Upon further review, it was determined that it is impractical and difficult to separate explicit or standalone commitments when almost all are associated with the performance of the AMP itself. Typically, these commitments involved updating procedures to encompass the inspection details or updating the frequency of inspection. In some cases, extensive commitments may be necessary to get approval through the NRC, including the installation of cathodic protection for buried piping, one-time inspections of specific SSCs, or adding new transients to be counted for the metal fatigue analyses associated with the X.M1 Fatigue Monitoring AMP. However, these plant-specific commitments have already been considered in the discussions contained in Appendix A.

Appendix C
Potential Candidates for Further Analysis

C-1. APPROACH

This appendix identifies potential candidates for further analysis related to cost/benefit by using risk insights to reduce commitment expenditures. These candidates include the application of the following approaches:

- New methodologies related to the IPA process (scoping, screening, and aging management review).
- RI performance-based approaches.
- Experimental capabilities to model degradation mechanisms and methods to accelerate degradation in a laboratory setting.
- Advanced detection and examination methods.
- Modern modeling techniques (e.g., finite element modeling) to predict degradation progression in the next 10, 20, or 40 years. A progression of how future research could be used will be included in support of this project.

C-1.1 IPA Process Methodology

Appendix A contains a lot of information regarding AMPs, which is ultimately what a nuclear licensee will commit to for the remainder of their extended license. However, development of these programs is the last step of the IPA process. Scoping SSCs into SLR, screening them in, and performing aging management reviews are direct inputs into the AMPs and the overall cost to the station if efforts are taken to minimize but still meet regulatory requirements.

Scoping: If any portion of a system meets the scoping criteria of 10 CFR 54.4(a)(1), (a)(2), and (a)(3), it is to be included within the scope of SLR. These systems in the scope of SLR are then further evaluated to determine the system components that support the identified system's intended function(s).

- The scope 54.4(a)(1) is safety-related (SR) systems, structures, and components (SSCs). There is no room for change to this rule without relying on an approach similar to what is described in C-1.2 below.
- The scope in 54.4(a)(2) is non-safety related (NSR) SSCs that may affect the intended functions of SR SSCs. These are either directly connected and provide structural support or not directly connected but have the potential to affect SR components through spatial interactions.
    - There could be a reduction in the 54.4(a)(2) scope an applicant needs to manage for SLR if a new, potentially RI, approach to scoping (a)(2) is applied. For example, any NSR component in a room with SR equipment is typically included in the scope of SLR for this reason, whether or not there are any realistic or probable expectations they could actually affect an SR component if failure occurred.
    - The SSCs for most plants that are only in scope of license renewal based on this criteria is relatively small, on the order of 5% of the total. Additionally, any SSC that is only in for 54.4(a)(2) will likely be managed by non-burdensome programs. Therefore, the cost to find a new approach/methodology for reducing 54.4(a)(2) scope would have relatively low benefit to the nuclear utilities.

- The scopes in 54.4(a)(3) is SSCs relied upon for regulated events (fire protection, environmental qualification, pressurized thermal shock [PWRs only], anticipated transients without scram, and station blackout). There is very little that could be done to minimize this contribution to the scope of SLR, and in most cases, these SSCs are already credited under 54.4(a)(1).

Screening: Screening refers to the process of determining which components associated with the in-scope systems and structures are subject to AMR in accordance with 10 CFR 54.21(a)(1) requirements. The screening process identifies passive, long-lived SSCs and screens active SSCs, components routinely replaced, or transient/non-permanent components out for further consideration. There are no valuable reduction in managed SLR components that could benefit from the screening process.

Aging Management Review: The process of AMR is to identify a system's environments (both internal and external) and the materials for the component types that are in-scope and screened-in. This combination of component type/material/environment results in typically standard aging effects that require management through the SPEO. These aging effects are managed using the AMPs described in Appendix A.

The AMR process is plant-specific and can be defined; however, the station decides as long as there is reasonable assurance the aging will be managed. Though, many applicants heavily rely on the GALL for SLR, NUREG-2191, to define which AMPs should be managing the various components and aging effects for each system that is in scope.

There is a potential to reduce burden to the plant when performing the AMR step of the IPA process during SLR application development. For example, non-safety significant or low-safety significant SSCs in a system could be prescribed a different AMP than what would generically be used. This use of a RI approach to the AMR process (more discussion on risk information in C-1.2 below) could allow for less SSCs in more burdensome AMPs and more SSCs in those that are relatively easy to implement.

C-1.2 Risk-Informed Performance-Based Approaches

EPRI has developed a framework for RI aging management (RIAM) [11]. The framework and pilot applications developed in collaboration with NEI and industry demonstrated that already available information can support the use of risk insights to support AMPs. The recommended approach has intentionally limited scope to simplify the framework implementation and minimize the efforts required by licensees to implement it. The approach can generally be described as a qualitative risk ranking method using a risk matrix heat map that would be used to prioritize inspections and other required AMP actions. The RIAM framework is not intended for use with scoping, screening, or aging management reviews. While the framework is not intended to support a quantitative risk assessment, many of its aspects could be used in a more comprehensive quantitative RI aging management approach. The EPRI's RIAM framework with the qualitative risk ranking and the ability to apply alternative treatments offers cost saving opportunities compared to the current deterministic requirements.

The advantage of simplified approaches to risk-informed evaluations is that they are relatively simple to implement. On the other hand, the disadvantages are the lack of a holistic approach and insufficient level of detail. Investments into development of a rigorous, quantitative approach that holistically addresses the risks associated with plant aging could provide much broader benefits and major cost savings.

A quantitative full-scope risk-informed aging management approach would need to address the five key principles from RG 1.174:

Principle 1: The proposed licensing basis change meets the current regulations unless it is explicitly related to a requested exemption.

Principle 2: The proposed licensing basis change is consistent with the defense-in-depth philosophy.

Principle 3: The proposed licensing basis change maintains sufficient safety margins.

Principle 4: When the proposed licensing basis changes result in an increase in risk, the increases should be small and consistent with the intent of the commission's policy statement on safety goals for the operations of NPPs.

Principle 5: The impact of the proposed licensing basis change should be monitored using performance measurement strategies.

The recommended approach is intended to be a holistic evaluation of aging effects and would need to include the following basic elements:

1. Review aging management requirements to identify aging effects that:
   a. Directly affect the ability to perform a PRA modeled key safety function (Principle 4)
   b. Increase the likelihood of a PRA modeled initiating event (Principle 4)
   c. Reduce defense-in-depth or safety margin not explicitly modeled in PRA (Principles 2 and 3).
2. Add new basic events to the PRA model as required to address failure modes related to aging (e.g., a loss of decay heat removal OR gate would likely need to include passive pipe break or cable failure basic events along with the active failure basic events for pumps and valves).
3. Perform laboratory tests and evaluations as necessary to develop robust algorithms for calculating failure probabilities as a function of age (this will allow a progressively larger failure probability to be applied for a given component type and environmental conditions over time and reset the failure probability when the component is repaired/replaced, or other mitigative actions are taken that would reduce the failure probability).
4. Adjust PRA model basic event probabilities and initiating event frequencies based on aging algorithms, component age, and mitigating measures.
5. Quantify the model and compare the increased failure probability due to aging effects (assuming that the as-built as-operated plant is identical 20 years from now with the exception of aging).
6. Use the quantification results to determine risk significance of aging over the duration of the LR period:
   a. When the risk is very small as defined by RG 1.174 Region 3 (e.g., early in the LR period), it may not be necessary to implement any AMPs
   b. As the plant ages, the risk will increase and eventually exceed the boundary for Region 3 triggering the need for AMP implementation.
7. Use the results (i.e., PRA importance measures) to identify and prioritize required testing/inspections or repair/replacement activities that will effectively mitigate risk.

Following a rigorous approach as described above would clearly show the risk significance associated with aging effects and would provide a technically defensible basis for an exemption from certain requirements that do not significantly improve plant safety.

There would be various levels of cost associated with implementing this approach. The following bullets provide a rough outline of the approach development process that would make up the majority of the required cost:

Start-up costs for developing a quantitative full-scope risk-informed aging management approach:

- Data gathering (literature review) to identify any available information that can support estimates of failure probabilities as a function of aging.
- Laboratory testing to address any data gaps.
- Development of algorithms/rules to define failure probabilities as a function of aging.
- Development of the framework for quantifying risk using a modified PRA model.
- Development of the methodology to address other risk-informed application requirements (e.g., defense-in-depth and safety margin).

Pilot plant costs:

- Plant-specific evaluation using the framework, methodology, and data developed above.
- Development of initial license amendment request (LAR) submittal (note that NRC review fees are typically waived for a pilot plant submittal).
- Incorporation of NRC comments, which may include adjustments to the framework/methodology and the plant-specific evaluation.

Subsequent plant costs (after there is a clear path forward defined by the pilot plant):

- Plant-specific evaluation following pilot plant approach.
- LAR submittal, NRC review, and request for additional information (RAI) responses.

There are significant benefits expected from a comprehensive quantitative full-scope risk-informed aging management approach:

- Removing management of certain SSCs. This could be in the scoping, screening, or aging management review phase of the IPA process. Age managing fewer components would have benefit across the entire nuclear fleet over 20-30 years for each plant.
- Relaxing aging management program requirements for low risk SSCs, similar to a 10 CFR 50.69 approach.

The real value for nuclear plants in using a comprehensive quantitative full-scope risk-informed aging management approach is to prioritize high-value inspections on SSCs that directly impact plant risk and reduce or eliminate inspections that have little or no value.

C-1.2.1 Demonstrated Success: Application of a Comprehensive Full-Scope Risk-Informed Approach to Address Generic Industry Issue

In 1996, the NRC opened Generic Safety Issue (GSI) 191 for pressurized water reactor (PWR) plants in following the emergency core cooling system (ECCS) strainer clogging events that occurred at boiling water reactor (BWR) plants in the early 1990s. Generic Letter (GL) 2004-02 was issued in 2004 requiring all U.S. PWRs to assess the potential effects of debris on ECCS strainer performance. In the 2006 – 2008 timeframe, plants replaced their original ECCS strainers (typically around 50 to 100 ft^2 strainers) with large, complex geometry strainers (on the order of 500 to 5,000 ft^2 strainers). As a result of ongoing research, additional technical issues were identified including chemical effects, downstream effects (ex-vessel and in-vessel), and boron precipitation. These issues made it very difficult for plants to show that the ECCS would perform as required for a design basis loss of coolant accident (LOCA), which includes a double-ended guillotine break (DEGB) on the large primary loop piping. The primary loop includes 30-inch diameter piping where an instantaneous DEGB would destroy insulation on a large portion of the surrounding pipes, steam generators, and other equipment.

Numerous deterministic methods were proposed for more realistic tests and analyses to show that the new strainers were adequate. The NRC staff closely scrutinized each proposed method and were hesitant to accept methods that significantly reduced the overall level of conservatism. For plants with predominantly fiberglass insulation, it appeared that the only success path would be a major plant modification to replace the fiberglass insulation with reflective metal insulation (RMI). The cost for this was estimated to be as high as $50-60 million and 200-300 rem of dose for a single plant.

In 2011, South Texas Project (STP) began a pilot project for a risk-informed approach to address GSI-191. The goal set for the technical team was to determine the actual risk significance by looking at all aspects of GSI-191 rigorously and realistically. This included benchtop testing, small- and large-scale strainer testing, advanced thermal-hydraulic modeling, probabilistic risk assessment (PRA) evaluations, a reassessment of LOCA frequencies, detailed engineering calculations that considered the full range of conditions (i.e., not limited to single failure criteria and other deterministic requirements), development of software that could statistically sample and evaluate thousands of break scenarios, and an evaluation of uncertainties.

The rigorous technical evaluation showed that it would be very unlikely for the STP strainers to fail, even for the largest break scenarios, and demonstrated that the risk is very low. The NRC staff had many questions on the testing, modeling, and other methods that were used. In many cases, the NRC's questions were addressed directly based on the rigor and level of detail used in the approach. In other cases, it was determined that simpler methods that had been previously accepted by the NRC were reasonably conservative (i.e., not overly conservative) and could be used to justify the conclusion of very low risk. In 2017, the NRC approved STP's license amendment request (LAR) along with their request for exemption from certain requirements in 10 CFR 50.46.

Although the process of developing a detailed approach to holistically evaluate the risk associated with GSI-191 was challenging, the pilot project accomplished three major things:

1. It allowed STP to avoid major plant modifications that carried a very high cost/dose with a negligible improvement on plant safety.
2. It created a path that several other plants followed to avoid unnecessary plant modifications.
3. It put the actual risk associated with GSI-191 into perspective. This allowed the NRC to relax requirements on the entire industry, making it easier for all plants to close out the issue.

Key lessons learned from risk-informed GSI-191 include the following items:

1. It is important to understand truth/reality, which can easily be masked by conservatisms.
2. The framework for a risk-informed evaluation should be defined in a way that allows the methods to be simplified or refined without changing the overall framework.
3. It is easier to start with a detailed approach and simplify the methods than it is to start with a simplified approach and later try to get NRC acceptance on refined methods.
4. A detailed evaluation has higher initial costs, but also provides the maximum benefit.
5. When the NRC staff can see that their technical concerns have been addressed rigorously, they are far more willing to accept a new approach than when a licensee tries to brush those concerns off as unimportant or overly conservative.
6. The lessons learned from the pilot evaluation can be used to streamline the approach for follow-on plants providing additional cost savings.

C-1.3 Experimental Capabilities

Use of laboratory testing and evaluations can be used to create more definitive age-related degradation mechanism rates and boundary conditions. These approaches can be used to better inform the mechanistic forms of age-related degradation and thus reduce or eliminate portions of AMPs. See C-1.1 recommendation number 3.

C-1.4 Advanced Detection and Examination Methods

Non-destructive testing (NDT) and examination (NDE) techniques are the industry standard for detection of aging mechanisms.

Typical NDT/NDE techniques include:

- Visual inspection
- Dye penetrant testing (DT)
- Magnetic-particle testing (MT)
- UT
- Radiography testing (RT).

C-1.4.1 Visual Inspection

Tools used in visual inspection includes:

- Mirror
- Magnifying glass
- Microscope
- Borescope
- Endoscope.

Visual inspection is typically an inexpensive method for detecting equipment flaws and defects. It is one of the most widely used methods for detecting discontinuities before they cause major problems (e.g., poor welding defects). Visual inspection is sometimes carried out with devices such as borescopes, fiberscopes, etc. Generally, most specimens are inspected visually to determine accuracy.

New means and methods of visually inspecting components and structures are evolving as camera technology has improved and miniaturization of components becomes more commonplace.

C-1.4.2 Dye Penetrant Testing

Dye penetration testing (PT) is based upon capillary action, where low surface tension fluid penetrates into clean and dry surface-breaking discontinuities. Penetrant may be applied to the test component by dipping, spraying, or brushing. After adequate penetration time has been allowed, the excess penetrant is removed; a developer is applied. The developer helps to draw penetrant out of the flaw where an invisible indication becomes visible to the inspector. Inspection is performed under ultraviolet or white light, depending upon the type of dye used—fluorescent or non-fluorescent which is used to identify defects.

Typical applications of PT include:

- Each single pass weld when a multi-pass weld process is used
- Parts with irregular shapes
- Low-cost applications

- Detection of surface and sub-surface defects.

C-1.4.3 Magnetic Particle Testing

MT is a combination of two non-destructive testing methods that are magnetic flux leakage testing and visual testing. Consider a bar magnet which has a magnetic field in and around the magnet. Any place that a magnetic line of force exits or enters the magnet is called a pole. A pole where a magnetic line of force exits the magnet is called a north pole, and a pole where a line of force enters the magnet is called a south pole. The first step in a magnetic particle inspection is to magnetize the component that is to be inspected. If any defects on or near the surface are present, the defects will create a leakage field. After the component has been magnetized, iron particles, either in a dry or wet suspended form, are applied to the surface of the magnetized part. The particles will be attracted and cluster at the flux leakage fields, thus forming a visible indication that the seen by the inspector.

Typical applications of MT include:

- Flaw detection (surface only)
- Leak detection
- Material sorting and chemical composition
- Micro-structure characterization.

C-1.4.4 Ultrasonic Testing

UT is a non-destructive test method that utilizes sound waves to detect cracks and defects in parts and materials. UT is also used to determine a material's thickness, such as measuring the wall thickness of a pipe.

Ultrasonic testing utilizes sound waves whose frequencies (50 kHz–50 MHz) are above the audible range for the human ear. The piezo-electric effect of the ultrasonic transducer makes it possible to transmit and receive from within the equipment. The instrument makes it possible to inspect the internal structure of the equipment and detect thickness changes, welds, cracks, voids, delamination, and other types of material or structural defects. The limitation of this method is that data acquisition and evaluation depends on the expertise of the technician.

Typical applications of UT include:

- Detect internal corrosion
- Measurement of metal section thickness
- Detection of failures and flaws
- Inspection of pipe and plate welds.

Many advancements in the means of performing UT have evolved in recent years. Miniaturization of components and further studies have developed improvements in this area.

C-1.4.5 Radiography Testing

Industrial RT is a method of non-destructive testing where many types of manufactured components can be examined to verify the internal structure and integrity of the specimen.

Because radiography waves have short wave lengths, they can penetrate and travel through structural materials such as steel and metallic alloys. Industrial radiography can be performed utilizing either x-rays or gamma rays. Both are forms of electromagnetic radiation. The difference between various forms of electromagnetic energy is related to the wavelength. X-rays and gamma rays have the shortest wavelength, and this property leads to the ability to penetrate, travel through, and exit various materials such as carbon steel and other metals.

Typical applications of RT include:

- Detection of porosity and internal cracks
- Measurement of geometry variations and thickness of components
- Identification of internal defects.

C-1.4.6 New Areas of NDE/NDT

The area of NDT/NDE is ever changing with new methods of testing and examination being developed and qualified on a constant basis. Cost-effectiveness and miniaturization of components are typical drivers of improvement in this area. In addition, new materials and manufacturing techniques also drive the importance of NDE/NDT in new environments.

Some areas that could be explored include:

- Acoustic emission testing
- Guided wave testing
- Impulse excitation technique
- Terahertz imaging
- Laser testing.

Note that special attention should be paid to any techniques that relate to the exploration of underground structures (buried piping, tanks, cables, etc.) without having to excavate these commodities. Great benefits in costs could be achieved if these commodities could be assessed remotely or with much less preparations.

C-1.4.7 Conclusion

NDE techniques have advanced significantly in the last 20–30 years and continue to advance. New methods are necessary to reduce costs and advance the industry in areas of NDE.

C-1.5 Modern Modeling Techniques

The commercial nuclear industry has come a long way since its beginnings in the 1950s. Modeling of core and containment was not possible, and codes and standards were under development. Now, computational fluid dynamics (CFD), computer-aided design (CAD), and many other modeling methods dominate the design of new plants and the evaluation of existing plant designs. Leveraging use of modern modeling techniques can pinpoint where aging and degradation of components, systems and structures can occur. This would require additional data to support the modeling methods and industry support to develop these methods.

Risk informed modeling is used extensively in the nuclear industry as a way of reducing risk for events or extending intervals for maintenance activities. These methods can be extended into other areas as the industry matures and more data is gathered during periods of extended operation.

Where system modeling may be useful is defining locations most susceptible to aging. If predictive models using key factors such as stagnant or low-flow areas, especially where chemical mixing is not as effective, reasonable assurance that aging would be found, if occurring, could be given using fewer inspections. This is potentially useful in XI.M20, Open-Cycle Cooling Water, XI.M21A, Closed Treated Water, XI.M32, One-Time Inspection, XI.M33, Selective Leaching, or XI.M36, External Surfaces Monitoring.

See Section C-1.2 for further details on RI activities.

Appendix D
Analysis of Opportunities for Economic Benefit or Other Benefits

D-1. APPROACH

This addendum provides an analysis of the economic benefit of the potential candidates provided in Appendix C. The analysis focuses on how the opportunity would allow for economic relief/benefit (e.g., reduction of costs) or other benefits (i.e., demonstrated lower risk).

A review of GALL-SLR [9] was performed to review each of the AMPs to understand the general commitments that plants have made relative to those programs through the LR and SLR process. Each of those programs and commitments were reviewed to determine the burden they cause to the utility including cost, time, risk, labor, plant operation, etc. These assessments were made qualitatively based on experience with implementing LR commitments at 12 nuclear units. Note, many of the programs and commitments are quite similar for LR and SLR and there have been no utilities to enter the SPEO. So, comparison with the LR process is the most representative experience for the purpose of this evaluation. Those relative burdens are listed in Table D-1 from high to low.

The potential to reduce burden includes such factors as the opportunity to reduce the costs by analysis (technical or risk informed) and the willingness of the NRC to accept the justification for the burden reduction.

Table D-1. AMP Burden Rankings.

AMP	Name of Program	Licensee Burden	Potential to Reduce Burden
X.E1	Environmental Qualification (EQ) of Electrical Components	Medium	Low
X.M1	Fatigue Monitoring	Medium	Low
X.M2	Neutron Fluence Monitoring	Low	Low
X.S1	Concrete Containment Unbonded Tendon Prestress	Medium	Low
XI.E1	Electrical Insulation for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements	Low	Low
XI.E2	Electrical Insulation for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Used in Instrumentation Circuits	Low	Low
XI.E3A	Electrical Insulation for Inaccessible Medium-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements	Medium	Medium
XI.E3B	Electrical Insulation for Inaccessible Instrument and Control Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements	Medium	Medium
XI.E3C	Electrical Insulation for Inaccessible Low-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements	Medium	Medium

Table D-1. (continued).

AMP	Name of Program	Licensee Burden	Potential to Reduce Burden
XI.E4	Metal-Enclosed Bus	Medium	Medium
XI.E5	Fuse Holders	Low	Low
XI.E6	Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements	Low	Low
XI.E7	High-Voltage Insulators	Low	Low
XI.M1	ASME Section XI Inservice Inspection, Subsection IWB, IWC, and IWD	Medium	Low
XI.M2	Water Chemistry	Low	Low
XI.M3	Reactor Head Closure Stud Bolting	Low	Low
XI.M4	BWR Vessel ID Attachment Welds	Medium	Low
XI.M7	BWR Stress Corrosion Cracking	Medium	Low
XI.M8	BWR Penetrations	Medium	Low
XI.M9	BWR Vessel Internals	Medium	Low
XI.M10	Boric Acid Corrosion	Medium	Low
XI.M11B	Cracking of Nickel-Alloy Components and Loss of Material Due to Boric Acid-Induced Corrosion in Reactor Coolant Pressure Boundary Components (PWR Only)	Low	Low
XI.M12	Thermal Aging Embrittlement of Cast Austenitic Stainless Steel (CASS)	Low	Low
XI.M16A	PWR Vessel Internals	High	Low
XI.M17	Flow-Accelerated Corrosion	Medium	Low
XI.M18	Bolting Integrity	Medium	Low
XI.M19	Steam Generators	Low	Low
XI.M20	Open-Cycle Cooling Water System	Low	Low
XI.M21A	Closed Treated Water Systems	Medium	Low
XI.M22	Boraflex Monitoring	Low	Low
XI.M23	Inspection of Overhead Heavy Load and Light Load (Related to Refueling) Handling Systems	Low	Low
XI.M24	Compress Air Monitoring	Low	Low
XI.M25	BWR Reactor Water Cleanup System	Low	Low
XI.M26	Fire Protection	Medium	Low
XI.M27	Fire Water System	High	Medium
XI.M29	Outdoor and Large Atmospheric Metallic Storage Tanks	High	High
XI.M30	Fuel Oil Chemistry	High	Medium
XI.M31	Reactor Vessel Material Surveillance	Low	Low
XI.M32	One-Time Inspection	Medium	Medium
XI.M33	Selective Leaching	Medium	Medium
XI.M35	ASME Code Class 1 Small-Bore Piping	Medium	Medium

Table D-1. (continued).

AMP	Name of Program	Licensee Burden	Potential to Reduce Burden
XI.M36	External Surfaces Monitoring of Mechanical Components	Medium	Low
XI.M37	Flux Thimble Tube Inspection	Low	Low
XI.M38	Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components	Medium	Low
XI.M39	Lubricating Oil Analysis	Low	Low
XI.M40	Monitoring of Neutron-Absorbing Materials Other Than Boraflex	Low	Low
XI.M41	Buried and Underground Piping and Tanks	High	Medium
XI.M42	Internal Coatings/Linings for In-Scope Piping, Piping Components, Heat Exchangers, and Tanks	Medium	High
XI.S1	ASME Section XI, Subsection IWE	Medium	Low
XI.S2	ASME Section XI, Subsection IWL	Medium	Low
XI.S3	ASME Section XI, Subsection IWF	Low	Low
XI.S4	10 CFR 50, Appendix J	Low	Low
XI.S5	Masonry Walls	Low	Low
XI.S6	Structures Monitoring	Low	Low
XI.S7	Inspection of Water-Control Structures Associated with Nuclear Power Plants	Low	Low
XI.S8	Protective Coating Monitoring and Maintenance	Low	Low

Assessment of the results indicates the following quantitative evaluation of the various AMPs:

		Potential to Reduce Burden		
		High	Medium	Low
Licensee Burden	High	1	4	1
	Medium	1	7	17
	Low	0	0	25

Based on these results from previous experience, those AMPs in the uppermost left portion of the table above are the ones that would show the most benefit from additional research into lessening the licensee burden to implement. Such efforts are discussed in other portions of the report specific to each AMP, but this evaluation methodology allows for additional focus and resources to be applied to the right areas for the maximum benefit with respect to reducing future SLR burden. For summary purposes and to align on future work in this area, the AMPs are listed below in 3 tiers from highest priority to focus additional efforts to lowest:

Tier 1 AMPs:

- XI.M27: Fire Water System
- XI.M29: Outdoor and Large Atmospheric Metallic Storage Tanks
- XI.M30: Fuel Oil Chemistry

- XI.M32: One-Time Inspection
- XI.M41: Buried and Underground Piping and Tanks
- XI.M42: Internal Coatings/Linings for In-Scope Piping, Piping Components, Heat Exchangers, and Tanks.

<u>Tier 2 AMPs:</u>

- XI.E3A: Electrical Insulation for Inaccessible Medium-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
- XI.E3B: Electrical Insulation for Inaccessible Instrument and Control Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
- XI.E3C: Electrical Insulation for Inaccessible Low-Voltage Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
- XI.E4: Metal Enclosed Bus
- XI.M16A: PWR Vessel Internals
- XI.M33: Selective Leaching
- XI.M35: ASME Code Class 1 Small-Bore Piping.

<u>Tier 3 AMPs:</u>

- All AMPs not included in Tier 1 or Tier 2