APPLICATION FOR RENEWED OPERATING LICENSES

OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3

Volume II

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3. IDENTIFICATION OF APPLICABLE AGING EFFECTS

3.1 INTRODUCTION

The second major activity of the *Oconee Integrated Plant Assessment*, the identification of the aging effects applicable to the structures and components that are subject to aging management review, is set forth in this chapter. [Footnote 1]

For those structures and components that are identified as being subject to an aging management review, §54.21(a)(3) requires a demonstration that the effects of aging will be adequately managed so that their intended function(s) will be maintained consistent with the current licensing basis for the period of extended operation. The information provided in Chapter 3 provides essential input to the aging management review required by §54.21(a)(3) as it identifies and discusses the applicable aging effects. [Footnote 2] The information provided in Chapter 3, along with the technical information provided in Chapters 2 and 4, is designed to allow the NRC to make the finding contained in §54.29(a)(1). [Footnote 3]

§54.21(a)(3) Reference

(a) An integrated plant assessment (IPA). The IPA must –

(1) For each structure and component identified in paragraph (a)(1) of this section, demonstrate that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation.

As described previously in Chapter 2, the *Oconee Integrated Plant Assessment* is divided into the engineering disciplines traditional to Duke; i.e., mechanical, civil/structural, and electrical. The process used by Duke to identify the applicable aging effects for structures and components is described in Section 3.2.

Consistent with the presentation of information in Chapter 2, the applicable aging effects for Reactor Building (Containment) components and Reactor Coolant System components are provided in Sections 3.3 and 3.4, respectively. The applicable aging effects for mechanical components, electrical components, and structural components are provided in Sections 3.5, 3.6, and 3.7, respectively.

1. Chapter 2 of OLRP-1001 discusses the identification of structures and components within the scope of license renewal that have been determined to be subject to aging management review.
2. The demonstration that these aging effects are adequately managed is provided in Chapter 4.
3. Refer to Section 1.1 for the text of NRC requirements to §54.29(a)(1).

3.2 DESCRIPTION OF THE PROCESS TO IDENTIFY APPLICABLE AGING EFFECTS

A description of the process used to identify the aging effects applicable to Oconee structures and components subject to an aging management review is provided in this Section. Section 3.2.1 describes the process used to identify the applicable aging effects. Section 3.2.2 provides a description of the service environment in applicable areas of Oconee Nuclear Station. This process is consistent with the guidance provided in NEI 95-10, Revision 0 [Reference 3.2-1, Section 4.2.1.1].

3.2.1 PROCESS OVERVIEW

The process by which Duke identifies applicable aging effects at Oconee consists of several stages. First, from a generic perspective, potential aging effects that could generally challenge the intended functions of structures and components subject to an aging management review have been identified by reviewing available industry literature. These potential aging effects have been evaluated to determine which ones are applicable to Oconee.

Second, the aging effects applicable to Oconee have been determined by reviewing the plant-specific materials of construction and service environments (see Section 3.2.2) for each structure and component that is subject to an aging management review. To provide reasonable assurance that the applicable aging effects for a specific material-environment combination are the only aging effects of concern for Oconee, Duke also has performed a review of industry experience and NRC generic communications relative to structures and components.

Finally, relevant Oconee experience has been reviewed to provide further confidence that the set of applicable aging effects for the specific material-environment combinations have been identified. Taken together, the steps of this process provide reasonable assurance that the aging effects applicable to Oconee structures and components subject to an aging management review have been identified.

3.2.2 SERVICE ENVIRONMENTS

The service environment in which components operate, along with other factors, establishes the applicable aging effects of concern for license renewal. This sub-section identifies the service environments for the areas that contain structures and components subject to an aging management review. The service environments identified in this section are thermal, radiation, and moisture. These environments are described in Sections 3.2.2.1 through 3.2.2.3.

3.2.2.1 Thermal Environmentals

Thermal data were obtained from Oconee engineering documents and combined into tables. Table 3.2-1 presents a summary of the thermal environmental conditions, by location, so that the structures and components installed in each one of the locations can be analyzed for aging resulting from location-specific, worst-case design environments.

3.2.2.2 Radiation Environmentals

Design radiation maximums specific to normal operation were obtained from the *Environmental Qualification Criteria Manual* [Reference 3.2-2]. These values are considered conservative maximums; the actual 40-year dose will be lower and, in some cases, much lower. For all areas of the plant not listed in the *Environmental Qualification Criteria Manual*, the 40-year dose (gamma) is negligible. Table 3.2-2 presents a summary of the radiation environments; sorted from highest to lowest radiation dose.

The expected normal dose for 60 years at Oconee can be determined by multiplying the current 40-year normal dose by a simple ratio of 1.5 (60/40). For example, if the normal 40-year dose listed in Table 3.2-2 for a given area is 3×10^4 rads, then the 60-year dose will be 4.5×10^4 rads.

3.2.2.3 Moisture

Exterior surfaces of structures and components located in yard areas are subject to moisture from weather conditions such as dew, rain, fog, snow, or sleet. Oconee is located in a rural area and is not near major industrial plants or seawater so the plant is not exposed to sulfate or chloride attack.

Components such as the Keowee structures, Intake Structure, and Condenser Cooling Water System piping are exposed to the waters of Lake Keowee. Water quality in Lake Keowee is excellent. Concentrations of all minerals and nutrients are very low, with total dissolved solids of less than of 25 mg/l.

The quality of the groundwater in the vicinity of Oconee is excellent. The Oconee groundwater pH ranges between 5.5 and 5.8; the chloride concentration ranges between 3.2 and 9.2 ppm; and the sulfate concentration ranges between 3.5 and 572 ppm.

Components located inside of structures may have short-term exposure to standing water from spills or normal system leakage. Localized corrosion that occurs as a result of a short-term event is corrected through normal plant maintenance activities. These conditions are considered to be event driven and not considered in license renewal aging management reviews

3.2.3 References for Section 3.2

3.2-1. *NEI 95-10, Revision 0, Industry Guideline for Implementing the Requirements of 10 CFR Part 54 - The License Renewal Rule*, Nuclear Energy Institute, March 1996.

3.2-2. *Oconee Nuclear Station Environmental Qualification Criteria Manual*, Rev. 12.

Table 3.2-1 Oconee Thermal Environments

Structure or Area	Specific Area Description and Comments	Bounding Temperature
Auxiliary Buildings	Main Steam Penetration Concrete (Penetration Rooms)	150°F (65.6°C)
	Areas Cooled by the Auxiliary Building Ventilation System	104°F (40.0°C)
	Spent Fuel Pool Areas	104°F (40.0°C)
	Equipment Rooms (designed for 86°F)	90°F (32.2°C)
	Control Rooms, Cable Rooms (designed for 74°F)	85°F (29.4°C)
	Control Battery Rooms	80°F (26.7°C)
	Areas Cooled by the Auxiliary Building Air Conditioning System	75°F (23.9°C)
Intake Structure	Areas Exposed to Site Ambient	105°F (40.6°C)
Keowee Structures	All Areas	105°F (40.6°C)
Reactor Buildings	Vessel Head and Area Around the Control Rod Drives (maintained near 150°F)	175°F (79.4°C)
	High Elevations in Steam Generator Cavities	132°F (55.6°C)
	Elevation Around Top of Reactor Coolant Pumps	126°F (52.2°C)
	Elevation 797+6	116°F (46.7°C)
Standby Shutdown Facility	Diesel Generator, Switchgear, Pump, HVAC Equipment Rooms	104°F (40.0°C)
	Control, Computer, Battery, Response (CAS) Rooms	72°F (22.2°C)
Turbine Buildings	General Areas	105°F (40.6°C)
Yard Structures	Areas Exposed to Site Ambient	105°F (40.6°C)
	Appendix R Warehouse	105°F (40.6°C)
	Cable Trenches and Direct Buried	80°F (26.7°C)

Table 3.2-2 Oconee Radiation Environments

Structure	Area	Maximum 40-Year Normal Operating Dose (rads)	Maximum 60-Year Normal Operating Dose (rads)
Reactor Buildings	Reactor Cavity Steam Generator Cavity Elev. 797+6 - zone 1 Elev. 825+0 - zone 1 Elev. 844+6 - zone 1	3×10^7	4.5×10^7
	Elev. 777+6 - zone 1	1×10^7	1.5×10^7
Auxiliary Buildings	Elev. 758+0 - zones 5-7 Elev. 771+0 - zones 1-8 Elev. 783+9 - zones 1-6 Elev. 796+6 - zones 1-2 Elev. 809+3 - zone 2 Elev. 822+0 - zones 2-3 Penetration Rooms	1×10^6	1.5×10^6
Reactor Buildings	Elev. 777+6 - zone 2	3×10^5	4.5×10^5
Auxiliary Buildings	Elev. 758+0 - zones 1-4 Elev. 796+6 - zones 3-4	1×10^5	1.5×10^5
Reactor Buildings	Elev. 777+6 - zone 3 Elev. 797+6 - zone 2 Elev. 825+0 - zone 2 Elev. 844+6 - zone 2 General	3×10^4	4.5×10^4
Auxiliary Buildings	Elev. 809+3 - zone 3 Elev. 822+0 - zone 1	1×10^4	1.5×10^4
	Elev. 771+0 - zones 9-10 Elev. 783+9 -zones 7, 8a-8d Elev. 796+6 - zones 5-6 Elev. 809+3 - zone 1	1×10^3	1.5×10^3
Turbine Buildings	All Areas	Less than 1×10^3	Less than 1.5×10^3
Auxiliary Buildings	Elev. 838+0 - zones 1a-e, 2	1×10^2	1.5×10^2
	Cable Spreading Rooms Control Rooms Electrical Equipment Rooms	Less than 1×10^2	Less than 1.5×10^2

Table 3.2-2 Oconee Radiation Environments (continued)

Structure	Area	Maximum 40-Year Normal Operating Dose (rads)	Maximum 60-Year Normal Operating Dose (rads)
Intake Structure	All Areas	Negligible	Negligible
Keowee Structures	All Areas		
Standby Shutdown Facility	All Areas		
Yard Structures	All Areas		

3.3 AGING EFFECTS FOR REACTOR BUILDING (CONTAINMENT) STRUCTURAL COMPONENTS

3.3.1 DESCRIPTION OF THE PROCESS TO IDENTIFY THE APPLICABLE AGING EFFECTS FOR REACTOR BUILDING (CONTAINMENT) STRUCTURAL COMPONENTS

Reactor Building (Containment) structural components that are within the scope of license renewal that require aging management reviews and their intended functions are identified in Section 2.3.

The process to determine the aging effects applicable to these Containment structural components begins with an understanding of the potential aging effects defined in industry literature. From this set of potential aging effects, the component materials, operating environment and operating stresses serve to define the applicable aging effects for each component that is subject to an aging management review. These applicable aging effects are then validated by a review of industry and Oconee operating experience to provide reasonable assurance that the full set of applicable aging effects are established for the aging management review. This process is more fully described in Section 3.2 of OLRP-1001.

To facilitate the identification of applicable aging effects, structural components of the Reactor Building (Containment) have been grouped as follows:

- Concrete components
- Steel components
- The post-tensioning system

Section 3.3.2 identifies the aging effects applicable to Containment concrete components. Section 3.3.3 identifies the aging effects applicable to Containment steel components, and Section 3.3.4 does the same for the Containment post-tensioning system.

3.3.2 Applicable Aging effects for Concrete Components

Containment concrete structural components are identified in Section 2.3.2 of OLRP-1001. As an aid to the reader, the types of concrete structural components which are subject to aging management review are repeated here and include:

- Dome and Cylinder Walls
- Floor
- Foundation Slab

The codes and standards used for the Containment design and fabrication including applicable edition are given in the Oconee UFSAR [Reference 3.3-1, Section 3.8.1]. The Containment concrete component design complies with the ACI 318-63 [Reference 3.3-2]. The concrete and reinforcing design parameters are identified in the Oconee UFSAR [Reference 3.3-1, Chapter 3.8]. Additional information on the environmental conditions at Oconee is provided in Section 3.2.2 of OLRP-1001.

The review to identify the applicable aging effects for concrete structural components considers the following potential aging effects which have been identified by reviewing available industry literature:

- Loss of material due to abrasion and cavitation, aggressive chemicals, corrosion of embedded steel/rebar, elevated temperature, or freeze-thaw. Loss of material includes scaling, spalling, pitting, and erosion;
- Cracking due to elevated temperature, fatigue, freeze-thaw, reaction with aggregates, shrinkage, or settlement;
- Change in material properties due to aggressive chemical attack, elevated temperature, irradiation embrittlement, or leaching of calcium hydroxide. Change in material properties is manifested in concrete components as increased permeability, increased porosity, reduction in pH, reduction in tensile strength, reduction in compressive strength, reduction in modulus of elasticity, and reduction in bond strength.

Consistent with the process described in Section 3.2, the applicable aging effects are determined by reviewing the materials of construction and ambient environment. Section 3.3.2.1 describes the ambient environments that Reactor Building (Containment) concrete components are exposed to at Oconee. Sections 3.3.2.2 through 3.3.2.7 describe the results when the process is applied to Containment concrete components at Oconee. The results are summarized in Table 3.3-1.

3.3.2.1 Environment

Containment concrete components are exposed to different service environments depending on their location. The Containment concrete foundation slab and the portion of the external cylinder wall below grade are exposed to backfill and groundwater. The groundwater chemistry plays a major role in the determination of the degradation of the below grade components. External surfaces of the Containment dome and cylinder wall above grade are exposed to the external atmospheric environment. The cylinder wall above grade enclosed by adjacent buildings is exposed to a controlled environment which protects it from external weather and temperature changes.

The top of the concrete floor is exposed to the internal environment of the Containment. High temperature, humidity and radiation play a role in the potential degradation of the concrete components located within this environment.

3.3.2.2 Loss of Material Assessment

Loss of material has been assessed and determined to be not applicable for the Oconee Containment concrete components. The Oconee concrete components are designed in accordance with ACI 318-63 and constructed in accordance with ACI 301 using ingredients conforming to ACI and ASTM standards which provide a good quality, dense, low permeability concrete [Reference 3.3-3]. In addition, the components are located in environments, both above and below grade, where they are not exposed to continuously flowing water, nor to temperatures which exceed the thresholds for degradation identified in ACI 318-63. Groundwater chemical concentrations have been tested at Oconee and it has been determined that they do not exceed the minimum threshold limits for degradation to occur which are described in the NUMARC PWR Containment Industry Report [Reference 3.3-4].

3.3.2.3 Cracking Assessment

Cracking is manifested in concrete components as a complete or incomplete separation of the concrete into two or more parts. Aging mechanisms and stressors that can lead to cracking include freeze-thaw, reaction with aggregates, shrinkage, settlement, elevated temperature or fatigue [Reference 3.3-5].

Cracking has been assessed and determined not to be a significant aging effect for the Oconee Containment concrete components. The prestressed concrete design places the cylinder and dome concrete in compression for all normal loading conditions over the current and extended period of operation. The precompression minimizes the number and width of cracks induced by shrinkage, temperature, or load. The concrete components are designed in accordance with ACI 318-63 [Reference 3.3-2] and constructed in accordance with ACI 301 [Reference 3.3-3] using ingredients conforming to ACI and ASTM standards which provide a good quality, dense, low permeability concrete.

During initial construction, concrete component constituents were carefully selected to mitigate aggregate reactions. Tests were performed on the aggregate contained in the Oconee Containment which indicated that they were not considered potentially reactive. Shrinkage in concrete is not a possible aging effect after 20 years [Reference 3.3-6]. The Oconee Containments are founded on bed rock thus precluding settlement. The concrete components are not exposed to temperatures which exceed the thresholds for degradation due to elevated temperature identified in ACI 318-63 [Reference 3.3-2].

Finally, a review of the loadings that concrete containments experience during normal operation indicates that the periodic Type A Integrated Leak Rate tests are the major sources of load changes. However, the number of cycles of Type A tests are generally low for a 60-year operating life with only low to moderate stress levels [Reference 3.3-4]. For all of these reasons, cracking was judged not to be an applicable aging effect for license renewal.

3.3.2.4 Change in Material Properties Assessment

The change in material properties aging effect is manifested in concrete components as increased permeability, increased porosity, reduction in pH, reduction in tensile strength, reduction in compressive strength, reduction in modulus of elasticity, and reduction in bond strength. Aging mechanisms and stressors which can lead to change in material properties include leaching of calcium hydroxide, elevated temperature, aggressive chemical attack, or irradiation embrittlement.

Change in material properties has been assessed and determined to be not applicable for the Oconee Containment concrete components for the following reasons. The Oconee Containment concrete components are designed in accordance with ACI 318-63 [Reference 3.3- 2] and constructed in accordance with ACI 301 [Reference 3.3-3] using ingredients conforming to ACI and ASTM standards which provide a good quality, dense, low permeability concrete. A dense concrete with a suitable cement content that has been well cured is less susceptible to calcium hydroxide leaching from percolating water because of its low permeability and low absorption rate.

The concrete components are not exposed to temperatures which exceed the thresholds for degradation identified in ACI 318-63 [Reference 3.3-2], nor are they exposed to chemical concentrations which exceed the minimum threshold limits where degradation may occur.

Change in material properties due to irradiation exposure is not an applicable aging effect because the Containment concrete components will not experience sufficient irradiation to cause embrittlement.

3.3.2.5 Industry Experience

In order to validate the set of applicable aging effects considered, and to assure no additional aging effects exist beyond those discussed herein, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. No concrete component aging effects were identified in NRC generic communications or licensee event reports. The following NUREGs were reviewed:

- NUREG/CR-6424, *Report on Aging of Nuclear Power Plant Reinforced Concrete Structures*
- NUREG/CR-4652, *Concrete Component Aging and its Significance Relative to Life Extension of Nuclear Power Plants*
- NUREG CP-100, *Concrete Degradation Monitoring and Evaluation*
- NUREG-1522, *Assessment of Inservice Conditions of Safety-Related Nuclear Plant Structures*
- NUREG-1557, *Summary of Technical Information and Agreements from Nuclear Management and Resources Council Industry Reports Addressing License Renewal*

These NRC documents concluded that concrete deterioration has generally been minor due to the high quality of the original construction. Most instances related to degradation occurred early in the life of the structure and have subsequently been effectively corrected. Degradation was due to either improper material selection, construction/design deficiencies or environmental effects.

3.3.2.6 Oconee Operating Experience

Oconee operating experience and previous Reactor Building Civil Inspections were reviewed to validate the applicable aging effects for Containment concrete components. This review included a survey of documented instances of Containment concrete component aging. Periodic condition inspections performed to date of the accessible exposed Containment concrete surfaces have indicated only a few areas of minor surface cracking and minor leaching. The degradation has been monitored and did not prevent the Containment concrete components from performing their intended functions consistent with the current licensing basis for the current or extended period of operation. The cause of the minor cracking is likely due to shrinkage. As the NRC Staff recognized in a Nuclear Regulatory Commission briefing, "shrinkage cracks are very common on concrete. Any time you build a structure out of concrete, your concrete shrinks and cracks develop, very minute cracks. These are not structural [Reference 3.3-7]." [Footnote 4]

3.3.2.7 Conclusion

Oconee Containment concrete components have been designed and fabricated in accordance with well established industry standards and construction practices. By considering these features along with the plant operating environments to which the concrete components are exposed, concrete cracking and leaching were judged not to be applicable aging effects for license renewal. From Oconee operating experience, some minor concrete cracking and leaching have been observed on a few exposed concrete surfaces. Engineering review of these locations has determined that the cracking and leaching will not challenge the intended functions of Containment under design basis loads. Additionally, this experience could also be considered as indirect symptomatic evidence for inaccessible areas. Since cracking and leaching have been observed and because of the importance of Containment in the radiological line of defense, the Oconee *Containment Inservice Inspection Plan* will serve to identify and manage any cracking and leaching that could lead loss of intended function. [Footnote 4]

4. This section has been revised to supplement the initial Duke response to RAI 3.3-1 which was provided by Duke letter dated January 14, 1998. The initial Duke response to RAI 3.3-1 was discussed during a meeting with the NRC staff on April 29, 1998. In addition, this revision completes the action to supplement the initial Duke response to RAI 3.3-5 as discussed during a meeting with the NRC staff on April 29, 1998.

Therefore, the applicable aging effects for Containment concrete components are cracking and change in material properties (due to leaching). These aging effects need to be managed for the period of extended operation because they could lead to loss of structural integrity of the Containment. These aging effects will be managed by the following program that is described in Chapter 4 of OLRP-1001:

- Containment Inservice Inspection Plan

3.3.3 Applicable Aging Effects for Steel Components

Containment steel components are identified in Section 2.3.3 of OLRP-1001. As an aid to the reader, the types of steel structural components of the Containment which are subject to an aging management review are repeated here and include:

- Liner Plate
- Anchors/Embedments/Attachments
- Personnel Hatch
- Equipment Hatch
- Mechanical Penetrations
- Electrical Penetrations
- Fuel Transfer Tube

The codes and standards used for the Containment design and fabrication including applicable edition are given in the Oconee UFSAR [Reference 3.3-1, Section 3.8.1]. The Containment steel component design complies with the American Society of Mechanical Engineers (ASME Code Section III - 1965) for the pressure boundary, and the American Institute of Steel Construction (AISC Manual of Steel Construction, sixth edition) for the structural steel.

The review to identify the applicable aging effects for steel structural components in an air environment considers the following potential aging effects which have been identified by reviewing available industry literature:

- Loss of material due to general corrosion
- Cracking due to fatigue or stress corrosion cracking
- Change in material properties due to elevated temperature or irradiation embrittlement

Consistent with the process described in Section 3.2, the applicable aging effects are determined by reviewing the materials of construction and ambient environment. Section 3.3.3.1 describes the ambient environments that Reactor Building (Containment) steel components are exposed to at Oconee. Sections 3.3.3.2 through 3.3.3.7 describe the results when the process is applied to the Containment steel components at Oconee. The results are summarized in Table 3.3-1.

3.3.3.1 Environment

Containment steel components are exposed to various service environments depending on their location. The liner plate and other steel components are exposed to the internal environment of the Containment. High temperature, humidity and radiation within the interior of the Containment play a role in the degradation of the components located within this environment. Embedments encased in concrete are protected from the external environment and the highly alkaline environment of the concrete protects the steel from corrosion.

3.3.3.2 Loss of Material Assessment

Loss of material in the Containment steel components may be caused by corrosion of the steel. Exposed steel components are coated for corrosion protection; therefore, loss of material due to corrosion is not an applicable aging effect as long as the coatings are maintained. Coatings for the liner, attachments to the liner, penetrations and hatches are identified in the Oconee UFSAR [Reference 3.3-1, Table 3-12]. [Footnotes 5, 6] For the liner behind miscellaneous welded attachments, loss of material due to corrosion is an applicable aging effect if the cavity formed between the attachment and the liner is not sealed to protect against moisture intrusion. For steel components encased in concrete, loss of material due to corrosion is not an applicable aging effect because the adjacent concrete provides an alkaline environment that is an effective inhibitor of corrosion. The only exception to this conclusion may be the liner below the floor if the expansion joint sealant is not maintained.

3.3.3.3 Cracking Assessment

Cracking of steel components may be caused by stress corrosion and fatigue. Cracking due to stress corrosion is not an applicable aging effect for the carbon steel components of the Oconee Containment because the relevant conditions necessary (corrosive environment, susceptible material, and tensile stresses) for stress corrosion cracking do not exist.

Dissimilar metal welds are used in certain Containment penetrations. Where dissimilar metals are used, appropriate welding techniques have been utilized. Bellows are not used in any Oconee Containment penetration. Cracking of dissimilar metal welds in Containment penetration welds subject to cyclic loads and thermal stresses during plant operations is not likely to occur because the welds are located in a non-aggressive environment. The potential for cracking of these welds due to fatigue is addressed below.

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5. The Oconee Coatings Program is described in Chapter 4 of OLRP-1001.
6. This section has been revised to supplement the initial Duke response to RAI 3.3-2 which was provided by Duke letter dated January 14, 1998. The initial Duke response to RAI 3.3-2 was discussed during a meeting with the NRC staff on April 29, 1998.

Cracking due to fatigue has been identified as a time-limited aging analysis and has been evaluated for the period of extended operation. The results of this evaluation are presented in Chapter 5 of OLRP-1001. This fatigue evaluation for the liner and penetrations for 60 years has determined that the original analysis remains valid for the period of extended operation. Furthermore, the design and operation of the steel components will not exceed 2 $x10^6$ loadings as specified by the American Institute of Steel Construction [Reference 3.3-8]. Cracking due to fatigue is not an applicable aging effect for the steel components of the Oconee Containment. [Footnote 7]

3.3.3.4 Change in Material Properties Assessment

The change in material properties aging effect driven by elevated temperature and irradiation is manifested in steel components as a reduction or increase in yield strength, reduction in modulus of elasticity, reduction in ultimate tensile ductility, and an increase in ductile-to-brittle transition temperature. Change in material properties due to elevated temperature is not an applicable aging effect because the steel components are not exposed to temperatures above the threshold where material property changes would occur. Structural steel has a high temperature threshold before significant strength reductions occur. Temperatures as high as 700^{o}F must be reached before small reductions in material properties occur [Reference 3.3-4] and temperatures during normal operation are well below this threshold.

Change in material properties due to irradiation exposure is not an applicable aging effect because the steel components of the Oconee Containment will not experience irradiation above the threshold necessary to cause embrittlement. The primary shield wall and the concrete pedestal under the reactor vessel provide shielding. In addition, the distance between the steel components and reactor vessel provides a further reduction in the irradiation levels at the steel components of the Oconee Containment [Reference 3.3-4].

7. This section has been revised to supplement the initial Duke response to RAI 3.3-3 which was provided by Duke letter dated January 14, 1998. The initial Duke response to RAI 3.3-3 was discussed during a meeting with the NRC staff on April 29, 1998.

3.3.3.5 Industry Experience

In order to validate the set of applicable aging effects considered, and to assure no additional aging effects exist beyond those discussed herein, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following documents were identified in this:

- NUREG/CR-6424, *Report on Aging of Nuclear Power Plant Reinforced Concrete Structures*
- ORNL/NRC/LTR-95/29, *Degradation Assessment Methodology for Application to Steel Containments and Liners of Reinforced Concrete Structures in Nuclear Power Plants*
- LER's associated with corrosion
- IE Bulletin 80-08, *Examination of Containment Liner Penetration Welds*
- IN 86-99, *Degradation of Steel Containments*
- IN 89-79, *Degraded Coatings and Corrosion of Steel Containment Vessels*
- NUREG-1540, *BWR Steel Containment Corrosion*
- NUREG-1557, *Summary of Technical Information and Agreements from Nuclear Management and Resources Council Industry Reports Addressing License Renewal*

3.3.3.6 Oconee Operating Experience

Oconee operating experience and previous Reactor Building Civil Inspections were reviewed to validate the applicable aging effects for Containment steel components. This review included a survey of documented instances of Containment steel component aging. As a result of this review, minor local coatings failures and minor local areas of corrosion Containment steel components have been observed. Coating degradation and minor local corrosion have been corrected by reapplication of protective coatings in accordance with existing coatings maintenance procedures applicable to the steel surfaces inside the Containment. This minor degradation has been repaired and did not prevent the Containment steel components from performing their intended functions consistent with the current licensing basis.

In November 1996, degraded expansion joint sealant between the basement slab/liner plate interface was identified during an inspection of the Unit 3 Containment. This was being performed by Duke personnel as required by 10 CFR 50, Appendix J, V. A., *Containment Inspection.* Corrective actions included the inspection of similar locations on Units 1 and 2. The liner plate in the vicinity of the Unit 1 normal sump was found to have corrosion while the Unit 2 liner plate had expansion joint sealants intact and no corrosion. Expansion joint sealant, expansion joint filler material and basement slab concrete were removed from the affected areas of the liner plate for both Units 1 and 3. Non-destructive examinations of the liner plate were performed and it was determined that the extent of corrosion of the liner plates of Units 1 and 3 were negligible, and much less than 10 % of the nominal wall thickness as allowed by IWE-3512. The affected areas of the liner plate were coated to protect against further corrosion. [Footnote 8]

3.3.3.7 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. This review confirms that loss of material is the applicable aging effect for Containment steel components.

Therefore, the applicable aging effect for the period of extended operation for the Containment steel components is loss of material due to corrosion:

- For the liner, hatches, and penetrations if the coatings are not maintained;
- For the liner below the concrete floor if the expansion joint sealants are not maintained; and
- For the liner behind welded attachments if the cavity formed between the attachment and the liner is not sealed.

This aging effect needs to be managed for the period of extended operation because corrosion could lead to a breech of the essentially leaktight barrier of the Containment steel components. This aging effect will be managed by the following programs that are described in Chapter 4 of OLRP-1001:

- Coatings Program
- Containment Inservice Inspection Plan
- Containment Leak Rate Testing Program

8. This section has been revised to incorporate the initial Duke response to RAI 3.3-10 which was provided by Duke letter dated January 14, 1998. The initial Duke response to RAI 3.3-10 was discussed during a meeting with the NRC staff on April 29, 1998.

3.3.4 Applicable Aging Effects for the Post-Tensioning System

The post-tensioning system is identified in Section 2.3.4 of OLRP-1001. As an aid to the reader, the components of the post-tensioning system within the scope of license renewal are repeated here and include:

- Tendon Wires
- Tendon Anchorage

The codes and standards used for the Containment design and fabrication, including applicable edition, are identified in the Oconee UFSAR, Section 3.8.1 [Reference 3.3-1]. The design of the Containment post-tensioning buttresses and anchorage zone complies with ACI 318-63 [Reference 3.3-2].

The review to identify the applicable aging effects for components of the post-tensioning system considers the following potential aging effects which have been identified by reviewing industry literature:

- Loss of material due to general corrosion;
- Cracking due to fatigue or stress corrosion cracking; and
- Change in material properties due to elevated temperature or irradiation embrittlement.

Consistent with the process described in Section 3.2, the applicable aging effects are determined by reviewing the materials of construction and ambient environment. Section 3.3.4.1 describes the ambient environments to which the Reactor Building (Containment) post-tensioning system are exposed at Oconee. Sections 3.3.4.2 through 3.3.4.5 describe the results when the process is applied to the Reactor Building (Containment) post-tensioning system at Oconee. The results are summarized in Table 3.3-1.

3.3.4.1 Environment

The Oconee Containment design incorporates a post-tensioning system that provides prestress forces to counteract forces resulting from the design loads. The post-tensioning system components are not exposed to the external atmosphere environment with the exception of the tendon end caps not enclosed by adjacent buildings. The anchorage system on the bottom of the vertical tendons is exposed to the moist environment of the tendon gallery. The tendon wires are encased in bulkfill grease. The tendon anchorages are enclosed in sealed end caps. [Footnote 9]

3.3.4.2 Loss of Material Assessment

The aging effect that could potentially result in loss of the ability of the post-tensioning system to impose compressive forces on the concrete containment structure is loss of material due to corrosion [Reference 3.3-4]. The effects of corrosion must be considered for both the tendon wires within the grease-filled conduits and for the anchorage providing the tendon wire terminations. Stressed components of the post-tensioning system are normally well protected against corrosion. The tendon and the anchorage are enclosed within the ducts and end caps that are filled with bulkfill grease. Potential grease leakage could occur and would be most likely at the tendon anchorage [Reference 3.3-4]. Loss of material due to corrosion may be an applicable aging effect for the tendon anchorage if the grease is not maintained.

Although the vertical tendon bottom anchorage is exposed to the moist environment of the tendon gallery, the end caps are coated for corrosion protection, the anchorage is encased in grease, and they are not in direct contact with water. Oconee experience has not identified any corrosion of the bottom anchorage of the vertical tendons. [Footnote 10]

The results of these evaluations are provided in the following paragraphs and summarized in Table 3.3-1.

3.3.4.3 Industry Experience

In order to validate the set of applicable aging effects considered, and to assure no additional aging effects exist beyond those discussed herein, a survey of industry experience was performed. This survey included NRC generic communications, licensee

9. This paragraph has been revised to supplement the initial Duke response to RAI 2.3-3 which was provided by Duke letter dated January 14, 1998. The initial Duke response to RAI 2.3-3 was discussed during a meeting with the NRC staff on April 29, 1998.

10. This section has been revised to supplement the initial Duke response to RAI 2.3-3 which was provided by Duke letter dated January 14, 1998. The initial Duke response to RAI 2.3-3 was discussed during a meeting with the NRC staff on April 29, 1998.

event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following documents were identified during this survey:

- NUREG/CR-4652, *Concrete Component Aging and its Significance Relative to Life Extension of Nuclear Power Plants*
- NUREG/CR-6424, *Report on Aging of Nuclear Power Plant Reinforced Concrete Structures*
- LERs associated with changes in liftoff force and corrosion
- IN 85-10, "Post-Tensioned Containment Tendon Anchor Head Failure"
- IN 91-80, "Failure of Anchor Head Threads on Post-Tensioning System during Surveillance Inspection"
- NUREG-1557, *Summary of Technical Information and Agreements from Nuclear Management and Resources Council Industry Reports Addressing License Renewal*

The documents identified tendon loss of prestress and corrosion as applicable aging effects. Loss of prestress is a time-limited aging analysis and is evaluated in Section 5.3 of OLRP-1001. Of the over 30 million tendons used throughout the western world (to 1978), the number of corrosion incidents (200 in completed permanent structures) is small. All of the corrosion-related incidents were related to either ill-conceived detailing, poor construction, or contaminants causing corrosive environments [Reference 3.3-9].

3.3.4.4 Oconee Operating Experience

In addition to the review of industry experience, Oconee operating experience and previous Reactor Building Tendon Surveillances were reviewed to validate the applicable aging effects. Minor pitting corrosion on bearing plates (this condition existed at the time of installation and no appreciable deterioration has occurred since installation) and minor grease leakage through the concrete shell and at anchorages have been observed. The corrosion was repaired by an existing maintenance procedure. The grease leakage is being monitored and there exists no evidence to date to show that the bulkfill grease has any detrimental effect on concrete. The NRC staff stated that it has completed its review of this matter and found it to be adequate [Reference 3.3-10]. The examination and testing of sample tendon wires have found no indication of corrosion of the wires.

Oconee experience has not identified any corrosion of the bottom anchorage of the vertical tendons located in the tendon gallery.

3.3.4.5 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. Therefore, loss of material due to corrosion was determined to be an applicable aging effect for the period of extended operation for the tendon anchorage if the grease is not maintained. Material loss at the tendon anchorage can ultimately lead to tendon failure if the corrosion progresses to the point of cracking of the tendon anchorage. This aging effect needs to be managed for the period of extended operation because it could, if not managed, result in an adverse impact on one or more of the intended functions listed in Table 2.3-1.

Loss of prestress is a time-limited aging analysis and is evaluated in Chapter 5.3 of OLRP-1001.

Loss of material due to corrosion of the tendon anchorage will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Containment Inservice Inspection Program

3.3.5 References for Section 3.3

3.3-1. *Oconee Nuclear Station, Updated Final Safety Analysis Report,* as revised.

3.3-2. ACI 318-63, *Building Code Requirements for Reinforced Concrete*, American Concrete Institute, Detroit, Michigan.

3.3-3. ACI 301, *Specifications for Structural Concrete for Buildings,* American Concrete Institute, Detroit, Michigan.

3.3-4. NUMARC Report Number 90-01, *Pressurized Water Reactor Containment Structure License Renewal Report,* Nuclear Management and Resource Council, Revision 1, September 1991.

3.3-5. ACI 201.1R-92, *Guide for Making a Condition Survey of Concrete in Service,* American Concrete Institute, Detroit, Michigan.

3.3-6. ACI 209R-82, *Prediction of Creep, Shrinkage, and Temperature Effects in Concrete Structures,* American Concrete Institute, Detroit, Michigan.

3.3-7 . *Transcript from the United States of America Nuclear Regulatory Commission Briefing on Containment Degradation,* Wednesday, October 16, 1996.

3.3-8. *Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings,* American Institute of Steel Construction, 1963.

3.3-9. NUREG/CR-4652, ORNL/TM-10059, *Concrete Component Aging and its Significance to Life Extension of Nuclear Power Plants,* Oak Ridge National Laboratory, Oak Ridge, TN, September 1986.

3.3-10. D. E. LaBarge (NRC) letter dated November 7, 1996 to J. W. Hampton (Duke), Reactor Building Post-Tensioning System Sixth Surveillance - Oconee Nuclear Station, Unit 3 (TAC NO. M93942).

Table 3.3-1 Applicable Aging Effects for Reactor Building (Containment) Components

Component	Applicable Aging Effect(s)	Aging Management Programs
Concrete		
Cylinder Wall Dome Floor Foundation Slab	Cracking Change in material properties due to leaching	Containment Inservice Inspection Plan • Examination Category L-A *Concrete*
Steel		
Anchorage/Embedments/ Attachments Electrical Penetrations Emergency Personnel Hatch Equipment Hatch Fuel Transfer Tubes Liner Plate Mechanical Penetrations Personnel Hatch	Loss of material due to corrosion • for the liner, hatches, and penetrations if the coatings are not maintained; • for the liner below the concrete floor if the expansion joint sealants are not maintained; and • for the liner behind welded attachments if the cavity formed between the attachment and the liner is not sealed	Coatings Program Containment Inservice Inspection Plan • Examination Category E-A *Containment Surfaces*, • Examination Category E-C *Containment Surfaces Requiring Augmented Examination*, • Examination Category E-D *Seals, Gaskets, and Moisture Barriers*, • Examination Category E-G *Pressure Retaining Bolting*, and • Examination Category E-P *All Pressure Retaining Components*. Welds within the scope of Examination Categories E-B *Pressure Retaining Welds* and E-F *Pressure Retaining Dissimilar Metal Welds* will be examined within the scope of the Examination Category E-A examination. Containment Leak Rate Testing Program

Table 3.3-1 Applicable Aging Effects for Reactor Building (Containment) Components (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Post-Tensioning System		
Tendon Anchorage Tendon Wires	Loss of material at tendon anchorage	Containment Inservice Inspection Plan • Examination Category L-B *Unbonded Post-Tensioning System*

3.4 AGING EFFECTS FOR REACTOR COOLANT SYSTEM COMPONENTS & CLASS 1 COMPONENT SUPPORTS

3.4.1 DESCRIPTION OF THE PROCESS TO IDENTIFY THE APPLICABLE AGING EFFECTS FOR REACTOR COOLANT SYSTEM COMPONENTS & CLASS 1 COMPONENT SUPPORTS

Reactor Coolant System components and Class 1 component supports within the scope of license renewal that require aging management review are identified in Section 2.4. Their intended functions are identified in Section 2.4. Mechanical and structural components of the Reactor Coolant System include:

- Reactor Coolant System Piping
- Pressurizer
- Reactor Vessel
- Reactor Vessel Internals
- Once Through Steam Generators
- Reactor Coolant Pumps
- Control Rod Drive Motor Tube Housings
- Letdown Coolers
- Class 1 Component Supports

Duke actively participated in a B&W Owners Group (B&WOG) effort that developed a series of topical reports whose purpose was to demonstrate that the aging effects for Reactor Coolant System components are adequately managed for the period of extended operation under a renewed license. The following is a list of the B&WOG topical reports applicable to the Oconee Reactor Coolant System that have been submitted to the NRC:

- BAW-2243A , Reactor Coolant System Piping [Reference 3.4-1] (submitted and approved by the NRC)

- BAW-2244A, Pressurizer [Reference 3.4-2] (submitted and approved by NRC)

- BAW-2251, Reactor Vessel [Reference 3.4-3] (submitted, under review by the NRC as of June 1998)

- BAW-2248, Reactor Vessel Internals [Reference 3.4-4] (submitted, under review by the NRC as of June 1998)

NRC-approved reports may be incorporated by reference provided the conditions of approval contained in the safety evaluation of the specific report are met. Time-limited aging analyses associated with components of the Oconee Reactor Coolant System are discussed in Section 5.4 of OLRP-1001.

The process to determine the aging effects applicable to Reactor Coolant System components begins with an understanding of the potential aging effects defined in industry literature. From this set of potential aging effects, the component materials, operating environment and operating stresses serve to define the applicable aging effects for each component that is subject to aging management review. These applicable aging effects are then validated by a review of industry and Oconee operating experience to provide reasonable assurance that the full set of applicable aging effects are established for the aging management review. This process is more fully described in Section 3.2 of OLRP-1001.

The review to identify the applicable aging effects for Reactor Coolant System components considers the following potential aging effects which have been identified by reviewing available industry literature:

- Loss of material
- Cracking (initiation and growth)—Cracking due to fatigue is a TLAA and is addressed in Chapter 5.
- Reduction of fracture toughness—Reduction of fracture toughness of the reactor vessel beltline region due to neutron embrittlement is a TLAA and is addressed in Chapter 5.
- Loss of mechanical closure integrity of bolted closures

The determination of aging effects that are applicable to Oconee considers the materials, environment, and stresses associated with the design of Oconee. The applicable aging effects for each of the Reactor Coolant System components are discussed in the following sections.

3.4.2 Process to Incorporate Approved B&WOG Topicals Reports by Reference

Duke used the following process to incorporate approved B&WOG Topical Reports by reference into OLRP-1001 as well as those B&WOG Topical Reports that have been submitted and are still under review by the staff:

(1) **Comparison of the component intended functions for the Reactor Coolant System components under review.** The Oconee-specific component screening review first identifies the component intended functions and then compares these functions to those identified in the generic B&WOG Topical Reports. Differences are noted and justification for the variances are provided.

(2) **Identification of the items that are subject to aging management review.** Oconee drawings and pertinent design and field change data are reviewed. The process establishes the full extent to which the scope of the generic B&WOG Topical Reports bound the Oconee Reactor Coolant System components.

(3) **Identification of the applicable aging effects**. An independent assessment of the applicable aging effects is performed by reviewing plant operating environment, operating stresses (qualitative), and Oconee-specific operating experience. This assessment serves to validate aging effects identified in the generic B&WOG Topical Reports. Aging effects for items that Duke determined to be subject to aging management review that were not included in the B&WOG Topical Reports are evaluated in this chapter.

The results of performing Steps (1) and (2) are provided in Section 2.4 of OLRP-1001, while the results of performing Step (3) are provided in Section 3.4 of OLRP-1001.

3.4.3 Reactor Coolant System Piping

Reactor Coolant System piping subject to aging management review is identified in Section 2.4.3 of OLRP-1001. As an aid to the reader, Reactor Coolant System piping items subject to aging management review are repeated here and include:

- Piping (including fittings, branch connections, safe ends, and thermal sleeves)
- Valve Bodies (pressure retaining parts of Reactor Coolant System isolation/boundary valves)
- Bolted Closures

As described in Section 2.4.3 of OLRP-1001, the Oconee plants are bounded by BAW-2243A with regard to scope of Reactor Coolant System piping and associated materials of construction. The approach for identifying applicable aging effects for the Reactor Coolant System piping is described in Section 3.4.1 of OLRP-1001.

3.4.3.1 Environment and Stress

The operating environment of the Oconee Reactor Coolant System piping is consistent with that described in BAW-2243A [Reference 3.4-1, Section 3.1.1]. The Oconee *Chemistry Control Program* includes specifications to periodically monitor the quality of the primary coolant. Limitations are established on dissolved oxygen, halides and other impurities. Corrective actions are taken in the event the primary coolant parameters are out of specification. The Oconee Reactor Coolant System chemistry is maintained in accordance with the Oconee *Chemistry Control Program.* [Footnote 11]

Reactor Coolant System piping is designed to accommodate all service loadings (i.e., Levels A through D); however, operation under Level A and B Service Conditions contribute to the normal aging stresses for the piping. The Oconee units have not been subjected to a Level C or D event. Therefore, the Oconee Reactor Coolant System piping is bounded by BAW-2243A with respect to the qualitative assessment of stress.

11. The Oconee Chemistry Control Program is described in Section 4.6 of OLRP-1001.

3.4.3.2 Applicable Aging Effects

The aging effects applicable to the Oconee Reactor Coolant System piping are consistent with those described in BAW-2243A [Reference 3.4-1, Chapter 3] since Oconee is bounded by the generic report with respect to materials of construction, operating environment, Level A and B service conditions, and operating experience. The results of the aging effects review are contained in BAW-2243A, which include the NRC approval letter [Reference 3.4-5]. The applicable aging effects for the Reactor Coolant System piping are summarized in Table 3.4-1.

3.4.3.3 Industry Experience

The industry experience for Reactor Coolant System piping is described in BAW-2243A [Reference 3.4-1, Chapter 3].

3.4.3.4 Oconee Operating Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects. The review of Oconee experience identified two recent leaks associated with Oconee Reactor Coolant System piping. The first leak occurred on April 21, 1997, on Oconee Unit 2. The cause of the leak was a crack in the weld connecting the piping to the nozzle safe-end on one of the two normal high pressure injection lines in the High Pressure Injection System. The cause was judged to be cracking due to thermal fatigue.

A second leak occurred on January 27, 1998, on Oconee Unit 1. A crack developed in a 1 inch NPS weld in a drain line off of the pressurizer surge line. The root cause of this leak was determined to have been a combination of stress corrosion cracking that developed on the external weld surface coupled with a mechanical vibration that drove the crack through-wall. Even though a synergistic combination of environmental conditions seems to have caused this leak, the piping data taken from the root cause investigation are of value here. During the investigation of the leak, destructive examination and internal surface examinations of the small-bore drain line piping showed no evidence of inside diameter-initiated cracking.

In addition, information from operating experience indicates that there are additional elements of bolting maintenance procedures that should be considered, such as personnel training, installation and maintenance procedures, plant-specific bolting degradation history, and corrective measures. The NRC captured the lessons from this experience in IE Bulletin 82-02 [Reference 3.4-6] and directed each licensee to assure that these lessons were being incorporated at their plant. In response to IE Bulletin 82-02 [References 3.4-7, 3.4-8, 3.4-9, and 3.4-10], Duke provided the results of the in-house investigation and provided assurance that bolting maintenance practices did indeed consider these lessons learned. In summary, routine maintenance practices has included use of properly trained personnel and procedural guidance to construct bolted closures. Additionally, as reported in the Duke responses, some of the Oconee Reactor Coolant System bolting that was inspected was found in a degraded condition and bolting was repaired or replaced as a part of this investigation. Along with Technical Specification Leakage Limits, ASME Section XI bolting examination (Examination Categories B-G-1 and B-G-2), the Boric Acid Wastage Surveillance Program and continuation of routine Oconee maintenance practices reviewed under IE Bulletin 82-02 will assure aging management of mechanical closure integrity for bolted closures in the Reactor Coolant System.

3.4.3.5 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. The applicable aging effects for the Reactor Coolant System piping are summarized in Table 3.4-1. These aging effects must be adequately managed so that the intended functions listed in Table 2.4-4 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be adequately managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Boric Acid Wastage Surveillance Program
- Chemistry Control Program
- Inservice Inspection Plan (supplemented by the CASS Flaw Evaluation Procedure described in Chapter 4)
- Program to Inspect High Pressure Injection Connections to the Reactor Coolant System
- Reactor Coolant System Operational Leakage Monitoring

In addition to the above, the following new activities have been identified for license renewal which are described in Section 4.3 of OLRP-1001:

- Alloy 600 Aging Management Program
- Small Bore Piping Inspection

3.4.4 Pressurizer

The pressurizer is identified in Section 2.4.4 of OLRP-1001. As an aid to the reader, pressurizer items subject to aging management review are repeated here and include:

- Pressurizer Vessel
- Nozzles
- Other Pressure Retaining Items
- Bolted Closures
- Integral Attachments
- Internal Spray Piping and Spray Head

As described in Section 2.4.4 of OLRP-1001, the Oconee plants are bounded by the B&WOG Topical Report with regard to scope of pressurizer items within the first five groups defined above. Internal spray piping and the pressurizer spray head were not within the scope of BAW-2244A; however, they are within the scope of license renewal and subject to aging management review for Oconee. The approach for identifying the applicable aging effects on the pressurizer is described in Section 3.4.1 of OLRP-1001.

3.4.4.1 Environment and Stress

The operating environment of the Oconee pressurizer is consistent with that described in BAW-2244A [Reference 3.4-2, Chapter 4]. The Oconee *Chemistry Control Program* includes specifications to periodically monitor the quality of the primary coolant. Limitations are established on dissolved oxygen, halides and other impurities. Corrective actions are taken in the event the primary coolant parameters are out of specification. Oconee Reactor Coolant System chemistry is maintained in accordance with the Oconee *Chemistry Control Program.* [Footnote 12]

The pressurizer is designed to accommodate all service loadings (i.e., Levels A through D); however, operation under Level A and B Service Conditions contribute to the normal aging stresses for the pressurizer. The Oconee units have not been subjected to a Level C or D event. Therefore, the Oconee pressurizers are bounded by BAW-2244A with respect to the qualitative assessment of stress.

12. The Oconee Chemistry Control Program is described in Chapter 4 of OLRP-1001.

3.4.4.2 Applicable Aging Effects

The applicable aging effects of the Oconee pressurizer are consistent with those described in BAW-2244A [Reference 3.4-2, Chapter 3]. The results of the aging effects review are contained in BAW-2244A [Reference 3.4-2] which includes the NRC approval letter [Reference 3.4-11]. The applicable aging effects for the pressurizer are summarized in Table 3.4-1.

The internal spray line is constructed from austenitic stainless steel and its applicable aging effect is cracking due to fatigue. The spray head is constructed from cast austenitic stainless steel and its applicable aging effect is cracking due to either thermal fatigue or reduction of fracture toughness. These aging effects for the spray line and spray head are consistent with those previously identified for piping in Section 3.4.3.2.

3.4.4.3 Industry Experience

The industry experience for the pressurizer is described in BAW-2244A [Reference 3.4-2, Chapter 3].

3.4.4.4 Oconee Operating Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for the pressurizer. This review included a survey of documented instances of pressurizer aging along with interviews with responsible engineering personnel. From this review, no applicable aging effects were identified beyond those identified in this section.

3.4.4.5 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. The applicable aging effects for the pressurizer are summarized in Table 3.4-1. These aging effects must be adequately managed so that the intended functions listed in Table 2.4-4 will be maintained consistent with the current licensing basis for the period of extended operation.

The applicable aging effects will be adequately managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Boric Acid Wastage Surveillance Program
- Chemistry Control Program
- Inservice Inspection Plan
- Reactor Coolant System Operational Leakage Monitoring

In addition to the above, the following new activities have been identified for license renewal which are described in Section 4.3 of OLRP-1001:

- Alloy 600 Aging Management Program
- Pressurizer Examinations
- Small Bore Piping Inspection

3.4.5 Reactor Vessel

The reactor vessel is identified in Section 2.4.5 of OLRP-1001. As an aid to the reader, reactor vessel items subject to aging management review are repeated here and include:

- Shell and Closure Head
- Nozzles
- Interior Attachments
- Bolted Closures

As described in Section 2.4.5 of OLRP-1001, the Oconee plants are bounded by BAW-2251 with regard to scope of reactor vessel items and associated materials of construction. The approach for identifying the applicable aging effects on the reactor vessel is described in Section 3.4.1.

3.4.5.1 Environment and Stress

The operating environment of the Oconee reactor vessel is consistent with that described in BAW-2251 [Reference 3.4-3, Chapter 3]. The Oconee *Chemistry Control Program* includes specifications to periodically monitor the quality of the primary coolant. Limitations are established on dissolved oxygen, halides and other impurities. Corrective actions are taken in the event the primary coolant parameters are out of specification. Oconee Reactor Coolant System chemistry is maintained in accordance with the Oconee *Chemistry Control Program.* [Footnote 13]

The reactor vessel is designed to accommodate all service loadings (i.e., Levels A through D); however, operation under Level A and B Service Conditions contribute to the normal aging stresses for the reactor vessel. The Oconee units have not been subjected to a Level C or D event. Therefore, the Oconee reactor vessels are bounded by BAW-2251 with respect to the qualitative assessment of stress.

3.4.5.2 Applicable Aging Effects

The aging effects applicable to the Oconee reactor vessel are consistent with those described in BAW-2251 since Oconee is bounded by the generic report with respect to materials of construction, operating environment, Level A and B Service Conditions, and operating experience. The applicable aging effects for the reactor vessel are summarized in Table 3.4-1.

13. The Oconee Chemistry Control Program is described in Section 4.6 of OLRP-1001.

3.4.5.3 Industry Experience

The industry experience for the reactor vessel is described in BAW-2251 [Reference 3.4-3, Chapter 3].

3.4.5.4 Oconee Operating Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for the reactor vessel. This review included a survey of documented instances of reactor vessel aging along with interviews with responsible engineering personnel. From this review, no applicable aging effects were identified beyond those identified in this section.

3.4.5.5 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. The applicable aging effects for the reactor vessel are summarized in Table 3.4-1. These aging effects must be adequately managed so that the intended functions listed in Table 2.4-4 will be maintained consistent with the current licensing basis for the period of extended operation.

The applicable aging effects will be adequately managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Chemistry Control Program
- CRDM Nozzle and Other Vessel Closure Penetrations Inspection Program
- Inservice Inspection Plan
- Reactor Coolant System Operational Leakage Monitoring
- Reactor Vessel Integrity Program

In addition to the above, the following new program has been identified for license renewal which is described in Section 4.3 of OLRP-1001:

- Alloy 600 Aging Management Program

3.4.6 Reactor Vessel Internals

The reactor vessel internals are identified in Section 2.4.6 of OLRP-1001. As an aid to the reader, reactor vessel internals assemblies subject to aging management review are repeated here and include:

- Plenum Assembly
- Core Support Shield Assembly
- Core Barrel Assembly
- Lower Internals Assembly
- Thermal Shield and Thermal Shield Restraint

As described in Section 2.4.6 of OLRP-1001, the Oconee plants are bounded by BAW-2248 with regard to scope of reactor vessel internals items within the first four groups defined above. The thermal shield and thermal shield upper restraint are not within the scope of BAW-2248 but are within the scope of license renewal and subject to aging management review for Oconee.

The approach for identifying the applicable aging effects on the reactor vessel internals is described in Section 3.4.1.

3.4.6.1 Environment and Stress

The operating environment, or chemistry of the fluid in contact with the Oconee reactor vessel internals, is maintained consistent with that described in BAW-2248 [Reference 3.4-4, Chapter 4]. The Oconee *Chemistry Control Program* includes specifications to periodically monitor the quality of the primary coolant. Limitations are established on dissolved oxygen, halides and other impurities. Corrective actions are taken in the event the primary coolant parameters are out of specification. Oconee Reactor Coolant System chemistry is maintained in accordance with the Oconee *Chemistry Control Program.* [Footnote 14]

The reactor vessel internals are designed to accommodate all service loadings (i.e., Levels A through D); however, operation under Level A and B Service Conditions contribute to the normal aging stresses for the reactor vessel internals. The Oconee units have not been subjected to a Level C or D event. Therefore, the Oconee reactor vessel internals are bounded by BAW-2248 with respect to the qualitative assessment of stress.

14. The Oconee Chemistry Control Program is described in Chapter 4 of OLRP-1001.

3.4.6.2 Applicable Aging Effects

The applicable aging effects of the Oconee reactor vessel internals are consistent with those described in BAW-2248 [Reference 3.4-4, Chapter 3]. The results of the aging effects review are contained in BAW-2248 [Reference 3.4-4], which is currently under NRC staff review. The thermal shield which surrounds the core barrel and the thermal shield restraint are constructed from austenitic stainless steel. The applicable aging effects are the same as those for the core barrel assembly: cracking and reduction of fracture toughness.

The applicable aging effects for the reactor vessel internals are summarized in Table 3.4-1.

3.4.6.3 Industry Experience

The industry experience for the reactor vessel internals is described in BAW-2248 [Reference 3.4-4, Chapter 3]. Subsequent to the issuance of BAW-2248, NRC issued Information Notice 98-11 on March 25, 1998. Information Notice 98-11 concerns cracking of reactor vessel internal baffle former bolts found at several foreign pressurized water reactors and includes, among other information, a brief discussion of the current and planned activities of the B&W Owners Group to address the potential for cracking of baffle bolts in domestic B&W plants.

3.4.6.4 Oconee Operating Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for reactor vessel internals. This review included a survey of documented instances of reactor vessel internals aging along with interviews with responsible engineering personnel. One additional aging effect was identified through this review: loss of material by wear of the round bars (i.e., LOCA lugs).

3.4.6.5 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. The applicable aging effects for the reactor vessel internals are summarized in Table 3.4-1. These aging effects must be adequately managed so that the intended functions listed in Table 2.4-4 will be maintained consistent with the current licensing basis of the period of extended operation.

The applicable aging effects will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inservice Inspection Plan

In addition to the above, the following new program has been identified for license renewal which is described in Section 4.3 of OLRP-1001:

- Reactor Vessel Internals Aging Management Program

3.4.7 Once Through Steam Generator

The once through steam generator is identified in Section 2.4.7 of OLRP-1001. As an aid to the reader, the once through steam generator items subject to aging management review include:

- Primary Pressure Boundary:
  - hemispherical heads,
  - support skirt transition ring,
  - primary nozzles,
  - Alloy 600 drain nozzle,
  - bolted closures,
  - tubesheets,
  - tubes, plugs, sleeves;
- Secondary Pressure Boundary:
  - shell, tubesheets, and integral attachments,
  - steam nozzles,
  - main feedwater nozzles,
  - emergency feedwater nozzles, instrumentation nozzles, temperature sensing connections,
  - bolted closures.

The following is a description of the aging effects applicable to the once through steam generators. The approach for identifying the applicable aging effects on the once through steam generators is described in Section 3.4.1.

3.4.7.1 Environment and Stress

The Oconee *Chemistry Control Program* includes specifications to periodically monitor the quality of the primary coolant and the secondary coolant. Limitations are established for the primary coolant on dissolved oxygen, halides and other impurities. Limitations are established on specific impurities in the secondary coolant. Oconee primary side chemistry and secondary side chemistry is maintained by the Oconee *Chemistry Control Program.* [Footnote 15]

15. The Oconee Chemistry Control Program is described in Section 4.6 of OLRP-1001.

The once through steam generator is designed to accommodate all service loadings (i.e., Levels A through D); however, operation under Level A and B Service Conditions contribute to the normal aging stresses for the once through steam generator items. The Oconee units have not been subjected to a Level C or D event.

3.4.7.2 Applicable Aging Effects for the Primary Pressure Boundary

Aging effects that may be applicable to the items that support the primary pressure boundary include loss of material, cracking, mechanical distortion of tubes, and loss of mechanical closure integrity. Aging mechanisms that may lead to reduction of fracture toughness of once through steam generator items include various forms of embrittlement (e.g., neutron and thermal). Neutron embrittlement is limited to the direct neutron flux of the reactor vessel beltline region and is not a concern for the once through steam generator. Thermal embrittlement is negligible for all pressurized water reactor materials except cast austenitic stainless steel, and once through steam generators at Oconee have no cast austenitic stainless steel parts.

3.4.7.2.1 LOSS OF MATERIAL ASSESSMENT

Loss of material may be due to intergranular attack, pitting, wear, erosion/corrosion, and wastage, as further discussed in the following paragraphs.

The Alloy 600 steam generator tubes are subject to loss of material due to intergranular attack, pitting, wear, or fretting, and erosion or erosion/corrosion. The plugs and sleeves installed inside the tubes may be made of Alloy 600 or Alloy 690 and are somewhat less susceptible to loss of material.

Intergranular attack of steam generator tubes is characterized by a relatively uniform attack of all grain boundaries over a portion of the tubing surface, leaving it weak and ineffective. Intergranular attack is caused by impurities that concentrate in steam generator secondary side crevices and sludge piles, where boiling occurs and circulation is poor. Once through steam generator tubes are roll expanded over only a portion of the tubesheet thickness. Consequently, a crevice exists between the tubes and the tube bore hole through the tubesheets that provides the opportunity for intergranular attack.

Pitting is a localized corrosion mechanism that produces small holes in the metal. Low fluid velocity or stagnation is usually associated with the development of pitting. Pitting has occurred in once through steam generator tubes.

Fretting and sliding wear of steam generator tubes at tube support locations has occurred in the industry. The forces imposed on the tubes by the secondary fluid cause high frequency vibration of the tubes and interaction with the tube support structures.

Erosion is the loss of surface metal due to the mechanical action of flowing fluid. Erosion/corrosion is the loss of material due to the combined actions of erosion by the flowing fluid and corrosion of the newly exposed base material by chemicals in the flowing fluid. Once through steam generator tube damage has occurred due to erosion/corrosion near the 14^{th} tube support plate in the three Oconee units.

The external surfaces of the primary pressure boundary components are subject to loss of material due to boric acid wastage. The leakage of primary coolant through adjacent bolted closures, and the subsequent evaporation and re-wetting cycles, could lead to the presence of a boric acid slurry on the bolting and external surfaces of the clad vessel. These alternate wetting and drying cycles could cause loss of material of the external surfaces.

Therefore, loss of material is an applicable aging effect for the once through steam generators at Oconee.

3.4.7.2.2 CRACKING ASSESSMENT

Because of the consequences of a breach of the primary system pressure boundary, cracking at welded joints is considered an applicable aging effect for items fabricated from carbon steel and low-alloy steel. Duke has not determined, however, that cracking (i.e., initiation) of these items will occur based on a mechanistic review. Welded joints are the more susceptible locations due to the various constituent zones within the joint, resulting in slight variations in residual stresses and mechanical properties Cracking at welded joints is an applicable aging effect for clad low-alloy steel heads, clad low-alloy tubesheets, and clad carbon steel nozzle forgings.. In addition, cracking of the Alloy 600 tubes, plugs, sleeves, and drain nozzle by primary water stress corrosion cracking is an applicable aging effect.

3.4.7.2.3 MECHANICAL DISTORTION ASSESSMENT

Steam generator tubes have been found to suffer a form of distortion called denting. Denting is the mechanical deformation of tubes due to corrosion of the tube support structures. The corrosion product is mostly magnetite. Because magnetite is less dense than the support structure, the corrosion products occupy more volume than the original base metal. As more magnetite forms, it expands into the crevice between the tube and the support structure. Eventually the crevice becomes completely filled and any further corrosion causes the tube to deform or the support structure to fracture. Therefore, mechanical distortion is an applicable aging effect for the once through steam generator tubes at Oconee.

3.4.7.2.4 LOSS OF MECHANICAL CLOSURE INTEGRITY ASSESSMENT

Stress relaxation and corresponding loss of preload may lead to localized leakage of reactor coolant and a loss of mechanical closure integrity. This localized leakage of borated coolant may cause corrosive attack and loss of material bolting, adjacent flange surfaces, and surfaces below the bolted connection leak path. Loss of mechanical closure integrity is directly associated with the condition of the closure bolting and bolting surfaces. Aging effects determined to be relevant for the mechanical closure are cracking, loss of bolt preload due to stress relaxation, and loss of material for low-alloy steel bolting due to boric acid wastage. Loss of mechanical closure integrity is an applicable aging effect for the once through steam generators at Oconee.

3.4.7.3 Applicable Aging Effects for the Secondary Pressure Boundary

Aging effects that may be applicable to the items that support the secondary pressure boundary include loss of material, cracking, and loss of mechanical closure integrity. Reduction of fracture toughness is not an applicable aging effect for the secondary pressure boundary items, as discussed in Section 3.4.7.2.

3.4.7.3.1 LOSS OF MATERIAL ASSESSMENT

The external surfaces of the secondary pressure boundary components are subject to loss of material due to boric acid wastage. The leakage of primary coolant through adjacent bolted closures, and the subsequent evaporation and re-wetting cycles, could lead to the presence of a boric acid slurry on the bolting and external surfaces of the secondary side of the steam generator. These alternate wetting and drying cycles could cause loss of material of the external surfaces.

Erosion is the loss of surface metal due to the mechanical action of flowing fluid. Erosion/corrosion is the loss of material due to the combined actions of erosion by the flowing fluid and corrosion of the newly exposed base material by chemicals in the flowing fluid. The steam nozzles may be affected due to the high fluid velocity through the nozzles. Erosion of secondary manways and handholes may occur as a result of leakage through bolted closures.

Therefore, loss of material is an applicable aging effect for the once through steam generators at Oconee.

3.4.7.3.2 CRACKING ASSESSMENT

As described in Section 3.4.7.2.2, cracking at welded joints of the secondary pressure boundary is considered an applicable aging effect for license renewal. Cracking at welded joints is an applicable aging effect for the once through steam generators at Oconee.

3.4.7.3.3 LOSS OF MECHANICAL CLOSURE INTEGRITY ASSESSMENT

Similar to the discussion above, loss of mechanical closure integrity of secondary manways, handholes, and feedwater pipe flanges may occur and is considered to be an applicable aging effect for license renewal. Therefore, loss of mechanical closure integrity is an applicable aging effect for the once through steam generators at Oconee.

3.4.7.4 Industry Experience

In order to validate the set of applicable aging effects considered, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following documents were identified in this survey:

- Numerous Information Notices
- IE Bulletin 79-13, *Cracking in Feedwater System Piping*
- IE Bulletin 82-02, *Degradation of Threaded Fasteners in the Reactor Coolant Pressure Boundary of PWR Plants*
- IE Bulletin 87-01, *Thinning of Pipe Walls in Nuclear Power Plants*
- GL 79-20, *Information Requested on PWR Feedwater Lines*
- GL 85-02, *Staff Recommended Actions Stemming from NRC Integrated Program for the resolution of Unresolved Safety issues Regarding Steam Generator Tube Integrity*
- GL 88-05, *Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants*
- GL 89-08, *Erosion/Corrosion Induced Pipe Wall Thinning*
- GL 91-17, *Generic Safety Issue 29, Bolting Degradation or Failure in Nuclear Power Plants*
- GL 95-03, *Circumferential Cracking of Steam Generator Tubes*

3.4.7.5 Oconee Operating Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for the once through steam generators. This review included a survey of documented instances of steam generator aging, along with interviews with responsible engineering personnel. From this review, no applicable aging effects were identified beyond those identified in this section.

3.4.7.6 Conclusion

As result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. The applicable aging effects for the once through steam generator are summarized in Table 3.4-1. These aging effects must be adequately managed so that the intended functions listed in Table 2.4-4 will be maintained consistent with the current licensing basis of the period of extended operation.

The applicable aging effects will be adequately managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Boric Acid Wastage Surveillance Program
- Chemistry Control Program
- Inservice Inspection Plan
- Reactor Coolant System Operational Leakage Monitoring
- Steam Generator Tube Surveillance Program

In addition to the above, the following new program has been identified for license renewal which is described in Section 4.3 of OLRP-1001:

- Alloy 600 Aging Management Program

3.4.8 Reactor Coolant Pumps

Reactor coolant pumps are identified in Section 2.4.8 of OLRP-1001. As an aid to the reader, reactor coolant pump items subject to aging management review are repeated here and include:

- Casing
- Cover
- Pressure-Retaining Bolting

The following is a description of the aging effects applicable to the reactor coolant pumps. The approach for identifying the applicable aging effects on the reactor coolant pumps is described in Section 3.4.1 of OLRP-1001.

3.4.8.1 Environment and Stress

The materials and operating environment of the reactor coolant pumps including the bolted closures and connections are similar to that evaluated in the Reactor Coolant System piping reviews (see Section 3.4.3).

3.4.8.2 Applicable Aging Effects

The casings are constructed of cast austenitic stainless steel similar to the valve bodies evaluated in Section 3.4.3. The applicable aging effects for the casing are cracking at welded joints and the reduction of fracture toughness. The applicable aging effect for the cover is reduction of fracture toughness. The bolted closures and connections of the reactor coolant pump casings are made of the same material as Reactor Coolant System piping bolted closures and connections evaluated in Section 3.4.3 and the applicable aging effects are cracking of the bolting material, loss of bolting preload, and loss of ferritic material.

3.4.8.3 Industry Experience

In order to validate the set of applicable aging effects, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following documents were identified in this survey:

- IE Bulletin 82-02, *Degradation of Threaded Fasteners in the Reactor Coolant Pressure Boundary of PWR Plants,*
- GL 88-05, *Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants*.

The results of the review of NRC generic communications for the Reactor Coolant System piping report [Reference 3.4-1] are also applicable to the reactor coolant pump. In addition, these applicable aging effects of the reactor coolant pump casings, covers, and bolted closures and connections are further validated by the reviews performed and documented in the *PWR Reactor Coolant System License Renewal Industry Report* [Reference 3.4-12].

3.4.8.4 Oconee Operating Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for reactor coolant pumps. This review included a survey of documented instances of reactor coolant pump aging along with interviews with responsible engineering personnel. From this review, no applicable aging effects were identified beyond those identified in this section.

3.4.8.5 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. The applicable aging effects for the reactor coolant pumps are consistent with those previously identified for Reactor Coolant System piping (see Section 3.4.3). The applicable aging effects for the reactor coolant pumps are summarized in Table 3.4-1. These aging effects must be adequately managed so that the intended functions listed in Table 2.4-4 will be maintained consistent with the current licensing basis for the period of extended operation.

The applicable aging effects will be adequately managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inservice Inspection Plan (as supplemented by the CASS Flaw Evaluation Procedure described in Chapter 4)

3.4.9 Control Rod Drive Tube Motor Housings

Control rod drive tube motor housings are identified in Section 2.4.9 of OLRP-1001 as being subject to aging management review. The following is a description of the aging effects applicable to the control rod drive tube motor housings. The approach for identifying the applicable aging effects on the control rod drive tube motor housings is described in Section 3.4.1.

3.4.9.1 Environment

The operating environment, or chemistry of the fluid in contact with the control rod drive tube motor housings, is maintained in a manner consistent with other Reactor Coolant System components, as previously described in Section 3.4.5.1. The Oconee *Chemistry Control Program* includes specifications to periodically monitor the quality of the primary coolant. Limitations are established on dissolved oxygen, halides and other impurities. Corrective actions are taken in the event the primary coolant parameters are out of specification. Oconee primary side chemistry and secondary side chemistry is maintained by the Oconee *Chemistry Control Program.* [Footnote 16]

The control rod drive tube motor housings have been designed to accommodate all service loadings (i.e., Levels A through D); however, operation under Level A and B Service Conditions contribute to the normal aging stresses for the control rod drive tube motor housings. The Oconee units have not been subjected to a Level C or D event.

3.4.9.2 Applicable Aging Effects

Applicable aging effects for the control rod drive tube motor housings include cracking at welded joints and loss of mechanical closure integrity. These effects are consistent with those previously identified in Section 3.4.3.2 for Reactor Coolant System piping (see Section 3.4.3.2).

3.4.9.3 Industry Experience

In order to validate the set of applicable aging effects considered, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. No documents related to aging effects of control rod drive tube motor housings were identified.

16. The Oconee Chemistry Control Program is described in Section 4.6 of OLRP-1001.

3.4.9.4 Oconee Operating Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for control rod drive tube motor housings. This review included a survey of documented instances of component aging along with interviews with responsible engineering personnel. From this review, no applicable aging effects were identified beyond those identified in this section.

3.4.9.5 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. The applicable aging effects for the control rod drive tube motor housings are consistent with those previously identified for Reactor Coolant System piping (see Section 3.4.3). The applicable aging effects for the control rod drive tube motor housings are summarized in Table 3.4-1. These aging effects must be adequately managed so that the intended functions listed in Table 2.4-4 will be maintained consistent with the current licensing basis of the period of extended operation.

The applicable aging effects will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Inservice Inspection Plan
- Reactor Coolant System Operational Leakage Monitoring

3.4.10 Letdown Coolers

Letdown coolers are identified in Section 2.4.10 of OLRP-1001 as subject to aging management review. The following is a description of the aging effects applicable to these stainless steel components. The approach for identifying the applicable aging effects on the letdown coolers is described in Section 3.4.1.

3.4.10.1.1 ENVIRONMENT

The Oconee letdown coolers are exposed to three environments. The letdown coolers are located in the Reactor Building, exposing the external surfaces to the Reactor Building Environment. Internally, water from the Reactor Coolant System passes through the tubes and is cooled by the Component Cooling System (treated water) on the shell side. The Oconee Chemistry Control Program includes specifications that periodically monitor the quality of the Reactor Coolant System and Component Cooling System water as described in Section 3.4.4.1. The Chemistry Control Program maintains corrosion inhibitors in the Component Cooling System and monitors certain impurities.

3.4.10.2 Applicable Aging Effect

The applicable aging effects for the Oconee letdown cooler stainless steel tubes include loss of material and cracking. No applicable aging effects were identified for the external surfaces of the letdown coolers exposed to the Reactor Building Environment. The applicable aging effects for the letdown coolers are summarized in Table 3.4-1.

3.4.10.3 Industry Experience

In order to validate the set of applicable aging effects considered, a survey of industry experience was performed. The survey of industry experience included NRC generic communications, licensee event reports form nuclear power plants other than Oconee, and NRC NUREGs. The following documents were identified in this survey:

- CR 76-06, *Stress-Corrosion Cracks in Stagnant, Low Pressure Stainless Piping Containing Boric Acid Solutions at PWR*
- GL 79-20, *Cracking in Feedwater Lines*
- IE Bulletin 79-13, Revisions 0, 1, 2, *Cracking in Feedwater System Piping*
- IE Bulletin 87-01, *Thinning of Pipe Walls in Nuclear Power Plants*
- IN 79-19, *Pipe Cracks in Stagnant Borated Water Systems and PWR Plants*
- IN 81-04, *Cracking in Main Steam Lines*
- IN 82-22, *Failures in Turbine Exhaust Lines*
- IN 84-32, *Auxiliary Feedwater Sparger and Pipe Hanger Damage*
- IN 86-106, *Revisions 0, 1, 2, 3, Feedwater Line Break*

- IN 87-36, *Significant Unexpected Erosion of Feedwater Lines*
- IN 88-17, *Summary of Response to NRC Bulletin 87-01, "Thinning of Pipe Walls in Nuclear Power Plants"*
- IN89-01, *Valve Body Erosion*
- IN 89-53, *Rupture of Extraction Steam Line on High Pressure Turbine*
- IN 91-18, *Revision 1, High-Energy Pipe Failures Caused by Wall Thinning*
- IN 91-28, *Cracking in Feedwater System Piping*
- GL 89-08, *Erosion/Corrosion-Induced Pipe Wall Thinning*
- BL 82-02, *Degradation of Threaded Fasteners in the Reactor Coolant Pressure Boundary of PWR Plants*
- IN 84-18, *Stress-Corrosion Cracking in Pressurized Water Reactors*
- GL 88-05, *Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants*
- IN 91-05, *Intergranular Stress-Corrosion Cracking in Pressurized Water Reactor Safety Injection Accumulator Nozzles*

No additional aging effects were identified from this review beyond those identified in this section.

3.4.10.4 Oconee Operating Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects. The review of Oconee operating experience identified that the Letdown Cooler heat exchanger tubes did experience cracking in the past as a result of improper operation of the coolers. The cooler design parameters were established for both coolers in a parallel configuration to be in operation during normal letdown and when cooling down following a reactor trip. For a number of years, only one cooler was in operation with the other in standby. During this period of time, a reactor trip served to increase flow through the operating cooler causing severe thermal and vibrational stresses on the tubes that eventually caused the tubes to crack. Two of the six letdown coolers have been replaced; the other four have been repaired and operating procedures have been changed to eliminate this practice. Even though this experience was due to off-normal operation, cracking of the heat exchanger tubes was detected and managed. These coolers have not experienced any more cracking of tubes.

No additional aging effects were identified from this review beyond those identified in this section.

3.4.10.5 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. The applicable aging effects for the letdown coolers are summarized in Table 3.4-1. These aging effects must be adequately managed so that the intended functions listed in Table 2.4-4 will be maintained consistent with the current licensing basis of the period of extended operation.

The applicable aging effects will be adequately managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Chemistry Control Program
- Reactor Coolant System Operational Leakage Monitoring

3.4.11 Class 1 Component Supports

Class 1 component supports are identified in Section 2.4.11 of OLRP-1001. As an aid to the reader, Class 1 component supports subject to aging management review are repeated here and include:

- Reactor Coolant System Class 1 Piping Supports
- Pressurizer Supports
- Reactor Vessel Support Skirt
- Control Rod Drive Service Structure
- Once Through Steam Generator Supports
- Reactor Coolant Pump Supports

The following is a description of the aging effects applicable to the Class 1 component supports. The aging effects for anchorage and embedments associated with these supports are addressed in Section 3.7.7 of OLRP-1001. The approach for identifying the applicable aging effects on the Class 1 component supports is described in Section 3.4.1.

3.4.11.1 Environment

The Class 1 component supports are located in the Reactor Building (Containment). The ambient environmental conditions for the Reactor Building are described in Section 3.2.2 of OLRP-1001.

3.4.11.2 Applicable Aging Effects

The surfaces of the Class 1 component supports are subject to loss of material by corrosion or boric acid wastage. The leakage of primary coolant through bolted closures, and the subsequent evaporation and re-wetting cycles, can lead to the presence of a boric acid slurry on the surfaces of the supports. These alternate wetting and drying cycles can cause loss of material of external surfaces where the coating is degraded. At Oconee, exposed surfaces of Class 1 component supports were covered with a protective coating to inhibit loss of material.

In addition, the once through steam generator upper lateral support structure contains Lubrite and this material is subject to change in material properties under the radiation exposure present in the Reactor Building.

3.4.11.3 Industry Experience

In order to validate the set of applicable aging effects, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following documents were identified in this survey:

- GL 88-05, *Boric Acid Corrosion of Carbon Steel reactor Pressure Boundary Components in PWR Plants*
- IE Bulletin 74-03, *Failure for Structural or Seismic Support Bolts on Class 1 Components*
- NUREG/CR-2952, *Preloading of Bolted Connections in Nuclear Reactor Component Supports*
- NUREG-1339, *Resolution of Generic Safety Issue 29: Bolting Degradation or Failure in Nuclear Power Plants*
- NUREG-1509, *Radiation Effects on Reactor Pressure Vessel Supports*

3.4.11.4 Oconee Operating Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for Class 1 component supports. This review included a survey of documented instances of component aging, along with interviews with responsible engineering personnel. From this review, no applicable aging effects were identified beyond those identified in this section.

3.4.11.5 Conclusion

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those discussed in this section have been observed. The applicable aging effects for Class 1 component supports are summarized in Table 3.4-1. These aging effects must be adequately managed so that the intended functions listed in Table 2.4-4 will be maintained consistent with the current licensing basis of the period of extended operation.

The applicable aging effects will be adequately managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Boric Acid Wastage Surveillance Program
- Inservice Inspection Plan
- Inspection Program for Civil Engineering Structures and Components

In addition to the above, the following new activity has been identified for license renewal which is described in Section 4.3 of OLRP-1001:

- OTSG Upper Lateral Support Inspection

3.4.12 References for Section 3.4

3.4-1. BAW-2243A, *Demonstration of the Management of Aging Effects for the Reactor Coolant System Piping*, The B&W Owners Group Generic License Renewal Program, June 1996.

3.4-2. BAW-2244A, *Demonstration of the Management of Aging Effects for the Pressurizer*, The B&W Owners Group Generic License Renewal Program, December 1997.

3.4-3. BAW-2251, *Demonstration of the Management of Aging Effects for the Reactor Vessel*, The B&W Owners Group Generic License Renewal Program, June 1996.

3.4-4. BAW-2248, *Demonstration of the Management of Aging Effects for the Reactor Vessel Internals*, The B&W Owners Group Generic License Renewal Program, July 1997.

3.4-5. D. M. Crutchfield (NRC) letter dated March 21, 1996 to Don Croneberger (BWOG GLRP), Acceptance for Referencing of Topical Report BAW-2243 - *Demonstration of the Management of Aging Effects for the Reactor Coolant System Piping*, Project No. 683.

3.4-6. IE Bulletin 82-02 dated June 2, 1982, *Degradation of Threaded Fasteners in Reactor Coolant Pressure Boundary of PWR Plants*.

3.4-7 William O. Parker, Jr. (Duke) letter dated July 29, 1982 to James P. O'Reilly, (NRC), Oconee Nuclear Station, Response to IE Bulletin 82-02, Docket Nos. 50-269, -270, and -287.

3.4-8. H. B. Tucker (Duke) letter dated November 15, 1982 to James P. O'Reilly, (NRC), Oconee Nuclear Station, Docket Nos. 50-269, -270, and -287.

3.4-9. H. B. Tucker (Duke) letter dated October 11, 1983 to James P. O'Reilly (NRC) Oconee Nuclear Station, Docket No. 50-269.

3.4-10. H. B. Tucker (Duke) letter dated October 11, 1983 to James P. O'Reilly (NRC), Oconee Nuclear Station, Docket No. 50-270.

3.4-11. C. I. Grimes (NRC) letter dated November 26, 1997 to David J. Firth (BWOG GLRP), Clarification in the Final Safety Evaluation Report for BAW-2244, *Demonstration of the Management of Aging Effects for the Pressurizer,* Project No. 683.

3.4-12. NUMARC 90-07-01, *PWR Reactor Coolant System License Renewal Industry Report,* Revision 1, Nuclear Management and Resource Council, May 1992.

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports

Components[1]	Applicable Aging Effect(s)	Aging Management Program / Activity
Low-Alloy Bolting > 2 inches in Diameter: Pressurizer Manway Studs Reactor Vessel Studs Reactor Coolant Pump Bolts	Cracking	Inservice Inspection Plan • Examination Category B-G-1 • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
	Loss of Preload/Closure Integrity	Inservice Inspection Plan • Examination Category B-G-1 • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
	Loss of Material	Boric Acid Wastage Surveillance Program
Low-Alloy Steel Bolting ≤ 2 inches in Diameter: Valve Bolting Pressurizer Heater Bundle Studs OTSG Manway Studs OTSG Inspection Opening Bolting	Cracking	Inservice Inspection Plan • Examination Category B-G-2 • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
	Loss of Preload/Closure Integrity	Inservice Inspection Plan • Examination Category B-G-2 • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
	Loss of Material	Boric Acid Wastage Surveillance Program

(1)-Due to the importance of the Reactor Coolant System components in the radiological line of defense and the consequences of a breach in the pressure boundary, specific component items are listed in Table 3.4-1.

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Stainless Steel Bolting ≤ 2 inches in Diameter: Valves CRDM Holddown Bolts RCP Cover-to-Seal Housing Bolts	Cracking	Inservice Inspection Plan • Examination Category B-G-2 • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
	Loss of Preload/Closure Integrity	Inservice Inspection Plan • Examination Category B-G-2 • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
Carbon Steel and Low-Alloy Items	Loss of Material on External Surfaces	Boric Acid Wastage Surveillance Program
Reactor Coolant System Piping , NPS ≥ 4 inches: Stainless Steel Clad Carbon Steel Piping Stainless Steel Piping	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-F • Examination Category B-J • Examination Category B-P
Hot Leg Flowmeter Assembly	Loss of Material (Carbon Steel) due to potential for cracking of Alloy 82/182 cladding	Chemistry Control Program Alloy 600 Aging Management Program

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Reactor Coolant System Piping, NPS ≥ 4 inches: Stainless Steel Clad Carbon Steel Branch Connections With Alloy 82/182 Weld Build-up	Cracking of Weld Build up and at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-F • Examination Category B-J • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
Reactor Coolant System Piping, 1 inch < NPS < 4 inches: Stainless Steel Piping and Stainless Steel Branch Connections	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-F • Examination Category B-J • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Small Bore Piping Inspections
Reactor Coolant System Piping, 1 inch < NPS < 4 inches: 2½-inch HPI Branch Connections and Safe-Ends With Thermal Sleeves	Displacement or Cracking of HPI/MU Thermal Sleeves	Program to Inspect High Pressure Injection Connections to the Reactor Coolant System

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Reactor Coolant System Piping, 1 inch < NPS < 4 inches: Stainless Steel Clad Carbon Steel Branch Connections With Alloy 600 Safe-Ends	Cracking at or near Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-F • Examination Category B-J • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Small Bore Piping Inspections Alloy 600 Aging Management Program
Reactor Coolant System Piping, 1 inch < NPS < 4 inches: Alloy 600 Branch Connections	Cracking at or Near Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-F • Examination Category B-J • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
Reactor Coolant System Piping, NPS ≤ 1 inch: Stainless Steel Piping Stainless Steel Branch Connections	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Small Bore Piping Inspections

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Reactor Coolant System Piping, NPS ≤ 1 inch: Stainless Steel Clad Carbon Steel Branch Connections With Alloy 600 Safe-Ends	Cracking at or Near Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
Reactor Coolant System Piping, NPS ≤ 1 inch: Alloy 600 Branch Connections	Cracking at or Near Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
Class 1 Reactor Coolant System Boundary/Isolation Valves, NPS ≥ 4 inches: Cast Stainless Steel Valve Bodies and Bonnets	Reduction of Fracture Toughness (CASS)	Chemistry Control Program Inservice Inspection Plan • Examination Category B-M-2 as supplemented by the CASS Flaw Evaluation Procedure • Examination Category B-P
Class 1 Reactor Coolant System Boundary/Isolation Valves, NPS < 4 inches: Cast Stainless Steel Valve Bodies and Bonnets	Reduction of Fracture Toughness (CASS)	Chemistry Control Program Inservice Inspection Plan • Examination Category B-M-2 as supplemented by the CASS Flaw Evaluation Procedure

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Pressurizer Vessel	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-B • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
	Cracking of Cladding	Pressurizer Examinations
Pressurizer, Full Penetration Welded Nozzles, NPS > 1 inch	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-D • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
Pressurizer, Safe Ends of Full Penetration Welded Nozzles, NPS > 1 inch	Cracking at or Near Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-F • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Pressurizer, Full Penetration Welded Nozzles, NPS < 1 inch	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Small Bore Piping Inspections
Pressurizer, Pressure Retaining Partial Penetration Welds	Cracking at or Near Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-E • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
Pressurizer, Pressure Retaining Dissimilar Metal Welds in Nozzles, NPS ≥ 4 inches	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-F • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Pressurizer, Pressure Retaining Dissimilar Metal Welds in Nozzles, 1 inch < NPS < 4 inches	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-F • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
Pressurizer, Pressure Retaining Dissimilar Metal Welds in Nozzles, NPS ≤ 1 inch	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
Pressurizer, Manway Forging (Oconee 3)	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-P • Bounded by examination of nozzles per Examination Category B-D Reactor Coolant System Operational Leakage Monitoring

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Pressurizer, Heater Bundle Diaphragm Plates	Cracking at or Near Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
Pressurizer, Immersion Heaters (Sheaths, End Plugs, and Welds)	Cracking	Chemistry Control Program Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Pressurizer Examinations
Pressurizer, Heater Sleeves (Oconee 1)	Cracking at or Near Welded Joints	Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
Pressurizer Integral Attachments	Cracking at Welded Joints	Inservice Inspection Plan • Examination Category B-H
Pressuirzer Internal Spray Line	Cracking at Welded Joints	Pressurizer Examinations
Pressuirzer Spray Head	Cracking	Pressurizer Examinations

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Reactor Vessel Shell and Closure Head	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-A
	Loss of Material (Internals Support Shelf)	Inservice Inspection Plan • Examination Category B-N-1
	Reduction of Fracture Toughness	Reactor Vessel Integrity Program
	Cracking of 508 Forgings due to intergranular separation	Time-limited aging analysis - See Section 5.4 of OLRP-1001.
Reactor Vessel Nozzles	Cracking at Welded Joints Cracking at Nozzle Inside Radius	Chemistry Control Program Inservice Inspection Plan • Examination Category B-D
Reactor Vessel Dissimilar Metal Welds in Nozzles, NPS ≥ 4 inches	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-F Alloy 600 Aging Management Program

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Reactor Vessel, Pressure Retaining Partial Penetration Welded Nozzles CRDM Nozzles Thermocouple Nozzles (Oconee 1) Incore Instrumentation Nozzles	Cracking at or Near Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-E • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring CRDM Nozzle and Other Vessel Closure Penetrations Inspection Program (CRDM Nozzles and Thermocouples only) Alloy 600 Aging Management Program (Incore Instrumentation Nozzles)
Reactor Vessel, Pressure Retaining Dissimilar Metal Welds in Nozzles, 1 inch < NPS < 4 inches	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-O • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring CRDM Nozzle and Other Vessel Closure Penetrations Inspection Program

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Reactor Vessel, Pressure Retaining Dissimilar Metal Welds in Nozzles, NPS ≤ 1 inch Thermocouple nozzle-to-flange	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring CRDM Nozzle and Other Vessel Closure Penetrations Inspection Program
Reactor Vessel Interior Attachment, Core Guide Lugs	Cracking at or Near Attachment Welds	Inservice Inspection Plan • Examination Category B-N-2
Reactor Vessel Bolted Closures, Pressure Retaining Seating Surfaces	Loss of Material	Inservice Inspection Plan • Examination Category B-G-1 • Examination Category B-N-2 • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
Reactor Vessel Internals	Loss of Material	Inservice Inspection Plan • Examination Category B-N-3 •
	Cracking of Base Metal, Welds, Bolting	Inservice Inspection Plan • Examination Category B-N-3 Reactor Vessel Internals Aging Management Program
	Reduction of Fracture Toughness of Base Metal, Welds, Bolting	Inservice Inspection Plan • Examination Category B-N-3 Reactor Vessel Internals Aging Management Program

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Reactor Vessel Internals (Continued)	Loss of Closure Integrity	Inservice Inspection Plan • Examination Category B-N-3 Reactor Vessel Internals Aging Management Program
	Reduction of Fracture Toughness (Oconee 3 Cast Stainless Steel Outlet Nozzles)	Inservice Inspection Plan • Examination Category B-N-3 as supplemented by the CASS Flaw Evaluation Procedure
OTSG Hemispherical Heads	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-B • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
OTSG Support Skirt Transition Ring (Oconee Units 1 and 2)	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-H
OTSG Primary Nozzles	Cracking at Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-D • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
OTSG Alloy 600 Drain Nozzles	Cracking at or Near Welded Joints	Chemistry Control Program Inservice Inspection Plan • Examination Category B-E • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Alloy 600 Aging Management Program
OTSG Primary Manways and Inspection Openings	Cracking at Welded Joints Loss of Mechanical Closure Integrity	Inservice Inspection Plan • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
OTSG Tubesheets (Primary)	Cracking at Welded Joints	Inservice Inspection Plan • Examination Category B-B • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
OTSG Tubes, Plugs, and Sleeves	Cracking Loss of Material Mechanical Distortion	Inservice Inspection Plan • Examination Category B-Q • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring Steam Generator Tube Surveillance Program

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
OTSG Shell, Tubesheets, Integral Attachments (Secondary)	Cracking at Welded Joints	Inservice Inspection Plan • Examination Category C-A • Examination Category C-C • Examination Category C-H
	Loss of Material (external surfaces)	Inservice Inspection Plan • Examination Category C-H Boric Acid Wastage Surveillance Program
OTSG Steam Nozzles, Main Feedwater Nozzles, Auxiliary Feedwater Nozzles, Instrumentation Nozzles, Temperature Sensing Connections	Cracking at Welded Joints	Inservice Inspection Plan • Examination Category C-B • Examination Category C-H
OTSG Secondary Manways and Handholes	Cracking at Welded Joints Loss of Mechanical Closure Integrity	Inservice Inspection Plan • Examination Category C-H
Reactor Coolant Pump Casing	Cracking at Welded Joints	Inservice Inspection Plan • Examination Category B-L-1 • Examination Category B-L-2 • Examination Category B-P
	Reduction of Fracture Toughness (Cast Austenitic Stainless Steel)	Inservice Inspection Plan • Examination Category B-L-1 • Examination Category B-L-2 as supplemented by the CASS Flaw Evaluation Procedure

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Reactor Coolant Pump Cover	Reduction of Fracture Toughness (Cast Austenitic Stainless Steel)	Inservice Inspection Plan • Examination Category B-L-2 as supplemented by the CASS Flaw Evaluation Procedure
Control Rod Drive Motor Tube Housings	Cracking at Welded Joints Loss of Mechanical Closure Integrity	Inservice Inspection Plan • Examination Category B-O • Examination Category B-P Reactor Coolant System Operational Leakage Monitoring
Letdown Cooler Stainless steel tubes	Loss of Material and Cracking	Reactor Coolant System Operational Leakage Monitoring
Reactor Coolant System Piping Supports and LOCA Restraints	Loss of Material	Inservice Inspection Plan • Examination Category F-A Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Pressurizer Support Plate Assemblies	Loss of Material Cracking at Welded Joints	Inservice Inspection Plan • Examination Category B-H Boric Acid Wastage Surveillance Program

Table 3.4-1 Applicable Aging Effects for Reactor Coolant System Components & Class 1 Component Supports (continued)

Components	Applicable Aging Effect(s)	Aging Management Program / Activity
Pressurizer Support Frame Assembly and LOCA Restraint	Loss of Material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Reactor Vessel Support Skirt, Support Flange	Loss of Material	Inservice Inspection Plan • Examination Category F-A Boric Acid Wastage Surveillance Program
Lower Control Rod Drive Service Support Skirt	Loss of Material	Boric Acid Wastage Surveillance Program
OTSG Support Skirt	Loss of Material	Inservice Inspection Plan • Examination Category F-A Boric Acid Wastage Surveillance Program
OTSG Upper Lateral Support Structure	Loss of Material	Boric Acid Wastage Surveillance Program
	Change in Material Properties of Lubrite Pads	OTSG Upper Lateral Support Inspection
Reactor Coolant Pump Motor - Vertical Support Assemblies	None Identified	None Required
Reactor Coolant Pump Motor - Lateral Support Assemblies	Loss of Material	Boric Acid Wastage Surveillance Program

3.5 AGING EFFECTS FOR MECHANICAL SYSTEM COMPONENTS

3.5.1 DESCRIPTION OF THE PROCESS TO IDENTIFY THE APPLICABLE AGING EFFECTS FOR MECHANICAL SYSTEM COMPONENTS

The mechanical system components within the scope of license renewal that require aging management reviews were identified and listed in Section 2.5 along with their intended functions.

The process to identify the aging effects applicable to these mechanical system components begins with an understanding of the potential aging effects defined in industry literature. From this set of potential aging effects, the component materials, operating environment and operating stresses serve to determine the applicable aging effects for each component subject to aging management review. These applicable aging effects are then validated by a review of industry and Oconee operating experience to assure the full set of applicable aging effects are established for the aging management review. This process is described more fully in Section 3.2.

Before applicable aging effects are identified for the mechanical system components, a preprocessing step is taken to the determine the applicable aging effects for groups of similar materials located in the same environment. In Section 3.5.2, the component materials of construction that are identified in Section 2.5 are considered along with the operating environments in order to determine the applicable aging effects.

These applicable aging effects are then identified on a system-by-system basis in Sections 3.5.3 through 3.5.11 for the Oconee mechanical system components within the scope of license renewal. The applicable aging effects for the mechanical system components within Keowee Hydroelectric Station and the Standby Shutdown Facility are identified in Sections 3.5.12 and 3.5.13, respectively. The tables at the end of Section 3.5 provide a system-by-system summary of the applicable aging effects for all mechanical system components subject to aging management review.

3.5.2 Applicable Aging Effects for Mechanical System Components

Applicable aging effects may be determined based upon consideration of the component materials of construction, operating environment, and operating stresses. In many instances, applicable aging effects may be determined irrespective of the specific component type being evaluated. Different component types constructed from the same material, located in the same environment, and operating under similar operating stresses will experience similar aging effects.

The mechanical system components within the scope of license renewal that require aging management reviews can be grouped into seven environments (six internal environments and a set of five external environments) in order to facilitate the identification of the applicable aging effects. The groupings are based on the environments to which the components are primarily exposed. In some instances, portions of a mechanical system may be exposed to one environment and a smaller portion exposed to a second environment. For example, air can occupy the upper portion of a partially filled, fuel oil tank. A brief description of each of the seven operating environments follows:

- The Air/Gas internal operating environment includes systems within the scope of license renewal using dry instrument air and compressed gases such as air, carbon dioxide, hydrogen, halon, and nitrogen.

- The Borated Water internal operating environment includes all systems within the scope of license renewal using borated water.

- The Oil/Fuel Oil internal operating environment includes systems within the scope of license renewal using fuel oil (liquid hydrocarbons used to fuel diesel engines) and lubricating oil (low to medium viscosity hydrocarbons used for bearing, gear, and engine lubricating).

- The Raw Water internal operating environment includes systems within the scope of license renewal using water from Lake Keowee.

- The Treated Water internal operating environment includes all systems within the scope of license renewal using demineralized water, except those using borated water which is also demineralized.

- The Ventilation Air internal operating environment includes filtered and unfiltered ventilation systems within the scope of license renewal.

- The External surface operating environment set includes the Reactor Building environment, Sheltered environment, Yard environment, Underground environment, and Embedded environment.

In the external surface environments, because components of similar materials will age similarly when exposed to the same environment, aging management for the mechanical system component external surfaces can be done on a environment, rather than a system basis. Section 3.5.2.7 contains both the identification of the applicable aging effects for these component external surfaces and the link to the aging management program in Section 4.0 of OLRP-1001.

Before describing the applicable aging effects for mechanical system components, the set of potential aging effects are identified. Potential aging effects are considered applicable if a material is exposed to service conditions that could cause it or the component to lose function during the extended period of operation. The set of mechanical system component potential aging effects are:

- <u>Loss of material</u> may be due to general corrosion, boric acid wastage, galvanic corrosion, crevice corrosion, pitting corrosion, erosion (including erosion caused by abrasive wear, erosive wear, cavitational wear, and droplet impingement wear), erosion/corrosion, microbiologically influenced corrosion, or selective leaching;

- <u>Fouling</u> may be due to macro-organisms, precipitation or silting. Fouling is not a material degradation phenomenon, but is an aging effect which could cause loss of component intended function for a limited set of component geometries in Oconee raw water systems. Fouling is addressed for the Oconee raw water systems in Sections 3.5.6, 3.5.11 and 3.5.12.

- <u>Cracking</u> is service-induced cracking (initiation and growth) of base metal or weld metal due to hydrogen damage, stress corrosion, intergranular attack, or vibration. Many of the mechanical components within the scope of license renewal are designed to USAS B31.7 Class II and Class III, USAS B31.1.0, ASME Section III Subsection ND and ANSI B31.1. For these components, cracking due to low cycle, thermal fatigue is considered to be a time-limited aging analysis and is addressed in Section 5.5.

- <u>Change in material properties</u> is a reduction in fracture toughness due to hydrogen embrittlement, radiation embrittlement, or thermal aging. Change in material properties was considered in all mechanical system components falling within the scope of license renewal. Except for the Reactor Coolant System components, discussed in Section 3.4, change in material properties was not found to be an applicable aging effect for the mechanical system components.

- Distortion which is a physical property change in a component caused by plastic deformation due to the temperature-related phenomenon of creep. Environments within Oconee Nuclear Station are not exposed to the required high temperatures necessary for this mechanism to occur. Therefore, distortion is not considered an applicable aging effect for any of the mechanical system components at Oconee.

Descriptions of the applicable aging effects for the materials of construction found within each of the environments are provided in Sections 3.5.2.1 through 3.5.2.7.

3.5.2.1 Applicable Aging Effects for an Air/Gas Environment

The air/gas internal operating environment includes systems within the scope of license renewal using dry instrument air and compressed gases such as air, carbon dioxide, hydrogen, halon, and nitrogen. The mechanical systems within the scope of license renewal that have components primarily exposed to an air/gas internal operating environment include:

- Breathing Air System
- Containment Hydrogen Control System
- Gaseous Waste Disposal System
- Instrument Air System
- Leak Rate Test System
- Nitrogen Purge and Blanketing System
- Post-Accident Monitoring System
- Carbon Dioxide System (Keowee)
- Depressing Air System (Keowee)
- Governor Air System (Keowee)
- Air Intake and Exhaust System (Standby Shutdown Facility)
- Starting Air System (Standby Shutdown Facility)

The materials of construction for mechanical system components within these systems are identified in Tables 2.5-2 through 2.5-25. The materials and specific air/gas environment combinations for the mechanical system components are carbon steel exposed to air and nitrogen, chrome-molybdenum exposed to air, and stainless steel exposed to air, hydrogen and nitrogen. The applicable aging effects for these material-environment combinations are discussed further in the following paragraphs.

Loss of material due to general corrosion is an applicable aging effect for carbon steel and chrome-molybdenum materials in air environments containing moisture. The plant air environments vary from clean, dry air to moist, unfiltered air whose purity is dictated by the source of the air. Portions of compressed and instrument air systems contain air that has been processed through dryers and filters which provide dry, oil free air to the downstream portions of the system. Moisture is not a concern for these portions of systems and general corrosion would not occur. General corrosion is the result of a chemical or electrochemical reaction between the material and the air environment when both oxygen and moisture are present. General corrosion is characterized by uniform attack resulting in material dissolution and sometimes corrosion product buildup. The stainless steel materials in the plant air environments are resistant to general corrosion.

Loss of material due to pitting corrosion is an applicable aging effect for carbon steel, chrome-molybdenum and stainless steel materials in an air environment containing the presence of concentrated contaminants such as halide ions, and particularly chloride ions. Pitting corrosion is a form of localized attack that results in depressions in the metal. The primary factor affecting the occurrence and rate of pitting corrosion is the severity of the contaminants in the air environment surrounding the metal.

Loss of material due to galvanic corrosion in an air environment can occur when materials with different electrochemical potentials are in contact in a wetted location. In all galvanic couples involving carbon steel, chrome-molybdenum, and stainless steel, the lower potential (more anodic) materials such as the carbon steel and chrome-molybdenum materials would be preferentially attacked in a galvanic couple.

Carbon steel and stainless steel in a nitrogen environment have no aging effects since the nitrogen has negligible amounts of free oxygen. Stainless steel in a hydrogen environment has no aging effects since the hydrogen serves to scavenge the free oxygen.

3.5.2.1.1 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects for mechanical components exposed to an air/gas internal operating environment, a review of industry and Oconee-specific experience was performed.

The survey of industry experience included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREG documents. The following documents were reviewed in this survey:

- IN 81-38, *Potentially Significant Equipment Failures Resulting from Contamination of Air-Operated Systems*
- GL 88-14, *Instrument Air Supply System Problems Affecting Safety-Related Equipment*

No unique aging effects were identified in the above documents beyond those identified in this section.

3.5.2.1.2 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for carbon steel, chrome-molybdenum, and stainless steel components in an air/gas environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.5.2.1.3 CONCLUSION

The applicable aging effects for the mechanical component materials exposed to an air/gas environment are:

- Loss of material due to general corrosion is an applicable aging effect for carbon steel and chrome-molybdenum materials in air environments containing moisture.
- Loss of material due to pitting corrosion is an applicable aging effect for carbon steel, chrome-molybdenum and stainless steel materials in an air environment containing the presence of concentrated contaminants such as halide ions, and particularly chloride ions.
- Loss of material due to galvanic corrosion is an applicable aging effect for carbon steel and chrome-molybdenum in an air environment when these materials are in contact with a material with a higher electrochemical potential and located in a wetted environment.

Association of these applicable aging effects to specific components is provided in the system-specific discussions in Sections 3.5.3 through 3.5.14 and in the tables at the end of Chapter 3.5.

3.5.2.2 Applicable Aging Effects for a Borated Water Environment

The borated water internal operating environment includes all systems within the scope of license renewal operating with borated water. The mechanical systems within the scope of license renewal which have components primarily [Footnote 17] exposed to a borated water environment include:

- Chemical Addition System
- Coolant Storage System
- Core Flood System
- High Pressure Injection System
- Liquid Waste Disposal System
- Low Pressure Injection System
- Nitrogen Purge and Blanketing System
- Reactor Building Spray System
- Spent Fuel Cooling System
- Reactor Coolant Makeup System (Standby Shutdown Facility)

The materials of construction for mechanical system components within these systems are identified in Tables 2.5-2 through 2.5-25. The mechanical system component materials exposed to a borated water environment are carbon steel, inconel (a nickel-base alloy) and stainless steel. Since the carbon steel material is unique to the Borated Water Storage Tank in the Low Pressure Injection System, the applicable aging effects for it are discussed in Section 3.5.5.3. With this exception, the applicable aging effects for inconel and stainless steel in a borated water environment are discussed further in the following paragraphs.

Loss of material due to pitting corrosion is an applicable aging effect for inconel and stainless steel in a borated water environment under certain relevant conditions. Pitting corrosion is a form of localized attack that results in depressions in the metal. Oxygen is required for the initiation of pitting corrosion with halogens and sulfates required for continued dissolution of the material. For a borated water environment, two sets of relevant conditions can lead to pitting corrosion. The first set of relevant conditions needed for the occurrence of pitting corrosion is the continual presence of halogens in excess of 150 ppb, oxygen in excess of 100 ppb and stagnant or low flow conditions. A second set of relevant conditions needed for the occurrence of pitting corrosion is the continual presence of sulfates in excess of 100 ppb, oxygen in excess of 100 ppb and stagnant or low flow conditions. If either set of relevant conditions are satisfied, loss of

17. Portions of several of these systems are also exposed to an air/gas environment.

material due to pitting corrosion is an applicable aging effect for inconel and stainless steel materials in a borated water environment.

Cracking due to stress corrosion cracking and intergranular attack of the inconel and stainless steel materials in a borated water environment is an applicable aging effect under certain relevant conditions. Stress corrosion cracking and intergranular attack require a combination of a susceptible material, a corrosive environment and tensile stress. Since tensile stresses are unknown in a component, the stresses are assumed to be sufficient to initiate stress corrosion cracking and intergranular attack if the other conditions are met. For inconel and stainless steel, the relevant conditions required for stress corrosion cracking are the continual presence of halogens in excess of 150 ppb or sulfates in excess of 100 ppb. The relevant conditions for intergranular attack in inconel and stainless steel are halogens in excess of 150 ppb or sulfates in excess of 100 ppb and temperatures in excess of 200^{O}F.

3.5.2.2.1 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects for mechanical components exposed to a borated water internal operating environment , a review of industry and Oconee-specific experience was performed.

The survey of industry experience included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREG documents. The following documents were reviewed in this survey:

- BAW-2243A, *Demonstration of the Management of the Aging Effects for the Reactor Coolant System*
- CR 76-06, *Stress-Corrosion Cracks in Stagnant, Low Pressure Stainless Piping Containing Boric Acid Solutions at PWRs*
- IN 79-19, *Pipe Cracks in Stagnant Borated Water Systems at PWR Plants*
- IE Bulletin 82-02, *Degradation of Threaded Fasteners in the Reactor Coolant Pressure Boundary of PWR Plants*
- IN 84-18, *Stress-Corrosion Cracking in Pressurized Water Reactors*
- GL 88-05, *Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants*
- IN 91-05, *Intergranular Stress-Corrosion Cracking in Pressurized Water Reactor Safety Injection Accumulator Nozzles*

No unique aging effects were identified from the above documents beyond those already identified in this section.

3.5.2.2.2 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for inconel and stainless steel components in a borated water environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.5.2.2.3 CONCLUSION

The applicable aging effects for the mechanical components exposed to a borated water environment are:

- Loss of material due to pitting corrosion is an applicable aging effect for inconel and stainless steel in a borated water environment in the continual presence of halogens in excess of 150 ppb, oxygen in excess of 100 ppb and stagnant or low flow conditions.
- Loss of material due to pitting corrosion is an applicable aging effect for inconel and stainless steel in a borated water environment in the continual presence of sulfates in excess of 100 ppb, oxygen in excess of 100 ppb and stagnant or low flow conditions.
- Cracking due to stress corrosion cracking of the inconel and stainless steel materials in a borated water environment is an applicable aging effect in the continual presence of halogens in excess of 150 ppb or sulfates in excess of 100 ppb.
- Cracking due to intergranular attack of the inconel and stainless steel materials in a borated water environment is an applicable aging effect in the continual presence of halogens in excess of 150 ppb or sulfates in excess of 100 ppb and temperatures in excess of 200^{O}F.

Association of these applicable aging effects to specific components is provided in the system-specific discussions in Sections 3.5.3 through 3.5.14 and in the tables at the end of Chapter 3.5.

3.5.2.3 Applicable Aging Effects for an Oil/Fuel Oil Environment

The oil/fuel oil internal operating environment includes the systems within the scope of license renewal using fuel oil (liquid hydrocarbons used to fuel diesel engines) and lubricating oil (low to medium viscosity hydrocarbons used for bearing, gear, and engine lubricating). The mechanical systems within the scope of license renewal which have components primarily [Footnote 18] exposed to an oil/fuel oil environment include:

- Reactor Coolant System (Reactor Coolant Pump Oil Collection)
- Generator High Pressure Oil System (Keowee)
- Governor Oil System (Keowee)
- Turbine Guide Bearing Oil System (Keowee)
- Standby Shutdown Facility Diesel Generator Fuel Oil System

The materials of construction for mechanical system components within these systems are identified in Tables 2.5-2 through 2.5-25. The mechanical system component materials exposed to a oil/fuel oil environment are brass, bronze, carbon steel, copper, and stainless steel. The applicable aging effects for these materials in an oil/fuel oil environment are discussed further in the following paragraphs.

Loss of material due to general corrosion is an applicable aging effect for carbon steel in oil/fuel oil environment at locations containing water. Since any significant amount of water contamination would accumulate at the lower portions of components such as tank bottoms, only a limited portion of the carbon steel components would be affected by general corrosion. General corrosion is the result of a chemical or electrochemical reaction on the material when both oxygen and moisture are present. General corrosion is normally characterized by uniform attack resulting in material dissolution and sometimes corrosion product buildup. The stainless steel, brass, bronze, and copper in the plant oil/fuel oil environments are resistant to general corrosion.

Loss of material due to pitting corrosion is an applicable aging effect for brass, bronze, carbon steel, copper, and stainless steel materials in an oil/fuel oil environment at locations containing oxygenated water with contaminants such as halide ions, particularly chloride ions. Pitting corrosion is a form of localized attack that results in depressions in the metal. Oxygen is required for the initiation of pitting corrosion with halogen or sulfates required for continued dissolution of the material.

18. Portions of several of these systems are also exposed to an air/gas environment.

Loss of material due to crevice corrosion is an applicable aging effect for brass, bronze, carbon steel, copper, and stainless steel materials in an oil/fuel oil environment at locations containing oxygenated water. Oxygen is required for the initiation of crevice corrosion. Oil and fuel oil do not contain oxygen in sufficient quantities for crevice corrosion to occur. Water contamination of the oil and fuel oil is required for the introduction of oxygen. Since any significant amount of water contamination would accumulate at the lower portions of the system in components such as tank bottoms, only a limited portion of the components would be affected by crevice corrosion.

Loss of material due to galvanic corrosion in an oil/fuel oil environment can occur only when materials with different electrochemical potentials are in contact in the presence of water. Since any significant amount of water contamination would accumulate at the lower portions of the system in components such as tank bottoms, only a limited portion of the components within a system would be affected by galvanic corrosion. In all galvanic couples found in the oil and fuel oil environment, the lower potential (more anodic) carbon steel material would be preferentially attacked.

Loss of material due to microbiologically influenced corrosion (MIC) is an applicable aging effect for brass, carbon steel, copper, and stainless steel materials exposed to fuel oil. MIC is a localized, corrosive attack accelerated by the influence of microbiological activity. Microbiological organisms present in the fuel oil can produce corrosive substances as a byproduct of their biological processes that disrupt the protective oxide layer on the component materials, leading to a material depression similar to pitting corrosion.

Cracking due to stress corrosion of the stainless steel material in a fuel oil environment is an applicable aging effect at locations containing oxygenated water. Stress corrosion cracking is an aging effect requiring a combination of a susceptible material, a corrosive environment and tensile stress. Since tensile stresses are unknown, the stresses are assumed to be sufficient to initiate stress corrosion cracking if the other conditions for its occurrence are met. Since any significant amount of water contamination would accumulate at the lower portions of the system in components such as tank bottoms, only a limited portion of the components would be affected by stress corrosion cracking.

3.5.2.3.1 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects for mechanical components exposed to an oil/fuel oil internal operating environment, a review of industry and Oconee-specific experience was performed.

The survey of industry experience included NRC generic communications, licensee event reports from other nuclear plants other than Oconee, and NRC NUREG documents. The following documents were reviewed in this survey.

- CR 80-11, *Emergency Diesel Generator Lube Oil Cooler Failures*
- IN 79-23, *Emergency Diesel Generator Lube Oil Coolers*
- IN 85-08, *Industry Experience on Certain Materials Used in Safety-Related Equipment*
- IN 89-07, *Failures of Small Diameter Tubing in Control Air, Fuel, Oil and Lube Oil Systems Render Emergency Diesels Inoperable*
- IN 91-46, *Degradation of Emergency Diesel Generator Fuel Oil Delivery Systems*
- IN 93-48, *Failure of Turbine-Driven Main Feedwater Pump to Trip Because of Contaminated Oil*
- IN 94-58, *Reactor Coolant Pump Lube Oil Fire*

No unique aging effects were identified in the above documents beyond those already identified in this section.

3.5.2.3.2 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for brass, bronze, carbon steel, copper, and stainless steel components in an oil/fuel oil environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.5.2.3.3 CONCLUSION

The applicable aging effects for the mechanical components exposed to an oil/fuel oil environment for the period of extended operation are:

- Loss of material due to general corrosion is an applicable aging effect for carbon steel in an oil/fuel oil environment at locations containing water.
- Loss of material due to pitting corrosion is an applicable aging effect for brass, bronze, carbon steel, copper, and stainless steel materials in an oil/fuel oil environment containing oxygenated water with contaminates such as halogens or sulfates.
- Loss of material due to crevice corrosion is an applicable aging effect for brass, bronze, carbon steel, copper, and stainless steel materials in an oil/fuel oil environment at locations containing oxygenated water.

- Loss of material due to galvanic corrosion in an oil/fuel oil environment is an applicable aging effect for carbon steel in contact with a material with a higher electrochemical potential in the presence of oxygenated water.
- Loss of material due to microbiologically influenced corrosion (MIC) is an applicable aging effect for brass, carbon steel, copper, and stainless steel materials exposed to fuel oil.
- Cracking due to stress corrosion of the stainless steel material in a fuel oil environment is an applicable aging effect at locations containing oxygenated water.

Association of these applicable aging effects to specific components is provided in the system-specific discussions in Sections 3.5.3 through 3.5.14 and in the tables at the end of Chapter 3.5.

3.5.2.4 Applicable Aging Effects for a Raw Water Environment

The raw water internal operating environment includes the systems within the scope of license renewal using water from Lake Keowee. The mechanical systems within the scope of license renewal which have components primarily [Footnote 19] exposed to a raw water internal operating environment include:

- Auxiliary Service Water System
- Condenser Circulating Water System
- High Pressure Service Water System
- Low Pressure Service Water System
- Service Water System (Keowee)
- Turbine Sump Pump System (Keowee)
- Turbine Generator Cooling Water System (Keowee)
- Auxiliary Service Water System (Standby Shutdown Facility)
- Sanitary Lift System (Standby Shutdown Facility)

The materials of construction for mechanical system components within these systems are identified in Tables 2.5-2 through 2.5-25. The mechanical system component materials exposed to a raw water environment are admiralty brass, brass, bronze, carbon steel, cast iron, copper, 90-10 copper-nickel, ductile cast iron, and stainless steel. The applicable aging effects for these materials in a raw water environment are discussed further in the following paragraphs.

Loss of material due to general corrosion is an applicable aging effect for admiralty brass, brass, bronze, carbon steel, cast iron, copper, 90-10 copper-nickel, and ductile cast iron component materials in a raw water environment. General corrosion is the result of a chemical or electrochemical reaction on the material when both oxygen and moisture are present. General corrosion is characterized by uniform attack resulting in material dissolution and sometimes corrosion product buildup. The stainless steel materials in the plant raw water environments are resistant to general corrosion.

Loss of material due to pitting corrosion is an applicable aging effect for admiralty brass, brass, bronze carbon steel, cast iron, copper, 90-10 copper-nickel, ductile cast iron, and stainless steel materials in a raw water environment. Pitting corrosion is a form of localized attack that results in depressions in the metal. Oxygen is required for the initiation of pitting corrosion with halogen or sulfates required for continued dissolution of the material. Pitting corrosion can be inhibited by maintaining an adequate flow rate

19. Portions of several of these systems are also exposed to an air/gas environment.

which prevents impurities from adhering to the material surface. The more susceptible locations for pitting corrosion to occur in materials in a raw water environment are locations of low or stagnant flow.

Loss of material due to galvanic corrosion in a raw water environment can occur only when materials with different electrochemical potentials are in contact in the presence of water. In all galvanic couples involving admiralty brass, brass, bronze, carbon steel, cast iron, copper, 90-10 copper-nickel, ductile cast iron, and stainless steel, the lower potential (more anodic) brass, bronze, carbon steel, copper, 90-10 copper-nickel, cast iron and ductile cast iron materials would be preferentially attacked in a galvanic couple.

Loss of material due to microbiologically influenced corrosion (MIC) is an applicable aging effect for admiralty brass, brass, bronze, carbon steel, cast iron, copper, 90-10 copper-nickel, ductile cast iron, and stainless steel materials exposed to raw water. MIC is a localized, corrosive attack accelerated by the influence of microbiological activity. Microbiological organisms present in the raw water can produce corrosive substances as a byproduct of their biological processes that disrupt the protective oxide layer on the component materials, leading to a material depression similar to pitting corrosion.

Loss of material due to selective leaching is an applicable aging effect for cast iron component materials in a raw water environment. Ductile cast iron is not susceptible to selective leaching because the material properties are different from cast iron. Selective leaching is the dissolution of iron at the metal surface that leaves a weakened network of graphite and iron corrosion products.

In addition, fouling which is not a material degradation phenomenon, but is an applicable aging effect for a limited set of component geometries in Oconee raw water systems, is addressed for the Oconee raw water systems in Sections 3.5.6, 3.5.11 and 3.5.12.

3.5.2.4.1 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects for mechanical components exposed to a raw water internal operating environment, a review of industry and Oconee-specific experience was performed.

The survey of industry experience included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREG documents. The following documents were reviewed in this search:

- IE Bulletin 81-03, *Flow Blockage of Cooling Water to Safety System components by Corbicula sp. (asiatic clam) and Mytilus sp. (mussel)*
- IN 85-24, *Failures of Protective Coatings in Pipes and Heat Exchangers*
- IN 85-30, *Microbiologically Induced Corrosion of Containment Service Water System*
- IN 88-37, *Flow Blockage of Cooling Water to Safety System Components*
- IN 89-01, *Valve Body Erosion*
- IN 89-76, *Biofouling Agent: Zebra Mussel*
- GL 89-13, *Service Water System Problems Affecting Safety-Related Equipment*
- IN 90-39, *Recent Problems with Service Water Systems*
- IN 94-03, *Deficiencies Identified During Service Water System Operational Performance Inspections*
- IN 94-59, *Accelerated Dealloying of Cast Aluminum-Bronze Valves Caused by Microbiologically Induced Corrosion*
- IN 94-79, *Microbiologically Influenced Corrosion of Emergency Diesel Generator Service Water Piping*

No unique aging effects were identified in the above documents beyond those already identified in this section.

3.5.2.4.2 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for admiralty brass, brass, bronze, carbon steel, cast iron, copper, 90-10 copper-nickel ductile iron, and stainless steel components in raw water environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.5.2.4.3 CONCLUSION

The applicable aging effects for the mechanical components exposed to a raw water environment are:

- Loss of material due to general corrosion is an applicable aging effect for admiralty brass, brass, bronze, carbon steel, cast iron, copper, 90-10 copper-nickel, and ductile cast iron component materials in a raw water environment.
- Loss of material due to pitting corrosion is an applicable aging effect for admiralty brass, brass, bronze carbon steel, cast iron, copper, 90-10 copper-nickel, ductile cast iron, and stainless steel materials in a raw water environment where the more susceptible locations for pitting are locations of low or stagnant flow.

- Loss of material due to galvanic corrosion in a raw water environment is an applicable aging effect for brass, bronze, carbon steel, cast iron, copper, 90-10 copper-nickel, and ductile cast iron when in contact with a material with a higher electrochemical potential in the presence of water.
- Loss of material due to microbiologically influenced corrosion (MIC) is an applicable aging effect for admiralty brass, brass, bronze, carbon steel, cast iron, copper, 90-10 copper-nickel, ductile cast iron, and stainless steel materials exposed to raw water.
- Loss of material due to selective leaching is an applicable aging effect for cast iron component materials in a raw water environment.

Association of these applicable aging effects to specific components is provided in the system-specific discussions in Sections 3.5.3 through 3.5.14 and in the tables at the end of Chapter 3.5. In addition, fouling which is not a material degradation phenomenon, but is an applicable aging effect for a limited set of component geometries in Oconee raw water systems, is addressed for the Oconee raw water systems in Sections 3.5.6, 3.5.11 and 3.5.12.

3.5.2.5 Applicable Aging Effects for a Treated Water Environment

The treated water internal operating environment includes all systems within the scope of license renewal using treated water, except those using borated water. The mechanical systems within the scope of license which have components primarily [Footnote 20] exposed to a treated water operating environment include:

- Chemical Addition System
- Component Cooling System
- Condensate System
- Demineralized Water System
- Emergency Feedwater System
- Feedwater System
- Filtered Water System
- Main Steam System
- Standby Shutdown Facility Drinking Water System

The materials of construction for mechanical system components within these systems are identified in Tables 2.5-2 through 2.5-25. The mechanical system component materials exposed to a treated water environment are admiralty brass, brass, carbon steel, cast iron, copper, low-alloy steel, and stainless steel. The applicable aging effects for these materials in a treated water environment are discussed further in the following paragraphs.

Loss of material due to general corrosion is an applicable aging effect for admiralty brass, brass, carbon steel, cast iron, copper, and low-alloy steel in a treated water environment due to the presence of oxygen. General corrosion is the result of a chemical or electrochemical reaction on the material when both oxygen and moisture are present. General corrosion is characterized by uniform attack resulting in material dissolution and sometimes corrosion product buildup. The stainless steel materials in the plant treated water environments are resistant to general corrosion.

Loss of material due to pitting corrosion is an applicable aging effect for admiralty brass, brass, carbon steel, cast iron, copper, low-alloy steel, and stainless steel materials in a treated water environment under certain relevant. Pitting corrosion is a form of localized attack that results in depressions in the metal. Oxygen is required for the initiation of pitting corrosion with halogens or sulfates required for continued dissolution of the material. For a treated water environment, two sets of relevant conditions can lead to pitting corrosion. The first set of relevant conditions needed for the occurrence of pitting

20. Portions of several of these systems are also exposed to an air/gas environment.

corrosion is the continual presence of halogens in excess of 150 ppb, oxygen in excess of 100 ppb and stagnant or low flow conditions. A second set of relevant conditions needed for the occurrence of pitting corrosion is the continual presence of sulfates in excess of 100 ppb, oxygen in excess of 100 ppb and stagnant or low flow conditions.

Loss of material due to galvanic corrosion in a treated water environment can occur only when materials with different electrochemical potentials are in contact in the presence of oxygenated water. In all galvanic couples involving admiralty brass, brass, carbon steel, cast iron, copper, low-alloy steel and stainless steel materials, the lower potential (more anodic) carbon steel, cast iron and low-alloy steel materials would be preferentially attacked in a galvanic couple.

Loss of material due to selective leaching is an applicable aging effect for cast iron component materials in a treated water environment. Selective leaching is the dissolution of iron at the metal surface that leaves a weakened network of graphite and iron corrosion products.

Loss of material due to erosion/corrosion is an applicable aging effect for carbon steel component materials in treated water systems under certain relevant conditions. Erosion-corrosion is a term used to describe the alternating pattern of oxide erosion due to fluid flow followed by corrosion of the newly exposed material surface which is again followed by oxide erosion as the pattern repeats. Relevant conditions required for erosion-corrosion to be a concern in treated water systems include physical parameters such as fluid temperature, fluid (steam) quality, fluid velocity, fluid pH, mechanical component geometry and configuration. Loss of material due to erosion-corrosion is considered an applicable aging effect for carbon steel component materials in a treated water environment when the system operates more than 2% of plant operating time at a temperature greater than 200°F, but where the steam is not superheated.

Cracking due to stress corrosion of the stainless steel materials in a treated water environment is an applicable aging effect under certain relevant conditions. Stress corrosion cracking is an aging effect requiring a combination of a susceptible material, a corrosive environment and tensile stress. Since tensile stresses are unknown, the stresses are assumed to be sufficient to initiate stress corrosion cracking if the other conditions require for occurrence are met. For stainless steel, the relevant conditions required for stress corrosion cracking is the continual presence of halogens in excess of 150 ppb or sulfates in excess of 100 ppb. If either of these relevant conditions is satisfied, stress corrosion cracking is an applicable aging effect for stainless steel materials in a treated water environment

3.5.2.5.1 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects for mechanical components exposed to a treated water internal operating, a review of industry and Oconee-specific experience was performed.

The survey of industry experience included NRC generic communications, licensee event reports from nuclear plants other than Oconee, and NRC NUREG documents. The following documents were reviewed in this search:

- GL 79-20, *Cracking in Feedwater Lines*
- GL 89-08, *Erosion/Corrosion-Induced Pipe Wall Thinning*
- IE Bulletin 79-13, Revisions 0, 1, 2, *Cracking in Feedwater System Piping*
- IE Bulletin 87-01, *Thinning of Pipe Walls in Nuclear Power Plants*
- IN 81-04, *Cracking in Main Steam Lines*
- IN 82-22, *Failures in Turbine Exhaust Lines*
- IN 84-32, *Auxiliary Feedwater Sparger and Pipe Hanger Damage*
- IN 86-106, Revisions 0, 1, 2, 3, *Feedwater Line Break*
- IN 87-36, *Significant Unexpected Erosion of Feedwater Lines*
- IN 88-17, *Summary of Responses to NRC Bulletin 87-01, "Thinning of Pipe Walls in Nuclear Power Plants"*
- IN 89-01, *Valve Body Erosion*
- IN 89-53, *Rupture of Extraction Steam Line on High Pressure Turbine*
- IN 91-18, *Revision 1, High-Energy Pipe Failures Caused by Wall Thinning*
- IN 91-28, *Cracking in Feedwater System Piping*

No unique aging effects were identified in the above documents beyond those already identified in this section.

3.5.2.5.2 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for admiralty brass, brass, carbon steel, cast iron, copper, low-alloy steel, and stainless steel components in a treated water environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.5.2.5.3 CONCLUSION

The applicable aging effects for the mechanical components exposed to a treated water environment are:

- Loss of material due to general corrosion is an applicable aging effect for admiralty brass, brass, carbon steel, cast iron, copper, and low-alloy steel in a treated water environment due to the presence of oxygen.
- Loss of material due to pitting corrosion is an applicable aging effect for admiralty brass, brass, carbon steel, cast iron, copper, low-alloy steel, and stainless steel materials in a treated water environment in the continual presence of halogens in excess of 150 ppb, oxygen in excess of 100 ppb and stagnant or low flow conditions.
- Loss of material due to pitting corrosion is an applicable aging effect for admiralty brass, brass, carbon steel, cast iron, copper, low-alloy steel, and stainless steel materials in a treated water environment in the continual presence of sulfates in excess of 100 ppb, oxygen in excess of 100 ppb and stagnant or low flow conditions.
- Loss of material due to galvanic corrosion is an applicable aging effect for carbon steel, cast iron, and low alloy steel when in contact with a material with a higher electrochemical potential in the presence of oxygenated water.
- Loss of material due to selective leaching is an applicable aging effect for cast iron component materials in a treated water environment.
- Loss of material due to erosion/corrosion is an applicable aging effect for carbon steel component materials in treated water systems which operate more than 2% of plant operating time at a temperature greater than 200°F, but where the steam is not superheated. Relevant conditions required for erosion-corrosion to be a concern in treated water systems include physical parameters such as fluid temperature, fluid (steam) quality, fluid velocity, fluid pH, mechanical component geometry and configuration.
- Cracking due to stress corrosion of the stainless steel materials in a treated water environment is an applicable aging effect in the continual presence of halogens in excess of 150 ppb or sulfates in excess of 100 ppb.

Association of these applicable aging effects to specific components is provided in the system-specific discussions in Sections 3.5.3 through 3.5.14 and in the tables at the end of Chapter 3.5.

3.5.2.6 Applicable Aging Effects for a Ventilation Air Environment

The ventilation internal operating environment includes filtered and unfiltered ventilation systems within the scope of license renewal. The mechanical systems within the scope of license renewal which are exposed to a ventilation air environment include:

- Auxiliary Building Ventilation System
- Control Room Pressurization and Filtration System
- Penetration Room Ventilation System
- Reactor Building Cooling System
- Reactor Building Purge System
- Standby Shutdown Facility HVAC System

The materials of construction for mechanical system components within these systems are identified in Tables 2.5-2 through 2.5-25. The mechanical system component materials exposed to a ventilation air environment are aluminum, brass, carbon steel, copper, 90-10 copper-nickel, galvanized steel, and stainless steel. The applicable aging effects for these materials in a ventilation air environment are discussed further in the following paragraphs.

Loss of material due to galvanic corrosion in a ventilation air environment can occur only when materials with different electrochemical potentials are in contact in the presence of water. In all galvanic couples involving aluminum, brass, carbon steel, copper, 90-10 copper-nickel, galvanized steel, and stainless steel materials, the lower potential (more anodic) aluminum, 90-10 copper-nickel, and galvanized steel would be preferentially attacked in a galvanic couple.

Loss of material due to boric acid wastage is an applicable aging effect for aluminum, brass, carbon steel, copper, and galvanized steel in a ventilation air environment containing the presence of a concentrated boric acid solution. Leaking fluid from a pressurized mechanical system containing borated water can vaporize, suspending the borated water in the air and allowing it to be transported to and deposited within the ventilation system components. If the boric acid deposits are re-dissolved by a wetted environment in the ventilation system, the boric acid solution will concentrate. When aluminum, brass, carbon steel, copper, and galvanized steel materials are exposed to a concentrated solution of boric acid, boric acid wastage can cause volumetric loss of material. Opportunities for Oconee ventilation systems to contain such a concentrated boric acid solution are limited to the Reactor Building Cooling System inside the Reactor Building. Loss of material due to boric acid wastage is an applicable aging effect for the aluminum, 90-10 copper-nickel, and galvanized steel in the Reactor Building Cooling System

3.5.2.6.1 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects for mechanical components exposed to a ventilation air internal operating environment, a review of industry and Oconee-specific experience was performed.

The survey of industry experience included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREG documents. No documents associated with the aging effects of ventilation air systems were identified.

3.5.2.6.2 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for aluminum, brass, carbon steel, copper, 90-10 copper-nickel, galvanized steel and stainless steel components in a ventilation air environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.5.2.6.3 CONCLUSION

The applicable aging effects for the mechanical components exposed to a ventilation air environment for the period of extended operation are:

- Loss of material due to galvanic corrosion is an applicable aging effect for aluminum, 90-10 copper-nickel, and galvanized steel in contact with a material with a high electrochemical potential in the presence of water.
- Loss of material due to boric acid wastage is an applicable aging effect for aluminum, 90-10 copper-nickel, and galvanized steel in a ventilation environment containing the presence of a concentrated boric acid solution. Opportunities for Oconee ventilation systems to contain such a concentrated boric acid solution are limited to the Reactor Building Cooling System inside the Reactor Building.

Association of these applicable aging effects to specific components is provided in the system-specific discussions in Sections 3.5.3 through 3.5.14 and in the tables at the end of Chapter 3.5.

3.5.2.7 Applicable Aging Effects for External Surface Environments

The preceding sections describe the applicable aging effects associated with the six internal operating environments of the mechanical components. This section describes the applicable aging effects associated with the set of five external surface environments to which these components are exposed. Additionally, because components of similar material will age similarly in the same environment, the aging management programs required to manage the applicable aging effects for all component external surfaces within these environments are identified. The mechanical components within the scope of license renewal are found in the following locations on the Oconee site:

- Reactor Building
- Sheltered (includes Auxiliary Building, Intake Structure, Turbine Building, Warehouse, Keowee Hydroelectric Plant, and Standby Shutdown Facility)
- Yard
- Underground
- Embedded

The determination of aging effects that are applicable to Oconee considers the materials, environment, and operating stresses associated with the component and system design. The applicable aging effects for the external surfaces of component materials exposed to these environments along with the aging management programs are discussed further in the following sections.

3.5.2.7.1 APPLICABLE AGING EFFECTS FOR THE REACTOR BUILDING ENVIRONMENT

The Reactor Building environment is a warm, moist air environment. Temperatures in the higher elevations inside the Reactor Building can reach 130°F during normal unit operation with relative humidity assumed to reach as high as 100 %. The Reactor Building environment is cooled by the Reactor Building Cooling System, which consists of three cooling units that reject heat to the Low Pressure Service Water System.

The systems with mechanical components exposed to the Reactor Building environment are:

- Breathing Air System
- Chemical Addition System
- Component Cooling System
- Containment Hydrogen Control System
- Coolant Storage System
- Core Flood System
- Demineralized Water System
- Emergency Feedwater System
- Feedwater System
- Filtered Water System
- Gaseous Waste Disposal System
- High Pressure Injection System
- Instrument Air System
- Leak Rate Test System
- Low Pressure Injection System
- Low Pressure Service Water System
- Main Steam System
- Nitrogen Purge and Blanket System
- Post-Accident Monitoring System
- Reactor Building Cooling System
- Reactor Building Purge System
- Reactor Building Spray System
- Standby Shutdown Facility Reactor Coolant Makeup System
- Reactor Coolant System
- Spent Fuel Cooling System

The materials of construction for the mechanical system components in these systems that are exposed to a Reactor Building environment are identified in Tables 2.5-2 through 2.5-25. Since different component types constructed from the same material, located in the same environment, and operating under similar operating stresses will experience similar aging effects, the applicable aging effects for the external surfaces of these components can be determined on a material basis. The materials of construction for the mechanical components within the scope of license renewal located inside the Reactor Building are aluminum, brass, bronze, carbon steel, copper, galvanized steel, inconel, and stainless steel. The applicable aging effects for these materials in the Reactor Building environment are discussed further in the following paragraphs.

Loss of material due to boric acid wastage is an applicable aging effect for the external surfaces of aluminum, brass, bronze, carbon steel, copper, and galvanized steel component materials located in the Reactor Building environment. Leaking fluid from a borated water system may expose the external surfaces of components made from these materials to a concentrated boric acid solution which can ultimately lead to volumetric loss of material. Loss of material due to boric acid wastage could lead to loss of the pressure boundary function.

Loss of material due to general corrosion is an applicable aging effect for carbon steel materials in the Reactor Building environment if the material is in contact with a moist air environment. General corrosion is the result of a chemical or electrochemical reaction between the material and the air environment when both oxygen and moisture are present. General corrosion is characterized by uniform attack resulting in material dissolution and sometimes corrosion product buildup.

Loss of material due to galvanic corrosion in the Reactor Building environment can occur when materials with different electrochemical potentials are in contact in the presence of water which is needed to establish the galvanic couple. In all galvanic couples involving aluminum, brass, bronze, carbon steel, copper, galvanized steel, inconel, and stainless steel materials, the lower potential (more anodic) carbon steel would be preferentially attacked in a galvanic couple. In the Reactor Building environment, only systems continually operating at a temperature where surface condensation occurs will have water present on their external surface.

No applicable aging effects were identified for inconel and stainless steel in the Reactor Building environment.

3.5.2.7.1.1 Industry Experience

In order to validate the set of applicable aging for mechanical component external surfaces exposed to the Reactor Building environment, a review of industry and Oconee-specific experience was performed. The survey of industry experience included NRC generic communications, licensee event reports from nuclear plants other than Oconee, and NRC NUREGs. The following documents were reviewed in this survey:

- IN 86-108, *Degradation of Reactor Coolant System Pressure Boundary Resulting From Boric Acid Corrosion*
- GL 88-05, *Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants*

No unique aging effects were identified in the above documents beyond those already identified in this section.

3.5.2.7.1.2 Oconee Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for the external surfaces of component materials in the Reactor Building environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.5.2.7.1.3 Conclusions

The applicable aging effects for mechanical components exposed to the Reactor Building environment are:

- Loss of material due to boric acid wastage is an applicable aging effect for the external surfaces of aluminum, brass, bronze, carbon steel, copper, and galvanized steel component materials located in the Reactor Building environment due to the potential for exposure to leaking fluid from borated water systems.
- Loss of material due to general corrosion is an applicable aging effect for carbon steel materials in the Reactor Building environment if the material is in contact with a moist air environment.
- Loss of material due to galvanic corrosion is an applicable aging effect for carbon steel in the Reactor Building environment when in contact with a material with a higher electrochemical potential in the presence of water.

3.5.2.7.1.4 Aging Management Programs

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 for the systems listed in Section 3.5.2.7.1 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the component external surface materials in the Reactor Building environment will be managed by monitoring and controlling either the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

Loss of material due to boric acid wastage of aluminum, brass, bronze, carbon steel, copper, and galvanized steel components will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Boric Acid Wastage Surveillance Program

Loss of material due to general corrosion and galvanic corrosion of carbon steel will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.5.2.7.2 APPLICABLE AGING EFFECTS FOR A SHELTERED ENVIRONMENT

The sheltered environment includes mechanical components located in the Auxiliary Building, Intake Structure, Turbine Building, Warehouse, Keowee Hydroelectric Plant, and Standby Shutdown Facility. The components located in these areas are exposed to moist air but are protected from dew and meteorological precipitation. The Auxiliary Building and Standby Shutdown Facility (SSF) are heated and cooled. The Turbine Building, Warehouse, and Keowee Hydroelectric Plant are heated in the winter and ventilated in the summer. The Intake Structure is neither heated nor cooled. The systems with mechanical components exposed to a sheltered environment are:

- Auxiliary Building Ventilation System
- Auxiliary Service Water System
- Breathing Air System
- Chemical Addition System
- Component Cooling System
- Condensate System
- Condenser Circulating Water System
- Containment Hydrogen Control System
- Control Room Pressurization and Filtration System
- Coolant Storage System
- Core Flood System
- Demineralized Water System
- Emergency Feedwater System
- Feedwater System
- Filtered Water System
- Gaseous Waste Disposal System
- High Pressure Injection System
- High Pressure Service Water System
- Instrument Air System
- Leak Rate Test System
- Liquid Waste Disposal System
- Low Pressure Injection System
- Low Pressure Service Water System
- Main Steam System
- Nitrogen Purge and Blanket System
- Penetration Room Ventilation System
- Post Accident Monitoring System
- Reactor Building Purge System
- Reactor Building Spray System
- Reactor Coolant System
- Spent Fuel Cooling System
- Air Intake and Exhaust System
- SSF Diesel Generator Fuel Oil System
- Sanitary Lift System
- SSF Auxiliary Service Water System
- SSF Drinking Water System
- SSF HVAC System
- Starting Air System
- Carbon Dioxide
- Depressing Air
- Generator High Pressure Oil System
- Governor Air System
- Governor Oil System
- Service Water System
- Turbine Generator Cooling Water System
- Turbine Guide Bearing Oil System
- Turbine Sump Pump System

The materials of construction for the mechanical system components in these systems that are exposed to a sheltered environment are identified in Tables 2.5-2 through 2.5-25.

Since different component types constructed from the same material, located in the same environment, and operating under similar operating stresses will experience similar aging effects, the applicable aging effects for the external surfaces of these components can be determined on a material basis. The materials of construction for the mechanical components within the scope of license renewal located inside the Sheltered environments are aluminum, brass, bronze, carbon steel, cast iron, chrome-molybdenum, copper, galvanized steel, low-alloy steel and stainless steel. The applicable aging effects for these materials in the sheltered environments are discussed further in the following paragraphs.

Loss of material due to boric acid wastage is an applicable aging effect for the external surfaces of aluminum, brass, bronze, carbon steel, cast iron, copper, and galvanized steel component materials located in the Auxiliary Building environment only. Leaking fluid from a borated water system may expose the external surfaces of components made from these materials to a concentrated boric acid solution which can ultimately lead to volumetric loss of material. Loss of material due to boric acid wastage could lead to a loss of the pressure boundary function.

Loss of material due to general corrosion is an applicable aging effect for carbon steel, cast iron, chrome-molybdenum and low-alloy steel materials in the sheltered environments if the materials are in contact with a moist air environment. General corrosion is the result of a chemical or electrochemical reaction between the material and the air environment when both oxygen and moisture are present. General corrosion is normally characterized by uniform attack resulting in material dissolution and sometimes corrosion product buildup.

Loss of material due to galvanic corrosion in the sheltered environments can occur when materials with different electrochemical potentials are in contact in the presence of water which is needed to establish the galvanic couple. In all galvanic couples involving aluminum, brass, bronze, carbon steel, cast iron, chrome-molybdenum, copper, galvanized steel, low-alloy steel and stainless steel materials, the lower potential (more anodic) carbon steel and cast iron would be preferentially attacked in a galvanic couple. In the sheltered environments, only systems continually operating at a temperature where surface condensation occurs will have water present on their external surface, which are the raw water systems.

No applicable aging effects were identified for stainless steel in the sheltered environments.

3.5.2.7.2.1 Industry Experience

In order to validate the set of applicable aging effects and for mechanical component external surfaces exposed to the sheltered environments, a review of industry and Oconee-specific experience was performed. The survey of industry experience included NRC generic communications, licensee event reports from nuclear plants other than Oconee, and NRC NUREGs. No documents associated with aging effects of external surfaces of mechanical components were identified. Documents identified in Section 3.5.2.7.1.1 are applicable for borated water systems in the Auxiliary Building.

3.5.2.7.2.2 Oconee Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for the external surfaces of component materials in the sheltered environments. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.5.2.7.2.3 Conclusions

The applicable aging effects for mechanical components exposed to the sheltered environments are:

- Loss of material due to boric acid wastage is an applicable aging effect for the external surfaces of aluminum, brass, bronze, carbon steel, cast iron, copper, and galvanized steel component materials located in the Auxiliary Building environment due to the potential for exposure to leaking fluid from borated water systems.
- Loss of material due to general corrosion is an applicable aging effect for the external surfaces of the carbon steel, cast iron, chrome-molybdenum, and low-alloy steel materials in the Sheltered environment if the material is in contact with the moist air environment.
- Loss of material due to galvanic corrosion is an applicable aging effect for carbon steel in the Sheltered environments when in contact with a material with a higher electrochemical potential in the presence of water. In the Sheltered environment the material couples identified in this section for systems containing service water meet this criteria.

3.5.2.7.2.4 Aging Management Programs

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 for the systems listed in Section 3.5.2.7.2 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the component external surface materials in the sheltered environments will be managed by monitoring and controlling either the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

Loss of material due to boric acid wastage of aluminum, brass, bronze, carbon steel, cast iron, copper, and galvanized steel components in the Auxiliary Building will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Boric Acid Wastage Surveillance Program

Loss of material due to general corrosion and galvanic corrosion of exposed surfaces of carbon steel will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.5.2.7.3 APPLICABLE AGING EFFECTS FOR THE YARD ENVIRONMENT

The yard environment includes mechanical components within the scope of license renewal located outside. These components are subject to the natural elements of precipitation, wind, sun, and varying temperatures. The systems with mechanical components exposed to the yard environment are:

- Air Intake and Exhaust System
- Condenser Circulating Water System
- Containment Hydrogen Control System
- High Pressure Service Water System
- Low Pressure Injection System
- Main Steam System
- Standby Shutdown Facility Auxiliary Service Water System
- Service Water System (Keowee)
- Turbine Generator Cooling Water System (Keowee)

The materials of construction for the mechanical system components in these systems which are exposed to the yard environment are identified in Tables 2.5-2 through 2.5-25. Since different component types constructed from the same material, located in the same environment, and operating under similar operating stresses will experience similar aging effects, the applicable aging effects for the external surfaces of these components can be determined on a material basis. The materials of construction for the mechanical components within the scope of license renewal located outside in the yard environment are aluminum, bronze, carbon steel, cast iron, chrome-molybdenum, galvanized steel, and stainless steel. The applicable aging effects for these materials in the yard environment are discussed further in the following paragraphs.

Loss of material due to general corrosion is an applicable aging effect for carbon steel, cast iron, and chrome-molybdenum materials in the yard environment if the materials are in contact with a moist air environment. General corrosion is the result of a chemical or electrochemical reaction between the material and the air environment when both oxygen and moisture are present. General corrosion is characterized by uniform attack resulting in material dissolution and sometimes corrosion product buildup.

Loss of material due to galvanic corrosion in the yard environments can occur when materials with different electrochemical potentials are in contact in the presence of water which is needed to establish the galvanic couple. In all galvanic couples involving aluminum, brass, bronze, carbon steel, cast iron, chrome-molybdenum, galvanized steel, and stainless steel materials, the lower potential (more anodic) carbon steel and cast iron would be preferentially attacked in a galvanic couple. In the yard environment, only systems continually operating at a temperature where surface condensation occurs will have water present on their external surface, which are the raw water systems.

No applicable aging effects were identified for aluminum, brass, bronze, galvanized steel or stainless steel components exposed to the yard environment.

3.5.2.7.3.1 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects for mechanical component external surfaces exposed to the yard environment, a review of industry and Oconee-specific experience was performed. The survey of industry experience included NRC generic communications, licensee event reports from nuclear plants other than Oconee, and NRC NUREGs. No documents associated with aging effects of external surfaces of mechanical components were identified.

3.5.2.7.3.2 OCONEE EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for the external surfaces of component materials in the yard environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.5.2.7.3.3 CONCLUSIONS

The applicable aging effects for mechanical components exposed to the yard environment are:

- Loss of material due to general corrosion is an applicable aging effect for the external surfaces of the carbon steel, cast iron, and chrome-molybdenum materials in the yard environment if the material is in contact with a moist air environment.
- Loss of material due to galvanic corrosion is an applicable aging effect for carbon steel and cast iron in the yard environment when in contact with materials with a higher electrochemical potential in the presence of water. In the yard environment the material couples identified in this section for systems containing service water meet this criteria. This aging effect is also applicable for the internal surfaces of these material couples.

3.5.2.7.3.4 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 for the systems listed in Section 3.5.2.7.3 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the component external surface materials in the yard environment are managed by monitoring and controlling either the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

Loss of material due to general corrosion and galvanic corrosion of exposed surfaces of carbon steel and cast iron will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.5.2.7.4 APPLICABLE AGING EFFECTS FOR AN UNDERGROUND ENVIRONMENT

The underground environment includes mechanical components that are located below grade. The soil and groundwater are untreated and could be corrosive to materials located there. The systems with mechanical components exposed to an underground environment are:

- Condenser Circulating Water System
- High Pressure Service Water System
- Service Water System (Keowee)
- Standby Shutdown Facility Diesel Generator Fuel Oil System
- Turbine Generator Cooling Water System (Keowee)

The materials of construction for the mechanical system components in these systems which are exposed to an underground environment are identified in Tables 2.5-2 through 2.5-25. Since different component types constructed from the same material, located in the same environment, and operating under similar operating stresses will experience similar aging effects, the applicable aging effects for the external surfaces of these components can be determined on a material basis. The materials of construction for the mechanical components within the scope of license renewal located in an underground environment are carbon steel, cast iron, and stainless steel. The applicable aging effects for these materials in the Underground environment are discussed further in the following paragraphs.

Loss of material due to general corrosion is an applicable aging effect for carbon steel and cast iron materials in the underground environment if the materials are in contact with soil or groundwater. General corrosion is the result of a chemical or electrochemical reaction between the material and the air environment when both oxygen and moisture are present. General corrosion is characterized by uniform attack resulting in material dissolution and sometimes corrosion product buildup.

Loss of material due to pitting corrosion is an applicable aging effect for the external surfaces of carbon steel, cast iron, and stainless steel materials in an underground environment if the materials are in contact with soil or groundwater. Pitting corrosion is a form of localized attack that results in depressions in the metal. Oxygen is required for initiation of pitting corrosion with contaminants such as halogens or sulfates required for continued material dissolution.

Loss of material due to microbiologically influenced corrosion (MIC) is an applicable aging effect for the external surfaces of carbon steel, cast iron, and stainless steel materials in an underground environment if the materials are in contact with soil or groundwater. MIC is a localized, corrosive attack accelerated by the influence of microbiological activity. Microbiological organisms present in the soil or groundwater can produce corrosive substances as a byproduct of their biological processes that disrupt the protective oxide layer on the component materials, leading to a material depression similar to pitting corrosion.

Loss of material due to galvanic corrosion in an underground environment can occur when materials with different electrochemical potentials are in contact in the presence of water. However, in an underground environment, galvanic corrosion occurs between the material and the surrounding soil and groundwater. Loss of material due to galvanic corrosion is an applicable aging effect for the external surfaces of carbon steel, cast iron, and stainless steel components in an underground environment if the materials are in contact with the soil or groundwater.

Loss of material due to selective leaching is an applicable aging effect for cast iron component materials in an underground environment if the materials are in contact with soil or groundwater. Selective leaching is the dissolution of iron at the metal surface that leaves a weakened network of graphite and iron corrosion products.

Cracking due to stress corrosion is an applicable aging effect for stainless steel in an underground environment if the materials are in contact with soil or groundwater. Stress corrosion cracking is an aging effect requiring a combination of a susceptible material, a corrosive environment and tensile stress. Since tensile stresses are unknown, the stresses are assumed to be sufficient to initiate stress corrosion cracking if the other conditions for its occurrence are met. For stainless steel in an underground environment, the presence of soil or groundwater could provide the corrosive environment conducive to stress corrosion cracking of stainless steel

3.5.2.7.4.1 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects for mechanical component external surfaces exposed to the underground environment, a review of industry and Oconee-specific experience was performed. The survey of industry experience included NRC generic communications, licensee event reports from nuclear plants other than Oconee, and NRC NUREGs. No documents specifically associated with aging effects of external surfaces of mechanical components were identified, but the following documents were reviewed in this survey:

- IN 85-24, *Failures of Protective Coatings in Pipes and Heat Exchangers*
- IN 85-30, *Microbiologically Induced Corrosion of Containment Service Water System*
- GL 89-13, *Service Water System Problems Affecting Safety-Related Equipment*
- IN 90-39, *Recent Problems with Service Water Systems*
- IN 94-79, *Microbiologically Influenced Corrosion of Emergency Diesel Generator Service Water Piping*

No unique aging effects were identified from the above documents beyond those already identified in this section.

3.5.2.7.4.2 OCONEE EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for the external surfaces of component materials in an underground environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. A review of Oconee operating experience has identified a limited number of concerns with components in an underground environment.

In 1992, the presence of standing water in the transformer yard and substantial quantities of water flowing down the Turbine Building basement wall opposing the transformer yard was reported. Upon investigation, the source of the water was identified to be a small hole which was centered in a deep symmetrical indentation in a buried Condenser Circulating Water System branch line pipe. The root cause was galvanic or pitting corrosion of the pipe at a pinhole coatings void.

Another, more recent, experience was reported in October 1997. A maintenance activity was performed on the main Unit 1 Condenser Circulating Water System discharge piping to remove existing internal coatings that contained asbestos. During this activity a small, one inch diameter hole was discovered in the 11 feet diameter piping. The hole was characterized as being nearly circular with pit walls steeply tapered from the outer diameter inward, implying that the corrosion initiated on the outer surface due to the presence of soil or groundwater. Analysis by Duke metallurgists determined that the root cause of this leak was a local galvanic cell created by a void in the exterior coating.

No unique aging effects were identified from the review or these incidents beyond those identified in this section.

3.5.2.7.4.3 CONCLUSIONS

The applicable aging effects for mechanical components exposed to an underground environment are:

- Loss of material due to general corrosion is an applicable aging effect for carbon steel and cast iron materials in the underground environment if the materials are in contact with soil or groundwater.
- Loss of material due to pitting corrosion is an applicable aging effect for the external surfaces of carbon steel, cast iron, and stainless steel materials in an underground environment if the materials are in contact with soil or groundwater.
- Loss of material due to microbiologically influenced corrosion (MIC) is an applicable aging effect for the external surfaces of carbon steel, cast iron, and stainless steel materials in an underground environment if the materials are in contact with soil or groundwater.
- Loss of material due to galvanic corrosion is an applicable aging effect for carbon steel, cast iron, and stainless steel component materials in an underground environment if the materials are in contact with soil or groundwater.
- Loss of material due to selective leaching is an applicable aging effect for cast iron component materials in an underground environment if the materials are in contact with soil or groundwater.
- Cracking due to stress corrosion is an applicable aging effect for stainless steel in an underground environment if the materials are in contact with soil or groundwater.

3.5.2.7.4.4 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 for the systems listed in Section 3.5.2.7.4 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the component external surface materials in the underground environment will be managed by monitoring and controlling either the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The relevant condition required for each of the applicable aging effects requires the presence of soil or groundwater. Oconee construction practice to preclude exposure of these component materials to soil and groundwater was to use a protective coating on the external surface of buried components. At Oconee, buried piping and other components (like the Standby Shutdown Facility Fuel Oil Tank) received an external protective coating during installation. Continued presence of an intact coating precludes the applicable aging effects on external surface material. The applicable aging effects will only be an issue if the coatings develop voids and even then the loss of material will be localized to the area of the void.

The underground CCW piping comprises greater than 90% (> 450,000 square feet) of below grade component surface area that could be exposed to soil or groundwater. The limited number of piping leaks identified for such a large surface area testifies to the success of the coatings used on components located below grade at Oconee. Because much of the CCW piping is available for internal inspection, discovery of an increasing amount of through wall corrosion would be indicative of a larger external coatings breakdown and would lead to more general corrective actions to assure component integrity. The localized nature of the limited number of piping leaks and none of these being considered a structural concern like would be caused by more wide-spread aging indicate that the aging effects on the external surfaces of these components can be managed by internal surface inspection and discovery of the symptomatic evidence of external aging. Locations where voids in the coatings occur will expose the component materials to soil or groundwater and will eventually lead to through wall corrosion. The behavior of all materials of concern here are bounded by the existing inspection on the carbon and stainless steel Condenser Circulating Water System intake and discharge piping and Standby Shutdown Facility Diesel Generator Fuel Oil Tank. Because this existing program covers the vast majority of buried component surface area and because the internal surfaces are accessible on a periodic basis, symptomatic evidence can be gathered to assess the condition of the external surfaces. The applicable aging effects will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Preventive Maintenance Activities

3.5.2.7.5 APPLICABLE AGING EFFECTS FOR AN EMBEDDED ENVIRONMENT

The embedded environment includes mechanical components within the scope of license renewal that are in contact with concrete on their external surfaces. The systems with mechanical components exposed to an embedded environment are:

- Chemical Addition System
- Condensate System
- Condenser Circulating Water System
- Coolant Storage System
- Liquid Waste Disposal System
- Low Pressure Service Water System
- Spent Fuel Cooling System (Fuel Transfer Tube)
- Turbine Sump Pump System (Keowee)

The materials of construction for the mechanical system components in these systems which are exposed to an embedded environment are identified in Tables 2.5-2 through 2.5-25. Since different component types constructed from the same material, located in the same environment, and operating under similar operating stresses will experience similar aging effects, the applicable aging effects for the external surfaces of these components can be determined on a material basis. The materials of construction for the mechanical components within the scope of license renewal located in an embedded environment are brass, carbon steel, and stainless steel. No applicable aging effects were identified for these components in an embedded environment due to the presence of the protective concrete cover.

3.5.2.7.5.1 INDUSTRY EXPERIENCE

In order to validate that no applicable aging effects exist for the mechanical component external surfaces exposed to an embedded environment, a review of industry and Oconee-specific experience was performed. The survey of industry experience included NRC generic communications, licensee event reports from nuclear plants other than Oconee, and NRC NUREGs. No documents associated with aging effects of external surfaces of mechanical components were identified.

3.5.2.7.5.2 OCONEE EXPERIENCE

Oconee operating experience was reviewed to validate that no applicable aging effects exist for the external surfaces of component materials in an embedded environment. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No aging effects were identified from this review.

3.5.2.7.5.3 CONCLUSIONS

From the Oconee aging management review and supported by a review of industry information, NRC generic communications, and Oconee operating experience, no aging effects for the component materials in an embedded environment have been identified.

3.5.2.7.5.4 AGING MANAGEMENT PROGRAMS

No aging management programs are required for brass, carbon steel and stainless steel components that are in an embedded environment due to the presence of the protective concrete cover on their external surface.

3.5.3 CONTAINMENT HEAT REMOVAL SYSTEMS

The Containment heat removal systems are those systems designed to remove heat from the Reactor Building following a design basis event and include the following:

- Reactor Building Cooling System
- Reactor Building Spray System

Section 2.5.3 provides a description of these systems and identifies the components requiring aging management review for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use this aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-1 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and are not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.3.1 Reactor Building Cooling System

3.5.3.1.1 ENVIRONMENTS

The Reactor Building Cooling System components are exposed externally to the ambient conditions within the Reactor Building. Internally, the system components are exposed to a ventilation air environment. The applicable aging effects for the materials in the ventilation air environment are identified in Section 3.5.2.6.

The Reactor Building Cooling System includes Reactor Building cooling units that are within the scope of license renewal. In order to remove post-accident heat sufficiently from the Reactor Building, the Reactor Building cooling units must remain functional. The Reactor Building cooling units, which are located in the Reactor Building, are exposed to raw water (from the Low Pressure Service Water System) through the tubes and ventilation air through the ducts and on the outside of the tubes. The applicable aging effects for the materials in the raw water environment are identified in Section 3.5.2.4 and for the materials in the ventilation air environment, the applicable aging effects are identified in Section 3.5.2.6.

3.5.3.1.2 APPLICABLE AGING EFFECTS

The Reactor Building Cooling System contains ductwork constructed of aluminum, galvanized steel, and stainless steel exposed to ventilation air. The applicable aging effect for the system components exposed to a ventilation air environment is loss of material in the aluminum and galvanized steel components. No applicable aging effects have been identified for the stainless steel components exposed to a ventilation air environment.

The Reactor Building cooling units are constructed of 90-10 copper-nickel tubes exposed to ventilation air and raw water, tube fins constructed from copper exposed to ventilation air, and stainless steel headers exposed to raw water. The applicable aging effects for the portions of the Reactor Building cooling units exposed to a raw water environment are loss of material and fouling. The applicable aging effect for the portions of the Reactor Building cooling units exposed to a ventilation air environment is loss of material.

3.5.3.1.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Reactor Building Cooling System components will be managed by monitoring and controlling either the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the aluminum, copper, 90-10 copper-nickel, and galvanized steel components exposed to a ventilation air environment will be managed by maintenance activities that inspect and clean the Reactor Building cooling units and ductwork. These maintenance activities will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Preventive Maintenance Activities

The loss of material and fouling for portions of the Reactor Building cooling units exposed to a raw water environment will be managed through testing to verify cooling unit heat removal capability and maintenance activities to inspect the internal portions of the cooling units. These testing and maintenance activities will be implemented by the following activities which are described in Chapter 4 of OLRP-1001:

- Heat Exchanger Performance Testing Activities
- Preventive Maintenance Activities

3.5.3.2 Reactor Building Spray System

3.5.3.2.1 ENVIRONMENTS

The Reactor Building Spray System is exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system is exposed to a borated water environment (upstream of the pump discharge valves) and to an air environment (downstream of the pump discharge valves). The applicable aging effects for the materials in the borated water environment are identified in Section 3.5.2.2 and for the materials in an air environment, the applicable aging effects are identified in Section 3.5.2.1.

3.5.3.2.2 AGING EFFECTS

The Reactor Building Spray System contains piping, valves, and other components constructed of stainless steel. The applicable aging effects for the system components exposed to a borated water environment are loss of material and cracking in the stainless steel components. The applicable aging effects for the system components exposed to an air environment are loss of material and cracking in the stainless steel components.

3.5.3.2.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Reactor Building Spray System will be managed by monitoring and controlling either the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the components constructed of stainless steel exposed to a borated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of loss of material and cracking. The relevant conditions in the Reactor Building Spray System will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

The loss of material and cracking for the stainless steel components exposed to an air environment have not been fully characterized and their applicability will need to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Reactor Building Spray System Inspection

3.5.4 Containment Isolation System

Containment isolation is an engineered safety feature that provides for the closure of all fluid penetrations not required for operation of the Engineered Safeguards System to prevent the leakage of uncontrolled or unmonitored radioactive materials to the environment following a design basis event. Containment Isolation includes the following systems:

- Breathing Air System
- Component Cooling System
- Demineralized Water System
- Filtered Water System
- Gaseous Waste Disposal System
- Instrument Air System
- Leak Rate Test System
- Liquid Waste Disposal System
- Nitrogen Purge and Blanket System
- Reactor Building Purge System

Section 2.5.4 provides a description of these systems and identifies the components requiring aging management review for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-2 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and are not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.4.1 Breathing Air System

3.5.4.1.1 ENVIRONMENTS

The Breathing Air System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to an air environment. The applicable aging effects for the materials in an air environment are identified in Section 3.5.2.1.

3.5.4.1.2 APPLICABLE AGING EFFECTS

The Breathing Air System contains piping and valves constructed of stainless steel. No applicable aging effects have been identified for the stainless steel components exposed to an air environment.

3.5.4.1.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Breathing Air System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.4.2 Component Cooling System

3.5.4.2.1 ENVIRONMENTS

The Component Cooling System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to a treated water environment. The applicable aging effects for the materials in a treated water environment are identified in Section 3.5.2.5.

3.5.4.2.2 APPLICABLE AGING EFFECTS

The Component Cooling System contains piping and valves constructed of carbon steel and stainless steel. The applicable aging effects for the system components exposed to treated water are the loss of material in the carbon steel components and cracking in the stainless steel components (cracking is applicable only to Unit 2).

3.5.4.2.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Component Cooling System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the carbon steel components exposed to a treated water environment will be managed by controlling the environment with a corrosion inhibitor. The environment will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

Cracking in the stainless steel components (applicable only to Unit 2) exposed to a treated water environment have not been fully characterized and its applicability will need to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Treated Water Systems Stainless Steel Inspection

3.5.4.3 Demineralized Water System

3.5.4.3.1 ENVIRONMENTS

The Demineralized Water System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to demineralized water (treated water environment). The applicable aging effects for the materials in a treated water environment are identified in Section 3.5.2.5.

3.5.4.3.2 APPLICABLE AGING EFFECTS

The Demineralized Water System contains piping and valves constructed of stainless steel. The applicable aging effects for the stainless steel components exposed to a treated water environment are loss of material and cracking.

3.5.4.3.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Demineralized Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the stainless steel components exposed to a treated water environment have not been fully characterized and their applicability will need to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Treated Water Systems Stainless Steel Inspection

3.5.4.4 Filtered Water System

3.5.4.4.1 ENVIRONMENTS

The Filtered Water System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to filtered water (treated water environment). The applicable aging effects for the materials in a treated water environment are identified in Section 3.5.2.5.

3.5.4.4.2 APPLICABLE AGING EFFECTS

The Filtered Water System contains piping and valves constructed of stainless steel. The applicable aging effects for the stainless steel components exposed to a treated water environment are loss of material and cracking.

3.5.4.4.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Filtered Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the stainless steel components exposed to a treated water environment have not been fully characterized and their applicability will need to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Treated Water Systems Stainless Steel Inspection

3.5.4.5 Gaseous Waste Disposal System

3.5.4.5.1 ENVIRONMENTS

The Gaseous Waste Disposal System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to nitrogen from an air/gas environment. The applicable aging effects for the materials in an air/gas environment are identified in Section 3.5.2.1.

3.5.4.5.2 APPLICABLE AGING EFFECTS

The Gaseous Waste Disposal System contains piping and valves constructed of stainless steel. No applicable aging effects have been identified for the stainless steel components in a nitrogen environment.

3.5.4.5.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Gaseous Waste Disposal System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.4.6 Instrument Air System

3.5.4.6.1 ENVIRONMENTS

The Instrument Air System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to an air environment. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1

3.5.4.6.2 APPLICABLE AGING EFFECTS

The Instrument Air System contains piping and valves constructed of carbon steel and stainless steel. No applicable aging effects have been identified for the carbon steel or the stainless steel components in a dry air environment.

3.5.4.6.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Instrument Air System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.4.7 Leak Rate Test System

3.5.4.7.1 ENVIRONMENTS

The Leak Rate Test System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to an air environment. The applicable aging effects for the materials in an air/gas environment are identified in Section 3.5.2.1.

3.5.4.7.2 APPLICABLE AGING EFFECTS

The Leak Rate Test System contains piping, valves, and other components constructed of carbon steel and stainless steel. No applicable aging effects have been identified for the carbon steel or the stainless steel components in an air environment.

3.5.4.7.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Leak Rate Test System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.4.8 Liquid Waste Disposal System

3.5.4.8.1 ENVIRONMENTS

The Liquid Waste Disposal System components are exposed externally to the ambient conditions within the Auxiliary Building with some portions of the system embedded in concrete. Internally, the system components are exposed to a borated water environment. The applicable aging effects for the materials in a borated water environment are identified in Section 3.5.2.2.

3.5.4.8.2 APPLICABLE AGING EFFECTS

The Liquid Waste Disposal System contains piping and valves constructed of stainless steel. The applicable aging effects for the stainless steel components exposed to a borated water environment are loss of material and cracking.

3.5.4.8.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Liquid Waste Disposal System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the stainless steel components exposed to a borated water environment have not been fully characterized and their applicability will need to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Treated Water Systems Stainless Steel Inspection

3.5.4.9 Nitrogen Purge and Blanketing System

3.5.4.9.1 ENVIRONMENTS

The Nitrogen Purge and Blanketing System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed primarily to a nitrogen environment with some portions exposed to a borated water environment during makeup to the core flood tanks. The applicable aging effects for the materials in an air/gas environment are identified in Section 3.5.2.1 and the materials in a borated water environment are identified in Section 3.5.2.2.

3.5.4.9.2 APPLICABLE AGING EFFECTS

The Nitrogen Purge and Blanketing System contains piping, valves, and other components constructed of carbon steel and stainless steel. No applicable aging effects have been identified for the carbon steel or stainless steel components exposed to a nitrogen environment. The applicable aging effects for the stainless steel components exposed to a borated water environment are loss of material and cracking. The carbon steel components are only exposed to a nitrogen environment.

3.5.4.9.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Nitrogen Purge and Blanketing System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the stainless steel components exposed to a borated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

The cracking in the stainless steel components exposed to a borated water environment has not been fully characterized and its applicability will need to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Reactor Building Spray System Inspection

3.5.4.10 Reactor Building Purge System

3.5.4.10.1 ENVIRONMENTS

The Reactor Building Purge System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to air (a ventilation air environment). The applicable aging effects for the materials in a ventilation air environment are identified in Section 3.5.2.6.

3.5.4.10.2 APPLICABLE AGING EFFECTS

The Reactor Building Purge System contains ductwork, piping, valves, and other components constructed of aluminum, brass, carbon steel, copper, galvanized steel, and stainless steel. No applicable aging effects have been identified for the components constructed from these materials in a ventilation air environment.

3.5.4.10.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Reactor Building Purge System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.5 Emergency Core Cooling Systems

The emergency core cooling systems are those systems designed to cool the reactor core and provide shutdown capability following a design basis accident and include the following:

- Core Flood System
- High Pressure Injection System
- Low Pressure Injection System

Section 2.5.5 provides a description of these systems and identifies the components requiring aging management for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use this aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-3 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and are not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.5.1 Core Flood System

3.5.5.1.1 ENVIRONMENTS

The Core Flood System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed primarily to a borated water environment with portions exposed to a nitrogen environment in the core flood tanks. The applicable aging effects for the materials in the borated water environment are identified in Section 3.5.2.2. For the materials exposed to nitrogen, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

3.5.5.1.2 APPLICABLE AGING EFFECTS

The Core Flood System contains piping, valves, and other components constructed of carbon steel, inconel, and stainless steel. The applicable aging effects for the system components exposed to a borated water environment are loss of material and cracking in the inconel and stainless steel components.

No applicable aging effects have been identified for the inconel and stainless steel components exposed to a nitrogen environment. The carbon steel is not exposed to borated water or nitrogen since the core flood tanks are cladded internally with stainless steel.

3.5.5.1.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Core Flood System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the subject components exposed to a borated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.5.2 High Pressure Injection System

3.5.5.2.1 ENVIRONMENTS

The High Pressure Injection System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed primarily to a borated water environment with portions exposed to a hydrogen environment inside the letdown storage tank. The applicable aging effects for the materials in the borated water environment are identified in Section 3.5.2.2. For the materials exposed to Hydrogen, applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

In order to maintain the reactor coolant pump seal flow path and prevent the dilution of borated water, components in the High Pressure Injection System must remain intact including the reactor coolant pump seal return coolers and the reactor coolant pump coolers (applicable to Unit 2 and Unit 3 only).

The reactor coolant pump seal return coolers, which are located in the Auxiliary Building, are exposed to treated water (from the Recirculated Cooling Water System) through the tubes and borated water (from the High Pressure Injection System) in the shell and on the outside of the tubes. The applicable aging effects for the materials in the treated water environment are identified in Section 3.5.2.5 and for the materials in the borated water environment, the applicable aging effects are identified in Section 3.5.2.2.

The reactor coolant pump coolers, which are located in the Reactor Building, are exposed to borated water (from the High Pressure Injection System) through the inner coil and treated water (from the Component Cooling System) in the outer coil and on the outside of the inner coil. The applicable aging effects for the materials in the borated water environment are identified in Section 3.5.2.2 and for the materials in the treated water environment, the applicable aging effects are identified in Section 3.5.2.5.

3.5.5.2.2 APPLICABLE AGING EFFECTS

The High Pressure Injection System contains piping, valves, and other components constructed of stainless steel. The applicable aging effects for the system components exposed to a borated water environment are loss of material and cracking in the stainless steel components. No applicable aging effects have been identified for the stainless steel components exposed to a hydrogen environment.

The channel heads of the reactor coolant pump seal return coolers are constructed from carbon steel with all other components of the coolers constructed from stainless steel. The applicable aging effects for components in the reactor coolant pump seal return coolers exposed to a treated water or borated water environment are the loss of material and cracking in the stainless steel components. The carbon steel components in these coolers are not within the scope of license renewal.

The reactor coolant pump coolers are constructed entirely from stainless steel. The applicable aging effect for the stainless steel reactor coolant pump coolers exposed to a borated water or a treated water environment is cracking.

3.5.5.2.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the High Pressure Injection System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the stainless steel components, including the heat exchangers, exposed to a borated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

The loss of material for the stainless steel components, including the heat exchangers, exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

Cracking in the stainless steel components, including the heat exchangers, exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect and monitoring for evidence that leakage has occurred. The relevant conditions will be controlled by and leakage monitoring will be performed by the following programs which are described in Chapter 4 of OLRP-1001:

- Chemistry Control Program (RCP seal return coolers only)
- Reactor Coolant System Operational Leakage Monitoring

3.5.5.3 Low Pressure Injection System

3.5.5.3.1 ENVIRONMENTS

The Low Pressure Injection System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building with portions of the system components being exposed to the yard environment (some piping, valves, and the borated water storage tank). Internally, the system components are exposed primarily to a borated water environment with portions exposed to an air environment (upper portion of the borated water storage tank). The applicable aging effects for the materials in the borated water environment are identified in Section 3.5.2.2 and for the materials in an air/gas environment the applicable aging effects are identified in Section 3.5.2.1.

In order to provide the necessary heat removal and maintain the Reactor Coolant System pressure boundary, the decay heat removal coolers must remain intact and provide a heat transfer function. The decay heat removal coolers, which are located in the Auxiliary Building, are exposed to borated water (from the Reactor Coolant System) through the tubes and raw water (from the Low Pressure Service Water System) in the shell and on the outside of the tubes. The applicable aging effects for the materials in the borated water environment are identified in Section 3.5.2.2 and for the materials exposed to the raw water environment the applicable aging effects are identified in Section 3.5.2.4.

3.5.5.3.2 APPLICABLE AGING EFFECTS

The Low Pressure Injection System contains piping, valves, and other components constructed of carbon steel and stainless steel. The applicable aging effects for the system components exposed to a borated water environment are loss of material in the carbon steel and stainless steel components and cracking in the stainless steel components.

The applicable aging effects for the system components exposed to an air environment are loss of material in the carbon steel components. There are no stainless steel components in this system exposed internally to an air environment.

The shell of the decay heat removal coolers is constructed from carbon steel with all other components of the heat exchangers constructed from stainless steel. The applicable aging effects for the components in the heat exchangers exposed to a borated water environment are loss of material and cracking in the stainless steel components. The carbon steel shell is not exposed to borated water.

The applicable aging effects for components in the decay heat removal coolers exposed to a raw water environment are loss of material in the carbon steel and stainless steel components and fouling in the stainless steel components.

3.5.5.3.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Low Pressure Injection System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the stainless steel components, including the decay heat removal coolers, exposed to a borated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effects. The relevant conditions will be controlled by following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

The loss of material for the carbon steel components exposed to an air environment or a borated water environment will be managed by inspecting the components for evidence that the coating has failed. This inspection will be performed by following activity which is described in Chapter 4 of OLRP-1001:

- Preventive Maintenance Activities

The loss of material for the portions of the decay heat removal coolers exposed to a raw water environment will be managed by the following program and activity which are described in Chapter 4 of OLRP-1001:

- Preventive Maintenance Activities
- Service Water Piping Corrosion Program

The loss of material due to galvanic corrosion of carbon steel components for the portions of the decay heat removal coolers exposed to a raw water environment has not been fully characterized and will need to be verified by a one-time inspection whose results will be applied to this cooler. The inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

Fouling in the portions of the decay heat removal coolers exposed to a raw water environment will be managed by the following activity which is described in Chapter 4 of OLRP-1001:

- Heat Exchanger Performance Testing Activities

3.5.6 AUXILIARY SYSTEMS

The auxiliary systems are those systems required to support the reactor during normal operation and include the following:

- Spent Fuel Cooling System
- Auxiliary Service Water System
- Condenser Circulating Water System
- High Pressure Service Water System
- Low Pressure Service Water System

Section 2.5.6 provides a description of these systems and identifies the components requiring aging management review for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use this aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-4 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and are not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.6.1 Spent Fuel Cooling System

3.5.6.1.1 ENVIRONMENTS

The Spent Fuel Cooling System components are exposed externally to the ambient conditions within the Auxiliary Building except for the spent fuel transfer tube, parts of which are exposed to the Reactor Building environment, immersed in borated water, or embedded in concrete. Internally, the system components are exposed to a borated water environment. The applicable aging effects for the materials in the borated water environment (internally as well as any external exposure to borated water) are identified in Section 3.5.2.2.

In order to maintain the necessary flow path to the spent fuel pool, the spent fuel coolers must remain intact. The spent fuel coolers, which are located in the Auxiliary Building, are exposed to treated water (from the Recirculating Cooling Water System) through the tubes and borated water (from the Spent Fuel Pool) in the shell and on the outside of the tubes. The applicable aging effects for the materials in the borated water environment are identified in Section 3.5.2.2 and for the materials in the treated water environment, the applicable aging effects are identified in Section 3.5.2.5.

3.5.6.1.2 APPLICABLE AGING EFFECTS

The Spent Fuel Cooling System contains piping, valves, and other components constructed of stainless steel including the spent fuel coolers. The applicable aging effects for the stainless steel components and heat exchangers exposed to a borated water environment are loss of material and cracking.

The applicable aging effects for the stainless steel components in the spent fuel coolers exposed to a treated water environment are loss of material and cracking.

3.5.6.1.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Spent Fuel Cooling System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the subject components exposed to a borated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

The loss of material and cracking for the portions of the spent fuel coolers exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.6.2 Auxiliary Service Water System

3.5.6.2.1 ENVIRONMENTS

The Auxiliary Service Water System components are exposed externally to the ambient conditions within the Auxiliary Building and the Turbine Building. Internally, the system components are exposed to a raw water environment (upstream of the pump discharge valve) and to an air environment (downstream of the pump discharge valve). The applicable aging effects for the materials in the raw water environment are identified in Section 3.5.2.4 and for the materials in an air/gas environment, the applicable aging effects are identified in Section 3.5.2.1.

3.5.6.2.2 APPLICABLE AGING EFFECTS

The Auxiliary Service Water System contains piping, valves, and other components constructed of carbon steel, cast iron, and stainless steel. The applicable aging effects for the system components exposed to a raw water environment are loss of material and fouling in the carbon steel, cast iron (except for fouling in the pump casing), and stainless steel components.

The applicable aging effects for the system components exposed to an air environment are loss of material in the carbon steel and stainless steel components. Cast iron components in this system are not exposed to an air environment.

3.5.6.2.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Auxiliary Service Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and fouling for the subject components exposed to a raw water environment will be managed by the following program and activity which are described in Chapter 4 of OLRP-1001:

- Service Water Piping Corrosion Program
- System Performance Testing Activities

The loss of material due to galvanic corrosion of the carbon steel and cast iron components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of the galvanic couple will be inspected with the results being applied to all the galvanic couples. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

The loss of material due to selective leaching of cast iron components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of cast iron components will be inspected with the results being applied to all cast iron components. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Cast Iron Selective Leaching Inspection

The loss of material for the subject components exposed to an air environment will be managed by visual inspection. The visual inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Preventive Maintenance Activities

3.5.6.3 Condenser Circulating Water System

3.5.6.3.1 ENVIRONMENTS

The Condenser Circulating Water System components are exposed externally to the ambient conditions within the Auxiliary Building and the Turbine Building, the Intake Structure, and outside yard with portions exposed externally to an embedded or underground environment. Internally, the system components are exposed to a raw water environment. The applicable aging effects for the materials in a raw water environment are identified in Section 3.5.2.4.

3.5.6.3.2 APPLICABLE AGING EFFECTS

The Condenser Circulating Water System contains piping, valves, and other components constructed of bronze, carbon steel, and stainless steel. The applicable aging effects for the system components exposed to a raw water environment are loss of material in the bronze, carbon steel, and stainless steel components.

3.5.6.3.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Condenser Circulating Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions that contribute to the onset and propagation of a specific aging effect.

The loss of material for the bronze, carbon steel, and stainless steel components exposed to a raw water environment will be managed by inspection and analysis to verify integrity of service water components. This inspection and analysis will be performed by the following program which is described in Chapter 4 of OLRP-1001:

- Service Water Piping Corrosion Program

The loss of material due to galvanic corrosion of the carbon steel components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of the galvanic couple will be inspected with the results being applied to all the galvanic couples. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

The loss of material for the underground large-diameter carbon steel piping exposed to a raw water environment will be managed by the inspection of the interior surfaces for signs of degradation. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Preventive Maintenance Activities

3.5.6.4 High Pressure Service Water System

3.5.6.4.1 ENVIRONMENTS

The High Pressure Service Water System components are exposed externally to the ambient conditions within the Auxiliary Building, Turbine Building, and outside yard with portions of the piping located underground. Internally, the system components are exposed primarily to a raw water environment with portions exposed to an air environment (in the dry pipe portion of the Fire Protection System). The applicable aging effects for the materials in the raw water environment are identified in Section 3.5.2.4 and for the materials in the air/gas environment, the applicable aging effects are identified in Section 3.5.2.1.

3.5.6.4.2 APPLICABLE AGING EFFECTS

The High Pressure Service Water System contains piping, valves, and other components constructed of bronze, cast iron, carbon steel, and stainless steel. The applicable aging effects for the system components exposed to a raw water environment are loss of material and fouling in the bronze, cast iron, carbon steel, and stainless steel components. Fouling of the cast iron pump casing is not an applicable aging effect.

The applicable aging effects for the system components exposed to an air environment are loss of material in the carbon steel, cast iron, and stainless steel components. No bronze components are exposed to an air environment.

3.5.6.4.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the High Pressure Service Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions that contribute to the onset and propagation of a specific aging effect.

The loss of material and fouling for the subject components exposed to a raw water environment will be managed by inspection and analysis to verify integrity of service water components, and testing, inspection, and maintenance activities. These actions will be performed by the following programs which are described in Chapter 4 of OLRP-1001:

- Service Water Piping Corrosion Program
- Fire Protection Program

The loss of material due to galvanic corrosion of the carbon steel and cast iron components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of the galvanic couple will be inspected with the results being applied to all the galvanic couples. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

The loss of material due to selective leaching of cast iron components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of cast iron components will be inspected with the results being applied to all cast iron components. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Cast Iron Selective Leaching Inspection

The loss of material for the subject components exposed to an air environment will be managed by testing, inspection, and maintenance activities. These actions will be performed by the following program which is described in Chapter 4 of OLRP-1001:

- Fire Protection Program

3.5.6.5 Low Pressure Service Water System

3.5.6.5.1 ENVIRONMENTS

The Low Pressure Service Water System components are exposed externally to the ambient conditions within the Reactor Building, Auxiliary Building, and Turbine Building with portions of the piping embedded. Internally, the system components are exposed to a raw water environment. The applicable aging effects for the materials in a raw water environment are identified in Section 3.5.2.4.

In order to maintain the Low Pressure Service Water System pressure boundary, the component coolers must remain intact. The component coolers, which are located in the Auxiliary Building, are exposed to raw water (from the Low Pressure Service Water System) through the tubes and treated water (from the Component Cooling System) in the shell and on the outside of the tubes. The applicable aging effects for the materials in the raw water environment are identified and for components in the treated water environment, the applicable aging effects are identified in Section 3.5.2.5.

3.5.6.5.2 APPLICABLE AGING EFFECTS

The Low Pressure Service Water System contains piping, valves, and other components constructed of brass, bronze, carbon steel, cast iron, copper, and stainless steel. The applicable aging effects for the system components exposed to a raw water environment are loss of material and fouling in the brass, bronze, carbon steel, cast iron, copper and stainless steel components.

The component coolers are constructed of admiralty brass tubes and tube sheets, and carbon steel channel heads and shell. The applicable aging effects for the heat exchanger components exposed to a raw water environment are loss of material in the admiralty brass and carbon steel components. The applicable aging effect for the heat exchanger components exposed to a treated water environment is loss of material in the admiralty brass and carbon steel components.

3.5.6.5.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Low Pressure Service Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions that contribute to the onset and propagation of a specific aging effect.

The loss of material and fouling for the system components (except the heat exchangers) exposed to a raw water environment will be managed by inspection and analysis to verify the integrity of the service water components. In addition, performance testing verifies the capability of these components to perform their component intended functions. These actions will be performed by the following program and activities which are described in Chapter 4 of OLRP-1001:

- Service Water Piping Corrosion Program
- System Performance Testing Activities

The loss of material due to galvanic corrosion of the carbon steel, copper, and brass components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of the galvanic couple will be inspected with the results being applied to all the galvanic couples. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

The loss of material for the portions of the component coolers exposed to a raw water environment will be managed by the testing and inspection of the coolers. These activities will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Preventive Maintenance Activities

The loss of material for the portions of the component coolers exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.7 PROCESS AUXILIARIES

The process auxiliary systems are those systems required to support the reactor during normal operation and include the following:

- Chemical Addition System
- Coolant Storage System

Section 2.5.7 provides a description of these systems and identifies the components requiring aging management review for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use this aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-5 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.7.1 Chemical Addition System

3.5.7.1.1 ENVIRONMENTS

The Chemical Addition System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to a treated water environment where samples are drawn from the secondary side of the steam generators and exposed to a borated water environment where samples are drawn from the primary side of the steam generators. The applicable aging effects for the materials in a treated water environment are identified in Section 3.5.2.5 and for the materials in the borated water environment, the applicable aging effects are identified in Section 3.5.2.2.

3.5.7.1.2 APPLICABLE AGING EFFECTS

The Chemical Addition System contains piping, valves, and other components constructed of stainless steel. The applicable aging effects for the stainless steel components exposed to a treated water environment are loss of material and cracking. The applicable aging effects for the stainless steel components exposed to a borated water environment are also loss of material and cracking.

3.5.7.1.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Chemical Addition System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the subject components exposed to treated water and borated water environments will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

In addition, loss of material and cracking for the stainless steel components exposed to a treated water environment in the caustic addition portion of this system cannot be fully characterized and their applicability needs to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Treated Water Systems Stainless Steel Inspection

3.5.7.2 Coolant Storage System

3.5.7.2.1 ENVIRONMENTS

The Coolant Storage System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building with portions of the system piping exposed to an embedded environment. Internally, the system components are exposed to a borated water environment. The applicable aging effects for the materials in the borated water environment are identified in Section 3.5.2.2.

3.5.7.2.2 APPLICABLE AGING EFFECTS

The Coolant Storage System contains piping, valves, and other components constructed of stainless steel. The applicable aging effects for the system components exposed to a borated water environment are loss of material and cracking in the stainless steel components.

3.5.7.2.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Coolant Storage System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking will be managed for the subject components exposed to a borated water environment by controlling the relevant conditions that could lead to the onset and propagation of the aging effects. The relevant conditions will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.8 Air Conditioning, Heating, Cooling and Ventilation Systems

The air conditioning, heating, cooling and ventilation systems are those systems designed to maintain the ambient air conditions within the Auxiliary Building and include the following:

- Auxiliary Building Ventilation System
- Control Room Pressurization and Filtration System
- Penetration Room Ventilation System

Section 2.5.8 provides a description of these systems and identifies the components requiring aging management review for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use this aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-6 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.8.1 Auxiliary Building Ventilation System

3.5.8.1.1 ENVIRONMENTS

The Auxiliary Building Ventilation System components are exposed externally to the ambient conditions within the Auxiliary Building. Internally, the system components are exposed to a ventilation air environment. The applicable aging effects for the materials in a ventilation air environment are identified in Section 3.5.2.6.

3.5.8.1.2 APPLICABLE AGING EFFECTS

The Auxiliary Building Ventilation System contains ductwork and other components constructed of aluminum, galvanized steel, and stainless steel. No applicable aging effects have been identified for the components constructed from these materials in a ventilation air environment.

3.5.8.1.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Auxiliary Building Ventilation System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.8.2 Control Room Pressurization and Filtration System

3.5.8.2.1 ENVIRONMENTS

The Control Room Pressurization and Filtration System components are exposed externally to the ambient conditions within the Auxiliary Building. Internally, the system components are exposed to a ventilation air environment. The applicable aging effects for the materials in a ventilation air environment are identified in Section 3.5.2.6.

3.5.8.2.2 APPLICABLE AGING EFFECTS

The Control Room Pressurization and Filtration System contains ductwork and other components constructed of aluminum, brass, carbon steel, copper, galvanized steel, and stainless steel. No applicable aging effects have been identified for the components constructed from these materials in a ventilation air environment.

3.5.8.2.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Control Room Pressurization and Filtration System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.8.3 Penetration Room Ventilation System

3.5.8.3.1 ENVIRONMENTS

The Penetration Room Ventilation System components are exposed externally to the ambient conditions within the Auxiliary Building. Internally, the system components are exposed to a ventilation air environment. The applicable aging effects for the materials in a ventilation air environment are identified in Section 3.5.2.6.

3.5.8.3.2 APPLICABLE AGING EFFECTS

The Penetration Room Ventilation System contains piping, valves, and other components constructed of aluminum, brass, carbon steel, copper, galvanized steel, and stainless steel. No applicable aging effects have been identified for the components constructed from these materials in a ventilation air environment.

3.5.8.3.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Penetration Room Ventilation System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.9 STEAM AND POWER CONVERSION SYSTEMS

The steam and power conversion systems are those systems designed to remove heat from the Reactor Coolant System and include the following:

- Main Steam System
- Condensate System
- Emergency Feedwater System
- Feedwater System

Section 2.5.9 provides a description of these systems and identifies the components requiring aging management review for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use this aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-7 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.9.1 Main Steam System

3.5.9.1.1 ENVIRONMENTS

The Main Steam System components are exposed externally to the ambient conditions within the Reactor Building, the Auxiliary Building, and the Turbine Building with portions of the system exposed to the yard environment. Internally, the system components are exposed to a treated water environment. The applicable aging effects for the materials in a treated water environment are identified in Section 3.5.2.5.

3.5.9.1.2 APPLICABLE AGING EFFECTS

The Main Steam System contains piping, valves, and other components constructed of carbon steel and stainless steel. The applicable aging effects for the system components exposed to a treated water environment are loss of material in the carbon steel and stainless steel components and cracking in the stainless steel components.

3.5.9.1.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Main Steam System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the carbon steel components exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. In addition, inspection and analysis will be performed to investigate and verify the integrity of the piping systems. Controlling the relevant conditions and verifying the integrity of the piping will be performed by the following programs which are described in Chapter 4 of OLRP-1001:

- Chemistry Control Program
- Piping Erosion/Corrosion Program

The loss of material and cracking for the stainless steel components exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. Controlling the relevant conditions will be performed by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.9.2 Condensate System

3.5.9.2.1 ENVIRONMENTS

The Condensate System components are exposed externally to the ambient conditions within the Turbine Building with portions of the system piping embedded. Internally, the system components are exposed primarily to a treated water environment with portions exposed to a vacuum environment at the top of the upper surge tanks and upper regions of the condenser hotwell. The applicable aging effects for the materials in a treated water environment are identified in Section 3.5.2.5. For the materials exposed to a vacuum, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

The Condensate System components include main condensers, condensate coolers, and generator water coolers that are within the scope of license renewal. In order to maintain the pressure boundary of the Condensate System (as well as the Condenser Circulating Water System), these heat exchangers, which are located in the Turbine Building, must remain intact. The main condensers and the condensate coolers are exposed to raw water through the tubes (condenser circulating water) and treated water in the shell and on the outside of the tubes (condensate). The generator water coolers are exposed to treated water through the tubes (condensate) and treated water in the shell and on the outside of the tubes (stator cooling water). The applicable aging effects for the materials in the treated water environment are identified in Section 3.5.2.5 and for the materials in the raw water environment the applicable aging effects are identified in Section 3.5.2.4.

3.5.9.2.2 APPLICABLE AGING EFFECTS

The Condensate System contains piping, valves, and other components constructed of brass, carbon steel, cast iron, copper, and stainless steel. The applicable aging effects for the system components exposed to a treated water environment are loss of material in the brass, carbon steel, cast iron, copper and stainless steel components and cracking in the stainless steel components. No applicable aging effects were identified for the system components exposed to a vacuum environment.

The tubes of the main condenser and the condensate coolers are constructed from stainless steel with all other components of the heat exchangers constructed from carbon steel. The applicable aging effects for components in the heat exchangers exposed to a treated water environment are loss of material in the carbon steel and stainless steel components and cracking in the stainless steel components. The applicable aging effects for components in the heat exchangers exposed to a raw water environment are loss of material in the carbon steel and stainless steel components.

The generator water coolers are constructed entirely from stainless steel. The applicable aging effect for stainless steel components in the heat exchangers exposed to a treated water environment is cracking.

3.5.9.2.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Condensate System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the system components exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

The loss of material due to selective leaching of cast iron components exposed to a treated water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of cast iron components will be inspected with the results being applied to all cast iron components. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Cast Iron Selective Leaching Inspection

The loss of material for the stainless steel components of the heat exchangers exposed to a raw water environment will be managed by testing and inspection to verify component integrity. These activities will be performed by following activity which is described in Chapter 4 of OLRP-1001:

- Preventive Maintenance Activities

The loss of material for the carbon steel components of the heat exchangers exposed to a raw water environment will be managed by inspection and analysis to verify integrity of service water components. This inspection and analysis will be performed by the following program which is described in Chapter 4 of OLRP-1001:

- Service Water Piping Corrosion Program

The loss of material due to galvanic corrosion of the carbon steel components of the heat exchangers exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of galvanic couples will be inspected with the results being applied to all galvanic couples. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

3.5.9.3 Emergency Feedwater System

3.5.9.3.1 ENVIRONMENTS

The Emergency Feedwater System components are exposed externally to the ambient conditions within the Reactor Building and the Turbine Building. Internally, the system components are exposed to a treated water environment. The applicable aging effects for the materials in a treated water environment are identified in Section 3.5.2.5.

3.5.9.3.2 APPLICABLE AGING EFFECTS

The Emergency Feedwater System contains piping, valves, and other components constructed of carbon steel, low-alloy steel, and stainless steel. The applicable aging effects for the system components exposed to a treated water environment are loss of material in the carbon steel, low-alloy steel, and stainless steel components and cracking in the stainless steel components.

3.5.9.3.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Emergency Feedwater System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the subject components exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.9.4 Feedwater System

3.5.9.4.1 ENVIRONMENTS

The Feedwater System components are exposed externally to the ambient conditions within the Reactor Building, Auxiliary Building, and Turbine Building. Internally, the system components are exposed to a treated water environment. The applicable aging effects for the materials in a treated water environment are identified in Section 3.5.2.5.

3.5.9.4.2 APPLICABLE AGING EFFECTS

The Feedwater System contains piping, valves, and other components constructed of carbon steel and stainless steel. The applicable aging effects for the system components exposed to a treated water environment are loss of material in the carbon steel and stainless steel components and cracking in the stainless steel components.

3.5.9.4.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Feedwater System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the carbon steel components exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. In addition, inspection and analysis is performed to investigate and verify the integrity of the piping systems. Controlling the relevant conditions and verifying the integrity of the piping will be performed by the following programs which are described in Chapter 4 of OLRP-1001:

- Chemistry Control Program
- Piping Erosion/Corrosion Program

The loss of material and cracking in the stainless steel components exposed to a treated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.10 POST-ACCIDENT HYDROGEN CONTROL

The post-accident hydrogen control systems are those systems designed to preclude excessive hydrogen concentrations from occurring within the Reactor Building following certain design basis accidents and include the following:

- Containment Hydrogen Control System
- Post-Accident Monitoring System

Section 2.5.10 provides a description of these systems and identifies the components requiring aging management review for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use this aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-8 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and are not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.10.1 Containment Hydrogen Control System

3.5.10.1.1 ENVIRONMENTS

The Containment Hydrogen Control System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to an air environment. The applicable aging effects for the materials in an air/gas environment are identified in Section 3.5.2.1.

The hydrogen recombiner is a part of the Containment Hydrogen Control System but is discussed separately since it is not a permanently installed piece of equipment. The hydrogen recombiner is exposed externally to the ambient conditions in an on-site warehouse. Internally, the system components are exposed to an air environment. The applicable aging effects for the materials in an air/gas environment are identified in Section 3.5.2.1.

3.5.10.1.2 APPLICABLE AGING EFFECTS

The Containment Hydrogen Control System contains piping, valves, and other components constructed of stainless steel. No applicable aging effects have been identified for the stainless steel components in an air environment.

The hydrogen recombiner contains mechanical components constructed of stainless steel. No applicable aging effects have been identified for the stainless steel components in an air environment.

3.5.10.1.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Containment Hydrogen Control System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

No applicable aging effects have been identified for the hydrogen recombiner, which is within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.10.2 Post-Accident Monitoring System

3.5.10.2.1 ENVIRONMENTS

The Post-Accident Monitoring System components are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to an air environment. The applicable aging effects for the materials in an air/gas environment are identified in Section 3.5.2.1.

3.5.10.2.2 APPLICABLE AGING EFFECTS

The Post-Accident Monitoring System contains piping, tubing, and valves constructed of stainless steel. No applicable aging effects have been identified for the stainless steel components in an air environment.

3.5.10.2.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Post-Accident Monitoring System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.11 Reactor Coolant Pump Motor Oil Collection System

The Reactor Coolant Pump Motor Oil Collection System is described in Section 2.5.11 of ORLP-1001. This system is a subsystem of the Reactor Coolant System. Due to the substantial differences between this subsystem and the remaining Reactor Coolant System, the oil collection system is addressed separately. The system intended function is to provide for oil collection and drainage as part of the fire protection of the reactor coolant pump motors.

The aging effects of the components applicable to the materials and environment combinations are described in Section 3.5.2. The following sections describe the applicable aging effects for the system components with the results summarized in Table 3.5-9.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.11.1 Environments

The Reactor Coolant Pump Motor Oil Collection System components are exposed externally to the ambient conditions within the Reactor Building. Internally, the system components are exposed primarily to an air environment with any oil leakage being collected and routed to the tanks. The applicable aging effects for the materials in an air/gas environment are identified in Section 3.5.2.1 and for the materials in the oil/fuel oil environment, the applicable aging effects are identified in Section 3.5.2.3.

3.5.11.2 Applicable Aging Effects

The Reactor Coolant Pump Motor Oil Collection System contains piping, valves, and other components constructed of brass, carbon steel, copper, and stainless steel. No applicable aging effects have been identified for the system components exposed to an air environment. The applicable aging effects for the system components exposed to an oil environment are loss of material in the brass, carbon steel, copper, and stainless steel components.

3.5.11.3 Aging Management Programs

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Reactor Coolant Pump Motor Oil Collection System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the subject components exposed to an oil environment has not been fully characterized and its applicability needs to be verified with a one-time inspection. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Reactor Coolant Pump Motor Oil Collection System Inspection

3.5.12 Reactor Coolant System Vents, Drains, and Instrument Lines

The portion of the Reactor Coolant System that is not Duke Inservice Inspection Class A is described in Section 2.5.12. It includes the mechanical components that are not included within the Duke Inservice Inspection Class A scope as defined in Section 2.4. These components are the vents, drains, and instrument lines within the Reactor Coolant System boundary.

The system intended functions are: (1) to maintain the Reactor Coolant System pressure boundary as a barrier to the release of fission products from the reactor core, and (2) to vent non-condensable gases and steam following postulated accidents or events. The aging effects of the components applicable to the materials and environment combinations are described in Section 3.5.2. The following sections describe the applicable aging effects for the system components with the results summarized in Table 3.5.1.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and are not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.12.1 Environments

The Reactor Coolant System Vents, Drains, and Instrument Lines are exposed externally to the ambient conditions within the Reactor Building and the Auxiliary Building. Internally, the system components are exposed to a borated water environment. The applicable aging effects for the materials in a borated water environment are identified in Section 3.5.2.2.

3.5.12.2 Applicable Aging Effects

The Reactor Coolant System Vents, Drains, and Instrument Lines contain piping, valves, and other components constructed of stainless steel. The applicable aging effects for the system components exposed to a borated water environment are loss of material and cracking in the stainless steel components.

3.5.12.3 Aging Management Programs

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Reactor Coolant System Vents, Drains, and Instrument Lines will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the stainless steel components exposed to a borated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.13 KEOWEE HYDROELECTRIC STATION

Keowee Hydroelectric Station (Keowee) is described in Section 1.4 of ORLP-1001. The systems at Keowee are those required to support the operation of the station and include the following:

- Carbon Dioxide System
- Depressing Air System
- Generator High Pressure Oil System
- Governor Air System
- Governor Oil System
- Service Water System
- Turbine Generator Cooling Water System
- Turbine Guide Bearing Oil System
- Turbine Sump Pump System

Section 2.5.13 provides a description of these systems and identifies the components requiring aging management review for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use this aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-11 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and are not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.13.1 Carbon Dioxide System

3.5.13.1.1 ENVIRONMENTS

The Carbon Dioxide System components are exposed externally to the ambient conditions within Keowee. Internally, the system components are exposed to an air environment as the system is open to the atmosphere. The only portions of the system normally exposed to carbon dioxide are storage bottles, including the shut-off valves. The storage bottles, including the shut-off valves, are vendor supplied and are not within the scope of license renewal. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

3.5.13.1.2 APPLICABLE AGING EFFECTS

The Carbon Dioxide System contains piping, valves, and other components constructed of carbon steel and stainless steel. The applicable aging effects for the system components exposed to an air environment are loss of material in the carbon steel components. No applicable aging effects have been identified for the stainless steel components in an air environment.

3.5.13.1.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects identified in the previous section need to be managed for the period of extended operation because they could, if not managed, result in an adverse impact on one or more of the component intended functions listed in Table 2.5-23. The applicable aging effects for the Carbon Dioxide System components are managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the subject components exposed to an air environment have not been fully characterized and its applicability needs to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Keowee Air and Gas Systems Inspection

3.5.13.2 Depressing Air System

3.5.13.2.1 ENVIRONMENTS

The Depressing Air System components are exposed externally to the ambient conditions within Keowee. Internally, the system components are exposed to an air environment. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

3.5.13.2.2 AGING EFFECTS

The Depressing Air System contains piping and valves constructed of carbon steel. The applicable aging effect for the system components exposed to an air environment is loss of material in the carbon steel components.

3.5.13.2.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the

Depressing Air System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the subject components exposed to an air environment have not been fully characterized and its applicability needs to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Keowee Air and Gas Systems Inspection

3.5.13.3 Generator High Pressure Oil System

3.5.13.3.1 ENVIRONMENTS

The Generator High Pressure Oil System components are exposed externally to the ambient conditions within the Keowee. Internally, the system components are exposed to a lubricating oil environment with portions exposed to an air environment. For the materials exposed to lubricating oil, the applicable aging effects are identified in the oil/fuel oil environment in Section 3.5.2.3. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

3.5.13.3.2 APPLICABLE AGING EFFECTS

The Generator High Pressure Oil System contains piping, valves, and other components constructed of brass, bronze, carbon steel, copper, and stainless steel. No applicable aging effects have been identified for the components constructed from these materials in the a lubricating oil environment or the air environment.

3.5.13.3.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Generator High Pressure Oil System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.13.4 Governor Air System

3.5.13.4.1 ENVIRONMENTS

The Governor Air System components are exposed externally to the ambient conditions within the Keowee. Internally, the system components are exposed to an air environment. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment Section 3.5.2.1.

3.5.13.4.2 APPLICABLE AGING EFFECTS

The Governor Air System contains piping, valves, and tanks constructed of carbon steel. The applicable aging effects for the system components exposed to an air environment are loss of material in the carbon steel components.

3.5.13.4.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Governor Air System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the subject components exposed to an air environment have not been fully characterized and its applicability needs to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Keowee Air and Gas Systems Inspection

3.5.13.5 Governor Oil System

3.5.13.5.1 ENVIRONMENTS

The Governor Oil System components are exposed externally to the ambient conditions within Keowee. Internally, the system components are exposed primarily to an oil environment with portions of the system exposed to air in upper portions of tanks. For the materials exposed to oil, the applicable aging effects are identified in an oil/fuel oil environment in Section 3.5.2.3. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment in 3.5.2.1.

3.5.13.5.2 AGING EFFECTS

The Governor Oil System contains piping, valves, and other components constructed of carbon steel and stainless steel. The applicable aging effect for the system components exposed to an oil environment is loss of material in the carbon steel and stainless steel components. No applicable aging effects have been identified for the system components exposed to an air environment.

3.5.13.5.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Governor Oil System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the subject components exposed to an oil environment will be managed by taking samples and determining water content. This analysis will be performed by the following program which is described in Chapter 4 of OLRP-1001:

- Keowee Oil Sampling Program

3.5.13.6 Service Water System

3.5.13.6.1 ENVIRONMENTS

The Service Water System components are exposed externally to the ambient conditions within Keowee with portions of the system exposed to an underground environment. Internally, the system components are exposed to a raw water environment and an air environment in the dry pipe portions of the Fire Protection System. The applicable aging effects for the materials in a raw water environment are identified in Section 3.5.2.4. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment Section 3.5.2.1.

3.5.13.6.2 AGING EFFECTS

The Service Water System contains mechanical components constructed of bronze, carbon steel, cast iron, ductile cast iron, and stainless steel. The applicable aging effects for the system components exposed to a raw water environment are loss of material and fouling in the bronze, carbon steel, cast iron, ductile cast iron, and stainless steel components. The applicable aging effects for the system components exposed to an air environment are loss of material in the cast iron, carbon steel, and stainless steel components. None of the other component materials are exposed to an air environment.

3.5.13.6.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Service Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and fouling for the subject components exposed to a raw water environment will be managed by inspection and analysis as well as testing, inspection, and maintenance activities to verify integrity of the components. These actions will be performed by the following programs which are described in Chapter 4 of OLRP-1001:

- Service Water Piping Corrosion Program
- Fire Protection Program

The loss of material due to galvanic corrosion of the carbon steel and cast iron components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of galvanic couples will be inspected with the results being applied to all galvanic couples. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

The loss of material due to selective leaching of cast iron components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of cast iron components will be inspected with the results being applied to all cast iron components. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Cast Iron Selective Leaching Inspection

The loss of material for the subject components exposed to an air environment will be managed by testing, inspection, and maintenance activities to verify integrity of the components. These actions will be performed by the following program which is described in Chapter 4 of OLRP-1001:

- Fire Protection Program

3.5.13.7 Turbine Generator Cooling Water System

3.5.13.7.1 ENVIRONMENTS

The Turbine Generator Cooling Water System components are exposed externally to the ambient conditions within the Keowee with some portions of the system exposed to the yard or underground environments. Internally, the system components are exposed to a raw water environment. The applicable aging effects for the materials in a raw water environment are identified in Section 3.5.2.4.

3.5.13.7.2 APPLICABLE AGING EFFECTS

The Turbine Generator Cooling Water System contains piping, valves, and other components constructed of brass, bronze, carbon steel, copper, and stainless steel. The applicable aging effects for the system components exposed to a raw water environment are loss of material and fouling in the brass, bronze, carbon steel, copper, and stainless steel components.

3.5.13.7.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Turbine Generator Cooling Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and fouling for the subject components exposed to a raw water environment will be managed by testing, inspection, analysis, and maintenance activities to verify integrity of service water components. These activities will be performed by the following program and activities which are described in Chapter 4 of OLRP-1001:

- Service Water Piping Corrosion Program
- System Performance Testing Activities
- Preventive Maintenance Activities

The loss of material due to galvanic corrosion of the brass, bronze, carbon steel, and copper components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of galvanic couples will be inspected with the results being applied to all galvanic couples. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

3.5.13.8 Turbine Guide Bearing Oil System

3.5.13.8.1 ENVIRONMENTS

The Turbine Guide Bearing Oil System components are exposed externally to the ambient conditions within the Keowee. Internally, the system components are exposed primarily to a lubricating oil environment except for the air environment that exists in the upper region of the upper oil reservoir and the lines that connect to it. For the materials exposed to lubricating oil, the applicable aging effects are identified in the oil/fuel oil environment in Section 3.5.2.3. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment Section 3.5.2.1.

The Turbine Guide Bearing Oil System includes the turbine guide bearing oil coolers that are within the scope of license renewal. In order to provide the necessary flow of lubrication oil to the turbine guide bearings, the turbine guide bearing oil coolers must remain intact. These heat exchangers, located in the Keowee Hydroelectric Station are exposed to lubricating oil (from the Turbine Guide Bearing Oil System) through the tubes and raw water (from the Turbine Generator Cooling Water System) in the shell and on the outside of the tubes. For the materials exposed to lubricating oil, the applicable aging effects are identified in the oil/fuel oil environment in Section 3.5.2.3. For the materials in the raw water environment, the applicable aging effects are identified in Section 3.5.2.4.

3.5.13.8.2 APPLICABLE AGING EFFECTS

The Turbine Guide Bearing Oil System contains piping, valves, and other components constructed of brass, carbon steel, copper, and stainless steel. No applicable aging effects have been identified for the components constructed from these materials in the lubricating oil or air environments.

The turbine guide bearing oil coolers are constructed entirely from stainless steel. No applicable aging effects have been identified for the stainless steel components in the heat exchangers exposed to a lubricating oil environment. The applicable aging effect for components in the turbine guide bearing oil coolers exposed to a raw water environment is loss of material in the stainless steel components.

3.5.13.8.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Turbine Guide Bearing Oil System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the portions of the turbine guide bearing oil coolers exposed to a raw water environment will be managed by taking oil samples and analyzing them for water contamination as evidence of cooler leakage. These activities will be performed by the following program which is described in Chapter 4 of OLRP-1001:

- Keowee Oil System Sampling Program

3.5.13.9 Turbine Sump Pump System

3.5.13.9.1 ENVIRONMENTS

The Turbine Sump Pump System components are exposed externally to the ambient conditions within Keowee with some portions of the system exposed to an embedded environment. Internally, the system components are exposed to a raw water environment. The applicable aging effects for the materials in a raw water environment are identified in Section 3.5.2.4.

3.5.13.9.2 APPLICABLE AGING EFFECTS

The Turbine Sump Pump System contains piping, valves, and other components constructed of brass, bronze, carbon steel, and stainless steel. The applicable aging effects for the system components exposed to a raw water environment are loss of material and fouling in the brass, bronze, carbon steel, and stainless steel components.

3.5.13.9.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Turbine Sump Pump System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and fouling for the system components exposed to a raw water environment will be managed by testing, inspection, and analysis to verify integrity of service water components. The inspection and analysis will be performed by the following program and activities which are described in Chapter 4 of OLRP-1001:

- Service Water Piping Corrosion Program
- System Performance Testing Activities

The loss of material due to galvanic corrosion of the carbon steel components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of the galvanic couple will be inspected with the results being applied to all the galvanic couples. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

3.5.14 STANDBY SHUTDOWN FACILITY

The Standby Shutdown Facility (SSF) is described in Section 1.4 of ORLP-1001. The systems at the Standby Shutdown Facility are those required to support the operation of the facility and include the following:

- Air Intake and Exhaust System
- Diesel Generator Fuel Oil System
- Drinking Water System
- Heating, Ventilation, and Air Conditioning System
- Reactor Coolant Makeup System
- Sanitary Lift System
- Standby Shutdown Facility Auxiliary Service Water System
- Starting Air System

Section 2.5.14 provides a description of these systems and identifies the components requiring aging management review for license renewal. The aging effects of specific material and environment combinations are described in Section 3.5.2. The following sections use this aging effect information to identify the applicable aging effects for the system components. The results are summarized in Table 3.5-12 for the components in each system.

The applicable aging effects for the component external surfaces are dependent on the component location rather than the system in which the component resides. Applicable aging effects for all component external surfaces are addressed in Section 3.5.2.7 and are not discussed here. The programs utilized to manage aging effects for the component external surfaces are described in Chapter 4 of OLRP-1001.

3.5.14.1 Air Intake and Exhaust System

3.5.14.1.1 ENVIRONMENTS

The Air Intake and Exhaust System components are exposed externally to the ambient conditions within the Standby Shutdown Facility with portions of the system piping exposed to the outside yard environment. Internally, the system components are exposed primarily to an air environment with portions exposed to an exhaust gas environment in the diesel exhaust piping during periodic operation. For the materials exposed to air and exhaust gases, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

3.5.14.1.2 APPLICABLE AGING EFFECTS

The Air Intake and Exhaust System contains piping, screens, and other components constructed of carbon steel, chrome-molybdenum, and stainless steel. No applicable aging effects have been identified for the system components exposed to an air/gas environment.

3.5.14.1.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Air Intake and Exhaust System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.14.2 Diesel Generator Fuel Oil System

3.5.14.2.1 ENVIRONMENTS

The Diesel Generator Fuel Oil System components are exposed externally to the ambient conditions within the Standby Shutdown Facility with the exception of some piping and the main fuel oil storage tank that are underground. Internally, the system components are exposed primarily to a fuel oil environment with portions of the system exposed to air in the upper portion and lines connecting to the top of the tanks. For the materials exposed to fuel oil, the applicable aging effects are identified in the oil/fuel oil environment in Section 3.5.2.3. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

3.5.14.2.2 AGING EFFECTS

The Diesel Generator Fuel Oil System contains piping, valves, and other components constructed of brass, carbon steel, copper, and stainless steel. The applicable aging effects for the system components exposed to a fuel oil environment are loss of material in the brass, carbon steel, copper, and stainless steel components and cracking in the stainless steel components.

No applicable aging effects for the brass, carbon steel, copper, and stainless steel components were identified in an air environment.

3.5.14.2.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Diesel Generator Fuel Oil System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking will be managed for the subject components exposed to a fuel oil environment by controlling the relevant conditions that could lead to the onset and propagation of the aging effect. The relevant conditions will be controlled by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.14.3 Drinking Water System

3.5.14.3.1 ENVIRONMENTS

The Drinking Water System components are exposed externally to the ambient conditions within the Standby Shutdown Facility. Internally, the system components are exposed to a treated water environment. The applicable aging effects for the materials in a treated water environment are identified in Section 3.5.2.5.

3.5.14.3.2 APPLICABLE AGING EFFECTS

The Drinking Water System contains piping, valves, and hose connections constructed of stainless steel. The applicable aging effects for the system components exposed to a treated water environment are loss of material and cracking in the stainless steel components.

3.5.14.3.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Drinking Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the subject components exposed to a treated water environment have not been fully characterized and its applicability needs to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Treated Water Systems Stainless Steel Inspection

3.5.14.4 Heating, Ventilation, and Air Conditioning System

3.5.14.4.1 ENVIRONMENTS

The Standby Shutdown Facility Heating, Ventilation, and Air Conditioning (HVAC) System is exposed externally to the ambient conditions within the Standby Shutdown Facility except for the portions of the system exposed to the outside yard environment. Internally, the system components are exposed to a ventilation air environment. The applicable aging effects for the materials exposed to the ventilation air environment are identified in Section 3.5.2.6.

In order to provide the necessary heating, ventilation, and air conditioning for the Standby Shutdown Facility, the Standby Shutdown Facility HVAC System heat exchangers in the scope of license renewal must remain functional. The Standby Shutdown Facility HVAC System includes three types of heat exchangers; water-cooled condensers (in scope and discussed in the SSF Auxiliary Service Water System), air-cooled condensers (out-of-scope), and air cooling coils. The cooling coils transfer heat from the supply air in the Standby Shutdown Facility HVAC System to the refrigerant while the condensers reject the heat from the refrigerant to either the SSF Auxiliary Service Water System or to the atmosphere. The air conditioning units that include air cooling coils and their corresponding air-cooled condensers are not in the scope of license renewal. Only the air cooling coils associated with the water-cooled condensers are within the SSF HVAC System boundary and in the scope of license renewal.

The cooling coils are exposed to refrigerant within the tubes of the heat exchanger while the external surface is exposed to the ventilation air environment within the ventilation ducts. The applicable aging effects for the materials of the heat exchangers exposed to a refrigerant environment will be discussed in the following section.

3.5.14.4.2 APPLICABLE AGING EFFECTS

The SSF HVAC System contains mechanical components other than heat exchangers that are constructed of aluminum, galvanized steel, and stainless steel. No applicable aging effects have been identified for the components constructed from these materials in a ventilation air environment.

The tubes of the cooling coils are constructed from copper with aluminum fins. The applicable aging effects for the components in the heat exchangers exposed to a ventilation air environment are loss of material in the aluminum components. No applicable aging effects have been identified for the copper components exposed to a ventilation air environment.

No applicable aging effects for the portions of the heat exchangers exposed to the refrigerant R22 were identified for the aluminum or copper components. When materials are exposed to "dry" gases, there are no identifiable aging effects. The SSF HVAC System is evacuated, dried, and charged with moisture-free freon. Moisture is removed from freon-based systems because any moisture would be subject to freezing and could possibly lead to significant damage to the system. As with other gases, materials exposed to a dried freon environment will not experience any applicable aging effects.

3.5.14.4.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effect for the SSF HVAC System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material for the portions of the air cooling coils exposed to a ventilation air environment will be managed by monitoring the system performance during normal operation. This monitoring will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Heat Exchanger Performance Testing Activities

3.5.14.5 Reactor Coolant Makeup System

3.5.14.5.1 ENVIRONMENTS

The Reactor Coolant Makeup System components are exposed externally to the ambient conditions within the Reactor Building. Internally, the system components are exposed to a borated water environment. The applicable aging effects for the materials in a borated water environment are identified in Section 3.5.2.2.

3.5.14.5.2 APPLICABLE AGING EFFECTS

The Reactor Coolant Makeup System contains piping, valves, and other components constructed of stainless steel. The applicable aging effects for the system components exposed to a borated water environment are loss of material and cracking in the stainless steel components.

3.5.14.5.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Reactor Coolant Makeup System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the subject components exposed to a borated water environment will be managed by controlling the relevant conditions that could lead to the onset and propagation of the aging effects. The relevant conditions will be controlled by following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.5.14.6 Sanitary Lift System

3.5.14.6.1 ENVIRONMENTS

The Sanitary Lift System components are exposed externally to the ambient conditions within the Standby Shutdown Facility. Due to the infrequent use of the system, the system components are primarily exposed internally to an air environment. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

3.5.14.6.2 APPLICABLE AGING EFFECTS

The Sanitary Lift System contains piping, valves, and hose connections constructed of stainless steel. The applicable aging effects for the system components exposed to an air environment are loss of material and cracking in the stainless steel components.

3.5.14.6.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Sanitary Lift System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and cracking for the subject components exposed to an air environment have not been fully characterized and their applicability needs to be verified by a one-time inspection. This inspection will be implemented by the following activity which is described in Chapter 4 of OLRP-1001:

- Treated Water Systems Stainless Steel Inspection

3.5.14.7 Standby Shutdown Facility Auxiliary Service Water System

3.5.14.7.1 ENVIRONMENTS

The Auxiliary Service Water System components are exposed externally to the ambient conditions within the Standby Shutdown Facility and the Auxiliary Building with portions of the system exposed to the yard environment. Internally, the system components are exposed to a raw water environment. The applicable aging effects for the materials in a raw water environment are identified in Section 3.5.2.4.

The Auxiliary Service Water System includes the water-cooled Standby Shutdown Facility HVAC condensers that are within the scope of license renewal. In order to provide the necessary heat removal and maintain the Auxiliary Service Water System and SSF HVAC System pressure boundaries, the water-cooled Standby Shutdown Facility HVAC condensers must remain functional. These heat exchangers, which are located in the Standby Shutdown Facility, are exposed to raw water (from the SSF Auxiliary Service Water System) through the tubes and refrigerant 22 (from the SSF HVAC System) in the shell and on the outside of the tubes.

The applicable aging effects for the materials in the raw water environment are identified in Section 3.5.2.4 and the applicable aging effects for a refrigerant environment, will be discussed in the following section.

The submersible pump is a part of the Auxiliary Service Water System in the Standby Shutdown Facility but is discussed separately since it is not a permanently installed piece of equipment. It normally is exposed externally to the ambient conditions within the Standby Shutdown Facility and, every two years, is placed in the intake canal (Lake Keowee) for testing. Internally, the system components are primarily exposed to an air environment with the occasional exposure to raw water during testing. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1. For the materials in the raw water environment, the applicable aging effects are identified in Section 3.5.2.4.

3.5.14.7.2 APPLICABLE AGING EFFECTS

The Auxiliary Service Water System contains piping, valves, and other components constructed of carbon steel and stainless steel. The applicable aging effects for the system components exposed to a raw water environment are loss of material and fouling in the carbon steel and stainless steel components.

The tubes and tubesheet of the water-cooled Standby Shutdown Facility HVAC condensers are constructed from 90-10 copper-nickel with all other components of the heat exchangers constructed from carbon steel. The applicable aging effects for the components in the heat exchangers exposed to a raw water environment are loss of material and fouling in the carbon steel and 90-10 copper-nickel components.

No applicable aging effects for the portions of the heat exchangers exposed to the refrigerant R22 were identified for the carbon steel or 90-10 copper-nickel components. When materials are exposed to "dry" gases, there are no identifiable aging effects. The SSF HVAC System is evacuated, dried, and charged with moisture-free freon. Moisture is removed from freon-based systems because any moisture would be subject to freezing and could lead to significant damage to the system. As with other gases, materials exposed to a dried freon environment will not experience any applicable aging effects.

The submersible pump casing is constructed of cast iron. No applicable aging effects have been identified for the cast iron pump casing in an air environment or raw water environment that would prevent it from performing its component intended function.

3.5.14.7.3 AGING MANAGEMENT PROGRAMS

The applicable aging effects must be adequately managed so that the intended functions listed in the appropriate tables in Section 2.5 will be maintained consistent with the current licensing basis for the period of extended operation. The applicable aging effects for the Auxiliary Service Water System components will be managed by monitoring and controlling the aging effects directly or the relevant conditions which contribute to the onset and propagation of a specific aging effect.

The loss of material and fouling for the system components exposed to a raw water environment will be managed by testing, inspection, and analysis to verify integrity of service water components. The inspection, testing, and analysis will be performed by the following program and activities which are described in Chapter 4 of OLRP-1001:

- Service Water Piping Corrosion Program
- System Performance Testing Activities

The loss of material due to galvanic corrosion of the carbon steel components exposed to a raw water environment has not been fully characterized and its applicability needs to be verified by a one-time inspection. A sample of galvanic couples will be inspected with the results being applied to all galvanic couples. This inspection will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Galvanic Susceptibility Inspection

The loss of material and fouling for the portions of the water-cooled Standby Shutdown Facility HVAC condensers exposed to a raw water environment will be managed by monitoring the system performance during normal operation. This monitoring will be performed by the following activity which is described in Chapter 4 of OLRP-1001:

- Heat Exchanger Performance Testing Activities

No applicable aging effects have been identified for the submersible pump casing, which is within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

3.5.14.8 Starting Air System

3.5.14.8.1 ENVIRONMENTS

The Starting Air System components are exposed externally to the ambient conditions within the Standby Shutdown Facility. Internally, the system components are exposed to an air environment. For the materials exposed to air, the applicable aging effects are identified in the air/gas environment in Section 3.5.2.1.

3.5.14.8.2 APPLICABLE AGING EFFECTS

The Starting Air System contains piping, tanks, and valves constructed of carbon steel. No applicable aging effects have been identified for the carbon steel components in an air environment.

3.5.14.8.3 AGING MANAGEMENT PROGRAMS

No applicable aging effects have been identified for the components of the Starting Air System within the scope of license renewal. Therefore, no aging management program is required during the period of extended operation.

Table 3.5-1 Applicable Aging Effects for Components of Containment Heat Removal Systems

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Reactor Building Cooling System				
Ductwork	Aluminum	Air	Loss of Material	Preventive Maintenance Activities
Ductwork	Galvanized Steel	Air	Loss of Material	Preventive Maintenance Activities
Ductwork	Stainless Steel	Air	None	None Required
Reactor Building Cooling Units				
HX Channel/Head	Stainless Steel	Raw Water	Loss of Material	Preventive Maintenance Activities
			Fouling	Heat Exchanger Performance Testing Activities
HX Tube Fins	Copper	Air	Loss of Material	Preventive Maintenance Activities
HX Tubes	90-10 Copper-Nickel	Raw Water	Loss of Material	Preventive Maintenance Activities
			Fouling	Heat Exchanger Performance Testing Activities
HX Tubes	90-10 Copper-Nickel	Air	Loss of Material	Preventive Maintenance Activities
Reactor Building Spray System				
Mechanical Expansion Joint	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Orifice	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Stainless Steel	Air	Loss of Material Cracking	Reactor Building Spray System Inspection
Pipe	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pump Casing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Spray Nozzle	Stainless Steel	Air	Loss of Material Cracking	Reactor Building Spray System Inspection
Valve Bodies	Stainless Steel	Air	Loss of Material Cracking	Reactor Building Spray System Inspection
Valve Bodies	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program

Table 3.5-2 Applicable Aging Effects for Components of Containment Isolation Systems

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Breathing Air System				
Pipe	Stainless Steel	Air	None identified	None Required
Valve Bodies	Stainless Steel	Air	None identified	None Required
Component Cooling System				
Pipe	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Pipe	Stainless Steel	Treated Water	Cracking (Unit 2)	Treated Water Systems Stainless Steel Inspection
Orifice	Stainless Steel	Treated Water	None identified	None required
Valve Bodies	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Valve Bodies	Stainless Steel	Treated Water	Cracking (Unit 2)	Treated Water Systems Stainless Steel Inspection
Demineralized Water System				
Pipe	Stainless Steel	Treated Water	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspection
Valve Bodies	Stainless Steel	Treated Water	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspection
Filtered Water System				
Pipe	Stainless Steel	Treated Water	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspection
Valve Bodies	Stainless Steel	Treated Water	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspection
Gaseous Waste Disposal System				
Pipe	Stainless Steel	Nitrogen	None identified	None required
Valve Bodies	Stainless Steel	Nitrogen	None identified	None required

Table 3.5-2 Applicable Aging Effects for Components of Containment Isolation Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Instrument Air System				
Pipe	Carbon Steel	Air	None identified	None required
Pipe	Stainless Steel	Air	None identified	None required
Valve Bodies	Carbon Steel	Air	None identified	None required
Valve Bodies	Stainless Steel	Air	None identified	None required
Leak Rate Test System				
Hose Connection	Carbon Steel	Air	None identified	None required
Hose Connection	Stainless Steel	Air	None identified	None required
Pipe	Carbon Steel	Air	None identified	None required
Pipe	Stainless Steel	Air	None identified	None required
Valve Bodies	Carbon Steel	Air	None identified	None required
Valve Bodies	Stainless Steel	Air	None identified	None required
Liquid Waste Disposal System				
Pipe	Stainless Steel	Borated Water	Cracking Loss of Material	Treated Water Systems Stainless Steel Inspection
Valve Bodies	Stainless Steel	Borated Water	Cracking Loss of Material	Treated Water Systems Stainless Steel Inspection

Table 3.5-2 Applicable Aging Effects for Components of Containment Isolation Systems (continued)

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Nitrogen Purge and Blanket System				
Pipe	Carbon Steel	Nitrogen	None identified	None required
Pipe	Stainless Steel	Nitrogen	None identified	None required
Pipe	Stainless Steel	Borated Water	Loss of Material	Chemistry Control Program
			Cracking	Reactor Building Spray System Inspection
Tubing	Stainless Steel	Nitrogen	None identified	None required
Tubing	Stainless Steel	Borated Water	Loss of Material	Chemistry Control Program
			Cracking	Reactor Building Spray System Inspection
Valve Bodies	Carbon Steel	Nitrogen	None identified	None required
Valve Bodies	Stainless Steel	Nitrogen	None identified	None required
Valve Bodies	Stainless Steel	Borated Water	Loss of Material	Chemistry Control Program
			Cracking	Reactor Building Spray System Inspection

Table 3.5-2 Applicable Aging Effects for Components of Containment Isolation Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Reactor Building Purge System				
Air Flow Monitor	Aluminum	Air	None	None Required
Air Flow Monitor	Galvanized Steel	Air	None identified	None required
Air Flow Monitor	Stainless Steel	Air	None identified	None required
Annubar Tube	Stainless Steel	Air	None identified	None required
Ductwork	Aluminum	Air	None identified	None required
Ductwork	Galvanized Steel	Air	None identified	None required
Ductwork	Stainless Steel	Air	None identified	None required
Filter	Aluminum	Air	None identified	None required
Filter	Galvanized Steel	Air	None identified	None required
Filter	Stainless Steel	Air	None identified	None required
Grill	Aluminum	Air	None identified	None required
Grill	Galvanized Steel	Air	None identified	None required
Grill	Stainless Steel	Air	None identified	None required
Pipe	Carbon Steel	Air	None identified	None required
Tubing	Brass	Air	None identified	None required
Tubing	Carbon Steel	Air	None identified	None required
Tubing	Copper	Air	None identified	None required
Valve Bodies	Carbon Steel	Air	None identified	None required

Table 3.5-3 Applicable Aging Effects for Components of Emergency Core Cooling Systems

Component Type	Material	Internal Environment	Aging Effects	Aging Management Program/Activity
Core Flood System				
Pipe	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Tank	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Tank	Stainless Steel	Nitrogen	None identified	None required
Tank Nozzle	Inconel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Tank Nozzle	Inconel	Nitrogen	None identified	None required
Tubing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
High Pressure Injection System				
Demineralizer	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Filter	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Flex Hose	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Flow Meter	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Flow Nozzle	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Mechanical Expansion Joint	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Orifice	Stainless Steel	Borated Water	Loss Of Material Cracking	Chemistry Control Program
Pipe	Stainless Steel	Borated Water	Loss Of Material Cracking	Chemistry Control Program
Pump Casing	Stainless Steel	Borated Water	Loss Of Material Cracking	Chemistry Control Program
Tank	Stainless Steel	Borated Water	Loss Of Material Cracking	Chemistry Control Program
Tank	Stainless Steel	Hydrogen	None Identified	None Required

Table 3.5-3 Applicable Aging Effects for Components of Emergency Core Cooling Systems

Component Type	Material	Internal Environment	Aging Effects	Aging Management Program/Activity
High Pressure Injection System (Continued)				
Tubing	Stainless Steel	Borated Water	Loss Of Material Cracking	Chemistry Control Program
Valve Bodies	Stainless Steel	Borated Water	Loss Of Material Cracking	Chemistry Control Program
Reactor Coolant Pump Coolers (Units 2 and 3 Only)				
HX Coil	Stainless Steel	Borated Water	Cracking	Chemistry Control Program
HX Coil	Stainless Steel	Treated Water	Cracking	Chemistry Control Program Reactor Coolant System Operational Leakage Monitoring
Reactor Coolant Pump Seal Return Coolers				
HX Shell	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubes	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubes	Stainless Steel	Treated Water	Loss of Material	Chemistry Control Program
			Cracking	Chemistry Control Program Reactor Coolant System Operational Leakage Monitoring
HX Tubesheet	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubesheet	Stainless Steel	Treated Water	Loss of Material	Chemistry Control Program
			Cracking	Chemistry Control Program Reactor Coolant System Operational Leakage Monitoring
HX Shell	Carbon Steel	Treated Water	None identified	None required

Table 3.5-3 Applicable Aging Effects for Components of Emergency Core Cooling Systems (continued)

COMPONENT TYPE	MATERIAL	INTERNAL ENVIRONMENT	AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Low Pressure Injection System				
Annubar Tube	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Orifice	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pump Casing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Tank	Carbon Steel (Lined)	Air	Loss of Material	Preventive Maintenance Activities
Tank	Carbon Steel (Lined)	Borated Water	Loss of Material	Preventive Maintenance Activities
Tubing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Decay Heat Removal Coolers				
HX Channel Heads	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Shell	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
HX Tubes	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubes	Stainless Steel	Raw Water	Loss of Material	Preventive Maintenance Activities
			Fouling	Heat Exchanger Performance Testing Activities
HX Tubesheet	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubesheet	Stainless Steel	Raw Water	Loss of Material Fouling	Preventive Maintenance Activities Heat Exchanger Performance Testing Activities

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Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Spent Fuel Cooling System				
Demineralizer	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Filter	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Flexible Hose	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Orifice	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pump Casing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Spent Fuel Transfer Tube	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Tank	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Tubing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Spent Fuel Coolers				
HX Channel Head	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
HX Shell	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubes	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubes	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubesheet	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubesheet	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
HX Plates	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
HX Plates	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program

Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Auxiliary Service Water System				
Annubar Tube	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Pipe	Carbon Steel	Air	Loss of Material	Preventive Maintenance Activities
Pipe	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Pipe	Stainless Steel	Air	Loss of Material	Preventive Maintenance Activities
Pipe	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Pump Casing	Cast Iron	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection Cast Iron Selective Leaching Inspection
Tubing	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Valve Bodies	Carbon Steel	Air	Loss of Material	Preventive Maintenance Activities
Valve Bodies	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Valve Bodies	Stainless Steel	Air	Loss of Material	Preventive Maintenance Activities
Valve Bodies	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities

Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Condenser Circulating Water System				
Mechanical Expansion Joint	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
Mechanical Expansion Joint	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
Orifice	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
Pipe	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Preventive Maintenance Activities (underground piping only) Galvanic Susceptibility Inspection
Pipe	Stainless Steel	Raw Water	Loss of Material	Service Water System Corrosion Program
Pump Casing	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
Pump Casing	Cast Iron	Raw Water	None identified	None required
Recirculating Cooling Water Heat Exchangers	Admiralty Brass Carbon Steel	Raw Water Treated Water	None identified	None required
Screens	Carbon Steel	Raw Water	None identified	None required
Screens	Stainless Steel	Raw Water	None identified	None required
Valve Bodies	Bronze	Raw Water	Loss of Material	Service Water Piping Corrosion Program
Valve Bodies	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
Valve Bodies	Stainless Steel	Raw Water	Loss of Material	Service Water System Corrosion Program

Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
High Pressure Service Water System				
Filter	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Fire Hydrant	Cast Iron	Air	Loss of Material	Fire Protection Program
Fire Hydrant	Cast Iron	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program Galvanic Susceptibility Inspection Cast Iron Selective Leaching Inspection
			Fouling	Fire Protection Program
Hose Rack	Bronze	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program
			Fouling	Fire Protection Program
Hose Rack	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program- Hose Stations Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Hose Rack	Stainless Steel	Raw Water	Loss of Material Fouling	Service Water Piping Corrosion Program Fire Protection Program Fire Protection Program
Mechanical Expansion Joint	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program- Deluge Valves Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Mechanical Expansion Joint	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program- Deluge Valves
			Fouling	Fire Protection Program

Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
High Pressure Service Water System (Continued)				
Mulsifyer	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Orifice	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program
			Fouling	Fire Protection Program
Pipe	Carbon Steel	Air	Loss of Material	Fire Protection Program
Pipe	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Pipe	Cast Iron	Air	Loss of Material	Fire Protection Program
Pipe	Cast Iron	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program Galvanic Susceptibility Inspection Cast Iron Selective Leaching Inspection
			Fouling	Fire Protection Program
Pipe	Stainless Steel	Air	Loss of Material	Fire Protection Program
Pipe	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program
			Fouling	Fire Protection Program
Pump Casing	Cast Iron	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program Galvanic Susceptibility Inspection Cast Iron Selective Leaching Inspection

Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
High Pressure Service Water System (continued)				
Tubing	Brass	Raw Water	None identified	None required
Tubing	Carbon Steel	Raw Water	None identified	None required
Tubing	Copper	Raw Water	None identified	None required
Tubing	Stainless Steel	Raw Water	None identified	None required
Sprinkler	Bronze	Air	Loss of Material	Fire Protection Program
Sprinkler	Bronze	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Strainer	Cast Iron	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program Galvanic Susceptibility Inspection Cast Iron Selective Leaching Inspection
			Fouling	Fire Protection Program
Valve Bodies	Bronze	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program- Surveillance Test
			Fouling	Fire Protection Program
Valve Bodies	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program- Surveillance Test Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Valve Bodies	Cast Iron	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program- Surveillance Test Galvanic Susceptibility Inspection Cast Iron Selective Leaching Inspection
			Fouling	Fire Protection Program

Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems (continued)

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
High Pressure Service Water System (continued)				
Valve Bodies	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Fire Protection Program- Surveillance Test
			Fouling	Fire Protection Program
Low Pressure Service Water System				
Annubar Tube	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Filter	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Filter	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Flex Hose	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities

Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Low Pressure Service Water (continued)				
Hose Rack	Bronze	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Hose Rack	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Mechanical Expansion Joint	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Mechanical Expansion Joint	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Orifice	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Pipe	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Pipe	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Pump Casing	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities

Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Low Pressure Service Water System (continued)				
Site Glass	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Strainer	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Strainer	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Tubing	Brass	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Tubing	Copper	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Tubing	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Valve Bodies	Bronze	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Valve Bodies	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Valve Bodies	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities

Table 3.5-4 Applicable Aging Effects for Components of Auxiliary Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Low Pressure Service Water System (continued)				
Component Coolers				
HX Channel Head	Carbon Steel	Raw Water	Loss of Material	Preventive Maintenance Activities
HX Shell	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
HX Tubes	Admiralty Brass	Raw Water	Loss of Material	Preventive Maintenance Activities
HX Tubes	Admiralty Brass	Treated Water	Loss of Material	Chemistry Control Program
HX Tubesheet	Admiralty Brass	Raw Water	Loss of Material	Preventive Maintenance Activities
HX Tubesheet	Admiralty Brass	Treated Water	Loss of Material	Chemistry Control Program

Table 3.5-5 Applicable Aging Effects for Components of Process Auxiliaries

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Chemical Addition System				
Accumulator	Stainless Steel	(Caustic Area)	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspections
Expansion Coil	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Flex Hose	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Orifices	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Stainless Steel	(Caustic Area)	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspections
Pipe	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Pump Casing	Stainless Steel	(Caustic Area)	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspection
Tubing	Stainless Steel	(Caustic Area)	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspection
Tubing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Stainless Steel	(Caustic Area)	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspection
Valve Bodies	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Coolant Storage System				
Pipe	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Spray Nozzle	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Tubing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program

Table 3.5-6 Applicable Aging Effects for Components of Air Conditioning, Heating, Cooling and Ventilation Systems

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Auxiliary Building Ventilation System				
Air Flow Monitors	Aluminum	Air	None identified	None required
Air Flow Monitors	Galvanized Steel	Air	None identified	None required
Air Flow Monitors	Stainless Steel	Air	None identified	None required
Air Handling Unit	Aluminum	Air	None identified	None required
Air Handling Unit	Galvanized Steel	Air	None identified	None required
Air Handling Unit	Stainless Steel	Air	None identified	None required
Ductwork	Aluminum	Air	None identified	None required
Ductwork	Galvanized Steel	Air	None identified	None required
Ductwork	Stainless Steel	Air	None identified	None required
Filter	Aluminum	Air	None identified	None required
Filter	Galvanized Steel	Air	None identified	None required
Filter	Stainless Steel	Air	None identified	None required
Grill	Aluminum	Air	None identified	None required
Grill	Galvanized Steel	Air	None identified	None required
Grill	Stainless Steel	Air	None identified	None required

Table 3.5-6 Applicable Aging Effects for Components of Air Conditioning, Heating, Cooling and Ventilation Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Control Room Pressurization and Filtration System				
Air Flow Monitor	Aluminum	Ventilation	None identified	None required
Air Flow Monitor	Aluminum	Ventilation	None identified	None required
Air Flow Monitor	Stainless Steel	Ventilation	None identified	None required
Air Handling Unit	Aluminum	Ventilation	None identified	None required
Air Handling Unit	Galvanized Steel	Ventilation	None identified	None required
Air Handling Unit	Stainless Steel	Ventilation	None identified	None required
Ductwork	Aluminum	Ventilation	None identified	None required
Ductwork	Galvanized Steel	Ventilation	None identified	None required
Ductwork	Stainless Steel	Ventilation	None identified	None required
Filter	Aluminum	Ventilation	None identified	None required
Filter	Galvanized Steel	Ventilation	None identified	None required
Filter	Stainless Steel	Ventilation	None identified	None required
Grill	Aluminum	Ventilation	None identified	None required
Grill	Galvanized Steel	Ventilation	None identified	None required
Grill	Stainless Steel	Ventilation	None identified	None required
Heater (PB Only)	Aluminum	Ventilation	None identified	None required
Heater (PB Only)	Galvanized Steel	Ventilation	None identified	None required
Heater (PB Only)	Stainless Steel	Ventilation	None identified	None required

Table 3.5-6 Applicable Aging Effects for Components of Air Conditioning, Heating, Cooling and Ventilation Systems (continued)

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Control Room Pressurization and Filtration System (continued)				
Tubing	Brass	Ventilation	None identified	None required
Tubing	Carbon Steel	Ventilation	None identified	None required
Tubing	Copper	Ventilation	None identified	None required
Tubing	Stainless Steel	Ventilation	None identified	None required
Penetration Room Ventilation System				
Filter	Carbon Steel	Air	None identified	None required
Grill	Aluminum	Air	None identified	None required
Grill	Galvanized Steel	Air	None identified	None required
Grill	Stainless Steel	Air	None identified	None required
Orifice	Stainless Steel	Air	None identified	None required
Pipe	Carbon Steel	Air	None identified	None required
Tubing	Brass	Air	None identified	None required
Tubing	Carbon Steel	Air	None identified	None required
Tubing	Copper	Air	None identified	None required
Tubing	Stainless Steel	Air	None identified	None required
Valve Bodies	Carbon Steel	Air	None identified	None required

Table 3.5-7 Applicable Aging Effects for Components of Steam and Power Conversion Systems

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Main Steam System				
EFWP Turbine Casing	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program Piping Erosion/Corrosion Program
Filter	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Orifice	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program Piping Erosion/Corrosion Program
Tubing	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Valve Bodies	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program Piping Erosion/Corrosion Program
Condensate System				
Demineralizer	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Mechanical Expansion Joint	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Filter	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Orifice	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Pipe	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Pump Casing	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Pump Casing	Cast Iron	Treated Water	Loss of Material	Chemistry Control Program Cast Iron Selective Leaching Inspection
Strainer	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Tank	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Tubing	Brass	Treated Water	Loss of Material	Chemistry Control Program
Tubing	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program

Table 3.5-7 Applicable Aging Effects for Components of Steam and Power Conversion Systems

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Condensate System (Continued)				
Tubing	Copper	Treated Water	Loss of Material	Chemistry Control Program
Tubing	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Valve Bodies	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Condensate Coolers				
HX Tubes	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubes	Stainless Steel	Raw Water	Loss of Material	Preventive Maintenance Activities
HX Tubesheet	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
HX Tubesheet	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
HX Shell	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
HX Channel Heads	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
Generator Water Coolers				
HX Channel Heads	Stainless Steel	Treated Water	Cracking	Chemistry Control Program
HX Tubes	Stainless Steel	Treated Water	Cracking	Chemistry Control Program
HX Shell	Stainless Steel	Treated Water	Cracking	Chemistry Control Program
HX Tubesheet	Stainless Steel	Treated Water	Cracking	Chemistry Control Program
Main Condensers				
HX Tubes	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
HX Tubes	Stainless Steel	Raw Water	Loss of Material	Preventive Maintenance Activities
HX Tubesheet	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program

Table 3.5-7 Applicable Aging Effects for Components of Steam and Power Conversion Systems (Continued)

Condensate System (Continued)				
HX Tubesheet	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
HX Shell	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
HX Channel Heads	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
Emergency Feedwater System				
Flow Nozzle	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Flow Sensor	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Orifice	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Pump Casing	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Pump Casing	Low Alloy Steel (6%)	Treated Water	Loss of Material	Chemistry Control Program
Tubing	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program
Tubing	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program

Table 3.5-7 Applicable Aging Effects for Components of Steam and Power Conversion Systems (continued)

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Feedwater System				
Emergency Feedwater Header	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program Piping Erosion/Corrosion Program
Flow Nozzle	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Main Feedwater Header	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program Piping Erosion/Corrosion Program
Pipe	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program– Enhanced Piping Erosion/Corrosion Program
Pipe	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Pump Casing	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Carbon Steel	Treated Water	Loss of Material	Chemistry Control Program Piping Erosion/Corrosion Program
Valve Bodies	Stainless Steel	Treated Water	Loss of Material Cracking	Chemistry Control Program

Table 3.5-8 Applicable Aging Effects for Components of Post-Accident Hydrogen Control Systems

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Containment Hydrogen Control System				
Flexable Hose	Stainless Steel	Air	None identified	None required
Hydrogen Recombiner	Stainless Steel	Air	None identified	None required
Pipe	Stainless Steel	Air	None identified	None required
Valve Bodies	Stainless Steel	Air	None identified	None required
Post-Accident Monitoring System				
Pipe	Stainless Steel	Air	None identified	None required
Tubing	Stainless Steel	Air	None identified	None required
Valve Bodies	Stainless Steel	Air	None identified	None required

Table 3.5-9 Applicable Aging Effects for Components of Reactor Coolant Reactor Coolant Pump Motor Oil Collection System

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Enclosures	Carbon Steel	Air	None identified	None required
Flex Hose	Carbon Steel	Air	None identified	None required
Flex Hose	Stainless Steel	Air	None identified	None required
Pipe	Carbon Steel	Air	None identified	None required
Pipe	Carbon Steel	Oil	Loss of Material	RCP Motor Oil Collection System Inspection
Tank	Carbon Steel	Air	None identified	None required
Tank	Carbon Steel	Oil	Loss of Material	RCP Motor Oil Collection System Inspection
Tubing	Brass	Air	None identified	None required
Tubing	Brass	Oil	Loss of Material	RCP Motor Oil Collection System Inspection
Tubing	Carbon Steel	Air	None identified	None required
Tubing	Carbon Steel	Oil	Loss of Material	RCP Motor Oil Collection System Inspection
Tubing	Copper	Air	None identified	None required
Tubing	Copper	Oil	Loss of Material	RCP Motor Oil Collection System Inspection
Tubing	Stainless Steel	Air	None identified	None required
Tubing	Stainless Steel	Oil	Loss of Material	RCP Motor Oil Collection System Inspection
Valve Bodies	Carbon Steel	Air	None identified	None required
Valve Bodies	Carbon Steel	Oil	Loss of Material	RCP Motor Oil Collection System Inspection
Valve Bodies	Stainless Steel	Air	None identified	None required
Valve Bodies	Stainless Steel	Oil	Loss of Material	RCP Motor Oil Collection System Inspection

Table 3.5-10 Applicable Aging Effects for Components of Reactor Coolant Vents and Drains

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Mechanical Expansion Joint	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pressure Breakdown Coil	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Tubing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Valve Bodies	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program

Table 3.5-11 Applicable Aging Effects for Components of Keowee Hydroelectric Station Systems

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Carbon Dioxide System				
Flex Hose	Carbon Steel	Air	Loss of Material	Keowee Air and Gas Systems Inspection
Nozzle	Carbon Steel	Air	None identified	None required
Pipe	Carbon Steel	Air	Loss of Material	Keowee Air and Gas Systems Inspections
Pipe	Stainless Steel	Air	None identified	None required
Tubing	Stainless Steel	Air	None identified	None required
Valve Bodies	Carbon Steel	Air	Loss of Material	Keowee Air and Gas Systems Inspections
Depressing Air System				
Pipe	Carbon Steel	Air/Gas	Loss of Material	Keowee Air and Gas Systems Inspections
Valve Bodies	Carbon Steel	Air/Gas	Loss of Material	Keowee Air and Gas Systems Inspections

Table 3.5-11 Applicable Aging Effects for Components of Keowee Hydroelectric Station Systems (continued)

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Generator High Pressure Oil System				
Filter	Stainless Steel	Oil	None identified	None required
Pipe	Copper	Air	None identified	None required
Pipe	Copper	Oil	None identified	None required
Pipe	Stainless Steel	Oil	None identified	None required
Pump Casing	Carbon Steel	Oil	None identified	None required
Tank	Carbon Steel	Oil	None identified	None required
Tubing	Brass	Oil	None identified	None required
Tubing	Carbon Steel	Oil	None identified	None required
Tubing	Copper	Oil	None identified	None required
Tubing	Stainless Steel	Oil	None identified	None required
Valve Bodies	Bronze	Air	None identified	None required
Valve Bodies	Bronze	Oil	None identified	None required
Valve Bodies	Copper	Air	None identified	None required
Valve Bodies	Copper	Oil	None identified	None required
Valve Bodies	Stainless Steel	Oil	None identified	None required
Governor Air System				
Pipe	Carbon Steel	Air	Loss of Material	Keowee Air and Gas Systems Inspection
Tank	Carbon Steel	Air	Loss of Material	Keowee Air and Gas Systems Inspection
Valve Bodies	Carbon Steel	Air	Loss of Material	Keowee Air and Gas Systems Inspections

Table 3.5-11 Applicable Aging Effects for Components of Keowee Hydroelectric Station Systems (continued)

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Governor Oil System				
Pipe	Carbon Steel	Air	None identified	None required
Pipe	Carbon Steel	Oil	Loss of Material	Keowee Oil Sampling Program
Pump Casing	Carbon Steel	Oil	Loss of Material	Keowee Oil Sampling Program
Tank	Carbon Steel	Air	None identified	None required
Tank	Carbon Steel	Oil	Loss of Material	Keowee Oil Sampling Program
Tubing	Stainless Steel	Air	None identified	None required
Tubing	Stainless Steel	Oil	Loss of Material	Keowee Oil Sampling Program
Valve Bodies	Carbon Steel	Oil	Loss of Material	Keowee Oil Sampling Program
Valve Bodies	Stainless Steel	Oil	Loss of Material	Keowee Oil Sampling Program
Service Water System				
Annubar	Stainless Steel	Raw Water	Loss of Material Fouling	Service Water Piping Inspection Program Fire Protection Program
			Fouling	Fire Protection Program
Filter	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Inspection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Fire Hydrant	Cast Iron	Air	Loss of Material	Fire Protection Program
Hose Rack	Bronze	Raw Water	Loss of Material Fouling	Fire Protection Program
Hose Rack	Carbon Steel	Raw Water	Loss of Material	Fire Protection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program

Table 3.5-11 Applicable Aging Effects for Components of Keowee Hydroelectric Station Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Service Water System (continued)				
Mulsifyer	Carbon Steel	Raw Water	Loss of Material	Fire Protection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Pipe	Carbon Steel	Air	Loss of Material	Fire Protection Program
Pipe	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Inspection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Pipe	Ductile Iron	Raw Water	Loss of Material	Service Water Piping Inspection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Pump Casing	Cast Iron	Raw Water	Loss of Material	Service Water Piping Inspection Program Galvanic Susceptibility Inspection Cast Iron Selective Leaching Inspection
Strainer	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Inspection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program
Tubing	Brass	Raw Water	None identified	None required
Tubing	Carbon Steel	Raw Water	None identified	None required
Tubing	Copper	Raw Water	None identified	None required
Tubing	Stainless Steel	Raw Water	None identified	None required

Table 3.5-11 Applicable Aging Effects for Components of Keowee Hydroelectric Station Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Service Water System (continued)				
Valve Bodies	Bronze	Raw Water	Loss of Material	Service Water Piping Inspection Program
			Fouling	Fire Protection Program- Piping
Valve Bodies	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Inspection Program Galvanic Susceptibility Inspection
			Fouling	Fire Protection Program- Piping
Valve Bodies	Cast Iron	Raw Water	Loss of Material	Service Water Piping Inspection Program Galvanic Susceptibility Inspection Cast Iron Selective Leaching Inspection
			Fouling	Fire Protection Program- Piping
Turbine Generator Cooling Water System				
Filter	Carbon Steel	Raw Water	Loss of Material	Preventive Maintenance Activities Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	Preventive Maintenance Activities System Performance Testing Activities
Filter	Stainless Steel	Raw Water	Loss of Material	Preventive Maintenance Activities Service Water Piping Corrosion Program
			Fouling	Preventive Maintenance Activities System Performance Testing Activities
Orifice	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Pipe	Brass	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities

Table 3.5-11 Applicable Aging Effects for Components of Keowee Hydroelectric Station Systems (continued)

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Turbine Generator Cooling Water System (Continued)				
Pipe	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Pipe	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Tubing	Brass	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Tubing	Copper	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Tubing	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Valve Bodies	Bronze	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Valve Bodies	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Valve Bodies	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities

Table 3.5-11 Applicable Aging Effects for Components of Keowee Hydroelectric Station Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Turbine Guide Bearing Oil				
Orifice	Stainless Steel	Oil	None identified	None required
Pipe	Carbon Steel	Air	None identified	None required
Pipe	Carbon Steel	Oil	None identified	None required
Pipe	Stainless Steel	Air	None identified	None required
Pipe	Stainless Steel	Oil	None identified	None required
Pump Casing	Carbon Steel	Oil	None identified	None required
Strainer	Stainless Steel	Oil	None identified	None required
Tank	Carbon Steel	Air	None identified	None required
Tank	Carbon Steel	Oil	None identified	None required
Tubing	Carbon Steel	Oil	None identified	None required
Tubing	Brass	Oil	None identified	None required
Tubing	Copper	Oil	None identified	None required
Tubing	Stainless Steel	Oil	None identified	None required
Valve Bodies	Stainless Steel	Oil	None identified	None required
Turbine Guide Bearing Oil Coolers				
HX Channel Heads	Stainless Steel	Oil	None identified	None required
HX Shell	Stainless Steel	Raw Water	Loss of Material	Keowee Oil Sampling Program
HX Tubes	Stainless Steel	Oil	None identified	None required

Table 3.5-11 Applicable Aging Effects for Components of Keowee Hydroelectric Station Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Turbine Guide Bearing Oil (Continued)				
HX Tubes	Stainless Steel	Raw Water	Loss of Material	Keowee Oil Sampling Program
HX Tubesheet	Stainless Steel	Oil	None identified	None required
HX Tubesheet	Stainless Steel	Raw Water	Loss of Material	Keowee Oil Sampling Program
Turbine Sump Pump System				
Filter	Bronze	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Filter	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Pipe	Brass	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Pipe	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Pump Casing	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities

Table 3.5-11 Applicable Aging Effects for Components of Keowee Hydroelectric Station Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Turbine Sump Pump System (continued)				
Valve Bodies	Bronze	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Valve Bodies	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities

Table 3.5-12 Applicable Aging Effects for Components of Standby Shutdown Facility Systems

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Air Intake and Exhaust System				
Muffler Silencer	Carbon Steel	Air	None identified	None required
Mechanical Expansion Joint	Chrome-Molybdenum	Air	None identified	None required
Pipe	Carbon Steel	Air	None identified	None required
Pipe	Chrome-Molybdenum	Air	None identified	None required
Screen	Carbon Steel	Air	None identified	None required
Screen	Chrome-Molybdenum	Air	None identified	None required
Tubing	Carbon Steel	Air	None identified	None required
Diesel Generator Fuel Oil System				
Orifice	Stainless Steel	Oil	Loss of Material Cracking	Chemistry Control Program
Pipe	Stainless Steel	Air	None identified	None required
Pipe	Stainless Steel	Oil	Loss of Material Cracking	Chemistry Control Program
Pump Casing	Carbon Steel	Oil	Loss of Material	Chemistry Control Program
Strainer	Stainless Steel	Oil	Loss of Material Cracking	Chemistry Control Program
Tank	Carbon Steel	Air	None identified	None required
Tank	Carbon Steel	Oil	Loss of Material	Chemistry Control Program
Tubing	Brass	Oil	Loss of Material	Chemistry Control Program
Tubing	Carbon Steel	Oil	Loss of Material	Chemistry Control Program
Tubing	Copper	Oil	Loss of Material	Chemistry Control Program
Tubing	Stainless Steel	Oil	Loss of Material Cracking	Chemistry Control Program

Table 3.5-12 Applicable Aging Effects for Components of Standby Shutdown Facility Systems (continued)

Mechanical Component	Material	Internal Environment	Applicable Aging Effects	Aging Management Program/Activity
Diesel Generator Fuel Oil System (continued)				
Valve Bodies	Stainless Steel	Air	None identified	None required
Valve Bodies	Stainless Steel	Oil	Loss of Material Cracking	Chemistry Control Program
Drinking Water				
Hose Connection	Stainless Steel	Treated Water	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspection
Pipe	Stainless Steel	Treated Water	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspection
Valve Bodies	Stainless Steel	Treated Water	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspections
Heating, Ventilation and Air Conditioning				
Air Handling Unit	Aluminum	Air	None identified	None required
Air Handling Unit	Galvanized Steel	Air	None identified	None required
Cooling Coil	Copper Aluminum	Air	Loss of Material	Heat Exchanger Performance Testing Activities
Ductwork	Aluminum	Air	None identified	None required
Ductwork	Galvanized Steel	Air	None identified	None required
Ductwork	Stainless Steel	Air	None identified	None required
Filter	Aluminum	Air	None identified	None required
Filter	Galvanized Steel	Air	None identified	None required
Filter	Stainless Steel	Air	None identified	None required

Table 3.5-12 Applicable Aging Effects for Components of Standby Shutdown Facility Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Heating, Ventilation and Air Conditioning (continued)				
Grill	Aluminum	Air	None identified	None required
Grill	Galvanized Steel	Air	None identified	None required
Grill	Stainless Steel	Air	None identified	None required
Heater (PB Only)	Aluminum	Air	None identified	None required
Heater (PB Only)	Galvanized Steel	Air	None identified	None required
Heater (PB Only)	Stainless Steel	Air	None identified	None required
Reactor Coolant Makeup System				
Accumulator	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Filter	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Orifice	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pipe	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pulsation Damper	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Pump Casing	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Tubing	Stainless Steel	Borated Water	Loss Of Material Cracking	Chemistry Control Program
Valve Bodies	Stainless Steel	Borated Water	Loss of Material Cracking	Chemistry Control Program
Sanitary Lift System				
Pipe	Stainless Steel	Air	Loss of Material Cracking	Treated Water Systems Stainless Steel Inspections

Table 3.5-12 Applicable Aging Effects for Components of Standby Shutdown Facility Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Standby Shutdown Facility Auxiliary Service Water System				
Air Ejector	Stainless Steel	Raw Water	Loss of Material Fouling	System Performance Testing Activities
Annubar Tube	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Orifice	Stainless Steel	Raw Water	Loss of Material Fouling	System Performance Testing Activities
Pipe	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Pipe	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Pump Casing	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
Pump Casing	Cast Iron	Air	None identified	None required
Pump Casing	Cast Iron	Raw Water	None identified	None required
SSF HVAC Condensers	Carbon Steel 90-10 Copper-Nickel	Raw Water	Loss of Material Fouling	Heat Exchanger Performance Testing Activities
Strainer	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Strainer	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Tubing	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities

Table 3.5-12 Applicable Aging Effects for Components of Standby Shutdown Facility Systems (continued)

MECHANICAL COMPONENT	MATERIAL	INTERNAL ENVIRONMENT	APPLICABLE AGING EFFECTS	AGING MANAGEMENT PROGRAM/ACTIVITY
Standby Shutdown Facility Auxiliary Service Water System (continued)				
Valve Bodies	Carbon Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program Galvanic Susceptibility Inspection
			Fouling	System Performance Testing Activities
Valve Bodies	Stainless Steel	Raw Water	Loss of Material	Service Water Piping Corrosion Program
			Fouling	System Performance Testing Activities
Starting Air System				
Pipe	Carbon Steel	Air	None identified	None required
Tank	Carbon Steel	Air	None identified	None required
Tubing	Carbon Steel	Air	None identified	None required
Valve Bodies	Carbon Steel	Air	None identified	None required

3.6 AGING EFFECTS FOR ELECTRICAL COMPONENTS

3.6.1 DESCRIPTION OF THE PROCESS TO IDENTIFY THE APPLICABLE AGING EFFECTS FOR ELECTRICAL COMPONENTS

Electrical system components within the scope of license renewal that require aging management reviews and their intended functions are identified and listed in Section 2.6.

The process to determine the aging effects applicable to these electrical components begins with an understanding of the potential aging effects defined in industry literature. From this set of potential aging effects, the component materials, operating environment and operating stresses serve to define the applicable aging effects for each component subject to aging management review. These applicable aging effects are validated by a review of industry and Oconee operating experience to provide reasonable assurance that the full set of applicable aging effects is established for the aging management review. This process is more fully described in Section 3.2 of OLRP-1001.

The electrical components that are subject to aging management review are:

- Bus
- Insulated Cables & Connections
- Insulators
- Transmission Conductors

Sections 3.6.2 through 3.6.5 describe the results when the process is applied to each of these electrical components. Table 3.6-1 summarizes the applicable aging effects for each electrical component.

3.6.2 BUS

3.6.2.1 Phase Bus

Isolated-phase bus, nonsegregated-phase bus, and segregated-phase bus subject to an aging management review is identified in Section 2.6.2.1 of OLRP-1001. The review to identify the applicable aging effects for bus considers the following potential aging effects which have been identified by reviewing available industry literature:

- Change in material properties
- Loss of material

The process to identify the aging effects applicable to bus is consistent with the process described in Section 3.2. The isolated-phase bus, nonsegregated-phase bus, and segregated-phase bus are constructed of similar materials and exposed to similar service environments. Therefore, a common assessment of aging effects for these phase bus is provided in the following section. The results are summarized in Table 3.6-1.

3.6.2.1.1 APPLICABLE AGING EFFECTS FOR PHASE BUS

Isolated-phase bus, nonsegregated-phase bus, and segregated-phase bus subject to aging management review are located in the Keowee Powerhouse, Keowee Transformer Yard, Keowee Vault, Turbine Buildings, Unit 1 & 2 Switchgear Blockhouse, Unit 3 Switchgear Blockhouse, and the Oconee Transformer Yard. The ambient environmental conditions for these areas are described in Section 3.2. These environmental conditions include temperatures up to 105°F (40.6°C), radiation less than 1×10^3 rads, and exposure to moisture from all forms of precipitation. Self-heating contributes an increase in temperature of the bus of up to 40°C.

Phase bus materials brass, bronze, copper, galvanized metals, grout, porcelain, and stainless steel have no applicable aging effects in their service environments. Phase bus materials aluminum, No-Ox grease, and silicone caulk may be susceptible to change in material properties. Steel may be susceptible to loss of material.

The bus assembly is constructed of sections of aluminum bus that are bolted together. Aluminum is also used on the enclosure ground strap connections. Aluminum is highly conductive but does not make a good contact surface pure aluminum plus air forms aluminum oxide which is a nonconductive surface. To prevent the formation of aluminum oxide on connection surfaces, the connections are cleaned with a wire brush (to remove any existing aluminum oxide) and covered with No-Ox grease to prevent air from contacting the aluminum surface. The No-Ox grease precludes oxidation of the aluminum surface thereby maintaining good conductivity at the bus connections. Therefore, change in material properties is not an applicable aging effect for the aluminum bus so long as the No-Ox grease covering is maintained.

No-Ox grease is used on the aluminum bus connections and the enclosure ground strap aluminum connections to prevent oxidation of the connection surfaces. No-Ox grease on electrical bus connections is replaced during each routine maintenance of the bus. No degradation of the No-Ox grease has ever been noted during the routine maintenance. Therefore, No-Ox grease is a consumable material and change in material properties is not an applicable aging effect.

Silicone caulk is used to seal around the aluminum bus as it enters and exits a wall bushing. Wall bushings are used as a thermal barrier as the bus passes from inside a building to the outside. The silicone caulk is a silicone rubber which has a useful upper temperature of 392°F (200°C). Silicone caulk, at the service conditions (ambient environment plus self-heating temperature rise) where it is applied, has a projected service life of greater than 60 years. Therefore, change in material properties is not an applicable aging effect for the silicone caulk.

Steel hardware (i.e., screws, bolts, washers, and nuts) is used on various parts of the bus enclosure assembly. Some sections of bus are installed outside where they are exposed to all forms of precipitation. All exposed steel hardware was factory coated to inhibit corrosion. After more than 20 years in its service environment, no signs of corrosion have been observed. Loss of material for steel hardware is not an applicable aging effect that would lead to a loss of intended function for the phase bus for the period of extended operation.

3.6.2.1.2 INDUSTRY EXPERIENCE

The industry experience review included a search of NRC generic communications. The following documents were identified in this search:

- Bulletin 79-27, *Loss of Non-Class 1E Instrumentation and Control Power System Bus During Operation*
- Generic Letter 91-11, *Resolution of Generic Issues 48, "LCOs for Class 1E Vital Instrument Buses," and 49, "Interlocks and LCOs for Class 1E Tie Breakers," Pursuant to 10 CFR 50.54(f)*
- IN 86-87, *Loss of Offsite Power Upon an Automatic Bus Transfer*
- IN 86-100, *Loss of Offsite Power to Vital Buses at Salem 2*
- IN 88-55, *Potential Problems Caused by Single Failure of an Engineered Safety Feature Swing Bus*
- IN 89-64, *Electrical Bus Bar Failures*
- IN 91-57, *Operational Experience on Bus Transfers*
- IN 92-09, *Overloading and Subsequent Lockout of Electrical Buses During Accident Conditions*
- IN 92-40, *Inadequate Testing of Emergency Bus Undervoltage Logic Circuitry*
- IN 93-28, *Failure to Consider Loss of DC Bus in Emergency Core Cooling System Evaluation May Lead to Nonconservative Analysis*

No unique aging effects were identified in the above documents beyond those identified in this section.

3.6.2.1.3 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to identify applicable aging effects for electrical bus. This review included a survey of documented instances of component aging along with interviews of responsible engineering personnel. No unique aging effects were identified from the review beyond those identified in this section.

3.6.2.1.4 CONCLUSION

Based upon the review of industry information, NRC generic communications and Oconee operating experience, no aging effects are applicable for phase bus. Therefore, no aging management program is necessary.

3.6.2.2 Switchyard Bus

Switchyard bus included in the aging management review is identified in Section 2.6.2.2 of OLRP-1001. The review to identify the applicable aging effects for the switchyard bus considers the following potential aging effects which have been identified by reviewing available industry literature:

- Change in material properties due to surface oxidation

The process to identify the aging effects that are applicable to switchyard bus is consistent with the process described in Section 3.2. The assessment of aging effects for switchyard bus is provided in the following section. The results are summarized in Table 3.6-1.

3.6.2.2.1 APPLICABLE AGING EFFECTS FOR SWITCHYARD BUS

Switchyard bus is located within the 230 kV Switchyard and is exposed to ambient environmental conditions for Yard Structures as described in Section 3.2 of OLRP-1001. These environmental conditions include temperatures up to 105°F (40.6°C), negligible radiation, and exposure to moisture from all forms of precipitation. Self heating contributes an increase in temperature of the bus of up to approximately 30°C.

The only material used for the 230 kV switchyard bus is aluminum. All bus connections within the review boundaries are welded connections. For the ambient environmental conditions at Oconee, no aging effects have been identified that could cause a loss of intended function.

3.6.2.2.2 INDUSTRY EXPERIENCE

In order to identify aging effects, and to assure no additional aging effects exist beyond those discussed herein, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. No documents involving switchyard bus were identified.

3.6.2.2.3 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to identify applicable aging effects for switchyard bus. This review included a survey of documented instances of component aging along with interviews of responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.6.2.2.4 CONCLUSION

Based upon the review of industry information, NRC generic communications, and Oconee operating experience, no aging effects are applicable for switchyard bus. Therefore, no aging management program is necessary.

3.6.3 Insulated Cables and Connections

Insulated cables and connections included in the aging management review are identified in Section 2.6.3 of OLRP-1001. A report published by the Department of Energy (DOE), *Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Cable and Terminations* [Reference 3.6-1] (DOE Cable AMG), provides a compilation and evaluation of information on the topic of aging and aging management for cables and their associated connections. The DOE Cable AMG evaluated the stressors acting on cable and connection components, industry data on aging and failure of these components, and the maintenance activities performed on cable systems. Also evaluated were the main subsystems within cables, including the conductors, insulation, shielding, tape wraps, jacketing, and drain wires, as well as all subcomponents associated with each type of connection.

The principal aging mechanisms and anticipated effects resulting from environmental and operating stresses were identified, evaluated, and correlated with plant experience to determine whether the predicted effects are consistent with field experience. As such, the information, evaluations, and conclusions contained in the DOE Cable AMG [Reference 3.6-1, Table 4-18, page 4-81] are used to identify potential aging effects for insulated cables and connections which are listed below:

- For low voltage cable connectors (< 2 kV) - loss of material due to moisture, leading to increased resistance and heating or loss of circuit continuity.
- For medium voltage cable (2 kV to 15 kV) - change in material properties due to moisture, leading to insulation breakdown and electrical failure.
- For medium voltage and low voltage cables - change in material properties due to excessive heat and radiation, leading to reduced insulation resistance or electrical failure.

The process to identify the aging effects applicable to insulated cables and connections is consistent with the process described in Section 3.2. The assessment of aging effects for insulated cables and connections is provided in the following section. The results are summarized in Table 3.6-1.

3.6.3.1 Applicable Aging Effects for Insulated Cables and Connections

The aging management review includes cables and connections installed in the locations identified in Table 2.6-9. The ambient environmental conditions for these locations are provided in Section 3.2 of OLRP-1001 and Tables 3.2-1 and 3.2-2. Moisture could affect cables and connectors located in the Intake Structure, Keowee Structure and Yard Structures. The bounding self-heating temperature rise for insulated cables and connections is provided in Table 3.6-2. Service conditions for insulated cables and connections at Oconee are provided in Table 3.6-3.

3.6.3.1.1 LOW-VOLTAGE CONNECTOR — MOISTURE

The DOE Cable AMG [Reference 3.6-1, Section 3.7.2.1.1.3] states that only 3% of all low-voltage connector failures were identified as being caused by moisture intrusion. Based on the total number of reported connector failures in the DOE Cable AMG, moisture intrusion accounted for a total of ten failures in all of the operating plants in the United States.

Structures and areas where electrical components may be exposed to moisture are indicated in Table 3.6-3. Connectors located in outside areas, such as the 230 kV Switchyard and Intake Structures, are in enclosures and not subject to moisture or precipitation. The moisture noted at Keowee was in the shaft well. This moisture, which came from wall seepage, is only enough seepage to cause mineral deposits on the wall. There is insufficient moisture to cause collection in any area. Therefore, aging effects related to moisture are not applicable to low-voltage connectors.

3.6.3.1.2 MEDIUM-VOLTAGE CABLE — MOISTURE

DOE Cable AMG, Section 3.7.4, describes a survey of 25 fossil and nuclear power plants which was conducted to determine the number and types of medium-voltage cable failures that have occurred. The survey identified only 27 failures in almost 1000 plant years of experience. The bulk of the failures that did occur were primarily related to wetting in conjunction with manufacturing defects or damaged terminations due to improper installation, which are not aging effects subject to aging management review.

Structures and areas where cable may be exposed to moisture are indicated in Table 3.6-3 and include areas exposed to outside ambient conditions (Intake Structure and Yard Structures), isolated areas at Keowee, cable trenches, and direct buried. Medium-voltage cables are not located in the isolated areas at Keowee where moisture was observed. The medium-voltage cables within scope and within any of these areas are listed in Table 3.6-4. Power cables installed in cable trenches, exposed to outside ambient conditions, direct buried, or run in conduit are evaluated in separate sections below.

3.6.3.1.2.1 Power Cable Installed in Cable Trenches

Cable trenches are subject to moisture from precipitation which can seep around the trench covers, down the trench sides, and collect for a time in the trench floor. The Condenser Cooling Water cable trenches have floor drainage pipes to drain water. The trenches from the Turbine Buildings to the 230 kV Switchyard, and the trenches in the 230 kV and 525 kV Switchyards, have concrete sides with a sand and gravel bottom for water drainage. The trench from the Standby Shutdown Facility is built with a drain to prevent flooding. In addition, power cables are mounted to the trench sides and kept off the trench floor. This type of limited exposure to moisture (as it runs down the side of the cable trench) does not present a moisture concern for power cables. Therefore, aging effects caused by exposure to moisture are not applicable to medium-voltage power cables installed in a cable trench.

3.6.3.1.2.2 Power Cables Exposed To Outside Ambient Conditions

The Condenser Cooling Water pump power cables are the only medium-voltage cables within scope that are exposed to direct precipitation. The Condenser Cooling Water pump power cables are exposed to precipitation where they exit the top of the Intake Structure to connect to the Condenser Cooling Water pump motors. These cables are all constructed with an overall jacket which prevents moisture from contacting the primary insulation. The UFSAR states that precipitation at Oconee occurs less than 10% of all hours of the year [Reference 3.6-2, Section 2.3.2.1]. This type of limited exposure to moisture (direct precipitation) does not present a moisture concern for these cables. Therefore, aging effects caused by exposure to moisture are not applicable to the cables with an overall jacket exposed to outside ambient conditions.

3.6.3.1.2.3 Direct Buried Power Cables

The Keowee emergency power cables to Transformer CT4 (CT4 cables) and the Transformer CX power cables are the only direct buried medium-voltage cables within scope. These cables are direct buried in a trench and are subject to precipitation water seepage from the surface as it flows down through the ground and the trench. The trench is constructed such that the cables are surrounded with layers of sand for rapid water drainage. These cables are single conductor with EPR primary insulation, covered by bronze armor and an overall PVC jacket. The overall PVC jacket is designed for direct burial and precludes moisture from contacting the primary cable insulation. In addition, the 13.8 kV CT4 cables carry power approximately four hours per outage and are energized without carrying power whenever a Keowee unit is generating power to the 230 kV Switchyard, meaning that the CT4 cables are actually energized less than 12% of the time. Therefore, aging effects caused by exposure to moisture are not applicable to these medium-voltage direct buried cables.

3.6.3.1.2.4 POWER CABLES RUN IN CONDUIT

The medium-voltage cables run in conduit are constructed with EPR primary insulation, copper shield tape and a PVC overall jacket. The overall jacket on the cables precludes moisture from contacting the primary cable insulation. Therefore, aging effects caused by exposure to moisture are not applicable to these medium-voltage cables run in conduit.

3.6.3.1.3 LOW & MEDIUM-VOLTAGE CABLE — RADIATION

Table 3.6-5 lists both the lowest threshold dose and the moderate damage dose of gamma radiation for insulated cable and connection materials included in the aging management review. The threshold value is the amount of radiation that causes incipient to mild damage. Once this threshold is exceeded, damage to the insulation increases from mild to moderate to severe as the total dose increases by one to two orders of magnitude (an increase of one million to ten million rads). The moderate damage value indicates the value at which the material has been damaged but is still functional. Additional information regarding specific insulation types is given in the right side column of Table 3.6-5. Comparing the radiation values given in Table 3.6-5 with the service conditions shown in Table 3.6-3 indicates that all of the insulation materials can withstand the maximum 60-year normal radiation dose for their installed locations. Aging effects caused by radiation exposure will not adversely affect the function of any cables during the current or extended period of operation and, therefore, are not applicable.

3.6.3.1.4 LOW & MEDIUM-VOLTAGE CABLE — HEAT

The total thermal life of insulated cable and connection materials can be calculated using the Arrhenius method as described in EPRI NP-1558 [Reference 3.6-3]. The Arrhenius method is normally used to calculate a thermal life at a given temperature; however, it can be used to calculate a maximum continuous temperature for a specific length of time. Therefore, using the Arrhenius method in this way, with the time period fixed at 60 years, calculations were performed to determine the maximum continuous temperature to which the material can be exposed so that the material will have the indicated “endpoint” at the end of 60 years.

As determined in NUREG/CR-6384 [Reference 3.6-4, page 5-57], the retention-of-elongation of most cable insulation materials can be reduced to 0% and the insulation still will be capable of withstanding a loss-of-coolant accident and remain functional. Because the insulated cables and connections subject to aging management review will not be subjected to an accident environment or are not required to function after being subjected to an accident environment, the endpoints chosen for this review are extremely conservative. The insulated cable and connection materials can be aged a great deal more without loss of function.

A comparison of the temperature values given in Table 3.6-6 with the service conditions shown in Table 3.6-3 indicates that all of the insulation materials except EP, EPR, EPDM, FR-EPR, and Hypalon used in power applications can withstand the bounding temperatures for 60 years. These materials and their applications are discussed below.

The bounding service temperature for EP, EPR, EPDM, FR-EPR and Hypalon is 158.45°F (70.25°C). The maximum 60-year life temperature for EP, EPR, EPDM and FR-EPR is 154.9°F (68.3°C), which is 3.55°F less than the bounding service temperature. The maximum 60-year life temperature for Hypalon is 154.0°F (67.8°C), which is 4.45°F less than the bounding service temperature. These differences (3.55°F and 4.45°F) are very small and are considered to be within the conservatisms incorporated into the bounding service temperature values, as explained below.

The 60-year life endpoint for EP, EPR, EPDM and FR-EPR is 40% retention-of-elongation and for Hypalon is 50% elongation. Since the cables and connections subject to an aging management review either will not be subjected to accident conditions or are not required to remain functional during or after an accident, these values can be reduced much further without a loss of function.

The Oconee units, since initial operation, have a capacity factor of less than 75%. The bounding temperature includes a self-heating temperature rise value that does not take this into account. Accounting for this time would lessen the aging effects from self-heating.

Given these conservatisms, reasonable assurance exists that EP, EPR, EPDM, FR-EPR and Hypalon insulated cables and connections will not thermally age through extended period of operation to the point that they will not be able to perform their function.

Therefore, no applicable thermal aging effects are identified for insulated cables and connections through the period of extended operation.

3.6.3.2 Industry Experience

The DOE Cable AMG [Reference 3.6-1, Table 3-5] includes an industry experience review that includes a review of NRC generic communications. The DOE Cable AMG review was used by Duke to identify the potential aging effects for insulated cables and connections.

3.6.3.3 Oconee Operating Experience

Oconee operating experience was reviewed to identify applicable aging effects for insulated cables and connections. This review included a survey of documented instances of component aging along with interviews of responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.6.3.4 Conclusion

Based the review of industry information, NRC generic communications, and Oconee operating experience, no aging effects are applicable for insulated cables and connections. Therefore, no aging management program is necessary.

3.6.4 INSULATORS

Electrical insulators included in the aging management review are identified in Section 2.6.4 of OLRP-1001. The review to identify the applicable aging effects for transmission conductors considers the following potential aging effects, which have been identified by reviewing available industry literature:

- Cracking
- Loss of material due to wear
- Surface contamination

The process to identify the aging effects that are applicable to insulators is consistent with the process described in Section 3.2. The assessment of aging effects for insulators at Oconee is provided in the following section. The results are summarized in Table 3.6-1.

3.6.4.1 Aging Effects Assessment for Insulators

Oconee insulators included in the aging management review are installed outside and are exposed to ambient environmental conditions for Yard Structures as described in Section 3.2 of OLRP-1001. These environmental conditions include temperatures up to 105°F (40.6°C), negligible radiation, and exposure to moisture from all forms of precipitation. Insulator materials included in the aging management review are porcelain, various galvanized metals, and cement.

3.6.4.1.1 CRACKING ASSESSMENT

Porcelain is essentially a hardened, opaque glass. As with any glass, if subjected to enough force it will crack or break. The most common cause of cracking or breaking of a porcelain insulator is being struck by an object. Cracking and breaking caused by physical damage is not an aging effect and is not subject to an aging management review.

Cracks have also been known to occur with insulators when the cement that binds the parts together expands enough to crack the porcelain. This phenomenon, know as cement growth, is caused by improper manufacturing process or materials which make the cement more susceptible to moisture penetration. Porcelain cracking caused by cement growth has occurred only in isolated bad batches of insulators used in strain applications. Inspections at Oconee did not identify any insulators from the known bad batches. Therefore, cracking is not an applicable aging effect for insulators at Oconee.

3.6.4.1.2 LOSS OF MATERIAL ASSESSMENT

Mechanical wear is an aging effect for strain and suspension insulators in that they are subject to movement. Movement of the insulators can be caused by wind blowing the supported transmission conductor, causing it to swing from side to side. If this swinging is frequent enough, it could cause wear in the metal contact points in an insulator string and between an insulator and the supporting hardware. Although this mechanism is possible, experience has shown that the transmission conductors do not normally swing and that when they do, they do not continue to swing for very long once the wind has subsided. Wear has not been identified during inspections of the Oconee insulators. Although rare, surface rust may form where galvanizing is burnt off due to flashover from lightning strikes. Loss of material is not an applicable aging effect that will cause a loss of function of the insulators at Oconee.

3.6.4.1.3 SURFACE CONTAMINATION ASSESSMENT

Insulator surfaces can be contaminated by various airborne materials such as dust, salt and industrial effluents. The buildup of surface contamination is gradual and in most areas such contamination is washed away by rain; the glazed insulator surface aids this contamination removal. A large buildup of contamination enables the conductor voltage to track along the surface more easily and can lead to insulator flashover.

Surface contamination can be a problem in areas where there are greater concentrations of airborne particles, such as near facilities that discharge soot or near the sea coast where salt spray is prevalent. Oconee is located in a mountainous area with moderate rainfall where airborne particle concentrations are comparatively low. Consequently, the rate of contamination buildup on the insulators is insignificant. At Oconee, as in most areas of the Duke transmission system, contamination build-up on insulators is not a problem. Therefore, surface contamination is not an applicable aging effect for the insulators.

3.6.4.2 Industry Experience

In order to identify aging effects considered, and to assure no additional aging effects exist beyond those discussed herein, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following document related to insulators was identified in this survey:

- IN 93-95, *Storm-Related Loss of Offsite Power Events Due to Salt Buildup on Switchyard Insulators*

No unique aging effects were identified in the above documents beyond those identified in this section.

3.6.4.3 Oconee Operating Experience

Oconee operating experience was reviewed to identify applicable aging effects for high voltage insulators. This review included a survey of documented instances of component aging along with interviews of responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.6.4.4 Conclusion

Based the review of industry information, NRC generic communications, and Oconee operating experience, no aging effects are applicable for high voltage insulators. Therefore, no aging management program is necessary.

3.6.5 Transmission Conductors

Transmission conductors included in the aging management review are identified in Section 2.6.5 of OLRP-1001. The review to identify the applicable aging effects for transmission conductors considers the following potential aging effect which has been identified by reviewing available industry literature:

- Loss of conductor strength

The process to identify the aging effects that are applicable to transmission conductors is consistent with the process described in Section 3.2. The assessment of aging effects applicable for transmission conductors at Oconee is provided in the following section. The results are summarized in Table 3.6-1.

3.6.5.1 Aging Effects Assessment for Transmission Conductors

Oconee transmission conductors are installed outside and are exposed to ambient environmental conditions for Yard Structures as described in Section 3.2 of OLRP-1001. These environmental conditions include temperatures up to 105 °F (40.6°C), negligible radiation, and exposure to moisture from all forms of precipitation. Self-heating temperature rise of transmission conductors is considered as appropriate.

The transmission conductors included in the aging management review are constructed of aluminum conductors steel reinforced (ACSR). The most prevalent mechanism contributing to loss of conductor strength of an ACSR transmission conductor is corrosion, which includes corrosion of the steel core and aluminum strand pitting. For ACSR conductors, degradation begins as a loss of zinc from the galvanized steel core wires. Corrosion rates depend to a great extent on air quality which includes suspended particles chemistry, SO_2 concentration in air, precipitation, fog chemistry, and meteorological conditions. Tests performed by Ontario Hydroelectric showed a 30% loss of composite conductor strength of an 80-year-old ACSR conductor due to corrosion [Reference 3.6-5].

Corrosion of ACSR conductors is a very slow acting aging effect that is even slower for rural areas such as Oconee, with generally less suspended particles and SO_2 concentrations in the air than urban areas. Duke has been installing and maintaining transmission conductors on its transmission system for more than 50 years and has not yet had to replace any conductors due to aging problems. This supports the conclusion that there are no applicable aging effects that could affect the function of the transmission conductors for the period of extended operation.

3.6.5.2 Industry Experience

In order to identify applicable aging effects, and to assure no additional aging effects exist beyond those discussed herein, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. No documents involving transmission conductors were identified.

3.6.5.3 Oconee Operating Experience

Oconee operating experience was reviewed to identify applicable aging effects for transmission conductors. This review included a survey of documented instances of component aging along with interviews of responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this section.

3.6.5.4 Conclusion

Based the review of industry information, NRC generic communications, and Oconee operating experience, no aging effects are applicable for transmission conductors. Therefore, no aging management program is necessary.

3.6.6 References for Section 3.6

3.6-1. SAND 96-0344, *Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Cable and Terminations*, September 1996, Sandia National Laboratories for the U.S. Department of Energy.

3.6-2. *Oconee Nuclear Station Updated Final Safety Analysis Report,* as revised.

3.6-3. EPRI NP-1558, "A Review of Equipment Aging Theory and Technology," September 1980, Electric Power Research Institute.

3.6-4. NUREG/CR-6384, "Literature Review of Environmental Qualification of Safety-Related Electric Cables," Vol. 1, April 1996, Brookhaven National Laboratory, Prepared for U.S. Nuclear Regulatory Commission.

3.6-5. IEEE Transactions on Power Delivery, Vol. 7, No. 2, April 1992, *Aged ACSR Conductors, Part I - Testing Procedures for Conductors and Line Items,* by D. G. Harvard, G. Bellamy, P. G. Buchan, H. A. Ewing, D. J. Horrocks, S. G. Krishnasamy, J. Motlis, and K. S. Yoshiki-Gravelsins; and *Aged ACSR Conductors, Part II - Prediction of Remaining Life*, by D. G. Harvard, M. K. Bissada, C. G. Fajardo, D. J. Horrocks, J. R. Meale, J. Motlis, M. Tabatabai, and K. S. Yoshiki-Gravelsins; Ontario Hydro, Toronto, Canada; 0885-8977/91/©1992 IEEE. (Contact IEEE, 445 Hoes Lane, Piscataway, NJ, USA 08855-1331, 732-981-0060 to obtain a copy of these papers.)

Table 3.6-1 Applicable Aging Effects for Electrical Components

Component	Applicable Aging Effect(s)	Aging Management Programs
Bus Isolated-Phase Bus Nonsegregated-Phase Bus Segregated-Phase Bus Switchyard Bus	None identified	None required
Insulated Cables and Connections	None identified	None required
Insulators	None identified	None required
Transmission Conductors	None identified	None required

Table 3.6-2 Self-Heating Temperature Rise for Insulated Cables & Connections

Specific Components	Specific Insulation Material	Bounding Self-Heating Temperature Rise
Power Application Cables and Connections	EP, EPR, EPDM, FR-EPR Hypalon Kapton Kerite-HTK Phenolic SR XLP, XLPE, Vulkene, FR-XLPE	29.65°C
	Butyl PE	10.0°C
I&C Application Cables and Connections	AVA Fiberglass Nylon Polyalkene PVC EP, EPR, EPD, FR-EPR (in the Reactor Buildings) XLP, XLPE, Vulkene, FR-XLPE (in the Reactor Buildings)	Insignificant

Table 3.6-3 Service Conditions for Insulated Cables and Connections

Stressor	Structure or Area	Specific Area or Insulation Material	Bounding Value
Moisture	Intake Structure	Areas exposed to outside ambient conditions	Precipitation
	Keowee Structures	Turbine shaft wells	Wall water seepage
	Yard Structures	Areas exposed to outside ambient conditions	Precipitation
		Cable trench	trench floor standing water
		Direct buried	surface water drainage, soil moisture
		Conduit	water collection
Radiation	Reactor Buildings	EP, EPR, EPDM, FR-EPR, XLP, XLPE, Vulkene, FR-XLPE	4.5×10^7 rads
	Auxiliary Buildings Intake Structure Keowee Structures Standby Shutdown Facility Turbine Buildings Yard Structures	All materials	1.5×10^6 rads
Temperature	Reactor Buildings	EP, EPR, EPDM, FR-EPR, XLP, XLPE, Vulkene, FR-XLPE	132°F (55.6°C)
	Auxiliary Buildings Intake Structure Keowee Structures Standby Shutdown Facility Turbine Buildings Yard Structures	EP, EPR, EPDM, FR-EPR Hypalon Kapton Kerite-HTK Phenolic SR XLP, XLPE, Vulkene, FR-XLPE	158.45°F (70.25°C)
		Butyl PE	123.1°F (50.6°C)
		AVA Fiberglass Nylon Polyalkene PVC	105°F (40.6°C)

Table 3.6-4 Medium Voltage Insulated Cables Exposed to Moisture

Description	Voltage	Potential Moisture Exposure Area	Cable Runs	
			From	To
Keowee Emergency Power Cables to Transformer CT4	13.8 kV	Direct Buried	Unit 1&2 Switchgear Blockhouse	Keowee Breaker Vault
Keowee Transformer CX Power Cables from Oconee	4160V	Direct Buried	Unit 1&2 Switchgear Blockhouse	Keowee Powerhouse
Auxiliary Service Water Switchgear Cables	4160V	Conduit	Unit 1&2 Switchgear Blockhouse	Oconee Transformer Yard Manholes to Turbine Building to Auxiliary Building
High Pressure Service Water Pumps A & B Cables	4160V	Conduit	Unit 1&2 Switchgear Blockhouse	Oconee Transformer Yard Manholes to Turbine Building
Condenser Circulating Water Pump Cables	4160V	Cable Trench, Outside ambient	Auxiliary Building	Intake Structure
Standby Shutdown Facility Switchgear OTS1 Power Cables	4160V	Cable Trench	Standby Shutdown Facility	Auxiliary Building
230 kV & 525 kV Switchyard Power Cables	4160V	Cable Trench	Turbine Building	230 kV Switchyard

Table 3.6-5 Radiation Dose Data for Insulated Cable and Connection Materials

Material	Lowest Threshold Dose	Moderate Damage Dose	Additional Information
Kapton	1 x 10^7 rads	2 x 10^8 rads	
XLP, XLPE, Vulkene, FR-XLPE	1 x 10^6 rads	1 x 10^8 rads	
Kerite-HTK	1 x 10^6 rads	1 x 10^8 rads	Although no value for Kerite is listed in Table 4-7 of the DOE Cable AMG, it has been tested for the nuclear industry at total doses in excess of the moderate damage dose. To be conservative, a threshold damage dose two orders of magnitude less than this is assumed.
EP, EPR, EPDM, FR-EPR	1 x 10^6 rads	5 x 10^7 rads	
Phenolic	~3 x 10^6 rads	~4 x 10^7 rads	The radiation resistance of phenolic varies depending on what it is “filled” with (e.g., glass, asbestos, etc.). The values for “unfilled” phenolic are chosen since it is the weakest.
PE	3.8 x 10^5 rads	2 x 10^7 rads	
PVC	1 x 10^5 rads	2 x 10^7 rads	
Butyl	7 x 10^5 rads	5 x 10^6 rads	
SR	1 x 10^6 rads	3 x 10^6 rads	
Hypalon	5 x 10^5 rads	2 x 10^6 rads	
Nylon	5 x 10^5 rads	2 x 10^6 rads	The values used here are for the most common (general purpose) formulation of nylon.
Polyalkene	No data	No data	No data could be obtained for polyalkene. However, the material was tested and is described as “irradiation cross-linked polyalkene,” which means that the material is subjected to radiation as part of the manufacturing process (similar to irradiation cross-linked polyethylene, commonly known as XLPE). Since the irradiation process is used to strengthen the material, it is assumed that it has a relatively high resistance to radiation after the manufacturing process.
AVA	None	None	AVA is a code for impregnated asbestos and varnished cambric insulation covered by asbestos braid or glass. Asbestos is a mineral and is not affected by radiation.
Fiberglass	None	None	Fiberglass is spun glass and is not affected by radiation (except for some change in color).

Table 3.6-6 Temperature Data for Insulated Cable And Connection Materials

Insulation	Maximum Temperature for 60-Year Life	Activation Energy (□), eV	"b"	Endpoint
SR	273°F (133.9°C)	1.81	-16.69	50% Retention-of-Elongation
Kapton	248°F (120.0°C)	3.916	-43.208	Failure
Phenolic	220.5°F (104.7°C)	1.37	-12.14	50% Retention of Impact Strength
Polyalkene	189°F (87.2°C)	1.11	-9.79	Mean-Time-To-Failure
XLP, XLPE, Vulkene, FR-XLPE	188.1°F (86.7°C)	1.35	-13.19	60% Retention-of-Elongation
Kerite-HTK	185.4°F (85.2°C)	1.07	-9.33	20% Retention-of-Elongation
EP, EPR, EPDM, FR-EPR	154.9°F (68.3°C)	1.10	-10.51	40% Retention-of-Elongation
Hypalon	154°F (67.8°C)	1.14	-11.13	50% Elongation
PE	131°F (55.0°C)	1.14	-12.37	T_{75} Induction Period
Nylon	129.9°F (54.4°C)	0.84	-7.44	28% Retention of Tensile Strength
Butyl	125.1°F (51.7°C)	1.10	-11.34	40% Retention-of-Elongation
PVC	111.9°F (44.4°C)	0.99	-10.00	Mean-Time-To-Failure
Fiberglass	Does not age from heat.	- -	- -	- -
AVA	No Data [Footnote 21]	No Data	No Data	No Data

21. AVA is a code for impregnated asbestos and varnished cambric insulation covered by asbestos braid or glass. It is rated for a maximum operating temperature of 230°F (110°C) for use in dry locations only.

3.7 AGING EFFECTS FOR STRUCTURAL COMPONENTS

3.7.1 DESCRIPTION OF THE PROCESS TO IDENTIFY THE APPLICABLE AGING EFFECTS FOR STRUCTURAL COMPONENTS

Structural components that are within the scope of license renewal and require aging management review are identified in Section 2.7. Their intended functions also are identified in Section 2.7.

The process to determine the aging effects applicable to structural components begins with an understanding of the potential aging effects defined in industry literature. From this set of potential aging effects, the component materials, operating environment and operating stresses serve to determine the applicable aging effects for each component subject to aging management review. These applicable aging effects are then validated by a review of industry and Oconee operating experience to provide reasonable assurance that the full set of applicable aging effects are established for the aging management review. This process is described more fully in Section 3.2 of OLRP-1001. To facilitate the identification of applicable aging effects, structural components have been grouped as follows:

- Concrete Structural Components
- Steel Structural Components in an Air Environment
- Steel Structural Components in a Fluid Environment
- Fire Barriers

Section 3.7.2 provides the determination of applicable aging effects for each of these categories. Sections 3.7.3 through 3.7.10 identify the applicable aging effects on a structure-by-structure basis, incorporating the information provided in Section 3.7.2 as appropriate. The tables at the end of Section 3.7 summarize the applicable aging effects for each structural component.

3.7.2 APPLICABLE AGING EFFECTS FOR STRUCTURAL COMPONENTS

3.7.2.1 Applicable Aging Effects for Concrete Structural Components

Concrete structural components are identified in Section 2.7 of OLRP-1001. As an aid to the reader, the types of concrete structural components that are subject to aging management review are repeated here and include:

- Anchorage (in concrete)
- Embedments (in concrete)
- Equipment Pads
- Flood Curbs
- Foundation Dowels
- Foundations
- Hatches
- Masonry Block and Brick Walls
- Missile Shields
- Pipe Piles
- Reinforced Concrete Beams, Columns, Floor Slabs, and Walls
- Roof Slabs
- Sumps
- Trenches

The review to identify the applicable aging effects for concrete structural components considers the following potential aging effects, which have been identified by reviewing available industry literature:

- Loss of material due to abrasion and cavitation, aggressive chemicals, corrosion of embedded steel and rebar, elevated temperature, or freeze-thaw. Loss of material includes scaling, spalling, pitting, and erosion;
- Cracking due to elevated temperature, fatigue, freeze-thaw, reaction with aggregates, shrinkage, or settlement;
- Change in material properties due to aggressive chemical attack, elevated temperature, irradiation embrittlement, or leaching of calcium hydroxide. Change in material properties is manifested in concrete components as increased permeability, increased porosity, reduction in pH, reduction in tensile strength, reduction in compressive strength, reduction in modulus of elasticity, and reduction in bond strength.

Consistent with the process described in Section 3.2, the applicable aging effects are determined by reviewing the materials of construction and ambient environment. Section 3.7.2.1.1 describes the ambient environments that concrete structural components are exposed to at Oconee. Sections 3.7.2.1.2 through 3.7.2.1.7 describe the results when the process is applied to concrete structural components at Oconee.

3.7.2.1.1 SERVICE ENVIRONMENTS

Concrete structural components are exposed to different service environments depending on their location. Below grade portions of the structures are exposed to back fill and groundwater. The groundwater chemistry is relevant in the determination of the degradation of below grade concrete components.

External surfaces of structures are exposed to the ambient environment. Oconee is located in a rural environment and is not located near major industrial plants or any body of saltwater. The end result is that Oconee concrete structures are not exposed to sulfate or chloride attack.

Internal portions of the structures and their components are exposed to internal environments which protect them from external weather and temperature changes. These internal environments may be controlled, such as in the control room of the Auxiliary Building, where the temperature and humidity are relatively mild. Other areas, such as some interior parts of the Turbine Building and Reactor Building, are exposed to higher temperatures, humidity, and radiation (Reactor Building). These variables play a major role in the potential degradation of the components located within these environments.

External portions of the Intake Structure and the Keowee Structures are exposed to the waters of Lake Keowee. The chemistry of the waters of Lake Keowee is relevant in the determination of the degradation of these structures.

Additional information on the environmental conditions at Oconee is provided in Section 3.2 of OLRP-1001.

3.7.2.1.2 LOSS OF MATERIAL ASSESSMENT

As water moves over a concrete surface, it can carry abrasive materials or it can create a negative pressure (vacuum) that can cause abrasion and cavitation. If significant amounts of concrete are removed by either of these processes, pitting or aggregate exposure occurs due to loss of cement paste. These degradations are readily detected by visual examination in accessible locations. Loss of material due to abrasion and cavitation is not an applicable aging effect for the Oconee concrete structures and components which are not exposed to continuously flowing water. Below-grade surfaces with exposure to ground water also are not affected, since any flow of groundwater is negligible and unable to cause significant abrasion and cavitation effects.

Loss of material due to abrasion and cavitation is an applicable aging effect for concrete structures and components which are exposed to continuously flowing water. The Intake Structure and the Keowee Structures are the only structures that are exposed to flowing water. Therefore, loss of material due to abrasion is an applicable aging effect for the Intake Structure and the Keowee Intake Structure, Penstock, and Spillway.

Repeated cycles of freezing and thawing can alter both the mechanical properties and physical form of the concrete, thus affecting the structural integrity of the component. Surfaces exposed to weather that can become saturated with water and freeze are vulnerable to freeze-thaw degradation [Reference 3.7-1]. Freeze-thaw damage starts at the surface and is readily detected by surface inspections. The resistance of the concrete to freeze-thaw is dependent on the amount of entrained air, permeability of the concrete to water penetration, and protection of concrete from freeze-thaw until adequate strength has developed [Reference 3.7-2]. For damage to occur by freezing of absorptive coarse aggregates, the aggregate must be saturated. Saturation can only occur when water is available from an outside source. Freeze-thaw damage typically occurs on relatively flat concrete surfaces such as pavement, where water can remain in contact with the concrete.

In general, loss of material due to freeze-thaw is not an applicable aging effect of concrete structures at Oconee due to their material of construction. However, the concrete in the Intake Structure and the Keowee Structures may become saturated and could be susceptible to freeze-thaw. Therefore, loss of material due to freeze-thaw is an applicable aging effect for the Intake Structure and the Keowee Intake Structure, Penstock, and Spillway.

3.7.2.1.3 CRACKING ASSESSMENT

Fatigue is a common degradation of structural members produced by periodic or cyclic loadings that are less than the maximum allowable static loading. Fatigue results in progressive, localized damage to structural materials. Two types of fatigue exist for structural components. The first type is low-cycle fatigue, which is a low frequency (<100 cycles for concrete structures and $<1 \times 10^5$ for steel structures) of high-level repeated loads due to abnormal events such as earthquakes or design basis winds. The localized fatigue damage caused by such loading may not occur or may occur only a few times during the service life of a structure. The other type of fatigue is high-cycle fatigue, which is a high frequency of low-level, repeated loads such as equipment vibration. Fatigue is not an issue for any concrete structures and components, other than equipment pads, because the concrete components are not exposed to cyclical loadings. Cracking due to fatigue is an applicable aging effect for equipment pads and needs to be managed for the extended period of operation.

Cracking due to freeze-thaw is an applicable aging effect for the Intake Structure and Keowee Intake Structure, Penstock and Spillway since they may become saturated and could be susceptible to freeze-thaw. Cracking due to freeze-thaw would lead to loss of material (See discussion in Section 3.7.2.1.2).

Cracking of masonry block walls can be caused by shrinkage, loading effects or deflection of supporting structures. Shrinkage and cracking of masonry block walls is generally small and occurs at block joints in the earlier stages of plant operation. Cracking could reduce the structural strength of the wall. Corrosion of embedded or reinforcing steel may occur as a result of moisture and oxygen intrusion through the cracks.

In response to IE Bulletin 80-11, Oconee inspected and analyzed all safety-related masonry walls. The inspections took place in the early 1980's, over ten years after the walls were installed. Any cracks that affected structural integrity were identified in the inspections and addressed in the analysis. In reinforced walls, the reinforcement limits the crack size and propagation. In unreinforced walls, the potential for crack propagation is significant. Therefore, cracking is considered an applicable aging effect for unreinforced masonry walls.

3.7.2.1.4 CHANGE IN MATERIAL PROPERTIES ASSESSMENT

Water, either from rain or melting snow, that contains small amounts of calcium ions can readily dissolve calcium compounds in concrete when it passes through cracks, inadequately prepared construction joints, or areas inadequately consolidated during placing. The most readily soluble calcium compound is calcium hydroxide (lime). The aggressiveness or affinity of water to leach calcium hydroxide depends on its dissolved salt content and its temperature. Since leaching occurs when water passes through the concrete, structures that are subject to flowing liquid, ponding, or hydraulic pressure are more susceptible to degradation by leaching than those structures that water merely passes over. When calcium hydroxide is leached away, other cementitious constituents become exposed to chemical decomposition, eventually leaving behind silica and alumina gels with little or no strength. Leaching over a long period of time increases the porosity and permeability of concrete, making it more susceptible to other forms of aggressive attack and reducing the strength of concrete. Leaching also lowers the pH of concrete and threatens the integrity of the exterior protective oxide film of rebar.

Resistance to leaching and efflorescence can be enhanced by using concrete with low permeability. A dense concrete with a suitable cement content that has been well cured is less susceptible to calcium hydroxide loss from percolating water because of its low permeability and low absorption rate. The Oconee concrete structures and components are designed in accordance with American Concrete Institute ACI 318-63 [Reference 3.7-3]. They are constructed in accordance with ACI 301 [Reference 3.7-4], using ingredients conforming to ACI and ASTM standards which provide a good quality, dense low permeability concrete. Therefore, change in material properties due to leaching is not an applicable aging effect for the Oconee concrete structural components.

Leaching is applicable to the Keowee Intake Structure, Penstock, Spillway and Powerhouse especially along expansion joints in the spillway. Leaching has been identified during inspections of Keowee structures. Therefore, change in material properties due to leaching is an applicable aging effect for the Keowee Intake Structure, Penstock, Spillway and Powerhouse.

3.7.2.1.5 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects considered, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following documents were reviewed in this survey:

- NUREG-1522, *Assessment of Inservice Conditions of Safety-Related Nuclear Plant Structures*
- NUREG/CR-3604, *Bolting Applications*
- NUREG/CR-6424, *Report on Aging of Nuclear Power Plant Reinforced Concrete Structures*
- IE Bulletin 80-11, *Masonry Wall Design*
- IN 87-65, *Plant Operation Beyond Analyzed Conditions*
- IN 87-67, *Lessons Learned from Regional Inspections of Licensee Actions in Response to IE Bulletin 80-11*
- IN 92-42, *Fraudulent Bolts in Seismically Designed Walls*

No additional aging effects were identified from this review beyond those identified in this section.

3.7.2.1.6 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for concrete components. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. The review identified several cracks. As example, in November 1996, a crack in an Oconee Auxiliary Building floor was discovered during operator rounds. The crack was determined to be the result of slab shrinkage during initial concrete placement. All cracks were evaluated and it was determined that these types of cracks in reinforced concrete structures, other than Reactor Building Containment, would not result in loss of function. No additional aging effects were identified from this review beyond those identified in this section.

3.7.2.1.7 CONCLUSION

As a result of the review of industry information, NRC generic communications, and Oconee operating experience, Duke did not observe any additional aging effects beyond those discussed in this section. Therefore, the applicable aging effects that could result in loss of function of concrete structural components are:

- Loss of material from concrete structural components due to abrasion and freeze-thaw at the Intake Structure and Keowee Intake Structure, Penstock and Spillway
- Cracking of equipment pads due to fatigue
- Cracking of unreinforced masonry block and brick walls
- Change in material properties due to leaching for the Keowee Intake Structure, Penstock, Spillway and Powerhouse.

The applicability of these aging effects to each Oconee structure is provided in Sections 3.7.3 through 3.7.10.

3.7.2.2 Applicable Aging Effects for Steel Structural Components in an Air Environment

Steel structural components in an air environment are identified in Section 2.7 of OLRP-1001. As an aid to the reader, the types of steel structural components in an air environment that are subject to aging management review are repeated here and include:

- Anchorage and Embedments (exposed surfaces)
- Battery Racks
- Cable Tray
- Conduit
- Cable Tray and Conduit Supports
- Checkered Plate
- Control Boards
- Control Room Ceiling
- Crane Rails and Girders
- Electrical and Instrument Panels and Enclosures
- Elevated Water Storage Tank (Exterior)
- Equipment Component Supports
- Expansion Anchors
- Flood, Pressure, and Specialty Doors
- HVAC Duct Supports
- Instrument Line Supports
- Instrument Racks and Frames
- Lead Shielding Supports
- Metal Siding
- Piles
- Pipe Supports
- Stairs, Platform, Grating Supports
- Structural Steel Beams, Columns, Plates and Trusses
- Sump Screens
- Transmission Towers
- Unit Vent Stack

The review to identify the applicable aging effects for steel structural components in an air environment considers the following potential aging effects, which have been identified by reviewing available industry literature:

- Loss of material due to general corrosion
- Cracking due to fatigue or stress corrosion
- Change in material properties due to elevated temperature or irradiation embrittlement

Consistent with the process described in Section 3.2, the applicable aging effects are determined by reviewing the materials of construction and ambient environments. Section 3.7.2.2.1 describes the ambient environments to which steel structural components in air are exposed at Oconee. Sections 3.7.2.2.2 through 3.7.2.2.7 describe the results when the process is applied to steel components in air at Oconee.

3.7.2.2.1 ENVIRONMENT

Steel structural components within the scope of Section 3.7 are exposed to different service environments depending on their location. Additional information on the environmental conditions at Oconee is provided in Section 3.2 of OLRP-1001.

3.7.2.2.2 LOSS OF MATERIAL ASSESSMENT

Loss of material in steel structural components may be caused by corrosion of the steel. Steel components at Oconee are typically coated. Degradation or damage to coating systems could, under aggressive environmental conditions, lead to local corrosion attack of the steel components. Once moisture and oxygen penetrate the coating to the base metal, local corrosion could result and spread under the coating system, eventually lifting the coating and exposing large areas to corrosion. For exposed steel structural components, loss of material due to corrosion is an applicable aging effect if the coatings are not maintained. If corrosion is allowed to degrade the steel components for an extended period of time, loss of material could affect the capability of the component to fulfill its intended function.

Metal housing systems, such as electrical panels, cabinets, etc., constructed of painted or galvanized sheet metal do not have a tendency to age with time [Reference 3.7-5]. Industry operating experience with metal housing systems indicates that they have performed without failure to the present [References 3.7-6 and 3.7-7]. Therefore, loss of material due to corrosion is not an applicable aging effect for control boards and electrical panels and enclosures.

Cable tray is constructed of galvanized sheet metal similar to metal housings and located in the same environment; therefore, cable tray would age similarly to the metal housings. Industry operating experience does not identify any aging effects for cable tray systems. Deficiencies which were identified were either event driven or were design/installation deficiencies. Therefore, loss of material due to corrosion is not an applicable aging effect for cable tray.

Steel components which are not coated (such as the inside of the Polar Crane girders) are susceptible to corrosion due to moisture in the atmosphere and need to be inspected. Corrosion is not applicable for components which are coated. Where there is a loss of coating, the component is susceptible to corrosion. Therefore, loss of material due to corrosion is an applicable aging effect where there is loss of the protective coating.

3.7.2.2.3 CRACKING ASSESSMENT

Stress corrosion cracking of steel occurs under tensile stresses, either applied (external) or residual (internal), in the presence of a corrosive environment. Three parameters are required for stress corrosion cracking to occur: (1) a corrosive environment, (2) a susceptible material, and (3) tensile stresses. Stress corrosion cracking is a phenomenon that occurs in sensitized stainless steels, but becomes significant only if tensile stress and a corrosive environment exist. Corrosive environments containing sodium hydroxide, seawater, nitrate solutions, sulfuric acids or aggressive groundwater (chlorides > 500ppm, sulfates > 1500ppm) are not present at Oconee. The internal environments of the Oconee structures do not contain aggressive chemicals under normal operating conditions. Therefore, the conditions necessary for stress corrosion cracking to occur do not exist for the steel components at Oconee. With the exception of high strength bolting (discussed below), stress corrosion cracking is not an applicable aging effect.

Industry experience has shown that high strength bolting (i.e., bolting with yield strength greater than 150 ksi) installed in Reactor Coolant System supports could be susceptible to stress corrosion cracking in humid environments like the Reactor Building. The key factors include high-strength materials, moist environments, and a high level of sustained tensile stress. Two types of high strength bolting that were used in anchor bolt applications at Oconee are ASTM A325 and ASTM A490. Specifically, the ASTM A490 bolts were used in reactor vessel support skirt and the steam generator support skirt. Other Reactor Coolant System support high strength bolting applications used ASTM A325 bolts. ASTM A325 bolts are excluded from the review for stress corrosion cracking failure, because the specified minimum yield strength is less than 150 ksi and no recorded failures have been identified in similar applications. ASTM A490 bolts have failed in similar applications in nuclear power plants due to stress corrosion cracking. The failures resulted from either improper heat treatment or the combination of high preload and the borated water environment.

Cracking of the bolting could result in insufficient support of the component. Therefore, based on industry experience, Duke concludes that cracking due to stress corrosion is an applicable aging effect for the high strength bolting used in the steam generator support skirt and the reactor vessel support skirt.

3.7.2.2.4 CHANGE IN MATERIAL PROPERTIES ASSESSMENT

Change in material properties due to elevated temperatures or irradiation embrittlement was determined not to be an applicable aging effect for steel structural components.

3.7.2.2.5 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects considered, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following documents were identified in this survey:

- IE Bulletin 79-02, *Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts, Revision 1, Supplement 1 and Revision 2*
- GL 80-47, *Additional Guidance on "Potential for Low Fracture Toughness and Lamellar Tearing on PWR Steam Generator and Reactor Coolant Pump Supports"*
- GL 87-02, *Implementation of Guidance From Unresolved Safety Issue A-12, "Potential for Low Fracture Toughness and Lamellar Tearing on Component Supports," November 26, 1980*
- IE Bulletin 74-03, *Failure of Structural or Seismic Support Bolts on Class I Components*
- IE Bulletin 74-03, *Supplement, Failure of Structural or Seismic Support Bolts on Class I Components*
- IN 80-36, *Failure of Steam Generator Support Bolting*
- IN 92-69, *Water Leakage from Yard Area Through Conduits into Buildings*
- NUREG CR-2952, *Preloading of Bolted Connections in Nuclear Reactor Component Supports*
- NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants: Resolution of Generic Technical Issue A-36*
- GL 88-05, *Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants*
- IN 89-77, *Debris in Containment Emergency Sumps and Incorrect Screen Configurations, and Supplement 1*

No additional aging effects were identified from this review beyond those identified in this section.

3.7.2.2.6 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for steel components in air. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. Oconee operating experience has identified loss of material of cable trays due to boric acid corrosion in the Reactor Building. Therefore, loss of material due to corrosion is an applicable aging effect for cable tray in the Reactor Building. Loss of material due to corrosion is not an applicable aging effect for cable tray in other Oconee structures. No additional aging effects were identified from this review beyond those identified in this section.

3.7.2.2.7 CONCLUSION

Based on a review of industry information, NRC generic communications, and Oconee operating experience, Duke did not observe additional aging effects beyond those discussed in this section. The applicable aging effects that could result in loss of function of the steel structural components in an air environment are:

- Loss of material due to corrosion when the component is not coated
- Cracking due to stress corrosion of high strength bolting used in steam generator support skirt and the reactor vessel support skirt

The applicability of these aging effects for each Oconee structure is provided in Sections 3.7.3 through 3.7.10 that follow.

3.7.2.3 Applicable Aging Effects for Steel Components in a Fluid Environment

Steel structures and structural components in a fluid environment are identified in Section 2.7 of OLRP-1001. As an aid to the reader, the types of steel structures and structural components in a fluid environment that are subject to an aging management review are repeated here and include:

- Elevated Water Storage Tank (Interior)
- Equipment Component Supports
- Fuel Transfer Canal Liner Plate
- Spent Fuel Pool Liner Plate
- Spent Fuel Storage Racks
- Structural Steel and Plates
- Trash Racks and Screens

The review to identify the applicable aging effects for structural components in a fluid environment considers the following potential aging effects, which have been identified by reviewing available industry literature:

- Loss of material due to crevice corrosion, galvanic corrosion, general corrosion, erosion and erosion-corrosion, microbiologically induced corrosion, or pitting corrosion
- Cracking due to fatigue, hydrogen damage, intergranular attack, or stress corrosion
- Change in material properties due to thermal embrittlement or irradiation embrittlement

Consistent with the process described in Section 3.2, the applicable aging effects are determined by reviewing the materials of construction and ambient environment. Section 3.7.2.3.1 describes the ambient environments to which steel components in fluid are exposed at Oconee. Sections 3.7.2.3.2 through 3.7.2.3.6 describe the results when the process is applied to steel components in fluid at Oconee.

3.7.2.3.1 ENVIRONMENT

Steel structures and components in fluid and within the scope of Section 3.7 are exposed to different service environments depending on their location. Steel structures and structural components in fluid may be located either in the waters of Lake Keowee or in a borated water environment. The results of chemical analyses of water from Lake Keowee are provided in Section 3.2 of OLRP-1001.

The borated water environment is associated with the spent fuel pool. The spent fuel pool contains an oxygen-saturated borated water environment with a concentration of approximately 1800 ppm boron. The spent fuel pool is designed with a clean up system that removes corrosion products, fission products, and other debris. Water quality is monitored and controlled on a regular basis by checking the chemical concentrations (e.g., chloride, fluoride, boron), pH, and other parameters. The normal pool water temperature is 120°F, and the Oconee UFSAR limits pool temperature to 183°F. Heat generated by the spent fuel is removed by a pool cooling system (See Section 2.5.6 of OLRP-1001).

3.7.2.3.2 LOSS OF MATERIAL ASSESSMENT

General corrosion is the result of a chemical or electro-chemical reaction between a material and an aggressive environment. General corrosion is normally characterized by uniform attack resulting in material dissolution and, in some cases, corrosion product buildup. At ordinary temperatures and in neutral or near-neutral media, oxygen and moisture are the basic requirements for the corrosion of iron. Both oxygen and moisture must be present, because oxygen alone or water free of dissolved oxygen does not corrode to any practical extent.

Carbon steel and low-alloy steels are susceptible to corrosion in systems using raw or untreated waters. Corrosion products consisting of hydrated oxides of iron (rust) form on exposed, unprotected surfaces of the steel. Corrosion of structural steel would be visible in accessible areas. Loss of material due to general corrosion is an applicable aging effect for the Intake trash racks and screens, the elevated water storage tank, Intake equipment component supports, and the Keowee structural steel and plates.

Microbiologically induced corrosion (MIC) occurs under the influence of micro-organisms. Micro-organisms are usually classified according to their ability to grow in the presence or absence of oxygen. Aerobic organisms grow in nutrient mediums containing dissolved oxygen. Anaerobic organisms grow most favorably in environments containing little or no oxygen. Selected aerobic organisms produce sulfuric acid by oxidizing sulfur or sulfur-bearing compounds. Selected anaerobic organisms reduce sulfate to sulfide ions, which influences both anodic and cathodic reactions on iron surfaces. MIC could occur in carbon steel and low-alloy steel, particularly under deposits and in crevices. Buildup of slime and bacteria in crevices could lead to MIC, despite high fluid flow rates. Therefore, loss of material due to MIC is an applicable aging effect for carbon and low-alloy steel in raw water for the Intake trash racks and screens, the elevated water storage tank, Intake equipment component supports, and the Keowee structural steel and plates.

Pitting corrosion is an aggressive corrosion mechanism that is more common with passive materials such as wrought austenitic stainless steels. Pitting corrosion attacks the passive films in localized areas. Once a pit penetrates the passive film, galvanic conditions occur because the metal in the pit is anodic relative to the passive films. With stagnant or low fluid flow conditions, impurities such as halides and sulfates remain in the pit and dissolution of the metal continues. Pitting corrosion can be inhibited by maintaining an adequate fluid flow rate, thus preventing impurities from adhering to the material surface. Low flow for carbon steel in raw water is defined to be < 3 fps. The Intake trash racks and screens, the elevated water storage tank, Intake equipment component supports, and the Keowee structural steel and plates are exposed to stagnant or low flow conditions; therefore, loss of material due to pitting corrosion is an applicable aging effect for the Intake trash racks and screens, the elevated water storage tank, Intake equipment component supports, and the Keowee structural steel and plates.

Oxygen levels in the fluid above 100 ppb are required to initiate pitting in wrought austenitic stainless, and some form of impurity -- such as chlorides, fluorides, or sulfates -- is required to continue dissolution of the material. Stagnant or low flow conditions that enable the impurity to adhere to the metal surface are also required for pitting corrosion to occur. Pitting corrosion is an applicable aging effect for stainless steel in a borated water environment where chloride levels exceed 150 ppb in oxygenated stagnant and low flow areas.

3.7.2.3.3 CRACKING ASSESSMENT

In a sensitized condition, as in the heat-affected zones of a weld and base metal, stainless steel may develop stress corrosion cracking under certain environmental conditions. Environmental effects play a large part in causing stress corrosion cracking in these sensitized areas. One of the most aggressive contributors to stress corrosion cracking is the dissolved oxygen concentration. The stainless steel structural components used in a fluid environment at Oconee are exposed to an oxygenated environment. At higher temperatures ($T > 200°F$), dissolved oxygen creates an aggressive environment that can lead to stress corrosion cracking of stainless steel. Exposure to temperatures less than 200°F eliminates oxygen as an aggressive environmental factor, and stress corrosion cracking is not an applicable aging effect for the stainless structural materials. Temperatures in the spent fuel pool environment are limited to 183°F. The sump liners are also not exposed to temperatures that exceed 200°F. Therefore, temperature does not play a role in cracking due to stress corrosion cracking of the stainless steel components in the borated water environment.

Also important are the chloride and sulfate levels in the borated water. In a borated water environment, regardless of temperature and dissolved oxygen, if chloride levels are greater than 150 ppb, stress corrosion cracking of austenitic stainless steel is an applicable aging effect, especially for the welds and heat-affected zone. The degree of sensitization to stress corrosion cracking is dependent on metal composition. For example, Type 304L stainless steel is relatively immune to intergranular stress corrosion cracking in borated water environments. This relative immunity due to the low carbon content (0.03% maximum) for Type 304L results in sensitization levels during welding so low that heat affected zones of the Type 304L are resistant to intergranular stress corrosion cracking in borated water environments. In addition to chlorides, sulfates may induce stress corrosion cracking at the welds and heat affected zones of the base metal. Cracking could occur where sulfates routinely exceed 100 ppb. Cracking due to stress corrosion is an applicable aging effect for stainless steel in an oxygenated borated water environment where chlorides and sulfates exceed the concentration limits defined above, or where temperatures routinely exceed 200°F.

3.7.2.3.4 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects considered, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following documents were identified in this survey:

- NUREG-1522, *Assessment of Inservice Conditions of Safety-Related Nuclear Plant Structures*
- GL 89-13, *Service Water System Programs Affecting Safety-Related Equipment*

No additional aging effects were identified from this review beyond those identified in this section.

3.7.2.3.5 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. No additional aging effects were identified from this review beyond those identified in this section.

3.7.2.3.6 CONCLUSION

In its review of industry information, NRC generic communications, and Oconee operating experience, Duke did not observe any additional aging effects beyond those discussed in this section. Therefore, the applicable aging effects that could result in loss of function of the steel structural components in a fluid environment are:

- Loss of material for uncoated carbon steel in a raw water environment
- Loss of material for stainless steel in a borated water environment
- Cracking of stainless steel in a borated water environment

The applicability of these aging effects to each Oconee structure is addressed in Sections 3.7.3 through 3.7.10 that follow.

3.7.2.4 Applicable Aging Effects for Fire Barriers

Fire barriers are identified in Section 2.7.2.4 of OLRP-1001. As an aid to the reader, the types of fire barriers that are subject to an aging management review are repeated here and include:

- Fire Doors (applicable aging effects are discussed in Section 3.7.2.2)
- Fire Walls (applicable aging effects are discussed in Section 3.7.2.1)
- Fire Barrier Penetration Seals

The review to identify the applicable aging effects for fire barrier penetration seals considers the following potential aging effects, which have been identified by reviewing available industry literature:

- Loss of material due to flaking
- Cracking due to vibration, movement, or shrinkage
- Change in material properties due to irradiation
- Separation due to vibration, movement, or shrinkage

Consistent with the process described in Section 3.2, the applicable aging effects are determined by reviewing the materials of construction and ambient environment. Section 3.7.2.4.1 describes the ambient environments to which fire barriers are exposed at Oconee. Sections 3.7.2.4.2 through 3.7.2.4.6 describe the results when the process is applied to fire barriers at Oconee.

3.7.2.4.1 ENVIRONMENT

Fire barrier penetration seals are located throughout the plant in a variety of environments. Located inside plant buildings, the fire barrier penetration seals are exposed to the ambient environment within each location. The internal environments of these structures may be controlled, such as in the control room of the Auxiliary Building, where the temperature and humidity are relatively mild. Other areas, such as some interior parts of the Turbine Building and Reactor Building, are exposed to higher temperatures, humidity, and radiation (Reactor Building). These variables play a major role in the potential degradation of the components located within this environment. Additional information on the environmental conditions at Oconee is provided in Section 3.2 of OLRP-1001.

3.7.2.4.2 CRACKING ASSESSMENT

Vibration of an item adjacent to, attached to, or penetrating a fire barrier penetration seal may cause cracking or delamination of the fire barrier penetration seal material over time. Cracking as a potential aging effect will most likely appear in grout, caulk, putty, and cementious fire resistant materials such as Firewall 50 / Monokote and Pyrocrete. Delaminations may occur in fire barrier penetration seals constructed of silicone foam and Pyrocrete. These degradations may reduce the fire resistance of the material and may result in inadequate protection. Therefore, cracking and delamination due to vibration is an applicable aging effect for the fire barrier penetration seals.

The differential movement of an item penetrating the fire barrier penetration seal may cause cracking of the fire barrier penetration seal or separation of the barrier and penetration seal assembly. Therefore, cracking due to movement is an applicable aging effect for fire barrier penetration seals.

Shrinkage may occur over time where fire barrier penetration seal material comes in contact with pipe surfaces. Shrinkage has been observed with silicone foam seal material. Shrinkage may also occur due to loss of hydration, and has been observed in Firewall 50. Therefore, cracking and delamination due to shrinkage is an applicable aging effect for fire barrier penetration seals.

3.7.2.4.3 SEPARATION

Separation is the destruction of the adhesion between a fire barrier material and adjacent surface. Separation is associated with fire barrier penetration seals where material separation creates a gap, allowing contact of separate fire zones. The aging mechanisms that could cause separation in fire barrier penetration seals are vibration, movement and shrinkage**.**

Vibration of the protected commodity may cause separation (disbondment) of fire barrier penetration seal material over time. Separation will most likely appear in fire barrier penetration seals used to close gaps between fire zones. Because of the elastomeric properties, vibration of an item penetrating a Nelson Multi-Cable Transit will not cause separation.

The differential movement of an item penetrating the fire barrier penetration seal could cause separation of the barrier and fire barrier penetration seal assembly. Therefore, separation due to movement is an applicable aging effect for fire barrier penetration seals.

Shrinkage could occur over time where fire barrier penetration seal material comes in contact with pipe surfaces. This has been observed with silicone foam seal material. Shrinkage also could occur due to loss of hydration, and has been observed in Firewall 50. Therefore, separation due to shrinkage is an applicable aging effect for fire barrier penetration seals. Separation due to shrinkage is not an applicable aging effect for Nelson Multi-Cable Transits.

3.7.2.4.4 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects considered, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. No documents that involve aging effects of fire barriers were identified in this survey.

3.7.2.4.5 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects. This review include a survey of any documented instances of component aging along with interview with responsible engineering personnel. Previous Oconee fire barrier inspections were also reviewed to determine if there were any aging effects which should be considered for the period of extended operation. Inspections have identified deficiencies associated with installation problems and missing tag numbers for fire barrier penetration seals. No deficiencies associated with aging of fire barrier penetration seals were identified. No additional aging effects were identified from this review beyond those identified in this section.

3.7.2.4.6 CONCLUSION

Based upon the review of industry information, NRC generic communications, and Oconee operating experience, Duke determined that no additional aging effects beyond those evaluated in Section 3.7.2.4 are applicable to Oconee fire barrier penetration seals. The applicable aging effects that could result in loss of function of Oconee fire barrier penetration seals are:

- Cracking
- Separation

The applicability of these aging effects for each Oconee structure is provided in Sections 3.7.3 through 3.7.10 that follow.

3.7.3 AUXILIARY BUILDING

Table 2.7-1 of OLRP-1001 identifies the structural components that are located within the Auxiliary Building. These structural components include concrete components, steel components in an air environment, steel components within a fluid environment, and fire barriers. The ambient environment within the Auxiliary Building is described in Section 3.2.2 of OLRP-1001. The following is a description of the aging effects applicable to the structural components within the Auxiliary Building. The results are summarized in Table 3.7-1.

3.7.3.1 Concrete Components

Auxiliary Building concrete components are exposed to different service environments depending on their location. Below grade portions of the concrete walls and foundation are exposed to backfill and groundwater. The groundwater chemistry plays a major role in the determination of the degradation of the below grade components. External surfaces of the roof and walls above grade are exposed to the external atmospheric environment. The concrete components which are located internal to the Auxiliary Buildings are in controlled environments, which protect them from external weather and temperature changes.

The identification of applicable aging effects for concrete components is described in Section 3.7.2.1 of OLRP-1001. Cracking must be adequately managed so that the intended functions listed in Table 2.7-1 will be maintained consistent with the current licensing basis for the period of extended operation.

This applicable aging effect will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.7.3.2 Steel Components in Air Environment

Steel components of the Auxiliary Buildings that are in an air environment are completely enclosed within the walls of the buildings and are exposed to an environment where the temperature and radiation exposure levels are less than the threshold levels where degradation may occur. In addition to the coating which is provided to prevent oxidation from occurring, the low relative humidity of the Auxiliary Building ensures that oxidation, if it does occur, will progress at a very slow rate.

The identification of applicable aging effects for steel components within an air environment is described in Section 3.7.2.2 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-1 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Battery Rack Inspections (for the battery racks)
- Crane Inspection Program (for the crane rails and girders)
- Oconee Inservice Inspection Plan - Examination Category F-A (for Class 1, 2, and 3 piping and equipment component supports)
- Inspection Program for Civil Engineering Structures and Components (for other steel components)

3.7.3.3 Steel Components in Fluid Environment

The Auxiliary Building steel components in fluid environments are the spent fuel pool liner, the spent fuel storage racks, and structural steel and plates. All are constructed of stainless steel and are exposed to borated water.

The identification of applicable aging effects for steel components within a borated water environment is described in Section 3.7.2.3 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-1 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

Degradation of the Boraflex contained in the spent fuel racks is considered to be a time-limited aging analysis and is evaluated in Section 5.7 of OLRP-1001.

3.7.3.4 Fire Barriers

Auxiliary Building fire barriers include fire walls, fire doors and penetration seals. These fire barriers are completely enclosed within the walls of the Auxiliary Building and are exposed to an environment where the temperature and radiation exposure levels are less than the threshold levels where degradation may occur.

The applicable aging effect for fire walls is cracking as described in Section 3.7.2.1. The applicable aging effect for fire doors is loss of material, as described in Section 3.7.2.2, and the applicable aging effects for fire barriers are described in Section 3.7.2.4. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-1 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Fire Protection Program

3.7.4 Earthen Embankments

Table 2.7-2 of OLRP-1001 identifies the earthen embankments that are within the scope of license renewal and are subject to aging management review for Oconee. These earthen embankments include the Intake Canal Dike, the Keowee River Dam, and the Little River Dam and Dikes. The following contains a description of the aging effects applicable to these structures. The results are summarized in Table 3.7-2.

3.7.4.1 Applicable Aging Effects

The review to identify the applicable aging effects for earthen embankments considers the following potential aging effects:

- Loss of material due to erosion
- Cracking due to settlement or frost heave
- Change in material properties due to desiccation

Consistent with the process described in Section 3.2, the applicable aging effects are determined by reviewing the materials of construction and ambient environment. Sections 3.7.4.1.1 through 3.7.4.4 describe the results when the process is applied to earthen embankments.

3.7.4.1.1 LOSS OF MATERIAL ASSESSMENT

Loss of material in earthen structures is caused by erosion. Erosion may result from wind, rain and surface runoff, subsurface seepage flow, or wave action. During dry periods, wind could erode loose surface soil from the earthen embankment. Wind erosion is generally limited to earthen embankments that are not provided with good ground cover vegetation or riprap. As described in Section 2.7 of OLRP-1001, the Intake Canal Dike, Keowee River Dam, and Little River Dam and Dikes are provided with ground cover and riprap to protect against loss of material due to wind. Therefore, loss of material due to erosion from wind is not an applicable aging effect for the Intake Canal Dike, Keowee River Dam, and the Little River Dam and Dikes.

The energy of rain and subsequent surface runoff could loosen soil particles and scour exposed surfaces. Erosion occurs when the loosened soil is carried away by surface flows. Topography is a major factor in the erosion process. Steeper topography increases the flow of water and results in more erosion. Loss of material due to runoff is minimized by good design practices, such as limiting embankment slopes to minimize overland flow velocities and providing ground cover vegetation or riprap in areas with high fluid velocities and hydraulic jumps. While the dams and dikes at Oconee are provided with ground cover and riprap to protect against loss of material due to rain and surface runoff, erosion is an applicable aging effect that needs to be managed for the period of extended operation for the Intake Canal Dike, Keowee River Dam, and the Little River Dam and Dikes.

Subsurface flow is caused by water seeping through the soil and forming underground soil "pipes." Foundations of all dams could have some seepage under prolonged storage conditions. It is important that foundation seepage be controlled or monitored in all areas to maintain a stable foundation and dam. Seepage becomes a safety concern when there has been any progressive increase in volume of flow and there is evidence of piping of solids or removal of soluble materials, when hydrostatic pressure has increased in the foundation, or if soft areas have developed in the embankment downstream.

Progressive seepage can lead to soil piping. Piping is internal erosion of the soil due to the velocity of the seeping water which could lead to rapid deterioration of the embankment. Indications of subsurface flow include new downhill springs or sudden unexplained water level drops, surface cracks, and unexplained settlement. Loss of material due to seepage and piping is an applicable aging effect for the Intake Canal Dike, Keowee River Dam, and the Little River Dam and Dikes.

Earthen structures may experience loss of material from wave action adjacent to the shore line. This effect is primarily caused by wind blowing across the water surface or by the flow of the water. Loss of material could cause a loss of slope stability of the dam and dikes due to the undercutting erosion action of the waves. This effect is precluded by installation of riprap at the shore line of the Intake Canal Dike, Keowee River Dam, and the Little River Dam and Dikes.

3.7.4.1.2 CRACKING ASSESSMENT

Cracking of earthen structures may result from settlement and frost heave. Settlement is found to some degree in all earthen structures. As the below-surface soil is loaded, it settles under the pressure of the overburden. Slowly-decreasing settlement due to consolidation is not a serious problem unless the crest camber is lost and the freeboard reduced below permissible limit. Typically, most settlement is discovered during or soon (generally less than one year) after construction. Sudden or rapid settlement may result from seepage through thin or degraded areas of the impermeable soil liner, or if large water fluctuations occur where expansive clay was used in the construction of the embankment. Differential settlement could cause transverse cracking of the embankment. Conditions causing settlement may be detected and corrected with a careful periodic inspection program. Cracking due to settlement is an applicable aging effect for the Intake Canal Dike, Keowee River Dam, and the Little River Dam and Dikes, and must be managed for the period of extended operation.

When the daily mean temperature remains below 32°F for a period of time, soil moisture begins to freeze. As groundwater continues to freeze, earthen structures may experience deformation caused by a phenomenon called frost heave. Frost heave is caused by water in the soil, which expands approximately 10% when it freezes. Over a period of extended cold, frost heave may cause permanent deformation and cracking of an earthen structure. However, this effect only occurs in areas with deep frost line with fine grain soils. Oconee Nuclear Station is not located in a geographic region where there is a deep frost line; therefore, cracking due to frost heave is not an applicable aging effect for Keowee River Dam, Little River Dam and Dikes, and the Intake Canal Dike.

3.7.4.2 Industry Experience

In order to validate the set of applicable aging effects considered, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. No documents were identified applicable to earthen embankments. Due to the existence of dams outside NRC jurisdiction, information on dams in general was also reviewed.

Previous investigations into the frequency of dam failure indicate that it decreases with later years of construction [Reference 3.7-8]. This is generally attributed to improvements in the methods of design and construction over time. The age of the dam is another factor that has been identified as having an effect on the rate of dam failure. Approximately half of the dam failures occur during the first five years of operation [Reference 3.7-9].

Earthen structures have extremely low failure rates. In fact, statistics on dam (earthen and concrete) failures, based on the sum of operation years of a regional group of dams, show a frequency of one failure every 1500 to 1800 dam years [Reference 3.7-10]. These statistics indicate that earthen structures have a natural resistance to aging.

The Executive Committee of the United States Committee on Large Dams (USCOLD) authorized the Dam Safety Committee’s Subcommittee on Dam Incidents and Accidents to compile a list of dam incidents from 1972 through 1986. The compilation of data was documented in *Lessons from Dam Incidents, USA-II* [Reference 3.7-11]. Approximately 164 incidents were documented for earthen dams over fifty feet in height. Six of the incidents involved major failure of an operating dam which resulted in complete abandonment of the dam. Seven of the incidents involved the failure of an operating dam which permitted the damage to be successfully repaired and the dam again placed in operation. The majority of the incidents (eighty-four) were identified as repairs that were required because of deterioration or to update certain features. The incidents were caused by piping, sliding, overtopping, or deficiency in the construction or design of the dam, foundation, or spillway.

No additional aging effects were identified from this review beyond those identified in this section.

3.7.4.3 Oconee Specific Experience

Oconee operating experience was reviewed to validate the identified applicable aging effects for earthen embankments. This review included a survey of any documented instances of aging along with interviews with responsible engineering personnel. No additional aging effects were identified from this review beyond those identified in this section.

3.7.4.4 Conclusion

Based upon the review of industry information, NRC generic communications, and Oconee operating experience, Duke concluded that no additional aging effects beyond those evaluated in Section 3.7.4.1 are applicable to the earthen embankments at Oconee. The applicable aging effects for earthen embankments that could result in loss of function are loss of material and cracking. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-2 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Federal Energy Regulatory Commission (FERC) Five Year Inspection

3.7.5 Intake Structure

Table 2.7-3 of OLRP-1001 identifies the structural components that are located within the Intake Structure. These structural components include concrete components, steel components in an air environment, and steel components in a fluid environment. The following is a description of the aging effects applicable to the structural components within the Intake Structure. The results are summarized in Table 3.7-3.

3.7.5.1 Concrete Components

Intake Structure concrete components are exposed to different service environments depending on their location. Below grade portions of the concrete are exposed to backfill and groundwater. Portions of the concrete are also exposed to water from Lake Keowee. The groundwater and lake water chemistry play a major role in the determination of degradation of the concrete within these areas. External surfaces are also exposed to the atmospheric environment.

The identification of applicable aging effects for concrete components is described in Section 3.7.2.1 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-3 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.7.5.2 Steel Components in Air Environment

Steel components within the Intake Structure are exposed to the external atmospheric environment and to the waters of Lake Keowee. The temperature and radiation exposure levels are less than the threshold levels where degradation may occur. Steel can corrode where an area of the protective covering is destroyed or otherwise removed and both oxygen and water are present.

The identification of applicable aging effects for steel in an air environment is described in Section 3.7.2.2 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-3 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components
- Oconee Inservice Inspection Plan - Examination Category F-A (piping supports)

3.7.5.3 Steel Components in Fluid Environment

The Intake Structure steel components that are exposed to the waters of Lake Keowee are the carbon steel trash racks and screens and equipment component supports. The identification of applicable aging effects for steel in a raw water environment is described in Section 3.7.2.3 of OLRP-1001. The aging effect must be adequately managed so that the intended functions listed in Table 2.7-3 will be maintained consistent with the current licensing basis for the period of extended operation.

The applicable aging effect will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.7.6 Keowee Structures

Table 2.7-4 of OLRP-1001 identifies the structural components that are located within the Keowee Structures. These structural components include concrete components, steel components in an air environment, and steel components in a fluid environment. The following is a description of the aging effects applicable to the structural components within Keowee. The results are summarized in Table 3.7-4.

3.7.6.1 Concrete Components

Keowee concrete components are exposed to different service environments depending on their location. Below grade portions of the concrete walls and foundations are exposed to backfill, groundwater, and lake water. The chemistry of the groundwater and lake water plays a major role in the determination of the degradation of the below grade components. Surfaces of the concrete above grade are exposed to the external atmospheric environment. The components located internal to the Keowee structures are protected from external weather and temperature changes.

The identification of applicable aging effects for concrete components is described in Section 3.7.2.1 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-4 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Duke Power Five-Year Underwater Inspection of Hydroelectric Dams and Appurtenances
- FERC Five Year Inspection
- Inspection Program for Civil Engineering Structures and Components
- Penstock Inspection

3.7.6.2 Steel Components in Air Environment

Steel components are completely enclosed within the walls of the Keowee Structures and are exposed to a relatively benign environment. The temperature and radiation exposure levels are less than the threshold levels where degradation may occur. Steel can corrode where an area of the protective covering is destroyed or otherwise removed and both oxygen and water are present.

The identification of applicable aging effects for steel in an air environment are described in Section 3.7.2.2 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-4 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Battery Rack Inspections (for the battery racks)
- Crane Inspection Program (for the crane rails and girders)
- Oconee Inservice Inspection Plan - Examination Category F-A (piping supports)
- Inspection Program for Civil Engineering Structures and Components (for other steel components)

3.7.6.3 Steel Components in Fluid Environment

The Keowee steel components that are exposed to the waters of Lake Keowee are structural steel and plates. The identification of applicable aging effects for steel in a raw water environment is described in Section 3.7.2.3 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-4 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Duke Power Five-Year Underwater Inspection of Hydroelectric Dams and Appurtenances (for Intake Steel)
- Penstock Inspection (for Penstock Steel)

3.7.7 Reactor Building (Internal Structural Components and the Unit Vent Stacks)

Table 2.7-5 of OLRP-1001 identifies the structural components that are located within the Reactor Building. These structural components include concrete components, steel components in an air environment, the secondary shield wall post-tensioning system, and the unit vent stacks. Components of the Reactor Building (Containment) essentially leaktight barrier are described in Section 2.3 of OLRP-1001 and the applicable aging effects are discussed in Section 3.3. Structural components that support components of the Reactor Coolant System are described in Section 2.4 of OLRP-1001 and the applicable aging effects are discussed in Section 3.4 . The following is a description of the aging effects applicable to the structural components within the Reactor Building and Unit Vent Stack. The results are summarized in Table 3.7-5.

3.7.7.1 Concrete Components

Reactor Building internal structure concrete components are exposed to the internal atmosphere of the Reactor Building. Higher temperature, humidity, and radiation play a major role in the potential degradation of the components located within this environment.

The identification of applicable aging effects for concrete components is described in Section 3.7.2.1 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-5 will be maintained consistent with the current licensing basis for the period of extended operation.

This applicable aging effect will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.7.7.2 Steel Components in Air Environment

Steel components are completely enclosed within the walls of the Reactor Building except for the Unit Vent Stack. The temperature and radiation exposure levels within the Reactor Building and in the external environment are less than the threshold levels where degradation may occur. Steel can corrode where the protective coating is destroyed or otherwise removed and both oxygen and water are present.

The identification of applicable aging effects for steel in an air environment is described in Section 3.7.2.2 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-5 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Boric Acid Wastage Surveillance Program
- Crane Inspection Program - Examination Category F-A (for the crane rails and girders)
- Oconee Inservice Inspection Plan (for Class 1, 2, and 3 piping and component supports)
- Inspection Program for Civil Engineering Structures and Components (for other steel components including the Unit Vent Stack)

Aging effects applicable to structural components within the evaluation of the Reactor Coolant System are addressed in Section 3.4 of OLRP-1001. Fatigue of the Polar Crane supports is considered to be a time-limited aging analysis and is evaluated in Section 5.7 of OLRP-1001.

3.7.7.3 Steel Components in a Fluid Environment

The Reactor Building steel component in a fluid environment is the fuel transfer canal liner plate which is constructed of stainless steel and exposed to borated water.

The identification of applicable aging effects for steel components within a borated water environment is described in Section 3.7.2.3 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-5 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Chemistry Control Program

3.7.7.4 Post-Tensioning System

3.7.7.4.1 APPLICABLE AGING EFFECTS

The aging effect that could potentially result in loss of the ability of the post-tensioning system to impose compressive forces is loss of material due to corrosion and cracking. Loss of material and cracking must be considered for both the tendon wires and for the anchorage providing the tendon wire terminations. Loss of material due to pitting corrosion can occur in the presence of halide ions, particularly chloride ions. Anchorage located in the Reactor Building internal atmosphere are not exposed to halide ions; therefore, loss of material due to pitting is not an applicable aging effect for tendon wires and anchorage.

Cracking due to stress corrosion results from the simultaneous presence of high tensile stresses and an aggressive environment. The high tensile stresses result from the prestressing of the tendons. The environmental factors known to contribute to stress corrosion cracking in carbon steels are hydrogen sulfide, ammonia, nitrate solutions, and seawater. While the Secondary Shield wall tendons are not exposed to these environmental factors, they may be exposed to borated water which could result in stress corrosion cracking. Therefore, cracking due to stress corrosion is an applicable aging effect.

3.7.7.4.2 INDUSTRY EXPERIENCE

In order to validate the set of applicable aging effects considered, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee, and NRC NUREGs. The following documents were identified in this survey:

- NUREG/CR-4652, *Concrete Component Aging and Its Significance Relative to Life Extension of Nuclear Power Plants*
- NUREG/CR-6424, *Report on Aging of Nuclear Power Plant Reinforced Concrete Structures*
- IN 85-10, *Post-Tensioned Containment Tendon Anchor Head Failure*
- IN 85-10 Supplement 1, *Post-Tensioned Containment Tendon Anchor Head Failure*
- IN 91-80, *Failure of Anchor Head Threads on Post-Tensioning System During Surveillance Inspection*

No additional aging effects were identified from this review beyond those identified in this section.

3.7.7.4.3 OCONEE OPERATING EXPERIENCE

Oconee operating experience was reviewed to validate the identified applicable aging effects for post-tensioning system components. This review included a survey of any documented instances of component aging along with interviews with responsible engineering personnel. Oconee documentation identified tendon wire corrosion and surface corrosion of the tendon anchorage hardware.

One Oconee report documented corrosion of the tendon wire and anchorage. On April 28, 1982, during the final Reactor Building interior inspection on Unit 2, one secondary shield wall vertical tendon was found broken. Subsequent detailed inspections of the Units 1, 2 and 3 secondary shield walls found one additional failed vertical tendon in Unit 2, no failures in Units 1 and 3, and some vertical tendons exhibiting corrosion in Units 2 and 3. The apparent cause of the corrosion was due to water accumulation in the bottom of the vertical tendon sheath. The corrosion had resulted in complete failure of all of the 90 1/4-inch diameter wires in the failed tendons. All failed tendons were replaced. The apparent cause of the failures was stress corrosion of the post-tensioning wires near the lower stressing washer caused by water accumulating in the tendon covers and lower portion of the tendon sheaths.

Modifications were made to prevent the build up of water in the tendon sheaths. In addition to the modifications, a surveillance program was designed to ensure that any future corrosion is detected, evaluated and corrective action is taken to minimize additional deterioration. The NRC was notified that the surveillance program was implemented to assure that any future corrosion is detected and corrective action is taken to prevent tendon failure. The 1982 incident was also documented in Reportable Occurrence Report RO-270/82-07, Revision 1 [Reference 3.7-12].

Therefore, Oconee experience validates that loss of material due to corrosion is an applicable aging effect for the tendon wires and anchorage when water is present. No additional aging effects were identified from this review beyond those identified in this section.

3.7.7.4.4 CONCLUSION

Based upon the review of industry information, NRC generic communications, and Oconee operating experience, no additional aging effects beyond those evaluated in Section 3.7.7.4.1 are applicable. Cracking and loss of material were determined to be applicable aging effects which could result in loss of function of the tendons and anchorage. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-5 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Tendon - Secondary Shield Wall - Surveillance Program

3.7.8 Standby Shutdown Facility

Table 2.7-6 of OLRP-1001 identifies the structural components that are located within the Standby Shutdown Facility. These structural components include concrete components and steel components in an air environment. The following is a description of the aging effects applicable to the structural components within the Standby Shutdown Facility. The results are summarized in Table 3.7-6.

3.7.8.1 Concrete Components

Standby Shutdown Facility concrete components are exposed to different service environments depending on their location. Below grade portions of the concrete walls and foundation are exposed to backfill and groundwater. The groundwater chemistry plays a major role in the determination of the degradation of the below grade components. External surfaces of the roof and walls above grade are exposed to the external atmospheric environment. The components which are located internal to the Standby Shutdown Facility are protected from external weather and temperature changes.

The identification of applicable aging effects for concrete components is described in Section 3.7.2.1 of OLRP-1001. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-6 will be maintained consistent with the current licensing basis for the period of extended operation.

The applicable aging effect will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.7.8.2 Steel Components in an Air Environment

Steel components are completely enclosed within the walls of the Standby Shutdown Facility and are exposed to a relatively benign environment. The temperature and radiation exposure levels are less than the threshold levels where degradation may occur. Steel can corrode where the protective coating is destroyed or otherwise removed and both oxygen and water are present.

The identification of applicable aging effects for steel in an air environment is described in Section 3.7.2.2 of OLRP-1001. Loss of material is the aging effect that is applicable to these steel components within the Standby Shutdown Facility. This aging effect must be adequately managed so that the intended functions listed in Table 2.7-6 will be maintained consistent with the current licensing basis for the period of extended operation.

This applicable aging effect will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Battery Rack Inspections (for the battery racks)
- Crane Inspection Program (for the crane rails and girders)
- Oconee Inservice Inspection Plan - Examination Category F-A (for piping and equipment component supports)
- Inspection Program for Civil Engineering Structures and Components (for other steel components)

3.7.9 Turbine Building

Table 2.7-7 of OLRP-1001 identifies the structural components that are located within the Turbine Building. These structural components include concrete components, steel components in an air environment, and fire barriers. The following is a description of the aging effects applicable to the structural components within the Turbine Building. The results are summarized in Table 3.7-7.

3.7.9.1 Concrete Components

Turbine Building concrete components are exposed to different service environments depending on their location. Below grade portions of the concrete walls, foundation, and pipe piles are exposed to backfill and groundwater. The groundwater chemistry plays a major role in the determination of the degradation of the below grade components. External concrete surfaces above grade are exposed to the external atmospheric environment. The components located internal to the Turbine Buildings are protected from external weather changes, but may be exposed to higher temperature and humidity.

The identification of applicable aging effects for concrete components is described in Section 3.7.2.1 of OLRP-1001. This aging effect must be adequately managed so that the intended functions listed in Table 2.7-7 will be maintained consistent with the current licensing basis for the period of extended operation.

The applicable aging effect will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.7.9.2 Steel Components in an Air Environment

Steel components are completely enclosed inside the walls of the Turbine Building. The temperature and radiation exposure levels are less than the threshold levels where degradation may occur. Steel can corrode where the protective coating is destroyed or otherwise removed and both oxygen and water are present.

The identification of applicable aging effects for steel in an air environment is described in Section 3.7.2.2 of OLRP-1001. Loss of material is the aging effect that is applicable to these steel components within the Turbine Building. This aging effect must be adequately managed so that the intended functions listed in Table 2.7-7 will be maintained consistent with the current licensing basis for the period of extended operation.

This applicable aging effect will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Crane Inspection Program (for the crane rails and girders)
- Inspection Program for Civil Engineering Structures and Components (for other steel components)

3.7.9.3 Fire Barriers

Turbine Building fire barriers include fire walls, fire doors and fire barrier penetration seals. These fire barriers are completely enclosed within the walls of the Turbine Building and are exposed to a relatively benign environment where the temperature and radiation exposure levels are less than the threshold levels where degradation may occur.

The applicable aging effect for fire walls is cracking as described in Section 3.7.2.1, applicable aging effect for fire doors is loss of material as described in Section 3.7.2.2 and applicable aging effects for fire barrier penetration seals are described in Section 3.7.2.4. These aging effects must be adequately managed so that the intended functions listed in Table 2.7-7 will be maintained consistent with the current licensing basis for the period of extended operation.

These applicable aging effects will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Fire Protection Program

3.7.10 Yard Structures

Table 2.7-8 of OLRP-1001 identifies the structural components that are located within the Yard Structures. These structural components include concrete components, steel components in an air environment and the Elevated Water Storage Tank. The following is a description of the aging effects applicable to the structural components within the Yard. The results are summarized in Table 3.7-8.

3.7.10.1 Concrete Components

Yard Structure concrete components are exposed to different service environments depending on their location. Below grade portions of the concrete foundations are exposed to backfill and groundwater. The groundwater chemistry plays a major role in the determination of the degradation of the below grade components. The components which are located internal to the Yard Structures (230 kV Relay House) are protected from external weather.

The identification of applicable aging effects for concrete components is described in Section 3.7.2.1 of OLRP-1001. This aging effect must be adequately managed so that the intended functions listed in Table 2.7-8 will be maintained consistent with the current licensing basis for the period of extended operation.

The applicable aging effect will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Inspection Program for Civil Engineering Structures and Components

3.7.10.2 Steel Components in an Air Environment

Steel components of the Yard Structures are either enclosed within the walls of the 230 kV Relay House or exposed to the external environment. The temperature and radiation exposure levels are less than the threshold levels where degradation may occur. Steel can corrode where the protective coating is destroyed or otherwise removed and both oxygen and water are present.

The identification of applicable aging effects for steel in an air environment is described in Section 3.7.2.2 of OLRP-1001. Loss of material is the aging effect that is applicable to these steel components within the Yard. This aging effect must be adequately managed so that the intended functions listed in Table 2.7-8 will be maintained consistent with the current licensing basis for the period of extended operation.

This applicable aging effect will be managed by the following programs which are described in Chapter 4 of OLRP-1001:

- Battery Rack Inspections (for the battery racks)
- Inspection Program for Civil Engineering Structures and Components (for other steel components)
- 230 kV Keowee Transmission Line Inspection

3.7.10.3 Elevated Water Storage Tank

The Elevated Water Storage Tank is exposed to an air environment on the exterior and a raw water environment on the interior. The applicable aging effects for steel in a raw water environment are described in Section 3.7.2.3 of OLRP-1001 and are applicable to the Elevated Water Storage Tank. Loss of material is the aging effect that is applicable to the Elevated Water Storage Tank. This aging effect must be adequately managed so that the intended functions listed in Table 2.7-8 will be maintained consistent with the current licensing basis for the period of extended operation.

This applicable aging effect will be managed by the following program which is described in Chapter 4 of OLRP-1001:

- Elevated Water Storage Tank Civil Inspection

3.7.11 References for Section 3.7

3.7-1. NUMARC Report Number 90-01, *Pressurized Water Reactor Containment Structures License Renewal Industry Report*, Nuclear Management and Resource Council, August 1989; Revision 1, September 1991.

3.7-2. NUMARC Report Number 90-06, *Class I Structures License Renewal Industry Report*, Nuclear Management and Resource Council, June 1990.

3.7-3. ACI 318-63, *Building Code Requirements for Reinforced Concrete,* American Concrete Institute, Detroit, Michigan.

3.7-4. ACI 301, *Specifications for Structural Concrete for Buildings,* American Concrete Institute, Detroit, Michigan.

3.7-5. *An Aging Assessment of Relay and Circuit Breakers and Systems Interactions,* prepared by Franklin Research Center for Brookhaven National Laboratory, NUREG/CR-4715, June 1987.

3.7-6. *Aging Management Guideline for Commercial Nuclear Power Plants - Motor Control Centers,* SAND 93-7069, Sandia National Laboratories, February 1994.

3.7-7. *Aging Management Guidelines for Commercial Nuclear Power Plants - Electrical Switchgear,* SAND 93-7027, Sandia National Laboratories, July 1993.

3.7-8. Baecher, G. B., M. E. Pate, and R. De Neufville, *Risk of Dam Failure in Benefit-Cost Analysis,* Water Resources Research, Vol. 16, No. 3, 1980.

3.7-9. Benjamin, Jack R., and Associates, *A Database for the Evaluation of the Frequency of Random Dam Failure,* Report 120-010-01, Palo Alto, California, 1982.

3.7-10. E. Gruner, "Classification of Risk," *Proceedings International Congress on Large Dams*, Vol. 1, Madrid, 1973, pp. 55-68.

3.7-11. *Lessons from Dam Incidents, USA-II*, American Society of Civil Engineers, New York, New York, 1988.

3.7-12. H. B. Tucker (Duke) letter dated July 27, 1983 to James P. O'Reilly (NRC), docket 50-270, Reportable Occurrence Report RO-270/82-07, Revision 1.

Table 3.7-1 Applicable Aging Effects for Auxiliary Building Structural Components

Component	Applicable Aging Effect(s)	Aging Management Programs
Concrete		
Anchorage (in concrete)	None identified	None required
Embedments (in concrete)	None identified	None required
Equipment Pads	Cracking	Inspection Program for Civil Engineering Structures and Components
Flood Curbs	None identified	None required
Foundation	None identified	None required
Hatches	None identified	None required
Masonry Block & Brick Walls	Cracking	Inspection Program for Civil Engineering Structures and Components
Reinforced Concrete Beams, Columns, Floor Slabs, Roof Slabs and Walls	None identified	None required
Sumps	None identified	None required
Steel in Air Environment		
Anchorage/Embedments (exposed surfaces)	Loss of material	Inspection Program for Civil Engineering Structures and Components
Battery Racks for the125 VDC Instrument and Control Batteries	Loss of material	Battery Rack Inspections
Cable Tray & Conduit	None identified	None required
Cable Tray & Conduit Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Checkered Plate	Loss of material	Inspection Program for Civil Engineering Structures and Components
Control Boards	None identified	None required
Control Room Ceiling	None identified	None required
Crane Rails & Girders	Loss of material	Crane Inspection Program

Table 3.7-1 Applicable Aging Effects for Auxiliary Building Structural Components (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Electrical & Instrument Panels & Enclosures	None identified	None required
Equipment Component Supports	Loss of material	Inservice Inspection Plan • Examination Category F-A Inspection Program for Civil Engineering Structures and Components
Expansion Anchors	Loss of material	Inspection Program for Civil Engineering Structures and Components
Flood, Pressure & Specialty Doors	Loss of material	Inspection Program for Civil Engineering Structures and Components
Instrument Line Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Instrument Racks & Frames	Loss of material	Inspection Program for Civil Engineering Structures and Components
Lead Shielding Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Metal Siding	Loss of material	Inspection Program for Civil Engineering Structures and Components
Pipe Supports	Loss of material	Inservice Inspection Plan • Examination Category F-A Inspection Program for Civil Engineering Structures and Components

Table 3.7-1 Applicable Aging Effects for Auxiliary Building Structural Components (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Stair, Platform & Grating Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Structural Steel Beams, Columns, Plates & Trusses	Loss of material	Inspection Program for Civil Engineering Structures and Components
Steel in Fluid Environment		
Spent Fuel Pool Liner Plate • Unit 1&2 Pool • Unit 3 Pool	Loss of material Cracking	Chemistry Control Program
Spent Fuel Storage Rack • Unit 1 & 2 • Unit 3	Loss of material Cracking	Chemistry Control Program
Structural Steel & Plates	Loss of material Cracking	Chemistry Control Program
Fire Barriers		
Fire Doors	Loss of material	Fire Protection Program
Fire Walls	Cracking	Fire Protection Program
Fire Barrier Penetration Seals	Cracking, Separation	Fire Protection Program

Table 3.7-2 Applicable Aging Effects for Earthen Embankments

Earthen Embankments	Applicable Aging Effect(s)	Aging Management Programs
Intake Canal Dike	Loss of material Cracking	FERC Five Year Inspection
Keowee River Dam	Loss of material Cracking	FERC Five Year Inspection
Little River Dam and Dikes	Loss of material Cracking	FERC Five Year Inspection

Table 3.7-3 Applicable Aging Effects for Intake Structural Components

Component	Applicable Aging Effect(s)	Aging Management Programs
Concrete		
Anchorage (in concrete)	None identified	None required
Embedments (in concrete)	None identified	None required
Foundation	None identified	None required
Reinforced Concrete Beams, Columns, Floor Slabs, and Walls	Loss of material	Inspection Program for Civil Engineering Structures and Components
Steel in Air Environment		
Anchorage/Embedments (exposed surfaces)	Loss of material	Inspection program for Civil Engineering Structures and Components
Cable Tray & Conduit	None identified	None required
Cable Tray & Conduit Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Checkered Plate	Loss of material	Inspection Program for Civil Engineering Structures and Components
Electrical & Instrument Panels & Enclosures	None identified	None required
Equipment Component Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components

Table 3.7-3 Applicable Aging Effects for Intake Structural Components (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Expansion Anchors	Loss of material	Inspection Program for Civil Engineering Structures and Components
Instrument Racks & Frames	Loss of material	Inspection Program for Civil Engineering Structures and Components
Pipe Supports	Loss of material	Inservice Inspection Plan • Examination Category F-A Inspection Program for Civil Engineering Structures and Components
Stairs, Platforms & Grating Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Structural Steel Beams, Columns, Plates & Trusses	Loss of material	Inspection Program for Civil Engineering Structures and Components
Steel in Fluid Environment		
Equipment Component Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Trash Rack & Screens	Loss of material	Inspection Program for Civil Engineering Structures and Components

Table 3.7-4 Applicable Aging Effects for Keowee Structural Components

Component	Applicable Aging Effect(s)	Aging Management Programs
Concrete		
Anchorage (in concrete)	None identified	None required
Embedments (in concrete)	None identified	None required
Equipment Pads	Cracking	Inspection Program for Civil Engineering Structures and Components
Foundation	None identified	None required
Foundation Dowels	None identified	None required
Hatches	None identified	None required
Masonry Block & Brick Walls	Cracking	Inspection Program for Civil Engineering Structures and Components
Penstock	Loss of material Change in material properties	Penstock Inspection
Intake and Spillway	Loss of material Change in material properties	Duke Power Five-Year Underwater Inspection of Hydroelectric Dams and Appurtenances FERC Five Year Inspection
Reinforced Concrete Beams, Columns, Floor Slabs, Roof Slabs and Walls	Change in material properties	FERC Five Year Inspection Inspection Program for Civil Engineering Structures and Components
Sump	None identified	None required

Table 3.7-4 Applicable Aging Effects for Keowee Structural Components (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment		
Anchorage/Embedments (exposed surfaces)	Loss of material	Inspection Program for Civil Engineering Structures and Components
Battery Racks for the 125 VDC Instrumentation and Control Batteries	Loss of material	Battery Rack Inspection
Cable Tray & Conduit	None identified	None required
Cable Tray & Conduit Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Checkered Plate	Loss of Material	Inspection Program for Civil Engineering Structures and Components
Control Boards	None identified	None required
Control Room Ceiling	None identified	None required
Crane Rails & Girders	Loss of material	Crane Inspection Program
Electrical & Instrument Panels & Enclosures	None identified	None required
Equipment Component Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Expansion Anchors	Loss of material	Inspection Program for Civil Engineering Structures and Components
Flood, Pressure & Specialty Doors	Loss of material	Inspection Program for Civil Engineering Structures and Components

Table 3.7-4 Applicable Aging Effects for Keowee Structural Components (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Instrument Line Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Instrument Racks & Frames	Loss of material	Inspection Program for Civil Engineering Structures and Components
Pipe Supports	Loss of material	Inservice Inspection Plan • Examination Category F-A Inspection Program for Civil Engineering Structures and Components
Stair, Platform, and Grating Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Structural Steel Beams, Columns, Plates & Trusses	Loss of material	Inspection Program for Civil Engineering Structures and Components
Steel in Fluid Environment		
Structural Steel & Plates	Loss of material	Duke Power Five Year Underwater Inspection for Hydroelectric Dams and Appurtenances (For Intake Steel) Penstock Inspection (For Penstock Steel)

Table 3.7-5 Applicable Aging Effects for Reactor Building Structural Components (Internal Structural Components and the Unit Vent Stacks)

Component	Applicable Aging Effect(s)	Aging Management Programs
Concrete		
Anchorage (in concrete)	None identified	None required
Embedments (in concrete)	None identified	None required
Equipment Pads	Cracking	Inspection Program for Civil Engineering Structures and Components
Flood Curbs	None identified	None required
Hatches	None identified	None required
Masonry Block & Brick Walls	Cracking	Inspection Program for Civil Engineering Structures and Components
Missile Shields	None identified	None required
Reinforced Concrete Beams, Columns, Floor Slabs, and Walls	None identified	None required
Sumps	None identified	None required
Steel in Air Environment		
Anchorage/Embedments (exposed surfaces)	Loss of material	Boric Acid Wastage Surveillance Program Inservice Inspection Plan • Examination Category F-A Inspection Program for Civil Engineering Structures and Components
	Cracking for anchorage for OTSG and reactor vessel support skirt	Boric Acid Wastage Surveillance Program Inservice Inspection Plan • Examination Category F-A

Table 3.7-5 Applicable Aging Effects for Reactor Building Structural Components (Internal Structural Components and the Unit Vent Stacks) (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Cable Tray & Conduit	Loss of Material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Cable Tray & Conduit Supports	Loss of material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Checkered Plate	Loss of material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Crane Rails & Girders	Loss of material	Crane Inspection Program
Electrical & Instrument Panels & Enclosures	None identified	None required
Equipment Component Supports	Loss of material	Boric Acid Wastage Surveillance Program Inservice Inspection Plan • Examination Category F-A Inspection Program for Civil Engineering Structures and Components

Table 3.7-5 Applicable Aging Effects for Reactor Building Structural Components (Internal Structural Components and the Unit Vent Stacks) (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Expansion Anchors	Loss of material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Flood, Pressure & Specialty Doors	Loss of material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Instrument Line Supports	Loss of material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Instrument Racks & Frames	Loss of material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components

Table 3.7-5 Applicable Aging Effects for Reactor Building Structural Components (Internal Structural Components and the Unit Vent Stacks) (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Lead Shielding Supports	Loss of material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Pipe Supports	Loss of material	Boric Acid Wastage Surveillance Program Inservice Inspection Plan • Examination Category F-A Inspection Program for Civil Engineering Structures and Components
Stairs, Platforms & Grating Supports	Loss of material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Structural Steel Beams, Columns, Plates & Trusses	Loss of material	Boric Acid Wastage Surveillance Program Inspection Program for Civil Engineering Structures and Components
Sump Screens	Loss of material	Inspection Program for Civil Engineering Structures and Components
Unit Vent Stack	Loss of material	Inspection Program for Civil Engineering Structures and Components

Table 3.7-5 Applicable Aging Effects for Reactor Building Structural Components (Internal Structural Components and the Unit Vent Stacks) (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Fluid Environment		
Fuel Transfer Canal Liner Plate	Loss of material Cracking	Chemistry Control Program
Miscellaneous		
Post-Tensioning System	Loss of material Cracking	Tendon - Secondary Shield Wall - Surveillance Program

Table 3.7-6 Applicable Aging Effects for Standby Shutdown Facility Structural Components

Components	Applicable Aging Effect(s)	Aging Management Programs
Concrete		
Anchorage (in concrete)	None identified	None required
Embedments (in concrete)	None identified	None required
Equipment Pads	Cracking	Inspection Program for Civil Engineering Structures and Components
Flood Curbs	None identified	None required
Foundation	None identified	None required
Hatches	None identified	None required
Reinforced Concrete Beams, Columns, Floor Slabs, Roof Slabs and Walls	None identified	None required
Steel in Air Environment		
Anchorage/Embedments (exposed surfaces)	Loss of material	Inspection Program for Civil Engineering Structures and Components
Battery Racks for the 125 VDC SSF Batteries	Loss of material	Battery Rack Inspections
Cable Tray & Conduit	None identified	None required
Cable Tray & Conduit Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Checkered Plate	Loss of material	Inspection Program for Civil Engineering Structures and Components
Control Boards	None identified	None required
Control Room Ceiling	None identified	None required
Crane Rails & Girders	Loss of material	Crane Inspection Program
Electrical & Instrument Panels & Enclosures	None identified	None required

Table 3.7-6 Applicable Aging Effects for Standby Shutdown Facility Structural Components (continued)

Components	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Equipment Component Supports	Loss of material	Inservice Inspection Plan • Examination Category F-A Inspection Program for Civil Engineering Structures and Components
Expansion Anchors	Loss of material	Inspection Program for Civil Engineering Structures and Components
Flood, Pressure & Specialty Doors	Loss of material	Inspection Program for Civil Engineering Structures and Components
HVAC Duct Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Instrument Line Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Instrument Racks & Frames	Loss of material	Inspection Program for Civil Engineering Structures and Components
Pipe Supports	Loss of material	Inservice Inspection Plan • Examination Category F-A Inspection Program for Civil Engineering Structures and Components
Stair, Platform & Grating Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components

Table 3.7-7 Applicable Aging Effects for Turbine Building Structural Components

Component	Applicable Aging Effect(s)	Aging Management Programs
Concrete		
Anchorage (in concrete)	None identified	None required
Embedments (in concrete)	None identified	None required
Equipment Pads	Cracking	Inspection Program for Civil Engineering Structures and Components
Flood Curbs	None identified	None required
Foundation	None identified	None required
Foundation Dowels	None identified	None required
Masonry Block & Brick Walls	Cracking	Inspection Program for Civil Engineering Structures and Components
Missile Shields	None identified	None required
Pipe Piles	None identified	None required
Reinforced Concrete Beams, Columns, Floor Slabs, and Walls	None identified	None required
Roof Slabs	None identified	None required
Sumps	None identified	None required
Steel in Air Environment		
Anchorage/Embedments (exposed surfaces)	Loss of material	Inspection Program for Civil Engineering Structures and Components
Cable Tray & Conduit	None identified	None required
Cable Tray & Conduit Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Checkered Plate	Loss of material	Inspection Program for Civil Engineering Structures and Components
Crane Rails & Girders	Loss of material	Crane Inspection Program

Table 3.7-7 Applicable Aging Effects for Turbine Building Structural Components (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Electrical & Instrument Panels & Enclosures	None identified	None required
Equipment Component Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Expansion Anchors	Loss of material	Inspection Program for Civil Engineering Structures and Components
Flood, Pressure & Specialty Doors	Loss of material	Inspection Program for Civil Engineering Structures and Components
Instrument Line Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Instrument Racks & Frames	Loss of material	Inspection Program for Civil Engineering Structures and Components
Pipe Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Stairs, Platforms, Grating Support	Loss of material	Inspection Program for Civil Engineering Structures and Components
Structural Steel Beams, Columns, Plates & Trusses	Loss of material	Inspection Program for Civil Engineering Structures and Components

Table 3.7-7 Applicable Aging Effects for Turbine Building Structural Components (continued)

Fire Barriers		
Fire Doors	Loss of material	Fire Protection Program
Fire Walls	Cracking	Fire Protection Program
Fire Barrier Penetration Seals	Cracking Separation	Fire Protection Program

Table 3.7-8 Applicable Aging Effects of Yard Structural Components

Component	Applicable Aging Effect(s)	Aging Management Programs
Concrete		
Anchorage (in concrete)	None identified	None required
Embedments (in concrete)	None identified	None required
Equipment Pads	Cracking	Inspection Program for Civil Engineering Structures and Components
Foundation	None identified	None required
Masonry Block & Brick Walls	Cracking	Inspection Program for Civil Engineering Structures and Components
Pipe Piles	None identified	None required
Reinforced Concrete Beams, Columns, Floor Slabs, and Walls	None identified	None required
Trenches	None identified	None required
Steel in Air Environment		
Anchorage/Embedments (exposed surfaces)	Loss of material	Inspection Program for Civil Engineering Structures and Components
230 kV Switchyard Battery Racks in the Relay House	Loss of material	Battery Rack Inspections
Cable Tray & Conduit	None identified	None required
Cable Tray & Conduit Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Checkered Plate	Loss of material	Inspection Program for Civil Engineering Structures and Components
Electrical & Instrument Panels & Enclosures	None identified	None required

Table 3.7-8 Applicable Aging Effects of Yard Structural Components (continued)

Component	Applicable Aging Effect(s)	Aging Management Programs
Steel in Air Environment (continued)		
Elevated Water Storage Tank (exterior)	Loss of material	Inspection Program for Civil Engineering Structures and Components
Equipment Component Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Expansion Anchors	Loss of material	Inspection Program for Civil Engineering Structures and Components
Piles	None identified	None required
Pipe Supports	Loss of material	Inspection Program for Civil Engineering Structures and Components
Structural Steel Beams, Columns, Plates & Trusses	Loss of material	Inspection Program for Civil Engineering Structures and Components
Transmission Towers	Loss of material	230 kV Keowee Transmission Line Inspection Program
Steel in Fluid Environment		
Elevated Water Storage Tank (interior)	Loss of material	Elevated Water Storage Tank Civil Inspection