ENTERGY NUCLEAR MANAGEMENT MANUAL
ENN-DC-149

VENDOR DOCUMENT REVIEW STATUS

☒ IPEC ☐ JAF ☐ PNPS ☐ VY

Document No.: **IP-RPT-06-AMM20** Rev. No. **0**

Document Title: **IP2 SBO and Appendix R Diesel Generator System**

ER No.: IP2-06-32959 Purchase Order No.

STATUS NO:

1. ☒ ACCEPTED
2. ☐ ACCEPTED AS NOTED RESUBMITTAL NOT REQUIRED
3. ☐ ACCEPTED AS NOTED RESUBMITTAL REQUIRED
4. ☐ NOT ACCEPTED
5. ☐ FOR INFORMATION

Acceptance does not constitute approval of design details, calculations, analyses, test methods, or materials developed or selected by the supplier and does not relieve the supplier from full compliance with contractual negotiations.

IPEC License Renewal Report Reviewer:

IPEC License Renewal Report Reviewer:

Responsible Engineer Jim Tuohy/ J. Tuohy 4-19-07
Print Name Signature Date

VENDOR DOCUMENT COMMENT RESOLUTION

Document No: **IP-RPT-06-AMM20** Rev. No: **0** ER No: IP2-06-32959

Document Title: **IP2 SBO and Appendix R Diesel Generator System**

Reviewer: Michael J. Vasely 4/13/07 Ext. 6887
Print Name/ Signature Date

Comment No:	Page No:	Section No:	Comment:	Disposition I/O*	Resolution:
			No Comments		

*I = Included, O = Omitted

Note: The reviewers' signature at the top of this page indicates concurrence with the resolution of their comments on the attached IPEC License Renewal Project Comment and Resolution Form.

RE: Jim Tuohy / J. Tuohy 4-19-07
Print Name/ Signature Date

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VENDOR DOCUMENT COMMENT RESOLUTION

Document No: **IP-RPT-06-AMM20** Rev. No: **0** ER No: IP2-06-32959

Document Title: **IP2 SBO and Appendix R Diesel Generator System**

Reviewer: JOHN C WHITNEY John C Whitney 4/12/07 Ext. 6888
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RE: Jim Tuohy / J. Tuohy 4-19-07
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VENDOR DOCUMENT COMMENT RESOLUTION

Document No: **IP-RPT-06-AMM20** Rev. No: **0** ER No: IP2-06-32959

Document Title: ***IP2 SBO and Appendix R Diesel Generator System***

Reviewer: F. Weinert / F. Weinert Ext. 7793
Print Name/ Signature Date

Comment No:	Page No:	Section No:	Comment:	Disposition I/O*	Resolution:
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2	No	other comments.			

*I = Included, O = Omitted

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RE: Jim Tuohy / J. Tuohy 4-19-07
Print Name/ Signature Date

- THIS IS NOT A QUALITY RECORD -

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Engineering Report Cover Sheet

Engineering Report Title:
Aging Management Review of the IP2 SBO and Appendix R Diesel Generator System

Engineering Report Type:

New ☒ Revision ☐ Cancelled ☐ Superseded ☐

Applicable Site(s)

IP1	☐	IP2	☒	IP3	☐	JAF	☐	PNPS	☐	VY	☐	WPO	☐
ANO1	☐	ANO2	☐	ECH	☐	GGNS	☐	RBS	☐	WF3	☐		

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Vendor Document No.: _____

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Prepared by: W. J. Russell W J Russell Date: 03/09/07
Responsible Engineer (Print Name/Sign)

Design Verified: N/A Date:
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Reviewed by: R. S. Smith Randall S. Smith Date: 3/9/07
Reviewer (Print Name/Sign)

Reviewed by*: N/A Date: _____
ANII (if required) (Print Name/Sign)

Approved by: Michael Strand / Michael Strand Date: 3/9/2007
Supervisor (Print Name/Sign)

*: For ASME Section XI Code Program plans per ENN-DC-120, if required

REVISION DESCRIPTION SHEET

Revision Number	Description	Pages and/or Sections Revised
0	Initial Draft	All new in accordance with ER No. 04-2-095 Revision 1

TABLE OF CONTENTS

1.0 Introduction

1.1 Purpose

This report is part of the aging management review (AMR) of the integrated plant assessment (IPA) performed to extend the operating licenses of Indian Point Energy Center (IPEC), Units 2 and 3. This report demonstrates the effects of aging on IPEC Unit 2 SBO and Appendix R Diesel Generator (ARDG) system passive mechanical components will be adequately managed so that the intended functions will be maintained consistent with the current licensing basis as required by 10 CFR 54.21(a)(3). For additional information on the license renewal project and associated documentation, refer to the License Renewal Project Plan.

The purpose of this report is to demonstrate that aging effects for passive mechanical components will be adequately managed for the period of extended operation associated with license renewal. The approach for demonstrating management of aging effects is to first identify the components that are subject to aging management review in Section 2.0. The next step is to define the aging effects requiring management for the system components in Section 3.0. Section 4.0 then evaluates if existing programs and commitments adequately manage those effects.

Applicable aging effects are determined using EPRI reports 1010639 *Non-Class 1 Mechanical Implementation Guideline and Mechanical Tools* and 1002950 *Aging Effects for Structures and Structural Components*. The EPRI reports provide the bases for identification of aging effects based on specific materials and environments and document confirmation of the validity of the aging effects through review of industry experience. License renewal guideline IPEC-LRPG-04, Mechanical System Screening and Aging Management Reviews, identifies aging effects from the EPRI reports that are potentially applicable to IPEC. This aging management review report (AMRR), in conjunction with IPEC-LRPG-04 and the EPRI reports, documents the identification and evaluation of aging effects requiring management for mechanical components in the ARDG systems. **(Ref. 1, 2, 3)**

1.2 System Description

As described in ER Response No. 04-2-095, Rev. 1, the IP2 ARDG system consists of a single diesel generator set, Cummins Power Generation Model 2700DQLA. The generator set is located in the IP1 turbine generator building at elevation 33'-0", under a section of the IP1 turbine pedestal. **(Ref. 18, 19)**

The system is normally in standby and must be started manually.

For additional description of the system and its components, see the ER Response No.04-2-095. **(Ref. 18)**

1.3 System and Component Intended Functions

As described in IPEC Report IP-RPT-06-LRD01, System and Structure Scoping Results, the ARDG system performs the following intended functions for 10 CFR 54.4(a)(1). **(Ref. 6)**

- The SBO and Appendix R diesel generator for IP2 (ARDG) has no intended function for 10 CFR 54.4(a)(1).

The ARDG system has the following intended functions for 10 CFR 54.4(a)(2). **(Ref. 6)**

- The SBO and Appendix R diesel generator for IP2 (ARDG) has no intended functions for 10 CFR 54.4(a)(2).

The ARDG system performs the following intended functions for 10 CFR 54.4(a)(3). **(Ref. 6)**

- Provide electrical power to selected equipment and power supplies relied upon for Appendix R and station blackout events.

Unit 1 turbine building supports the intended functions of the Unit 2 ARDG system. **(Ref. 6)**

For license renewal, the primary intended function of the ARDG system components is to maintain system pressure boundary integrity. The cooling system tubes have the function of heat transfer. For additional information on system and component functions, see the ER Response No. 04-2-095. **(Ref. 18)**

Refer to IPEC Report IP-RPT-06-LRD01, System and Structure Scoping Results, for additional information on scoping and intended functions of systems and structures for license renewal. **(Ref. 6)**

2.0 Screening

Passive, long-lived components that perform a license renewal component intended function are subject to aging management review. Bolting, filter housing, flexible connector, heat exchanger, heater housing, piping, pump casing, sight glass, silencer, tank, turbocharger and compressor casings, and valve body in the ARDG systems are passive, long-lived components.

The following major components of the ARDG systems are included in this AMR.

1. exhaust flexible connectors [(2)ARDG-EXH-FLEX CONN-SS]
2. heat exchangers [(2)ARDG-JWHX, (2)ARDG-ACHX, (2)ARDG-LOC, (2)ARDG-AC]
3. piping [(2)ARDG-PIPING-CS, (2)ARDG-PIPING-EXH-CS, (2)ARDG-PIPING-EXH-DRAIN-CS, (2)ARDG-PIPING-LO-CS]
4. pumps [(2)ARDG COOLING WATER PUMP CASING]
5. silencer [(2)ARDG-SILENCER]
6. tank [(2)ARDG-SURGE-TANKS-CS]

Components in the IP2 ARDG system that are included in this AMR are those that maintain the cooling water pressure boundary from the diesel to the jacket water and aftercooler heat exchangers and the return to the diesel, the lube oil system, and the air intake and exhaust piping from the diesel to the atmosphere outside the IP1 turbine building. The ARDG elastomer flex hoses, elastomer expansion joints, and disposable filters (oil and air) are periodically replaced. Therefore, the flex hoses, expansion joints and disposable filters are not subject to aging management review. The filter housings are subject to aging management review. **(Ref. 9, 12)**

The components included in this report have the ARDG system code in the component database. No components with any other system code are included in this report. Fuel oil system components associated with IP2 ARDG are evaluated in IP-RPT-06-AMM21, Fuel Oil Systems.

Some equipment in the ARDG system is insulated. For the evaluation of insulation, refer to IP-RPT-06-AMC04, Aging Management Review of Bulk Commodities. **(Ref. 8)**

A list of ARDG system mechanical components subject to aging management review is included in License Renewal Information System (LRIS) report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20. Flow diagrams associated with these systems, highlighted to identify components requiring aging management review, are available as drawings: **(Ref. 12)**

IPEC Unit 2

To be determined

3.0 Aging Effects Requiring Management

EPRI reports 1010639 and 1002950 are the basis for identifying and evaluating aging effects requiring management. License renewal guideline IPEC-LRPG-04, Mechanical System Screening and Aging Management Reviews, identifies aging effects from the EPRI reports that are potentially applicable to IPEC. For additional information on aging effects, refer to IPEC-LRPG-04 and the EPRI reports. **(Ref. 1, 2, 3)**

License Renewal Information System (LRIS) report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20 is a list of ARDG system components that form the system pressure boundary. These components, highlighted on the associated LRA drawings, require aging management review.

The following sections document the determination of aging effects requiring management for specific component materials and environments. Internal surfaces are reviewed first, followed by heat exchangers, and external surfaces. For aging mechanisms that are not always applicable, the following notes indicate why the mechanism is, or is not, applicable to the material and environment under evaluation.

Notes for Aging Effect Tables in Subsequent Subsections

Note	Aging mechanism applies when ...
1	temperature is >220degF.
2	material is in electrolytic contact with dissimilar metals higher in the galvanic series.
3	frequently (i.e., system normally operating) subject to high-velocity constricted flow, high-velocity fluid direction change or fluid contains high levels of particulates (river water).
4	system identified as susceptible in FAC program.
5	material is gray cast iron.
6	material is gray cast iron, environment is outdoor air or untreated air, and pooling is possible.
7	temperature is >140degF and significant moisture is present.
8	temperature is >270degF.
9	material is CASS and temperature is >482degF.
10	environment is outdoor air or untreated air and pooling is possible.
11	material is uninhibited and contains >15%Zn or is aluminum bronze with >8% Al and fluid contains ammonia or an ammonium compound.
12	material is uninhibited and contains >15%Zn or is aluminum bronze with >8% Al.
13	material is uninhibited and contains >15%Zn or is aluminum bronze with >8% Al, environment is outdoor air or untreated air, and pooling is possible.
14	aluminum alloy contains >12%Zn or >6% magnesium.
15	titanium alloy is not ASTM grade 1, 2, 7, 11, or 12 and contains >5% aluminum (Al), more than 0.2% Oxygen (O), or any tin (Sn).
16	temperature is >160degF.
17	temperature is <220degF.
18	glass is exposed to very hot water (>212degF), hydrofluoric acids, or caustics.
19	temperature is >95degF.
20	heat transfer is an intended function.
21	environment is outdoor air, condensation, or soil; or indoor air with component internal temperature <212degF.

Notes for Aging Effect Tables in Subsequent Subsections

Note	Aging mechanism applies when …
22	environment is outdoor air, condensation, or soil and material is in electrolytic contact with dissimilar metals higher in the galvanic series.
23	environment is outdoor air, condensation, or soil.
24	environment is soil.
25	material is gray cast iron and environment is condensation, soil, or outdoor air with potential for pooling.
26	material is uninhibited, contains >15%Zn, or is aluminum bronze with >8%Al and environment is condensation, soil, or outdoor air with potential for pooling.
27	carbon steel is in a system containing boric acid.
28	environment is indoor air or outdoor air with exposure to sunlight, fluorescent lighting, ozone or ionizing radiation.

3.1 Internal Aging Effects Applicable to the ARDG System

The following table lists internal environments for ARDG system components. Subsequent subsections document the determination of aging effects requiring management for specific component materials in these environments. Internal environment descriptions are in IPEC-LRPG-04. **(Ref. 3)**

Internal Environment	Nominal Internal Temperature (°F)	Discussion	Major Components (see Section 2.0)
air – indoor	≤ 105°F **(Ref. 4, 17)** IP1 turbine building	air intake filter housing maximum temperatures assumed the same as shown in references for comparable buildings	
condensation	≤ 105°F **(Ref. 4)** IP1 turbine building	exhaust system drain piping and valve	
exhaust gas	Approximately 1000°F **(Ref. 20)**	engine exhaust subsystem	(2)ARDG-EXH-FLEX CONN-SS, (2)ARDG-PIPING-EXH-CS, and (2)ARDG-SILENCER
lube oil	≤ 200°F **(Ref. 20)**	lube oil pump casing, filter housing, and piping	(2)ARDG-PIPING-LO-CS, (2)ARDG-LO-PUMP CASING-CS
treated water	≤ 190°F **(Ref. 19, 20, 21, 22)**	carbon steel diesel cooling water subsystem	(2)ARDG-PIPING-CS, (2)ARDG COOLING WATER PUMP CASING

3.1.1 Carbon Steel Internal Surfaces Exposed to Condensation

Exhaust subsystem drain piping and drain valves are carbon steel. See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of carbon steel components. **(Ref. 18)**

AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Cracking	Thermal fatigue	Y☐/N☒(1)
Loss of material	General corrosion	Y
	Galvanic corrosion	Y☐/N☒(2)
	Crevice corrosion	Y
	Erosion	Y☐/N☒(3)
	Flow-accelerated corrosion	Y☐/N☒(4)
	Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
	Pitting corrosion	Y
	Selective leaching	Y☐/N☒(5)

3.1.2 Carbon Steel Internal Surfaces Exposed to Air-Indoor

The intake air filter housing is carbon steel. See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of carbon steel components. **(Ref. 18)**

AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Cracking	Thermal fatigue	Y☐/N☒(1)
Loss of material	General corrosion	Y

3.1.3 Carbon Steel Internal Surfaces Exposed to Treated Water

System piping components with pipe code J-1 are carbon steel. The turbocharger housing is carbon steel and has treated cooling water flowing through it. The coolant heater housing and the surge tanks are carbon steel. Fouling is an aging effect for the turbocharger housing only. See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of carbon steel components. **(Ref. 18)**

AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Cracking	Thermal fatigue	Y☐/N☒(1)
Loss of material	General corrosion	Y
	Galvanic corrosion	Y☐/N☒(2)
	Crevice corrosion	Y
	Erosion	Y☐/N☒(3)
	Flow-accelerated corrosion	Y☐/N☒(4)
	Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
	Pitting corrosion	Y
	Selective leaching	Y☐/N☒(5)
Fouling	n/a	Y☒/N☐(20)

3.1.4 Carbon Steel Internal Surfaces Exposed to Exhaust Gas

System piping components with pipe code D-8 are carbon steel. The turbocharger and diesel exhaust silencer are carbon steel. See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of carbon steel components. **(Ref. 18)**

AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Cracking	Thermal fatigue	Y☒/N☐(1)
Loss of material	General corrosion	Y
	Galvanic corrosion	Y☐/N☒(2)
	Crevice corrosion	Y
	Erosion	Y☐/N☒(3)
	Pitting corrosion	Y
	Selective leaching	Y☐/N☒(6)

3.1.5 Carbon Steel Internal Surfaces Exposed to Lube Oil

Lube oil filter housing, piping, pump casing, and valves are carbon steel. See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of carbon steel components. **(Ref. 18)**

AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Cracking	Thermal fatigue	Y☐/N☒(1)
Loss of material	General corrosion	Y
	Galvanic corrosion	Y☐/N☒(2)
	Crevice corrosion	Y
	Microbiologically influenced corrosion (MIC)	Y
	Pitting corrosion	Y
	Selective leaching	Y☐/N☒(5)

3.1.6 Stainless Steel Internal Surfaces Exposed to Exhaust Gas

Diesel engine exhaust flexible connectors are stainless steel. See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of stainless steel components. **(Ref. 18)**

AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Cracking	Stress corrosion/IGA	Y☐/N☒ (7)
	Thermal fatigue	Y☒/N☐ (8)
Loss of material	Crevice corrosion	Y☒/N☐(10)
	Pitting corrosion	Y☒/N☐(10)

3.1.7 Copper Alloy Internal Surfaces Exposed to Treated Water

Sight glass housings are copper alloy (>15% Zn assumed). See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of copper alloy components. **(Ref. 12)**

AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Cracking	Stress corrosion/IGA	Y☐/N☒(11)
Loss of material	Galvanic corrosion	Y☐/N☒ (2)
	Crevice corrosion	Y
	Erosion	Y☐/N☒ (3)
	Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
	Pitting corrosion	Y
	Selective leaching	Y☒/N☐(12)

3.1.8 Glass Internal Surfaces

Sight glasses in this system are exposed to treated water. See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of glass components. **(Ref. 12)**

AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Change in material properties	Hydrolytic attack	Y☐/N☒(18)

3.2 IP2 ARDG Jacket Water and Aftercooler Heat Exchangers Aging Effects

The IP2 ARDG jacket and aftercooler water heat exchangers are shell and tube heat exchangers. City water (< 95°F) flows through the stainless steel tubes and treated water (> 140°F) flows through the carbon steel shell. **(Ref. 23)**

The bonnet (end channel) is the same material as the shell [carbon steel].

The carbon steel bonnet (end channel) is exposed to the same internal environment as the tubes.

The tube sheet is the same material as the bonnet and shell [carbon steel] and is exposed to the same environments. Therefore, the tube sheet is not listed as a specific component type.

See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of heat exchanger components and materials.

COMPONENT TYPE	AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Heat exchanger tube internal surfaces	Cracking	Stress corrosion/IGA	Y☐/N☒ (7)
		Thermal fatigue	Y☐/N☒ (8)
	Loss of material	Crevice corrosion	Y
		Erosion	Y☐/N☒ (3)
		Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
		Pitting corrosion	Y
	Reduction in fracture toughness	Thermal embrittlement	Y☐/N☒ (9)
	Fouling	n/a	Y☒/N☐(20)
Heat exchanger tube external surfaces	Cracking	Stress corrosion/IGA	Y☒/N☐ (7)
		Thermal fatigue	Y☐/N☒ (8)
	Loss of material	Crevice corrosion	Y
		Erosion	Y☐/N☒ (3)
		Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
		Pitting corrosion	Y
		Wear	Y
	Reduction in fracture toughness	Thermal embrittlement	Y☐/N☒ (9)
	Fouling	n/a	Y☒/N☐(20)

COMPONENT TYPE	AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Heat exchanger shell internal surfaces	Cracking	Thermal fatigue	Y☐/N☒(1)
	Loss of material	General corrosion	Y
		Galvanic corrosion	Y☐/N☒(2)
		Crevice corrosion	Y
		Erosion	Y☐/N☒(3)
		Flow-accelerated corrosion	Y☐/N☒(4)
		Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
		Pitting corrosion	Y
		Selective leaching	Y☐/N☒(5)
Heat exchanger bonnet internal surfaces	Cracking	Thermal fatigue	Y☐/N☒(1)
	Loss of material	General corrosion	Y
		Galvanic corrosion	Y☒/N☐(2)
		Crevice corrosion	Y
		Erosion	Y☐/N☒(3)
		Flow-accelerated corrosion	Y☐/N☒(4)
		Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
		Pitting corrosion	Y
		Selective leaching	Y☐/N☒(5)

3.3 IP2 ARDG Lube Oil Cooler Heat Exchanger Aging Effects

The lube oil cooler [(2)ARDG-LOC] heat exchanger is a small shell and tube heat exchanger. Treated water (< 190°F) flows through the copper alloy tubes and lube oil (< 200°F)] flows through the carbon steel shell. **(Ref. 18)** Since the cooler is small and does not have high flows, wear of the tubes is not a potential aging effect.

The bonnet (end channel) is the same material as the shell. The bonnet (end channel) is exposed to the same internal environment as the tubes.

The tube sheet is the same material as the tubes and is exposed to the same environments. Therefore, the tube sheet is not listed as a specific component type.

See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of heat exchanger components and materials.

COMPONENT TYPE	AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Heat exchanger tube internal surfaces	Cracking	Stress corrosion/IGA	Y☐/N☒(11)
	Loss of material	Galvanic corrosion	Y☐/N☒(2)
		Crevice corrosion	Y
		Erosion	Y☐/N☒(3)
		Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
		Pitting corrosion	Y
		Selective leaching	Y☐/N☒(12)
	Fouling	n/a	Y☒/N☐(20)
Heat exchanger tube external surfaces	Cracking	Stress corrosion/IGA	Y☐/N☒(11)
	Loss of material	Crevice corrosion	Y
		Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
		Pitting corrosion	Y
		Selective leaching	Y☐/N☒(12)
		Wear	N
	Fouling	n/a	Y☒/N☐(20)

COMPONENT TYPE	AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Heat exchanger shell internal surfaces	Cracking	Thermal fatigue	Y☐/N☒(1)
	Loss of material	General corrosion	Y
		Galvanic corrosion	Y☒/N☐(2)
		Crevice corrosion	Y
		Microbiologically influenced corrosion (MIC)	Y
		Pitting corrosion	Y
		Selective leaching	Y☐/N☒(5)
Heat exchanger bonnet internal surfaces	Cracking	Thermal fatigue	Y☐/N☒(1)
	Loss of material	General corrosion	Y
		Galvanic corrosion	Y☒/N☐(2)
		Crevice corrosion	Y
		Erosion	Y☐/N☒(3)
		Flow-accelerated corrosion	Y☐/N☒(4)
		Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
		Pitting corrosion	Y
		Selective leaching	Y☐/N☒(5)

3.4 Turbocharger Aftercooler Aging Effects

The turbocharger aftercooler is an enclosed housing unit with copper alloy (>15% Zn assumed) cooling coils (tubes). The carbon steel housing (identified as component type shell) provides support for the cooling coils and pressure boundary for intake air. Treated water at <220°F flows through passageways in the housing (shell) and through the tubes. External surfaces of the tubes and internal surfaces of the housing are exposed to air – indoor. **(Ref. 20, 22)**

The aluminum fins are exposed to the same external environment as the tubes. The tubes are short spans of straight tubes with fins that are not subject to wear on their external surfaces due to the short periods of time the ARDG is in operation. See LRIS report, "Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2) for a list of heat exchanger components and materials.

COMPONENT TYPE	AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Heat exchanger tube internal surfaces	Cracking	Stress corrosion/IGA	Y☐/N☒(11)
	Loss of material	Galvanic corrosion	Y☐/N☒ (2)
		Crevice corrosion	Y
		Erosion	Y☐/N☒ (3)
		Microbiologically influenced corrosion (MIC)	Y☒/N☐(17)
		Pitting corrosion	Y
		Selective leaching	Y☒/N☐(12)
	Fouling	n/a	Y☒/N☐(20)
Heat exchanger tube external surfaces	Cracking	Stress corrosion/IGA	Y☐/N☒(11)
	Loss of material	Crevice corrosion	Y☐/N☒(10)
		Pitting corrosion	Y☐/N☒(10)
		Selective leaching	Y☐/N☒(13)
	Fouling	n/a	Y☒/N☐(20)
	Loss of material	Wear	Y☐/N☒
Heat exchanger fins	Fouling	n/a	Y☒/N☐(20)
Heat exchanger housing internal surfaces with water	Cracking	Thermal fatigue	Y☐/N☒(1)
	Loss of material	General corrosion	Y
		Galvanic corrosion	Y☐/N☒(2)
		Crevice corrosion	Y
		Erosion	Y☐/N☒(3)
		Flow-accelerated corrosion	Y☐/N☒(4)
		Microbiologically influenced corrosion (MIC)	Y
		Pitting corrosion	Y
		Selective leaching	Y☐/N☒(5)

COMPONENT TYPE	AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Heat exchanger shell (housing) internal surfaces exposed to indoor air	Cracking	Thermal fatigue	Y☒/N☐(1)
	Loss of material	General corrosion	Y

3.5 External Aging Effects Applicable to ARDG System Components and Bolting

Insulation, if used on stainless steel components in this system is free of contaminants that could cause cracking of stainless steel. **(Ref. 14)**

The following table lists external environments for ARDG system components. External environment descriptions are in LRPG-04 **(Ref. 3)**.

External Environment	Nominal External Temperature (°F)	Discussion	Major Components (see Section 2.0)
air – indoor	≤ 105°F **(Ref. 4, 17)** IP1	maximum temperatures assumed the same as shown in references for comparable buildings	(2)ARDG-EXH-FLEX CONN-SS, (2)ARDG-PIPING-CS, (2)ARDG-PIPING-EXH-CS, (2)ARDG-PIPING-EXH-DRAIN-CS, (2)ARDG-PIPING-LO-CS, (2)ARDG-COOLING WATER PUMP CASING, and (2)ARDG-SILENCER
air – outdoor	-15°F to 93°F **(Ref. 4)**	outside temperature range	(2)ARDG-PIPING-EXH-CS

Materials of components in the ARDG system are identified in the subsections of Section 3.1. The following sections document the determination of aging effects requiring management for specific component materials in external environments. Pressure retaining bolting in this system may be carbon steel or stainless steel and is exposed to the same external environments.

3.5.1 Air – Indoor External Environment

MATERIAL	AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Carbon steel	Loss of material	General corrosion	Y☒/N☐(21)
		Galvanic corrosion	Y☐/N☒(22)
		Crevice corrosion	Y☐/N☒(23)
		Microbiologically influenced corrosion (MIC)	Y☐/N☒(24)
		Pitting corrosion	Y☐/N☒(23)
		Selective leaching	Y☐/N☒(25)
		Boric acid corrosion	Y☐/N☒(27)
Stainless steel	Loss of material	Crevice corrosion	Y☐/N☒(23)
		Microbiologically influenced corrosion (MIC)	Y☐/N☒(24)
		Pitting corrosion	Y☐/N☒(23)
Copper alloy >15% zn	Loss of material	Galvanic corrosion	Y☐/N☒(22)
		Crevice corrosion	Y☐/N☒ (23)
		Microbiologically influenced corrosion (MIC)	Y☐/N☒ (24)
		Pitting corrosion	Y☐/N☒ (23)
		Selective leaching	Y☐/N☒ (26)
Glass	Change in material properties	Hydrolytic attack	Y☐/N☒ (18)

3.5.2 Air – Outdoor External Environment

MATERIAL	AGING EFFECT	AGING MECHANISM	Applicable to ARDG System Components
Carbon steel	Loss of material	General corrosion	Y☒/N☐(21)
		Galvanic corrosion	Y☐/N☒(22)
		Crevice corrosion	Y☒/N☐(23)
		Microbiologically influenced corrosion (MIC)	Y☐/N☒(24)
		Pitting corrosion	Y☒/N☐(23)
		Selective leaching	Y☐/N☒(25)
		Boric acid corrosion	Y☐/N☒(27)

3.6 Operating Experience

The review of site-specific operating experience and recent industry operating experience completed in IPEC Report IP-RPT-06-LRD05, Operating Experience Review Results, did not identify aging effects applicable to the ARDG system passive mechanical components not addressed in this aging management review report. **(Ref. 11)**

4.0 Demonstration That Aging Effects Will Be Managed

Section 2.0 describes components of the ARDG systems that are subject to aging management review. For those components, Section 3.0 documents the determination of aging effects requiring management. The aging management review is completed by demonstrating that existing programs, when continued into the period of extended operation, can manage the aging effects identified in Section 3.0. No further action is required for license renewal when the evaluation of an existing program demonstrates that it is adequate to manage the aging effect such that corrective action may be taken prior to loss of the system intended functions. Alternately, if existing programs cannot be shown to manage the aging effects for the period of extended operation, then action will be proposed to augment existing or create new programs to manage the identified effects of aging.

Demonstration for the purposes of this license renewal technical evaluation is accomplished by establishing a clear relationship among

1) the components under review,

2) the aging effects on these items caused by the material-environment-stress combinations which, if undetected, could result in loss of the intended function such that the system could not perform its function(s) within the scope of license renewal in the period of extended operation, and

3) the credited aging management programs whose actions serve to preserve the system intended function(s) for the period of extended operation.

Attachment 2 lists component types and identifies the aging effects requiring management for each material and environment combination. The Bolting Integrity Program, External Surfaces Monitoring Program, Heat Exchanger Monitoring Program, Oil Analysis Program, Periodic Surveillance and Preventive Maintenance Program, Selective Leaching Program, and Water Chemistry Control – Closed Cooling Water Program in combination will manage the effects of aging, thereby precluding loss of the intended functions of the system. Sections 4.1 through 4.7 provide the clear relationship between the component, the aging effect, and the aging management program actions that preserve the intended functions for the period of extended operation. Section 4.8 identifies applicable time-limited aging analyses. For a comprehensive review of programs credited for license renewal of IPEC and a demonstration of how these programs will manage aging effects, see IPEC Report IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical. **(Ref. 10)**

4.1 Bolting Integrity Program

Activities under the Bolting Integrity Program include periodic inspection, material selection, thread lubricant control, assembly and torque requirements, and repair and replacement requirements. For the IP2 SBO and Appendix R diesel generator system, the Bolting Integrity Program manages loss of material for carbon steel and stainless steel bolted connections exposed to indoor and outdoor air through inspections for leakage and loss of material.

This program applies to component types indicated on Attachment 2. For additional information on this program, see IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical. **(Ref. 10)**

4.2 External Surfaces Monitoring Program

Under the External Surfaces Monitoring Program, visual inspections manage aging effects on components. For the ARDG system, the External Surfaces Monitoring Program manages loss of material for external carbon steel components by visual inspection of external surfaces. Since some internal carbon steel surfaces in this system are exposed to the same environment as the external surfaces, external surfaces will be representative of internal surfaces. Thus, the External Surfaces Monitoring Program will also manage loss of material on internal carbon steel surfaces.

This program applies to component types indicated on Attachment 2. For additional information on this program, see IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical. **(Ref. 10)**

4.3 Heat Exchanger Monitoring Program

The Heat Exchanger Monitoring Program manages loss of material for the jacket water and aftercooler heat exchangers tubes [(2)ARDG-JWHX, (2)ARDG-ACHX] by non-destructive examinations, such as eddy-current and visual inspections performed to identify degradation prior to loss of intended function.

This program applies to component types indicated on Attachment 2. For additional information on this program, see IPEC Report IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical. **(Ref. 10)**

4.4 Oil Analysis Program

The Oil Analysis Program maintains oil systems free of contaminants (primarily water and particulates) thereby preserving an environment that is not conducive to cracking, loss of material, or fouling. This program manages loss of material for carbon steel and copper alloy components wetted by oil.

This program applies to component types indicated on Attachment 2. For additional information on this program, see IPEC Report IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical. **(Ref. 10)**

4.5 Periodic Surveillance and Preventive Maintenance Program

The following activities, under the Periodic Surveillance and Preventive Maintenance Program, manage aging effects for ARDG system components.

Scope	Parameters Monitored	Detection of Aging	Acceptance Criteria
Internal surfaces of diesel exhaust gas components: • Flexible connectors • Piping • Silencer • Exhaust drain piping and valve bodies • turbocharger housing	Cracking and surface condition for crevice or pitting corrosion; also general corrosion for carbon steel components	Every 5 years, visually inspect a sample of the internal surfaces of diesel exhaust gas components to manage cracking and loss of material.	No detectable cracking or significant corrosion
Periodically inspect: • Internal surfaces of ARDG turbocharger housing and aftercooler housing and the external of the tubes and fins within the aftercooler housing	fouling and loss of material	Visually inspect every 5 years for fouling and loss of material, as applicable.	No detectable fouling deposits or loss of material
Periodically inspect: • Internal surfaces of the jacket water heat exchanger carbon steel bonnet • Internal inspection of the jacket water heat exchanger stainless steel tubes	Loss of material Loss of material and fouling	Visually inspect every 5 years for fouling and loss of material, as applicable	No detectable fouling deposits or loss of material

This program applies to component types indicated on Attachment 2. For additional information on this program, see IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical. **(Ref. 10)**

4.6 Selective Leaching Program

The Selective Leaching Program ensures the integrity of components made from gray cast iron or copper alloy susceptible to selective leaching that are exposed to raw water, treated water, steam, or soil (groundwater). By one-time visual inspection and testing of a representative sample of the component population, the Selective Leaching Program will verify the absence of significant loss of material due to selective leaching for IPEC Unit 2 ARDG system uninhibited copper alloy >15% zinc surfaces exposed to treated water.

This program applies to component types indicated on Attachment 2. For additional information on this program, see IPEC Report IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical. **(Ref. 10)**

4.7 Water Chemistry Control – Closed Cooling Water Program

The Water Chemistry Control – Closed Cooling Water Program manages loss of material, cracking and fouling of ARDG system carbon steel, copper alloy, and stainless steel components by minimizing levels of contaminants in the water. This program also minimizes fouling on heat transfer surfaces of the jacket cooling water, aftercooler, intercooler and lube oil heat exchangers and the turbocharger housing. The One-Time Inspection Program for Water Chemistry utilizes inspections or non-destructive examinations of representative samples to verify that the Water Chemistry Control – Closed Cooling Water Program has been effective at managing aging effects for carbon steel piping, valve bodies, pump casings, heater housings, sight glasses, tanks, turbocharger housings, and heat exchangers in the ARDG system.

This program applies to component types indicated on Attachment 2. For additional information on this program and the One-Time Inspection Program for Water Chemistry, see IPEC Report IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical. **(Ref. 10)**

4.8 Time-Limited Aging Analyses

The analysis of metal fatigue is a TLAA applicable to portions of this system subjected to elevated temperatures.

See IPEC Reports IP-RPT-06-LRD03, TLAA and Exemption Evaluation Results, and IP-RPT-06-LRD04, TLAA – Mechanical Fatigue, for further review of time-limited aging analyses. **(Ref. 15, 16)**

5.0 Summary and Conclusions

The following aging management programs address the aging effects requiring management for the ARDG system.

- Bolting Integrity Program
- External Surfaces Monitoring Program
- Heat Exchanger Monitoring Program
- Oil Analysis Program
- Periodic Surveillance and Preventive Maintenance Program
- Selective Leaching Program
- Water Chemistry Control – Closed Cooling Water Program

For additional review of programs credited for license renewal of IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical. **(Ref. 10)**

Attachment 2 contains the aging management review results for the ARDG System.

In conclusion, programs described in Section 4.0 will provide reasonable assurance that the effects of aging on the ARDG system will be managed such that the intended functions will be maintained consistent with the current licensing basis throughout the period of extended operation.

6.0 References

1. *Non-Class 1 Mechanical Implementation Guideline and Mechanical Tools*, Revision 4, EPRI, Palo Alto, CA: 2001. 1010639 (Mechanical Tools)

2. *Aging Effects for Structures and Structural Components*, Revision 1, EPRI, Palo Alto, CA: 2003. 1002950 (Structural Tools)

3. IPEC-LRPG-04, Mechanical System Screening and Aging Management Reviews

4. IP2 Updated Final Safety Analysis Report (UFSAR) Section N.N

5. IP2 DBD-Later, Design Basis Document for the IP2 SBO and Appendix R Diesel Generator Set System, Rev. Later, [date - Later]

6. IP-RPT-06-LRD01, System and Structure Scoping Results

7. IP-RPT-06-AMM30, Aging Management Review of Nonsafety-Related Systems and Components Affecting Safety-Related Systems

8. IP-RPT-06-AMC04, Aging Management Review of Bulk Commodities

9. *Industry Guideline for Implementing the Requirements of 10 CFR Part 54 – The License Renewal Rule*, NEI 95-10, Revision 6, June 2005

10. IP-RPT-06-LRD07, Aging Management Program Evaluation Results – Non-Class 1 Mechanical

11. IP-RPT-06-LRD05, Operating Experience Review Results

12. Flow Diagrams - Later

13. Specification No. 9321-01-248-18, IP2 Specification for Fabrication of Piping Systems Turbine Generating Plant

14. IP2 MM92-250, Spec for Insulations (Thermal/Acoustics (Con Ed Class A and Non-Class), Rev. 2

15. IP-RPT-06-LRD03, TLAA and Exemption Evaluation Results

16. IP-RPT-06-LRD04, TLAA – Mechanical Fatigue

17. IP2 RPT-196-1, Rev. 1, EQ Program Environmental Parameters Report [1/8/04]

18. ER Response No. 04-2-095, Rev. 1, Station Blackout and Appendix R Diesel Generator Set

19. Operator's Manual, GenSet Model DQLA, DQLB, Cummins Power Generation

20. IP-RPT-06-AMM17, Emergency Diesel Generator Systems AMRR

21. Not Used

22. IP-RPT-06-AMM18, Security Generators AMRR

23. Heat Exchanger Specification Sheet, Atlas Industrial Manufacturing Co., Proposal No. A-333-06

See License Renewal Information System (LRIS) report,
"Attachment 1 Passive Components by AMRR," for IP-RPT-06-AMM20(2).

IP2

ENVIRONMENT: AIR - INDOOR (EXTERNAL)

Comp ID	Comp Type	Comp Name	Material
(2)ARDG BOLTING-CS	bolting	ARDG CARBON STEEL BOLTING	carbon steel
(2)ARDG BOLTING-SS	bolting	ARDG STAINLESS STEEL BOLTING	stainless steel
(2)ARDG-AC	heat exchanger (fins)	ARDG TURBOCHARGER AFTERCOOOLER	aluminum

ENVIRONMENT: AIR - INDOOR (INTERNAL)

Comp ID	Comp Type	Comp Name	Material
(2)ARDG-AC	turbocharger housing	ARDG TURBOCHARGER AFTERCOOOLER	carbon steel
(2)ARDG-AIR-FILTER-HOUSINGS	filter housing	ARDG CARBON STEEL AIR FILTER HOUSINGS	carbon steel

ENVIRONMENT: CONDENSATION (INTERNAL)

Comp ID	Comp Type	Comp Name	Material
(2)ARDG-PIPING-EXH-DRAIN	piping	CARBON STEEL EXHAUST DRAIN PIPING	carbon steel
(2)ARDG-VALVE-EXH-DRAIN	valve body	CARBON STEEL EXHAUST DRAIN VALVE	carbon steel

ENVIRONMENT: EXHAUST GAS (INTERNAL)

Comp ID	Comp Type	Comp Name	Material
(2)ARDG EXH-FLEX CONN	flex conn	ARDG SS EXHAUST FLEXIBLE CONNECTOR	stainless steel
(2)ARDG-PIPING-EXH	piping	ARDG CARBON STEEL EXHAUST PIPING	carbon steel
(2)ARDG-SILENCER	silencer	ARDG EXHAUST SILENCER	carbon steel
(2)ARDG-TURBOCHARGER	turbocharger	ARDG TURBOCHARGER	carbon steel

ENVIRONMENT: LUBE OIL (EXTERNAL)

Comp ID	Comp Type	Comp Name	Material
(2)ARDG-LOC	heat exchanger (tubes)	ARDG LUBE OIL COOLER	copper alloy

ENVIRONMENT: LUBE OIL (INTERNAL)

Comp ID	Comp Type	Comp Name	Material
(2)ARDG-LOC	heat exchanger (shell)	ARDG LUBE OIL COOLER	carbon steel
(2)ARDG-LO-FILTER-HOUSING	filter housing	ARDG CARBON STEEL LUBE OIL FILTER HOUSING	carbon steel
(2)ARDG-LO-PUMP CASING	pump casing	ARDG CARBON STEEL LUBE OIL PUMP CASING	carbon steel
(2)ARDG-PIPING-LO	piping	ARDG CARBON STEEL LUBE OIL PIPING	carbon steel
(2)VALVE-CS	valve body	CARBON STEEL VALVE	carbon steel

ENVIRONMENT: TREATED WATER (INTERNAL)

Comp ID	Comp Type	Comp Name	Material
(2)ARDG COOLING WATER PUMP CASING	pump casing	ARDG DIESEL DRIVEN COOLING WATER PUMP CASING	carbon steel
(2)ARDG-AC	turbocharger housing	ARDG TURBOCHARGER AFTERCOOOLER	carbon steel
(2)ARDG-AC	heat exchanger (tubes)	ARDG TURBOCHARGER AFTERCOOLER	copper alloy
(2)ARDG-ACHX	heat exchanger (bonnet)	ARDG AFTERCOOLER HEAT EXCHANGER	carbon steel
(2)ARDG-ACHX	heat exchanger (shell)	ARDG AFTERCOOLER HEAT EXCHANGER	carbon steel
(2)ARDG-ACHX	heat exchanger (tubes)	ARDG AFTERCOOLER HEAT EXCHANGER	stainless steel
(2)ARDG-HEATER-HOUSING	heater housing	ARDG COOLANT HEATER HOUSING	carbon steel
(2)ARDG-JWHX	heat exchanger (shell)	ARDG JACKET WATER HEAT EXCHANGER	carbon steel
(2)ARDG-JWHX	heat exchanger (bonnet)	ARDG JACKET WATER HEAT EXCHANGER	carbon steel
(2)ARDG-JWHX	heat exchanger (tubes)	ARDG JACKET WATER HEAT EXCHANGER	stainless steel
(2)ARDG-LOC	heat exchanger (bonnet)	ARDG LUBE OIL COOLER	carbon steel
(2)ARDG-LOC	heat exchanger (tubes)	ARDG LUBE OIL COOLER	copper alloy
(2)ARDG-PIPING	piping	ARDG COOLING WATER PIPING	carbon steel
(2)ARDG-SURGE TANK SIGHT GLASS	sight glass	ARDG SURGE TANK SIGHT GLASS	copper alloy >15% zn
(2)ARDG-SURGE TANK SIGHT GLASS	sight glass	ARDG SURGE TANK SIGHT GLASS	glass
(2)ARDG-SURGE-TANK	tank	ARDG CARBON STEEL SURGE TANK	carbon steel
(2)ARDG-VALVES	valve body	ARDG CARBON STEEL VALVES	carbon steel

ENVIRONMENT: TREATED WATER >140°F (EXTERNAL)

Comp ID	Comp Type	Comp Name	Material
(2)ARDG-ACHX	heat exchanger (tubes)	ARDG AFTERCOOLER HEAT EXCHANGER	stainless steel

ENVIRONMENT: TREATED WATER >140°F (EXTERNAL)

Comp ID	Comp Type	Comp Name	Material
(2)ARDG-JWHX	heat exchanger (tubes)	ARDG JACKET WATER HEAT EXCHANGER	stainless steel

IP2

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs
Bolting	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	Bolting integrity
Bolting	Pressure boundary	Stainless steel	Air - indoor (ext)	None	None
Filter housing	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Filter housing	Pressure boundary	Carbon steel	Air - indoor (int)	Loss of material	External surfaces monitoring
Filter housing	Pressure boundary	Carbon steel	Lube oil (int)	Loss of material	Oil analysis
Flex conn	Pressure boundary	Stainless steel	Air - indoor (ext)	None	None
Flex conn	Pressure boundary	Stainless steel	Exhaust gas (int)	Cracking-fatigue	Metal fatigue TLAA
Flex conn	Pressure boundary	Stainless steel	Exhaust gas (int)	Loss of material	Periodic surveillance and preventive maintenance

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs
Heat exchanger (bonnet)	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Heat exchanger (bonnet)	Pressure boundary	Carbon steel	Treated water (int)	Loss of material	Periodic surveillance and preventive maintenance
Heat exchanger (bonnet)	Pressure boundary	Carbon steel	Treated water (int)	Loss of material	Water chemistry control - closed cooling water
Heat exchanger (fins)	Heat transfer	Aluminum	Air - indoor (ext)	Fouling	Periodic surveillance and preventive maintenance
Heat exchanger (shell)	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Heat exchanger (shell)	Pressure boundary	Carbon steel	Lube oil (int)	Loss of material	Oil analysis
Heat exchanger (shell)	Pressure boundary	Carbon steel	Treated water (int)	Loss of material	Water chemistry control - closed cooling water
Heat exchanger (tubes)	Heat transfer	Copper alloy	Air - indoor (ext)	Fouling	Periodic surveillance and preventive maintenance
Heat exchanger (tubes)	Heat transfer	Copper alloy	Lube oil (ext)	Fouling	Oil analysis

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs
Heat exchanger (tubes)	Heat transfer	Copper alloy	Treated water (int)	Fouling	Water chemistry control - closed cooling water
Heat exchanger (tubes)	Heat transfer	Stainless steel	Treated water (int)	Fouling	Periodic surveillance and preventive maintenance
Heat exchanger (tubes)	Heat transfer	Stainless steel	Treated water >140°f (ext)	Fouling	Water chemistry control - closed cooling water
Heat exchanger (tubes)	Pressure boundary	Copper alloy	Air - indoor (ext)	None	None
Heat exchanger (tubes)	Pressure boundary	Copper alloy	Lube oil (ext)	Loss of material	Oil analysis
Heat exchanger (tubes)	Pressure boundary	Copper alloy	Treated water (int)	Loss of material	Water chemistry control - closed cooling water
Heat exchanger (tubes)	Pressure boundary	Stainless steel	Treated water (int)	Loss of material	Periodic surveillance and preventive maintenance
Heat exchanger (tubes)	Pressure boundary	Stainless steel	Treated water >140°f (ext)	Cracking	Water chemistry control - closed cooling water
Heat exchanger (tubes)	Pressure boundary	Stainless steel	Treated water >140°f (ext)	Loss of material	Water chemistry control - closed cooling water

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs
Heat exchanger (tubes)	Pressure boundary	Stainless steel	Treated water >140°f (ext)	Loss of material-wear	Heat exchanger monitoring
Heater housing	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Heater housing	Pressure boundary	Carbon steel	Treated water (int)	Loss of material	Water chemistry control - closed cooling water
Piping	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Piping	Pressure boundary	Carbon steel	Air - outdoor (ext)	Loss of material	External surfaces monitoring
Piping	Pressure boundary	Carbon steel	Condensation (int)	Loss of material	Periodic surveillance and preventive maintenance
Piping	Pressure boundary	Carbon steel	Exhaust gas (int)	Cracking-fatigue	Metal fatigue TLAA
Piping	Pressure boundary	Carbon steel	Exhaust gas (int)	Loss of material	Periodic surveillance and preventive maintenance
Piping	Pressure boundary	Carbon steel	Lube oil (int)	Loss of material	Oil analysis

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs
Piping	Pressure boundary	Carbon steel	Treated water (int)	Loss of material	*Water chemistry control - closed cooling water*
Pump casing	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Pump casing	Pressure boundary	Carbon steel	Lube oil (int)	Loss of material	Oil analysis
Pump casing	Pressure boundary	Carbon steel	Treated water (int)	Loss of material	Water chemistry control - closed cooling water
Sight glass	Pressure boundary	Copper alloy >15% zn	Air - indoor (ext)	None	None
Sight glass	Pressure boundary	Copper alloy >15% zn	*Treated water (int)*	*Loss of material*	*Selective leaching*
Sight glass	Pressure boundary	Copper alloy >15% zn	Treated water (int)	Loss of material	Water chemistry control - closed cooling water
Sight glass	Pressure boundary	Glass	Air - indoor (ext)	None	None
Sight glass	Pressure boundary	Glass	Treated water (int)	None	None

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs
Silencer	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Silencer	Pressure boundary	Carbon steel	Exhaust gas (int)	Cracking-fatigue	Metal fatigue TLAA
Silencer	Pressure boundary	Carbon steel	Exhaust gas (int)	Loss of material	Periodic surveillance and preventive maintenance
Tank	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Tank	Pressure boundary	Carbon steel	Treated water (int)	Loss of material	Water chemistry control - closed cooling water
Turbocharger	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Turbocharger	Pressure boundary	Carbon steel	Exhaust gas (int)	Cracking-fatigue	Metal fatigue TLAA
Turbocharger	Pressure boundary	Carbon steel	Exhaust gas (int)	Loss of material	Periodic surveillance and preventive maintenance
Turbocharger housing	Heat transfer	Carbon steel	Air - indoor (int)	Fouling	Periodic surveillance and preventive maintenance

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs
Turbocharger housing	Heat transfer	Carbon steel	Treated water (int)	Fouling	Water chemistry control - closed cooling water
Turbocharger housing	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Turbocharger housing	Pressure boundary	Carbon steel	Air - indoor (int)	Loss of material	External surfaces monitoring
Turbocharger housing	Pressure boundary	Carbon steel	Treated water (int)	Loss of material	Water chemistry control - closed cooling water
Valve body	Pressure boundary	Carbon steel	Air - indoor (ext)	Loss of material	External surfaces monitoring
Valve body	Pressure boundary	Carbon steel	Condensation (int)	Loss of material	Periodic surveillance and preventive maintenance
Valve body	Pressure boundary	Carbon steel	Lube oil (int)	Loss of material	Oil analysis
Valve body	Pressure boundary	Carbon steel	Treated water (int)	Loss of material	Water chemistry control - closed cooling water