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December 8, 2020

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Serial No.: 20-328B
NRA/SS: R0
Docket No.: 50-336
License No.: DPR-65

DOMINION ENERGY NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2
SUPPLEMENT TO PROPOSED LICENSE AMENDMENT REQUEST TO REVISE THE MILLSTONE UNIT 2 TECHNICAL SPECIFICATIONS FOR STEAM GENERATOR INSPECTION FREQUENCY

By letter dated October 8, 2020 (ADAMS Accession No. ML20282A594), Dominion Energy Nuclear Connecticut (DENC) submitted a proposed license amendment request (LAR) to the Nuclear Regulatory Commission (NRC) in accordance with 10 CFR 50.90, to revise Millstone Power Station Unit 2 (MPS2) Technical Specification (TS) 6.26, "Steam Generator (SG) Program," Item d.2. The LAR reflected a proposed change to the required SG tube inspection frequency from every 72 effective full power months (EFPM), or at least every third refueling outage, to every 96 EFPM. Because MPS2 has an 18-month operating cycle, a 96 EFPM frequency essentially requires the inspection to be performed every fifth refueling outage. The NRC staff concluded that additional information was needed to enable the NRC to proceed with its detailed technical review regarding the acceptability of the proposed LAR.

On November 20, 2020, a teleconference was held between the NRC staff and DENC to discuss the information delineated as necessary to assess the acceptability of the proposed amendment. Based on these discussions, DENC decided to supplement the LAR by providing a revised SG Integrity Condition Monitoring and Operational Assessment (CMOA) for MPS2 Refueling Outage 24 (2R24). A submittal date of December 10, 2020 was agreed upon for the LAR Supplement.

Per communication dated November 20, 2020 (ADAMS Accession No. ML20325A376), the NRC formally provided DENC an opportunity to supplement the proposed LAR discussed above.

It should be noted that the attachment to this LAR Supplement supersedes the LAR Attachment 3 (submitted in DENC letter dated October 8, 2020) in its entirety. The revised MPS2 SG CMOA for 2R24 attached to this LAR Supplement demonstrates that the SG structural and accident induced leakage performance criteria would be met during the five-cycle operating period (i.e. preceding MPS2 Refueling Outage 2R29 in fall 2024), for existing and potential degradation mechanisms. For the two existing degradation mechanisms observed at MPS2 (fan bar wear and foreign object wear), the LAR Supplement attachment justifies there is reasonable assurance that the structural integrity performance criterion will be met for a five-cycle operating period. The conclusions of the no significant hazards evaluation and the environmental considerations evaluation have not changed based on the revised MPS2 SG CMOA attached to this LAR Supplement.

Should you have any questions or require additional information, please contact Shayan Sinha at (804) 273-4687.

Respectfully,

Mark D. Sartain
Vice President – Nuclear Engineering and Fleet Support

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Mr. Mark D. Sartain, who is Vice President – Nuclear Engineering and Fleet Support of Dominion Energy Nuclear Connecticut, Inc. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 8th day of December, 2020.

My Commission Expires: 12/31/24.

CRAIG D SLY
Notary Public
Commonwealth of Virginia
Reg. # 7518653
My Commission Expires December 31, 2024

Notary Public

Commitments contained in this letter: None

Attachment: Revised Millstone Unit 2 Steam Generator Integrity Condition Monitoring and Operational Assessment, Refueling Outage 2R24

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ATTACHMENT

REVISED MILLSTONE UNIT 2 STEAM GENERATOR INTEGRITY CONDITION MONITORING AND OPERATIONAL ASSESSMENT REFUELING OUTAGE 2R24

DOMINION ENERGY NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2

Millstone Unit 2 Steam Generator Integrity Condition Monitoring and Operational Assessment

Refueling Outage (2R24)

December 2020

Revision 1

Record of Revisions

Revision	Date	Description
0	April 2017	Issued to Dominion Energy Millstone Unit 2 in support of return to Mode 4 power following 2R24
1	December 2020	This revision updates the Operational Assessment to evaluate an interval of five operating cycles between steam generator inspections. Technical content changes are limited to Section 6 (Operational Assessment) of the report. Deterministic evaluation of foreign object wear beyond the 2R24 RFO for newly identified foreign objects has been deleted because those foreign objects were verified to be removed. Minor consistency changes are made as appropriate throughout the rest of the document.

Table of Contents

1. Executive Summary

This document evaluates the Millstone Unit 2 steam generator (SG) as-found condition (condition monitoring assessment) and the anticipated condition during the next operating period (operational assessment). This evaluation is based on the inspection activities performed in SG25 and SG26 during the 2R24 refueling outage. The condition monitoring (CM) assessment concludes that none of the three SG Program performance criteria (structural integrity, operational leakage, or accident induced leakage) were exceeded during the operating period prior to 2R24. The operational assessment (OA) concludes that there is reasonable assurance that operation of the Millstone Unit 2 SGs throughout the operating period preceding the next examination (up to five fuel cycles) will not cause any of the three performance criteria to be exceeded.

Revision 1 of this report amends the 2R24 OA to evaluate an interval of five operating cycles between SG inspections. Two degradation mechanisms were identified during the 2R24 SG inspections, structure wear (fan bar) and foreign object wear. No new locations of structure wear were identified during the 2R24 SG inspections. Additional calculations were performed which evaluate the projected growth at fan bar wear locations previously identified. Four new locations of foreign object wear were identified during the 2R24 SG inspections. Foreign objects attributed to be the cause of the foreign object wear at each location were confirmed to be removed following secondary side FOSAR (foreign object search and retrieval) activities, arresting the progression of the foreign object wear. The revised OA concludes that there is reasonable assurance that operation of the Millstone Unit 2 SGs throughout the operating period preceding the next examination (up to five fuel cycles) will not cause any of the three performance criteria to be exceeded. The current plant Technical Specifications do not allow for inspection intervals greater than three cycles for plants with SG tubes fabricated with Alloy 690 material. Dominion Energy has submitted a license amendment request to change this requirement to allow a maximum of five cycles between inspections.

This evaluation was performed in accordance with the following Millstone and industry requirement documents:

- Millstone Unit 2 Technical Specifications (TS 6.26)
- Dominion Energy fleet-wide steam generator (SG) program (Ref. [8.1])
- Dominion Energy SG Condition Monitoring and Operational Assessment (CMOA) procedure (Ref. [8.2])
- EPRI Steam Generator Integrity Assessment Guidelines (IAG) (Ref. [8.7])
- EPRI Steam Generator Integrity Assessment Guidelines (IAG) (Ref. [8.8])
- April 2010 Interim Guidance on the IAG (Ref. [8.9])
- NEI 97-06 (Ref. [8.3])

Descriptions of specific SG activities performed during 2R24, and the degradation mechanisms targeted by the inspection program are provided in Section 3.0.

Key findings:

- Tube Degradation
  - The only tube degradation mechanisms detected were fan bar wear and foreign object wear
  - No degradation exceeded the 40 %TW technical specification plugging criteria
  - No indications of lattice support wear were reported

- Foreign Objects
  - A variety of foreign objects were located and removed from the SG secondary side
  - Some foreign objects could not be removed, but these objects were deemed benign

- Tube Plugging
    - Plugging was not required or performed during the 2R24 outage

- Secondary Side Inspections
    - Identified no concerns relative to long-term performance and reliability

2. Introduction / Background

NEI 97-06 was developed to provide the industry with guidance and standards for assessing the structural and leakage integrity of steam generator tubes and to provide the basis for plant specific SG integrity programs. NEI 97-06 and the Millstone Unit 2 Technical Specifications (TS 6.26) establish three specific steam generator performance criteria:

- Structural Integrity – Margin of 3.0 against burst under normal steady state power operation and a margin of 1.4 against burst under the most limiting design basis accident. Additional requirements are specified for non-pressure accident loads.
- Operational Leakage – RCS operational primary-to-secondary leakage through any one steam generator shall not exceed 150 GPD.
- Accident Induced Leakage – Leakage shall not exceed the value assumed in the limiting accident analysis (150 GPD per SG).

This Technical Evaluation constitutes a condition monitoring and operational assessment of each tube degradation mechanism identified during the 2R24 primary and secondary side inspections. The CM assessment is performed to verify that the condition of the tubes, as reflected by the inspection results, meets the above performance criteria. Indications of degradation, if found, are evaluated to confirm that the safety margins against leakage and burst were not exceeded at the end of the previous operating cycle. The results of the condition monitoring evaluation are used as a basis for the OA which demonstrates that the anticipated performance of the steam generators, including any degraded tubes remaining in service, will not exceed the performance criteria for leakage and tube burst during the next operating period.

A pre-outage Degradation Assessment (Ref. [8.4]) was performed to identify existing degradation mechanisms as well as degradation mechanisms which could potentially occur in the near term within the Millstone Unit 2 steam generators. The assessment also identified the appropriate inspection scope, techniques to be utilized during the subject inspection, and applicable detection and sizing information for the identified degradation mechanisms. The 2R24 inspections were performed in accordance with the Degradation Assessment.

All of the acquired eddy current data was analyzed by two independent analysis paths: manual primary analysis and secondary computerized analysis (ZETEC RevospECT). All results were passed through a resolution process. Any discrepancies between the two analysis teams were resolved by a third team of analysts (primary and secondary resolution analysts). The BWXT Lead Level III coordinated the analysis process and provided additional analysis expertise as required. The Dominion Energy ET Level III and an Independent Qualified Data Analyst (IQDA), a role defined within the EPRI PWR SG Examination Guidelines (Ref. [8.5]), served in oversight roles. The inspections were performed per the requirements of Ref. [8.5] and all inspection techniques utilized for degradation detection and/or sizing were qualified per these guidelines.

The Millstone Unit 2 Analysis Reference Manual (Ref. [8.6]), updated and approved prior to commencement of the inspection, served as the principal guidance document for data evaluation. As with past practice, Millstone Unit 2-specific examination technique specification sheets (ETSS) were used in conjunction with Ref. [8.6] to summarize instructions relative to acquisition and analysis setups and analysis screening parameters.

The naming convention of the steam generators in this report has been changed from what has been used in recent outages. The naming convention has been inconsistent in the past and this has caused some confusion among the various Dominion Energy and vendor organizations. In recent outages, the steam generators have been called SG1 and SG2 in the various reports including the CMOA. The steam generators are now designated as SG25 (formerly SG1) and SG26 (formerly SG2). These designations are consistent with the original manufacturing naming convention.

3. Scope of Activities, Evaluated Degradation Mechanisms, Tube Plugging

Scope of Activities

The SG activities planned for 2R24 were described in the Degradation Assessment (Ref. [8.4]) and are summarized below.

3.1.1 Primary Side

The following primary side activities were performed in SG25 and SG 26 during the 2R24 outage.

- Visual examination of both channel heads (as-found / as-left), specifically including the divider plate / tubesheet interface, and previously installed tube plugs.
- Eddy current bobbin probe and rotating +Point™ probe examinations as described in Table 3-1. Table 3-1 provides a breakdown of the actual number of primary side tube examinations performed during the outage including additional tests necessary to bound foreign objects and to address unresolved bobbin indications. Table 3-1 also summarizes the results of the examination.

3.1.2 Secondary Side

The following secondary side activities were performed in SG25 and SG26 during the 2R24 outage.

- Chemical cleaning of the secondary side using AREVA's Deposit Minimization Treatment (DMT) process
- High pressure sludge lancing.
- Post-sludge lancing visual examination of top-of-tubesheet annulus and no-tube lane to assess as-left material condition and cleanliness, and to identify and remove any retrievable foreign objects (FOSAR).
- Visual investigation of accessible locations having eddy current indications potentially related to foreign objects, and removal of retrievable foreign objects.
- Steam drum visual inspections to evaluate the material condition and cleanliness of key components such as moisture separators, drain systems, and interior surfaces.

Table 3-1
Millstone 2R24 ECT Summary

	SG25	SG26	Total
Number of Installed Tubes	8523*	8523	17046
Number of Tubes In Service Prior to 2R24	8504	8510	17014
Number of Tubes Inspected F/L w/Bobbin Probe**	8504	8510	17014
Previously Plugged Tubes	19*	13	32
Number of Tubes Incomplete w/Bobbin Probe due to Obstruction	0	0	0
Number of Exams with +Point™ (Total)	2623	2702	5325
•Hot Leg Tubesheet TSH +3/-3 Periphery	1256	1269	2525
•Hot Leg Tubesheet PTE	1	0	1
•Hot Leg Tubesheet 01HTSH	3	7	10
•Hot Leg Tubesheet PLP Bounding	18	49	67
•Cold Leg Tubesheet TSC +3/-3 Periphery	1245	1253	2498
•Cold Leg Tubesheet 01CTSC	0	4	4
•Cold Leg Tubesheet TSC +10/-3	11	0	11
•Cold Leg Tubesheet PLP Bounding	22	30	52
•Hot Leg Special Interest	34	39	73
•U-Bend Special Interest	7	5	12
•Cold Leg Special Interest	6	11	17
•Hot Leg Additional RPC	20	22	42
•Cold Leg Additional RPC	0	13	13
Tubes with Max FB Wear ≥ 40 %	0	0	0
Tubes with Max FB Wear ≥20% but <40%	0	0	0
Tubes with Max FB Wear <20%	2	2	4
Tubes with Max SVI / VOL / WAR≥ 40 %	0	0	0
Tubes with Max SVI / VOL / WAR≥20% but <40%	1	13	14
Tubes with Max SVI / VOL / WAR<20%	0	2	2
Total Tubes Plugged as a Result of this Inspection	0	0	0

* One tubesheet location in SG25 (R57 C156) was not drilled in the cold leg tubesheet. The hot leg hole for this tube was plugged with a welded plug. Although this location was never tubed, it is included in the counts of installed tubes and plugged tubes.

** A number of tubes were examined in hot leg / cold leg segments to achieve full length coverage.

3.2 Evaluated Degradation Mechanisms

Prior to this outage, only fan bar wear and foreign object wear had been identified in the MPS2 SGs, therefore these degradation mechanisms were the only mechanisms classified in the DA (Ref. [8.4]) as "existing." As discussed in Ref. [8.4], one other mechanism was classified as "potential" (lattice support wear). It is primarily "existing" and "potential" damage mechanisms that were targeted by the 2R24 inspection.

It is a requirement of the Millstone SG program that all tube locations identified as currently experiencing (i.e., "existing") or potentially susceptible to degradation (i.e., "potential"), be examined with qualified NDE techniques within specific time periods. These periods are prescribed in TS 6.26.d.2. The first inspection period of the MPS2 SGs had a duration of 144 EFPM and ended after the 2R20 outage. The second inspection period has a duration of 120 EFPM and started during Cycle 21. This was the third steam generator inspection in the second inspection period but was the second inspection of each SG.

Table 3-2 summarizes the examinations performed to date and their compliance with the inspection period requirements. For example, in the table an entry of 200 indicates that "200%" of the tubes were examined within the second period. More succinctly, it means that each tube was examined at least twice within the given period. As shown in the table, all tubes were inspected at least four times time during the first period. In addition, all in-service tubes have already been inspected twice during the second inspection period thus meeting the minimum sampling requirements for the second inspection period.

3.3 Tube Plugging

Based on the inspection results, tube plugging was not required or performed during the 2R24 outage. Table 3-3 provides a summary of the MPS2 tube plugging to date.

Table 3-2 – Summary of SG Inspection Sampling Through the 2R24 Outage (TS 6.26)

Degradation Mechanism			FO Wear (potential)		Lattice Support Wear (potential)		FB Wear (potential)	
Location Affected			TSH to TSC		Support Intersections		FB Intersections	
Number of Tubes in Susceptible Region			8,523		8,523		8,523	
Principal ECT Probe for Detection			Bobbin[A]		Bobbin		Bobbin	
Steam Generator			SG25	SG26	SG25	SG26	SG25	SG26
Outage	Date	SG EFPM Since Period Start	CUMULATIVE SAMPLE EXAMINED **(PERCENT)**					
2R12	Oct-94	0.0	29	28	29	28	29	28
Mid Cycle 13	Jun-97	6.0	100	53	100	53	100	53
2R13	Apr-00	16.0		153		153		153
2R14	Mar-02	35.8	200		200		200	
2R15	Oct-03	52.7		253		253		253
2R16 (mid-period)	Apr-05	68.6	300		300		300	
2R17	Oct-06	84.8						
2R18	Apr-08	101.3	400	353	400	353	400	353
2R19	Oct-09	116.9						
2R20 (last in period)	Apr-11	133.0	500	453	500	453	500	453
2R21	Oct-12	5.0						
2R22	Apr-14	21.1		100		100		100
2R23	Oct-15	37.5	100		100		100	
2R24	Apr-17	54.0	200	200	200	200	200	200

A) FO and FO wear detection is augmented with secondary side visual exams and top of tubesheet (TTS) +Point/Array probe sampling.

Table 3-3 – Millstone SG Tube Plugging Attributes

DATE	Preservice 2R11		Oct-94 2R12		May-97 MCO13		Jun-00 2R13		Feb-02 2R14		Oct-03 2R15		Apr-05 2R16		Oct-06 2R17		Apr-08 2R18		Oct-09 2R19		Apr-11 2R20		Oct-12 2R21	
SG EFPY	0.0		1.3		1.8		2.6		4.3		5.7		7.0		8.4		9.8		11.1		12.4		13.7	
SG ID	25	26	25	26	25	26	25	26	25	26	25	26	25	26	25	26	25	26	25	26	25	26	25	26
FO Wear ≥40 %TW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Unretrieved FO with or w/o Wear <40 %TW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	10	11	0	0
FO Wear <40 %TW w/o FO Present	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Lattice Support Wear & Fan Bar Wear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inspectability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-Total	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	2	0	0	10	11	0	0
TOTAL	1		0		0		0		0		0		0		0		10		0		21		0	

DATE	Apr-14 2R22		Oct-15 2R23		Apr-17 2R24		Oct-18 2R25		Total per SG	
SG EFPY	15.1		16.4		17.8					
SG ID	25	26	25	26	25	26	25	26	25	26
FO Wear ≥40 %TW	0	0	0	0	0	0			2	0
Unretrieved FO with or w/o Wear <40 %TW	0	0	0	0	0	0			11	13
FO Wear <40 %TW w/o FO Present	0	0	0	0	0	0			5	0
Lattice Support Wear & Fan Bar Wear	0	0	0	0	0	0			0	0
Inspectability	0	0	0	0	0	0			0	0
Other	0	0	0	0	0	0			1	0
Sub-Total	0	0	0	0	0	0	0	0	19	13
TOTAL	0		0		0		0		32	

Total Plugging by Category

2	FO Wear >40 %TW
24	Unretrieved FO with or w/o Wear <40 %TW
5	FO Wear <40 %TW w/o FO Present
0	Lattice Support Wear & Fan Bar Wear
0	Inspectability
1	Other

☐ SG Inspected

4. Inspection Results

This section provides the results of both the primary and secondary side inspections performed during the 2R24 outage. In general, only the specific results that relate to the condition monitoring assessment and the operational assessment will be discussed herein. The implications of these results with respect to the CMOA are discussed in Sections 5.0 and 6.0, respectively.

4.1 Channel Head inspections

The hot and cold leg channel heads stay well welds and divider plate welds were visually examined in SG25 and SG26 prior to the installation of eddy current probe manipulators. The examination revealed no evidence of divider plate or staywell weld degradation, and no foreign objects were identified.

Plug visual examinations were performed on all previously installed plugs in SG25 and SG26. No indications of plug degradation, leakage, or misplacement were identified.

4.2 Primary Side Tube Inspections

The primary side inspection scope was performed, and a brief tally of the number of indications reported is provided in Section 3.1.1 and Table 3-1. Results of potential significance to SG integrity are discussed in this section. Table 4-1 identifies all indications of tube degradation identified during the 2R24 examination.

4.2.1 Inspectability Issues

No indications of signal interference prevented the effective examination of tube regions planned for examination during 2R24.

4.2.2 Geometric Discontinuities

Dents (DNTs), bulges (BLGs), and tubesheet overexpansions (OXPs and OVRs) result in elevated residual stresses and, in susceptible tube materials, have been implicated in the development of stress corrosion cracking (SCC). Although SCC is not considered to be a potential degradation mechanism in the MPS2 A690TT tubing, sampling inspections of these geometric discontinuities with +Point probes were performed during 2R24. None of these examinations revealed tube degradation associated with the discontinuities.

4.2.3 Fan Bar Wear

The primary examination technique for fan bar wear detection and sizing is the bobbin coil probe (ETSS 96041.3). A total of four fan bar wear indications in four tubes were reported during the examination; two indications in each SG (Table 4-1). All four have been reported during previous outage inspections

Table 4-1 – 2R24 Tube Degradation Summary

SG	Row	Col	Location	ETSS	Axial Length (in)	Circ Length (in)	Maximum Depth 2R24	Depth Reported Prior Outage	Initially Reported	Signal Present Prior to Current Outage?	Cause	Foreign Object Remaining?	In-Situ Tested?	Plugged & Stabilized?
25	40	155	F06 - 1.76"	96041.3	3.15*	N/A	13% TW	12% TW 2R23	2R14	Yes	Fan Bar Wear	N/A	No	No
25	140	93	F08 - 0.66"	96041.3	3.15*	N/A	19% TW	14% TW 2R23	2R14	Yes	Fan Bar Wear	N/A	No	No
25	92	143	TSH + 10.91"	27901.1	0.24	0.37	23% TW	NDD 2R23	2R24	Yes	Foreign Object Wear	No	No	No
26	28	5	TSC + 21.65"	27901.1	0.28	0.43	25% TW	27% TW 2R22	2R15	Yes	Foreign Object Wear	No	No	No
26	29	4	TSC + 22.2"	27901.1	0.27	0.43	26% TW	25% TW 2R22	2R18	Yes	Foreign Object Wear	No	No	No
26	37	120	F07 - 0.83"	96041.3	3.15*	N/A	12% TW	8% TW 2R22	2R15	Yes	Fan Bar Wear	N/A	No	No
26	44	5	TSC + 17.91"	27902.1	0.43	0.38	10% TW	11% TW 2R22	2R20	Yes	Foreign Object Wear	No	No	No
26	59	10	TSC + 17.33"	27901.1	0.38	0.43	23% TW	24% TW 2R22	2R15	Yes	Foreign Object Wear	No	No	No
26	98	143	TSH + 8.76"	27901.1	0.33	0.37	20% TW	20% TW 2R22	2R18	Yes	Foreign Object Wear	No	No	No
26	99	80	F06 + 1.28"	96041.3	3.15*	N/A	13% TW	15% TW 2R22	2R15	Yes	Fan Bar Wear	N/A	No	No
26	118	41	TSH + 12.81"	27902.1	0.48	0.37	12% TW	12%TW 2R22	2R18	Yes	Foreign Object Wear	No	No	No
26	119	42	TSH + 12.97"	27903.1	0.38	0.43	29% TW	24% TW 2R22	2R18	Yes	Foreign Object Wear	No	No	No
26	122	123	TSH + 2.53"	27901.1	0.33	0.54	34% TW	NDD 2R22	2R24	No	Foreign Object Wear	No	No	No
26	123	46	TSH + 18.15"	27903.1	0.23	0.37	25% TW	22% TW 2R22	2R15	Yes	Foreign Object Wear	No	No	No
26	124	45	TSH + 19.27"	27903.1	0.38	0.32	31% TW	26% TW 2R22	2R18	Yes	Foreign Object Wear	No	No	No
26	124	123	TSH + 1.77"	27901.1	0.38	0.43	36% TW	NDD 2R22	2R24	No	Foreign Object Wear	No	No	No
26	125	48	TSH + 19.53"	27903.1	0.33	0.43	36% TW	32% TW 2R22	2R15	Yes	Foreign Object Wear	No	No	No
26	125	122	TSH + 1.36"	27902.1	0.53	0.37	23% TW	NDD 2R22	2R24	No	Foreign Object Wear	No	No	No
26	126	49	TSH + 19.97"	27903.1	0.49	0.48	39% TW	34% TW 2R22	2R15	Yes	Foreign Object Wear	No	No	No
26	128	107	TSH + 0.06"	27901.1	0.28	0.37	26% TW	29% TW 2R22	2R20	Yes	Foreign Object Wear	No	No	No

* Conservative assumed length

4.2.4 Foreign Objects and Foreign Object Wear

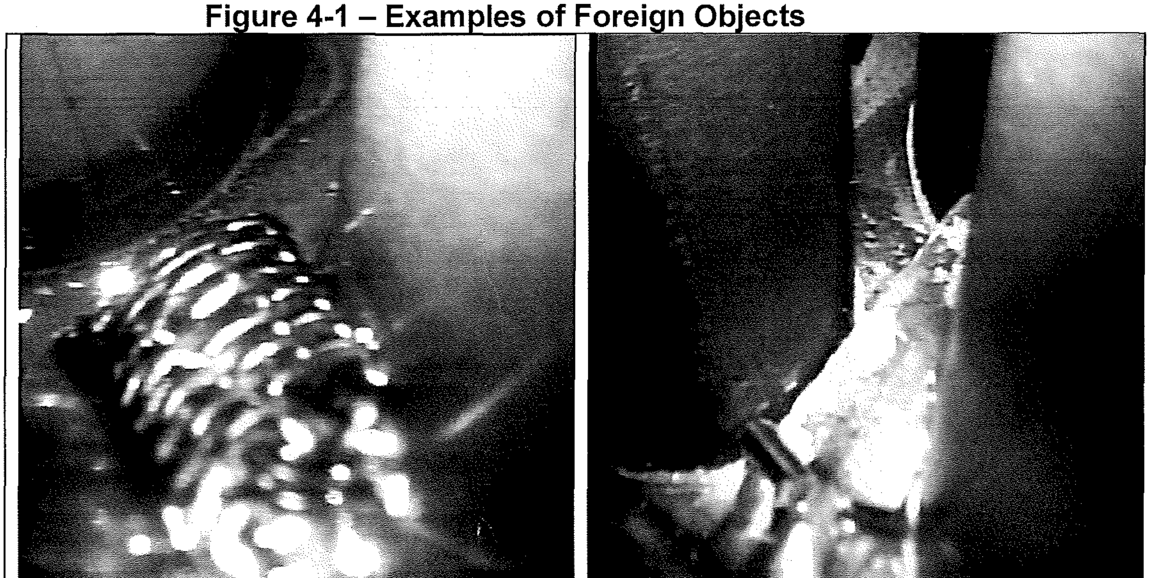
One of the most significant potential threats to tube integrity found during 2R24 was foreign object (FOs). This section provides a discussion of the FO degradation mechanism for 2R24.

A comprehensive approach was applied to foreign objects or foreign object wear during 2R24. The BWXT Loose Parts Tracker (LPT) database contains information on foreign objects detected by either eddy current or by visual examination techniques during 2R24. Prior to the 2R23 examination, the AREVA Foreign Objects Tracking System (FOTS) database for the Millstone Unit 2 SGs was used to develop a list of any foreign object locations that required evaluation during the examination. Based on history and the potential for wear, the appropriate examination scope was planned and documented in the DA.

The +Point™ probe was used to perform a 50% examination of the outer 6 rows of the hot and cold leg periphery and open tube lane. Since foreign objects normally contact more than a single tube, the +Point™ probe examination provided an improved probability of detecting foreign objects or foreign object wear within this band. Due to the tube spacing in the tri-pitch steam generator, few foreign objects are capable of traveling more than a few rows into the tube bundle. The cross flow velocity of the incoming feedwater, and consequently the potential for foreign object wear, is also highest within this zone. Compared to the bobbin exam, the +Point examination provides a significant improvement in the probability of detection of foreign objects that are most likely to cause wear and FO wear within this region.

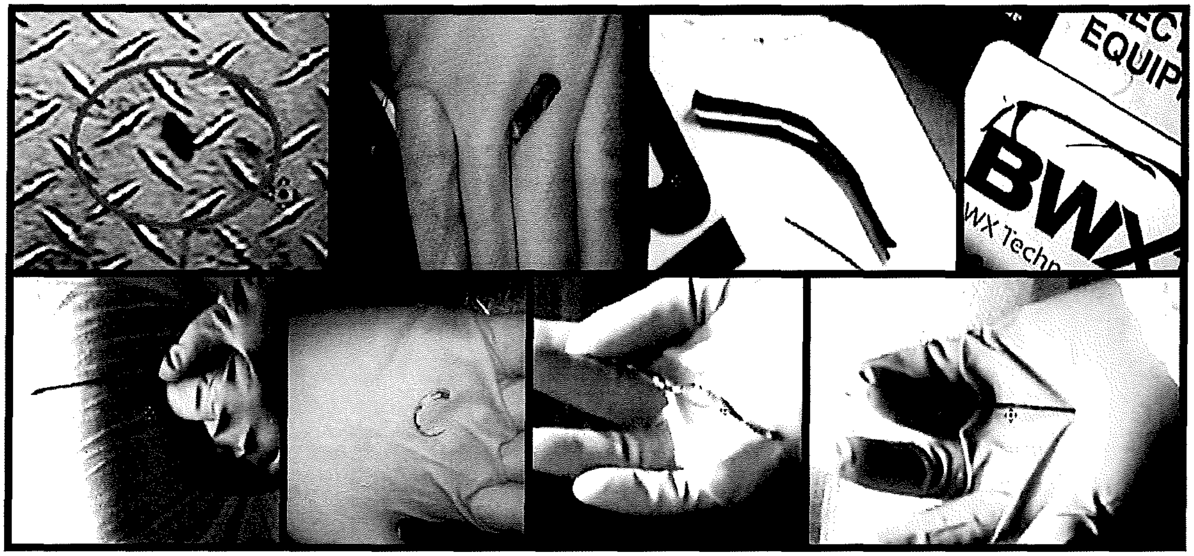
During the 2R24 examination, any new confirmed Possible Loose Part (PLPs), PLP related indications, or new FO wear indications reported by the eddy current examination were investigated by the Secondary Side Inspection (SSI) crew as far as possible and any new objects identified by SSI within the tube bundle region were tested by the +Point™ eddy current technique. When possible the FO's were removed by FOSAR. The combined examinations were coordinated through the use of the LPT database. Some of the foreign objects identified during this inspection are shown in Figure 4-1 while Figure 4-2 shows foreign objects that were removed.

Figure 4-1 – Examples of Foreign Objects



Wire Screen	Metallic Object

Figure 4-2 –Foreign Objects Retrieved



Attachment 1 and 2 contain a full listing of the historical and emergent foreign object items addressed in SG 25 and SG26, respectively, during 2R24. A wide range of cases were addressed as will be presented below.

4.2.5 Summary of Foreign Object Wear

A comprehensive program was defined for detection of foreign objects and foreign object wear. This program consisted of planned examinations for known locations, a 50% examination of the outer six rows with the +Point™ probe, a 100% bobbin coil examination, bounding examinations with +Point™, SSI of the top of tubesheet annulus and bundle periphery and FOSAR as required.

Per Table 4-1, SG 25 had one tube wear location that was newly detected with a wear depth of 23% in tube R92 C143, located approximately 11" above the hot leg tubesheet.

- A review of previous bobbin data indicates that this wear has been present in this tube since 1997; however, this was the first time that a +Point probe had been used at this location.
- One tube adjacent to this tube, R90 C143, and a tube adjacent to that tube but not adjacent to the worn tube, R89 C144, both contained PLP indications at a similar elevation to the wear indication on R92 C143, but neither tube had any indications of wear identified by +Point™ coil. A review of previous +Point™ and bobbin data in these two tubes indicates that this loose part has been present at this location since 2008.
- A review of the location by SSI confirmed the presence of the part between R90 C143 and R89 C144. However, it could not be accessed for removal.
- Since the wear indication has been present since 1997, and the nearby PLP has been present since 2008 with no movement or initiation of wear in the associated tubes, this object does not represent a threat to tube integrity over the next five cycles.

Also per Table 4-1, SG 26 had 12 previously reported foreign object wear locations with no significant change in sized depth from 2R22. SG 26 also reported three new wear locations in tubes R122 C123 (34% TW), in R124 C123 (36% TW) and in R125 C122 (23%tw). None of these locations had an indication of a foreign object and FOSAR found no part at any of these locations.

With no growth continuing in the historical foreign object wear locations and no part at the new foreign object wear locations, these tubes do not represent a threat to tube integrity over the next five cycles. The combination of the 100% bobbin coil examination of the full tube bundle, the +Point™ examination of the outer six rows of the periphery and open tube lane and the SSI examination of the tubesheet annulus and periphery, there is reasonable assurance that there are no currently existing parts within the tube bundle high flow region that could threaten tube integrity over the next five cycles.

4.2.6 Inspection Result Classification Category

The inspection results from SG 25 and SG26 were classified as category C1 per Section 3.7 of the Examination Guidelines (Ref [8.5]) with respect to fan bar wear. Specifically, there were no fan bar wear indications equal to or greater than 40 %TW and no previously reported fan bar wear indications grew more than 10%TW since the last inspection (Table 4-1). Less than 5% of the inspected tubes were degraded by fan bar wear.

Similarly, the inspection results for SG 25 and SG 26 were classified as C1 with respect to foreign object wear. Specifically, there were no foreign object wear indications equal to or greater than 40 %TW and no previously reported foreign object wear indications grew more than 10%TW since the last inspection (Table 4-1). Less than 5% of the inspected tubes were degraded by foreign object wear.

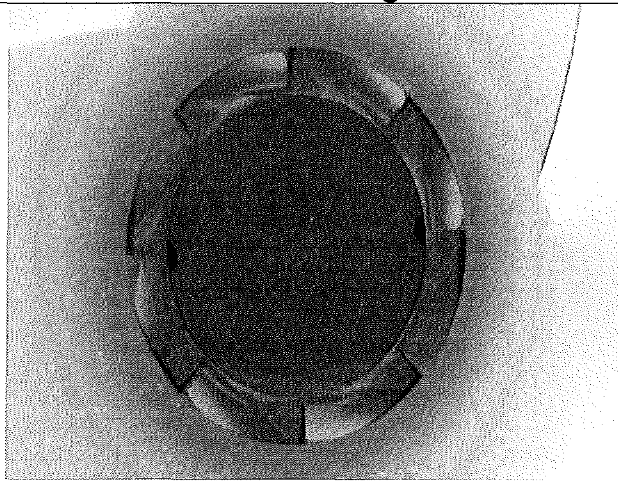
4.3 Secondary Side Inspections

Secondary side structures and material conditions must be evaluated to assess any potential impact on SG tube integrity. Any foreign objects, or degradation of internals that could produce foreign objects, are important because tube integrity could be impacted. Visual examinations were performed during this outage to develop the information needed for the evaluation. FOSAR results of potential significance to tube integrity were discussed above in Section 4.2.4. This section provides an overall summary of observations made during the secondary side examination.

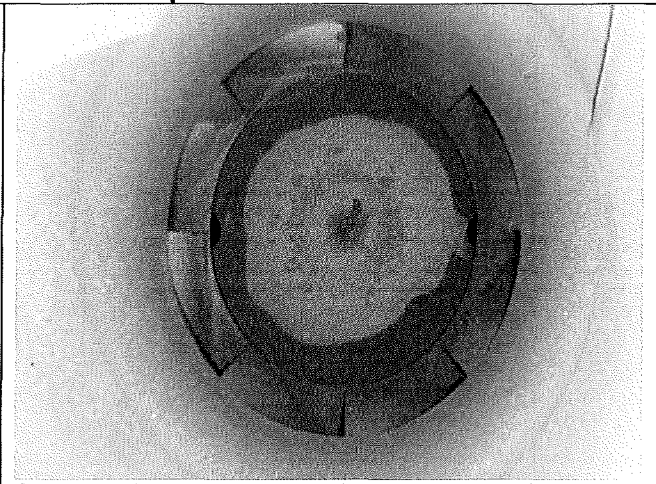
4.3.1 Steam Drum

A visual examination of steam drum components was performed in SG25 and SG26. In the areas examined, sludge accumulation was light, with a harder underlying crystalline coating of sludge noted. Due to water clarity issues following refill after DMT, visual inspection of the U-bend structures (arch bars, J-tabs and fan bars) was not possible. Sludge deposits on the primary and secondary moisture separators were light and tightly adhering. Very little deposit was removed from these surfaces when rubbed with a gloved hand. The primary separators examined were in good condition with no evidence of material degradation. The curved arm assemblies within the primary separators were inspected and found to be in good condition. The edges of the steam outlet to the assemblies were sharp, indicating no noticeable flow assisted corrosion. Evidence of early stage flow assisted corrosion of the secondary moisture separators was noted. Severe degradation of these separators can eventually lead to the introduction of loose parts that may migrate to the tube bundle. However, based on limited operational wear observed through 2R24, significant structural degradation is not expected to occur over the next five cycles of operation. This condition should be monitored during future outages.

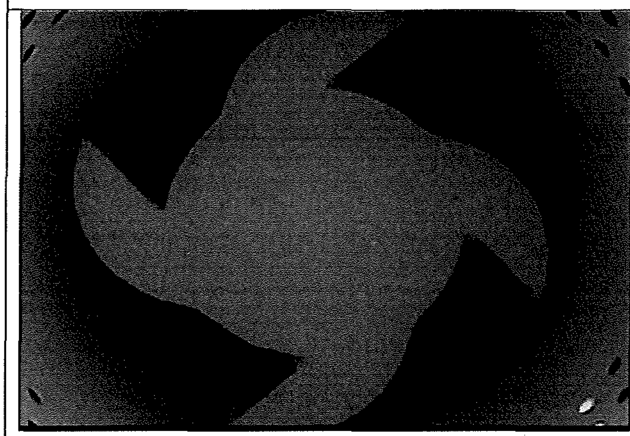
Figure 4-3 – Steam Drum Components



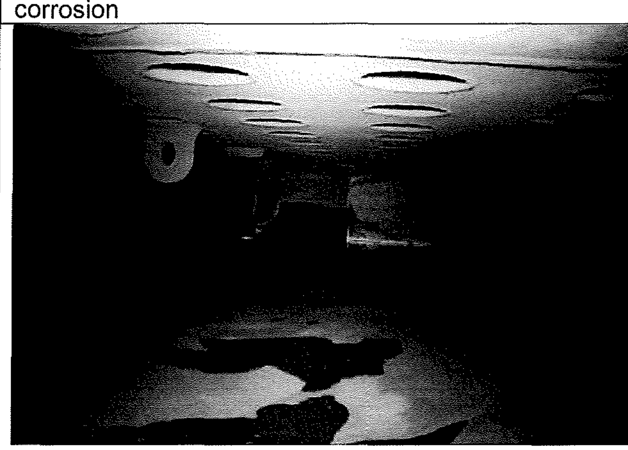
Typical separator baseplate



Separator baseplate with early stage flow assisted corrosion



Typical curved arm primary separator



Underside of primary deck

4.3.2 Top of Tubesheet Cleanliness

Post-lancing visual examinations in SG25 and SG26 identified no loose sludge in the annulus at the top of tubesheet. The no-tube lane and staywell regions were clear as well. The blowdown flow holes in the tubesheet showed no evidence of flow induced erosion. Due to the application of DMT, a total of 2608 pounds of deposit was removed from SG 25 and a total of 2584 pounds of deposit was removed from SG 26 (See Table 4-2). The 1st support lattice, shroud, and shroud support components examined were in good condition. Jacking studs showed no indication of movement between the shell and shroud. (See Figure 4-4)

Table 4-2 DMT Deposit Removal Quantities

		Fe Step	Pass Step	Cu Step	LVRs/FVR	TOTALS
SG 25	Magnetite Removed (lbs)	1442	291	213	16.1	1963
	Cu Removed (lbs)	0.6	3.3	11.6	0.7	16.2
	Lancing (lbs)					629
	Total (lbs)					2608.2
SG 26	Magnetite Removed (lbs)	1442	291	213	16.1	1963
	Cu Removed (lbs)	0.6	3.3	11.6	0.7	16.2
	Lancing (lbs)					605.5
	Total (lbs)					2584.7
	Grand Total (lbs)					5192.9

There was a light dusting of sludge noted in the annulus of both SGs. Discoloration of the outer surface of most tubes was noted. This was attributed to the application of DMT, and does not represent a deleterious condition. The no-tube lane and staywell area was clean and the blowdown flow holes showed no evidence of erosion. The 1st support lattice, shroud, and shroud support components examined were in good condition with no evidence of material degradation. Jacking studs showed no indication of movement.

4.4 Summary

Consistent with expectations documented in the DA (Ref. [8.4]), the only conditions of potential significance to SG integrity identified during the 2R24 SG examinations were secondary side foreign objects, foreign object tube wear, and fan bar tube wear. The significance of these findings with respect to the condition monitoring assessment and operational assessment are discussed in the sections that follow.

Figure 4-4 – Lower Bundle Components

Typical Top of Tubesheet | 1st Lattice Components

5. Condition Monitoring Assessment

The condition monitoring (CM) assessment is an evaluation of tube structural and leakage integrity during the operating period since the last inspection. The CM is based on current inspection results. As discussed in Section 4.0 and presented in Table 4-1, the modes of tube degradation detected were foreign object wear and fan bar wear. The sizing techniques used to determine the dimensions of the flaws listed in Table 4-1 are also identified in the table. The sizing performance of the techniques, along with the reported flaw dimensions were used to evaluate the structural integrity of the tubes.

A review of the screening guidance of Ref. [8.7] provides the basis for concluding that non-pressure accident loads are not limiting for MPS2 degradation located beyond the constraint of the tubesheet. The reference states that circumferential degradation and the circumferential component of volumetric degradation is limiting with respect to non-pressure loads and advises that non-pressure loads are not significant contributors to burst for tubes with flaws that are below the top tube support and which are less than 270° in circumferential extent, or for flaws located on the tube flanks within the u-bend (e.g., fan bar wear). All flaws identified during this outage meet this criteria and therefore it is appropriate to use the EPRI Flaw Handbook (Ref. [8.10]) methods, which consider pressure loading only, to establish the structural limits for all of the MPS2 tube degradation identified.

To perform the CM for fan bar wear and foreign object wear, the limiting degradation size must be compared with an appropriate structural integrity limit which accounts for the material property uncertainty, model uncertainties and NDE sizing uncertainties. Since the circumferential extent of all of the indications listed in Table 4-1 can be shown to be <135°, it is appropriate to use the EPRI Flaw Handbook (Ref. [8.10]) "Part-Throughwall Axial Volumetric Degradation" flaw model to evaluate the CM limit. Using this model as implemented by the EPRI FHC (Ref. [8.10]), CM limit curves were developed in the Degradation Assessment [8.4] for each flaw type and sizing ETSS.

Figures 5-1 through 5-4 provide the CM limit curves for flaws sized with ETSSs 96004.3, 27901.1, 27902.1, and 27903.1 respectively. The CM curves represent the structural performance criteria derived by conservatively accounting for material property uncertainties, model uncertainties, and NDE depth sizing uncertainties. The uncertainties were combined using Monte Carlo techniques as described in Ref. [8.7].

The figures also display the length and depth of each flaw. Because each flaw plotted in Figures 5-1 through 5-4 lies below the CM limit curve, it is concluded that the structural performance criteria set forth in the MPS2 Technical Specifications was not exceeded by any of the evaluated flaws. This also provides reasonable assurance that none of these flaws would have leaked under accident conditions.

No primary-to-secondary SG tube leakage was reported during the previous operating period; therefore, the operational leakage performance criteria was not exceeded during the operating period preceding this outage.

5.1 Condition Monitoring Conclusion

Based upon the evaluations documented in this report, all degradation identified during the 2R24 inspection satisfied condition monitoring requirements for SG tube structural and leakage integrity. Further, the conditions observed during 2R24 also serve to validate the conclusions of all previous outage operational assessments with respect to projected compliance with technical specification SG performance criteria. Specifically, the 2R24 findings are consistent with the assumptions, expectations, and projections documented in previous operational assessments.

Figure 5-1

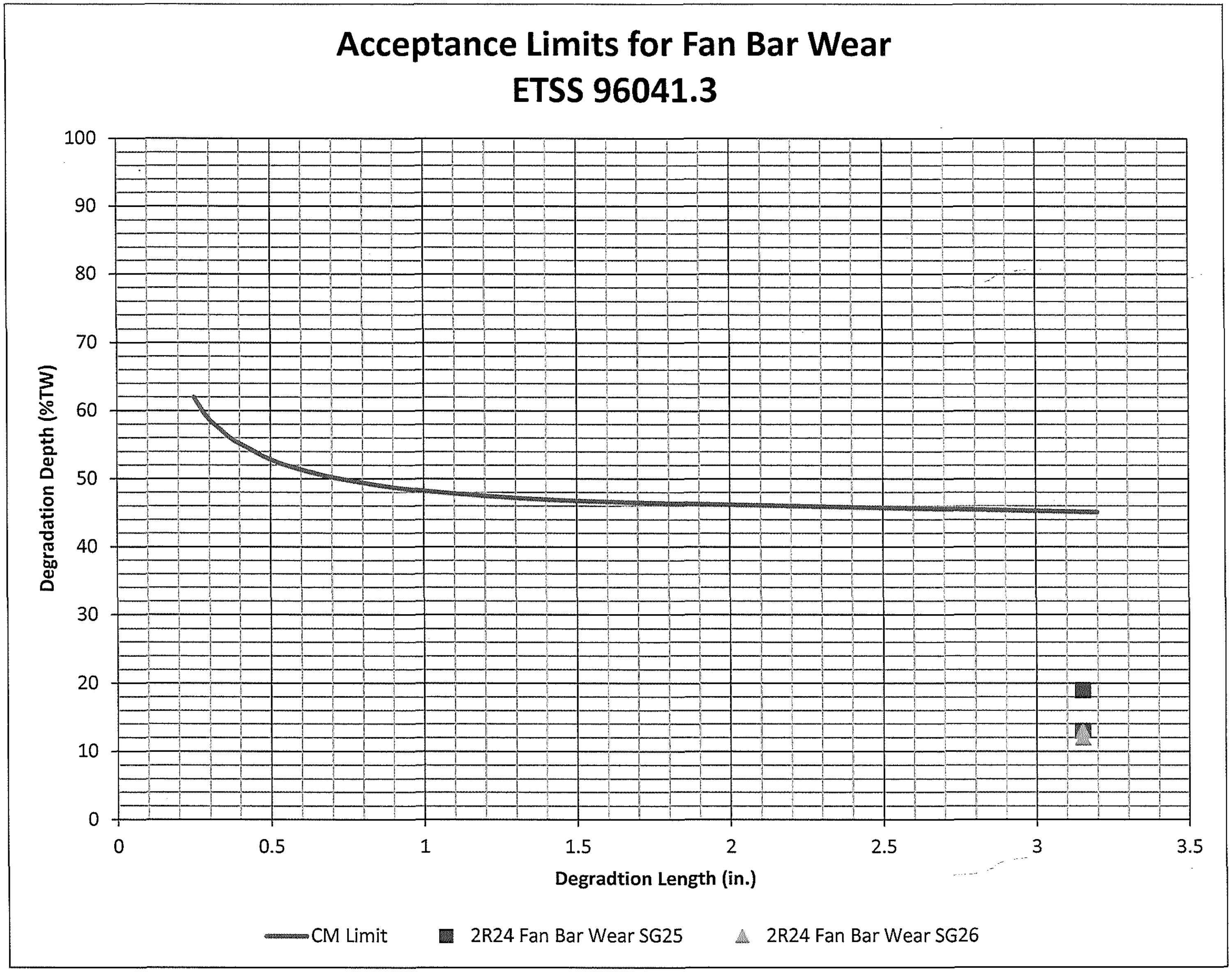

Acceptance Limits for Fan Bar Wear
ETSS 96041.3
Degradation Depth (%TW)
100
90
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
3.5
Degradtion Length (in.)
CM Limit
2R24 Fan Bar Wear SG25
2R24 Fan Bar Wear SG26

Figure 5-2

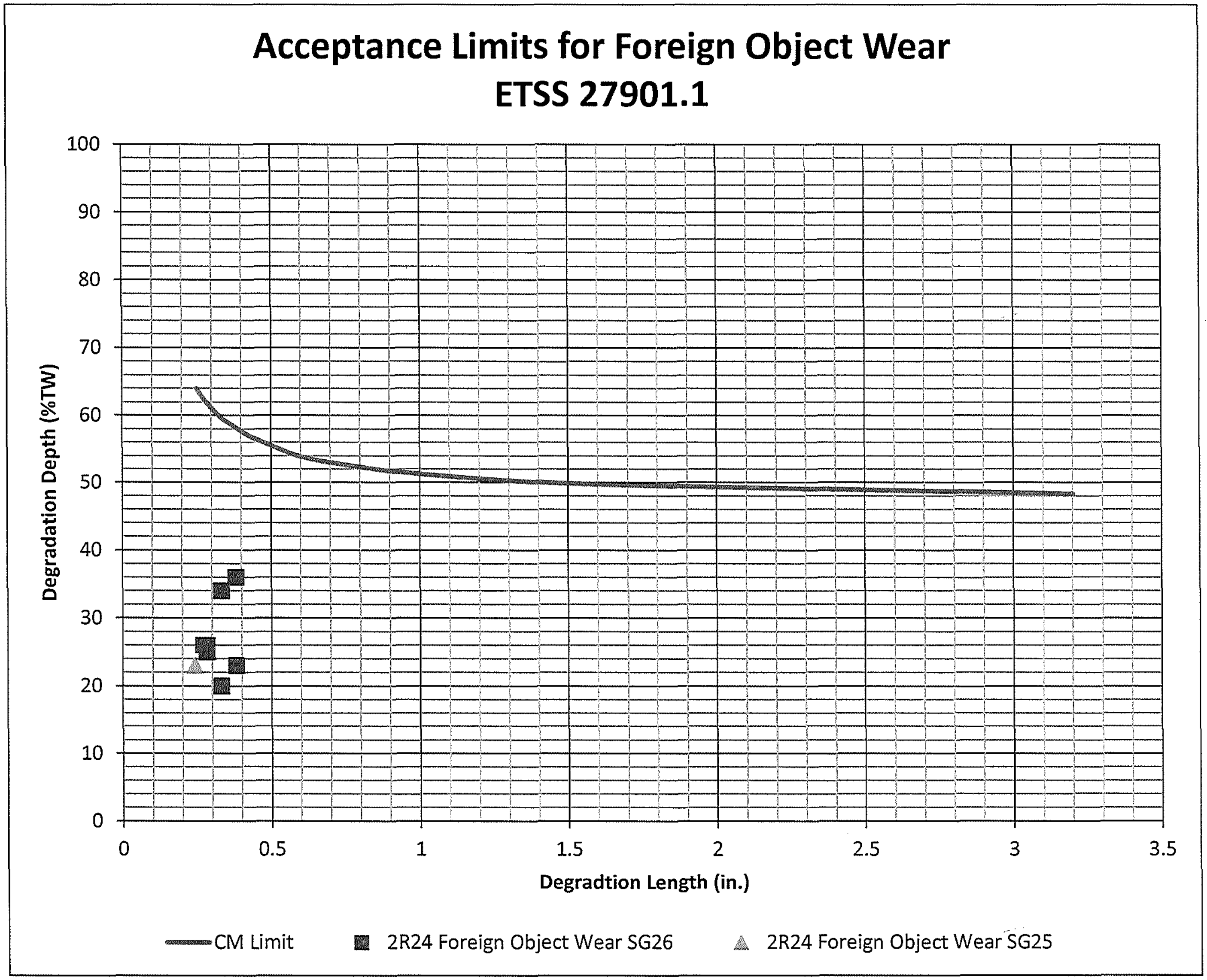

Acceptance Limits for Foreign Object Wear
ETSS 27901.1
100
90
80
70
60
50
40
30
20
10
0
Degradation Depth (%TW)
0
0.5
1
1.5
2
2.5
3
3.5
Degradtion Length (in.)
CM Limit
2R24 Foreign Object Wear SG26
2R24 Foreign Object Wear SG25

Figure 5-3

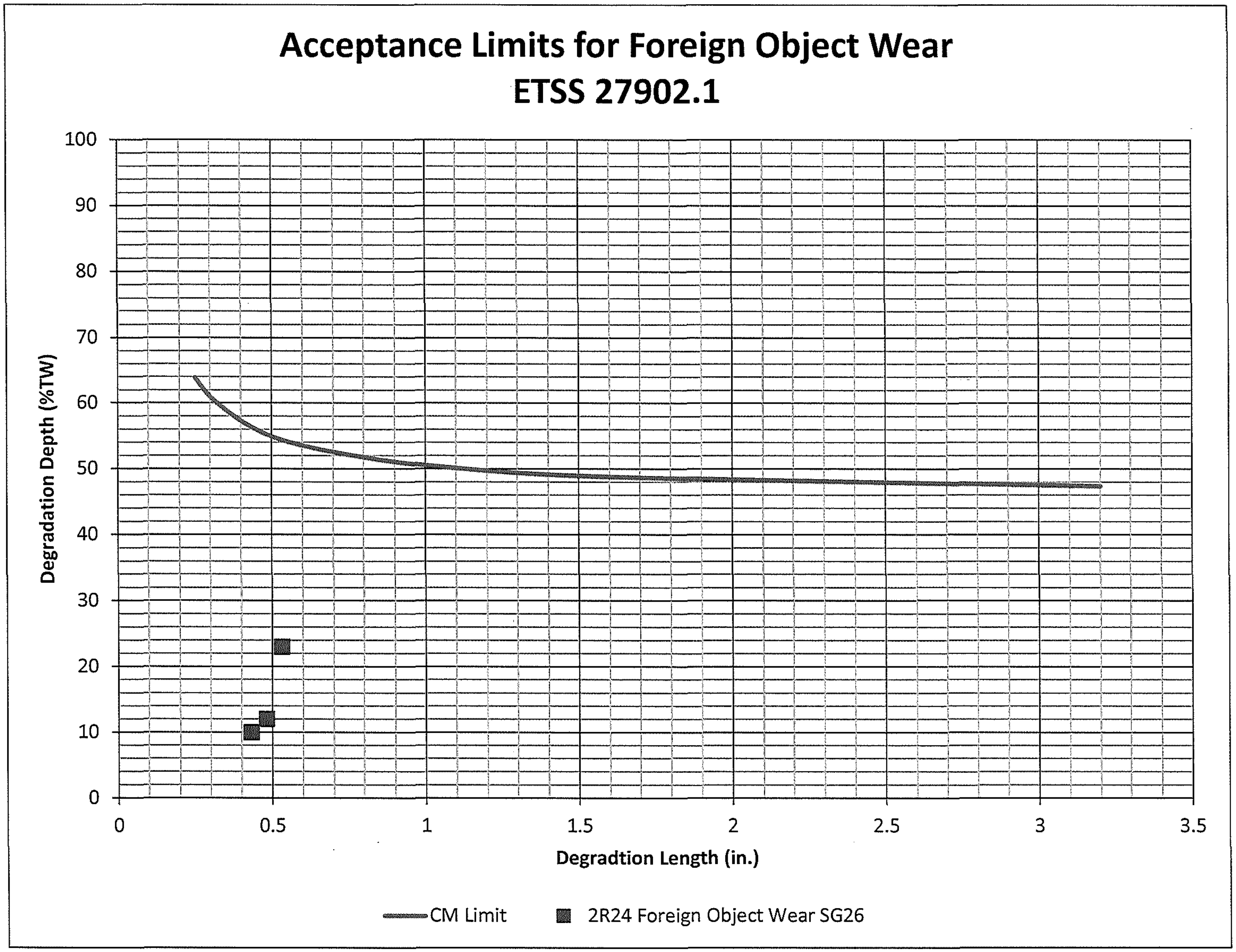
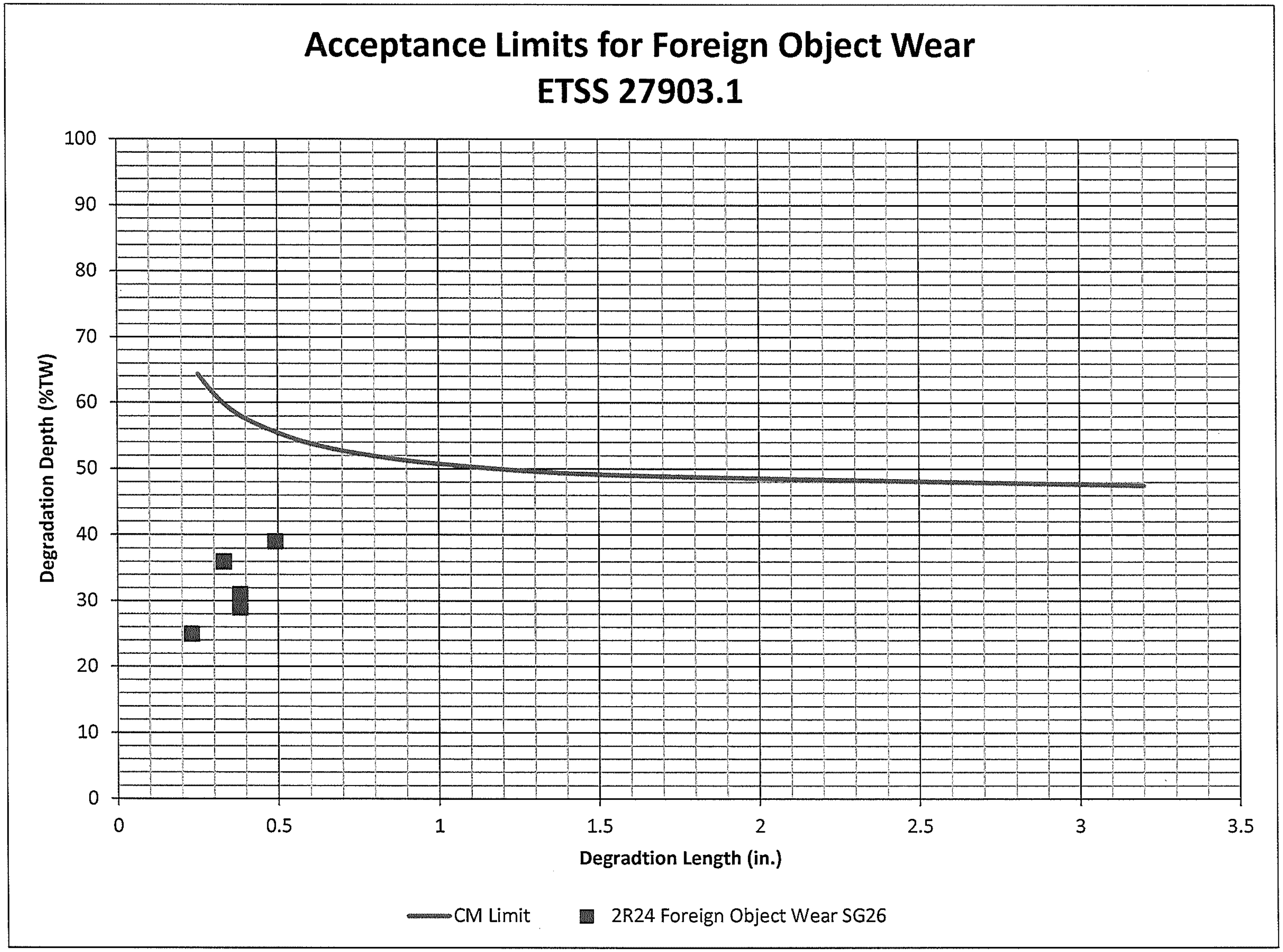

Acceptance Limits for Foreign Object Wear
ETSS 27902.1
100
90
80
70
60
50
40
30
20
10
0
Degradation Depth (%TW)
0
0.5
1
1.5
2
2.5
3
3.5
Degradtion Length (in.)
CM Limit
2R24 Foreign Object Wear SG26

Figure 5-4


Acceptance Limits for Foreign Object Wear
ETSS 27903.1
100
90
80
70
60
50
40
30
20
10
0
Degradation Depth (%TW)
0
0.5
1
1.5
2
2.5
3
3.5
Degradtion Length (in.)
CM Limit
2R24 Foreign Object Wear SG26

6. Operational Assessment

The operational assessment (OA) must demonstrate that the structural integrity performance criteria will not be exceeded prior to the next scheduled examination in either of the Millstone Unit 2 SGs. The MPS2 technical specifications limit the period between inspections to a maximum of three fuel cycles for an individual SG. Hence, this amended OA supplemented with the LAR evaluates the limiting operating interval (i.e., five fuel cycles) for both SGs based upon the current outage primary and secondary side inspection results. Per Table D-1 of the Degradation Assessment [8.4], the expected operating interval between 2R24 and 2R29 will be 78 EFPM or 6.5 EFPY. For this analysis, the five-cycle inspection interval will be conservatively assumed to be 7.0 EFPY.

Given the superior resistance of the A690TT tube material to corrosion and anticipated continued diligence in chemistry monitoring and control, there is minimal near term threat of corrosion initiation. Consistent with Ref. [8.7], this operational assessment addresses degradation mechanisms known to exist in the MPS2 steam generators including fan bar wear and foreign object wear, as well as relevant potential degradation mechanisms such as lattice support wear, tube-to-tube wear, and thinning.

The first two subsections below assess future fan bar wear and foreign object wear against the structural performance criteria. The third subsection assesses future compliance with accident induced and operational leakage performance criteria and the fourth subsection considers secondary side internals degradation.

6.1 Fan Bar Wear

For the purposes of this OA, future fan bar wear can be grouped into two categories:

- Wear that currently exists in in-service tubes, whether detected during 2R24 or not
- Wear which will initiate during the next five fuel cycles.

Because wear which has already initiated will continue to grow, it is assumed to be more limiting in the future than wear which has not yet initiated. This evaluation will focus on wear flaws that have already initiated. This requires consideration of NDE sizing uncertainty, NDE probability of detection (POD), and the rate of future wear flaw growth.

6.1.1 Beginning of Cycle (BOC) Fan Bar Wear Depth

The beginning of cycle fan bar wear depth is an upper bound estimate of the depth of wear left in-service prior to the next operating interval. This value accounts for the fact that NDE techniques have an imperfect probability of detection, and must account for known flaws left in service following the tube inspection. Consistent with Ref. [8.7], Table 8-1, the most limiting BOC fan bar wear depth to be used in this analysis will be the largest flaw left in service. In the technique qualification program (ETSS 96041.3) all flaws ranging in depth from 4 %TW to 90 %TW were detected. Due to the high POD for fan bar wear detection, undetected flaws are not an issue for structural integrity.

The deepest fan bar wear indication returned to service measured 19%TW with a bobbin probe. As shown in Table A-1 of the Degradation Assessment [8.4], the NDE (Non-Destructive Examination) sizing parameters for the bobbin technique (ETSS 96041.3) are a slope of 0.99 and an intercept of 2.73%TW. Using the slope and intercept, a best estimate real depth of 21.5%TW (19 x 0.99 + 2.73) is obtained for an indication with a measured depth of 19%TW.

A standard error of 3.36% TW is the uncertainty associated with this technique. Further adjusting this value upward to an upper 95th percentile gives an NDE uncertainty of 5.53% TW (3.36 x 1.645). Adding this uncertainty to the best estimate value of 21.5% TW yields a bounding real depth of 27% TW (21.5 + 5.5) for indications returned to service.

6.1.2 Fan Bar Wear Growth

Table 6.1 below provides wall loss measurement data for each MPS2 SG tube exhibiting structural wear to date.

Table 6.1: SG Tube Wall Loss Measurement Data

			Percent Through Wall Each Outage						
Row	Column	S/G	2R14	2R15	2R16	2R18	2R20	2R22	2R23	2R24
40	155	1	9		9	11	11		12	13
140	93	1	9		9	12	12		14	19
37	120	2		6		9	9	8		12
99	80	2		11		11	15	15		13

Only four tubes, (two in each SG), have any recorded wear at support structures and all four wear indications are minor fan bar wear. No wear has been detected at the lattice grid support. Fan bar wear was first detected in SG25 during 2R14 (March 2002) and in SG26 during 2R15 (October 2003).

Apparent growth rates of indications without prior detection could represent a detection issue and not a growth rate issue. In other words, these indications could have existed during previous examinations at degradation depths below detectability or the reporting threshold, making growth rate estimates erroneously high. Additionally, the sample of tubes exhibiting fan bar wear is too small to be statistically significant. Short cycle lengths can generate large NDE measured growth rates, simply because actual growth rates are small in comparison to the NDE sizing variability. Table 6.1 above provides wall loss measurement data for each MPS2 SG tube exhibiting structure wear to date.

In some instances, the effects of NDE sizing variability is evidenced by the apparent negative growth rates. Therefore, it is more reliable to establish growth rates by trending the progression of the degradation over multiple inspections.

A summary of the growth rates for fan bar wear is provided in Table 6.2. The highest average growth rate observed between the two MPS2 SGs over the time from first detection to the most recent inspection was 0.74% TW/EFPY. While the inspection results of the MPS2 SGs support the use of a 0.74% TW/EFPY growth rate value, the following evaluation of the 2R24 CMOA will assume 3% TW/EFPY. This wear rate is conservative and easily bounds the wear observed in the small sample of tubes that exhibit fan bar wear.

Table 6.2 – Fan Bar Wear Growth Rates

SG	Row	Col	Location	Maximum Depth 2R24	Size When First Detected	Average Growth Rate Since Detection
1	40	155	F06	13% TW	9% TW (2002)	0.30% per EFPY
1	140	93	F08	19% TW	9% TW (2002)	0.74% per EFPY
2	37	120	F07	12% TW	6% TW (2003)	0.50% per EFPY
2	99	80	F06	13% TW	11% TW (2003)	0.17% per EFPY

MPS2 utilizes an 18-month operating cycle. A 96-month operating interval will result in a maximum of four outages without SG examinations being performed (i.e. an inspection every fifth refueling outage). MPS2 has averaged 1.371 EFPY per operating cycle. Conservatively assuming 1.4 EFPY per operating cycle and applying a growth rate of 3.0% TW/EFPY over a five-cycle bounding inspection interval of seven EFPY, gives a total growth of 21.0% TW (3.0% x 7 EFPY) until the next planned inspection. Further applying this total growth to the bounding depth of 27% TW gives a projected 2R29 depth of 48% TW (27 + 21.0) for indications detected and returned to service during the 2R24 outage.

The allowable real depth Structural Limit (SL) for fan bar wear with a bounding length of 3.20" is 50.2% TW as shown in the ETSS 96041.3 OD Axial Thinning Evaluation found in Appendix C of the 2R24 DA (Reference 8.6). The projected real depth of 48.0 % TW was calculated with various conservatisms (as described above), and is within the allowable real depth of 50.2% TW; therefore, there is reasonable assurance that the structural integrity, operational leakage, or accident induced leakage performance criterion will be met for this mechanism for the five cycles of operation (at which time, another inspection and OA will be performed).

6.2 Foreign Object Wear

Foreign object wear is the primary degradation mechanism of concern at Millstone Unit 2 based on previous plugging history. Although several new foreign object wear indications were reported during the 2R24 outage, many foreign objects were visually confirmed and removed. Many of these foreign objects were in locations where tube degradation is possible.

The 2R24 inspection scope for foreign objects and associated wear was extensive and included both visual and eddy current inspections. Visual inspections included both the annulus and no-tube lane at the top of the tubesheet in both steam generators. These visual inspections included looks into the tube bundle at all peripheral and no-tube lane locations. The eddy current examinations included full length bobbin probe examinations of all tubes, 50% rotating probe examinations of an approximate six tube deep periphery at the top of tubesheet (+/- 3 in) in both legs, and bounding rotating probe examinations of potential foreign object associated indications. All evidence of foreign objects and foreign object wear was tracked and evaluated in the BWXT Loose Parts Tracker (LPT), and objects were retrieved where possible. Tubes adjacent to irretrievable foreign objects with a potential to cause tube wear have been stabilized and plugged during past outages. Migration of those foreign objects that remain is unlikely due to the tri-pitch design of the steam generator tubing and is evidenced by noting past examination history which indicates no apparent change in location following initial detection (except for FO movement that is attributed to waterlancing, which would not be performed without an associated primary side inspection). Consequently, no foreign objects capable of causing tube degradation are known to remain adjacent to in-service tubes. This aggressive ECT and FOSAR campaign has significantly reduced the potential for future foreign object wear. With these extensive inspections and subsequent part removal, there is reasonable confidence that no parts capable of causing significant tube degradation remain in the tube bundle.

Despite the extensive inspections and removal of multiple parts, the OA still has to consider the potential for tube degradation from parts remaining in the bundle or potentially entering the bundle during the next inspection interval. For the purposes of the OA, the discussion of foreign objects and associated wear will be segregated into the following categories:

1) foreign object wear without evidence of a part present,
2) eddy current PLPs (Potential Loose Parts) without wear,
3) foreign objects known to have remained in the steam generators, and
4) foreign objects that may enter the steam generators.

As discussed previously, the SG work activities performed during this refueling outage included secondary side visual inspections of the steam drum and upper tube bundle in SG25 and SG26. These examinations identified no foreign objects, or any conditions which could credibly generate foreign objects, capable of impacting tube integrity.

Based upon the following discussions, there is reasonable assurance that operation of SG25 and SG26 for five cycles will not generate foreign object wear flaws which exceed the structural integrity, operational leakage, or accident induced leakage performance criteria.

6.2.1 Foreign Object Wear with No Part Present

The four new foreign object (FO) wear indications (maximum depth 36 %TW) identified during 2R24 were confirmed to have no foreign object remaining in the vicinity. A summary of the growth rates for new foreign object wear indications is provided in Table 6.3. Without the objects in-place continued degradation is not possible. Consequently, none of the new flaws in in-service tubes pose a future tube integrity threat.

Table 6.3 New Foreign Object Wear

SG	Row	Col	Location	ETSS	Maximum Depth 2R24	Depth Reported Prior Outage	Cause	Delta EFPY
26	122	123	TSH + 2.53"	27901.1	34% TW	NDD 2R22	Foreign Object Wear	2.74
26	124	123	TSH + 1.77"	27901.1	36% TW	NDD 2R22	Foreign Object Wear	2.74
26	125	122	TSH + 1.36"	27902.1	23% TW	NDD 2R22	Foreign Object Wear	2.74
25	92	143	TSH + 10.91"	27901.1	23% TW	NDD 2R23	Foreign Object Wear	1.375

The OA must also consider the growth of foreign object wear indications identified and left in service. Historical foreign object wear indications where the foreign objects had been previously removed were re-sized during 2R24 and were left in service. All of these historical indications are in SG 26. A summary of the growth rates for historical foreign object wear indications is provided in Table 6.4. Some variation in sizing can be expected from one inspection to the next. As expected, these indications exhibited virtually no growth as compared with previous outage sizing and considering technique sizing variability and uncertainty.

Table 6.4 Historical Foreign Object Wear Indications

SG	Row	Col	Location	ETSS	Maximum Depth 2R24	Depth Reported Prior Outage	Cause	Delta %TW Growth	Delta EFPY	%TW Growth per EFPY
26	28	5	TSC + 21.65"	27901.1	25% TW	27% TW 2R22	Foreign Object Wear	-2	2.74	-0.7
26	29	4	TSC + 22.2"	27901.1	26% TW	25% TW 2R22	Foreign Object Wear	1	2.74	0.4
26	44	5	TSC + 17.91"	27902.1	10% TW	11% TW 2R22	Foreign Object Wear	-1	2.74	-0.4
26	59	10	TSC + 17.33"	27901.1	23% TW	24% TW 2R22	Foreign Object Wear	-1	2.74	-0.4
26	98	143	TSH + 8.76"	27901.1	20% TW	20% TW 2R22	Foreign Object Wear	0	2.74	0
26	118	41	TSH + 12.81"	27902.1	12% TW	12%TW 2R22	Foreign Object Wear	0	2.74	0
26	119	42	TSH + 12.97"	27903.1	29% TW	24% TW 2R22	Foreign Object Wear	5	2.74	1.8
26	123	46	TSH + 18.15"	27903.1	25% TW	22% TW 2R22	Foreign Object Wear	3	2.74	1.1
26	124	45	TSH + 19.27"	27903.1	31% TW	26% TW 2R22	Foreign Object Wear	5	2.74	1.8
26	125	48	TSH + 19.53"	27903.1	36% TW	32% TW 2R22	Foreign Object Wear	4	2.74	1.5
26	126	49	TSH + 19.97"	27903.1	39% TW	34% TW 2R22	Foreign Object Wear	5	2.74	1.8
26	128	107	TSH + 0.06"	27901.1	26% TW	29% TW 2R22	Foreign Object Wear	-3	2.74	-1.1

6.2.2 Eddy Current PLPs without Wear

Thirty-two (32) cases of eddy current PLPs without wear were reported during the 2R24 inspections. Some of the PLPs were newly reported while others had been reported in previous outages. For some of the newly reported PLPs, reviews of the previous eddy current results showed that the suspected part was present in a previous outage(s), but was not reported. The eddy current PLPs with history (either previously reported or previously present based on lookup) were deemed acceptable based on their presence over multiple cycles without causing any detectable wear and will continue to be monitored during future SG inspections. Some of the PLP locations near the periphery of the bundle were visually inspected. Locations with no visual evidence of a part were considered acceptable based on the confirmed absence of a part. All PLP indications were further dispositioned as either PLM (monitor), PLR (part removed), or PLS (signal with no part observed). Based on these analyses, all eddy current PLP locations were acceptable for the next five cycles of operation.

6.2.3 Foreign Object Wear from Parts Remaining in the Steam Generators

Tables 2-8 and 2-9 of the Degradation Assessment [8.4] identified known parts remaining in SG25 and SG26 respectively. During 2R24, these locations were re-examined using eddy current and/or visual inspections to confirm that the part was still present and that no wear was caused by these parts. Each of these parts have been monitored for at least four cycles of operation with no noted changes in tube wear. It is reasonable to expect similar results following five operating cycles before the next steam generator inspection campaign. Parts newly identified during the 2R24 steam generator inspection campaign remaining in SG25 and SG26 had no associated tube wear noted and have all been dispositioned as presenting no risk to tube degradation. Attachments 1 and 2 of this document summarize the results of those inspections which show there is reasonable assurance that operation of SG25 and SG26 for five operating cycles with these parts remaining will not generate foreign object wear flaws which exceed the structural integrity, operational leakage, or accident induced leakage performance criteria.

6.2.4 Foreign Objects That May Enter the Steam Generators

No foreign objects capable of causing tube degradation were known to remain in the MPS2 steam generators following the 2R24 inspection activities. Based on the discussion presented in section 6.2.1 above, there is evidence to conclude that continued wear at tube locations where foreign objects have been removed is not credible.

Foreign objects may enter the steam generator tube bundle at any time during an operating cycle and cause wear on the tubes. Dominion Energy performs eddy current and visual inspections to identify objects and retrieve them; however, this cannot preclude foreign object events. Industry operating experience proves that wear from foreign objects initially leads to low level leakage. The MPS2 primary-to-secondary leakage monitoring program implemented is capable of identifying leakage at very low levels. If such leakage is identified, MPS2 TSs and procedures require a unit shutdown when necessary to avoid the potential of tube rupture or exceeding the leakage performance criteria.

Historical findings and current FOSAR and eddy current examinations provide reasonable assurance that operation until the next planned inspection will not generate foreign object wear that exceeds the SG structural integrity performance criteria (SIPC). In the unlikely event that significant degradation does occur, primary to secondary leakage monitoring procedures in place at MPS2 provide a high degree of confidence of safe unit shutdown without challenging the SIPC or leakage performance criteria.

6.3 Potential Degradation Mechanisms

DAs have been performed per the SG Program described in MPS2 TS 6.26. As previously noted, there have been only two degradation mechanisms detected in the MPS2 SGs, (i.e., wear at the tube bundle U-bend support structures or fan bar and wear caused by foreign objects).

Two additional degradation mechanisms are considered to have the potential to occur in the future. These degradation mechanisms are lattice support wear and tube-to-tube wear. Tube thinning adjacent to support structures was also identified as a degradation mechanism with a low likelihood of initiation and progression.

6.3.1 Lattice Support Wear

Tube wear has been detected on other B&W replacement steam generators at the lattice support structures. However, no tube wear has been detected as lattice support wear at MPS2 in nearly 30 years of operation and is unlikely to initiate and rapidly progress to an unacceptable depth during the interval between inspections.

6.3.2 Tube-to-Tube Wear

Tube-to-tube wear has been reported at Palisades Nuclear Plant, both units at the San Onofre Nuclear Generating Station (SONGS), and several of the replacement Once Through Steam Generators (OTSGs). Although the OTSG experience is not relevant to MPS2 due to the different design, the Palisades and SONGS experiences have potential applicability to MPS2. The tube-to-tube wear reported at Palisades is believed to be related to tubes having less than the nominal gap from one tube to the other. The SONGS experience was caused by fluid elastic instability in the U-bend region. However, neither of these conditions are known to exist in MPS2 SGs and no tube-to-tube wear has been detected at MPS2.

6.3.3 Thinning

Thinning is a general term used to describe two different SG damage mechanisms. The first is a wastage mechanism resulting from the use of phosphate-based secondary chemistry controls. This mechanism has not been observed in plants that do not use phosphate chemistry (such as MPS2) and is therefore not a threat to the MPS2 SGs. The other is a type of thinning observed in Westinghouse Model 51 SGs caused by acid-sulfate crevice conditions within cold leg deposits. Under modern chemistry control regimes, this mechanism is unlikely to develop because sulfate limits are very low and resulting crevice pH is typically not acidic.

The other mechanisms evaluated in previous DAs were concluded to have a very low likelihood of initiation and progression.

Based upon the following discussions, there is reasonable assurance that operation of SG25 and SG26 for five cycles will not generate any potential degradation mechanisms which would exceed the structural integrity, operational leakage, or accident induced leakage performance criteria.

6.4 Leakage Performance Criteria

No tube leakage was reported during the previous operating cycle. As discussed above, no degradation is expected to exceed SG tube structural integrity limits during the next inspection interval in either SG25 or SG26. Further, no degradation of the type, that can result in throughwall penetration while still meeting structural integrity limits (i.e., cracking), is expected. As a result, there is reasonable assurance that the accident induced leakage performance criteria and operational leakage performance criteria will not be exceeded during the operating period prior to the next SG tube inspection in either of the MPS2 SGs.

6.5 Secondary Side Internals Degradation

No degradation of secondary side internals which could impact tube integrity prior to the next examination was identified during the 2R24 SG secondary side inspections. There were no reported difficulties during the insertion of sludge lance equipment into the secondary side handholes. Therefore, it can be concluded that wrapper drop has not occurred. The eddy current examination performed during 2R24 revealed no indication of missing support structures. The absence of secondary side structural degradation provides a high level of confidence that tube degradation caused by secondary support deterioration will not occur in any of the steam generators prior to the next inspection in each SG. A visual examination of internal components in SG25 and SG26 in the upper bundle and steam drum revealed no degradation and none is expected for the foreseeable future. Consequently, there is no expected degradation mechanism of secondary side components that could threaten tube integrity prior to the next inspection. These findings support an interval of five operating cycles before the next SG secondary side inspection.

6.6 Operational Assessment Conclusion

Based upon the evaluations above, there is reasonable assurance that the structural and leakage performance criteria will not be exceeded prior to the next planned inspection in either of the MPS2 SGs; supporting an inspection interval of five operating cycles until 2R29.

7. Conclusions

As indicated by the results of the current outage primary side and secondary side examinations, the Millstone Unit 2 steam generators continue to satisfy the structural and leakage integrity requirements delineated in the Dominion Energy SG Program and MPS2 technical specifications. Specifically, no degradation exceeding the performance criteria was identified during this or any previous MPS2 SG inspection.

This evaluation has demonstrated that there is reasonable assurance that operation of the MPS2 SGs for up to five fuel cycles between inspections will not cause the structural or leakage integrity performance criteria to be exceeded. In addition, the absence of conditions which challenge the SG program performance criteria validates prior outage operational assessment assumptions and conclusions regarding structural and leakage integrity.

8.0 References

8.1 Dominion Fleet Administrative Procedure, "Steam Generator Program," ER-AP-SGP-101, Revision 11

8.2 Dominion Fleet Administrative Procedure, "Steam Generator Condition Monitoring and Operational Assessments," ER-AP-SGP-103, Revision 6

8.3 NEI, "Steam Generator Program Guidelines," NEI 97-06, Rev. 3, January 2011

8.4 Dominion Engineering Technical Evaluation ETE-MP-2017-1015, "Millstone Unit 2 Steam Generator Integrity Degradation Assessment (2R24)", Revision 0, 2/23/2017

8.5 EPRI, "Pressurized Water Reactor Steam Generator Examination Guidelines: Revision 7," 1013706, October 2007

8.6 Unit 2 Steam Generator Eddy Current Data Analysis Reference Manual U2-24-SIP-REF01, Revision 8, April 2017

8.7 EPRI, "Steam Generator Integrity Assessment Guidelines: Revision 3," 1019038, November, 2009

8.8 EPRI, "Steam Generator Integrity Assessment Guidelines: Revision 4," 3002007571, June 2016

8.9 EPRI, "Interim Guidance Regarding Steam Generator Integrity Assessment Guidelines, Revision 3", SGMP-IG-09-03, November 2009

8.10 EPRI, "SGMP: SG Degradation Specific Management Flaw Handbook, Revision 2," 3002005426, October 2015

8.11 EPRI Software, "Steam Generator Management Program: Flaw Handbook Calculator (SGFHC) for Excel 2010 v1.0", 3002003048, June 2014

ATTACHMENT 1 LPT SG25

SG25 PLP / Foreign Objects Detected in 2R24

Ref ID	Description	Affected Tube Locations	ECT Results	History/ Change?	2R24 Results/Disposition
2521	Newly Detected Metal Screen	R30 C97 R31 C98 R32 C97 TSC + 0"	No PLP or wear on bounding tubes	Newly detected, but likely present in system previously	ECT: No PLP or wear in bounding tubes SSI: Part could not be removed Part dispositioned to remain in the SG based on previous engineering assessment of metal screen
2522	Historical Weld Slag (2R20 FK7)	R41 C160 R42 C159 R40 C159 R43 C158 R41 C158 R44 C157 R42 C157 TSH +1"	PLP No Wear	Location unchanged since 2R16	ECT: PLPs detected with no wear SSI: Part confirmed to be in same location
2523	Historical Weld Slag (2R20 FK1)	R24 C101 R23 C102 R24 C103 R25 C102 TSC +0"	PLP No Wear	Location unchanged since 2R14	ECT: PLPs detected in four tubes with no wear SSI: Part confirmed to be in same location
2524	Historical Weld Slag (2R20 FK48)	R119 C66 R121 C66 R120 C67 TSC +0"	Tubes plugged in 2R20	Location unchanged since 2R20	ECT: No PLP or wear in bounding tubes SSI: Part confirmed to be in same location
2525	Historical Weld Slag (2R20 FK21)	R78 C141 R76 C141 R77 C142 TSC +0"	Tubes plugged in 2R18	Location unchanged since 2R18	ECT: No PLP or wear in bounding tubes SSI: Part confirmed to be in same location

Ref ID	Description	Affected Tube Locations	ECT Results	History/ Change?	2R24 Results/Disposition
2526	Rectangular Metallic Object (2R20 FK26)	R92 C27 R94 C27 TSH + 0"	PLP No Wear	Newly detected, but likely present in system previously	ECT: PLPs detected with no wear SSI: Part removed
2527	Machine Shaving	R109 C40 R110 C41 R111 C40	PLP No Wear	Newly detected	ECT: PLPs detected with no wear SSI: Part removed
2528	Historical Metallic Object	R89 C144 R90 C143	PLP Wear on adjacent tube	PLPs newly detected, but present in history back to 2008 WAR newly detected, but present back to 1997	ECT: PLPs detected with no wear SSI: Part could not be removed Part dispositioned to remain in the SG based on history back to 2008 with no change
-	ECT PLP (2R20 FK26)	R36 C5 R42 C5 R44 C5 01H +2"	PLP No Wear	Detected in 2R20	ECT: PLP with no wear; characterized as weld splatter conforming to tube surface SSI: Location not accessible
-	ECT PLP (2R20 FK30)	R122 C43 R121 C42 01H +2"	PLP No Wear	Detected in 2R20	ECT: INRs reported in same location as previous PLPs with no wear; previously characterized as weld splatter conforming to tube surface SSI: Location not accessible

Note: ET inspections were performed following first FOSAR campaign.

ATTACHMENT 2 LPT SG26

SG26 PLP / Foreign Objects Detected in 2R24

Ref ID	Description	Affected Tube Locations	ECT Results	History/ Change?	2R24 Results/Disposition
261	Flexitallic Gasket	R32 C5 R33 C4 TSH +1"	No PLP or wear on bounding tubes	Newly detected	ECT: No PLP or wear in affected and bounding tubes SSI: Part removed.
262	Flexitallic Gasket	R82 C19 R83 C18 R83 C20 R84 C19 R85 C20 TSH +0"	No PLP or wear on bounding tubes	Newly detected	ECT: No PLP or wear in affected and bounding tubes SSI: Part removed.
263	Flexitallic Gasket	R121 C114 R122 C113 R122 C115 R123 C112 R123 C114 R124 C111 R124 C113 R125 C112 TSH +1"	No PLP or wear on bounding tubes	Newly detected	ECT: No PLP or wear in affected and bounding tubes SSI: Part removed.

Ref ID	Description	Affected Tube Locations	ECT Results	History/ Change?	2R24 Results/Disposition
264	Wire	R135 C104 R136 C103 R136 C105 R137 C104 TSH +0"	No PLP or wear on bounding tubes	Newly detected	ECT: No PLP or wear in affected and bounding tubes. SSI: Part removed.
265	Flexitallic Gasket	R125 C98 R126 C97 R127 C98 R128 C97 TSH +0"	No PLP or wear on bounding tubes	Newly detected	ECT: No PLP or wear in affected and bounding tubes SSI: Part removed.
266	Rust slag	R138 C99 (in annulus) TSH +0"	No PLP or wear on bounding tubes	Newly detected	ECT: No PLP or wear in affected and bounding tubes SSI: Part removed.
267	Sludge Rock or Scale	R19 C104 R20 C103 R21 C104 TSH +1"	No PLP or wear on bounding tubes	Newly detected	ECT: No PLP or wear in affected and bounding tubes SSI: Removal not attempted Part dispositioned to remain in the SG based on sludge rock characterization. Sludge rocks or scale do not lead to tube degradation based on OPEX.

Ref ID	Description	Affected Tube Locations	ECT Results	History/ Change?	2R24 Results/Disposition
268	Sludge Rocks	-	No PLP or wear in associate lanes	-	ECT: No PLP or wear in associated lanes SSI: Characterization identified observed features as likely relating to sludge rocks on the tubesheet
269	Historical Flexitallic Gasket (2R22 FK8)	R38 C81 R40 C81 TSH +0"	No PLP or wear on bounding tubes	Two tubes plugged in 2R18. Gasket no longer present.	ECT: No PLP or wear in bounding tubes; originally affected tubes already plugged SSI: Gasket no longer present.
2610	Historical Nut (2R22 FK22)	R93 C138 R94 C137 C95 C138 TSH +0"	PLP No Wear	Object has been monitored since 2000 with no wear. Part moved 1 row closer to the periphery, likely as a result of waterlancing	ECT: PLPs reported closer to the periphery. Part appears to have moved. No wear in the vicinity SSI: Part not monitored visually
2611	Historical Flexitallic Gasket (2R22 FK10)	R97 C144 R98 C143 R94 C143 R96 C141 R95 C144 R96 C143 R97 C142 R93 C144 R95 C142 R98 C141 TSC +0"	PLP No Wear	Eight tubes plugged in 2R20; Location unchanged since 2R22	ECT: No PLPs or wear in bounding tubes SSI: Gasket confirmed to be in same location

Ref ID	Description	Affected Tube Locations	ECT Results	History/ Change?	2R24 Results/Disposition
2612	Rectangular Metallic Object	R24 C67 R26 C67 TSH +0"	PLP No Wear	Newly detected	ECT: No PLP or wear in affected and bounding tubes SSI: Part removed.
2613	Sludge Rock	R20 C65 R22 C65 TSH +0"	No PLP or wear on bounding tubes	Newly detected	ECT: No PLP or wear in affected and bounding tubes SSI: Part could not be removed Part dispositioned to remain in the SG based on sludge rock characterization. Sludge rocks do not lead to tube degradation based on OPEX
-	Historical ECT PLP (2R22 FK4)	R66 C157 R67 C156 R68 C155 R69 C156 R72 C155 R75 C154 R78 C153 R81 C152 01H +2"	PLP No Wear	Unchanged since initial detection in 2R20	ECT: PLPs reported in same location with no wear; characterized as weld splatter conforming to tube surface SSI: Location not accessible
-	Historical ECT PLP (2R22 FK6)	R18 C165 R19 C166 R20 C165 R17 C166 R16 C167 01C +2"	INR No Wear	Location unchanged since initial detection in 2R20	ECT: INRs reported in same location as previous PLPs with no wear; characterized as weld splatter conforming to tube surface SSI: Location not accessible
Note: ET inspections were performed following first FOSAR campaign.					