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Braidwood Station, Unit 1 Updated Steam Generator Tube Inspection Report

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Braidwood Station, Unit 1 Updated Steam Generator Tube Inspection Report Introduction

In Reference 1, Constellation Energy Generation (CEG) submitted a request for an amendment to Renewed Facility Operating License No. NPF-72 for the Braidwood Station (Braidwood), Unit 1 to adopt Technical Specifications Task Force (TSTF)-577, "Revised Frequencies for Steam Generator Tube Inspections" and Reference 2, Supplement to Application to Revise Technical Specifications to Adopt TSTF-577, "Revised Frequencies for Steam Generator Tube Inspections". Reference 1 and 2 were approved by the Nuclear Regulatory Commission (NRC) in Reference 3. As noted in Reference 2, "CEG will submit SG Tube Inspection Reports meeting the revised TS 5.6.9 requirements within 60 days after implementation of the license amendment at Braidwood." Based on NRC approval (Reference 3) TSTF-577 was implemented at Braidwood Station on September 13, 2023.

Braidwood Unit 1 Technical Specification (TS) 5.6.9, "Steam Generator Tube Inspection Report," states "A report shall be submitted within 180 days after the initial entry into MODE 4 following completion of an inspection performed in accordance with the Specification 5.5.9, 'Steam Generator (SG) Program'." This enclosure provides the revised 180-day report with the revised Braidwood Unit 1 TS 5.6.9 reporting requirements in accordance with References 3. Each Braidwood Unit 1 TS 5.6.9 reporting requirement is listed below along with the associated information based on the inspection performed during the Braidwood Unit 1 Cycle 23 October 2022 refueling outage (A1R23), which was the last inspection of the Braidwood Unit 1 replacement steam generators (Reference 4). This report follows the template provided in Appendix G to the Electric Power Research Institute (EPRI) *Steam Generator Management Program: Steam Generator Integrity Assessment Guidelines, Revision 5* (Reference 5), which provides additional information beyond the Braidwood Unit 1 TS 5.6.9 reporting requirements.

1. Design and operating parameters

The original SGs at Braidwood Unit 1 were replaced in 1998 with four Babcock & Wilcox replacement Steam Generators (SGs), which have thermally treated Alloy 690 tubing. The SGs had operated for four fuel cycles since the previous inspection at A1R19. Table 1 provides the Braidwood Unit 1 SG design and operating parameter information.

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Table 1: Braidwood Unit 1 - Steam Generator Design and Operating Parameters

SG Model / Tube Material / Number of SGs per Unit	Babcock & Wilcox (Canada) Replacements / Alloy 690TT / 4
Number of tubes per SG / Nominal Tube Diameter / Tube Thickness	6,633 / 0.6875 in. / 0.040 in
Support Plate Style / Material	Lattice Tube Support Grids and Fan Bars / stainless steel
Last Inspection Date	October 2022
Effective full power months (EFPM) Since Last Inspection	68.801 EFPM [5.734 effective full power years (EFPY)] (from A1R19 to A1R23)
Total Cumulative SG EFPY	22.71 EFPY (as of A1R23)
Mode 4 Initial Entry	10/18/2022 from A1R23
Observed Primary-to-Secondary Leak Rate	No observed leakage
Nominal Thot at Full Power Operation	617°F
Loose Parts Strainer	Each main feedwater pump has small diameter holes in an inlet strainer to prevent the introduction of foreign material into the piping leading to the SGs.
Degradation Mechanism Sub-Population	Tubes located on the periphery of the tube bundle are in the highest cross-flow region and were considered in the A1R23 Degradation Assessment to be more susceptible to foreign object wear.
SG program guideline deviations since last Inspection	None
SG Schematic	See Figure 1

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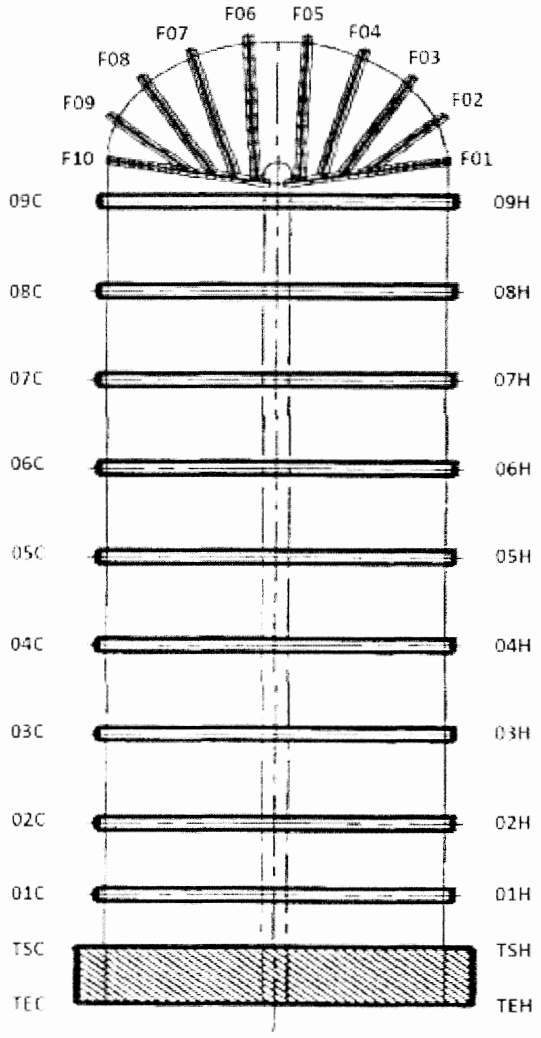
Figure 1



Tube Support Arrangement for Braidwood Unit 1 B&W Replacement SGs

Notes:
TEC - Tube End Cold Leg
TEH - Tube End Hot Leg
TSC – Top-of-Tubesheet Cold Leg
TSH – Top-of-Tubesheet Hot Leg
01C – 09C – Lattice Grid Tube Supports on Cold Leg side
01H – 09H – Lattice Grid Tube Supports on Hot Leg side
F01 – F10 – U-Bend Fan Bar Tube Supports

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2. The scope of the inspections performed on each SG (TS 5.6.9.a) and if applicable, a discussion of the reason for scope expansion

The following inspections were performed during A1R23 to ensure that 100% of the tubes were inspected during the period as required by TS 5.5.9.d.2

Primary Side Eddy Current Scope:

- 100% full-length bobbin coil eddy current examination of all in-service tubes in all four SGs.
- All Hot leg Dent & Dings >2.0 volts, Plus-Point probe in all four SGs.
- 57% peripheral array (X-Probe) examination on the Hot Leg for potential foreign objects and associated wear (peripheral locations are where crossflow velocities are the highest)
- 43% of peripheral array (X-Probe) examination Cold Leg for potential foreign objects and associated wear.

There was no scope expansion required or performed during the A1R23 eddy current inspections.

In addition to the eddy current inspections, visual inspections were also performed on both the primary and secondary sides. Primary side visual inspections included the channel head bowl cladding and the divider plate. Secondary side visual inspections were performed at the top of the tubesheet for the detection of foreign objects, assessment of hard deposit buildup in the tube bundle interior kidney region, and for determining the effectiveness of the tubesheet cleaning performed in the four SGs.

3. The nondestructive examination techniques utilized for tubes with increased degradation susceptibility (TS 5.6.9.b)

Tubes located on the periphery of the tube bundle are in the highest cross-flow region and were considered in the Degradation Assessment (DA) to be more susceptible to foreign object wear, especially near the tubesheet where most foreign objects are located. As a compensatory measure, tubes in this region were tested with an array (X-probe) which has increased sensitivity for detection of foreign objects and foreign object wear close to the tubesheet This scope encompassed 57% of the hot leg tubes and 43% of the cold leg tubes from the top-of-tubesheet to the 1st tube support (01C/01H).

4. For each degradation mechanism found: The nondestructive examination technique utilized (TS 5.6.9.c.1)

Steam Generator eddy current examination techniques used (see Table 2 below) were qualified in accordance with Appendix H or Appendix I of the EPRI PWR SG Examination Guidelines Revision 8. Each examination technique was evaluated to be applicable to the tubing and the degradation mechanisms found in the Braidwood Station Unit 1 SGs during A1R23.

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Table 2: Non-Destructive Examination (NDE) Techniques for Each Existing Degradation Mechanism Found During A1R23

Location	Degradation Mechanism	Orientation	Probe	EPRI ETSS	EPRI ETSS Rev
Fan Bar (U-bend)	Wear	Vol	Bobbin	I-96041.1 (D) 96004.3 (D&S)	6 13
Lattice Grid (Horz. Support)	Wear	Vol	Bobbin	96004.3 (D&S)	13
Foreign Object at top of tubesheet or lattice grid	Wear	Vol	Array +Point +Point	1790X.1 (D) 21998.1 (S) 27902.1 (S)	0 4 2

(D) = Detection
(S) = Sizing

5. **For each degradation mechanism found: The location, orientation (if linear), measured size (if available), and voltage response for each indication. For tube wear at support structures less than 20 percent through-wall, only the total number of indications needs to be reported (TS 5.6.9.c.2)**

Volumetric wear at support structures was the primary degradation mechanism detected during the A1R23 inspection. The wear indications detected were located at either fan bar U-bend or horizontal lattice grid tube support structures. Table 3 provides the number of indications reported during the A1R23 inspection.

Table 3: Number of Indications Detected for Each Degradation Mechanism in A1R23

Degradation Mechanism	1A SG Indications	1B SG Indications	1C SG Indications	1D SG Indications	Total
Fan Bar (U-bend support) wear	8	18	39	21	86
Lattice grid Support Wear	3	4	3	1	11
Foreign Object Wear	5	1	10	0	16

A detailed listing of all the Fan Bar wear indications reported during the A1R23 inspection including the measured voltages and depths from the bobbin coil is provided in Attachment A (same data as submitted under Reference 4).

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Table 4 provides a listing of all the lattice grid wear indications reported during the A1R23 inspection including the measured depths from the bobbin coil.

Table 4: A1R23 Lattice Grid Wear Indications

SG	Row	Col	Location	A1R23 Depth (%TW)	Voltage (Bobbin)
1A	39	70	01H -1.16	11	0.64
1A	75	108	07H -1.22	5	0.21
1A	118	71	01C +0.99	6	0.31
1B	47	24	08H -1.43	6	0.27
1B	87	24	01C -0.82	9	0.43
1B	90	107	07H +0.48	9	0.49
1B	119	70	02C +0.76	11	0.72
1C	9	92	05C -1.62	8	0.42
1C	47	56	05H -1.68	6	0.28
1C	73	90	05H +1.41	4	0.20
1D	41	70	08H -1.61	6	0.22

Table 5 provides a listing of all the foreign object wear indications reported during the A1R23 inspection including the measured voltages and depths from the plus-point probe. Indications of tube wear at support structures are provided regardless of percent through-wall depth and the voltages provided correspond to the bobbin coil.

Table 5: A1R23 Foreign Object Wear Indications

SG	Row	Col	Location	+ Point (Voltage)	+Point Depth (%TW)	Axial Extent (in)	Circ Extent (deg)
1A	96	107	TSH +0.12	0.15	12	0.31	49
1A	98	107	TSH +0.12	0.15	12	0.26	54
1A	97	108	TSH +0.22	0.16	12	0.26	55
1A	17	138	TSH +0.17	0.24	16	0.20	60
1A	20	139	TSH +0.04	0.10	9	0.17	66
1B	98	47	TSH +0.00	0.27	17	0.17	43
1C	18	3	TSC +1.08	0.11	13	0.22	45
1C	20	3	TSC +0.17	0.15	14	0.17	54
1C	18	5	TSC +2.22	0.51	42	0.25	66
1C	93	54	TSH +0.12	0.35	19	0.36	45
1C	6	59	TSC +0.26	0.26	23	0.28	62
1C	3	64	TSC +0.22	0.41	34	0.28	72
1C	2	65	TSC +0.12	0.37	31	0.28	74
1C	1	72	TSH +0.28	0.06	6	0.11	35
1C	5	72	TSH +0.28	0.61	25	0.22	66
1C	2	73	TSH +0.25	0.08	8	0.14	43

6. **For each degradation mechanism found: A description of the condition monitoring assessment and results, including the margin to the tube integrity performance criteria and comparison with the margin predicted to exist at the inspection by the previous forward-looking tube integrity assessment (TS 5.6.9.c.3). Discuss any degradation that was not bounded by the prior operational assessment in terms of projected maximum flaw dimensions, minimum burst strength, and/or accident induced leak rate. Provide details of any in situ pressure test.**

A condition monitoring (CM) assessment was performed as required by the Braidwood Unit 1 SG program. The tube degradation detected during the A1R23 inspection was due to fan wear, lattice grid wear and foreign object wear at the tubesheet. The deepest indication for each mechanism met condition monitoring analytically as shown in Figures 2, 3 and 4a and 4b below. The margin to the structural and condition monitoring limit curve for each detected wear indication can be determined from Figures 2, 3 and 4a and 4b. The CM limit curves include uncertainties for material properties, NDE depth sizing, and the burst pressure relationship. Because the deepest flaws have a depth less than the conservatively determined CM limit for all degradation mechanisms, the structural integrity performance criterion was met for the operating interval prior to A1R23. A summary of the CM results from A1R23 as compared to the predictions from the most recent prior inspection (A1R19) is provided in Table 6.

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Figure 2: Condition Monitoring Results for Fan Bar Wear

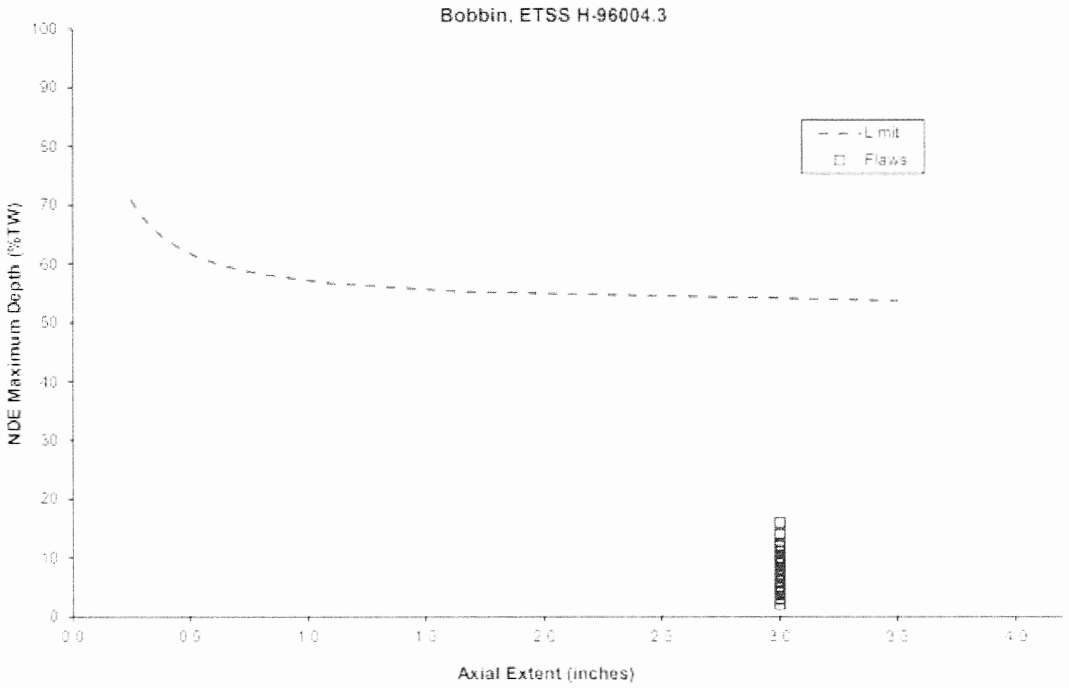

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Figure 3: Condition Monitoring Results for Lattice Grid Wear

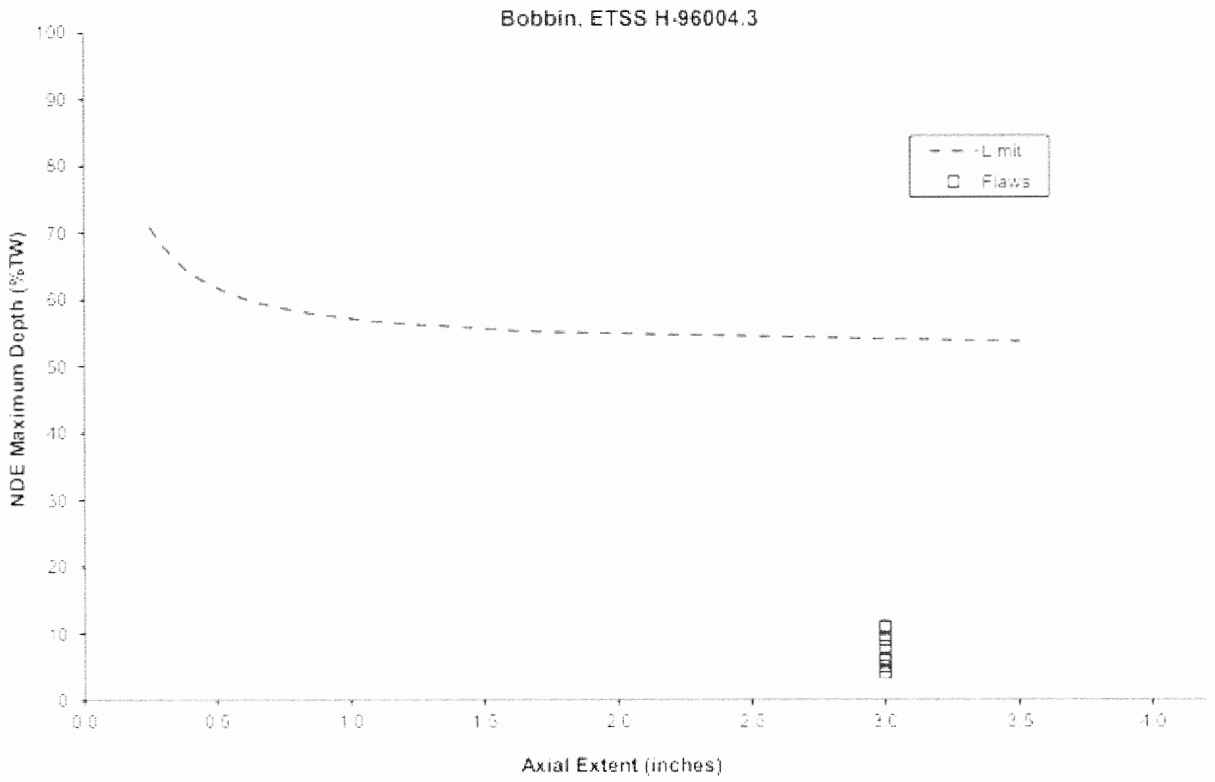

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Figure 4a: Condition Monitoring Results for Foreign Object Wear (ETSS 27902.1)

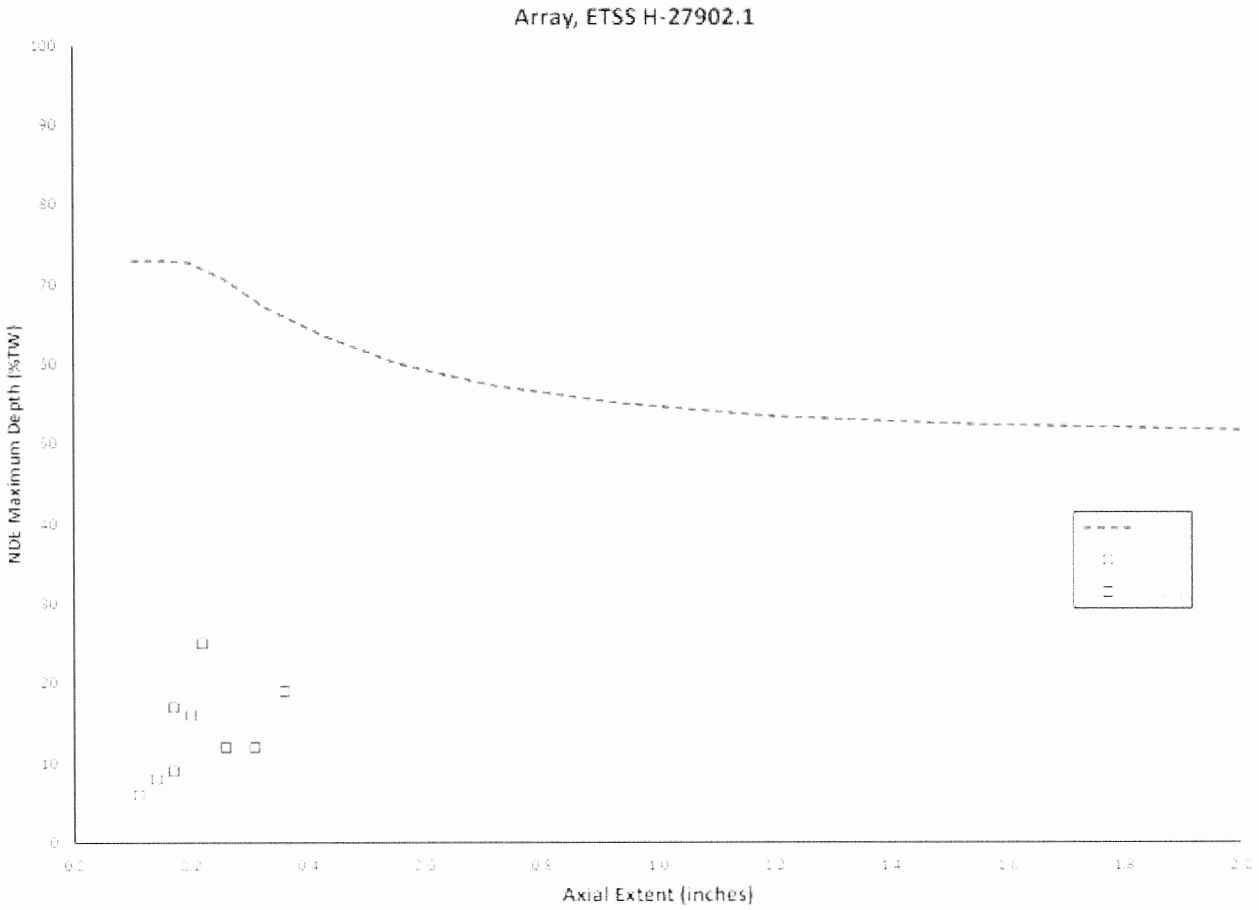

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Figure 4b: Condition Monitoring Results for Foreign Object Wear (ETSS 21.998.1)

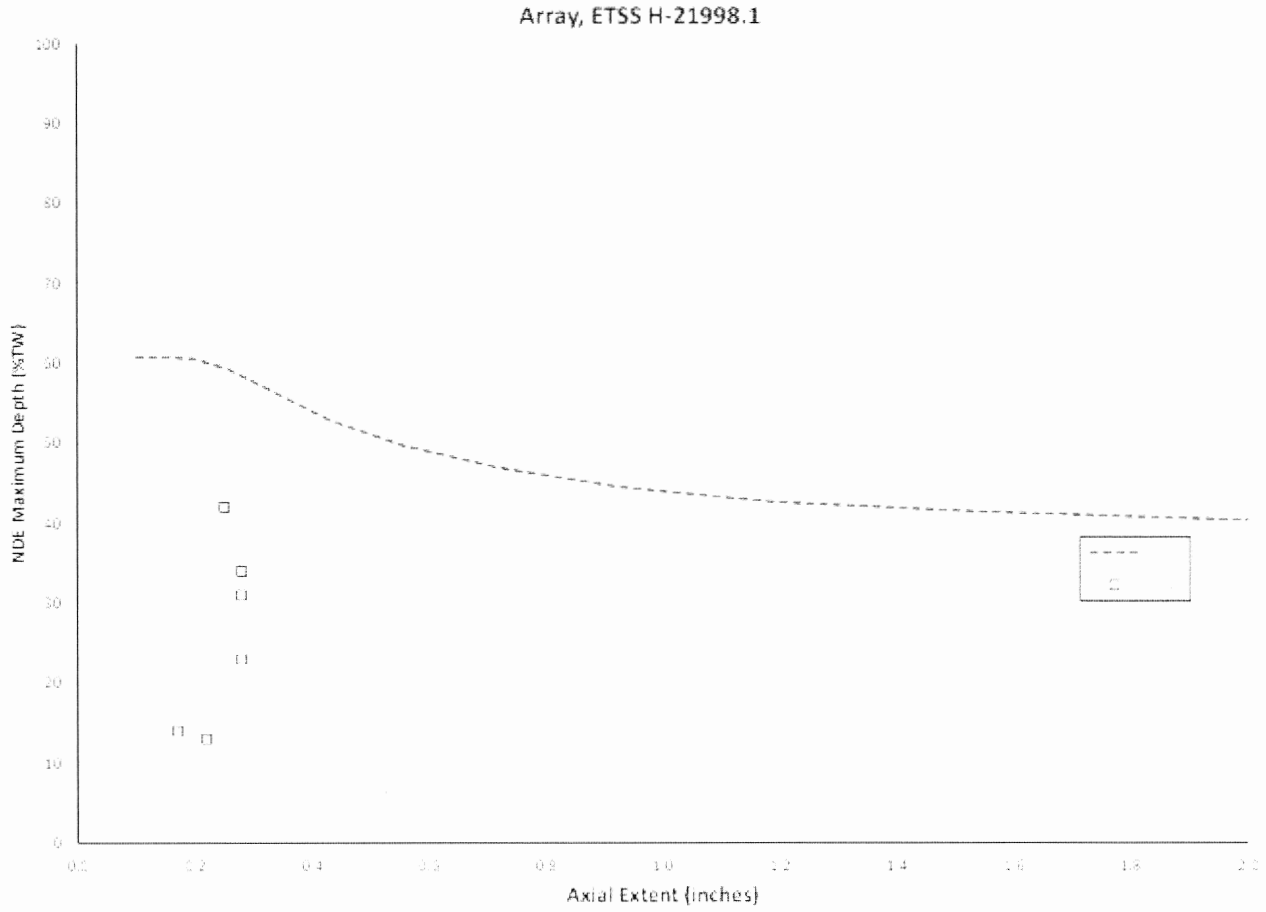

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Table 6: Comparison of Prior OA Projections to As-Found Results

Parameter	A1R23 Projection	A1R23 As-Found
Inspection Interval	5.83 EFPY (from A1R19)	5.734 EFPY
Fan Bar Wear Maximum Depth	34.8 %TW	16 %TW
Lattice Grid Wear Maximum Depth	28.0 %TW	11 %TW
Foreign Object Wear Maximum Depth	< 57.6 %TW	42 %TW
Tube-to-tube Wear	31.7%TW	None

The most severe indication in A1R23 had an estimated depth of 42%TW from the plus-point probe exam. Since foreign object wear is a random event and there had only been 2 of 7 new foreign object wear indications that required to be plugged, one tube for being over the 40% Tech Spec limit and the other tube having the part remaining. There was no prediction for new foreign object wear made during the prior inspection in A1R19.

Because volumetric wear indications will leak and burst at essentially the same pressure, accident-induced leakage integrity is also demonstrated. Operational leakage integrity was demonstrated by the absence of any detectable primary-to-secondary leakage during the operating interval prior to A1R23. Because tube integrity was demonstrated analytically, in-situ pressure testing was not required nor performed during A1R23. There were no tube pulls planned or performed during A1R23.

7. For each degradation mechanism found: The number of tubes plugged during the inspection outage (TS 5.6.9.c.4). Also, provide the tube location and reason for plugging.

Tables 7a & b provides the number of tubes plugged for each degradation mechanism detected, location, and reason for plugging during A1R23 As a result of the A1R23 SG inspections, performed in accordance with TS 5.5.9.d, the modes of tube degradation found were Fan Bar wear, Lattice Grid wear, and secondary side foreign object (FO) wear. One tube (1C SG R18-C5) was plugged for FO Wear for exceeding the tech spec criteria of 40%TW. The other tube (1C SG R93-C54) was plugged for both FO Wear (19%TW) and an Eddy Current possible loose part (PLP) indication which could not be visually inspected. In addition, 12 tubes were plugged as a preventative measure when the FO could not be removed or properly characterized from visual inspections. Inspection results justified a 5-cycle inspection interval with no adverse consequences for all four SGs.

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Table 7a: Number of Tubes Plugged, location and Reason for Each Degradation Mechanism in A1R23 (TS 5.6.9.c.4)

SG	Row	Col	Location	Reason for Plugging
1C	18	5	TSC +2.22	Exceeded TS criteria of ≥ 40%
1C	93	54	TSH +0.12	Tube had FO wear and ECT PLP present
1C	94	53	TSH	Preventatively plugged[1]
1C	91	54	TSH	Preventatively plugged[1]
1C	93	54	TSH	Preventatively plugged[1]
1C	95	54	TSH	Preventatively plugged[1]
1C	92	55	TSH	Preventatively plugged[1]
1C	94	55	TSH	Preventatively plugged[1]
1C	109	60	TSH	Preventatively plugged[2]
1C	111	60	TSH	Preventatively plugged[2]
1C	113	60	TSH	Preventatively plugged[2]
1C	108	61	TSH	Preventatively plugged[2]
1C	110	61	TSH	Preventatively plugged[2]
1C	112	61	TSH	Preventatively plugged[2]

Notes:
1: All bounding tubes related to tube 93-54 were No Degradation Detected (NDD) and no PLPs with ECT. Visual inspections could not be performed on this location.
2: No wear, but FO was visually seen, but unable to confirm description

Table 7b: Number of Tubes Plugged for Each Degradation Mechanism in A1R23 (TS 5.6.9.c.4)

Degradation Mechanism	1A SG	1B SG	1C SG	1D SG	Total
Fan Bar Wear	0	0	0	0	0
Lattice Grid Wear	0	0	0	0	0
Foreign Object Wear	0	0	2	0	0
Preventative	0	0	12	0	0
Total Plugged during A1R23	0	0	14	0	14

8. **The repair methods utilized, and the number of tubes repaired by each repair method (section 5.6.7.c.5).**

   Not Applicable

9. **An analysis summary of the tube integrity conditions predicted to exist at the next scheduled inspection (the forward-looking tube integrity assessment) relative to the applicable performance criteria, including the analysis methodology, inputs, and results (TS 5.6.9.d). The effective full power months of operation permitted for the current operational assessment.**

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Based on application of conservative U-bend support structure (fan bars) and lattice grid wear growth rates and foreign object susceptibility, the condition of the Braidwood Unit 1 SG tubes has been analyzed with respect to continued operability of the SGs without exceeding the SG tube integrity performance criteria at the next scheduled SG inspection in the Spring of 2030 (A1R28).

Fan Bar Wear Operational Assessment (OA)

For the Fan Bar OA, the Mixed Arithmetic/Simplified Statistical method from Section 8 of Reference 5 was used. Using this method, a worst-case end-of-cycle (EOC) depth was projected by applying NDE uncertainties and a growth allowance to the deepest flaw returned to service. This projected EOC depth is then compared to an allowable EOC depth which is calculated using a Monte Carlo analysis which incorporates uncertainties in the burst pressure relationship and material properties.

The deepest fan bar indication returned to service was 16%TW. The NDE sizing parameters for ETSS 96004.3 are a slope of 0.97, an intercept of 2.50, and a standard error of 3.10. Using the slope and intercept, a best estimate real depth of 18.0%TW (0.97 x 16 + 2.5) is obtained for an indication with a measured depth of 16%TW.

The standard error of 3.10 from ETSS 96004.3 is the technique uncertainty. Adjusting this value upward to an upper 95th percentile gives an NDE uncertainty of 5.1%TW (3.10 x 1.645). Adding this uncertainty to the best estimate value of 18.0%TW from the previous paragraph yields a bounding real depth of 23.1%TW (18.0 + 5.1) returned to service.

This hypothesized real depth of 23.1%TW must then be grown at an upper 95th growth rate for the next inspection interval. For this operational assessment, wear at support structures is being evaluated for five fuel cycles of 1.5 EFPY each. The highest upper 95th percentile growth rate for any steam generator over the last two inspection was 0.93%TW per EFPY. Since the growth rates are so low for fan bar wear at Braidwood Unit 1, a conservative growth rate of 1.5%TW per EFPY was used in the operational assessment. This value conservatively bounds the maximum growth rate from the last two operating intervals. Applying a growth of 7.3%TW (1.0 x 7.3) gives a bounding real depth at the end of the upcoming inspection interval of 34.1%TW (23.1 + 7.3). For a flaw with an assumed bounding length of 1.7 inches, the allowable structural depth at the end of the upcoming inspection cycle is 57.1%TW. Since the projected depth of 30.4%TW is less than 57.1%TW, there is reasonable assurance that structural integrity will be maintained for Fan Bar wear for the next five cycles of operation.

Lattice Grid Wear OA

For lattice grid wear, the OA was performed in a manner similar to what was done for fan bar wear. Unlike fan bar wear, however, there is too little data from which to calculate a reliable upper 95th percentile growth rate. There were eleven (11) lattice grid wear indications reported during the A1R23 outage. The deepest indication measured 11%TW with a bobbin probe. One (1) of these indications were newly reported, not present in past history. The largest growth was 11%TW over an operating interval of 5.733 EFPY giving a maximum growth rate of 0.52%TW per EFPY. Similar to fan bar wear, since the growth rates for lattice grid wear are so low, growth rate of 1.0%TW per EFPY will be used for this operational assessment.

The lattice grid flaws are typically short and occur at one edge of a lattice grid. However, since length measurements were not made for these indications, a bounding flaw length of 3.5 inches from the longest lattice grid intersection of 3.15 inches was assumed. This length was obtained from the "high bar" lattice grids which was from the maximum lattice grid length of 1.01" sized during A1R23. This is very conservative based on the flaw lengths observed in previous outages.

Using the same Mixed Arithmetic/Simplified Statistical method Section 8 of Reference 5 and the same bobbin ETSS (96004.3), a best estimate real depth of 13.2%TW (0.97 x 11 + 2.5) is obtained for a measured depth of 11%TW. Applying upper 95th percentile NDE uncertainties yields a bounding real depth of 18.3%TW (13.2 + 1.645 x 3.1) returned to service. Further applying a growth rate of 1.0%TW per EFPY (as discussed above) over 7.3 EFPY gives a projected real EOC depth of 25.6%TW (18.3 + 1.0 x 7.3). For a flaw with an assumed bounding length of 3.5 inches, the allowable structural depth at the end of the upcoming inspection cycle is 56.0%TW. Since the projected depth of 25.6%TW is less than 56.0%TW, there is reasonable assurance that structural integrity will be maintained for lattice grid wear for the next five cycles of operation.

Tube Wear from Existing, Remaining, and New Foreign Objects OA

Largest depth indication detected during A1R23, was a 42%TW. All of the foreign objects that were classified as potentially causing tubes wear, Priority 1, were removed from the steam generators or tubes preventively plugged around the object(s). The remaining objects were classified as Priority 3, not potentially causing tube wear based on their composition, size and/or low-flow location. This included objects such as sludge rocks and tube scale which are considered benign based on no known history of causing tube wear. A summary of the OA results predicted at the next inspection (or longer) is provided in Table 8.

Table 8: Comparison of OA Projections at Next SG Inspection to Structural Limits

Degradation Mechanism (wear)	Maximum depth (%) Predicted at Next Inspection	Structural limit depth (%)
Fan Bar U-bend support	30.4	57.1
Lattice Grid support	25.6	56.0
Existing FO Wear	34.0	59.0-66.3% (technique and length dependent)
Remaining FOs	< 20%TW Wear	60-75% (technique and length dependent)
New FOs	Limiting flaw won't challenge structural or leakage integrity after 5 operating cycles	60-75% (technique and length dependent)

10. The number and percentage of tubes plugged to date, and the effective plugging percentage in each SG (TS 5.6.9.e).

Table 9 shows the number of tubes plugged before and after the A1R23 outage and the percentage of tubes currently plugged (total and effective). No sleeves have been installed in Braidwood Unit 1.

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Table 9: Tube Plugging to Date (Number and Percentage per SG) (TS 5.6.9.e)

	1A SG	1B SG	1C SG	1D SG	Total
Total Plugged prior to A1R23	32	40	16	1	89
Total Plugged during A1R23	0	0	14	0	14
Total Stabilized during A1R23	0	0	1	0	1
Total Plugged through A1R23	32	40	30	1	103
Total Percent Plugged through A1R23	0.48%	0.60%	0.45%	0.02%	0.39%

11. The results of any SG secondary-side inspection (TS 5.6.9.f). The number, type, and location (if available) of loose parts that could damage tubes removed or left in service in each SG.

Secondary Side Scope:

- Sludge lancing in all four SGs including "post sludge lance" Foreign Object Search and Retrieval (FOSAR)
- Feedring Inspection (1A SG)
- Steam Drum Internal Inspections (1A & 1B SG)
- Upper Bundle Inspection (1A SG)

Secondary Side Visual Inspections of Tubesheet and FOSAR

Secondary side tubesheet visual inspections were performed following sludge lancing activities in all four SGs. High flow regions of the annulus, no tube lane and periphery (6-8 tubes deep) were visually inspected for foreign material. Additionally, eight columns for the full depth of the tube bundle interior ("kidney" region) were evaluated for sludge lancing effectiveness and sludge accumulation.

Secondary side foreign object search and retrieval (FOSAR) inspections at the tubesheet were performed in all four SGs. This included visual examination of tube bundle periphery tubes from the hot leg and cold leg annulus and center no tube lane. Twenty-one (21) foreign object locations all of which were assumed metallic, were identified by visual inspections and/or eddy current examinations and are summarized in Table 10

Foreign object wear is the primary degradation mechanism of concern at Braidwood-1 based on previous history. In A1R23, one tube was plugged for FO Wear of 42%TW, one tube was plugged for FO wear of 19%TW with an ECT PLP still present, and 12 other locations were plugged as a preventative measure when the FO could not be removed or properly characterized from visual inspections.

Visual inspections included both the annulus and no-tube lane at the top of the tubesheet in all four steam generators. These visual inspections included looking into the tube bundle at all peripheral and no-tube lane locations. The eddy current examinations included tubesheet array probe inspections of all tubes in the high-flow regions at the periphery and no-tube lane on both the hot (~3800 tubes) and cold sides (~2900 tubes) in all four steam generators. With these extensive inspections and subsequent object removal, there is reasonable confidence that no object capable of causing significant tube degradation remains in the tube bundle adjacent to in-service tubes.

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A total of 14 metallic or potential metallic foreign objects within the tube bundle in SGs A, B, and C were not removed during A1R23 and are included in the total list of all foreign objects remaining in the SGs in Table 10.

A top of tubesheet in-bundle visual inspection in a sample of tube columns was also performed in each SG for the purpose of assessing and trending the level of hardened deposit buildup in the kidney region.

Based upon the extensive secondary side inspections, object removals, and engineering assessments performed during the 1AR23 outage, there is reasonable assurance that during the next five operating cycles foreign object wear will not exceed the structural and leakage integrity performance criteria.

Table 10: Foreign Object Summary

SG	Affected Tubes	Location	Ref ID	A1R23 Disposition	Status	Material
1A	N/A Below Manway Handhole	TSC	A001	Object was removed. Nearest adjacent tubes were NDD with ECT. No further actions required in A1R23.	Retrieved	Gasket
1A	R104-C73 R105-C72	TSC	A003	Object identified with visual inspections and was removed. All affected and bounding tubes are NDD with ECT. No further actions required in A1R23.	Retrieved	Gasket
1A	R104-C79 R105-C78	TSC	A004	Object identified with visual inspections was removed. All affected and bounding tubes are NDD with Bobbin. No further actions required in A1R23.	Retrieved	Gasket
1A	R57-C134 R58-C133 R59-C132 R60-C133	TSH	A005	Acceptable to remain in the SG. All affected and bounding tubes are NDD with ECT. Object is extremely thin wire or possibly fibrous material and not expected to cause wear on a tube. No further actions required in A1R23.	Remains	Wire Bristle or Thin Fiber (1.0L x 0.001D)
1A	R97-C32 R98-C33	TSH	A006	Acceptable to remain in the SG. All affected and bounding tubes are NDD with ECT. Object is extremely thin wire or possibly fibrous material and not expected to cause wear on a tube. No further actions required in A1R23.	Remains	Wire Bristle or Thin Fiber (2.0L x 0.001D)
1A	R83-C22 R84-C23	TSH	A007	Acceptable to remain in the SG. All affected and bounding tubes are NDD with ECT. Object is extremely thin wire or possibly fibrous material and not expected to cause wear on a tube. No further actions required in A1R23.	Remains	Wire Bristle or Thin Fiber (2.0L x 0.001D)
1A	R77-C18 R78-C19	TSH	A008	Acceptable to remain in the SG. All affected and bounding tubes are NDD with ECT. Object is extremely thin wire or possibly fibrous material and not expected to cause wear on a tube. No further actions required in A1R23.	Remains	Wire Bristle or Thin Fiber (2.0L x 0.001D)

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SG	Affected Tubes	Location	Ref ID	A1R23 Disposition	Status	Material
1A	R71-C72 R72-C71 R73-C72	TSC	A009	Object was removed. All affected and bounding tubes are NDD with Bobbin. No further actions required in A1R23.	Retrieved	Gasket
1A	R103-C74 R104-C73 R105-C74	TSC	A010	Object identified with visuals during retrieval of A003 and was removed. All affected and bounding tubes are NDD with Bobbin. No further actions required in A1R23.	Retrieved	Gasket
1A	R81-C22 R82-C23 R83-C22 R84-C23	TSC	A011 (A001 from 1R19)	Object was confirmed unchanged from A1R19. All bounding tubes are NDD with ECT. No further actions required in A1R23.	Remains	Legacy 2016 metallic weld slag (1.5L x 0.1W x 0.1H)
1B	R115-C58 R116-C59 R117-C58	TSC	B001	Object was identified visually and removed from the SG. All affected and bounding tubes are NDD with ECT. No further actions required in A1R23.	Retrieved	Wire
1B	R116-C85 R117-C86	TSH	B003	Acceptable to remain in the SG. All affected and bounding tubes are NDD with ECT. Object is extremely thin wire or possibly fibrous material and not expected to cause wear on a tube. No further actions required in A1R23.	Remains	Wire Bristle or Thin Fiber
1B	C58-59 R27-28	TSC	B005	Object confirmed with visuals during retrieval of B001. All affected and bounding tubes are NDD. Acceptable to remain in the SG without plugging based on evaluation performed in Section **Error! Reference source not found.**. No further actions required at A1R23.	Remains	Gasket (~2.0L x 0.125W x 0.031H
1C	C60-61 R99-104	TSC	C004	Visually confirmed as a gasket. Part was removed from the SG. No further actions required in A1R23.	Retrieved	Gasket
1C	R3-C48	TSH	C005 (1R19 C001)	Visually confirmed as unchanged from A1R19. Affected and bounding tubes are NDD with ECT. Acceptable to remain in the SG without tube plugging. No further actions required at A1R23	Remains	Legacy metallic snare collar (0.14L x 0.11W x 0.3H)
1C	R44-C75	TSC	C006 (1R19 C004)	Visually confirmed as unchanged from A1R19. Affected and bounding tubes are NDD with ECT. Acceptable to remain in the SG without tube plugging. No further actions required at A1R23	Remains	Legacy 2016 metallic gasket (1.5L x 0.188W x 0.05H)
1C	<u>Affected</u> R109-C60 R110-C61 R111-C60 <u>Bounding</u> R108-C61 R112-C61 R113-C60	TSH	C007	Object was visually identified from periphery but unable to confirm descriptions. All affected and bounding tubes are NDD. Object evaluated for potential to cause wear and results in projected depths at A1R23 in excess of 40%TW. Plug and stabilize affected and bounding tubes 108-61, 112-61, and 113-60 at A1R23.	Remains	Potential White Object (assumed Gasket 2L x 0.125W x 0.031H)

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SG	Affected Tubes	Location	Ref ID	A1R23 Disposition	Status	Material
1C	R18-C3 R18-C5 R20-C3 R22-C3 R23-C4 R25-C4	TSC	C008 / C009	ECT identified PLPs with wear in three tubes (13%TW in 18-3, 42%TW in 18-5, and 14%TW in 20-3). Visual inspections confirmed two objects which were removed from the SG. Array retests after removal confirmed no PLPs. Tube 18-5 to be plugged in A1R23, remaining tubes to be left in-service.	Retrieved	ECT PLP w/ Wear Gasket and Weld Splatter
1C	R33-C102	TSH	1R19 C008	Visually confirmed as unchanged from A1R19. Affected and bounding tubes are NDD with ECT. Acceptable to remain in the SG without tube plugging. No further actions required at A1R23	Remains	Legacy metallic gasket (0.5L x 0.2W x 0.2H)
1C	R33-C102	TSH	1R19-C009	Visually confirmed as unchanged from A1R19. Affected and bounding tubes are NDD with ECT. Acceptable to remain in the SG without tube plugging. No further actions required at A1R23	Remains	Legacy metallic wire (0.92L x 0.188W x 0.5H)
1C	R93-C54	TSH	N/A	ECT identified PLPs with wear in one tube (19%TW in R93-C54). All bounding tubes were NDD and no PLPs with ECT. Visual inspections could not be performed on this location. Affected tube R93-C54 and all 1-tube bounding tubes plugged in A1R23.	Remains	New ECT FO w/ PLP

Visual inspection of the Feedring, upper tube bundle and the lattice grids

During the Feedring inspections in the 1A SG, no anomalous structural conditions or foreign objects were observed. Additionally, no erosion or component degradation was identified.

During visual inspections in the 1A SG of the lattice grids at the uppermost (9th) support location for the hot leg and cold leg some deposit accumulation was identified on the hot leg side at the lattice grids and on the tube surfaces. Deposit loading on the tube and structure surfaces, and within lattice openings was relatively minor in the regions examined. No degradation was noted.

Steam drum visual inspections

Steam drum visual inspections were performed in the 1A and 1B SGs. No evidence of foreign material, degradation or structural distortion was observed in the steam drum. The primary and secondary moisture separators were in good condition. The inlet vanes, outlet ports, vent holes, and skimmer vanes internals of 14 secondary moisture separators internals and internals of 6 primary moisture separators in each SG were visually inspected for degradation and none was found.

No repairs were required for the secondary side inspection, and it was concluded that a 5-cycle inspection interval was justified with no adverse consequences for all 4 SGs.

12. The scope, method, and results of secondary-side cleaning performed in each SG

Prior to the secondary side FOSAR inspections, sludge, scale, foreign objects, and other deposit accumulations at the top of the tubesheet were removed as part of the top of

tubesheet high pressure water lancing process. The weight of deposits removed from each SG by this cleaning process is provided in Table 11. Given Braidwood Unit 1 had operated 4 cycles from the last sludge lancing in A1R19, the amount of accumulation per SG was expected. A visual inspection of the upper lattice grids showed no significant deposit accumulation and no conditions that would adversely impact tube integrity.

Table 11: A1R23 SG Deposit Removal Weights

SG	Weight
SG 1A	21.25 lbs
SG 1B	14.75 lbs
SG 1C	17.25 lbs
SG 1D	37.25 lbs
All SGs	90.5 lbs

13. The results of primary side component visual inspections performed in each SG.

Visual Inspection of Installed Tube Plugs and Tube-to-Tubesheet Welds

All previously installed tube plugs (89) were visually inspected for signs of degradation and leakage. The tube-to-tubesheet welds were visually inspected during eddy current. No degradation or anomalies were found.

SG Channel Head Bowl Visual Inspections

Each SG hot and cold leg primary channel head was visually examined in accordance with the recommendations of Westinghouse NSAL 12-01 and NRC IN 2013-20 for evidence of breaches in the cladding or cracking in the divider to channel head weld and for evidence of wastage of the carbon steel channel head. No evidence of cladding breaches, wastage or corrosion in the channel head was identified. Also, no cracking in the divider to channel head weld was identified.

References

1. CEG letter to NRC, RS-22-086, Application to Revise Technical Specifications to Adopt TSTF-577, "Revised Frequencies for Steam Generator Tube Inspections", dated August 10, 2022 (ML22222A068)

2. CEG letter to NRC, RS-23-050, Application to Revise Technical Specifications to Adopt TSTF-577, "Revised Frequencies for Steam Generator Tube Inspections" (ML23143A136)

3. NRC letter to CEG," BRAIDWOOD STATION, UNIT NOS. 1 AND 2 - ISSUANCE OF AMENDMENTS 233 AND 233 RE: ADOPTION OF TSTF-577, "REVISED FREQUENCIES FOR STEAM GENERATOR TUBE INSPECTIONS," REVISION 1 (EPID L-2022-LLA-0115)", dated July 26, 2023 (ML23188A129)

4. Constellation Generation letter (BW230019) to NRC, "Braidwood Station, Unit 1 Steam Generator Tube Inspection Report for Refueling Outage 23," dated April 5, 2023 (ML23095A129)

5. Steam Generator Management Program: Steam Generator Integrity Assessment Guidelines, Revision 5, EPRI, Palo Alto, CA, December 2021 (3002020909)

Enclosure 1

ATTACHMENT A - Fan Bar Wear Indications (SG 1A)

SGID	INSPDATE	ROW	COL	PER	VOLTS	DEG	CHN	LOCN	INCH1	PDIA	PTYPE
1A	10/1/2022	31	4	3	0.21	0	P2	F05	1.06	0.56	CBAFN
1A	10/1/2022	68	49	5	0.24	0	P2	F04	0.79	0.56	CBAFN
1A	10/1/2022	71	62	5	0.28	0	P2	F04	-1.19	0.56	CBAFN
1A	10/1/2022	63	70	5	0.29	0	P2	F05	0.5	0.56	CBAFN
1A	10/1/2022	77	84	2	0.15	0	P2	F05	-0.98	0.56	CBAFN
1A	10/1/2022	84	87	6	0.31	0	P2	F05	-0.8	0.56	CBAFN
1A	10/1/2022	99	90	11	0.57	0	P2	F05	-1.24	0.56	CBAFN
1A	10/1/2022	109	90	8	0.43	0	P2	F05	-1.23	0.56	CBAFN

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ATTACHMENT A - Fan Bar Wear Indications (SG 1B)

SGID	INSPDATE	ROW	COL	PER	VOLTS	DEG	CHN	LOCN	INCH1	PDIA	PTYPE
1B	10/1/2022	42	137	7	0.37	0	P2	F06	0.94	0.56	CBAFN
1B	10/1/2022	45	130	5	0.24	0	P2	F05	-1.28	0.56	CBAFN
1B	10/1/2022	52	63	4	0.2	0	P2	F05	1.2	0.56	CBAFN
1B	10/1/2022	57	42	6	0.3	0	P2	F05	-1.73	0.56	CBAFN
1B	10/1/2022	60	73	7	0.38	0	P2	F05	-1.9	0.56	CBAFN
1B	10/1/2022	65	70	4	0.23	0	P2	F06	-1.65	0.56	CBAFN
1B	10/1/2022	68	65	3	0.19	0	P2	F05	0.87	0.56	CBAFN
1B	10/1/2022	71	62	3	0.19	0	P2	F04	0.83	0.56	CBAFN
1B	10/1/2022	73	102	8	0.36	0	P2	F05	1.18	0.56	CBAFN
1B	10/1/2022	76	73	9	0.47	0	P2	F05	-0.86	0.56	CBAFN
1B	10/1/2022	78	57	8	0.48	0	P2	F07	-1.38	0.56	CBAFN
1B	10/1/2022	80	71	3	0.15	0	P2	F05	1.12	0.56	CBAFN
1B	10/1/2022	82	69	5	0.33	0	P2	F06	-1.37	0.56	CBAFN
1B	10/1/2022	82	79	5	0.25	0	P2	F06	1.9	0.56	CBAFN
1B	10/1/2022	88	69	5	0.27	0	P2	F08	1.04	0.56	CBAFN
1B	10/1/2022	100	57	7	0.42	0	P2	F07	1.77	0.56	CBAFN
1B	10/1/2022	107	68	7	0.38	0	P2	F05	1.49	0.56	CBAFN
1B	10/1/2022	111	70	5	0.27	0	P2	F06	-1.32	0.56	CBAFN

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ATTACHMENT A - Fan Bar Wear Indications (SG 1C)

SGID	INSPDATE	ROW	COL	PER	VOLTS	DEG	CHN	LOCN	INCH1	PDIA	PTYPE
1C	10/1/2022	35	70	4	0.37	0	P2	F05	1.85	0.56	CBAFN
1C	10/1/2022	54	79	7	0.31	0	P2	F06	0.63	0.56	CBAFN
1C	10/1/2022	55	56	7	0.34	0	P2	F05	1.85	0.56	CBAFN
1C	10/1/2022	57	78	9	0.51	0	P2	F06	0.71	0.56	CBAFN
1C	10/1/2022	59	68	4	0.22	0	P2	F05	0.61	0.56	CBAFN
1C	10/1/2022	66	61	11	0.62	0	P2	F07	1.81	0.56	CBAFN
1C	10/1/2022	74	63	4	0.17	0	P2	F06	-1.28	0.56	CBAFN
1C	10/1/2022	74	75	5	0.26	0	P2	F05	-1.14	0.56	CBAFN
1C	10/1/2022	76	65	4	0.18	0	P2	F05	1.32	0.56	CBAFN
1C	10/1/2022	77	66	6	0.3	0	P2	F05	-0.54	0.56	CBAFN
1C	10/1/2022	77	68	12	0.66	0	P2	F05	-0.96	0.56	CBAFN
1C	10/1/2022	79	66	7	0.33	0	P2	F05	-0.89	0.56	CBAFN
1C	10/1/2022	79	94	12	0.66	0	P2	F06	-1.18	0.56	CBAFN
1C	10/1/2022	80	63	7	0.33	0	P2	F06	-1.45	0.56	CBAFN
1C	10/1/2022	90	79	14	0.83	0	P2	F06	1.51	0.56	CBAFN
1C	10/1/2022	91	72	9	0.48	0	P2	F06	0.7	0.56	CBAFN
1C	10/1/2022	92	57	8	0.39	0	P2	F05	1.44	0.56	CBAFN
1C	10/1/2022	92	69	14	0.94	0	P2	F05	-0.9	0.56	CBAFN
1C	10/1/2022	93	78	6	0.33	0	P2	F05	-0.7	0.56	CBAFN
1C	10/1/2022	94	63	8	0.38	0	P2	F05	-1.76	0.56	CBAFN
1C	10/1/2022	94	85	7	0.39	0	P2	F04	0.69	0.56	CBAFN
1C	10/1/2022	95	58	8	0.39	0	P2	F05	-0.64	0.56	CBAFN
1C	10/1/2022	96	57	10	0.51	0	P2	F05	0.68	0.56	CBAFN
1C	10/1/2022	97	86	9	0.46	0	P2	F05	1.21	0.56	CBAFN
1C	10/1/2022	97	88	5	0.23	0	P2	F05	1.54	0.56	CBAFN
1C	10/1/2022	98	59	9	0.45	0	P2	F05	1.21	0.56	CBAFN
1C	10/1/2022	99	84	7	0.31	0	P2	F07	0.85	0.56	CBAFN
1C	10/1/2022	100	75	7	0.35	0	P2	F05	-1.55	0.56	CBAFN
1C	10/1/2022	101	60	9	0.45	0	P2	F05	1.63	0.56	CBAFN
1C	10/1/2022	101	84	9	0.43	0	P2	F07	0.73	0.56	CBAFN
1C	10/1/2022	102	61	10	0.55	0	P2	F05	1.01	0.56	CBAFN
1C	10/1/2022	103	86	9	0.47	0	P2	F05	-0.65	0.56	CBAFN
1C	10/1/2022	104	63	8	0.39	0	P2	F05	1.53	0.56	CBAFN
1C	10/1/2022	105	72	10	0.52	0	P2	F03	-0.54	0.56	CBAFN
1C	10/1/2022	106	59	9	0.44	0	P2	F05	1.02	0.56	CBAFN
1C	10/1/2022	107	70	8	0.39	0	P2	F05	1.89	0.56	CBAFN
1C	10/1/2022	107	76	5	0.23	0	P2	F05	-1.39	0.56	CBAFN
1C	10/1/2022	107	80	6	0.32	0	P2	F05	1.86	0.56	CBAFN
1C	10/1/2022	111	88	5	0.21	0	P2	F08	1.85	0.56	CBAFN

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ATTACHMENT A - Fan Bar Wear Indications (SG 1D)

SGID	INSPDATE	ROW	COL	PER	VOLTS	DEG	CHN	LOCN	INCH1	PDIA	PTYPE
1D	10/1/2022	35	138	8	0.35	0	P2	F05	0.99	0.56	CBAFN
1D	10/1/2022	45	56	5	0.18	0	P2	F06	-0.99	0.56	CBAFN
1D	10/1/2022	50	57	5	0.2	0	P2	F05	1.25	0.56	CBAFN
1D	10/1/2022	72	71	5	0.3	0	P2	F06	0.91	0.56	CBAFN
1D	10/1/2022	81	70	11	0.56	0	P2	F06	-1.61	0.56	CBAFN
1D	10/1/2022	85	68	10	0.6	0	P2	F07	1.43	0.56	CBAFN
1D	10/1/2022	85	70	16	1.05	0	P2	F06	-1.38	0.56	CBAFN
1D	10/1/2022	86	67	8	0.36	0	P2	F06	0.66	0.56	CBAFN
1D	10/1/2022	86	69	10	0.63	0	P2	F07	-1.56	0.56	CBAFN
1D	10/1/2022	87	64	8	0.49	0	P2	F06	1.26	0.56	CBAFN
1D	10/1/2022	93	70	11	0.69	0	P2	F06	-1.08	0.56	CBAFN
1D	10/1/2022	95	68	9	0.43	0	P2	F05	-1.26	0.56	CBAFN
1D	10/1/2022	95	68	9	0.44	0	P2	F06	1.21	0.56	CBAFN
1D	10/1/2022	96	69	8	0.4	0	P2	F08	0.7	0.56	CBAFN
1D	10/1/2022	97	72	8	0.49	0	P2	F06	0.51	0.56	CBAFN
1D	10/1/2022	97	74	9	0.54	0	P2	F08	-0.86	0.56	CBAFN
1D	10/1/2022	99	64	7	0.35	0	P2	F05	-1.32	0.56	CBAFN
1D	10/1/2022	100	67	3	0.21	0	P2	F08	1.32	0.56	CBAFN
1D	10/1/2022	103	68	7	0.33	0	P2	F07	-1.28	0.56	CBAFN
1D	10/1/2022	104	53	11	0.56	0	P2	F05	1.36	0.56	CBAFN
1D	10/1/2022	104	77	5	0.24	0	P2	F06	-1.58	0.56	CBAFN