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RS-20-154 10 CFR 50.90

December 16, 2020

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

Braidwood Station, Units 1 and 2
Renewed Facility Operating License No. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Subject: Application for Revision to TS 5.5.9, "Steam Generator (SG) Program," for a One-Time Deferral of Steam Generator Tube Inspections

In accordance with 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," Exelon Generation Company, LLC (EGC) requests an amendment to the Technical Specifications (TS) for Renewed Facility License Nos. NPF-72 and NPF-77 for Braidwood Station, Units 1 and 2 (Braidwood).

This proposed amendment request revises TS 5.5.9, "Steam Generator (SG) Program," for a one-time revision to the frequency for SG tube inspections. The requested TS amendments support deferral of the TS required inspections until the next Unit 1 refueling outage.

Circumstances are present in that the Centers for Disease Control and Prevention (CDC) and the State of Illinois have issued recommendations advising isolation activities (e.g., social distancing, group size limitations, self-quarantining, etc.) to prevent the spread of the COVID-19 virus. The nature of the SG inspections prevents compliance with the CDC and State of Illinois guidance for social distancing because workers must be in constant proximity to each other. Additionally, the hot and radiological environment in which the work is performed increases the likelihood of individuals contracting and adds to the potential rapid spread of the virus. These inspections require a specialty vendor that maintains unique and complex qualifications. Losing individuals with these qualifications due to a virus spread would cause a situation where the proper technical knowledge would not be available to satisfactorily complete this work (minimal 10-day isolation and likely to be more than one individual based on the close proximity for the work).

As a result of the current pandemic situation, an Operational Assessment (OA) has been developed to justify deferral of the SG inspections until the next Unit 1 refueling outage (approximately 70 effective full power months from the last inspection). EGC has determined this deferral to involve less risk than performing the inspections under the current situation.

The attached request is subdivided as follows:

- Attachment 1 provides a description and assessment of the proposed change.

- Attachment 2 provides the existing TS page for Braidwood, marked up to show the proposed change.

- Attachment 3 provides the revised (i.e., clean, camera ready) TS pages for Braidwood. Although the proposed change only affects Braidwood Station, Unit 1, this submittal is being docketed for Braidwood Station, Units 1 and 2, since the TS are common to Units 1 and 2 for Braidwood.

- Attachment 4 provides Framatome Inc. Document No. 51-9320766-000, Braidwood 1 Steam Generator Operational Assessment Deferral of the Spring 2021 Steam Generator Inspections

The proposed change has been reviewed by Braidwood Plant Operations Review Committee in accordance with the requirements of the EGC Quality Assurance Program.

Approval of the proposed amendments is requested by February 15, 2021, which will support the Braidwood Unit 1 Spring 2021 refueling outage (A1R22). The requested approval date is based on contractual obligations associated with minimizing vendor support for A1R22 scope. Once approved, the amendments shall be implemented within 5 days.

In accordance with 10 CFR 50.91, "Notice for public comment; State consultation," paragraph (b), EGC is notifying the State of Illinois of this application for license amendment by transmitting a copy of this submittal and its attachment to the designated State Officials.

This submittal contains no regulatory commitments. Should you have any questions concerning this submittal, please contact Mr. Phillip A. Henderson at (630) 657-4327.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 16th day of December 2020.

Respectfully,

Dwi Murray
Sr. Manager – Licensing
Exelon Generation Company, LLC

Attachments:
1) Description and Assessment
2) Proposed Technical Specifications Change (Mark-Up)
3) Revised Technical Specifications Pages (Clean)
4) Framatome Inc. Document No. 51-9320766-000, Braidwood 1 Steam Generator Operational Assessment Deferral of the Spring 2021 Steam Generator Inspections

cc: NRC Regional Administrator, Region III
NRC Senior Resident Inspector – Braidwood Station
Illinois Emergency Management Agency – Division of Nuclear Safety

ATTACHMENT 1
Description and Assessment

Subject: Application for Revision to TS 5.5.9, "Steam Generator (SG) Program," for a One-Time Deferral of Steam Generator Tube Inspections

ATTACHMENT 1
Description and Assessment

1.0 SUMMARY DESCRIPTION

In accordance with 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," Exelon Generation Company, LLC (EGC) requests amendments to the Technical Specifications (TS) for Renewed Facility License Nos. NPF-72 and NPF-77 for Braidwood Station, Units 1 and 2 (Braidwood).

This proposed amendment request revises TS 5.5.9, "Steam Generator (SG) Program," for a one-time revision to the frequency for SG tube inspections. The requested TS amendments support deferral of the TS required inspections until the next Unit 1 refueling outage, which is scheduled in Fall 2022 (A1R23).

2.0 DETAILED DESCRIPTION

2.1 Reason for the Proposed Change

On January 27, as renewed on April 21, 2020, a Public Health Emergency (PHE) was declared for the entire United States in responding to the coronavirus (i.e., COVID-19 Virus). On March 9, 2020, the State of Illinois declared a disaster proclamation over the coronavirus outbreak. The Centers for Disease Control and Prevention (CDC) issued recommendations advising "social distancing" or sequestering individuals to prevent the spread of the COVID-19 virus.

On May 5, 2020, the Governor of Illinois announced that the State of Illinois would use health statistics and health care capacity to implement a five-phase plan to reopen the state. As of November 20, 2020, Braidwood is in a region that is in Phase 4 of this plan, which includes additional mitigation actions for Tier 3 of its COVID-19 Resurgence Mitigation Plan. Additional actions for Tier 3 of this plan includes restrictions to 25% capacity for many public places, limits group gatherings to 10 people or less, and recommends that employees work remotely if possible. These restrictions were put in place due to the state experiencing exponential spread of COVID-19 in every region, statewide positivity rates at record highs, and hospitalization rates surpassing the Spring 2020 peak.

To support the specific SG inspections during the Braidwood Unit 1 Spring 2021 refueling outage, there will be an estimated 175 people onsite, many of whom travel from other areas of the country. As such, this request is being made to support Braidwood's proactive efforts to follow the CDC recommendations (e.g., social distancing, group size limitations, self-quarantining, etc.) by limiting the number of people onsite and in our neighboring communities.

EGC has implemented practices beyond the CDC recommendations. These include self-screening questions of all workers prior to reporting to work, temperature monitoring, and questioning of all people prior to entering a company site or property and maximizing remote enabled employees. Braidwood has performed a detailed review of items for the Spring 2021 refueling outage to minimize the number of people who have to travel to the site. Items that are not necessary for nuclear safety or reliable generation are being deferred from the scope of the Spring 2021 refueling outage.

The nature of the SG inspections conflicts with the CDC recommendations since it requires workers to be in constant proximity to each other in a hot and radiological environment, increasing the likelihood of individuals contracting COVID-19 and potentially inducing a rapid spread (e.g., craft support for closure assembly/disassembly, platform construction, robot manipulations). The personal protective equipment (PPE), consisting of masks issued to all individuals onsite, are required to be used in situations where social distancing cannot be maintained, adds time and individual effort to activities, which in turn can potentially increase human performance and safety risk. Additionally, these inspections require a specialty vendor that maintains unique and complex qualifications. Losing people due to a spread of the COVID-19 virus would cause a situation where the proper technical knowledge would not be available to satisfactorily complete this work (e.g., minimal 10-day isolation and likely to be more than one individual based on having to work in close proximity for the work). This could result in not meeting the TS requirement for tube integrity and examination scope and limit the ability to reassemble the SGs.

As a result of the current and ongoing pandemic situation, an Operational Assessment (OA) has been developed to justify deferral of the SG inspections until the next Unit 1 refueling outage in the Fall of 2022 (approximately 70 effective full power months from the last inspection). Attachment 4 provides this OA, which addresses both existing and potential degradation mechanisms. EGC has determined this deferral to involve less risk than performing the inspections under the current situation.

2.2 Description of the Proposed Change

The proposed change to Braidwood TS 5.5.9, "Steam Generator (SG) Program," is being requested as described below (added text **underlined and bolded**).

TS 5.5.9.d.2 currently states (in part):

> For Unit 1, after the first refueling outage following SG installation, inspect each SG at least every 72 effective full power months or at least every third refueling outage (whichever results in more frequent inspections). In addition, the minimum number of tubes inspected at each scheduled inspection shall be the number of tubes in all SGs divided by the number of SG inspection outages scheduled in each inspection period as defined in a, b, c, and d below. If a degradation assessment indicates the potential for a type of degradation to occur at a location not previously inspected with a technique capable of detecting this type of degradation at this location and that may satisfy the applicable tube plugging criteria, the minimum number of locations inspected with such a capable inspection technique during the remainder of the inspection period may be prorated. The fraction of locations to be inspected for this potential type of degradation at this location at the end of the inspection period shall be no less than the ratio of the number of times the SG is scheduled to be inspected in the inspection period after the determination that a new form of degradation could potentially be occurring at this location divided by the total number of times the SG is scheduled to be inspected in the inspection period. Each inspection period defined below may be extended up to 3 effective full power months to include a SG inspection outage in an inspection period and the subsequent inspection period begins at the conclusion of the included SG inspection outage.

ATTACHMENT 1
Description and Assessment

The revised TS 5.5.9.d.2 (in part) will state:

> For Unit 1, after the first refueling outage following SG installation, inspect each SG at least every 72 effective full power months or at least every third refueling outage (whichever results in more frequent inspections)**, with the exception that each SG is to be inspected during the fourth refueling outage in A1R23 following inspections completed in refueling outage A1R19.** In addition, the minimum number of tubes inspected at each scheduled inspection shall be the number of tubes in all SGs divided by the number of SG inspection outages scheduled in each inspection period as defined in a, b, c, and d below. If a degradation assessment indicates the potential for a type of degradation to occur at a location not previously inspected with a technique capable of detecting this type of degradation at this location and that may satisfy the applicable tube plugging criteria, the minimum number of locations inspected with such a capable inspection technique during the remainder of the inspection period may be prorated. The fraction of locations to be inspected for this potential type of degradation at this location at the end of the inspection period shall be no less than the ratio of the number of times the SG is scheduled to be inspected in the inspection period after the determination that a new form of degradation could potentially be occurring at this location divided by the total number of times the SG is scheduled to be inspected in the inspection period. Each inspection period defined below may be extended up to 3 effective full power months to include a SG inspection outage in an inspection period and the subsequent inspection period begins at the conclusion of the included SG inspection outage.

Attachment 2 provides the existing TS page for Braidwood Station, Units 1 and 2, marked up to show the proposed change. To assist the NRC's review of the proposed change, Attachment 3 provides the revised (i.e., camera-ready) TS pages.

Although the proposed change only affects Braidwood Station, Unit 1, this submittal is being docketed for Braidwood Station, Units 1 and 2, since the TS are common to Units 1 and 2 for the Braidwood Station.

3.0 TECHNICAL EVALUATION

3.1 System Description

The Braidwood SGs are vertical shell and U-tube heat exchangers with integral moisture separating equipment. Braidwood Unit 1 contains four (4) feedring replacement steam generators (RSGs) designed and fabricated by Babcock and Wilcox (BWXT) of Cambridge, Ontario, Canada. These RSGs were installed in 1998. The nomenclature used for in-service inspection is SG A, SG B, SG C and SG D for the four RSGs in Braidwood Unit 1.

Each steam generator contains 6633 Thermally Treated Alloy 690 (A690TT) U-tubes that have an outer diameter of 0.6875” with 0.040” wall thickness. Stainless steel lattice grids and fan bars support the tubing in the straight legs and U-bends, respectively. The tubing within the tubesheets was hydraulically expanded throughout the full thickness of the tubesheet. The low row U-Bend radii are as follows, Row-1 (3.973”), Row-2 (3.691”), Row-3 (3.632”), and Row-4

(3.720") with Row-3 radius being the tightest radius U-Bend. The U-bend region of rows 1 through 21 were stress relieved following bending.

The feedring and J-tubes were fabricated with materials that are not susceptible to flow accelerated corrosion (FAC): seamless ferritic chrome moly steel SA-335 GR P22 and Inconel 690 SB-167, respectively. The steam drum internals are fabricated from carbon steel with a minimum chromium content specified (0.12% to 0.19%) to minimize FAC. The design incorporates two levels of steam separation equipment: 95 curved arm primary (CAP) cyclones and 95 secondary cyclones.

3.2 Technical Analysis

The current Braidwood Unit 1 TS requirement (5.5.9.d.2) is to inspect each SG at least every 72 effective full power months (EFPM) or at least every third refueling outage (whichever results in more frequent inspections). The proposed revision allows the one-time inspection deferral of each SG to after four operating cycles following refueling outage A1R19 performed in October 2016. This equates to approximately 70 EFPM of operation since the last SG inspection.

Significant operating experience has been gained over the course of 17 years since the current TS inspection frequency was established and provides a basis for deferring the inspection by one operating cycle.

The susceptibility to stress corrosion cracking (SCC) in Alloy 690TT has not been seen in the SG Fleet. Only wear mechanisms, i.e., support wear, tube-to-tube wear and foreign object wear, have been documented thus far for the Alloy 690TT fleet.

Based on this operating experience and a supporting 4-cycle Operational Assessment (OA), the proposed TS change to require inspection of the tubing after four operating cycles, approximately 70 EFPM, can be technically justified and is presented below.

To justify the deferral of the inspections to after a fourth operating cycle, the SG Program requires assessments to ensure safe SG inspection intervals that are based on measurable parameters that monitor SG performance, such as results of SG tube inspections and operational leakage. Objective criteria to assess performance were established based on deterministic analyses and performance history. In addition, the TS requirements on operational leakage require a plant shutdown if the limits are exceeded. During the extended operating cycle from A1R22 to A1R23, Braidwood Unit 1 will decrease its normal 100 gallons per day (gpd) shutdown criteria for primary-to-secondary leakage required by the EPRI Steam Generator Management Program: PWR Primary-to-Secondary Leak Guidelines (Reference 10) down to 30 gpd for confirmed and sustained leakage at or above that level. This ensures that the failure to meet a performance criterion, while undesirable, will not result in an immediate safety concern. Therefore, the proposed one-time extension of the existing SG inspection frequency is acceptable.

3.2.1 Recent Operational Experience Summary

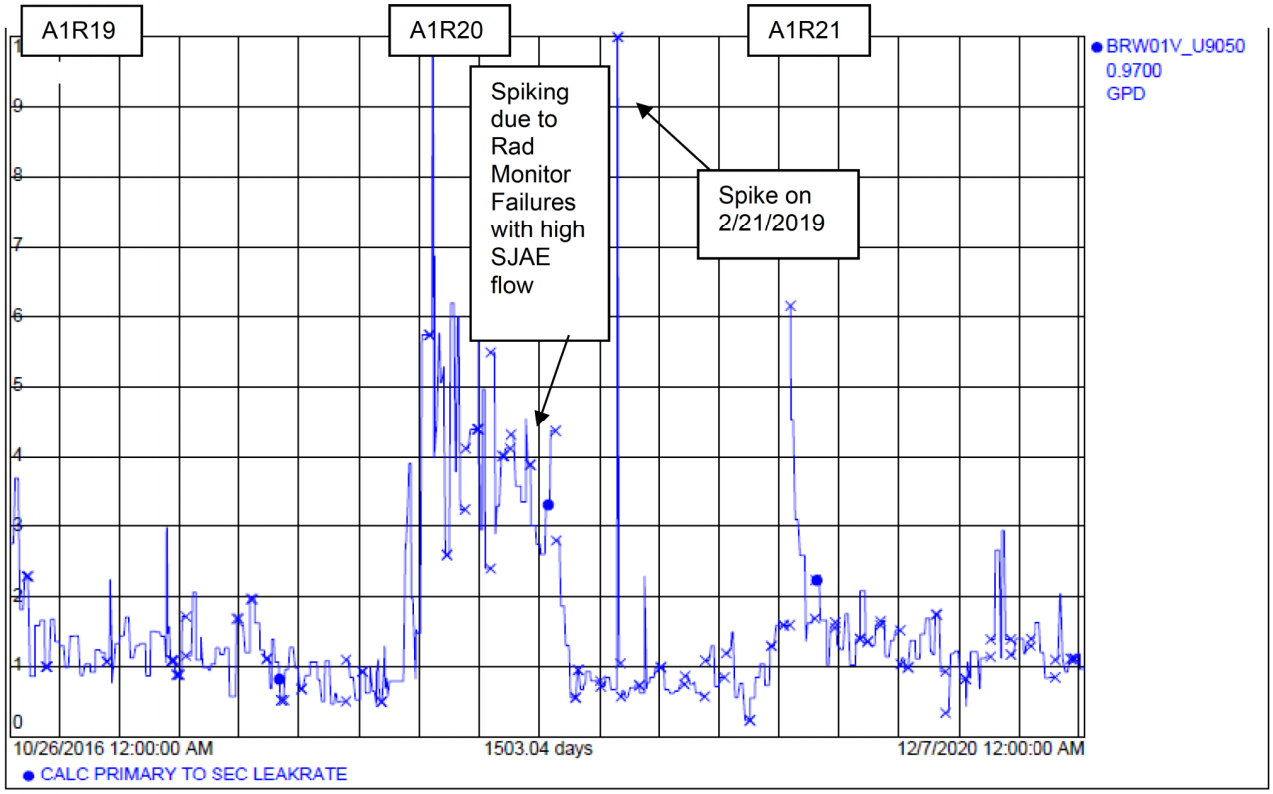
3.2.1.a Trends of Primary to Secondary Leakage

The primary to secondary leak (PSL) rate determination utilizes the Condenser Offgas method, which uses steam jet air ejector (SJAE) flow, with leak rate calculated based on mass-balance of noble gas isotopes. Leak rates are continuously monitored using on-line radiation monitors and supporting software available in the control room. During unit start-ups, these flows are normally higher due to systems being returned to service. The high SJAE flow causes a higher apparent primary to secondary leak rate during start-up and post outage which are not related to actual primary to secondary leakage.

No confirmed primary to secondary side leakage has been noted for operating Cycles 20, 21, 22 and none is expected through the remainder of the operating cycle. As shown in Figure 1, all trends are below 3 gallons per day (gpd), except for spiking which occurred post A1R20 due to multiple failures of 1PR027J Radiation monitor with higher than normal SJAE flow causing a false PSL greater than 3 gpd. In addition, a spike occurred around February 21, 2019 due to 1PR27J being taken out of service temporarily. Chemistry obtained a sample when 1PR027J was not available. Other typical spikes which occurred post refueling outages were due to air in-leakage issues and not related to actual primary to secondary leakage.

Section 3.2.4 discusses the threshold for actions due to confirmed primary-to-secondary leakage and planned mitigating strategy that will be implemented during the extended operating cycle from A1R22 to A1R23.

Figure 1: Primary to Secondary Leak Rate for Operating Cycles 20, 21, and 22



3.2.1.b Summary of Most Recent Primary and Secondary (e.g., FOSAR) Inspections, Detected Degradation and Its Location

The Braidwood Unit 1 (A1R19) report, "Braidwood Station, Unit 1 Steam Generator Tube Inspection Report for Refueling Outage 19," dated February 27, 2017 (Reference 3) contains the high-level summary of the most recent primary and secondary inspections, including all degradation detected and location of the degradation.

3.2.1.c Number of Tubes Plugged and Reason for Plugging

The number of tubes plugged for Braidwood Unit 1 and plugging percentage are noted in Table 1. Table 2 represents the reasons for tube plugging during each SG inspection outage since replacement.

ATTACHMENT 1
Description and Assessment

Table 1: Braidwood Unit 1 Plugging Status

Plugging Summary (Post A1R19)	SG 1A	SG 1B	SG 1C	SG 1D	TOTAL
Total Tubes Plugged	32	40	16	1	89
Total PCT Plugged	0.48%	0.60%	0.24%	0.02%	0.335%
Plugging Limit	5%	5%	5%	5%	5%

ATTACHMENT 1
Description and Assessment

Table 2: Braidwood Unit 1 Plugging History by Degradation Mechanism[3]

Date	Outage	EFPY	Fan Bar Wear	OD Vol Near TSPs	Foreign Object (FO) Wear	Preventative Due to FO	Other	Total
	PSI [2]	0	0	0	0	0	3	3
03/00	A1R08	1.292	1	0	0	0	0	1
9/01	A1R09 [1]	2.734						
04/03	A1R10	4.222	0	0	15	6	0	21
10/04	A1R11	5.643	0	0	5	0	0	5
4/06	A1R12	7.093	0	0	2	26	0	28
10/07	A1R13	8.489	0	0	1	20	0	21
04/09	A1R14	9.897	0	0	2	3	0	5
10/10	A1R15 [1]	11.324						
4/12	A1R16	12.758	0	0	1	0	0	1
9/13	A1R17 [1]	14.057						
4/15	A1R18 [1]	15.547						
9/16	A1R19	16.976	0	0	0	4	0	4
4/18	A1R20 [1]	18.426						
10/19	A1R21 [1]	19.876						
TOTALS			1	0	26	55	3	89

Note 1: SG Inspections not performed.
Note 2: Replacement SGs (RSGs) were installed during A1R07.
Note 3: Braidwood Unit 1 RSGs do not have any sleeves installed.

3.2.1.d Relevant Operating Experience that Could Impact Tube Integrity

Deposit Loading

Based on the deposit loading amounts for Braidwood Unit 1, as shown below, the deposits do not impose an adverse impact to tube integrity. Sludge lancing is performed during SG inspections as shown in Table 3 below. The Unit 1 SG water level has trended steady and visual inspections of the uppermost tube supports during A1R19 showed only trace amounts of deposits.

Table 3: Braidwood Unit 1 Historical Deposits Since Cycle 9

RFO	Iron (as Fe3O4) Transported (4 SG Total, lbs)	Deposits Removed via Blowdown during Cycle (4 SG Total, lbs)	Deposits Removed via Sludge Lancing and Blowdown (4 SG Total, lbs)	Deposits Remaining (cycle net) (4 SG Total, lbs)	Cumulative Deposits Remaining (4 SG Total, lbs)
A1R09	425	21	0	404	808
A1R10	435	22	260	153	961
A1R11	335	17	0	318	1279
A1R12	440	22	184	234	1513
A1R13	431	22	197	213	1726
A1R14	308	15	388	-95	1631
A1R15	351	406(1)	0	-55	1576
A1R16	320	280	100	-60	1516
A1R17	128	280	0	-152	1364
A1R18	166	298	0	-132	1232
A1R19	145	381	98.5	-334.5	897.5
A1R20	133	156	0	-23	874.5
A1R21	401(2)	50	0	351	1225.5

(1) Poly Acrylic Acid (PAA) Dispersant injection started during cycle prior to A1R15
(2) Higher than normal due to three Unit forced outages which affects estimate of iron transport for Cycle 21

Chemistry (Unit 1 Operating Cycles 20, 21 and 22)

There has been no major adverse SG chemistry conditions during Cycle 20, 21 or Cycle 22 (to-date).

Cycle 20 SG Chemistry:

- Minor Chemistry Effectiveness Indicator (CEI-R) penalties for sodium >0.80 ppb were accrued during startup from A1R19.
- A chronic low-level sodium source on the secondary side was present throughout the cycle.

Cycle 21 SG Chemistry:

- No CEI-R points were accrued in Cycle 21.
- No chemistry excursions noted.

Cycle 22 SG Chemistry (as of November 2020):

- To-date, no CEI-R penalties accrued.
- No chemistry excursions noted to-date.

Steam Drum

Steam drum inspections were performed during A1R16 in SG 1C and during A1R19 in SG 1D. No evidence of foreign material, degradation, or structural distortion was observed in the steam drum regions. The primary and secondary separators were in good condition. Some fouling from trace amounts of scale deposits of the upper tube bundle was observed, primarily on the hot leg side, as expected.

Therefore, based on the operating experience summary described above, it was concluded that one additional operating cycle is justified with no adverse consequences to extend the planned SG inspection until the next Unit 1 refueling outage in the Fall of 2022 (A1R23).

Foreign Material

Table 4 provides a listing of foreign objects remaining in the SGs at the conclusion of A1R19. One foreign object in SG A (weld slag) could not be removed, resulting in the plugging of four tubes in a high flow region. The remaining 7 foreign objects left in the steam generators are considered to be benign foreign objects. Three of the foreign objects are legacy objects that were re-observed in A1R19. Historically, wear has never been detected at Braidwood Unit 1 at tubes with benign foreign objects remaining in the SG.

A search of issue reports related to foreign material events was performed for Braidwood Unit 1 operating Cycles 20, 21, and 22 (to-date), and no indications of ingress of foreign material into the Unit 1 SGs occurred from other systems during that time frame.

Foreign Object Review

Table 4: Foreign Objects Remaining in SGs from A1R19

SG	Part ID	Description	Row	Col	Leg	Length	Width	Height	Metallic?	Legacy?
A	A001	Weld Slag[1]	81	22	CL	1.5	0.1	0.1	Yes	No
B	B004	Gasket	24	75	HL	1.5	0.01	0.01	Yes	No
C	C001	Snare Collar	3	48	HL	0.14	0.11	0.3	Yes	Yes
C	C002	Machining Remnant	32	69	CL	0.1	0.01	0.01	Yes	No
C	C003	Machining Remnant	32	69	CL	0.1	0.01	0.01	Yes	No
C	C004	Gasket	44	75	CL	1.5	0.188	0.05	Yes	No
C	C008	Gasket[2]	33	102	HL	0.920	0.050	0.188	Yes	Yes
C	C009	Wire[2]	33	102	HL	0.50	0.020	0.020	Yes	Yes

1) Potentially affected tubes surrounding this foreign object were preventatively plugged.
2) Dimensions were switched for C008 and C009 between A1R16 and A1R19 SG inspections, now corrected.

3.2.2 Condition Monitoring (CM) During Refueling Outage A1R19 (October 2016)

A summary of the Condition Monitoring (CM) results for A1R19 was submitted to the NRC on February 27, 2017, (Reference 3). The detailed inspection results and inputs used to perform the CM assessment are provided in the CM and OA developed for A1R19 (Reference 4).

3.2.2.a For Each Degradation Mechanism Detected, the Most Limiting As Found Condition Compared to the Tube Performance Criteria

For each degradation mechanism detected at the last Braidwood Unit 1 SG inspection in A1R19 (October 2016), the most limiting as found condition was compared to the tube performance criteria and is provided in Table 5.

The limiting case degraded condition detected at A1R19 for each degradation mechanism was less than the condition monitoring limit; therefore, Structural Integrity Performance Criteria (SIPC) were satisfied. The severity of the limiting degraded condition for each degradation mechanism is expressed as a percent through wall (%TW) depth and compared to the CM limit calculated for a given bounding axial extent. The SIPC is met if the as found worst case depth ("Maximum Depth Recorded" in Table 5) is less than the allowable depth ("CM Limit Depth" in Table 5). As can be seen for all degradation mechanisms detected in A1R19, the smallest margin, was for foreign object wear and was approximately 33.8%TW.

Table 5: Summary of Condition Monitoring Performance for Existing Degradation Mechanisms during A1R19 (October 2016) (Reference 4)

Degradation Mechanism Detected at A1R19	Maximum Depth Recorded (%TW)	Projected Max Depth at A1R19 from A1R17 OA (%TW)	CM Limit Depth (%TW)	Margin to CM Limit (%TW)	Bounding (B) or Actual Max (A) Axial Extent (inch)	Sizing ETSS
Fan Bar Wear	16	58.2	54.8	38.8	1.7 (B)	96004.3
Lattice Grid Wear	9	48.6	53.4	44.4	3.15 (B)	96004.3
Foreign Object Wear	27	Limiting flaw won't challenge structural or leakage integrity	60.8	33.8	0.53 (A)	27902.1

3.2.2.b Discuss any tubes that required flaw profiling to demonstrate condition monitoring was met

No tubes required flaw profiling to demonstrate that the CM limit was not exceeded.

3.2.3 Operational Assessment (OA) Supporting an Additional Operating Cycle

The existing degradation mechanisms observed at Braidwood Unit-1 that require an OA are as follows:

- Fan Bar support wear
- Lattice Grid support wear
- Foreign Object wear

In addition to the existing degradation mechanisms stated above, one potential degradation mechanism (tube-to-tube wear) was considered as input for Braidwood's request to operate for 4-cycles between SG inspections.

3.2.3.a Inspection Strategy Details During A1R19 Inspection for the Degradation Mechanisms Described Above are as Follows:

All mechanical wear mechanisms – Full-length bobbin inspection of 100% of in-service tubes using qualified techniques were used to detect mechanical wear. Additional analysis and exams were performed on the tube periphery where the flow velocities and operating experience have shown a greater susceptibility to foreign object wear. Specifically, Bobbin probe examination of all in-service tubes within five tubes of the no-tube lane and periphery was enhanced using Westinghouse Auto-History Compare (AHC) software via EPRI SG Examination Guidelines Appendix H qualified ETSS-FOW-AHC-BOB for foreign object wear detection at the top of the tubesheet (TTS) on both the hot leg and the cold leg. In addition, at the TTS where the bobbin probe's detection capabilities were challenged due to noise, supplemental array probe testing was used. These exams were performed on the tube periphery where the flow velocities and operating experience have shown a greater

susceptibility to foreign object wear. Bobbin probe was used to depth size all detected wear at structures. The +Point™[1] probe was used to depth and length size all foreign object wear.

3.2.3.b Operational Assessment Summary for All Degradation Mechanisms; Including Predicted Margin to the Tube Integrity Performance Criteria at A1R23 (Fall 2022):

NEI 97-06 (Reference 1) requires that a "forward looking" operational assessment be performed to determine if the steam generator tubing will continue to meet specific structural and leakage integrity performance criteria throughout the operating period preceding the next inspection.

The technical justification for deferring the A1R22 SG tube examination by one operating cycle for mechanical wear at structures mechanisms is based on a new OA provided in Attachment 4 that was performed in accordance with EPRI SG Integrity Assessment Guidelines (Reference 2). This OA supplements the current OA (Reference 4) from the end of operating Cycle 22 condition to the end of operating Cycle 23, thus justifying operation of the SGs for four operating cycles between SG eddy current inspections. The OA provided, Attachment 4, fully supports the deferral of the A1R22 SG inspections until the next Unit 1 refueling outage (A1R23) where, for the existing and potential degradation mechanisms:

(1) Structural integrity performance criterion (SIPC) margin requirement of three times normal operating pressure (3xNOPD) on tube burst will be satisfied at A1R23, and
(2) Accident-induced leakage performance criteria (AILPC) for the limiting accident condition will be met for the end of Cycle 23 condition.

SG tubing is subject to two types of degradation; existing degradation, or degradation modes previously observed within the Braidwood Unit 1 SGs, and potential degradation, or degradation modes not yet observed within the Braidwood Unit 1 SGs but judged to have a meaningful likelihood of occurrence based on operation of similar units or laboratory testing.

There is reasonable assurance that with a deferral of the next Braidwood Unit 1 SG examination from A1R22 to A1R23, the SG structural and leakage integrity performance criteria will remain satisfied throughout the operating period preceding A1R23. Table 6 summarizes the projected margin to SIPC and AILPC at A1R23 for each tube degradation mechanism evaluated.

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[1] *+Point are trademarks or registered trademarks of Zetec, Inc., its subsidiaries and/or affiliates in the United States of America and may be registered in other countries through the world. All rights reserved. Unauthorized use is strictly prohibited. Other names may be trademarks of their respective owners*

Table 6: Braidwood Unit 1 Tube Integrity Margin Summary

Degradation Mechanism	SIPC		AILPC	
	Structural Limit (at bounding length)	Projected Upper Bound Depth at A1R23	Limit	A1R23 Projection
Fan Bar Support Wear	58.0 %TW	34.8 %TW	0.218 GPM	Zero Leakage
Lattice Grid Support Wear	56.6 %TW	28.0 %TW	0.218 GPM	Zero Leakage
Foreign Object Wear	57.6 %TW	< 57.6 %TW	0.218 GPM	Zero Leakage
Tube-to-tube Wear(1)	55.5 %TW	31.7 %TW	0.218 GPM	Zero Leakage

Notes:
1. Tube-to-tube wear has not been identified in the Braidwood Unit 1 SGs after ~17 EFPY of operation. It is considered a potential degradation mechanism and the operational assessment assumes a bounding scenario considering an undetected indication at A1R19.

During prior outages the condition of secondary side components of both the upper tube bundle as well as the steam drum has been routinely monitored. Inspections during A1R19 and A1R16 have not identified any anomalous structural conditions, foreign objects or flow accelerated corrosion (FAC) of any components. Therefore, there is reasonable assurance that secondary side component degradation will not generate foreign objects within the SGs prior to A1R23; supporting the deferral of secondary side inspections until A1R23.

In summary, the required technical justification for deferral of the planned SG examinations during A1R22, Attachment 4, shows that even with conservative OA predictions for all existing structural wear degradation mechanisms and the potential degradation mechanism, sufficient margin exists to justify extended operation of Braidwood Unit 1 until A1R23 (Fall 2022).

Methodology and OA Results for Mechanical Wear Due to Foreign Objects

During the Fall 2016 refueling outage at Braidwood Unit 1 (A1R19), Foreign Object Search and Retrieval (FOSAR) was performed at the top of the secondary tubesheet in all four SGs. These inspections identified a small variety of foreign objects and material at the top of tubesheet. All new and previous foreign object wear indications including their location and size were previously reported to the NRC for A1R19 via Reference 3.

Before returning from A1R19, a 3-cycle OA covering the potential for future Foreign Object (FO) wear was developed (Reference 4). This assessment addressed the foreign objects identified during the A1R19 eddy current inspections and FOSAR. To support a fourth operating cycle, the revised OA, as documented in Attachment 4, was developed to supersede the A1R19 OA.

It should be noted that during A1R19, and prior outages, all foreign objects deemed to have the

potential for causing foreign object wear or that have caused wear were removed from the SGs, when possible. When foreign object removal is not possible, in order to prevent further tube wear, all tubes in contact with the foreign object causing active tube wear are preventatively plugged and stabilized.

In summary, the result of the revised foreign object OA (Attachment 4), which is based on a wear evaluation for the remaining foreign objects identified in A1R19 and potential new ones, concludes that they will not cause significant tube wear sufficient to degrade tube structural or leakage integrity to below acceptance criteria for at least four cycles at current operating conditions. Since the SG inspection in A1R19, there have been no identified foreign object intrusions into the SGs or Feedwater system at Braidwood Unit 1.

3.2.4 Mitigating Strategies

The normal Mode 1 (Power Operation) requirement under the EPRI Steam Generator PWR Primary-to-Secondary Leak Guidelines (Reference 10) state that Action Level 1 is reached at a leakage rate of 30 gallons per day (gpd). However, the guidelines require a site to enter an "Increased Monitoring" condition when total primary-to-secondary leakage is detected to be equal to or greater than 5 gpd. After entering the increased monitoring condition, radiation monitors alert/alarm set points are reset, as necessary, to above their existing baseline reading (but not over 30 gpd) to permit detection of rapidly increasing leakage.

EGC procedure CY-AP-120-340, "Primary-to-Secondary Leak Program," (Reference 5) currently in effect has lower administrative limits on Primary-to-Secondary leakage in order to ensure Braidwood Unit 1 is prepared to quickly respond should the leakage rate increase. Steam Generator Management Program Monitoring condition is entered when normal radiochemical grab sampling and process radiation monitors indicate leakage of greater than or equal to 3 gpd. This describes the condition in which leakage has been detected and quantified and is greater than or equal to 3 gpd but is not in a range that can be accurately monitored by most radiation monitors. When this occurs, Engineering is notified, and the appropriate Corrective Action Processes are initiated to document and track the excursion. These activities are described in EGC procedure ER-AP-420-0051, "Conduct of Steam Generator Management Program Activities." (Reference 6)

When operational leakage is equal to or greater than 3 gpd is confirmed during the operating period between inspections, at the next outage, in situ pressure testing, tube pull, or analysis should be performed to quantify the expected accident leak rate to assess compliance with accident leakage performance criteria. In addition, prior to entering an outage, an action plan is developed to address means of identifying the defective tube(s), flowchart sampling methods to bound the defect and provide reasonable assurance that unit restart is prudent.

During the extended operating cycle from A1R22 to A1R23, Braidwood Unit 1 will lower its normal 100 gpd shutdown criteria for primary-to-secondary leakage down to 30 gpd for confirmed and sustained leakage at or above that level. This action will provide more margin by requiring shutdown at a lower leakage level, thereby lowering the likelihood of a steam generator tube burst.

Braidwood Unit 1 maintains a Loose Parts Detection System on the Steam Generators that monitors for activity on the primary side of the Hot Leg and Cold Leg. Planned maintenance during refueling outage A1R22 will ensure the system is fully functional. Should a loose part be present in the hot leg or cold leg primary bowl during operating Cycle 23, Braidwood Unit 1 will take appropriate action to minimize any damage to the Steam Generators.

4.0 REGULATORY ANALYSIS

Applicable Regulatory Requirements/Criteria

Section 182a of the Atomic Energy Act requires applicants for nuclear power plant operating licenses to include technical specifications as part of the license. The Commission's regulatory requirements related to the content of the technical specifications are contained in Title 10, Code of Federal Regulations (10 CFR), Section 50.36, "Technical Specifications," of 10 CFR Part 50 "Domestic Licensing of Production and Utilization Facilities." The Technical Specification requirements in 10 CFR 50.36 include the following categories: (1) safety limits, limiting safety systems settings and control settings, (2) limiting conditions for operation, (3) surveillance requirements, (4) design features, and (5) administrative controls. As required by 10 CFR 50.36(c)(5), administrative controls are the provisions relating to organization and management, procedure, recordkeeping, review and audit, and reporting necessary to assure operation of the facility in a safe manner.

For Braidwood Unit 1, SG tube integrity is maintained by meeting the performance criteria specified in Braidwood TS 5.5.9, "Steam Generator (SG) Program," for structural and leakage integrity, consistent with the Braidwood Updated Final Safety Analysis Report (UFSAR), Section 5.4.2. In addition, Braidwood TS 3.4.13, "RCS Operational LEAKAGE," requires a limit on operational primary-to-secondary leakage, beyond which the plant must be shut down. Braidwood TS 3.4.19, "Steam Generator (SG) Tube Integrity," requires that SG tube integrity be maintained and all SG tubes satisfying the tube plugging criteria shall be plugged in accordance with the SG Program.

Should an existing flaw that exceeds the tube integrity repair limit not be detected during the periodic tube surveillance required by the plant TS, the operational leakage limit provides added assurance of timely plant shutdown before tube structural and leakage integrity are impaired.

The proposed one-time revision to TS 5.5.9 to defer the SG inspection to be performed after four operating cycles following refueling outage A1R19 does not alter Braidwood Unit 1 compliance with the referenced TS LCOs or the requirements of 10 CFR 50.36.

As stated in 10 CFR 50.59(c)(1)(i), a licensee is required to submit a license amendment pursuant to 10 CFR 50.90 if a change to the technical specifications is required. Furthermore, the requirements of 10 CFR 50.59 necessitate that the NRC approve technical specification changes before the changes are implemented. EGC's submittal meets the requirements of 10 CFR 50.59(c)(1)(i) and 10 CFR 50.90.

General Design Criterion (GDC) 14, "Reactor Coolant Pressure Boundary (RCPB)," of Appendix A "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 requires,

among other things, that the reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture. The proposed change continues to provide steam generator tube inspections that will contribute to a robust RCPB.

GDC 15, "Reactor Coolant System (RCS) Design," the reactor coolant system and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences. The proposed change does not negatively impact steam generator tube integrity during normal operation or anticipated operational occurrences.

GDC 30, "Quality of reactor coolant pressure boundary," requires that components which are part of the RCPB shall be designed, fabricated, erected, and tested to the highest quality standards practical. The proposed change does not reduce quality standards for steam generator design, fabrication, or testing.

GDC 31, "Fracture prevention of reactor coolant pressure boundary," requires the RCPB be designed with sufficient margin to assure that when stressed under operating, maintenance, testing, and postulated accident conditions (1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The proposed change does not alter the fracture prevention design of the steam generator tubes.

GDC 32, "Inspection of reactor coolant pressure boundary," the steam generator tubes are designed to permit periodic inspection and testing to assess their structural and leak tight integrity. The proposed change does not eliminate periodic inspection or testing of the steam generator tubes.

EGC also analyzed the consequences of postulated design basis accidents (DBAs), such as a SG tube rupture and a steam line break. These analyses consider primary-to-secondary leakage that may occur during these events and must show that the offsite radiological consequences do not exceed the applicable limits of 10 CFR 50.67, "Accident source term," or 10 CFR 100.11, "Determination of exclusion area, low population zone, and population center distance," for offsite doses; GDC 19 for control room operator doses (or some fraction thereof as appropriate to the accident); or the NRC-approved licensing basis (e.g., a small fraction of these limits). No accident analyses for Braidwood are being changed because of the proposed amendments, and therefore, no radiological consequences of any accident analysis are being changed. The proposed change maintains the accident analyses and consequences that the NRC has reviewed and approved for the postulated DBAs for SG tubes.

EGC has reviewed the basis for conformance to these GDC, as described in the Braidwood Station UFSAR and has concluded that the proposed one-time revision to defer the Braidwood Unit 1 Steam Generator inspection to be performed after four operating cycles following refueling outage A1R19 remains in conformance with all requirements.

4.2 No Significant Hazards Consideration

Exelon Generation Company, LLC (EGC) requests amendments to the Technical Specifications (TS) for Renewed Facility License Nos. NPF-72 and NPF-77 for Braidwood Station, Units 1 and 2.

This proposed amendment request revises TS 5.5.9, "Steam Generator (SG) Program," for a one-time revision to the frequency for SG tube inspections. The requested TS amendment supports deferral of the TS required inspections until the next Unit 1 refueling outage, which is scheduled in Fall 2022 (A1R23).

EGC has evaluated the proposed change against the criteria of 10 CFR 50.92(c) criteria to determine if the proposed change results in any significant hazards. The following is the evaluation of each of the 10 CFR 50.92(c) criteria:

1) Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

   Response: No.

   The proposed one-time change will defer the SG inspection to be performed after four operating cycles. This change does not physically change the SGs, the plant, or the way the SGs or plant are operated. This change also does not change the design of the SG. Inspection frequencies and inspection activities are not an initiator to a SG tube rupture accident, or any other accident previously evaluated. As a result, the probability of an accident previously evaluated is not significantly increased. The SG tubes inspected by the SG Program continue to be required to meet the SG Program performance criteria and to be capable of performing any functions assumed in the accident analysis. As a result, the consequences of any accident previously evaluated are not significantly increased.

   Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2) Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

   Response: No.

   The proposed one-time change will defer the SG inspection to be performed after four operating cycles. The proposed change does not alter the design function or operation of the SGs or the ability of an SG to perform its design function. The SG tubes continue to be required to meet the SG Program performance criteria. An analysis has been performed which evaluates all credible failure modes. This analysis resulted in no new or different kind of accident then has been previously evaluated. The proposed change does not create the possibility of a new or different kind of accident due to credible new failure mechanisms, malfunctions, or accident initiators that not considered in the design and licensing bases.

Therefore, the proposed change does not create the possibility of a new or different kind of accident from any accident previously evaluated.

3) Does the proposed amendment involve a significant reduction in a margin of safety?

Response: No.

The proposed one-time change will defer the SG inspection to be performed after four operating cycles. The proposed change does not change any of the controlling values of parameters used to avoid exceeding regulatory or licensing limits. The proposed change does not affect a design basis or safety limit, or any controlling value for a parameter established in the UFSAR or the license.

Therefore, the proposed change does not involve a significant reduction in a margin of safety.

Based on the above, EGC concludes that the proposed amendments do not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92(c), and, accordingly, a finding of "no significant hazards consideration" is justified.

4.3 Precedent

The following precedent applies to the Braidwood Unit 1 application for a one-time deferral of the Steam Generator Inspections:

- Letter from J. S. Wiebe (U.S. Nuclear Regulatory Commission) to B. C. Hanson (Exelon Generation Company, LLC), "Braidwood Station, Unit 2 – Issuance of Amendment No. 209 RE: One-Time Extension of Steam Generator Inspections [COVID-19] (EPID L-2020-LLA-0069)," dated May 1, 2020 (ML20111A000) (Reference 7)

- Letter from D. J. Galvin (U.S. Nuclear Regulatory Commission) to K. J. Peters (Vistra Operations Company LLC), "Comanche Peak Nuclear Power Plant, Unit Nos. 1 and 2 – Issuance of Amendment Nos. 173 and 173 Regarding Revision to Technical Specification 5.5.9, 'Unit 1 Model D76 and Unit 2 Model Steam Generator (SG) Program' (Exigent Circumstances) (EPID L-2020-LLA-0072)," dated April 17, 2020 (ML20108E878) (Reference 8)

- Letter from J. S. Wiebe (U.S. Regulatory Commission) to B. C. Hanson (Exelon Generation Company, LLC), "Byron Station, Unit 1 and 2 – Issuance of Amendment Nos. 222 and 222 RE: One-Time Extension of Unit No. 2 Steam Generator Inspections [COVID-19] (EPID-L-2020-LLA-0156)," dated September 21, 2020 (ML20246G865) (Reference 9)

4.4 Conclusion

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

5.0 ENVIRONMENTAL CONSIDERATION

EGC has determined that the proposed amendments would change requirements with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. However, the proposed amendments do not involve (i) a significant hazards consideration, (ii) a significant change in the types or a significant increase in the amounts of any effluents that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed change meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendments.

6.0 REFERENCES

1. Nuclear Energy Institute (NEI) 97-06, Revision 3, "Steam Generator Program Guidelines," January 2011

2. Electric Power Research Institute (EPRI) Report 3002007571, "Steam Generator Management Program: Steam Generator Integrity Assessment Guidelines," Revision 4, June 2016

3. Braidwood Station, Unit1 Steam Generator Tube Inspection Report for Refueling Outage 19 (ML17058A085)

4. EC 406789, "Braidwood Unit 1 A1R19 Condition Monitoring and Operational Assessment (CMOA), Including Foreign Object Evaluation," dated October 2016.

5. CY-AP-120-340, "Primary-to-Secondary Leak Program," Revision 10

6. ER-AP-420-0051, "Conduct of Steam Generator Management Program Activities," Revision 24

7. Letter from J. S. Wiebe (U.S. Nuclear Regulatory Commission) to B. C. Hanson (Exelon Generation Company, LLC), "Braidwood Station, Unit 2 – Issuance of Amendment No. 209 RE: One-Time Extension of Steam Generator Inspections [COVID-19] (EPID L-2020-LLA-0069)," dated May 1, 2020 (ML20111A000)

8. Letter from D. J. Galvin (U.S. Nuclear Regulatory Commission) to K. J. Peters (Vistra Operations Company LLC), "Comanche Peak Nuclear Power Plant, Unit Nos. 1 and 2 – Issuance of Amendment Nos. 173 and 173 Regarding Revision to Technical Specification 5.5.9, 'Unit 1 Model D76 and Unit 2 Model Steam Generator (SG) Program' (Exigent Circumstances) (EPID L-2020-LLA-0072)," dated April 17, 2020 (ML20108E878)

9. Letter from J. S. Wiebe (U.S. Regulatory Commission) to B. C. Hanson (Exelon Generation Company, LLC), "Byron Station, Unit 1 and 2 – Issuance of Amendment Nos. 222 and 222 RE: One-Time Extension of Unit No. 2 Steam Generator Inspections [COVID-19] (EPID-L-2020-LLA-0156)," dated September 21, 2020 (ML20246G865)

10. EPRI Steam Generator Management Program: PWR Primary-to-Secondary Leak Guidelines, Revision 4, Report 1022832, dated November 2011

ATTACHMENT 2

Braidwood Station, Units 1 and 2
Renewed Facility Operating License No. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Proposed Technical Specifications Change (Mark-Up)

5.5.9 Steam Generator (SG) Program (continued)

The tube-to-tubesheet weld is not part of the tube. In addition to meeting the requirements of d.1, d.2, and d.3 below, the inspection scope, inspection methods, and inspection intervals shall be such as to ensure that SG tube integrity is maintained until the next SG inspection. A degradation assessment shall be performed to determine the type and location of flaws to which the tubes may be susceptible and, based on this assessment, to determine which inspection methods need to be employed and at what locations.

1. Inspect 100% of the tubes in each SG during the first refueling outage following SG installation.

2. For Unit 1, after the first refueling outage following SG installation, inspect each SG at least every 72 effective full power months or at least every third refueling outage (whichever results in more frequent inspections). In addition, the minimum number of tubes inspected at each scheduled inspection shall be the number of tubes in all SGs divided by the number of SG inspection outages scheduled in each inspection period as defined in a, b, c, and d below. If a degradation assessment indicates the potential for a type of degradation to occur at a location not previously inspected with a technique capable of detecting this type of degradation at this location and that may satisfy the applicable tube plugging criteria, the minimum number of locations inspected with such a capable inspection technique during the remainder of the inspection period may be prorated. The fraction of locations to be inspected for this potential type of degradation at this location at the end of the inspection period shall be no less than the ratio of the number of times the SG is scheduled to be inspected in the inspection period after the determination that a new form of degradation could potentially be occurring at this location divided by the total number of times the SG is scheduled to be inspected in the inspection period. Each inspection period defined below may be extended up to 3 effective full power months to include a SG inspection outage in an inspection period and the subsequent inspection period begins at the conclusion of the included SG inspection outage.

, with the exception that each SG is to be inspected during the fourth refueling outage in A1R23 following inspections completed in refueling outage A1R19.

ATTACHMENT 3

Braidwood Station, Units 1 and 2
Renewed Facility Operating License No. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Revised Technical Specifications Pages (Clean)

5.5.9 Steam Generator (SG) Program (continued)

The tube-to-tubesheet weld is not part of the tube. In addition to meeting the requirements of d.1, d.2, and d.3 below, the inspection scope, inspection methods, and inspection intervals shall be such as to ensure that SG tube integrity is maintained until the next SG inspection. A degradation assessment shall be performed to determine the type and location of flaws to which the tubes may be susceptible and, based on this assessment, to determine which inspection methods need to be employed and at what locations.

1. Inspect 100% of the tubes in each SG during the first refueling outage following SG installation.

2. For Unit 1, after the first refueling outage following SG installation, inspect each SG at least every 72 effective full power months or at least every third refueling outage (whichever results in more frequent inspections), with the exception that each SG is to be inspected during the fourth refueling outage in A1R23 following inspections completed in refueling outage A1R19. In addition, the minimum number of tubes inspected at each scheduled inspection shall be the number of tubes in all SGs divided by the number of SG inspection outages scheduled in each inspection period as defined in a, b, c, and d below. If a degradation assessment indicates the potential for a type of degradation to occur at a location not previously inspected with a technique capable of detecting this type of degradation at this location and that may satisfy the applicable tube plugging criteria, the minimum number of locations inspected with such a capable inspection technique during the remainder of the inspection period may be prorated. The fraction of locations to be inspected for this potential type of degradation at this location at the end of the inspection period shall be no less than the ratio of the number of times the SG is scheduled to be inspected in the inspection period after the determination that a new form of degradation could potentially be occurring at this location divided by the total number of times the SG is scheduled to be inspected in the inspection period. Each inspection period defined below may be extended up to 3 effective full power months to include a SG inspection outage in an inspection period and the subsequent inspection period begins at the conclusion of the included SG inspection outage.

ATTACHMENT 4

Braidwood Station, Units 1 and 2
Renewed Facility Operating License No. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Framatome Inc. Document No. 51-9320766-000
Braidwood 1 Steam Generator Operational Assessment Deferral of the Spring 2021 Steam Generator Inspections

Framatome Inc.

Engineering Information Record

Document No.: 51 - 9320766 - 000

Braidwood 1 Steam Generator Operational Assessment Deferral of the Spring 2021 Steam Generator Inspections

Safety Related? ☒ YES ☐ NO

Does this document establish design or technical requirements? ☐ YES ☒ NO

Does this document contain assumptions requiring verification? ☐ YES ☒ NO

Does this document contain Customer Required Format? ☐ YES ☒ NO

Signature Block

Name and Title/Discipline	Signature	P/LP, R/LR, M, A-CRF, A	Date	Pages/Sections Prepared/Reviewed/ Approved or Comments
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Note: P/LP designates Preparer (P), Lead Preparer (LP)
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R/LR designates Reviewer (R), Lead Reviewer (LR)
A-CRF designates Project Manager Approver of Customer Required Format (A-CRF)
A designates Approver/RTM – Verification of Reviewer Independence

Project Manager Approval of Customer References (N/A if not applicable)

Name (printed or typed)	Title (printed or typed)	Signature	Date
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000	All	Original release

Table of Contents

Page

List of Tables

Page

List of Figures

Page

1.0 PURPOSE

This report provides an operational assessment (OA) of Braidwood Unit-1 steam generators (SGs). The purpose is to demonstrate that the primary and secondary side examinations currently planned for refueling outage A1R22 (end of Cycle 22, spring 2021) may be safely deferred by one additional operating cycle to A1R23 (fall 2022).

2.0 BACKGROUND

2.1 Regulatory Requirements

Technical specification 5.5.9, Exelon SG Program procedures [3.a, 3.b, 3.c], and NEI 97-06 [1] require that a "forward looking" operational assessment be performed to determine if the steam generator tubing will continue to meet specific structural and leakage integrity performance criteria throughout the operating period preceding the next inspection. The performance criteria are:

- Structural Integrity Performance Criteria (SIPC) – 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. Based upon the guidance of Reference [2.a, Section 3.7.2], it is concluded that these non-pressure accident loads are not relevant for the degradation types and locations that could credibly occur in the Braidwood Unit-1 SGs prior to A1R23.
- Operational Leakage Performance Criteria – The operational leakage limit is specified as 150 gallons per day (gpd) through any one SG [3.c].
- Accident Induced Leakage Performance Criteria (AILPC) – Leakage shall not exceed a total of 1 gallon per minute (gpm) among all four SGs for events which do not involve a faulted SG. For events which do involve a faulted SG, assumed leakage is 0.5 gpm for the faulted SG, and 0.218 gpm for each intact SG. [3.c].

2.2 Methodology

The methodology used in this document is consistent with the OA performed at the last SG inspection at A1R19 [Ref. 3.e]. This OA also incorporates the following technical information requested by the NRC specifically for SG inspection deferral requests to address personnel exposure to the COVID-19 pandemic.

1. Recent operational experience including
    a. Primary-to-secondary leakage
    b. Summary of primary and secondary inspections
    c. Summary of degradation detected
    d. Summary of tube plugging
    e. Relevant operating experience that could impact tube integrity
2. Previous inspection condition monitoring
    a. Most limiting as-found condition compared to tube performance criteria
3. Operational assessment for additional operating cycle
    a. Degradation mechanisms considered

b. Inspection strategy for each mechanism at prior inspection

c. Predicted margin to tube integrity performance criteria

2.3 SG Design and OA Inputs

The Braidwood Unit-1 power plant design incorporates four recirculating steam generators (SG) designed and fabricated by Babcock and Wilcox of Cambridge, Ontario, Canada; installed as replacements in September 1998. The thermally treated Inconel 690 tubes were installed with a full depth hydraulic expansion into the tubesheet. The tubes are supported in the straight section by nine 410 stainless steel lattice grid supports which are comprised of high, medium, and low bars. The tubes are supported in the U-bend by ten 410 stainless steel fan bar / collector bars and the number of supports varies by row. The U-bend regions of row 1 through row 21 received additional thermal stress relief following the tube bending process. Due to a crossover tube arrangement in the low-row region, Row 3 has the tightest radius in the U-bend (3.632").

The feedring and J-tubes were fabricated with materials that are not susceptible to flow accelerated corrosion: seamless ferritic chrome moly steel SA-335 GR P22 and Inconel 690 SB-167 [3.h], respectively. The steam drum internals are fabricated from carbon steel. The design incorporates two levels of steam separation equipment: 95 curved arm primary (CAP) cyclones and 95 secondary cyclones.

Table 2-1 identifies basic input information used in this evaluation. The nominal full power steady state primary to secondary pressure differential (NOPD) value of 1270 psi used in prior inspections [3.d] continues to be conservative based upon a review of Braidwood Unit-1 operating data from A1R19 (October 2016) through 9-30-2020 where a bounding (high) primary side RCS pressure of 2250 psig (Figure 2-1) and bounding (low) secondary side SG pressure of 980 psig (Figure 2-2) is used (2250 – 980 =1270 psi). This NOPD value is expected to continue to be bounding during the additional operating cycle from A1R22 to A1R23.

Table 2-1: Basic OA Inputs

Tube Material	Thermally Treated Alloy 690 (A690TT) [3.c]
Tube OD	0.6875 inch [3.c]
Tube Wall Thickness	0.040 inch [3.c]
Number of Installed Tubes (per SG)	6633 [3.c]
Mean Tube Material Yield plus Ultimate Strength (S_Y+S_U) at Operating Temperature	117.4 ksi [3.d]
Standard Deviation of (S_Y+S_U)	2.4 ksi [3.d]
Primary Hot Leg Temperature	~617 °F [3.c, 3.d]
Bounding Primary Side Pressure	2250 psig (Figure 2-1)
Bounding Secondary Side Pressure	980 psig (Figure 2-2)
Nominal Full Power Steady State Primary to Secondary Pressure Differential (NOPD)	1270 psi [3.d]
Main Steam Line Break Pressure Differential (MSLB PD)	2560 psi [3.c]
Assumed Operating Duration from A1R19 to A1R23	69.96 EFPM 5.83 EFPY 4 cycles

Figure 2-1: Primary Side RCS Pressure since A1R19

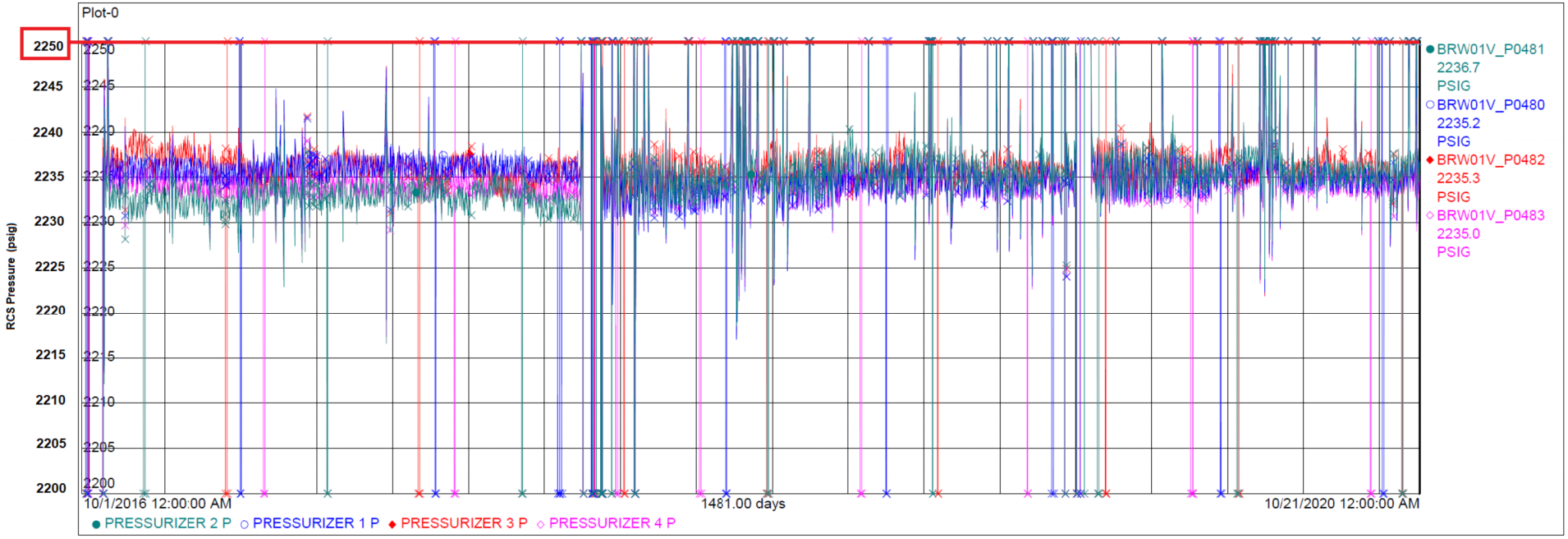

Figure 2-2: Secondary Side Main Steam Pressure since A1R19

2.4 Inspection Timeline

Table 2-2 provides a brief description of the Braidwood Unit-1 SG inspections performed or to be performed from the most recent fall 2016 100% SG inspection outage (A1R19) through the fall 2022 outage (A1R23). A detailed description of the inspection history and inspection scope is provided in various References [3.d, 3.e, 3.i]. As discussed above, the purpose of this OA is to determine if the planned A1R22 examinations may be safely deferred until A1R23. The table shows the scope as-planned prior to the deferral.

2.5 Recent Operating Experience

Based on the recommendations of Reference [2.a, Section 11.2.4], Braidwood Unit-1 and industry operating experiences that might impact SG tube integrity or the assessment of tube integrity must be considered when evaluating extended inspection intervals. Important factors include chemistry excursions and transients, sustained

power level changes, unusual operating transients, foreign material intrusion events, and industry identification of new degradation mechanisms. An extensive evaluation of these factors was performed in the spring of 2018 and the fall of 2019 to assess the acceptability of both the A1R20 and A1R21 SG inspection skips [3.f, 3.g]. The evaluations identified no Braidwood Unit-1 or industry operating experiences that would undermine the existing integrity assessments and identified no new degradation mechanisms as credible threats to Braidwood Unit-1 SG integrity. A more recent review of industry operating experience by the author in support of this OA similarly identified no concerns beyond those addressed in this report. Going forward, Exelon has identified no plans to implement power uprates, load following operations, or other operational changes that could meaningfully impact Braidwood Unit-1 SG degradation initiation and growth through A1R23. Note that Braidwood Unit 1 occasionally performs economic dispatch activities which involve planned load drops for short time periods. Preliminary EPRI studies and surveys have not identified or anticipate any adverse impacts associated with economic dispatch.

Table 2-2: Braidwood Unit-1 SG Inspection Scope Timeline

End of Cycle	Date	Refueling Outage	Cumulative SG EFPY	Inspection Scope: SG A, SG B, SG C, and SG D
19	Fall 2016	A1R19	16.98	• Visual examination of hot and cold leg channel heads • Full length bobbin probe examination of 100% of the tubes • Bobbin examination of all in-service tubes within five tubes of the no-tube lane or periphery using Westinghouse ETSS-FOW-AHC-BOB for foreign object wear detection from the top of the tubesheet to 0.60" above the tubesheet on both the hot leg and the cold leg • Array examination of 955 periphery tubes with expansion noise levels >1.70V, from tube end to 1st support. • +Point™ probe examination: - All new PLPs and new foreign object wear indications including a two-tube bounding region - All foreign objects identified by SSI and select legacy foreign object locations including a two-tube bounding region - 100% of hot leg dents and dings ≥2V - Miscellaneous areas of special interest • Sludge lancing / TTS SSI / FOSAR • SSI upper steam drum internals in SGD only
20	Spring 2018	A1R20	18.43	N/A
21	Fall 2019	A1R21	19.85	N/A

End of Cycle	Date	Refueling Outage	Cumulative SG EFPY	Inspection Scope: SG A, SG B, SG C, and SG D	
22	Spring 2021	A1R22	21.33(1)	• Visual examination of hot and cold leg channel heads • Full length bobbin probe examination of 100% of the tubes • 50% Array TTS examinations, with all tubes selected located in the periphery of the SG. - Approximately 100% of the tubes 12 tubes deep from the no tube lane and 15 tubes deep from the periphery. • +Point™ probe examination: - All new PLPs and new foreign object wear indications including a two-tube bounding region - All foreign objects identified by SSI and select legacy foreign object locations including a two-tube bounding region - 100% of hot leg dents and dings ≥2V - Miscellaneous areas of special interest • Sludge lancing / TTS SSI / FOSAR in all four SGs • Upper bundle visual inspections in SGA only • SSI upper steam drum internals in SGA and SGB only	Original Plan
23	Fall 2022	A1R23	22.81(1)	N/A	Original Plan

Notes:

1. Estimated EOC 22 and 23 EFPY values are based on a cycle length of 1.48 EFPY which bounds prior actual cycle lengths.

2.6 Degradation Mechanisms

The most recent degradation assessment [3.d] provides detailed discussion regarding the susceptibility of Braidwood Unit-1 SG tubes to various degradation mechanisms. The only three tube degradation mechanisms identified to date (i.e., "existing" mechanisms) in the Braidwood Unit-1 SGs are summarized in Table 2-3. The table also includes one degradation mechanism that has not been identified but which could reasonably be expected to occur (i.e. "potential" mechanisms). Based upon a review of Braidwood Unit-1 operations and industry operating experience (Section 2.5), it is concluded that no other degradation mechanisms pose a credible threat to Braidwood Unit-1 SG tube integrity prior to A1R23. Each degradation mechanism identified in this table is evaluated within this OA.

Table 2-3: Evaluated Degradation Mechanisms

Type	Mechanism	Detection Strategy	Evaluated in Section
Existing	Fan bar support wear	• Full length bobbin probe examinations	4.1.1
Existing	Lattice grid support wear	• Full length bobbin probe examinations	4.1.2
Existing	Foreign object wear	• Selected array probe and +Point™ probe examinations of TTS periphery tubes • Full length bobbin probe examinations • TTS SSI / FOSAR	4.1.3
Potential	Tube-to-tube wear	• Full length bobbin probe examinations • +Point™ or array probe examination of proximity indications	4.1.4

3.0 ASSUMPTIONS

Various assumptions used during the course of this evaluation are identified within the applicable section discussions. None of the assumptions require verification beyond this report's independent review and approval process.

4.0 OPERATIONAL ASSESSMENT

The condition monitoring and operational assessment (CMOA) performed during A1R19 [3.e] determined that the Braidwood Unit-1 SGs satisfied the technical specification performance criteria and concluded that the SGs could be safely operated until A1R22 (spring 2021) over an interval length of 4.5 EFPY. The OA herein evaluates the acceptability of one additional cycle of operation prior to performing the next SG inspection during A1R23 over a total assumed interval length of 5.83 EFPY.

References [3.e] and [3.i] provide detailed tabulations of A1R19 inspection results as well as the CM assessment of the A1R19 findings. No additional tube examinations have been performed since A1R19; therefore, that information will not be repeated in this report.

4.1 Tube Degradation Structural Integrity

The OA must evaluate degradation that was detected, characterized and accepted for continued operation at the most recent inspection outage. It must also consider degradation that may have existed but was not detected, either because of imperfect inspection probability of detection (POD) or because the tube was not examined.

The bobbin probe is the principal detection method used for existing and potential degradation in the Braidwood Unit-1 SGs and the A1R19 bobbin probe inspection included 100% of the tubes. Therefore, this OA considers two scenarios to project the limiting A1R23 flaw depth: a) for existing degradation mechanisms, flaws detected during A1R19 and returned to service, and b) for the potential degradation mechanism not detected during A1R19.

Note that although existing degradation mechanisms may have generated flaws that were undetected during A1R19, and new flaws may initiate subsequent to the A1R19 examination, for the degradation mechanisms of interest, the depths of flaws returned to service during A1R19 will be more limiting.

The following sections summarize the evaluations performed for the degradation mechanisms discussed in Section 2.6.

4.1.1 Fan Bar Support Wear

Fan bar support wear is the primary degradation identified in the Braidwood Unit-1 SGs with a total of 84 indications detected during A1R19, 17 of which were newly reported. The maximum reported depth was 16%TW based on Bobbin ETSS 96004.3.

The maximum measured depth (16%TW) must be adjusted to conservatively account for NDE sizing uncertainty in order to determine the upper bound depth (UBD) at the beginning of Cycle 20 (BOC20). This was accomplished by applying the sizing uncertainty parameters for the Bobbin ETSS used for sizing at A1R19 (96004.3 Revision 13) to generate the upper 95% probability / 50% confidence (95%/50%) depth estimate. The ETSS 96004.3 sizing uncertainty parameters are: slope=0.97, intercept=2.50, and standard error of regression=3.10. The adjustment was performed as follows:

BOC20 UBD = upper 95%/50% maximum depth of in-service fan bar wear at the beginning of Cycle 20

BOC20 UBD = (0.97)(16)+(2.50)+(1.645)(3.10)[1]

BOC20 UBD = 23.1%TW

For the OA, a conservative growth rate must be assumed for fan bar wear going forward. A growth rate of 2.0 %TW/EFPY is assumed, which is bounding of the maximum growth rate from all four SGs of 0.93 %TW/EFPY.

Adjusting the BOC20 UBD upward to reflect depth growth during the 5.83 EFPY period between A1R19 and A1R23, yields the end of Cycle 23 (EOC23) UBD:

EOC23 UBD = BOC20 UBD + (5.83 EFPY)(2.0%TW/EFPY)

EOC23 UBD = 34.8%TW

The projected EOC23 UBD must be compared with the appropriate structural limit. In this case the appropriate limit conservatively accounts for uncertainties in material strength and in the burst pressure relationship. The structural limit for a conservatively assumed 1.7 inch long flaw (assumed bounding length based on historical fan bar wear dimensions) with limited circumferential extent is 58.0%TW [3.d]. Since the projected value of EOC23 UBD is less than 58.0%TW, it is concluded that fan bar wear reported during A1R19 will not challenge the structural integrity performance criteria prior to the next inspection outage at A1R23.

[1] In accordance with [2.a], analyst sizing uncertainty is adequately represented by the standard error of regression, often referred to as the technique uncertainty.

4.1.2 Lattice Grid Support Wear

A total of 11 indications of lattice grid support wear were detected in the Braidwood Unit-1 SGs during A1R19, only 2 of which were newly detected. The maximum reported depth was 9%TW based on Bobbin ETSS 96004.3.

The maximum measured depth (9%TW) must be adjusted to conservatively account for NDE sizing uncertainty in order to determine the upper bound depth (UBD) at the beginning of Cycle 20 (BOC20). This was accomplished by applying the sizing uncertainty parameters for the Bobbin ETSS used for sizing at A1R19 (96004.3 Revision 13) to generate the upper 95% probability / 50% confidence (95%/50%) depth estimate. The ETSS 96004.3 sizing uncertainty parameters are: slope=0.97, intercept=2.50, and standard error of regression=3.10. The adjustment was performed as follows:

BOC20 UBD = upper 95%/50% maximum depth of in-service fan bar wear at the beginning of Cycle 20

BOC20 UBD = (0.97)(9)+(2.50)+(1.645)(3.10)[1]

BOC20 UBD = 16.3%TW

For the OA, a conservative growth rate must be assumed for fan bar wear going forward. A growth rate of 2.0 %TW/EFPY is assumed, which is bounding of the maximum growth rate used in the prior OA of 1.17 %TW/EFPY.

Adjusting the BOC20 UBD upward to reflect depth growth during the 5.83 EFPY period between A1R19 and A1R23, yields the end of Cycle 23 (EOC23) UBD:

EOC23 UBD = BOC20 UBD + (5.83 EFPY)(2.0%TW/EFPY)

EOC23 UBD = 28.0%TW

The projected EOC23 UBD must be compared with the appropriate structural limit. In this case the appropriate limit conservatively accounts for uncertainties in material strength and in the burst pressure relationship. The structural limit for a conservatively assumed 3.5 inch long axial flaw with limited circumferential extent is 56.6%TW [3.d] bounding the longest lattice grid intersection of 3.15 inches. Since the projected value of EOC23 UBD is less than 56.6%TW, it is concluded that lattice grid wear reported during A1R19 will not challenge the structural integrity performance criteria prior to the next inspection outage at A1R23.

4.1.3 Foreign Object Wear

There were 13 indications of foreign object wear identified in the Braidwood Unit-1 SGs during A1R19, all located at the top-of-tubesheet (TTS). Four tubes (with four indications) were plugged because the foreign object could not be removed from the SG. The tubes with the remaining nine indications were returned to service because the depth of the wear indication did not exceed the plugging criteria of 40%TW and the objects that caused the wear were confirmed to be no longer present. The deepest wear returned to service was sized at 25%TW using +Point ETSS 27902.1 Revision 2.

Since the objects that caused the wear in the tubes that were returned to service are no longer present at the locations of the wear indications, there is no mechanism to cause future growth. Consequently, these flaws will not grow to exceed the applicable structural limit (57.6%TW) for an axial flaw with limited circumferential extent and an assumed length of 2.0 inches which is bounding of the largest measured length [3.e]. Therefore, there is reasonable assurance that these flaws will not violate the performance criteria going forward to A1R23.

The A1R19 inspection scope for foreign objects and associated wear was extensive and included both visual and eddy current inspections. Visual examinations performed following sludge lancing included both the annulus and no-tube lane at the top of the tubesheet in all four steam generators. These examinations viewed all rows and columns into the tube bundle interior at all peripheral and no-tube lane locations. A bobbin probe technique specifically qualified for detection of foreign object wear, ETSS-FOW-BOB (Rev. 0), was implemented in

conjunction with ECT data history compare algorithms in order to enhance foreign object wear detection close to the top of the tubesheet [3.d]. In addition, array probe examinations were performed at select TTS locations exhibiting higher noise signals that may interfere with the ability of the bobbin probe to detect foreign object wear in the periphery.

During A1R19, 5 pieces of Flexitallic gasket, 2 pieces of weld slag, 2 pieces of machining remnants, a wire and a cylindrical piece of metal were identified and categorized based on potential to cause wear, with all the priority 1 items identified for removal. Of the four (4) priority 1 items, all were removed with exception of a large piece of weld slag, resulting in four adjacent tubes being removed from service. The remaining seven (7) foreign objects (Table 4-1) were determined to be benign and were classified as Priority 3 (no significant wear projected through the next SG inspection). Historically, at Braidwood Unit 1 no wear has been detected at locations of legacy Priority 3 foreign objects left in service. End of cycle 23 (EOC23) depths after 4 operating cycles were projected for these objects based on the foreign object assessment methodology developed specifically for Braidwood 1, assuming conservative velocities, densities, and limiting wear scar length over a 6 EFPY operating interval [3.j, Appendix D]. The deepest predicted EOC23 wear (24.9%TW) is not expected to exceed the conservative structural limit (57.6%TW) for an axial flaw with limited circumferential extent and an assumed length of 2.0 inches.

With these inspections and subsequent object retrievals, there is reasonable assurance that no objects capable of causing significant tube degradation remained in the SGs following A1R19.

However, the possibility that new foreign objects capable of causing wear entering the SGs and the potential development of new foreign object wear during the operating period through A1R23 must be considered. It is difficult to predict if and when foreign object wear will occur. However, by examining the operating history of the Braidwood Unit-1 SGs with respect to foreign object wear [3.j], a judgment of the risk can be developed. The objects identified during A1R19, following three cycles of operation were consistent, both in terms of quantity and type of material, with findings of previous inspections at Braidwood. This suggests that the parts did not originate from a single, recent intrusion event, but rather from minor intrusion events occurring over multiple cycles. The absence of foreign object wear exceeding the plugging limit during A1R19 (following 3 cycles of operation) and during A1R16 (following two cycles of operation), provides reasonable assurance that deferral of the SG examinations to A1R23 will not generate foreign object wear that violates the SG structural integrity performance criteria. In the unlikely event that significant degradation does occur, primary to secondary leakage monitoring procedures in place at Braidwood Unit-1 provide a high degree of confidence of safe unit shutdown without challenging the performance criteria.

As required by ER-AA-2006, loose parts are be evaluated for their potential impact on plant systems and components. Seven potential impacts were addressed under Table 6-1 of Reference [3.e] and remain unchanged for the additional cycle of operation.

Table 4-1: Priority 3 Foreign Objects Left in Service at A1R19

SG	Part ID	Description	Row	Col	Leg	Length	Width	Height	Legacy?	Density (kg/m^3)	Velocity (m/s)	EOC23 Max Predicted Depth (%TW)[1]
B	B004	Gasket	24	75	HL	1.5	0.01	0.01	No	400	1.75	24.9
C	C001	Snare Collar	3	48	HL	0.14	0.11	0.3	Yes[2]	800	3.5	6.5
C	C002	Machining Remnant	32	69	CL	0.1	0.01	0.01	No	800	1.0	6.5
C	C003	Machining Remnant	32	69	CL	0.1	0.01	0.01	No	800	1.0	6.5
C	C004	Gasket	44	75	CL	1.5	0.188	0.05	No	800	1.0	13.5
C	C008	Gasket	33	102	HL	0.5	0.02	0.02	Yes[2]	400	2.0	25.9
C	C009	Wire	33	102	HL	0.92	0.188	0.5	Yes[2]	400	2.0	25.9

Notes:

1. EOC23 depths are based on the most limiting wear scar length for an operating interval of 6 EFPY [3.j, Appendix D].
2. No wear has been detected at locations of legacy Priority 3 foreign objects left in service.

4.1.4 Tube-to-Tube Wear

No tube-to-tube wear has been identified in the Braidwood Unit-1 SGs. Therefore, only wear that is postulated to have been present but not detected during the A1R19 examination is evaluated in this section.

During the A1R19 examination, bobbin probe technique ETSS 13091.1 (Revision 1) was used for the detection of tube-to-tube wear. As with the lattice grid and fan bar wear mechanisms, the bobbin probe provides excellent detection capability for tube-to-tube wear. A review of ETSS 13091.1 reveals that all 40 of the test samples, some as shallow as 7%TW and 16 less than 20%TW, were detected during the development of this technique. In the absence of Braidwood Unit-1 noise measurement data for these techniques, the depth at POD=0.95 and thus, BOC20 UBD, was assumed to be 20%TW.

Without any history of tube-to-tube wear in the Braidwood Unit-1 SGs, or in any other recirculating SG manufactured by BWXT Canada, and no history of any proximity indications in the U-bend, the postulation of tube-to-tube wear and the assumption of future growth rate are highly speculative. For the purpose of this OA the future growth rate of hypothetical tube-to-tube wear is assumed to be 2%TW/EFPY. Adjusting the BOC20 UBD upward to reflect depth growth during the 5.83 EFPY period between A1R19 and A1R23, yields the EOC23 UBD:

EOC23 UBD = BOC20 UBD + (5.83 EFPY)(2.0%TW/EFPY)

EOC23 UBD = 31.7%TW

Due to the tendency of tube-to-tube wear to be significantly longer than the support wear evaluated in earlier sections, the structural limit used earlier is not applicable. For this degradation mechanism a flaw length of 30 inches was assumed and the corresponding structural limit for axially oriented volumetric degradation with limited circumferential extent was determined to be 55.5%TW [2.b, flaw model 5.3.3]. Consistent with the structural limits discussed earlier, this limit conservatively accounts for uncertainties in material strength and in the burst pressure relationship. Since the projected value of EOC23 UBD is less than 55.5%TW, it is concluded that tube-to-tube wear will not challenge the structural integrity performance criteria prior to the next inspection outage (A1R23).

4.2 Tube Degradation Leakage Integrity

Consistent with Reference [2.a, Section 9.6], for volumetric degradation of the type and length detected or postulated to occur in the Braidwood Unit-1 SGs, the onset of pop-through leakage and burst are coincident. This means that if the degradation satisfies the structural integrity performance criteria (i.e., does not burst at 3xNOPD) then the degradation will not pop-through and leak at the much lower main steam line break pressure differential (i.e., MSLB PD), or the still lower normal operating pressure differential (i.e., NOPD).

As discussed in Sections 4.1.1, 4.1.2, 4.1.3, and 4.1.4, there is reasonable assurance that no degradation will violate the structural integrity performance criteria prior to A1R23 SG examinations. Therefore, there is reasonable assurance that the accident-induced leakage performance criteria and the normal operating leakage performance criteria will remain satisfied throughout the operating period preceding A1R23.

4.3 Secondary Side Components

Degradation of SG secondary side components that could impact the ability of the SGs to perform their intended safety functions must be considered. The principal concern is component degradation that could produce foreign objects that could, in-turn, impact tube integrity. During prior outages the condition of secondary side components of both the upper tube bundle as well as the steam drum has been routinely monitored. Inspections during A1R19 and A1R16 have not identified any anomalous structural conditions, foreign objects or flow accelerated corrosion

(FAC) of any components. Therefore, there is reasonable assurance that secondary side component degradation will not generate foreign objects within the SGs prior to A1R23; supporting the deferral of secondary side inspections until A1R23.

4.4 Operational Assessment Conclusion

There is reasonable assurance that with a deferral of the next Braidwood Unit-1 SG examination from A1R22 to A1R23, the SG structural and leakage integrity performance criteria will remain satisfied throughout the operating period preceding A1R23. Table 4-2 summarizes the projected margin to SIPC and AILPC at A1R23 for each tube degradation mechanism evaluated.

Table 4-2: Braidwood Unit-1 Tube Integrity Margin Summary

Degradation Mechanism	SIPC		AILPC	
	Limit (at bounding length)	Projected Upper Bound Depth at A1R23	Limit	A1R23 Projection
Fan Bar Support Wear	58.0 %TW	34.8 %TW	0.218 GPM	Zero Leakage
Lattice Grid Support Wear	56.6 %TW	28.0 %TW	0.218 GPM	Zero Leakage
Foreign Object Wear	57.6 %TW	< 57.6 %TW	0.218 GPM	Zero Leakage
Tube-to-tube Wear(1)	55.5 %TW	31.7 %TW	0.218 GPM	Zero Leakage

Notes:
1. Tube-to-tube wear has not been identified in the Braidwood Unit 1 SGs after ~20 EFPY of operation. It is considered a potential degradation mechanism and the operational assessment assumes a bounding scenario considering an undetected indication at A1R19.

5.0 COMPUTER FILES

Table 5-1 identifies computer files used in the course of this operational assessment. All files were transferred to the following Framatome ColdStor directory:

\cold\General-Access\51\51-9320766-000\official

Table 5-1: Computer Files

Filename	File Type	File Size (kB)	Description	Modified Date and Time
318Y-TR-01 R01.pdf	PDF	11,498,105	Braidwood Unit 1 Foreign Object Assessment Methodology	10/7/2020 3:16 PM
7720-O&M-1_R05.pdf	PDF	8,120,951	Braidwood Unit 1 Operating and Maintenance Manual	9/2/2016 1:59 PM
A1R19 CMOA.PDF	PDF	2,134,280	Braidwood Unit 1 A1R19 CM Final OA	10/13/2020 9:45 AM
A1R19 Final DA Rev 002.pdf	PDF	1,943,592	Braidwood Unit 1 A1R19 Degradation Assessment	10/7/2020 2:10 PM
A1R21 EOC final for Framatome.docx	Word	1,375,739	Braidwood Unit 1 A1R21 EOC inputs from site	10/7/2020 2:18 PM
Brw U1 Press data_10-29-2020.xlsx	Excel	654,283	Braidwood Unit 1 SG Pressures since A1R19	10/29/2020 3:35 PM
CALCULATORV1 XL2010 Tube-to-tube wear.xlsm	Excel	744,147	Flaw Handbook Calculator used to determine structural limit for tube-to-tube wear	10/30/2020 10:55 AM
EC 387375 pre-mode CMOA.PDF	PDF	4,890,042	Braidwood Unit 1 A1R16 CM Preliminary OA	10/8/2020 7:43 AM
EC 387376 FO Evaluation.pdf	PDF	6,484,257	Braidwood Unit 1 A1R16 Foreign Object Evaluations	10/7/2020 2:48 PM
EC 387377 CMOA.PDF	PDF	3,457,649	Braidwood Unit 1 A1R16 CM Final OA	10/28/2020 12:10 PM
EC 623069 A1R20 Skip DA & CMOA reivew.pdf	PDF	1,072,673	Braidwood Unit 1 A1R20 Skip Inspection	10/21/2020 1:34 PM
EC 627494 A1R21 SKIP DA & CMOA Review.pdf	PDF	1,011,463	Braidwood Unit 1 A1R21 Skip Inspection	10/21/2020 1:36 PM
RE BWD 1 Primary Pressure.pdf	PDF	283,026	E-mail transmittal of Braidwood Unit 1 RCS Pressure since A1R19	10/26/2020 3:36 PM
Braidwood 1 Primary Pressure Data (Oct-2016 to Oct 2020).pdf	PDF	87,492	Computer printout of Braidwood Unit 1 RCS Pressure since A1R19	11/19/2020 4:01 PM

6.0 REFERENCES

References identified with an (*) are maintained within Braidwood Records System and are not retrievable from Framatome Records Management. These are acceptable references per Framatome Administrative Procedure 0402-01, Attachment 7. See page 2 for Project Manager Approval of customer references.

1. NEI 97-06, “Steam Generator Program Guidelines”, Rev. 3, March 2011
2. EPRI Documents
    a. EPRI Report 3002007571, “SG Integrity Assessment Guidelines, Revision 4,” June 2016
    b. EPRI Report 3002003048, “Steam Generator Management Program: Flaw Handbook Calculator (SGFHC) for Excel 2010 v1.0,” June 2014
3. * Braidwood Documents
    a. Braidwood Technical Specifications 5.5.9, “Steam Generator (SG) Tube Surveillance Program”
    b. Exelon Procedure ER-AP-420, “SG Management Program,” Revision 18
    c. Exelon Procedure ER-AP-420-0051, "Conduct of SG Management Program Activities," Revision 24
    d. BWXT Document 0182-AST-100459, Rev. 002, “Braidwood Unit 1 A1R19 Steam Generator Degradation Assessment”
    e. BWXT Document 0182-AST-100873, Rev. 000, “Braidwood A1R19 Steam Generator Condition Monitoring and Final Operational Assessment”
    f. Exelon Document EC 623069, Revision 000, “Braidwood Unit 1 (A1R20) DA Document Review of CMOA (A1R19) EPNS: 1RC01BA, 1RC01BB, 1RC01BC, and 1RC01BD”
    g. Exelon Document EC 627494, Revision 000, “A1R21 SG DA/CMOA Skip Review”
    h. BWI Document BWI-222-7720-O&M-1. Rev 5, “Commonwealth Edison Company Byron/Braidwood Nuclear Generating Station Replacement Steam Generators Operating and Maintenance Manual”, July 2000
    i. Exelon Letter, NRC Docket No. STN 50-456, “Braidwood Station, Unit 1 - Steam Generator Tube Inspection Report for Refueling Outage 19”, February 27 , 2017 (ML17058A085)
    j. BWXT Document 318Y-TR-01, Revision 1, “Exelon Corporation Byron Unit 1, Braidwood Unit 1 – RSG Foreign Object Assessment Methodology”

APPENDIX A: ABBREVIATIONS AND ACRONYMS

AILPC	Accident Induced Leakage Performance Criteria
BOC	Beginning Of Cycle
CM	Condition Monitoring Assessment
CMOA	Condition Monitoring and Operational Assessment
DA	Degradation Assessment
ECT	Eddy Current Test
EFPY	Effective Full Power Years
EOC	End Of Cycle
ETSS	Examination Technique Specification Sheet
FAC	Flow Assisted Corrosion
FOSAR	Foreign Object Search And Retrieval
GPD	Gallons Per Day
GPM	Gallons Per Minute
ID	Inner Diameter
MSLB PD	Main Steam Line Break Pressure Differential
NOPD	Normal Operating Pressure Differential
OA	Operational Assessment
OD	Outer Diameter
POD	Probability Of Detection
RCS	Reactor Coolant System
SG	Steam Generator
SIPC	Structural Integrity Performance Criteria
SSI	Secondary Side Inspection
TSH	Tube Sheet Hot
TSP	Tube Support Plate
TTS	Top of Tubesheet
UBD	Upper Bound Depth