

Braidwood Unit 2 TS 5.5.9 LAR NRC Pre-submittal Meeting

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Agenda

- Background
- Technical Specifications (TS) Requirement
- Braidwood Unit 2 Steam Generators Design, Current Condition and Review of Applicable Degradation Mechanisms
- Braidwood Unit 2 Historical Secondary Side and Foreign Object Search and Retrieval (FOSAR) Activities
- Braidwood Unit 2 Loose Part Detection System Status
- License Amendment Request Development
- Timeline for Submittal

Background

- License Amendment Request (LAR) due to uncertainty of specialty vendor work force availability and to limit risk of exposure to site/local supplemental workers resulting from COVID-19 pandemic for upcoming Braidwood Unit 2 Outage (A2R21)
- TS 5.5.9.d.3 requirement: 100% bobbin inspection of all 4 SGs tubes and 50% Array/+Point inspection scope of specific locations identified as susceptible to cracking potentially not detectable by the bobbin probe is required for A2R21
- Requesting One-time change to Braidwood TS 5.5.9.d.3 requirements to defer all SGs inspections by one outage, i.e., from April 2020 to October 2021 (~18 months)
- 100% bobbin and 100% Array/+Point inspection for potential degradation mechanisms are planned in A2R21 to prepare for future implementation of TSTF-577, Revised Frequencies for Steam Generator Tube Inspections
- TSTF-577 submitted to the NRC for pre-submittal meeting in April 2020, provides the framework for this LAR

COVID-19 Risk During Braidwood 2 SG Inspections

- Over 170 employees from across the U.S. required to mobilize on-site to support A2R21 steam generator inspections
- The nature of the work prevents meeting CDC recommendations for social distancing (e.g., Craft support for closure assembly / disassembly, platform construction, robot manipulations).
- Industry vendors are supporting multiple overlapping outages (low bench strength) and maintain unique and complex qualifications.
- No contingencies available for certain COVID-19 situations:
 - Example: Inspections and subsequent actions require specialized qualifications to complete. An outbreak affecting personnel and limiting their availability after SG disassembly and inspections have started would result in not meeting the TS requirement for tube integrity/examination scope and limit ability to reassemble SGs
 - Result : No “exit strategy” if an outbreak occurs mid-inspection

Braidwood Unit 2 TS Requirement (5.5.9.d.3)

- Current wording: “inspect each SG at least every 48 effective full power months or at least every other refueling outage (whichever results in more frequent inspections).”
- LAR request: “inspect each SG at least every third refueling outage” (will result in ~52 EFPM interval between SG inspections).
- Not requesting change to any other TS requirements or deviations from NEI/EPRI “Mandatory” or “Needed” requirements or relaxation of any Structural Integrity Performance Criteria
- Request meets requirements of proposed changes to TS 5.5.9 resulting from TSTF-577 for 600TT tubing units: “inspect 100% of the tubes in each SG at least every 72 effective full power months”

Braidwood 2 SG Design / Operating Parameters

Four (4) Westinghouse Model D-5 Steam Generators, recirculating U-bend Steam Generators with pre-Heater

Tube Information:

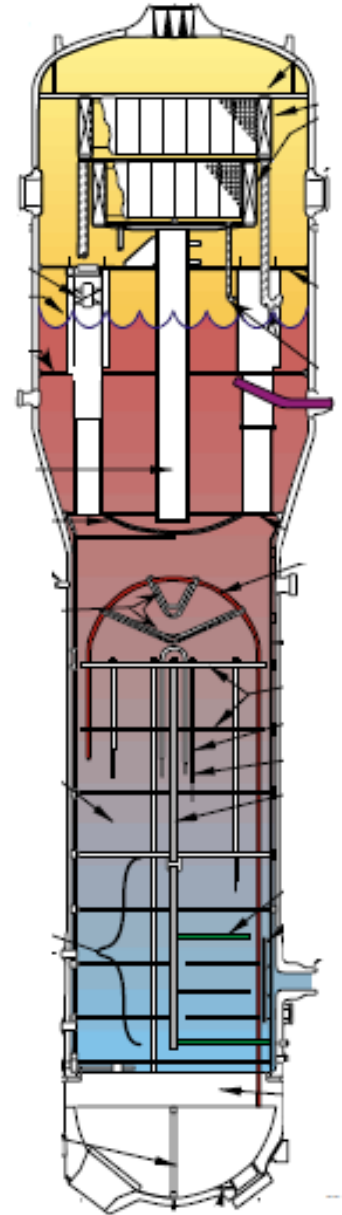
- Number of Tubes per SG: 4,570
- Tube Material: Alloy 600TT
- Nominal OD and Thickness: 0.750" x 0.043"

Tube Support Plate (TSP) Information:

- TSP Material: SS
- TSPs quatrefoil broached (TSPs drilled in preheater regions)
- Tubes hydraulically expanded full length of the Tubesheet

Normal Operating Parameters:

- NOP (Primary) = 2250 psia
- NOPD = 1363 psid
- $T_{\text{Hot}} = 611^{\circ}\text{F}$
- Operating Cycle Length = ~18 months
- SG EFPY at April 2020 Outage = 28.5



Braidwood Unit 2 Tube Plugging to Date

	SG A	SG B	SG C	SG D	Total
Total No. Tubes Plugged through A2R19 ⁽¹⁾	107	66	72	44	289
Percent Tubes Plugged through A2R19	2.34%	1.44%	1.58%	0.96%	1.58%
Allowable Percent Tubes Plugged	5%	5%	5%	5%	5%
⁽¹⁾ No SG inspections were performed during A2R20 (2018).					

Braidwood A2R19 (2017) Indications by Degradation Mechanism

Degradation Mode	SG A	SG B	SG C	SG D	Total
AVB Wear	464	125	317	198	1104
Quatrefoil TSP Wear	1	0	0	1	2
Drilled Baffle Wear	0	3	0	0	3
Foreign Object Wear	7	7	0	4	18
Dent/Ding ODSCC in a High Stress Tube	0	0	0	0	0 ⁽¹⁾
TSP ODSCC in High Stress Tubes	0	0	0	0	0 ⁽²⁾

(1) Indications detected during A2R16 (2012)

(2) Nine (9) indications detected from A2R10 (2003) through A2R16 (2012)

Degradation Mechanisms Summary

- Anti-Vibration Bar Wear
 - Affects all Westinghouse Alloy 600TT SGs
 - Slow, predictable growth rate (Avg < 1.5%/EFPY)
 - Tubes not plugged until 40%TW TS limit is reached
 - Over last 7 operating cycles, have plugged 24 tubes (~3.5 tubes per cycle). At last inspection after 2 cycles, plugged 7 tubes
 - Likelihood of this type flaw failing Condition Monitoring (CM) after 1 additional operating cycle is very low.
- Tube Support Wear (Quatrefoil and Baffle plate)
 - Affects only 5 tubes, deepest is 28%TW
 - No measurable growth and no tubes plugged at last 3 inspections
 - Likelihood of this type flaw failing CM after 1 additional operating cycle is very low.

Degradation Mechanisms Summary (continued)

- Foreign Object (FO) Wear
 - No new FO wear in A2R17 or A2R19 at Top of Tubesheet or in Preheater Section. All FOs which could cause significant wear were removed in A2R19.
 - All new Foreign Object wear in A2R17 and A2R19 due to FOs lodged in quatrefoil tube support openings, 3 in A2R17 and 7 in A2R19.
 - FOs are generally considered no longer present when eddy current is performed and indications do not grow. If FO is still present, tube is plugged.
 - Deepest recent occurrence was 39%TW after 2-cycles but very small diameter, so no structural concern.
 - CM limit for these flaws is 64.8%TW
 - Likelihood of this type flaw failing CM after 1 additional operating cycle is very low.

Degradation Mechanisms Summary (continued)

- Previously Observed Degradation Mechanism
 - ODSCC in potentially high stress tubes at tube support or at a low voltage ding (freespan)
 - Observed 9 cracks in 5 tubes, most recent in 2012
 - 68 potentially high stress tubes remain in service
 - Since 2012, completed two “clean” inspections of all 68 tubes using Array probe (TSPs) and +Point probe (dents/dings)
- Potential Degradation Mechanisms (not observed at Braidwood Unit 2)
 - ODSCC in non-high stress tubes (dent, ding, freespan)
 - ODSCC/PWSCC at the top of tubesheet expansion transitions and sludge pile
 - PWSCC within the tubesheet expansion region
 - PWSCC in Row 1 and Row 2 U-bend region
 - ODSCC/PWSCC at pre-heater baffle plate expansion transitions
 - Pitting

Braidwood Unit 2 Historical Secondary Side Activities

	SG	A2R12	A2R13	A2R14	A2R15	A2R16	A2R17	A2R18	A2R19	A2R20	A2R21 (Planned)
Steam Drum Inspection	A	--	X	--	--	--	X	--	--	--	X ⁽²⁾
	B	--	X	X	X	--	X	--	--	--	X
	C	--	X	X	--	--	--	--	X	--	
	D	X	X	--	--	--	--	--	X	--	
Preheater/Waterbox	A	--	--	--	X	--	--	--	X	--	
	B	--	--	--	--	X	--	--	--	--	X
	C	X	--	--	--	X	X ⁽¹⁾	--	X	--	
	D	--	--	X	--	--	X	--	--	--	X
Upper Bundle TSP 08/11	C	X	X	--	--	X	X	--	X	--	X
Sludge Lance/FOSAR	A/B/C/D	X	X	X	X	X	X ⁽³⁾	--	X	--	X
(1) Inspection limited to specific locations. (2) SG 2A could be replaced with SG 2D if there are schedule conflicts due to 2A RCP replacement. (3) No sludge lancing performed due to planned ASCA in A2R19.											

- Steam Drum observed degradation – FAC wear on Primary Moisture Separators
 - Trended since 2005. No through wall penetration expected until after 2024
- Preheater/Waterbox Observed degradation – 2 detached backing (fit-up) blocks.
 - No other backing blocks have been found detached since 2003
- Upper bundle- minor quatrefoil blockage.
 - No measurable impact on SG levels or tube support wear initiation or growth
- Soft Chemical Cleaning and Sludge Lancing in 2017 - removed 3,480 lbs.

Braidwood Unit 2 Foreign Object Search and Retrieval (FOSAR) Activities

- Foreign objects (FOs) based on location, size and type are evaluated, prioritized and removed from Top of Tubesheet or preheater baffle, if required
- Last FOSAR performed in all 4 SGs in A2R19 (2017) after 2 operating cycles
 - No new Foreign object wear at top of tubesheet or preheater baffle observed
 - 5 wires in high flow regions were removed
 - All remaining FOs (16) were analyzed to be benign, i.e., are not predicted to cause appreciable wear until the next inspection
 - These FOs consist of small wires (bristles), scale and sludge “rocks” found on a preheater baffle. Based on their small size and mass or hardness tube wear doesn’t occur
 - Three fixed, legacy objects (wedge, bushing and weld slag) which have not caused any tube wear over 9 or more operating cycles. All tubes in contact with weld slag were preventatively plugged

Braidwood Unit 2 Loose Part Detection System (LPDS)

- Braidwood has 2 channels per SG. Technical Requirements Manual (TRM) 3.3.d requires 1 of 2 channels Operable
 - Braidwood currently has two SG LPDS channels inoperable. Channel 7 (2B SG Hot Side) spiking and Channel 12 (2D SG Cold Side) failing
 - Current A2R21 scope will repair both channels

License Amendment Request Development

- Technical justification for extending inspection intervals for cracking mechanisms in Alloy 600TT SGs was presented to NRR during a Steam Generator Task Force (SGTF) meeting held on 2/24/2020
- Braidwood Unit 2 will use technical approach for Alloy 600TT presented at SGTF meeting
 - Accounts for undetected cracks, initiation of new cracks and growth of cracks over 3 operating cycles
 - Braidwood Unit 2's $T_{\text{Hot}} = 611^{\circ}\text{F}$, lower than “Lead Plants” so lower crack growth rates can be assumed
- Operational Assessment (OA) being performed for 3-cycle operation
 - Will address all existing and potential degradation mechanisms applicable to Braidwood Unit 2
 - Standard OA methods will be used for other existing degradation mechanisms

Timeline for Submittal

- Submittal targeted for April 7, 2020
 - Technical justification for 3-cycle operation
 - Preliminary OA for limiting degradation mechanisms
 - Summary of degradation history and methodology used to develop OA
- Braidwood Unit 2 Outage (A2R21) begins April 20, 2020
- Final OA for all degradation mechanisms will be completed prior to A2R21
- Changes to the schedule will be communicated to NRR Project Manager

Closing Remarks

- LAR for Unit 2 one-time SG inspection deferral is based on the previously discussed technical approach for Alloy 600TT
- Operational Assessment will address all existing and potential degradation mechanisms to support 3-cycle operation