



November 13, 1995
BW/95-0109

U.S. Nuclear Regulatory Commission
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Subject: ComEd Braidwood Station Unit 1 Fifth Refuel Outage
Steam Generator Inservice Inspection Report
Docket No. STN 50-456

References: (1) NUREG-1276, Technical Specifications, Braidwood Station,
Unit Nos. 1 and 2

Gentlemen:

Specification 4.4.5.5.a of Reference (1) requires that within 15 days following the completion of each inservice inspection of steam generator tubes, the number of tubes plugged or repaired in each Steam Generator shall be reported to the Commission in a Special Report pursuant to Specification 6.9.2. A total of 139 tubes were plugged during the Braidwood Unit 1 fifth refuel outage. Table 1 of Attachment A contains a list of the reasons these tubes were plugged.

Specification 4.4.5.5.d of Reference (1) requires that for the implementation of a voltage based repair criteria for Steam Generator tube support plate intersections, the staff should be notified prior to returning the Steam Generators to service should certain conditions arise. None of the conditions of Specification 4.4.5.5.d arose.

Specification 4.4.5.5.e of Reference (1) requires that the results of inspections of F* tubes be reported to the Commission prior to the resumption of plant operation. F* was not applied to any Steam Generator tubes during the Braidwood Unit 1 fifth refuel outage. F* has never been applied to any tubes in the Unit 1 Steam Generators.

Attached is a report on the results from the Braidwood Unit 1 Fifth Refuel Outage (A1R05) Steam Generator eddy current examination. The examination began on October 7, 1995, and was completed on November 13, 1995. The examination incorporated the requirements of the 3.0 Volt Interim Plugging Criteria for tube support plate intersections. A Technical Specification amendment for the 3.0 Volt Interim Plugging Criteria was approved by the NRC on November 9, 1995. The attachments summarize the results of this inspection and include a tube plugging history for Braidwood Unit 1.

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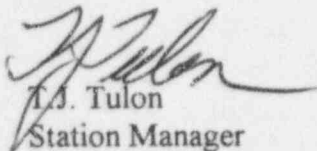
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Please direct any questions regarding this submittal to Doug Huston, Braidwood Licensing Supervisor, (815) 458-2801, extension 2511.

Very truly yours,



T.J. Tulon
Station Manager
Braidwood Nuclear Station

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Attachments

cc: Senior Resident Inspector - Braidwood
Braidwood Project Manager - NRR
Regional Administrator - R111

ATTACHMENT A

Summary of Braidwood Unit 1 Cycle 5 Refueling Outage Steam Generator Inspection Results

During the Braidwood Unit 1 Cycle 5 Refueling Outage (A1R05), the following Steam Generator (SG) eddy current examinations were performed per Technical Specification (TS) 4.4.5:

- 100% of the inservice tubes in all SGs were examined full length by a bobbin coil probe.
- Rotating Pancake Coil (RPC) inspection of 100% of the hot-leg Top-of-Tubesheet roll transition regions. Any circumferential cracks found at the Top-of-Tubesheet were further inspected using the Plus Point probe.
- RPC inspections of a minimum of 20% of the Row 1 and 2 U-Bend sections of the tubes in each SG.
- RPC inspection of a minimum of 20% of the tubes expanded at Preheater baffles in the 1C SG.
- RPC inspection of all hot-leg distorted support indications (DSIs) greater than 3.0 volts, all cold-leg DSIs greater than 1.0 volt, and a minimum of 20% of the hot-leg DSIs between 1.0 volt and 3.0 volts.
- Additional RPC inspections to meet the requirements of Generic Letter 95-05, i.e., dents, large mixed residuals, wedge area tubes, etc.

All inspections were performed in accordance with the Braidwood/Byron eddy current inspection guidelines which include the use of an alternate probe wear criteria as discussed in Reference 1. A 0.610 inch bobbin coil eddy current probe was used to inspect all SG Tube Support Plate (TSP) intersections where the Interim Plugging Criteria (IPC) was applied. One tube did not pass the 0.610 inch bobbin coil probe. This tube had never allowed a 0.610 inch probe to pass in the past therefore, the obstruction was not caused by a corrosion induced dent. The dented tube was inspected by a RPC probe with no degradation identified. Although no degradation was identified, the station elected to plug this tube.

Table 1 is a summary of the tubes that are plugged in the Unit 1 Steam Generators. During the A1R05 outage, a total of 139 tubes were plugged including eighty-five tubes due to tube expansion to lock the TSPs. One tube was plugged due to a TSP indication greater than 3.0 volts and fourteen tubes in wedge areas were plugged due to TSP indications confirmed by RPC. Two tubes were plugged due to Anti-Vibration Bar wear greater than 40% throughwall, and seven tubes were plugged due to miscellaneous reasons. Table 2 contains a tube plugging history for the Braidwood Unit 1 Steam Generators. Table 3 lists the thirty tubes that were plugged due to indications at the top-of-tubesheet roll transition region. F* criteria was not applied to any tubesheet indication (TS 4.4.5.5.e). The data contained in Table 3 has been modified from the field data. Further evaluation of the top-of-tubesheet indications were performed since the field data had been closed. The field data did not identify any Mixed Mode Indications. Two Mixed Mode Indication are now present. Along with the change to the Mixed Mode Indications, some of the arc lengths have been changed. No missing TSP signals were observed. No circumferential crack-like indications were detected at the TSP intersections (TS 4.4.5.5.d.2). No indications

were identified that extend beyond the confines of the TSP (TS 4.4.5.5.d.3). No indications were identified at the TSP elevations that are attributable to Primary Water Stress Corrosion Cracking (PWSCC) (TS 4.4.5.5.d.4). No corrosion induced dents were found. There was one cold-leg bobbin coil indication greater than 1.0 volt, but this indication was not confirmed by the RPC probe.

Table 4 is a summary of the IPC data. Table 4 is based on the A1R05 Growth Rate Data Base. This database contains modifications to the voltages assigned to the tube support plate indications, i.e. the maximum voltage indication from the field database is 3.56 volts, while the maximum voltage indication from the growth rate database is 3.17 volts. Minor adjustments to the voltage measurements are typical in IPC inspections. A total of 4136 TSP indications were identified during the A1R05 outage. As mentioned above, only one was greater than 3.0 volts. 765 indications were between 1.0 and 3.0 volts with 270 (35.3%) inspected by the RPC probe. Of the indications that were inspected by the RPC probe to support the requirements of Generic Letter 95-05, no degradation was identified by the RPC probe for the tubes with dents or with large mixed residuals. All dents greater than 5 volts (81) were inspected using the RPC probe. 35.4% of the dents between 2.5 and 5.0 volts were also inspected using the RPC probe (RPC inspected 51 of the 144 dents). Since there are no copper components in the Braidwood Unit 1 secondary systems, no TSP intersections were found to have interfering signals from copper deposits.

One of the requirements for selecting tubes for expansion to lock the TSP was that the tube shall not contain a circumferential crack at the Top-of-Tubesheet Roll Transition. To ensure the absence of circumferential cracks, the RPC data was reviewed by a circumferential crack industry expert. This review is in addition to the Primary and Secondary Analysts review. Once the RPC data confirmed no circumferential crack existed, the tube was examined by the Plus Point probe. The results from the Plus Point probe examination were reviewed by the same industry expert. None of the tubes selected for expansion contained a circumferential crack. The requirements for tube expansion were met by expanding twenty-one tubes per SG at a total of seventy-four locations. One expansion at the 8H TSP in the 1C SG did not meet the minimum bulge requirement; therefore, a twenty-second tube was selected for expansion at the 8H TSP in this SG. Other expansions in the failed tube met the expansion acceptance criteria, therefore credit was given for these other acceptable expansions. The same selection technique used to select the first twenty-one tubes for expansion was used to select the twenty-second tube in the 1C SG.

After the seventy-four expansions were performed, the bulge size was verified to meet the acceptance criteria by bobbin coil profilometry. To examine for axial and circumferential cracking of the parent tube and the expansion sleeve, the expanded area was examined by the Gimble Plus Point probe. The normal Plus Point probe could not be used due to it not being able to expand to reach the maximum diameter of the bulge.

The Probability of Burst (POB) and primary-to-secondary leak rate during a Steam Line Break (SLB) accident were calculated using the actual measured end-of-cycle (EOC) voltage distributions. Since there was a mid-cycle Steam Generator tube inspection in February of 1995, for clarity, the first-half of Cycle 5 is referred to as Cycle 5A and the second-half as Cycle 5B.

The calculated conditional EOC-5B POB based on the actual measured EOC voltage distributions and taking credit for the TSPs being locked is less than $4\text{E-}6$. This POB meets the requirement of being less than $1\text{E-}2$ (TS 4.4.5.5.d.5). The SLB leakage based on the actual measured EOC voltage distribution is 0.07 gallons per minute (gpm). This SLB leakage meets the requirement of being less than 26.8 gpm (TS 4.4.5.5.d.1) when taking credit for the lower reactor coolant Dose Equivalent Iodine-131 limit of 0.35 microCuries per gram. Since the POB and SLB leak rate was determined using the actual measured EOC voltage distribution, the estimated SLB leak rate and POB based on projected EOC-6 voltage distribution will be reported to the staff within 90 days of Mode 2 as required by Generic Letter 95-05.

The POB and SLB leak rate was also calculated based on the TSPs not being locked, i.e. freespan leak and burst. These calculations were performed to compare to the EOC-5B projected POB and SLB leak rate. The EOC-5B projected POB and SLB leak rate were calculated using the EOC-5A voltage distribution and projecting this voltage distribution using a probability of detection of 0.6 and Monte Carlo. The actual EOC-5B POB was $6.49\text{E-}04$ as compared to the projected EOC-5B POB of $4.49\text{E-}03$. The actual EOC-5B SLB leak rate was 0.07 gpm as compared to the projected EOC-5B SLB leak rate of 0.48 gpm. This shows that the actual measured POB and SLB leak rate are conservative relative to the projected POB and SLB leak rate.

References

1. Letter to Office of Nuclear Reactor Regulation from Harold D. Pontious, Jr., "Additional Information regarding Commonwealth Edison Company's Supplement to Technical Specification Amendment for 3 Volt Interim Plugging Criteria for Byron Unit 1 and Braidwood Unit 1," dated September 15, 1995.

Table 1

Braidwood Unit 1 Fifth Refuel Outage (A1R05) SG Tube Plugging Results

	1A SG	1B SG	1C SG	1D SG	TOTALS
Total Tubes	4578	4578	4578	4578	18312
Previously Plugged Tubes	505	102	706	365	1678
Total Tubes Inspected This Outage	4073	4476	3872	4213	16634
A1R05 Tube Support Plate Pluggable	1	0	0	0	1
Anti-Vibration Bar Wear Pluggable	0	1	1	0	2
Confirmed Wedge Location Pluggable Indications	10	0	1	3	14
Top-of-Tubesheet Pluggable Indications (Circ/Axial/Mixed Mode)	8/1/0	2/0/1	8/1/1	5/3/0	23/5/2
Tubes Plugged due to Administrative Reasons	1 AVB 2 Loose Parts	1 AVB	1 TSP VOL 2 Dents	0	7
Tubes Plugged due to TSP Locking to Support the 3.0 Volt IPC	21	21	22	21	85
A1R05 Total Tubes Plugged	44	26	37	32	139
Restart Total Tubes Available	4029	4450	3835	4181	16495
Total Tubes Plugged	549	128	743	397	1817
Percentage of Tubes Plugged	12.0	2.8	16.2	8.7	9.9

SG Tube Plugging Limits are a maximum of 30% in any one SG with a maximum of 24% total.

Table 2

Braidwood Unit 1 SG Tube Plugging History

	Total	% Plugged	PWSCC	AVB WEAR	FREESPAN	ODSCC	WEDGE	TTS CIRC	OTHER
(PSI) SG-A	4	0.09							1-Factory, 3-Baseline
(PSI) SG-B	1	0.02							1-Factory
(PSI) SG-C	8	0.17							8-Baseline
(PSI) SG-D	1	0.02							1-Baseline
(A1R01) SG-A	5	0.20		2					3-Foreign Object
(A1R01) SG-B	1	0.04			1				
(A1R01) SG-C	0	0.17							
(A1R01) SG-D	0	0.02							
1.162 EFPY									
(A1R02) SG-A	11	0.44		2		8			1-Foreign Object
(A1R02) SG-B	2	0.09		1					1-NRC Bulletin 88-02
(A1R02) SG-C	19	0.59		1		18			
(A1R02) SG-D	4	0.11				4			
0.861 EFPY									
(A1R03) SG-A	37	1.25		4		33			
(A1R03) SG-B	11	0.33				11			
(A1R03) SG-C	82	2.38		2		80			
(A1R03) SG-D	44	1.07				44			
1.132 EFPY									
Oct '94 SG-C	117	4.94			1	116			
0.852 EFPY									
(A1R04) SG-A	186	5.31		1	2	170	13		
(A1R04) SG-B	43	1.27			4	19	0		20-TSP Expansion Preps
(A1R04) SG-C	140	7.99			5	127	8		
(A1R04) SG-D	122	3.74		1		110	11		
1.1468 EFPY NOTE: In R04, a 1.0 Volt IPC was approved for ODSCC.									
(A1M05) SG-A	262	11.03		2		236	17	4	1-MMI at TTS, 2-VOL at TTS, 1-SAI (OD) at TTS
(A1M05) SG-B	44	2.23				41	2		1-VOL at TTS
(A1M05) SG-C	340	15.42		1		315	12	11	1-VOL at TTS
(A1M05) SG-D	194	7.97				180	13		1-SAI (OD) at TTS
0.7142 EFPY NOTE: The 15 Circumferential Cracks + the 1 MMI were "stabilized" with a sleeve.									
(A1R05) SG-A	44	11.99				1	10	8	1-SAI (OD) at TTS, 1 Admin AVB, 2 Loose Parts, 21 Expanded Tubes
(A1R05) SG-B	26	2.80		1				2	1-MMI at TTS, 1 Admin AVB, 21 Expanded Tubes
(A1R05) SG-C	37	16.23		1			1	8	1-SAI (OD) at TTS, 1-MMI at TTS, 1-TSP VOL, 2 DNTs, 22 Expanded Tubes
(A1R05) SG-D	32	8.67					3	5	3-SAI (OD) at TTS, 21 Expanded Tubes
0.506 EFPY NOTE: 3.0 Volt IPC approved for A1R05 outage									

Total Plugged 1817
 % Plugged 9.92
 Total EFPY 5.522

Table 3

A1R05 SG Hot-Leg Top-of-Tubesheet Roll Transition Indications

Circumferential Cracks

Steam Generator	Row	Col	A1M05 Reanalysis Arc Length (degrees)	A1R05 RPC Arc Length (degrees)	A1R05 + Point Arc Length (degrees)	Delta RPC Arc Length (degrees)	Comments
1A	20	38	54	104	129	50	
	27	38	227	312	159	85	
	21	41	176	182	220	6	
	22	41	232	227	259	-5	
	20	42	152	186	213	34	
	46	45	323	337	338	14	
	25	49	257	258	242	1	
	29	61	164	162	127	-2	
1B	23	70	83	159	76	76	
	25	70	169	203	175	34	
1C	9	68	182	187	69	5	
	15	99	165	238	242	73	
	13	102	163	190	326	27	
	2	109	280	357	274	77	
	4	109	284	306	290	24	
	9	110	319	329	344	10	
	3	111	232	250	314	18	
	4	111	316	354	100	38	
1D	11	49	139	146	197	7	
	24	53	72	107	63	35	
	30	53	352	356	360	4	
	8	66	321	336	323	15	
	16	69	154	180	295	26	

Axial Cracks

Steam Generator	Row	Col	A1M05 Reanalysis (volts/degrees)	A1R05 RPC Analysis (volts/degrees)	Delta RPC Analysis (volts/deg)	Comments
1A	37	99	* *	0.62 54		
1C	20	47	* *	0.9 52		
1D	10	68	* *	0.73 42		
1D	20	69	* *	0.86 58		
1D	20	71	* *	0.68 74		

Mixed Mode Cracks

Steam Generator	Row	Col	A1M05 Reanalysis Arc Length (length/deg)	A1R05 RPC Analysis (length/deg)	A1R05 + Point Arc Length (degrees)	Delta RPC Arc Length (length/deg)	Comments
1B	21	72	0.35	0.38		0.03	Axial length in inches
			238	305	353	67	Circumferential degrees
1C	21	54	0.2	0.17		-0.03	Axial length in inches
			263	304	286	41	Circumferential degrees

* Need to size crack

Table 4

Summary of A1R05 Steam Generator Eddy Current IPC Data

	1A SG	1B SG	1C SG	1D SG	TOTAL	Comments
TSP Indications	1031	556	1480	1069	4136	
TSP Indications RPC'd	66	90	105	61	327	
TSP Indications Confirmed by RPC	45	50	52	53	200	
TSP Indications >1.00 Volts	188	88	301	189	766	
TSP Indications >1.00 Volts RPC'd	49	84	83	55	271	35.3% RPC'd between 1 and 3 volts
TSP Indications >1.00 Volts Confirmed by RPC	35	47	46	50	178	
TSP Indications >3.00 Volts	1	0	0	0	1	
TSP Indications <1.00 Volts	843	468	1179	880	3370	
TSP Indications <1.00 Volts RPC'd	17	6	22	11	56	
TSP Indications <1.00 Volts Confirmed by RPC	10	3	6	3	22	
RPC Confirmed TSP Indications in Wedge Area	10	0	1	3	14	
TSP Indications Repaired	21	2	19	11	53	
TSP Indications Repaired >1.00 Volts	4	1	3	2	10	
Maximum TSP Indication (Volts)	3.17	2.03	2.94	2.64	3.17	
Total TSP Dents	80	42	63	45	230	
TSP Dents >5.00 Volts	30	6	39	6	81	All RPC'd, all NDD
TSP Dents 2.50 - 5.00 Volts	49	33	24	38	144	
TSP Dents 2.50 - 5.00 Volts RPC'd	18	11	14	8	51	35.4% RPC'd, all NDD
TSP Dents <2.50 Volts	1	3	0	1	5	
Mixed Residual Indications	3	14	1	7	25	All RPC'd, all NDD
Top-of-Tubesheet Circumferential Cracks/Axial Cracks/Mixed Mode Cracks	8/1/0	2/0/1	8/1/1	5/3/0	23/5/2	1D SG, Dent >5V at CL Tubesheet, NDD by RPC. 1C SG, Dent >5V at HL Tubesheet, NDD by RPC.
Tubes Expanded for 3 Volt IPC	21	21	22	21	85	1 expansion in 1C SG at 8H TSP failed minimum bulge diameter. Expanded another tube at the 8H TSP.

Attachment B

Westinghouse Report

Interim Plugging Criteria Return to Power Report

November 1995