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November 19, 2002

U. S. Nuclear Regulatory Commission
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Ladies and Gentlemen:

DOCKET NUMBER 50-483
CALLAWAY PLANT UNIT 1
UNION ELECTRIC CO.
FACILITY OPERATING LICENSE NPF-30
SPECIAL REPORT 2002-03
C-3 Classified Inservice Inspection Results for Steam Generator Tube Inspections

The enclosed Special Report is submitted in accordance with Technical Specification 5.5.9, Table 5.5.9-2, which states:

> "Results of steam generator tube inspections, which fall into Category C-3, shall be reported to the Commission within 30 days and prior to resumption of plant operation. This report shall provide a description of investigations conducted to determine cause of the tube degradation and corrective measures taken to prevent recurrence."

The required failure mechanism determination investigation and corrective measures taken to prevent recurrence have been completed and are detailed in the enclosed report.

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Manager, Callaway Plant

WAW/ewh

Enclosure

A001

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SPECIAL REPORT TO THE NRC
STEAM GENERATOR A (EBB01A) CATEGORIZED AS C-3 CONDITION IN REFUEL 12

At 1110 on 11/05/02, AmerenUE Callaway Plant determined that steam generator A (EBB01) qualified as Category C-3 in accordance with the requirements of Technical Specification (T/S) 5.5.9, Table 5.5.9-2. At 1419 of that same day, the required ENS notification was made to the NRC Operations Center per 10CFR50.72(b)(2).

Additionally, T/S 5.5.9 refers to T/S 5.6.10 for further reporting requirements. T/S 5.6.10(c) states, "Results of steam generator tube inspections, which fall into Category C-3, shall be reported to the Commission within 30 days and prior to resumption of plant operations. This report shall provide a description of investigations conducted to determine cause of the tube degradation and corrective measures taken to prevent recurrence."

This report is intended to satisfy that requirement.

Callaway Steam Generator History

The Westinghouse Model F steam generators installed at Callaway consist of approximately 78% low temperature mill annealed (LTMA) Alloy 600 tubing and 22% (innermost 10 rows) Alloy 600 thermally treated (TT) tubing.

Callaway Plant first identified primary and secondary side Stress Corrosion Cracking (SCC) of the steam generator tubes in 1995 (Refuel 7). Since that outage, all four steam generators have been inspected each refueling, with the result that an increasing number of tubes have been repaired due to corrosion of the tubes at the hot leg top of tube sheet as shown in Figure 1 and Table 1. Sample RPC inspections are performed each outage at the support plates (dents), low row U-bends, and free span (dings) areas to provide early identification of any cracking that may occur in these locations. None has been identified to date.

The trend of top of tube sheet indications in all four steam generators is provided in Figure 1.

The extent of the tube degradation found during Refuel 12 was not unexpected. Past inspection results and tube degradation prediction models indicated that the degradation of the mill-annealed tubing would accelerate as the plant ages. This has generally been true of other plants with original Westinghouse steam generators fabricated with Alloy 600 MA tubing.

The tube degradation model for Callaway was updated prior to Refuel 12. Based on past experience, plant operating conditions, and experience at other plants, 123 tubes were predicted to be defective due to SCC (ID and OD) and IGA/SCC. The actual number identified was 113 in all four steam generators at the expansion transition or in the expanded portion of the tubing found using a Rotating Pancake Coil (RPC). Of the tubes with tubesheet defects, 84 were found in steam generator A as shown in Table 2 and Attachment 1. Since the number of defective tubes exceeded 1% of the inspected tubes for RPC inspection, the inspection results are classified as C-3.

As Figure 1 demonstrates, Steam Generator A has consistently had more SCC indications than any other steam generator.

No service-induced degradation was identified in the 600TT tubing.

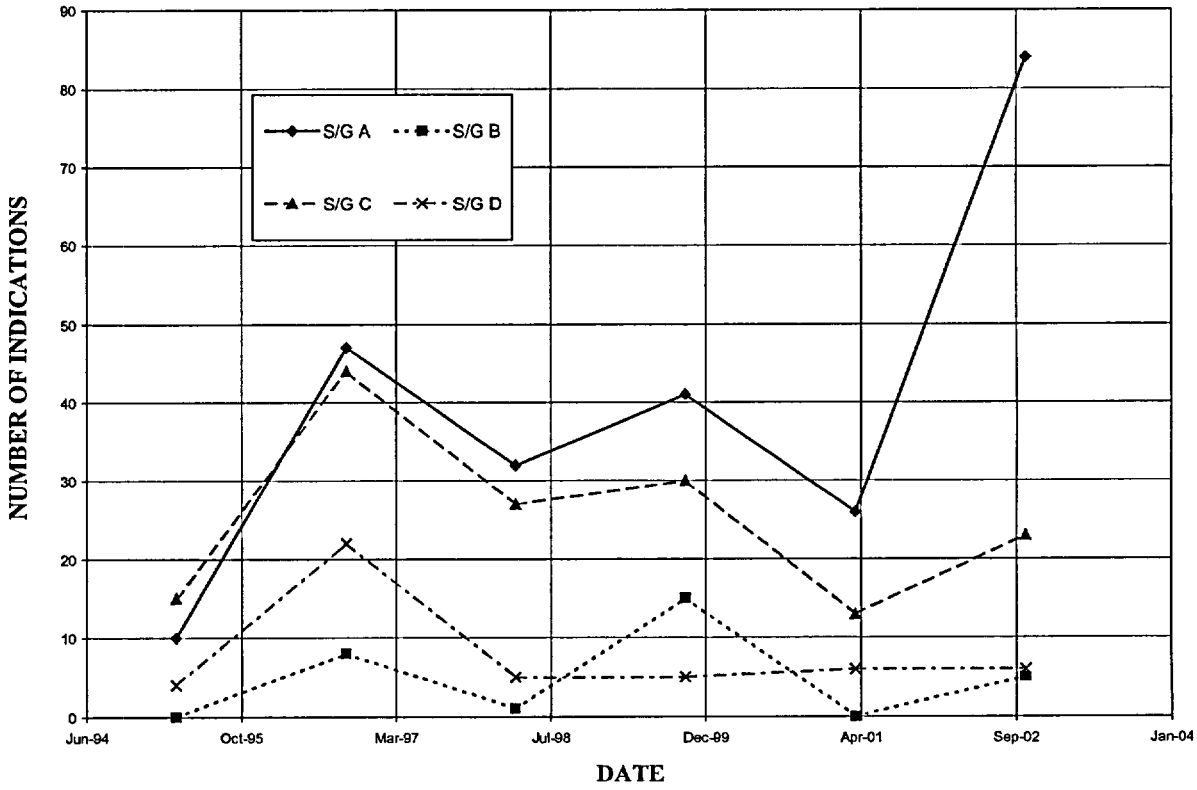

Figure 1 Top of Tubesheet Cracks Trending by Steam Generator

Examination of Steam Generator A

The original inspection scope for 'A' steam generator was as follows:

- 100% (5431 tubes) of the hot leg top-of-tubesheet with a +Point RPC probe
- 100% (5431 tubes) full-length of the tubes with a standard bobbin coil probe

Upon completion of the original scope of inspection, a total of ninety-one (91) tubes (as identified in Attachment 1) required repair:

- Three tubes as a result of anti-vibration bar (AVB) wear greater than 40% through-wall
- Four tubes due to small volumetric indications near support (or flow baffle) plates

- 84 tubes due to Stress-Corrosion Cracking (SCC) or Inter-Granular Attack (IGA) indications at the expansion transition region or in the expanded tube

Seven of the 84 indications discovered in Steam Generator A were found in the region added to the inspection scope using the new H-Star requirements for the top-of-tube sheet inspections.

Investigation for Cause of Degradation

Stress-corrosion cracking (PWSCC/ODSCC) has been identified in the hot leg tube sheet expansion and transition regions in all Westinghouse-designed steam generators (operating at 607°F or above) fabricated with LTMA tubing which were not peened prior to the start of plant operations.

Callaway Plant has determined that, based on the definition of active damage mechanism provided in the EPRI PWR Steam Generator Examination Guidelines, hot leg expansion axial/circumferential PWSCC and hot leg top of tube sheet ODSCC/IGA are active damage mechanisms in Callaway's steam generators.

Stress Corrosion Cracking occurs in the high stress expansion transition located at or below the top of the tube sheet and can initiate from either the primary or secondary side, and occurs due to the combination of the following:

- high residual stresses in and slightly above the expansion transition,
- the concentration of bulk water impurities to aggressive levels in the residual crevice between tube and tubesheet at the TTS, and in occluded areas formed by sludge,
- the insulating effect of sludge at the TTS which can raise the tube OD metal temperature up to primary water temperature in some cases, and
- the presence of a thin cold worked layer on the tube OD from abrasive polishing, often with high residual stresses, which increases susceptibility to crack initiation.

All indications identified at the top of the tube sheet in Refuel 12 are small in size as shown in Figure 2 and 3. None exceeded the condition monitoring limits for the specific type of degradation identified. In-situ testing was performed on indications based on screening criteria developed in the Plant's Degradation Assessment. The screening criteria are specified based on the type of degradation that exists or could potentially exist in the steam generators. Five indications in Steam Generator A exceeded these screening criterion. All indications were tested to 3 times Normal Operating Primary to Secondary Pressure Differential (4350 psi). None of the indications exhibited any leakage at any target pressure up to 3 times normal operating differential pressure during the test sequence. A list of tubes tested in steam generator A and target pressures are attached. (Table 3)

There were no new forms of degradation found in steam generator A. All forms of degradation were anticipated and addressed in the Refuel 12 Degradation Assessment.

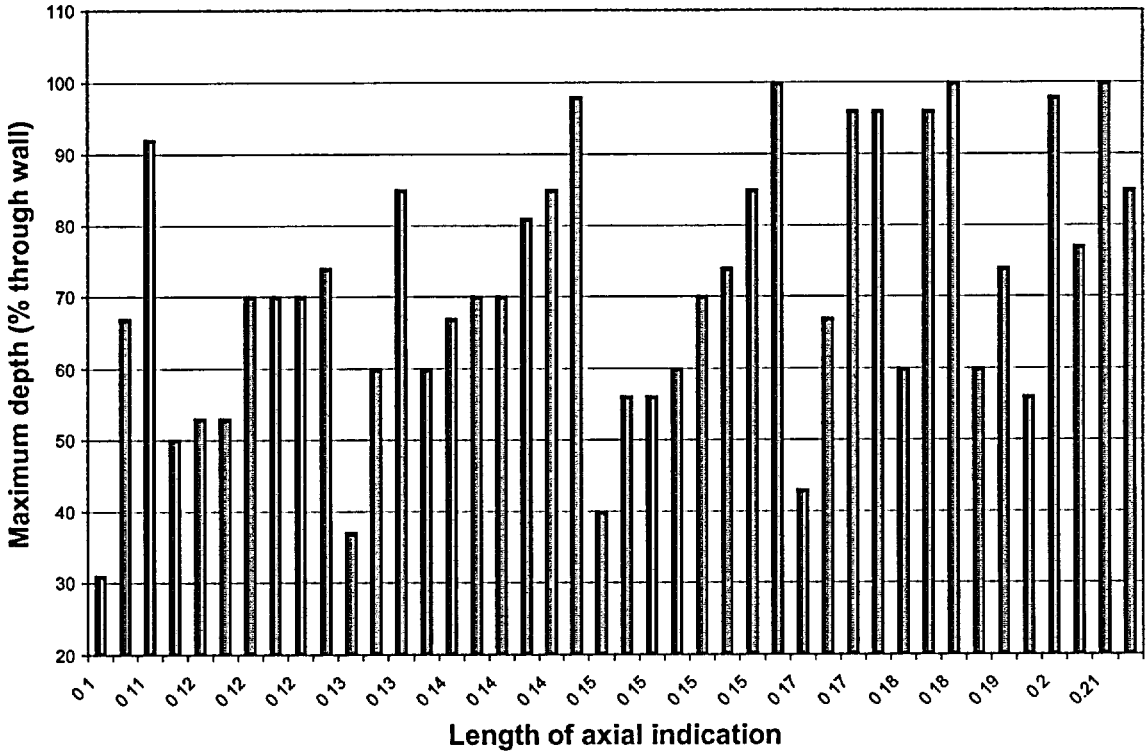

Figure 2 Refuel 12 Steam Generator Axial Indications

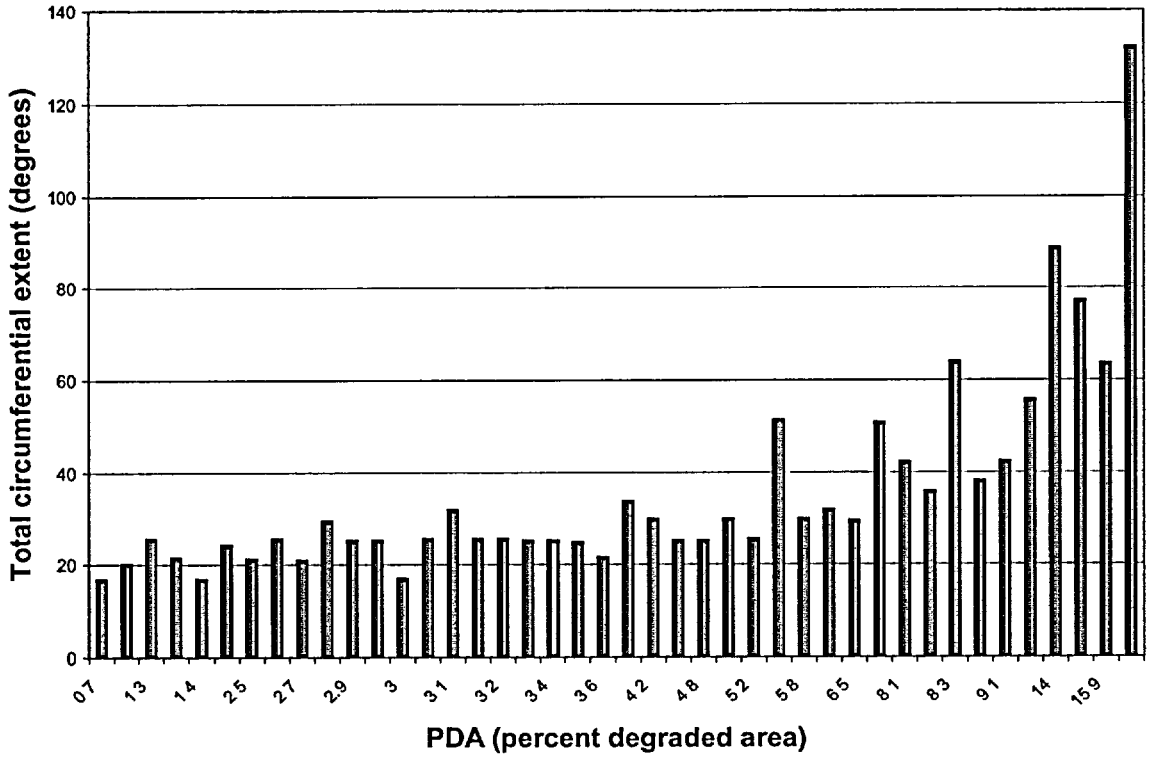

Figure 3 Refuel 12 Steam Generator A Circumferential Indications

Table 1 Steam Generator A Indications and Tubes Repaired Since Refuel 7

Indication	RF07	*RF08	RF09	**RF10	RF11	RF12
Axial ID	5	9	14	15	23	39
Circumferential ID	4	26	17	21	2	43
Axial OD	0	0	1	0	0	0
Axial unknown	1	3	0	0	0	0
Circumferential OD	2	1	0	3	1	0
Circumferential unknown	0	6	0	0	0	0
Volumetric Indications	0	5	0	3	0	4
Total tubes with TTS indications	11	47	32	41	26	84
Tubes plugged due to AVB wear	0	0	0	0	0	3
Tubes plugged due to TSP wear	0	0	0	1	0	4
Tubes plugged due to loose parts	0	0	0	0	0	0
Total tubes repaired	11	48	32	42	26	91

* 44 tubes were sleeved with Westinghouse Laser Welded Sleeves at the top of the tubesheet.
** 31 tubes were sleeved with Framatome Electrosleeves at the top of the tubesheet.

Seven indications in RF12 are due to an expanded scope in the tubesheet based on the H-star criteria.

Refuel 7 – 1 tube has both axial PWSCC and circumferential ODSCC
Refuel 12 – 2 tubes have both axial and circumferential PWSCC

Table 2 Steam Generator A Tubes Plugged

Inspection Period	Steam Generator A
Pre-service	8
Refuel 1	0
Spring '87	--
Refuel 2	3
Refuel 3	--
Refuel 4	6
Refuel 5	--
Refuel 6	19
Refuel 7	11
Refuel 8	4
Refuel 9	32
Refuel 10	11
Refuel 11	26
Refuel 12	91
TOTAL	211

Steam Generator A is 3.75% plugged
Equivalent plugging due to sleeves is 3.79%

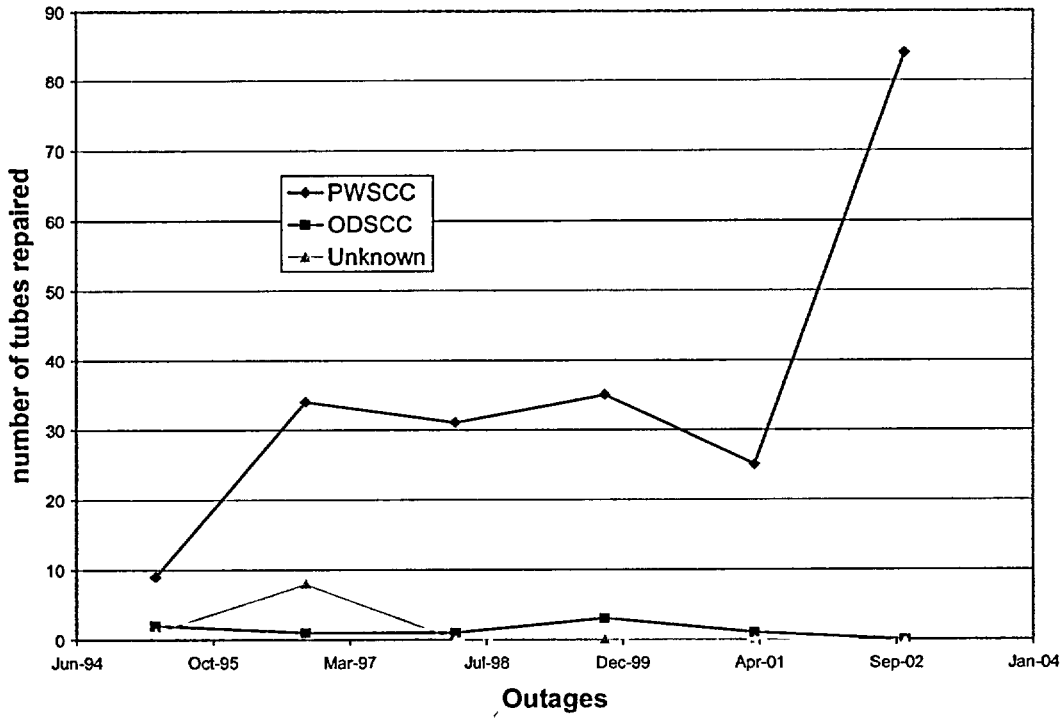

Figure 4 Steam Generator A Cumulative TTS Degradation

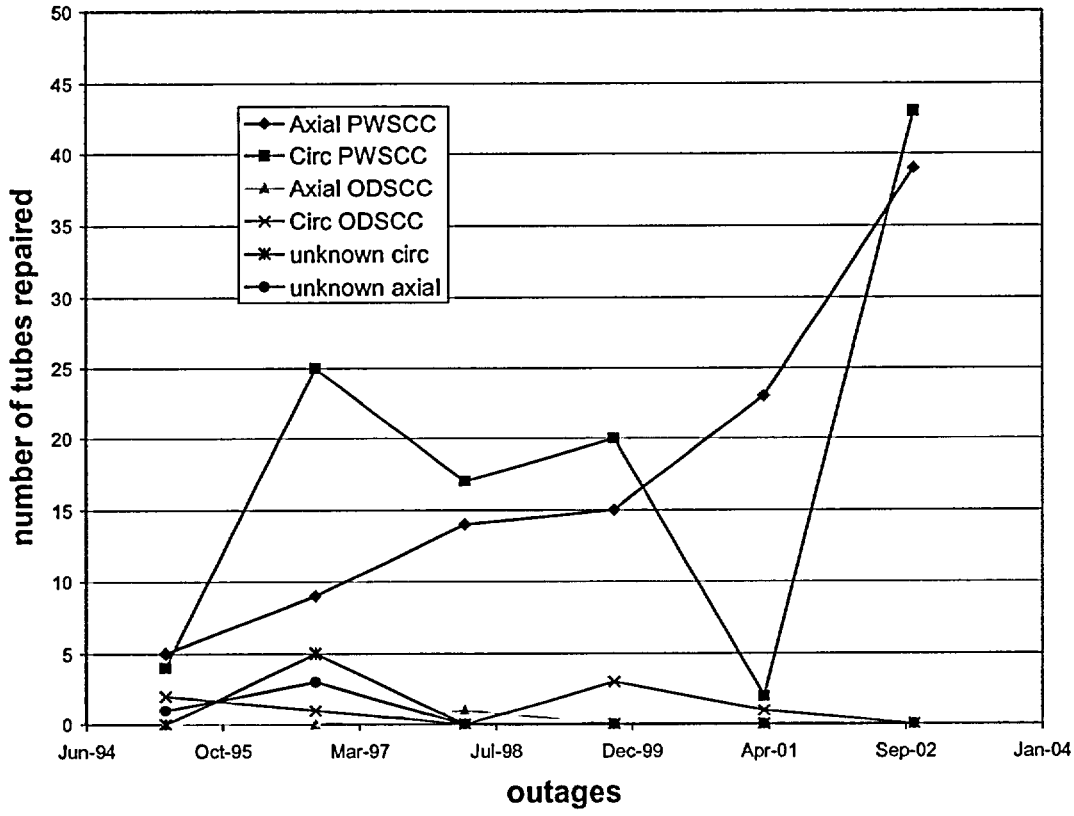

Figure 5 Steam Generator A Cumulative TTS Degradation by Type

Table 3 Steam Generator A In-situ Pressure Testing Results

Steam Generator A					
Tube/Defect/ Location		Test Pressures (psi)	Hold Time (min)	Leak Rate (gpm)	Average Pressurization Rate (psi/sec)
Row	Column	1550	2	0	15
23	97	2900	2	0	24
SCI @ TSH –8.4		3400	2	0	15
		3900	2	0	14
		4350	2	0	16
24	88	1550	2	0	15
SCI @ TSH –5.6		2900	2	0	29
		3400	2	0	17
		3900	2	0	14
		4350	2	0	14
25	71	1550	2	0	12
MCI @ SBH –1.72		2900	2	0	14
		3400	2	0	14
		3900	2	0	17
		4350	2	0	14
34	80	1550	2	0	8
SCI @ TSH –4.76		2900	2	0	15
		3400	2	0	15
		3900	2	0	11
		4350	2	0	10
46	73	1550	2	0	14
SAI @ TSH +0.03		2900	2	0	17
		3400	2	0	13
		3900	2	0	15
		4350	2	0	11

SAI – Single Axial Indication
SCI – Single Circumferential Indication
MCI – Multiple Circumferential Indication
SBH – Bottom Hot Leg Sleeve
TSH – Top of Tubesheet Hot Leg

Actions to Prevent Recurrence

All tubes with detected degradation at the top of the tubesheet were plugged in Steam Generator A. Additionally, all tubes with circumferential crack indications were stabilized and plugged. Callaway Plant anticipates similar degradation discovered in Refuel 12 at the end of Cycle 13. This is based on industry operating experience with Alloy 600 LTMA tubing and plant specific inspections results for the last 6 inspections. Callaway Plant will continue to perform a 100% top of tubesheet inspection with a RPC probe to the H-star distance during the next scheduled inspection. Callaway Plant anticipates replacing the existing steam generators in Refuel 14 with new Steam Generators utilizing Alloy 690 TT tubing. Industry experience has shown that this tubing is less susceptible to stress corrosion cracking.

Callaway Plant will continue to follow the requirements of NEI 97-06 and the referenced EPRI guidelines for future cycles of operation. These guidelines include maintaining primary and secondary water chemistry below recommended levels, primary to secondary leakage monitoring, inspection scope and frequency, pressure testing

degraded tubes, and performing integrity assessments to ensure tube structural and leakage integrity.

The Condition Monitoring and Preliminary Operational Assessment, performed in accordance with the EPRI Integrity Assessment Guidelines, during Refuel 12 addresses the as-found condition of the steam generator tubing and justifies operation for Cycle 13. The assessment is based on degradation identified and conservative analysis to assure tube structural and leakage integrity for the entire cycle length.

ATTACHMENT 1 – INDICATIONS IDENTIFIED IN STEAM GENERATOR A DURING REFUEL 12

ROW	COL	REPAIR		REASON FOR REPAIR	IN-SERVICE
		HOT LEG	COLD LEG		
1	34	PLUGGED	PLUGGED	MVI @ 01C –0.39	NO
11	68	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.12	NO
11	98	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.06	NO
12	64	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.23	NO
12	65	PLUGGED	PLUGGED	SAI @ TSH +0.1	NO
12	99	PLUGGED	PLUGGED	SVI @ TSH +0.07	NO
13	66	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.16	NO
13	75	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.16	NO
14	83	PLUGGED	PLUGGED	SAI @ TSH +0.08	NO
15	48	PLUGGED	PLUGGED	SVI @ 07H +0.26	NO
16	72	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.17	NO
17	43	PLUGGED	PLUGGED	SCI @ TSH –0.1	NO
17	51	PLUGGED	PLUGGED	SAI @ TSH +0.12	NO
17	101	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.06	NO
18	42	PLUGGED-STABILIZED	PLUGGED	MCI @ TSH –6.02	NO
18	44	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –0.96	NO
18	49	PLUGGED	PLUGGED	MAI @ TSH +0.01	NO
18	50	PLUGGED	PLUGGED	SAI @ TSH –0.01	NO
19	42	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.05	NO
19	68	PLUGGED-STABILIZED	PLUGGED	MCI @ TSH +0.24	NO
19	69	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –5.45	NO
20	39	PLUGGED	PLUGGED	SAI @ TSH –0.01	NO
20	50	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.11	NO
20	82	PLUGGED	PLUGGED	SAI @ TSH +0.08	NO
21	45	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –2.3	NO
21	59	PLUGGED	PLUGGED	SAI @ TSH +0.09	NO
21	64	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.06	NO
22	58	PLUGGED	PLUGGED	SAI @ TSH +0.05	NO
22	72	PLUGGED	PLUGGED	SAI @ TSH +0.07	NO
23	43	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –0.33	NO
23	78	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –7.88	NO
23	84	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.16	NO
23	97	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –8.4	NO
24	80	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.2	NO
24	88	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –5.6	NO
24	103	PLUGGED	PLUGGED	SAI @ TSH +0.1	NO
25	62	PLUGGED	PLUGGED	SAI @ TSH +0.06	NO
25	71	PLUGGED	PLUGGED	MCI @ SBH –1.72	NO*
25	88	PLUGGED	PLUGGED	SAI @ TSH +0.1	NO
25	91	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.00	NO
25	99	PLUGGED	PLUGGED	SAI @ TSH +0.00	NO
26	53	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –2.59	NO
				SAI @ TSH +0.06	NO
26	77	PLUGGED-STABILIZED	PLUGGED	MCI @ TSH +0.11	NO
26	109	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.07	NO
27	60	PLUGGED	PLUGGED	SAI @ TSH +0.05	NO
27	68	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.07	NO
27	83	PLUGGED-STABILIZED	PLUGGED	MCI @ TSH +0.05	NO

ATTACHMENT 1 – INDICATIONS IDENTIFIED IN STEAM GENERATOR A DURING REFUEL 12

ROW	COL	REPAIR		REASON FOR REPAIR	IN-SERVICE
		HOT LEG	COLD LEG		
27	100	PLUGGED-STABILIZED	PLUGGED	MCI @ TSH +0.14	NO
30	64	PLUGGED	PLUGGED	SAI @ TSH –0.03	NO
31	76	PLUGGED	PLUGGED	SAI @ TSH +0.08	NO
31	101	PLUGGED	PLUGGED	SAI @ TSH +0.13	NO
32	65	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –3.18	NO
32	82	PLUGGED	PLUGGED	SAI @ TSH +0.07	NO
33	74	PLUGGED	PLUGGED	SAI @ TSH +0.08	NO
33	108	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.08	NO
34	73	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –3.53	NO
34	80	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –4.76	NO
34	89	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.05	NO
34	98	PLUGGED	PLUGGED	SAI @ TSH +0.08	NO
37	83	PLUGGED	PLUGGED	SAI @ TSH +0.06	NO
38	88	PLUGGED	PLUGGED	SAI @ TSH +0.05	NO
39	37	PLUGGED	PLUGGED	42% @ AV5 +0.15	NO
				40% @ AV4 +0.00	NO
39	41	PLUGGED	PLUGGED	42% @ AV4 –0.05	NO
39	61	PLUGGED	PLUGGED	SAI @ TSH +0.00	NO
39	83	PLUGGED	PLUGGED	SAI @ TSH +0.04	NO
39	88	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –1.98	NO
39	90	PLUGGED	PLUGGED	SAI @ TSH +0.02	NO
39	92	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.13	NO
41	54	PLUGGED	PLUGGED	SAI @ TSH +0.00	NO
41	82	PLUGGED	PLUGGED	SAI @ TSH +0.06	NO
41	95	PLUGGED	PLUGGED	MAI @ TSH +0.03	NO
42	62	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –0.62	NO
43	36	PLUGGED	PLUGGED	SVI @ TSH +0.03	NO
44	35	PLUGGED	PLUGGED	SVI @ TSH +0.09	NO
44	36	PLUGGED	PLUGGED	SVI @ TSH +0.13	NO
44	59	PLUGGED	PLUGGED	SAI @ TSH +0.05	NO
44	62	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –0.67	NO
44	75	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.09	NO
44	81	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.1	NO
46	48	PLUGGED	PLUGGED	47% @ AV2 +0.00	NO
				41% @ AV3 +0.00	NO
				44% @ AV4 +0.00	NO
46	50	PLUGGED	PLUGGED	MAI @ TSH +0.00	NO
46	61	PLUGGED-STABILIZED	PLUGGED	MAI @ TSH –0.75	NO
				SCI @ TSH –0.74	NO
46	73	PLUGGED	PLUGGED	SAI @ TSH +0.03	NO
47	49	PLUGGED	PLUGGED	SAI @ TSH +0.00	NO
47	50	PLUGGED	PLUGGED	SAI @ TSH +0.01	NO
47	57	PLUGGED	PLUGGED	SVI @ FBH +0.07	NO
48	61	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH –0.98	NO
48	70	PLUGGED-STABILIZED	PLUGGED	SCI @ TSH +0.06	NO

ATTACHMENT 1 – INDICATIONS IDENTIFIED IN STEAM GENERATOR A DURING REFUEL 12

ROW	COL	REPAIR		REASON FOR REPAIR	IN-SERVICE
		HOT LEG	COLD LEG		
49	48	PLUGGED	PLUGGED	SAI @ TSH +0.02	NO
49	62	PLUGGED	PLUGGED	SAI @ TSH +0.17	NO
59	67	PLUGGED	PLUGGED	SVI @ 02C +0.13	NO

*Tube 25-71 does not require additional stabilization due to a 12.00" Westinghouse Laser Welded Sleeve installed at the Hot Leg Tube Sheet area.

SAI	Single Axial Indication
MAI	Multiple Axial Indication
SCI	Single Circumferential Indication
MCI	Multiple Circumferential Indication
SVI	Single Volumetric Indication
MVI	Multiple Volumetric Indication
TSH	Tube Sheet Hot
TSC	Tube Sheet Cold
AV#	Anti-Vibration Bar (where # is the anti-vibration bar number)
O1H	First Support Plate Hot
TSH	Top of Tubesheet Hot
SBH	Bottom of Sleeve Hot