Omaha Public Power District

444 South 16th Street Mall
Omaha NE 68102-2247

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SUBJECT: Fort Calhoun Station (FCS) Steam Generator Eddy Current Test Report - 2001 Refueling Outage

Pursuant to FCS Unit No. 1 Technical Specification 3.17(5)(ii), Omaha Public Power District (OPPD) submits the attached FCS Steam Generator Eddy Current Test Report which summarizes testing performed during the Spring 2001 Refueling Outage.

Please contact me if you have any questions.

Sincerely,

MT Frans

M. T. Frans
Manager
Nuclear Licensing

MTF/JKM/rlj

Attachment

c: E. W. Merschoff, NRC Regional Administrator, Region IV
A. B. Wang, NRC Project Manager
W. C. Walker, NRC Senior Resident Inspector
Winston & Strawn (w/o Attachment)

A001

FORT CALHOUN STATION
STEAM GENERATOR EDDY CURRENT TEST REPORT
2001 REFUELING OUTAGE

INTRODUCTION

This report summarizes steam generator eddy current test results obtained during the Fort Calhoun Station (FCS) 2001 Refueling Outage (RFO). Omaha Public Power District (OPPD) submitted summaries of results of the two previous eddy current inspections to the NRC in the following documents:

- *Fort Calhoun Station (FCS) Steam Generator Eddy Current Test Report - 1998 Refueling Outage,* dated October 27, 1998 (LIC-98-0141)

- *Fort Calhoun Station (FCS) Steam Generator Eddy Current Test Report - 1999 Refueling Outage,* dated April 25, 2000 (LIC-00-0039)

DESCRIPTION OF FCS STEAM GENERATORS

FCS has two steam generators of the vertical recirculating type manufactured by Combustion Engineering Inc. (CE). The steam generators each contain 5005 tubes installed in low alloy steel tubesheets by a full depth explosive expansion process. The tubes are seal welded to the primary faces of the tubesheets. The steam generator tubes at Fort Calhoun are seamless Inconel Alloy 600 with an outside diameter of ¾ inch and a nominal wall thickness of 0.048 inch.

All tube supports in the FCS steam generators are carbon steel. The vertical supports at the top of the tube bundle are of the vertical strap/scallop bar design typical of early CE steam generators. Support is provided in the U-bend region by diagonal bars, or "batwings", also a common CE design. The uppermost horizontal support is a partial drilled plate which supports all tubes in rows 74 and above. The remaining horizontal supports are of the egg crate lattice type which have drilled tube support plates integrated into the egg crates on both the hot and the cold leg sides at each elevation. Approximately 975 tubes pass through at least one drilled plate, and several hundred tubes pass through all of the drilled plates. The solid drilled plates also have ¼ inch diameter flow holes nominally in the center of each triangular array of three tubes.

FCS steam generator support notations referenced throughout this report can be found on Figure 1.

SCOPE OF EXAMINATION

Westinghouse conducted an inservice eddy current examination of the steam generator tubes at FCS in March and April of 2001. An eddy current inspection was performed on 100% of the tubes in the steam generators. Eddy current techniques included bobbin coil and various rotating coil technologies to further investigate bobbin indications and other suspect regions. The examination program was conducted to meet the requirements of FCS Technical Specification Section 3.17.

The test program included:

1. Full length bobbin coil testing of 100% of the tubes in steam generators RC-2A and RC-2B. This 100% exam encompassed 4838 tubes in RC-2A and 4848 tubes in RC-2B.

2. Rotating coil examinations at the top of the hot leg tubesheet of 100% of the tubes in steam generators RC-2A and RC-2B with Plus Point® probes. This 100% exam encompassed 4838 tubes in RC-2A and 4848 tubes in RC-2B.

3. Rotating coil exams of 724 locations at the top of the cold leg tubesheet in RC-2A and 762 locations at the top of the cold leg tubesheet in RC-2B to continue monitoring for volumetric degradation which was first identified at this location in 1996. This examination represents a critical area in the central region (or sludge pile region) where experience has indicated this damage mechanism is occurring.

4. Rotating coil examinations in the tight radius U-bendss of 49 tubes in each steam generator (20% of the tubes in rows 1 through 4).

5. Rotating coil exams at hot leg tube support intersections in both steam generators (approximately 2871 exams in RC-2A and 4029 exams in RC-2B). These included 20% of the dents at supports H1 through H7 and V1 in each steam generator and 100% of the drilled tube support intersections at H6 through H8 in each steam generator. Additional exams in RC-2B included 100% of the drilled tube support plate intersections at H2, 100% of the dented drilled tube support plate intersections at H4, and 100% of the dented egg crate intersections at H7.

6. Rotating coil exams of 466 tubes in RC-2A and 460 tubes in RC-2B from DBH to H6 or DBH to H5. This exam was performed in response to several relatively large amplitude freespan axial indications in the region of the drilled tube support plates in the upper bundle area identified during the 1999 inspection.

7. Rotating coil exams of 365 indications for the purposes of characterizing indications detected with the bobbin coil and providing positive identification of potential tube defects.

BOBBIN COIL EXAMINATIONS

The tubes in the bobbin coil inspection plan were examined full length with a 0.540" or 0.560" bobbin probe, and indications were flagged for further characterization with rotating coil technology. The data was independently analyzed by two groups of certified Level IIA or Level III data analysts. Any discrepancies between the two sets of evaluation results were reviewed and resolved by a Lead Level III Eddy Current Examiner.

The examination was conducted with a Zetec MIZ-30® digital eddy current acquisition system and analyzed utilizing the Eddynet 98® digital analysis system. The frequencies utilized during the bobbin coil examination were as follows:

400 kHz frequency differential and absolute
100 kHz frequency differential and absolute
600 kHz frequency differential and absolute
20 kHz frequency differential and absolute
400/100 kHz frequency differential support ring mix
400/100 kHz frequency absolute support ring mix

The primary frequency of 400 kHz satisfied the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code for the examination of non-ferromagnetic steam generator tubing. A technique using the differential support mix and a voltage base of 2.75 volts on the 20% outside diameter (OD) ASME signal was used to perform dent sizing consistent with current industry techniques. The 100 kHz frequency is provided for the confirmation of flaw indications and as a frequency used in the mixes to eliminate support and OD deposit signals. The 100 kHz absolute frequency detects gradual wall thickness variations. The 600 kHz frequency is for information only. The 20 kHz frequency is provided to facilitate locating the probe position in the steam generator. The 400/100 kHz differential frequency mix is used to eliminate the tube support signal and OD tube deposit signals. The 400/100 kHz absolute frequency mix is used to detect gradual wall loss.

ROTATING COIL EXAMINATIONS

Rotating coil examinations were performed at the top-of-tubesheet transitions on the hot and cold leg sides, in tight radius U-bendss, at dented tube support intersections, in upper bundle freespan locations from DBH to H6 or DBH to H5, and at bobbin coil suspect indications as a diagnostic tool. Various versions of the Plus Point® probe were used for the rotating coil examinations.

The tubes in the top of the tubesheet program were inspected in the expansion transition regions of each steam generator. The data was analyzed for the presence of crack-like or volumetric indications similar to those previously found in the expansion transition regions at FCS and at other plants. Terrain plots were used during the analysis effort to improve the probability of detecting circumferential cracks.

The rotating coil exams performed at tight radius U-bendss, dents, freespan sections, and tube support intersections were performed to determine if stress corrosion cracking is present in suspect areas of the steam generators, to verify bobbin coil results, and to characterize the indications seen with the bobbin coil probe.

The frequencies used for the 3-coil top-of-tubesheet examination were as follows:

400 kHz Pancake, Mid-Frequency Plus Point® coil, and High-Frequency Pancake coil

300 kHz Pancake and Mid-Frequency Plus Point® coil
100 kHz Pancake and Mid-Frequency Plus Point® coil
700 kHz High-Frequency Pancake coil
20 kHz Pancake and Mid-Frequency Plus Point® coil

The frequencies used for the single coil mid-frequency tight radius U-bend rotating coil examinations were as follows:

400 kHz Mid-Frequency Plus Point® coil
300 kHz Mid-Frequency Plus Point® coil
200 kHz Mid-Frequency Plus Point® coil
100 kHz Mid-Frequency Plus Point® coil
20 kHz Mid-Frequency Plus Point® coil

The frequencies used for the single coil high frequency tight radius U-bend examinations were as follows:

800 kHz High-Frequency Plus Point® coil
600 kHz High-Frequency Plus Point® coil
400 kHz High-Frequency Plus Point® coil
300 kHz High-Frequency Plus Point® coil

The frequencies for the flex probe rotating coil examinations were as follows:

400 kHz Pancake and Mid-Frequency Plus Point® coil
300 kHz Pancake and Mid-Frequency Plus Point® coil
100 kHz Pancake and Mid-Frequency Plus Point® coil
20 kHz Pancake and Mid-Frequency Plus Point® coil

The Plus Point® screening technique was revised in the 2001 examination to be more sensitive than the technique used in 1999. The 1999 examination used EPRI technique ETSS 96402. This technique was replaced with ETSS 20409.1, which was used for the 2001 examination. The primary difference between the two techniques is the test frequency and the span (size) setting used to view the data. In 1999, the 400 kHz frequency channel was the primary detection channel and the span setting was established at one grid division for the 40% OD circumferential notch. The 2001 screening technique used the 300 kHz frequency channel and the span setting was established at two grid divisions for the 20% inside diameter circumferential notch.

ULTRASONIC TEST EXAMINATION

Previous steam generator eddy current inspections at Fort Calhoun revealed the presence of OD degradation at the top-of-tubesheet region in the cold leg. The most probable morphology of the degradation was OD pitting; however, many of the indications were circumferential in orientation. Ultrasonic testing (UT) examination was proposed as a method of confirming that the eddy current indications were not a result of, or did not occur in conjunction with, outside diameter stress corrosion cracking (ODSCC). UT was also proposed as a way of depth sizing the pitting indications. Part of preparations for this inspection included a performance demonstration of the Westinghouse UTEC system in accordance with Appendix J of Revision 5 of the EPRI *PWR Steam Generator Examination Guidelines*.

INSPECTION RESULTS

The numbers and locations of each type of indication found are summarized in Tables 1 and 2. Support notations are shown on Figure 1 and definitions of indication acronyms can be found in the Appendix.

There were no circumferential or axial cracking indications detected at the tubesheet expansion transitions. However, axial ODSCC was detected in the sludge pile region just above the tubesheet.

There were 129 axial indications recorded at various elevations of both steam generators. The majority of the indications reside in the freespan tubing between H6 and DBH in the critical area where the drilled tube support plates are superpositioned. Historical data reviews from the 1999 refueling outage inspection were conducted by the senior analyst during the course of the 2001 refueling outage examination. Of the 129 indications, 108 indications were reviewed to determine whether the flaw was present and if so, did it appear to grow. Some indications that were detected by the Plus Point® coil only could not be reviewed because that area of the tube had not been tested by Plus Point® in 1999. The results from this data review are qualitative in nature with no detailed sizing performed. There were 61 indications reviewed in RC-2A and 47 indications reviewed in RC-2B. In RC-2A, 33 indications (54%) showed growth. In RC-2B, 8 indications (17%) showed growth.

Six circumferential volumetric indications (CVIs) were identified at the top of the cold leg tube sheet in steam generator RC-2B. These were detected by the Plus Point® coil examination of the cold leg critical area which focuses on the sludge pile region of the tube bundle. None of the CVIs showed change compared to the 1999 eddy current test (ECT) data. Numerous bobbin coil distorted expansion indications (DEIs) were reported outside of the critical area. All of these were tested with the Plus Point® and none of the bobbin indications were confirmed as a flaw. All of the CVIs were subsequently examined using an ultrasonic technique, and the damage mechanism was confirmed to be pitting. The maximum depth of any individual pit was 39% through-wall by UT.

Thirteen single volumetric indications (SVIs) were found at various locations of both steam generators. Two of these indications were located in RC-2A just above support C3 near the

periphery of the tube bundle. The damage mechanism that produced these flaws is mechanical wear from loose parts. Seven SVIs were detected in the hot leg side of the steam generators either just above the tubesheet or between H6 and H8. This is the region where axial ODSCC occurs and the damage mechanism which produced the eddy current indications is presumed to be inter-granular attack (IGA). Four of the SVIs were detected just above the cold leg tubesheet. In addition, two tubes with multiple volumetric indications (MVIs) were reported in the same region. All of the volumetric indications at the cold leg top of tubesheet were included in the ultrasonic examination. As with the CVIs, these SVIs and MVIs were identified as shallow pits by UT.

Ten single circumferential indications (SCIs) were found in hot leg drilled support plates in each steam generator. The maximum circumferential extent of the indications was 103 degrees, and the maximum indicated depth by Plus Point® phase analysis was 59% through-wall. Several of the indications show growth from the last cycle. Of the ten SCIs reported, five are associated with a dent reported from the bobbin coil. The dent voltages range from 9.3 volts to 79.1 volts. The other five indications are at locations that are likely dented, but the dents are either not visible by the bobbin coil or are below the dent reporting threshold of 3 volts.

Two obstructed tubes were encountered in RC-2B. One was obstructed at H8 and one at V1. The term obstructed is used to denote that a 0.540" diameter bobbin probe will not pass through the tube due to denting.

One tube in RC-2A and four tubes in RC-2B were preventively placed on the plugging list due to volumetric indications in the freespan tubing. These indications are most likely manufacturing burnish marks (MBMs). However, the 1984 data, which is used for historical verification of MBMs, was not available for these tubes.

One tube in RC-2A was preventively placed on the plugging list due to excessive noise on the Plus Point® coil.

All of the tubes with the above indications were plugged. Tubes with circumferential indications were also stabilized by inserting a wire rope stabilizer through the area of circumferential degradation to preclude the tube from severing if the degradation were to continue to progress. A total of 51 tubes were plugged in RC-2A and 70 tubes were plugged in RC-2B. No tubes were repaired by sleeving.

All pluggable indications are reported in Tables 3 and 4. Support notation for each steam generator is shown in Figure 1. Depth estimates were made only on pluggable indications for the purpose of providing input to assessments of overall steam generator condition. No tubes were left in service on the basis of sizing.

IN-SITU PRESSURE TESTS AND RESULTS

In-situ pressure tests were performed on 13 defects in 6 tubes with the Westinghouse in-situ pressure test device to verify structural and leakage performance criteria were satisfied. Specifically, these tubes were tested to demonstrate that leakage would be below 150 gallons per day at normal operating differential pressure (NODP), below 1 gallon per minute at peak accident (main steam line break (MSLB)) differential pressure, and that they would be able to sustain a pressure of 3 times NODP without burst.

The 13 defects tested covered axial and circumferential indications. None of the indications exceeded screening criteria for pressure testing. Table 5 shows the indications tested with the in-situ pressure test method and gives the results of each test. None of the indications leaked at pressures up to 3 times NODP. Based on the eddy current and in-situ pressure test results, the performance criteria were met for the entire previous operating cycle, and the requirement for condition monitoring was satisfied.

CONCLUSIONS

As a result of the inspection, OPPD has reached the following conclusions:

1. A 100% top-of-tubesheet expansion transition inspection was performed on the hot leg side of each steam generator with Plus Point® probe technology. There were no circumferential or axial cracking indications detected at the tubesheet expansion transition. However, axial ODSCC was detected in the sludge pile region just above the tubesheet.

2. No cracking was identified in the tight radius U-bendss.

3. Volumetric indications (CVI, SVI, MVI) were detected at the top-of-tubesheet in the cold leg side of steam generator RC-2B. However, these indications are no longer active based on the eddy current and UT results. It was confirmed by the UT that these represent a pitting damage mechanism.

4. Single axial indications (SAIs) and multiple axial indications (MAIs) in both steam generators in the freespan and at tube support intersections, primarily in the tube support plate region between DBH and H6, show growth when compared to previous outage data, indicating progression of the outside diameter stress corrosion cracking mechanism in the upper bundle region.

5. SAIs and MAIs in both steam generators just above the top of the hot leg tubesheet show growth from previous exams indicating progression of the outside diameter stress corrosion cracking mechanism in this region.

6. Single circumferential indications (SCIs) were found in hot leg drilled support plates in each

steam generator. The maximum circumferential extent of the indications was 103 degrees, and the maximum indicated depth by Plus Point® phase analysis was 59% through-wall. Several of the indications show growth from the last cycle.

7. Based on the results of the extensive eddy current examination and the in-situ pressure tests performed, the steam generator tube performance criteria were met for the entire previous operating cycle, and the requirements for condition monitoring were fulfilled.

All tubes with identified degradation were plugged. Tubes with circumferential indications were stabilized. Overall, 51 tubes were plugged in steam generator RC-2A, and 70 tubes were plugged in steam generator RC-2B. To date, RC-2A has a total of 218 tubes plugged (4.36%), and RC-2B has a total of 227 tubes plugged (4.54%).

TABLE 1

	STEAM GENERATOR RC-2A INDICATION[3] LISTING BY LOCATION[1,2]								
Location	SAI	MAI	SCI	SVI	CVI	MVI	VOL	OBS	Total
HTS	14	1		1					16
HTS+									0
H1									0
H1+									0
H2									0
H2+									0
H3									0
H3+	1								1
H4	1								1
H4+									0
H5									0
H5+									0
H6	4		1						5
H6+	12								12
H7	5	1	2						8
H7+	17	2							19
H8	3		2					1	6
H8+	2								2
DIAG									0
DIAG+									0
V1								1	1
V1+									0
V2									0
V2+									0
V3									0
V3+									0
DIAG									0
C8+									0
C8									0
C7+									0
C7									0
C6+									0
C6									0
C5+									0
C5									0
C4+									0
C4									0
C3+									0
C3				2					2
C2+									0
C2									0
C1+									0
C1									0
CTS+							1		1
CTS									0
TOTAL	59	4	5	3	0	0	1	2	74

[1] Numbers are totals and include multiple locations for each tube if separated by more than ~1"
[2] Locations are +/- 2", Locations with a "+" are >2" from support location.
[3] Indication Definitions are given in Appendix after Tables.

TABLE 2

	STEAM GENERATOR RC-2B INDICATION[3] LISTING BY LOCATION[1,2]								
Location	SAI	MAI	SCI	SVI	CVI	MVI	VOL	OBS	Total
HTS	2			1					3
HTS+				1					1
H1									0
H1+									0
H2	9		1						10
H2+									0
H3	1								1
H3+									0
H4	2								2
H4+	1								1
H5	1								1
H5+	5								5
H6	8								8
H6+	13			1					14
H7	9		1	1					11
H7+	9			1					10
H8	3		3	1					7
H8+	3								3
DIAG									0
DIAG+									0
V1									0
V1+							1		1
V2									0
V2+									0
V3									0
V3+									0
DIAG									0
C8+									0
C8									0
C7+									0
C7									0
C6+									0
C6									0
C5+									0
C5									0
C4+									0
C4									0
C3+							1		1
C3									0
C2+									0
C2									0
C1+							1		1
C1									0
CTS+							1		1
CTS				4	6	2			12
TOTAL	66	0	5	10	6	2	4	0	93

[1] Numbers are totals and include multiple locations for each tube if separated by more than ~1"
[2] Locations are +/- 2", Locations with a "+" are >2" from support location.
[3] Indication Definitions are given in Appendix after Tables.

TABLE 3
LIST OF RC-2A TUBES PLUGGED

Row	Line	Flaw Type[1]	Estimated Depth (%)	Location
12	61	SAI	42	HTS+0.37
23	64	SAI	31	HTS+0.75
23	78	SAI	28	HTS+0.70
24	53	SAI	44	HTS+0.76
24	67	SAI	30	HTS+1.26
25	60	SAI	38	HTS+1.61
26	67	SAI	35	HTS+0.52
27	54	SAI	26	HTS+1.02
28	61	SAI	29	HTS+2.00
28	69	MAI	34	HTS+0.98
28	69	SAI	37	HTS+1.16
29	60	MAI	47	HTS+1.48
29	60	SAI	32	HTS+1.82
29	62	SAI	41	HTS+1.63
29	62	SAI	29	H4-1.84
31	64	SAI	36	HTS+1.57
59	110	SVI	43	C3+1.40
61	110	SVI	33	C3+1.03
67	106	DFI/VOL	0	CTS+20.64
79	58	OBS	0	N/A
82	55	SAI	30	H7+1.40
84	73	OBS	0	N/A
85	54	SAI	33	H7-0.23
85	56	SAI	29	H8+3.65
85	56	SAI	28	H7+3.10
85	56	SAI	27	H8+3.17
85	60	SAI	31	H6+3.95
86	57	SAI	37	H3+15.75
86	59	SAI	36	H6+3.52
86	59	SAI	30	H6+4.62
86	61	SAI	39	H6+1.22
87	62	SAI	30	H7+14.29
87	68	SAI	53	H6+0.01
88	57	SAI	30	H8+1.30
88	59	SAI	40	H6+1.05
88	67	SAI	36	H6+13.23
89	56	SAI	31	H6+21.59

TABLE 3 (Continued)
LIST OF RC-2A TUBES PLUGGED

Row	Line	Flaw Type[1]	Estimated Depth (%)	Location
89	56	SAI	33	H7+12.44
89	56	SAI	46	H7-0.66
89	56	SAI	27	H7+13.36
89	56	SAI	27	H7+11.22
89	58	SAI	32	H8+1.22
89	68	SAI	39	H7+15.66
90	61	SAI	32	H6+6.41
90	67	SAI	30	H7+6.01
90	73	SAI	37	H6+3.25
90	73	SAI	29	H6+2.80
91	60	SAI	26	H7+4.18
92	35	SVI	25	HTS+0.19
92	57	SAI	31	H6+8.83
92	59	SAI	35	H6+5.22
92	61	SAI	33	H7-0.01
92	61	SAI	35	H7+2.28
92	63	SAI	30	H6+6.27
93	68	MAI	29	H7+3.18
93	68	MAI	38	H7+1.94
93	68	SAI	28	H7+3.76
93	68	SAI	36	H7+0.97
93	70	SAI	27	H7+11.75
93	70	SAI	47	H8-0.33
93	70	SAI	32	H7+2.11
93	70	SAI	29	H7+2.54
93	70	SAI	27	H7+14.53
93	70	SAI	28	H7+13.11
93	70	SAI	40	H6+0.67
94	51	NSY	0	N/A
94	57	SCI	57	H8-0.13
95	54	MAI	29	H7+13.96
95	54	SAI	28	H7+9.25
95	54	SAI	32	H7+15.15
97	70	SAI	29	H6+17.23
101	54	SCI	57	H6+0.18
101	58	SCI	35	H7+0.26
101	58	SCI	26	H8-0.65
101	60	SCI	52	H7-0.17

[1] Flaw Type Definitions are given in Appendix after Tables.

TABLE 4
LIST OF RC-2B TUBES PLUGGED

Row	Line	Flaw Type[1]	Estimated Depth (%)	Location
14	63	SVI	23	CTS+0.05
15	60	SVI	79	CTS-0.01
17	48	CVI	24	CTS-0.02
17	52	CVI	12	CTS+0.03
17	64	CVI	24	CTS-0.07
17	90	SVI	65	CTS+0.10
17	92	CVI	56	CTS+0.02
17	94	MVI	29	CTS+0.03
17	94	SVI	67	CTS-0.08
20	73	SAI	22	HTS+0.83
23	68	CVI	39	CTS-0.08
24	63	SAI	48	HTS+1.88
26	63	CVI	61	CTS+0.00
30	45	SAI	18	H5+28.69
42	53	MVI	40	CTS+0.00
47	16	SAI	33	H6+25.73
52	59	DFI/VOL	0	CTS+8.85
61	56	DFI/VOL	0	C1+18.64
64	57	DFI/VOL	0	C3+5.10
67	72	SAI	32	H2+0.61
71	72	SAI	36	H2-0.13
74	33	SCI	22	H8+0.07
74	63	SVI	40	H7-0.53
75	64	SAI	38	H6+2.38
76	63	SAI	36	H2+0.20
76	65	SAI	48	H6+0.17
76	67	SAI	40	H7+1.60
76	71	SAI	53	H7+6.92
77	62	SAI	39	H6+20.80
77	68	SAI	38	H8-0.61
77	72	SAI	33	H7+1.23
78	69	SAI	30	H6+1.90
78	69	SAI	35	H2-0.04
78	69	SAI	46	H6+2.74
78	69	SAI	27	H6+1.11
78	73	SAI	36	H7+1.13
79	62	SAI	36	H2-0.17

TABLE 4 (Continued)
LIST OF RC-2B TUBES PLUGGED

Row	Line	Flaw Type[1]	Estimated Depth (%)	Location
79	62	SAI	36	H6+19.53
79	64	SAI	32	H2+0.11
79	64	SAI	32	H7+15.54
79	66	SAI	37	H2+0.24
79	66	SAI	36	H7+12.83
79	66	SAI	27	H6+17.18
79	70	SAI	30	H7+4.51
80	65	SAI	42	H5+0.67
80	65	SAI	38	H3+0.00
80	65	SAI	29	H7+10.66
80	67	SAI	37	H2+0.00
80	67	SAI	32	H6+2.87
80	67	SAI	37	H6+4.34
80	67	SAI	41	H7+2.02
80	67	SAI	41	H6+2.77
80	73	SAI	48	H4+0.18
80	73	SAI	35	H2+0.11
80	73	SAI	33	H6+1.95
80	73	SAI	39	H6+19.76
81	74	SAI	39	H7+0.87
83	62	SAI	25	H5+37.24
84	61	SAI	31	H8+2.87
84	61	SAI	37	H6+1.48
84	65	SAI	39	H5+3.24
85	62	SAI	35	H6+1.60
87	30	DFI/VOL	0	V1+14.73
87	38	SAI	30	H8+0.21
87	60	SCI	59	H8+0.26
87	72	SAI	35	H7+1.49
87	72	SCI	40	H7+0.70
88	51	SAI	36	H6+5.24
88	59	SAI	34	H6+3.05
88	65	SAI	32	H7+0.20
88	65	SAI	26	H5+37.76
88	65	SAI	25	H5+38.13
88	65	SAI	37	H7+1.20
88	71	SAI	29	H6+1.11

TABLE 4 (Continued)
LIST OF RC-2B TUBES PLUGGED

Row	Line	Flaw Type[1]	Estimated Depth (%)	Location
89	60	SAI	41	H7+0.26
89	68	SAI	41	H4-1.26
89	82	SVI	20	H7+2.41
90	65	SAI	38	H7+3.11
90	67	SAI	29	H7+0.93
90	71	SAI	45	H8+0.01
90	75	SAI	39	H6+21.28
91	68	SCI	13	H8+0.10
93	70	SAI	22	H7+15.23
93	74	SAI	29	H7+13.24
93	74	SAI	30	H7+14.75
94	53	SVI	51	HTS+8.17
96	63	SAI	31	H6+11.08
96	69	SVI	32	H6+18.12
97	70	SAI	25	H8+9.84
98	51	SCI	29	H2+0.77
98	67	SAI	35	H4+3.13
100	77	SVI	9	HTS+0.33
102	69	SVI	41	H8+0.62

[1] Flaw Type Definitions are given in Appendix after Tables.

Table 5
IN-SITU PRESSURE TESTS

SG RC-2A Hot		Crack Profile						Pressure (psig)			
Row	Line	Location	Orientation	Volts	Depth Est. (%tw)	Length (in.)	Circ Extent (deg)	Target	Actual	Hold Time (min)	Leakage (gpm)
29	60	HTS+1.48	Multiple Axial	0.58	47	0.36	N/A	1503	1600	2	0
								2825	2900	2	0
								3325	3400	2	0
								3825	3900	2	0
								4325	4400	2	0
								4509	4600	2	0
86	61	H6+1.22	Single Axial	0.50	39	1.12	N/A	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4425	5	0
								4509	4600	5	0
87	68	H6+0.01	Single Axial	0.74	53	0.53	N/A	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4400	5	0
								4509	4600	5	0
93	70	H8-0.33	Single Axial	0.53	47	0.54	N/A	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4400	5	0
								4509	4600	5	0
93	70	H6+0.67	Single Axial	0.39	40	0.54	N/A	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4400	5	0
								4509	4600	5	0
93	70	H7+2.11	Single Axial	0.21	32	0.37	N/A	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4400	5	0
								4509	4600	5	0

Table 5 (Continued)
IN-SITU PRESSURE TESTS

SG RC-2A Hot		Crack Profile						Pressure (psig)			
Row	Line	Location	Orientation	Volts	Depth Est. (%tw)	Length (in.)	Circ Extent (deg)	Target	Actual	Hold Time (min)	Leakage (gpm)
93	70	H7+14.53	Single Axial	0.19	27	0.25	N/A	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4400	5	0
								4509	4600	5	0
93	70	H7+13.11	Single Axial	0.19	28	0.40	N/A	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4400	5	0
								4509	4600	5	0
93	70	H7+11.75	Single Axial	0.18	27	0.45	N/A	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4400	5	0
								4509	4600	5	0
93	70	H7+2.54	Single Axial	0.17	29	0.23	N/A	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4400	5	0
								4509	4600	5	0
101	58	H8-0.65	Single Circ.	0.53	26	N/A	67	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3850	5	0
								4325	4350	5	0
								4509	4600	5	0
101	58	H7+0.26	Single Circ.	0.52	35	N/A	103	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3850	5	0
								4325	4350	5	0
								4509	4600	5	0
94	57	H8-0.13	Single Circ.	0.52	57	N/A	88	1503	1600	5	0
								2825	2900	5	0
								3325	3400	5	0
								3825	3900	5	0
								4325	4400	5	0
								4509	4550	5	0

APPENDIX

DEFINITIONS

The acronyms defined below are used in Tables 1 through 5.

CVI: Circumferential Volumetric Indication – Volumetric indication with orientation in a circumferential plane (pluggable)

DFI: Differential Freespan Indication – An indication in the freespan that gives a flaw-like response on the bobbin coil (diagnostic/review required)

MAI: Multiple Axial Indication – Axial indications in the same plane (pluggable)

MVI: Multiple Volumetric Indication – Volumetric indications in the same plane (pluggable)

NSY: Noisy Tube – Any undesired signal or signals in a tube that may obscure for interpretation those signals that are of interest (diagnostic/review required)

OBS: Obstructed Tube – Tube which will not permit full length passage of the 0.540 inch diameter bobbin probe (pluggable)

SAI: Single Axial Indication – Axially oriented crack-like indication (pluggable)

SCI Single Circumferential Indication – Circumferentially oriented crack-like indication (pluggable)

SVI: Single Volumetric Indication – Indication which represents that volumetric (non-oriented) degradation is present (pluggable)

VOL: Volumetric – Indication which is volumetric in nature and generally associated with tube manufacturing (diagnostic/review required)

FIGURE 1
FCS STEAM GENERATOR ELEVATION DRAWING

HTE	Hot Leg Tube End
HTS	Hot Leg Tubesheet
H1-H6	Hot Leg Full Supports
H7	Hot Leg Partial Egg Crate
H8	Hot Leg Partial Drilled Support
DBH	Diagonal Bar Hot Leg
V1-V3	Vertical Supports
DBC	Diagonal Bar Cold Leg
C8	Cold Leg Partial Drilled Support
C7	Cold Leg Partial Egg Crate
C1-C6	Cold Leg Full Supports
CTS	Cold Leg Tubesheet
CTE	Cold Leg Tube End