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May 12, 1997
LIC-97-082

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-137
Washington, DC 20555

Reference: Docket No. 50-285

SUBJECT: Fort Calhoun Station (FCS) Steam Generator Eddy Current Test Report - 1996 Refueling Outage

Attached is the FCS Steam Generator Eddy Current Test Report which summarizes testing performed during the Fall 1996 Refueling Outage. This submittal fulfills the reporting requirements of FCS Technical Specification 3.17(5)(ii).

Please contact me if you have any questions.

Sincerely,

S. K. Gambhir
Division Manager
Engineering & Operations Support

SKG/mcc

Attachment

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FORT CALHOUN STATION
STEAM GENERATOR EDDY CURRENT TEST REPORT
1996 REFUELING OUTAGE

INTRODUCTION

This report summarizes steam generator eddy current results obtained during the Fort Calhoun Station (FCS) 1996 Refueling Outage. 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 Steam Generator Eddy Current Test Report - 1993 Refueling Outage*, dated March 18, 1994 (LIC-94-0056)
- *Fort Calhoun Station Steam Generator Eddy Current Test Report - 1995 Refueling Outage*, dated July 18, 1995 (LIC-95-0138)

EXECUTIVE SUMMARY

A thorough inspection was performed on 100% of the tubes in the FCS Steam Generators during the 1996 Refueling Outage. Eddy current techniques included bobbin coil and various rotating pancake coil (RPC) technologies to further investigate bobbin indications and other suspect regions. OPPD originally intended that all bobbin indications would be characterized utilizing diagnostic techniques, such as RPC, which are qualified in accordance with Appendix H of the EPRI PWR Steam Generator Examination Guidelines. This was the case for approximately 1200 bobbin indications. After the 1996 Refueling Outage, however, OPPD determined that 9 indications affecting 6 tubes had been sized with the bobbin probe without additional diagnostic testing. OPPD has evaluated the potential consequences and has determined that this condition does not cause any violation of FCS Technical Specifications, that there will be no adverse impact from a leakage or structural integrity standpoint, and that the steam generators are considered operable until the next scheduled eddy current inspection.

The 1996 inspection revealed that a small number of axial cracks exist in freespan sections as well as just above the top of the hot leg tubesheets in the FCS steam generators. Circumferentially oriented volumetric indications were also detected at the top of the cold leg tubesheet in steam generator RC-2A. Additionally, a number of volumetric indications were dispositioned as being pluggable based on historical review of 1984 and 1985 eddy current data which indicated some change in the eddy current signal and, therefore, potential growth of the indication. No circumferential cracking was detected during any of the inspections. In-situ pressure testing was performed on

5 tubes with various types of indications; no leakage occurred at pressures at or slightly exceeding three times normal operating differential pressure. Historical data review revealed that the axial cracking detected is either dormant or very slowly progressing. A total of 36 tubes were plugged in Steam Generator RC-2A and 21 tubes were plugged in RC-2B. All circumferentially oriented indications were stabilized as well.

Based on the exams performed and plugging of suspect tubes, the FCS Steam Generators are considered operable until the next scheduled eddy current inspection during the 1998 Refueling Outage.

SCOPE OF EXAMINATION

ABB/Combustion Engineering conducted an inservice eddy current examination of the steam generator tubes at FCS in October and November 1996. 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% testing encompassed 4949 tubes in RC-2A and 4950 tubes in RC-2B.

2. Rotating Pancake Coil (RPC) testing of the top of the hot leg tubesheet of 100% of the tubes in Steam Generators RC-2A and RC-2B.

3. RPC testing in the tight radius U-bends of 48 tubes in each steam generator (20% of the tubes in Rows 1 through 4).

4. RPC testing of a minimum of 20% of the known dents at the lowest tube support on the hot leg side (H1) which were previously measured at greater than 5 volts and a minimum of 20% of the dents at H1 which were previously measured at less than 5 volts.

5. RPC testing in excess of 20% of the dents on the hot leg side of each Steam Generator which were previously measured as having radial reduction greater than or equal to 10 mils.

6. RPC testing of 50 tubes in each Steam Generator in areas predicted to have potentially high impurity deposition using thermal hydraulic modeling.

7. Bounding pattern RPC programs to bound five axial indications radially by a minimum of 5 tubes. This scope expansion added full length RPC exams on the hot leg side from the square bend to the top of tubesheet of 121 tubes in RC-2A and 103 tubes in RC-2B. It also added tube support intersection testing of all hot leg side supports below the diagonal supports of 60 tubes in RC-2A.

8. RPC exams of 1000 cold leg expansion transitions in RC-2A and 25 cold leg expansion transitions in RC-2B to bound circumferential volumetric indications found in the RC-2A cold leg.

9. RPC exams to characterize approximately 1200 indications detected with the bobbin probe.

BOBBIN COIL EXAMINATIONS AND RESULTS

The tubes in the bobbin coil inspection plan were examined full length. Tube wall degradation was evaluated using the phase analysis technique for determination of the origin and percentage of tube wall loss represented by the indication. The data were 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 95® digital analysis system. The frequencies utilized during the bobbin coil examination were as follows:

400 KHz differential and absolute
100 KHz differential and absolute
600 KHz differential and absolute
10 KHz differential and absolute
400/100 KHz differential support ring mix
600/100 KHz differential copper mix
400/600/100 KHz differential transition 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 tubes. During inspections previous to 1996, all dent measurements were performed using the 400 KHz absolute. This technique was again used during the 1996 inspection, but only to perform a comparison to historic data on a select group of tubes. All other dent analysis was performed using the differential support mix and a voltage base of 2.75 volts on the 20% OD ASME signal to standardize dent testing with current industry practices.

The 100 KHz frequency was provided to assist in the confirmation of flaw indications. The 100 kHz absolute detected gradual wall thickness variations. The 600 KHz frequency was provided to assist the analysts with additional mixing capabilities in the event of excessive outside diameter (OD) tube deposits. The 10 KHz frequency was provided to facilitate locating the probe position in the steam generator. The 400/100 KHz and the 600/100 KHz mixes were used to eliminate the tube support and OD tube deposit signals. The 400/600/100 mix was used to evaluate areas of sharp transition such as top of tubesheet expansion transitions. Other mixes were performed as required by the data analyst.

Steam Generators RC-2A and RC-2B both were found to have indications in the 1-19% range, 20-39% range and 40% or greater range. Support notation for each steam generator is shown in Figure 1. All indications which were reported with a percent through-wall value are listed in Tables 1 and 2. Not all pluggable indications can be directly interpreted from the percent through-wall list due to decisions made during diagnostic examination and historic review. The pluggable tube lists in Tables 3 and 4 provide summary descriptions of the reason each tube was plugged.

Indications which were present during past inspections generally did not show significant growth, but may have been dispositioned as pluggable based on current data analysis guidelines. Methods used to disposition bobbin indications varied somewhat based on the location of each indication of interest. However, the following logic generally applied:

> If a bobbin coil indication confirmed by RPC was reported as ≥40% through-wall, the tube was plugged. If the bobbin coil detected an indication which was confirmed to be cracklike (either axial or circumferential) by RPC, the tube was plugged. If the bobbin coil detected an indication at a tube support intersection and RPC confirmed the presence of a cracklike or volumetric indication, the tube was plugged. If the bobbin coil detected a freespan indication at a location other than at the tube supports, and RPC showed a volumetric indication (not axial or circumferential), but the indication showed change from a review of 1984 and 1985 historical data, the tube was plugged. Indications which did not fall into one of the above categories generally were left in service.

All bobbin coil techniques used were intended to meet the current requirements of the EPRI Appendix H qualifications. All tubes were originally inspected full length with the .540"/.560" probe, and indications were flagged for later characterizing and/or sizing with qualified techniques.

Bobbin coil dent measurements of a pre-selected historic sample of tubes which had previously restricted passage of the .560" probe were performed utilizing the traditional method from past inspections, whereby the sizing is based on the machined

dent in the calibration standard, and one volt equals one mil average radial reduction in tube diameter on the 400 kHz absolute channel. Comparison of current to past data indicated that there has been little change in the average dent size of the test group. OPPD therefore concluded that active denting, last observed in the mid-1980's, continues to be arrested.

Bobbin coil dent measurements were also performed using the industry standard technique which utilizes the primary 400/100 KHz differential mix channel, and bases the sizing on the 20% Flat Bottom Holes in the ASME standard at 2.75 volts. This information is now available for use to track dented locations during future inspections.

ROTATING COIL EXAMINATIONS AND RESULTS

Rotating coil examinations were performed at the top-of-tubesheet transitions on the hot and cold legs, in low-row U-bends and at bobbin coil suspect indications as a diagnostic tool. A special region of each steam generator was also inspected where it was concluded by thermal-hydraulic analysis that the potential for deposits and resultant axial cracks may be higher than elsewhere in the steam generators.

The tubes in the Top of the Tubesheet RPC Program were inspected in the expansion transition regions of each steam generator. The data were analyzed for the presence of crack-like indications similar to those found in the expansion transition regions at other plants. Terrain plots were used during the analysis effort to improve the probability of detecting circumferential cracks.

The RPC exams performed at U-bends, 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.

Plus Point and conventional (or Delta Coil) RPC probes were both used during this inspection. The Plus Point probe was the main probe used for the bulk of the RPC examination and Delta coil probe was used on a very limited basis as a supplement to Plus Point for characterization of indications.

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

400 kHz Pancake, Mid-Freq. Plus coil, and High-Freq. Plus coil
200 KHz Pancake, and Mid-Freq. Plus coil
100 KHz Pancake, and Mid-Freq. Plus coil
700 KHz Pancake, and High-Freq. Plus coil

The frequencies used for the U-bend RPC examinations were as follows:

400 KHz Mid-Freq. Plus coil
300 KHz Mid-Freq. Plus coil
100 KHz Mid-Freq. Plus coil
10 KHz Mid-Freq. Plus coil

The frequencies for the Delta probe RPC examinations were as follows:

400 KHz Pancake, Axial and Circumferential coils
200 KHz Pancake, Axial and Circumferential coils
100 KHz Pancake, Axial and Circumferential coils
300 KHz Pancake, Axial and Circumferential coils

Other special coil arrangements including two-coil (pancake and mid-freq. Plus Point) and three coil (pancake, mid-freq. plus coil and 0.080" pancake coil) techniques were used, but with the same frequency arrangements listed above.

There was no circumferential cracking found during any of the examinations. No axial indications were found in upper bundle areas predicted to have high deposition of impurities. Tubes with volumetric indications in these areas which showed change from historical data were preventively plugged.

Diagnostic exams were performed on approximately 1200 bobbin coil indications. One tube, Row 7 Line 26 in SG RC-2A, was found to have a 2.6" freespan axial indication confirmed with rotating coil examination. This indication spawned a special RPC expansion program in other suspect areas. A total of four additional freespan axial indications were found in both steam generator RC-2A and RC-2B. All of these tubes were plugged.

Six tubes with axial indications found just above the top of the hot leg tubesheet expansion were also plugged. These indications were short in length, and were bounded by the 100% examination of the hot leg expansion transitions.

One circumferential indication was found (Row 101 Line 54) in the hot leg of steam generator RC-2B, but is believed to be from a loose part, as it is on the periphery, is well above the top-of-tubesheet transition, and shows a volumetric rather than crack-like tendency. The indication was stabilized and plugged due to its circumferential orientation. Other circumferentially oriented indications were also found on the cold leg of steam generator RC-2A. It was concluded that the indications were volumetric with circumferential orientation and were reported as CVI (Circumferential Volumetric Indications).

The CVI indications were originally flagged with the bobbin coil examination as DTI (Distorted Tubesheet Indication) on the cold leg of steam generator RC-2A. After initial diagnostic inspection of these indications, a 1000 tube (20%) sample in steam generator RC-2A was inspected and additional CVI indications were found and bounded in Row 17. A sample of 25 tubes from the same area were also inspected in steam generator RC-2B, but no similar indications were found. All CVI indications were stabilized and plugged.

IN-SITU PRESSURE TEST RESULTS

Five tubes with defects were tested with the ABB/CE In-Situ Pressure Test device. These tubes were tested to demonstrate that leakage would be below allowable limits at normal operating differential pressure (NODP), at 1.4 times peak accident (main steam line break (MSLB)) pressure, and that they would be able to sustain a pressure of 3 times NODP without burst in accordance with Draft NRC Regulatory Guide 1.121.

The five indications tested covered the known defect types in the steam generators, which are axial indications, non-oriented volumetric indications, and circumferentially oriented volumetric indications. Table 5 shows the tubes tested with the In-Situ Pressure Test method, summarizes the reason each tube was tested, and gives the results of each test. None of the five tubes tested experienced catastrophic failure when pressurized to 3 times NODP, nor did they leak at NODP or 1.4 times MSLB pressure.

RPC testing performed with the Plus Point probe after the In-Situ Pressure tests showed no change in the signal produced by the defects when compared to the data taken prior to the In-Situ tests. The indications tested by this method bounded the severity of the other known indications in the steam generators, as well as any indications which may be present and not detected. Therefore, based on the In-Situ pressure test results and extensive historical reviews of eddy current data which show little or no growth of indications in the FCS steam generators since 1984, operation until the next scheduled inspection is justified.

CONCLUSIONS

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

1. Bobbin coil indications of through-wall degradation generally showed little change from the last inspections and only minor change from the 1984 100% inspection.

2. After an extensive (100%) top-of-tubesheet expansion transition inspection on the hot leg side of each steam generator and a 20% sample of the cold leg expansion transitions in RC-2A with RPC, there were no circumferential cracks detected. One circumferential indication was found in steam generator RC-2B at 9.5 inches above the hot leg tubesheet, but is believed to be from a loose part due to its height and location on the periphery. The indication also appeared volumetric rather than crack-like in nature. This tube was stabilized and plugged. There were no circumferential cracks detected as a result of RPC examinations performed in other suspect areas such as dented tube support intersections and tight radius U-bends.

3. The most significant indications for all inspections included:

   Circumferential Volumetric Indications on the top of tubesheet in the cold leg side of steam generator RC-2A, all of which were located in Row 17.

   Volumetric indications in both steam generators which required plugging due to minor change when compared to data from 1984 and 1985.

   Axial indications detected in both steam generators, both in the freespan and just above the top of the hot leg tubesheet. These appear to be dormant or very slowly progressing based on historical reviews performed.

4. Three tubes in steam generator RC-2A and two tubes in steam generator RC-2B were examined with an in-situ pressure test tool to verify structural integrity. All tubes tested met the requirements of Draft NRC Regulatory Guide 1.121, and none showed evidence of leakage. RPC testing conducted after the pressure tests showed the indications had not changed as a result of the pressure tests.

5. All tubes with the above significant indications were plugged. Circumferential indications were stabilized as well. Overall, 36 tubes were plugged in steam generator RC-2A and 21 tubes were plugged in steam generator RC-2B.

6. Based on the results of the extensive eddy current examination and the in-situ pressure tests performed, operation of the FCS steam generators until the next scheduled inspection during the 1998 FCS Refueling Outage is justified.

FORT CALHOUN
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
DHB	Diagonal Hot Bottom Edge
DHT	Diagonal Hot Top Edge
V1-V3	Vertical Supports
DCT	Diagonal Cold Top Edge
DCB	Diagonal Cold Bottom Edge
C8	Cold Leg Partial Drilled Support
C7	Cold Leg Partial Egg Crate
C6-C1	Cold Leg Full Supports
CTS	Cold Leg Tubesheet
CTE	Cold leg Tube End

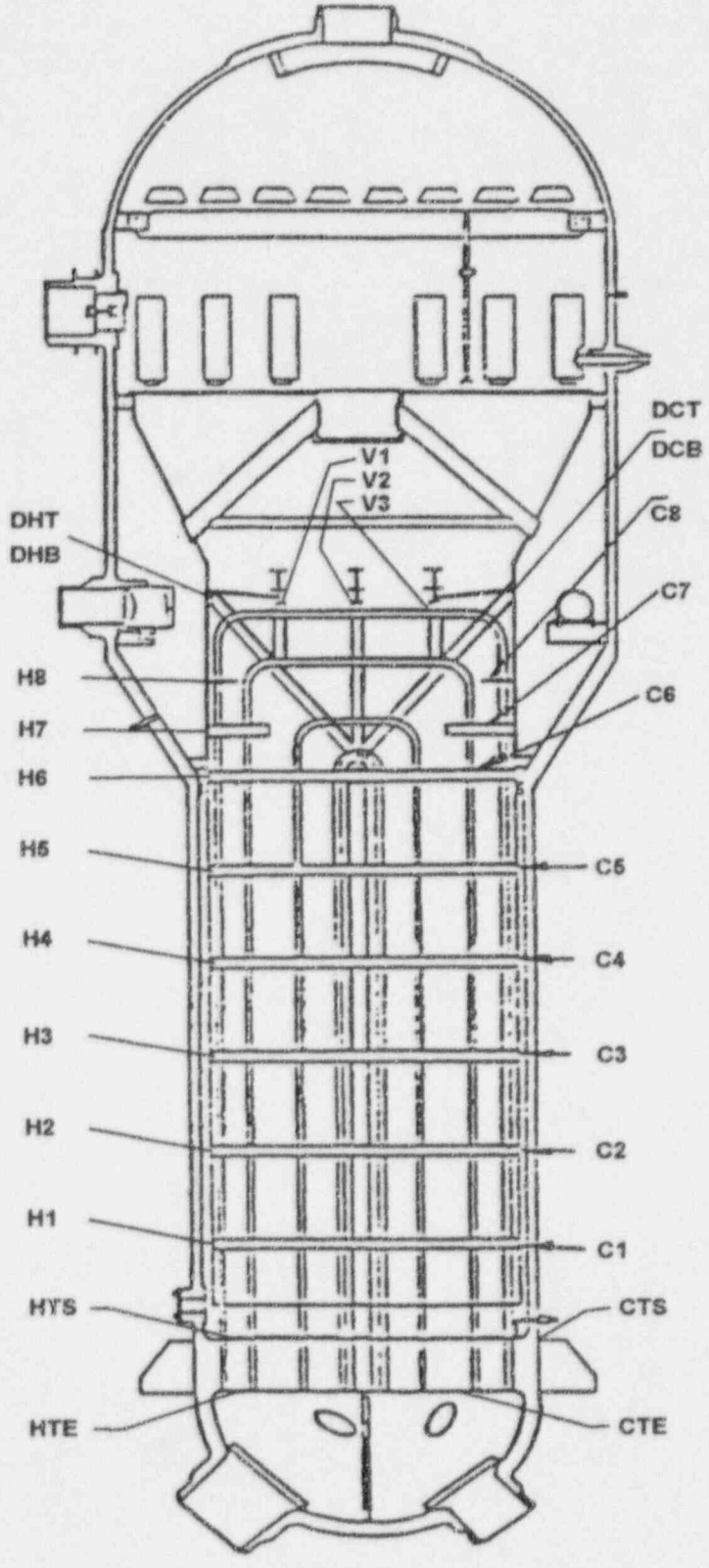

Figure 1

LIC-97-082

TABLE 1

LIST OF RC-2A INDICATIONS

Row/Line	%tw	Location	Row/Line	%tw	Location
8/125	56	HTS + 3.06	34/37	7	HTS + 4.87
8/125	15	CTS + 3.02	35/50	19	HTS + 1.86
11/94	35	HTS + 2.29	35/50	11	HTS + 1.01
12/49	12	CTS + 3.16	35/96	20	HTS + 3.93
13/100	24	HTS + 4.51	38/73	22	HTS + 2.67
15/100	13	HTS + 6.11	38/93	7	HTS + 3.88
15/106	85	C2 + 0.57	39/44	2	HTS + 4.25
18/95	14	HTS + 1.02	39/50	12	HTS + 1.15
19/36	36	CTS + 0.6	39/52	8	HTS + 1.78
20/69	45	HTS + 0.68	39/66	27	HTS + 1.67
20/77	37	HTS + 0.33	40/43	9	HTS + 2.48
21/36	11	HTS + 2.35	40/51	28	HTS + 0.74
21/36	2	HTS + 3.92	41/64	22	HTS + 0.67
22/85	19	CTS + 3.82	41/86	12	HTS + 3.4
23/36	7	HTS + 3.66	41/96	14	HTS + 3.69
23/38	7	HTS + 3.39	42/25	11	HTS + 1.37
23/92	23	HTS + 1.05	42/71	30	HTS + 0.87
23/108	3	HTS + 1.15	43/86	19	HTS + 3.39
25/94	7	HTS + 3.78	43/86	1	HTS + 2.74
27/40	2	HTS + 4.73	44/15	4	HTS + 0.38
27/120	13	CTS + 24.12	45/86	28	HTS + 1.67
27/120	7	HTS + 32.27	46/53	4	HTS + 3.78
28/23	25	HTS + 1.03	47/46	19	HTS + 2.34
28/41	7	HTS + 3.4	48/53	16	HTS + 5.03
28/63	13	HTS + 5.59	48/117	50	C5 + 4.37
28/73	34	HTS + 1.26	51/58	11	HTS + 2.44
29/40	14	HTS + 5.44	51/90	6	HTS + 3.26
29/42	19	HTS + 0.56	52/47	8	HTS + 1.46
29/60	30	HTS + 6.26	52/53	2	HTS + 1.98
29/70	35	HTS + 4.38	52/59	24	HTS + 3.54
29/96	19	HTS + 3.58	54/65	18	HTS + 3.6
29/102	5	HTS + 1.92	56/47	14	HTS + 2.72
29/104	25	HTS + 1.68	56/53	14	HTS + 2.97
30/105	8	HTS + 1.07	56/55	15	HTS + 2.87
31/36	10	HTS + 2.48	57/50	12	HTS + 3.34
31/40	2	HTS + 5.43	57/98	3	HTS + 0.99
32/47	14	HTS + 4.53	58/61	47	HTS + 1.2
32/113	4	H1 + 22.53	58/81	2	HTS + 3.78
33/80	3	HTS + 5.47	58/89	9	HTS + 3.25
34/31	36	HTS + 1.07	59/64	23	HTS + 3.23

LIC-97-082

TABLE 1

LIST OF RC-2A INDICATIONS

Row/Line	%tw	Location	
59/66	16	HTS + 3.65	
59/70	15	HTS + 1.12	
62/67	8	HTS + 3.2	
62/71	2	HTS + 3.75	
62/89	6	CTS + 2.2	
65/58	31	HTS + 3.04	
67/28	22	H4 - 1.82	
73/58	14	HTS + 1.27	
77/46	12	HTS + 0.47	
83/86	27	DHB + 7.96	
94/43	33	HTS + 2.45	

TABLE 2

LIST OF RC-2B INDICATIONS

Row/Line	%tw	Location	Row/Line	%tw	Location
7/80	6	HTS + 1.59	27/88	18	HTS + 5.15
9/66	36	HTS + 1.67	27/88	9	HTS + 3.02
9/110	24	HTS + 0.62	27/88	8	HTS + 4.59
10/33	24	HTS + 1.99	27/90	13	HTS + 2.87
12/27	4	HTS + 8.45	27/90	12	HTS + 5.51
13/38	36	HTS + 1.23	27/90	12	HTS + 4.59
13/78	39	HTS + 0.73	28/21	11	HTS + 2.17
13/108	12	HTS + 1.37	28/41	20	HTS + 9.85
14/15	10	HTS + 2.16	28/41	10	HTS + 2.62
15/70	35	HTS + 0.75	28/47	3	HTS + 3.41
15/100	2	HTS + 5.13	28/51	13	HTS + 4.39
15/110	17	HTS + 0.87	28/57	35	HTS + 6.54
18/43	28	HTS + 2.39	28/81	3	HTS + 5.52
20/93	33	HTS + 4.22	28/83	9	HTS + 6.78
20/97	25	HTS + 3.33	28/91	2	HTS + 1.71
20/103	16	HTS + 2.75	29/18	15	HTS + 1.08
20/107	18	HTS + 2.08	29/54	27	HTS + 6.31
21/14	18	HTS + 0.91	29/64	17	HTS + 4.54
21/90	29	HTS + 3.97	29/64	9	HTS + 16.95
21/90	19	HTS + 5.34	29/80	4	HTS + 7.47
21/94	19	HTS + 2.24	29/80	2	HTS + 16.16
22/15	11	HTS + 1.24	29/84	10	HTS + 4.42
22/23	5	HTS + 1.4	29/86	8	HTS + 3.55
22/31	5	HTS + 4.69	29/86	4	HTS + 4.47
22/89	2	HTS + 13.39	29/90	15	HTS + 3.63
22/93	16	HTS + 2.14	29/90	9	HTS + 5.72
22/93	1	HTS + 8.23	30/31	18	HTS + 4.32
23/12	24	HTS + 0.85	30/33	15	HTS + 5.01
23/90	2	HTS + 2.28	30/43	9	HTS + 7.32
24/17	9	HTS + 1.56	30/63	9	HTS + 9.58
24/19	16	HTS + 2.28	30/83	22	HTS + 0.89
24/33	8	HTS + 3.71	30/37	7	HTS + 4.22
24/37	32	HTS + 5.34	31/84	10	HTS + 5.02
25/18	27	HTS + 1.89	31/84	9	HTS + 3.6
25/44	8	HTS + 4.96	31/84	7	HTS + 7.12
25/56	19	HTS + 29.76	31/84	6	HTS + 8.09
25/80	16	HTS + 4.8	31/84	5	HTS + 5.48
25/90	34	HTS + 4.08	31/88	14	HTS + 2.79
27/42	19	HTS + 4.86	31/88	11	HTS + 2.47
27/46	19	HTS + 9.38	31/88	9	HTS + 3.41
27/84	20	HTS + 3.62	32/47	2	HTS + 6.98

TABLE 2

LIST OF RC-2B INDICATIONS

Row/Line	%tw	Location	Row/Line	%tw	Location
32/79	10	HTS + 4.39	37/50	13	HTS + 4.9
32/87	9	HTS + 4.47	37/56	13	HTS + 8.53
33/20	9	HTS + 0.74	37/60	7	HTS + 6.21
33/34	25	HTS + 11.8	37/62	4	HTS + 6.06
33/46	6	HTS + 5.29	37/82	6	HTS + 4.98
33/78	10	HTS + 2.18	37/102	5	HTS + 0.78
33/80	31	HTS + 1.57	38/37	4	HTS + 3.83
33/80	21	HTS + 7.49	38/55	6	HTS + 5.87
33/104	5	HTS + 0.83	38/63	20	HTS + 5.58
34/57	9	HTS + 6.4	38/63	7	HTS + 5.22
34/59	20	HTS + 2.96	38/63	1	HTS + 6.4
34/75	3	HTS + 7.68	38/79	9	HTS + 7.28
34/89	18	HTS + 3.91	38/85	8	HTS + 3.54
35/22	4	HTS + 1.68	38/101	15	CTS + 1.19
35/52	17	HTS + 8.89	39/48	18	HTS + 1.14
35/52	16	HTS + 10.26	39/48	11	HTS + 8.56
35/78	14	HTS + 7.08	39/50	38	HTS + 2.02
35/78	9	HTS + 8.2	39/58	6	HTS + 8.18
35/80	12	HTS + 5.46	39/60	18	HTS + 3.99
35/88	24	HTS + 4.26	39/60	14	HTS + 6.5
35/88	11	HTS + 3.95	39/60	6	HTS + 6.21
35/88	7	HTS + 5.28	39/64	12	HTS + 4.9
35/88	2	HTS + 2.07	39/76	5	HTS + 6.82
36/35	5	HTS + 2.97	39/84	10	HTS + 3.06
36/45	24	HTS + 9.64	39/84	9	HTS + 1.76
36/45	17	HTS + 8.61	39/102	9	HTS + 0.96
36/47	6	HTS + 24.16	39/120	13	H6 + 11.75
36/47	6	HTS + 22.58	40/65	11	HTS + 6.66
36/69	18	HTS + 6.09	40/65	8	HTS + 8.82
36/79	19	HTS + 0.86	40/65	5	HTS + 5.12
36/87	23	HTS + 2.41	40/81	14	HTS + 2.22
36/87	7	HTS + 2.98	40/83	21	HTS + 5.05
36/87	6	HTS + 4.04	40/83	14	HTS + 4.35
36/93	11	HTS + 2.76	40/83	8	HTS + 2.51
36/95	6	HTS + 3.39	40/83	8	HTS + 1.77
36/103	35	HTS + 0.66	40/83	4	HTS + 3.74
37/32	5	HTS + 3.95	41/56	19	HTS + 2.6
37/38	17	HTS + 9.81	41/56	14	HTS + 6.88
37/38	11	HTS + 3.84	41/56	12	HTS + 4.77
37/44	15	HTS + 6.39	41/60	10	HTS + 5.79
37/50	14	HTS + 5.47	41/70	24	HTS + 1.74

LIC-97-082

TABLE 2

LIST OF RC-2B INDICATIONS

Row/Line	%tw	Location	Row/Line	%tw	Location
41/74	3	HTS + 16.36	47/52	3	HTS + 5.28
41/76	16	HTS + 3.03	47/62	12	HTS + 3.09
41/84	18	HTS + 2.48	47/74	5	HTS + 2.81
42/45	8	HTS + 5.79	47/78	12	HTS + 2.33
42/69	3	HTS + 3.52	47/78	9	HTS + 4.38
42/83	14	HTS + 16.52	47/78	4	HTS + 3.41
42/83	10	HTS + 4.85	47/80	5	HTS + 3.33
42/83	5	HTS + 3.13	47/82	29	HTS + 1.35
42/85	19	HTS + 2.97	48/47	5	HTS + 5.27
42/85	7	HTS + 3.77	48/53	15	HTS + 4.36
42/85	7	HTS + 3.43	48/69	14	HTS + 2.94
43/50	7	HTS + 5.72	48/69	14	HTS + 17.21
43/82	1	HTS + 3.9	48/69	9	HTS + 2.25
44/33	27	HTS + 4.3	48/69	4	HTS + 3.22
44/33	15	HTS + 3.59	48/69	1	HTS + 4.43
44/71	2	HTS + 10.42	48/71	18	HTS + 2.92
44/75	5	HTS + 6.38	48/71	6	HTS + 4.67
44/77	9	HTS + 5.76	48/73	21	HTS + 8.58
44/77	5	HTS + 11.65	48/73	12	HTS + 3.15
44/77	4	HTS + 15.45	48/73	3	HTS + 4.07
44/77	3	HTS + 10.08	48/75	10	HTS + 3.97
44/79	8	HTS + 9.53	48/77	15	HTS + 9.81
44/79	6	HTS + 4.17	49/44	24	HTS + 2.71
44/85	15	HTS + 3.45	49/44	18	HTS + 3.26
44/101	28	HTS + 0.79	49/54	16	HTS + 2.93
45/44	21	HTS + 2.56	49/54	9	HTS + 4.25
45/50	4	HTS + 5.18	49/54	4	HTS + 4.61
45/60	11	HTS + 6.01	49/70	24	HTS + 4.93
45/62	2	HTS + 3.66	49/78	16	HTS + 4.84
45/74	14	HTS + 3.02	50/63	17	HTS + 4.78
45/78	11	HTS + 1.96	50/69	16	HTS + 8.55
46/39	13	HTS + 3.52	51/26	13	HTS + 0.71
46/51	7	HTS + 3.98	51/26	12	HTS + 1.05
46/53	5	HTS + 5.1	51/28	11	HTS + 1.46
46/55	9	HTS + 4.52	51/42	8	HTS + 4.97
46/55	9	HTS + 5.26	51/60	24	HTS + 2.72
46/55	4	HTS + 4.06	51/60	4	HTS + 3.55
46/73	8	HTS + 3.21	51/64	5	HTS + 3.45
46/73	7	HTS + 2.29	51/66	5	HTS + 3.74
46/77	9	HTS + 4.66	51/66	1	HTS + 2.78
47/52	15	HTS + 3.67	51/68	10	HTS + 5.59

TABLE 2

LIST OF RC-2B INDICATIONS

Row/Line	%tw	Location	Row/Line	%tw	Location
51/84	11	HTS + 2.42	59/70	7	HTS + 3.66
52/27	19	HTS + 1.24	60/51	1	C2 + 0.14
52/27	8	HTS + 0.96	64/89	16	HTS + 2.61
52/51	21	HTS + 4.03	65/86	21	HTS + 3.02
52/57	21	HTS + 3.5	66/55	4	HTS + 3.07
52/57	9	HTS + 3.91	67/90	10	HTS + 18.67
52/63	5	HTS + 4.09	69/36	22	HTS + 0.8
52/67	10	HTS + 3.78	70/71	20	HTS + 35.61
52/69	16	HTS + 2.49	70/83	13	HTS + 1.5
52/69	15	HTS + 3.27	71/48	10	HTS + 1.86
53/56	3	HTS + 4.58	71/60	23	HTS + 16.21
53/64	2	HTS + 5.07	71/62	25	HTS + 2.55
53/94	10	HTS + 2.38	72/65	1	HTS + 2.47
54/43	36	HTS + 0.75	77/76	20	HTS + 1.49
54/61	5	HTS + 11.78	79/68	8	HTS + 0.61
54/65	16	HTS + 19.86	81/80	36	HTS + 5.37
54/67	15	HTS + 16.97	89/56	11	HTS + 5.03
54/69	16	HTS + 18.7	93/86	49	C3 + 0.03
54/69	7	HTS + 25.28	94/53	19	HTS + 8.59
54/73	34	HTS + 1.81			
55/56	16	HTS + 4.31			
55/56	5	HTS + 3.28			
55/62	9	HTS + 2.49			
55/64	20	HTS + 14.49			
55/64	15	HTS + 6.79			
55/64	12	HTS + 12.31			
55/74	10	HTS + 1.8			
55/98	18	HTS + 0.98			
55/110	6	HTS + 3.77			
56/51	31	HTS + 3.1			
56/69	17	HTS + 4.74			
56/73	12	HTS + 1.88			
57/48	22	HTS + 4.33			
57/56	11	HTS + 2.5			
57/62	24	HTS + 16.48			
57/62	15	HTS + 3.44			
57/66	2	HTS + 3.48			
57/68	9	HTS + 5.16			
58/73	10	HTS + 4.76			
59/32	3	HTS + 1.34			
59/50	25	HTS + 3.89			

TABLE 3

LIST OF RC-2A TUBES PLUGGED

Row/Line	Flaw Type	Location	Reason Plugged
7/26	SAI	H2 +6.12	Axial Indication
8/125	VOL	HTS+3.23	Sized greater than 40% through wall
15/106	VOL	C2 +.57	Sized greater than 40% through wall
17/56	CVI	CTS+0.02	Unfamiliar damage type
17/60	CVI	CTS +0.02	Unfamiliar damage type, Historical review indicated change
17/62	CVI	CTS +0.08	Unfamiliar damage type, Historical review indicated change
17/64	CVI	CTS+0.01	Unfamiliar damage type, Historical review indicated change
17/66	CVI	CTS+0.14	Unfamiliar damage type, Historical review indicated change
17/70	CVI	CTS+0.11	Unfamiliar damage type, Historical review indicated change
17/72	CVI	CTS+0.14	Unfamiliar damage type, Historical review indicated change
17/74	CVI	CTS+0.05	Unfamiliar damage type, Historical review indicated change
17/76	CVI	CTS+0.11	Unfamiliar damage type, Historical review indicated change
17/78	CVI	CTS+0.08	Unfamiliar damage type, Historical review indicated change
17/86	CVI	CTS+0.23	Unfamiliar damage type, Historical review indicated change
17/88	VOL	CTS+0.24	Historical review indicated change
17/100	CVI	CTS+0.03	Unfamiliar damage type, Historical review indicated change
17/104	CVI	CTS+0.09	Unfamiliar damage type, Historical review indicated change
18/63	VOL	CTS+0.06	Historical review indicated change
20/69	SAI	HTS+1.01	Axial Indication
23/68	SAI	HTS+0.84	Axial Indication
28/71	SAI	HTS+1.23	Axial Indication
28/73	SAI	HTS+1.42	Axial Indication
33/82	SAI	H1+1.20	Axial Indication
34/59	VOL	HTS +0.08	Historical review indicates possible change
39/68	MAI	HTS+17-26	Axial Indications
40/77	VOL	HTS+0.25	Historical review indicates change
47/64	VOL	DHB +0.0	Historical review indicates change
47/84	VOL	C6 +20.58	Historical review indicates change
48/117	PIT	C5+4.1	Sized greater than 40% through wall
58/61	PIT	HTS+1.34	Sized greater than 40% through wall
71/54	VOL	DHT+2.7-5.1	Historical review indicates change
71/58	VOL	V1+7.53, V1+8.3	Historical review indicates change
71/62	VOL	DHT+5.37, DHT+6.68	Historical review indicates change
80/25	VOL	H7 -.94	Historical review indicates change
82/77	VOL	HTS+0.04	Historical review indicates change
93/66	VOL	H7 +3.32, H7+4.82	Historical review indicates change

Definitions of indications can be found at the bottom of Table 4.

TABLE 4

LIST OF RC-2B TUBES PLUGGED

Row/Line	Flaw Type	Location	Reason Plugged
14/69	SAI	HTS+0.39	Axial Indication
15/64	SAI	HTS+0.93	Axial Indication
17/78	VOL	CTS+0.0	Historical review indicates possible change
17/96	VOL	CTS+0.0	Historical review indicates possible change
27/84	VOL	HTS +0.19	Historical review indicates change
32/79	MAI	HTS+16-36	Axial Indications
35/72	VOL	HTS+28.88	Historical review indicates change
36/73	MAI	HTS+21-38	Axial Indications
46/85	VOL	H4+36.03	Historical review indicates change
59/32	VOL	H7+1.81	Historical review indicates change
60/51	VOL	C2 +0.13	Flaw at support, assumed to be active
60/73	OBS	V2	Obstructed to 0.540" diameter probe
61/66	VOL	H4+0.28	Flaw at support, assumed to be active
69/68	VOL	H3+6.34, H3+10.4	Historical review indicates change
71/96	VOL	H7 +21.41	Historical review indicates change
77/96	VOL	H4+17.83	Historical review indicates change
88/63	VOL	H1+3.70	Historical review indicates change
91/64	VOL	C2 +0.7	Flaw at support, assumed to be active
93/86	PIT	C3 +.03	Sized greater than 40% through wall
100/79	VOL	HTS+13.35	Historical review indicates change
101/54	SCI	HTS+9.5	Circumferential oriented volumetric flaw, historical review indicated change

Definitions:

CVI - Circumferential Volumetric Indication
DSI - Distorted Support Indication
DTI - Distorted Tubesheet Indication
MAI - Multiple Axial Indications
NQI - Non-Quantifiable Indication
OBS - Obstructed Tube
PIT - Pitlike Indication
SAI - Single Axial Indication
SCI - Single Circumferential Indication
VOL - Volumetric (non-oriented) Indication

IN-SITU PRESSURE TESTS

S/G	Tube	Defect Description	Reason for Test	Bobbin Resp.	RPC Resp.	Pressure	Leakage	Pressure	Leakage	Pressure	Leakage	Bobbin History
RC-2A	R7L26	SAI, 2.6" long, H2+6.12	Believed worst case at time of test	1.1 V NQI	5.2 V SAI	1600 psi	0	2500 psi	0	4600 psi	0	Little change from 1984 data
RC-2A	R17L72	CVI, 360 deg, CTS+0.14	Unfamiliar flaw type, possible significance, most significant circumferential	12.9 V DTI	4.6 V peak CVI	1800 psi	0	2800 psi	0	5000 psi	0	Not present in 1984
RC-2A	R39L68	MAI, HTS+17-26	Threshold of bobbin detectability	Non report-able	1 V MAI	1600 psi	0	2500 psi	0	4650 psi	0	Not seen with bobbin in 1996 or prior exams
RC-2B	R93L86	VOL @ C3+.02	Most significant non-oriented volumetric	0.8 V DSI	2 V Pit-like ind.	1600 psi	0	2500 psi	0	4650 psi	0	1990 - Not present
RC-2B	R32L79	MAI, HTS+16-36	Worst case cracks	1.4 V NQI	3.3 V MAI	1650 psi	0	2550 psi	0	4650 psi	0	1995 - no change 1992 - no change 1984 - no change

In-Situ pressure test results show that each of these indications meet Draft Reg. Guide 1.121 structural integrity requirements, as well as demonstrating leakage integrity at worst case accident pressure. Post in-situ RPC exams showed no change in any of these indications as a result of the hydro tests.

Definitions:

CVI - Circumferential Volumetric Indication
DSI - Distorted Support Indication
DTI - Distorted Tubesheet Indication
MAI - Multiple Axial Indications
NQI - Non-Quantifiable Indication
SAI - Single Axial Indication
VOL - Volumetric (non-oriented) Indication