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Seabrook Station

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April 24, 2003

Docket No. 50-443
NYN-03035

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Seabrook Station
Steam Generator Inservice Inspection

FPL Energy Seabrook, LLC encloses pursuant to Seabrook Station Technical Specification Surveillance Requirement 4.4.5.5b, a report documenting the results of inservice inspections conducted on the Steam Generators during the eighth refueling outage which occurred in May 2002.

Should you require further information regarding this matter, please contact me at (603) 773-7194.

Very truly yours,

FPL Energy Seabrook, LLC

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cc:

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ENCLOSURE TO NYN-03035

NORTH ATLANTIC ENERGY SERVICE CORPORATION

SEABROOK STATION

STEAM GENERATOR INSERVICE INSPECTION

May, 2002

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1.0 Introduction

In May 2002, Seabrook's eighth refueling outage; Steam Generators A, B, C, and D were inspected. This was accomplished in accordance with Seabrook Station Technical Specification 4.4.5. This report presents the results of the inspection pursuant to Technical Specification 4.4.5.5.b. and NEI 97-06. The following results are presented:

- Scope of inspections performed.
- Active degradation mechanisms found.
- NDE Techniques used for each degradation mechanism.
- Number of tubes plugged or repaired during the inspection outage for each active damage mechanism. Repair methods used and the number of tubes repaired by each repair method.
- Total number and percentage of tubes plugged and/or repaired to date and the effective plugging percentage in each steam generator.
- Description of the tube integrity assessment.
- Description of corrective actions implemented, if any.
- Evaluation of circumstances if condition monitoring results exceeded the pervious cycle of operational assessment.

Seabrook Station is a Westinghouse four-loop pressurized water reactor with Model F steam generators. The generators are U-bend heat exchangers, with tube bundles fabricated using thermally treated Inconel 600 tubing. A row and column number identifies each tube. There are 59 rows and 122 columns in each steam generator, for a total of 5,626 tubes. Nominal tube OD is 0.688" with a 0.040" nominal wall.

The Technical Specifications require a tube to be plugged when tube wall-loss equals or exceeds 40% of nominal wall. There were 10 tubes that were required to be plugged as a result of eddy current inspection. There were also 6 tubes that did not exceed the plugging limit, but were preventively plugged.

2.0 Scope of Inspections Performed

Westinghouse Electric Corp. conducted the inservice inspection of steam generators. The data acquisition and analysis was conducted in accordance with the ASME Code; Seabrook Station Technical Specifications and procedures, EPRI Steam Generator Examination Guidelines, and the Seabrook Steam Generator Eddy Current Data Analysis Guidelines Manual. The acquisition and analysis techniques were all qualified in accordance with Appendix H of the EPRI PWR Steam Generator Examination Guidelines.

Pre-Outage Inspection Plan

The pre-outage inspection plan included 2 SGs, A and D. Reference 1 identifies AVB wear as an active degradation mechanism, based on OR06 and OR07 inspection data, in SGs A, B and D, according to the definition of active degradation mechanisms contained in the EPRI ISI guidelines (Reference 2), and an ongoing degradation mechanism in SG C.

The Operational Assessments for OR07 and OR06 (References 3 and 4) provide justification of the operability of the SGs for the respective 2-cycle intervals based on the observed growth rates of AVB wear, the only ongoing degradation mechanisms in the Seabrook SGs. The next inspection of the Seabrook SGs will be at OR09.

The base inspection performed at OR08 met both the technical specification requirements and the requirements of the EPRI Inspection guidelines (Reference 2). The Seabrook base inspection for OR08 included:

- 100% full length bobbin inspection of Steam Generators A and D (except R1, R2 U-bends)
- 50% hot leg TTS, ± 3", +Point inspection of Steam Generators A and D. Only the HL was inspected since the potential for TTS degradation is significantly less on the CL due to the lower temperatures on the CL. The axial extent of the inspection was locally increased as necessary to encompass the height of the sludge pile.
- 50% small radius (Row 1 and Row 2) U-bend +Point inspection of Steam Generators A and D
- 40% sample straight section dings and dents > 5 volts by bobbin with + Point[1]
- +Point examination of all "I-code" indications that were new or not resolved after history review
- Visual inspection of installed plugs in both the hot and cold leg, utilizing remote video techniques

Inspection Expansion

During the inspection of SG D, a number of outside diameter originating axial cracks were detected. Originally reported as DSI in the bobbin inspection, subsequent +Point and UTEC inspection of the DSI indications confirmed the presence of axial OD cracking. Since the confirmation of axial OD cracking created a C-2 condition in the SG as defined by Reference 2, an expansion of the inspection to the unscheduled SGs was required. Although only a 20% sample was required, Seabrook elected to perform 100% bobbin inspection in SGs B and C, and disposition of all bobbin I-codes by +Point.

[1] Dings and dents are considered the same population in the Model F SG, since the use of stainless steel TSPs obviates the potential for denting. A dent is considered a ding that coincidentally occurs at a structure such as a TSP or an AVB.

Ultrasonic Inspection

Ultrasonic Testing was performed, using the Ultrasonic Test Eddy Current (UTEC) system, to provide additional insight into the axial OD cracking indications confirmed by the +Point Probe. Since OD cracking at the TSPs has not previously been detected in the Model F or Model F-type SGs with Alloy 600TT tubing, confirmation by an independent testing technique was desired prior to expanding the inspection. Of the 42 indications confirmed by +Point as OD cracking, 19 were tested with UTEC. In addition, one indication (R2C48-TSH) initially recorded as a single volumetric indication (SVI) after +Point testing, was examined with the UTEC probe. This indication was determined to be a geometric indication without evidence of degradation.

Selection of the indications to be tested by UTEC was based on the relative ranking of +Point voltages, the number of locations that could be practically tested and the objective to obtain a significant sample of the SAI and MAI population based on the +Point tests.

Tube Removal

Because the OD cracking was a new degradation mechanism at Seabrook, three tubes were designated for removal from SG-D for destructive examination. The tubes planned for removal, R4C63-HL, R5C62 HL and R9C63-CL, were selected to include the largest indication based on both bobbin and +Point voltage, provide a significant number of intersections (7), and provide broad coverage across the region of occurrence (i.e., HL and CL section). Tooling interference issues resulted in an inability to remove tube R4C63. The 2 tubes removed provided 4 intersections that still met the above criteria for selection of the tubes to be removed.

Destructive examination of the tubes was performed, which confirmed that the degradation morphology was ODSCC.

Root Cause Analysis

An evaluation was performed to determine the root cause of the cracking observed at the TSPs. The principal cause of cracking was determined to be elevated residual stresses in the degraded tubes that made them more susceptible to corrosion in the operating environment. A characteristic shape in the bobbin signal trace was identified that correlated with the degraded tubes and which showed that there were an additional six undegraded tubes that exhibit the elevated residual stresses. The reported ODSCC is not considered to be a new and generic degradation mechanism for the model F SGs.

3.0 Active Degradation Mechanisms

The EPRI Rev. 5 ISI Guidelines (Reference 2) define "Active Damage Mechanism" as:

1. A combination of 10 or more new indications of degradation ($\geq$ 20% TW) and previous indications of degradation that display an average growth rate $\geq$ 25% of the repair limit per cycle in any one SG. (For the 2 of 4-alternating inspection plan utilized by Seabrook, the growth rate criterion equates to an observed increase in depth of wear of 20% since the prior inspection.)

2. Alternatively, the existence of 1 or more new or previously identified indications of degradation, including cracks, which display a growth $\geq$ the repair limit in one cycle of operation shall require designation of the degradation mode as an active degradation mechanism.

OD Cracking

Since OD cracking was confirmed at several TSP locations, and no acceptable sizing technique is available for this degradation mechanism, the tubes with these indications must be plugged. Consequently OD cracking at the TSPs meets definition 2, above, for an active degradation mechanism in SG-D at Seabrook.

AVB Wear

TABLE 3 summarizes the current data with regard to AVB wear to evaluate if AVB wear is an active degradation mechanism in the Seabrook SGs. Neither of the definitions of an active degradation mechanism is met for any of the Seabrook SGs; therefore AVB wear is not an active degradation mechanism as defined by the EPRI ISI guidelines. However, as noted in Table 5, AVB wear is clearly an ongoing degradation mechanism, and planning of future inspections should consider the continuing nature of AVB wear

4.0 NDE Techniques for Damage Mechanisms

All damage mechanisms associated with OR08 were grouped according to their likelihood of occurrence:

Active

Defined as a combination of 10 or more new indications of degradation (>20%TW) and previous indications of degradation which display an average growth rate equal to or greater than 25% of the repair limit per cycle in any one S/G. The following damage mechanisms and previous indications of degradation that display an average growth rate are considered active for OR08:

- Tube Wear @ AVB's. EPRI ETSS #96004

Relevant

Defined as degradation found in similar plants with the same tubing material and similar design features, as well as mechanisms observed at Seabrook, which do not meet the active definition. Degradation relevant to Seabrook are:

- Loose Part Wear EPRI ETSS #96001 for Bobbin and # 21998 for RPC
- Baffle/ Support Plate Wear EPRI ETSS #96004 for bobbin; #21998 for RPC

Potential

Defined as degradation not found in similar plants but judged to have meaningful potential to occur based on historical or lab data. The following damage mechanisms are considered potential for OR08:

- U-Bend PWSCC EPRI ETSS #96511
- Ding SCC EPRI ETSS #20510 for RPC-ID and #21409 for RPC-OD
- Sludge Pile ODSCC EPRI ETSS #96008 for bobbin and 21409
- ODSCC @ transition zone TSH EPRI ETSS # 21409 and 21410 for RPC
- PWSCC @ transition zone TSH EPRI ETSS # 20510 and 120511 for RPC
- Pitting in the presence of Copper EPRI ETSS #96005 for bobbin

5.0 Plugging

Table 1 summarizes the degradation attribution of tubes plugged during OR08 at Seabrook. Table 2 lists the tubes that were plugged. In SG-A, 13 tubes were plugged, seven of them preventively to box a tube with a resident foreign object. In SG-D, 22 tubes were plugged. No tubes were plugged in either SG-B or SG-C.

In all SGs, tubes plugged for AVB wear included at least one indication that exceeded the 40% TW Technical Specification plugging criterion. Other tubes with significant AVB wear were examined for unusual wear patterns and growth rates; none was judged to have growth rates or wear patterns that indicated administrative plugging was warranted.

In SG-A, a wear indication was detected in R6C2 just above the 5th support plate on the HL side at the edge of the tube bundle. The +Point data indicated the presence of a foreign object. Similarly, the Bobbin coil detected a possible loose part (PLP) in the adjacent tube, R7C2. Because the foreign object could not be removed, both of these tubes were plugged. In addition, six tubes surrounding these tubes were plugged to provide a bounding zone to prevent the very unlikely event of wear propagation. Removal of the resident foreign object should be planned for the next inspection of the SGs. If the object is removed, the 7 tubes adjacent to R6C2 may be recovered for service.

In SG-D, forty-two distorted support plate indications (Bobbin- DSI) were reported on 15 tubes. Inspection with +Point indicated that these indications were axial OD cracking. A number of these indications were tested with UT, which confirmed the presence of OD cracking. As a result, the 15 tubes on which these indications were reported were plugged.

6.0 Eddy Current Testing Results

The following table is a summary of the indications found during OR08. Among these indications, only the AVB indications and ODSCC represent a tube degradation mechanism. Disposition of all other indications was performed in accordance with the guidelines of the Degradation Assessment.

AVB Wear

SG	Number of Indications	Number ≥40% TW	New Indications		New Tubes[3]
			Number	Max Depth	
A[1]	303	6 (5 tubes)	57	19%	26
B[2]	175	0	40	19%	24
C[2]	223	0	36	18%	21
D[1]	530	7 (6 tubes)	117	23%	52

1. 2 cycles of operation
2. 1 cycle of operation
3. New tubes are tubes reported with indications that had no prior history of indications.

Summary of OR08 Inspection Results [1]

Indication	Description	SG A	SG-B	SG-C	SG D
SAI/MAI	OD Axial Cracks (SAI/MAI)	0	0	0	39/3
PCT [2]	AVB % Wear (Bobbin Sizing)(Total/≥40%)	303/6	175/0	223/0	530/7
DNG/DNS	Freespan Ding (Total / >5V)	166/30	206/34	158/33	149/39
DNT	Dents at Structures (Total / >5V)	102/25	664/366	351/144	95/42
PLP	Possible Loose Parts (Number of Tubes)	9	10	3	10
PVN	Permeability Variation (>2V, >1V @ AVBs)	0	0	0	0
VOL	Volumetric Indications - +Point	3	2	2	2
WAR	Wear (non-crack-like) at FDB and TSP	1	0	0	1

1. Numbers are by location and may differ from EC database due to duplicate entries in database
2. PCT calls at non-AVB locations included in other categories

In SG-D, 16 tubes were found that were incorrectly coded at OR06. History lookups revealed that of these 16 tubes, 2 (R10C60, R9C60) had not been inspected since the baseline inspection and 3 others (R6C61, R7C61 and R8C60) had not been inspected since OR02. The current inspection revealed no degradation on any of the tubes. The issue was entered into the corrective action program.

7.0 Description of Tube Integrity Assessment

Axial ODSCC is an active damage mechanism that has been observed only in SG-D. There were no confirmed indications of OD axial cracking in SGs A, B or C. Conservative projection, using a fully probabilistic multi-cycle analysis approach, of the OD cracking to EOC9 indicates that all structural and leakage criteria will continue to be satisfied until that time.

Based on the Root Cause Evaluation (References 14 and 15), it is believed that the population of tubes susceptible to ODSCC in the near term is limited to 21 tubes in SG-D. Fifteen of these tubes are the degraded tubes plugged during OR08; the remaining six are the in-service tubes that that exhibit the characteristic bobbin signal that correlates to an elevated residual stress condition. It is planned by Seabrook to inspect and repair (by plugging) these tubes at OR09.

AVB wear is an ongoing operational degradation mechanism that has been observed at Seabrook. (Wear due to loose parts depends specifically on presence of objects, and not on operational conditions.) Based on application of conservative prior AVB wear growth rates, the condition of the Seabrook SGs tubes has been analyzed with respect to continued operability of the SGs until the end of cycle 9 for SGs A, B, C and D without exceeding the structural integrity requirements of draft Reg. Guide 1.121. Conservative projection of the AVB wear to EOC9 indicates that all structural criteria will continue to be satisfied until that time.
Wear due to the presence of a foreign object in SG-A is expected to continue; however, a boundary zone was established by plugging all of the tubes adjacent to the tube experiencing wear. The boundary zone provides adequate margin for operation until, at least, OR09.

Wear at the FDB intersections has been shown to have no growth by comparing the signal from OR08 to those from OR06. Since there is no growth of these indications, and the indications are currently structurally acceptable, these indications will continue to be structurally acceptable until the next scheduled inspection at OR09.

The remnants of the tubes that were removed were analyzed and were shown to have no potential to damage any active tubes. Thus, the tube remnants do not restrict continued operation of the SGs for the life of the SGs.

8.0 REFERENCES

1. Seabrook Station Technical Specification 3/4.4.5.

2. NEI 97-06, Rev 1, "Steam Generator Program Guidelines"

3. EPRI PWR Steam Generator Examination Guidelines, Revision 5.

4. Westinghouse Report SG-SGDA-02-10, Rev 2, "Steam Generator Degradation Assessment for Seabrook, OR08 Refueling Outage"

5. Westinghouse Report SG-SGDA-02-22, Rev 1, "Seabrook OR08 Condition Monitoring Assessment and Operational Assessment"

Table 1

Seabrook OR08 Tube Plugging Summary

SG	No. Plugged	Attribution	Comment
A	5	(PCT) AVB Wear	All with indications >40% TW
	8	VOL; R6C2 at 5H+1.39"	7 adjacent tubes preventively plugged because foreign object could not be removed
B	0	N/A	
C	0	N/A	
D	15	(SAI/MAI) ODSCC at the TSPs	See Table 4
	6	(PCT) AVB Wear	All with indications >40% TW
	1	(VOL) R13C3, 01C+0.19"	Prior foreign object

Table 2
Tubes Plugged

SG	Tube	Attribution	SG	Tube	Attribution
A (13)	R46C61	AVB Wear	D (22)	R39C17	AVB Wear
	R47C61	AVB Wear		R46C46	AVB Wear
	R41C41	AVB Wear		R56C46	AVB Wear
	R52C87	AVB Wear		R42C50	AVB Wear
	R53C87	AVB Wear		R49C50	AVB Wear
	R6C2	Foreign Object (FO) Wear		R56C76	AVB Wear
	R7C2	FO- Preventive		R13C3	Volumetric ≥40%
	R5C1	FO- Preventive		R9C24	SAI (OD crack)
	R5C2	FO- Preventive		R9C26	SAI (OD crack)
	R5C3	FO- Preventive		R5C62	SAI (OD crack)
	R6C1	FO- Preventive		R9C62	SAI (OD crack)
	R6C3	FO- Preventive		R4C63	SAI (OD crack)
	R7C3	FO- Preventive		R9C63	SAI (OD crack)
				R4C65	SAI (OD crack)
				R5C80	SAI (OD crack)
				R5C81	SAI/MAI (OD crack)
				R6C81	SAI (OD crack)
				R5C82	SAI (OD crack)
				R5C83	SAI/MAI (OD crack)
				R6C85	SAI (OD crack)
				R5C86	SAI/MAI (OD crack)
				R5C88	SAI (OD crack)
No tubes were plugged in SGs B and C.					

Table 3
AVB Wear - Assessment of Active Degradation Mechanism

	New Indications		Growth Rates (1)	
SG-A	**Tube/AVB**	**%TWD**	**Tube/AVB**	**□%TWD**
1	R53C45 AV3	19	R41C41 AV2	10
2	R36C94 AV4	19	R41C41 AV3	9
3	R47C31 AV2	18	R41C41 AV4	8
4	R47C61 AV6	18	R41C41 AV5	8
5	R42C72 AV4	18	R36C81 AV4	8
6	R34C87 AV4	18	R52C87 AV4	8
7	R48C31 AV1	17	R53C87 AV5	8
8	R46C61 AV6	17	R48C31 AV3	7
9	R41C68 AV6	17	R41C35 AV3	7
10	R39C79 AV4	17	R57C61 AV2	7
SG-B				
1	R54C66 AV3	19	R51C70 AV6	13
2	R47C68 AV3	19	R54C87 AV5	8
3	R50C68 AV3	19	R50C95 AV6	7
4	R55C68 AV4	19	R33C109 AV4	7
5	R30C106 AV6	19	R56C82 AV5	6
6	R39C49 AV1	18	R35C44 AV1	5
7	R23C56 AV1	18	R46C50 AV5	5
8	R30C61 AV2	18	R39C60 AV2	5
9	R31C66 AV6	18	R30C66 AV2	5
10	R57C68 AV5	18	R30C81 AV2	5
SG-C				
1	R11C67 AV1	18	R40C46 AV2	7
2	R9C41 AV1	17	R51C51 AV5	7
3	R40C46 AV6	17	R40C39 AV4	5
4	R34C28 AV4	16	R55C39 AV1	5
5	R47C76 AV2	16	R40C46 AV5	5
6	R34C28 AV5	15	R42C66 AV1	5
7	R41C32 AV6	15	R54C87 AV5	5
8	R57C50 AV2	15	R30C113 AV2	5
9	R51C51 AV4	15	R41C30 AV5	4
10	R41C63 AV2	15	R46C36 AV4	4
SG-D				
1	R39C36 AV5	23	R42C50 AV2	18
2	R56C69 AV6	23	R56C46 AV4	17
3	R34C17 AV2	19	R46C46 AV4	16
4	R34C17 AV3	19	R52C90 AV2	16
5	R40C21 AV1	19	R46C46 AV3	15
6	R40C21 AV4	19	R56C46 AV5	14
7	R45C22 AV5	19	R49C50 AV5	14
8	R31C23 AV6	19	R46C46 AV2	13
9	R43C27 AV6	19	R42C50 AV5	13
10	R45C28 AV6	19	R56C46 AV3	12

1. SG –A and –D growth rates are 2-cycle growth rates; SG-B and –C are 1-cycle growth rates.