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April 18, 2007

Docket No.: 50-424

NL-07-0774

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555-0001

Vogtle Electric Generating Plant Unit 1
1R13 Steam Generator Tube Inspection Report

Ladies and Gentlemen:

In accordance with the requirements of Vogtle Electric Generating Plant Technical Specification 5.6.10, Southern Nuclear Operating Company submits this report of the steam generator (SG) tube inspections performed during the Unit 1 thirteenth maintenance/refueling outage (1R13). Initial entry into Mode 4 occurred on October 25, 2006.

This letter contains no NRC commitments. If you have any questions, please advise.

Sincerely,

B. J. George
Manager, Nuclear Licensing

BJG/DRG/daj

Enclosure: 1R13 Steam Generator Tube Inspection Report

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Enclosure

Vogtle Electric Generating Plant Unit 1
1R13 Steam Generator Tube Inspection Report

1R13 STEAM GENERATOR TUBE INSPECTION REPORT

Introduction

The 1R13 outage was conducted after cumulative service equivalent to ~ 17 EFPY (effective full power years); the Cycle 13 power generation was ~1.4 EFPY. Analyses based on conservative assumptions used in the Condition Monitoring and Operational Assessments demonstrated that there were no tubes that exceeded the Reg. Guide 1.121 and NEI-97-06 Revision 2 criteria for tube integrity. The steam generator (SG) tubing eddy current inspections were performed by the Steam Generator Maintenance Services Group of the Westinghouse Nuclear Services Division. Secondary data analysis was performed by ANATEC under direct contract to Southern Nuclear.

1R13 Inspection Scope

The base scope for 1R13 involved the scheduled inspections listed below. The inspection program addressed the known degradation mechanisms observed in Vogtle Unit 1 in prior inspections as well as those regarded as potential degradation mechanisms.

- 100% Bobbin examination of tubes in SGs 2 and 3, full length except for Rows 1 and 2, which are inspected from tube end to tube support plate (TSP) #7 from both hot leg side (HL) and cold leg side (CL).
- 50% +Point (mid-range) examination of small radius U-bends (Row 1 and Row 2) in SGs 2 and 3.
- ≥50% +Point examination (mid-range) top of tubesheet region (TTS) on HL side, ± 3", in SGs 2 and 3.
- +Point tests (mid-range) of Special Interest, HL, and CL, of bobbin possible flaw locations (including U-bends). Tubes indicating Seabrook-type U-bend offset behavior in the 1R11 data and statistical review to identify the 2 sigma populations; any of these tubes with DSIs (Distorted Support Indication) that are not confirmed will nonetheless be preventively plugged.
- +Point inspection of expanded tubesheet section bulges (BLGs) and overexpansions (OXPs) to include 25% of SG1 (26 tubes), SG2 (52 tubes), and SG3 (14 tubes) populations and 100% of SG4 population (78 tubes), TSH-17" to TSH+3".
- 100% +Point examination of dents/dings ≥ 5 volts in U-bends.
- +Point exams for 2 tube depth around the entire periphery of the bundle at the top of the tubesheet (±3") including HL side, CL side, and down the tube lane on both sides.
- Visual inspection of tube plugs in all 4 SGs.

As a result of indications found at the top of the tube sheet, the +Point examination at the top of the tube sheet was expanded from 50% of SGs 2 and 3 to 100% of all four SGs.

Damage Mechanisms Found and NDE Techniques Utilized

The following damage mechanisms were discovered in the Vogtle Unit 1 SGs during 1R13:

- Outside diameter stress corrosion cracking (ODSCC) at the top of the tube sheet was found in all 4 SGs. The +Point probe was used to inspect 100% of the top of the tube sheet in all four SGs.
- Loose parts wear was found in SGs 1, 2 and 3. +Point probe sizing was used to size the wear scars. Areas with potential loose parts and/or wear are identified during the bobbin inspections.
- Antivibration bar (AVB) wear was found in SGs 2 and 3. AVB wear is identified during the bobbin inspection except for rows 1 and 2 which are inspected with the +Point probe.
- Oxide removal patterns on several row 1 tubes in SG 2 were identified visually at 8 to 11 inches above the top of the tube sheet. +Point examination indicated shallow wall loss, possibly as a result of ultrasonic energy cleaning which had been used in previous outages.

Service Induced Indication Descriptions

Outside diameter stress corrosion cracking identified in Vogtle 1R13 is provided in the following table.

Vogtle 1 ODSCC Indications for 1R13

SG	Row	Col	Ind type (1)	Maxi-mum Voltage	Maximum % Depth (Phase Sizing)	Adjusted Maximum % Depth (Amplitude Sizing)	Circum-ferential Extent	Percent Degraded Area (PDA_{NDE})
1	1	103	SCI(3)	0.14	NQ (2)	45	69	4.4
1	3	103	SCI(3)	0.13	NQ (2)	45	31	3.6
1	3	119	SCI(3)	0.14	NQ (2)	45	77	7.9
2	2	109	SCI(3)	0.55	50	50	123	12.7
2	2	113	SCI(3)	0.16	NQ (2)	45	100	5.1
3	2	106	SCI(3)	0.16	73	73	38	3.2
3	5	118	SCI(3)	0.45	36	45	99	10.2
3	6	112	SCI(3)	0.18	50	50	84	3.9
4	4	107	SCI(3)	0.12	34	45	30	1.5
4	6	105	MCI(4)	0.48	63	63	182	18.2
4	8	106	SCI(3)	0.19	NQ (2)	45	31	1.5
4	8	108	MCI(4)	0.51	NQ (2)	45	216	13.8
4	8	113	SCI(3)	0.26	NQ (2)	45	106	5.2
4	9	107	SCI(3)	0.10	NQ (2)	45	91	7.4
4	11	115	MCI(4)	0.41	27	45	95	4.8
4	22	84	SCI(3)	0.25	72	72	84	14.4
4	25	51	MCI(4)	0.37	74	74	57	6.3
4	5	68	SAI(5)	1.77	68	92	0.46 inches long	Not Applicable

(1) The inspection result was classified as an indication type in accordance with a convention of 3-letter codes used for grouping and tracking various types of indications.
(2) NQ – Not quantifiable.
(3) SCI – Single circumferential indication
(4) MCI – Multiple circumferential indication
(5) SAI – Single axial indication

The circumferential ODSCC flaws were located at the bottom of the hydraulic expansion transition at the top of the tube sheet. The axial ODSCC flaw began at the bottom of the hydraulic expansion transition and extended into the expanded section of the tube inside the tube sheet. All tubes with ODSCC flaws were removed from service.

Loose parts wear, either identified or re-confirmed in Vogtle 1R13, is provided in the following table.

Vogtle 1 Loose Parts Wear Indications for 1R13

SG	Row	Column	Volts	% Depth	Location
1	39	100	1.70	12	TSH(1)
1	41	100	1.97	14	TSH(1)
1	41	100	4.93	30	TSH(1)
1	41	101	3.47	23	TSH(1)
1	41	102	3.23	21	TSH(1)
1	41	103	3.59	23	TSH(1)
2	6	1	0.08	8	1C(2)
2	16	6	0.14	13	BPC(3)
2	16	7	0.40	29	BPC(3)
2	39	46	0.74	42	BPC(3)
3	30	111	1.94	29	BPH(4)

(1) TSH – Tubesheet region on HL side.
(2) 1C – 1st TSP on CL side.
(3) BPC – Flow distribution baffle plate (FDB) on CL side
(4) BPH – FDB on HL side

All tubes with loose parts wear were visually examined, except SG 2 row 66 column 1 and SG 2 row 39 column 46. Row 39 column 46 was plugged as a result of exceeding the 40% plugging limit. Row 6 column 1 was left in service as a result of not identifying any loose parts in inspections of tubes surrounding row 6 column 1 and its shallow 8% depth.

AVB wear continued to be identified in Vogtle 1R13 in SGs 2 and 3. AVB wear identified is provided in the table below.

Vogtle 1 Steam Generator 2 AVB Wear Indications for 1R13

Row	Column	Location (1)	% Depth	Row	Column	Location (1)	% Depth
26	49	AV2	10	40	98	AV5	16
28	112	AV6	10	41	33	AV4	27
32	12	AV3	15	41	33	AV5	22
34	106	AV3	14	41	42	AV3	13
35	13	AV3	11	41	42	AV4	31
35	13	AV4	12	41	42	AV5	36
35	13	AV5	12	41	102	AV3	14
35	13	AV6	10	41	102	AV5	20
35	14	AV5	10	42	76	AV1	11
35	17	AV3	13	42	76	AV2	29
35	32	AV4	13	42	76	AV3	14
35	83	AV3	12	42	76	AV4	19
35	83	AV5	10	42	76	AV5	34
35	83	AV6	13	42	76	AV6	17
35	104	AV3	11	42	86	AV3	10
35	105	AV5	7	42	92	AV4	14
37	97	AV3	12	42	92	AV5	13
38	15	AV6	10	42	94	AV3	17
38	89	AV2	13	42	94	AV4	21
38	89	AV5	15	42	94	AV5	12
38	106	AV5	11	42	96	AV4	17
38	108	AV4	7	42	96	AV5	15
39	38	AV2	18	42	97	AV2	13
39	103	AV5	12	42	97	AV3	15
39	105	AV5	11	42	97	AV4	24
40	37	AV4	13	42	100	AV3	15
40	93	AV2	15	42	100	AV4	16
40	93	AV5	20	43	68	AV3	15
57	79	AV5	14	57	72	AV1	13
43	68	AV5	12	48	98	AV3	9
43	87	AV2	14	48	98	AV5	14
43	87	AV3	17	48	98	AV6	13
43	87	AV4	9	49	89	AV3	13
43	87	AV5	22	49	89	AV4	21
43	88	AV2	13	49	89	AV5	22
43	88	AV3	18	50	83	AV2	12
43	88	AV5	15	50	84	AV2	14
43	91	AV2	28	50	84	AV3	31
43	91	AV3	17	50	84	AV4	17
43	91	AV4	10	50	84	AV5	14

(1) AV# – Location of AVB intersection with the tube (there are up to 6)

Vogtle 1 Steam Generator 2 AVB Wear Indications for 1R13 (continued)

Row	Column	Location (1)	% Depth		Row	Column	Location (1)	% Depth
43	91	AV5	26		50	89	AV2	15
43	93	AV2	11		50	89	AV3	16
43	93	AV3	19		50	89	AV4	30
43	93	AV4	20		50	92	AV2	16
43	94	AV2	12		50	92	AV3	15
43	95	AV4	16		51	81	AV2	12
43	98	AV3	13		51	81	AV4	13
43	98	AV4	28		52	91	AV2	15
43	98	AV5	32		53	61	AV5	10
43	98	AV6	10		53	79	AV2	14
43	103	AV3	7		53	79	AV3	18
46	49	AV3	24		53	83	AV2	27
46	49	AV4	14		53	83	AV3	25
46	50	AV1	20		54	84	AV2	12
46	50	AV2	32		54	84	AV3	23
46	50	AV3	31		54	84	AV4	21
46	50	AV4	28		54	84	AV5	23
46	50	AV5	23		54	85	AV2	13
46	50	AV6	13		54	85	AV3	33
46	58	AV2	14		54	85	AV4	28
46	58	AV5	12		54	85	AV5	38
48	97	AV1	12		55	59	AV3	11
48	97	AV2	19		55	83	AV5	17
48	97	AV3	34		55	84	AV5	23

(1) AV# – Location of AVB intersection with the tube (there are up to 6)

Vogtle 1 Steam Generator 3 AVB Wear Indications for 1R13

Row	Column	Location (1)	% Depth		Row	Column	Location (1)	% Depth
28	8	AV6	19		42	43	AV2	17
36	13	AV5	17		42	43	AV5	18
36	34	AV2	14		42	43	AV6	10
36	34	AV5	18		42	50	AV1	8
36	44	AV5	12		42	50	AV2	25
37	107	AV5	12		42	50	AV3	15
37	108	AV6	10		42	50	AV4	32
38	69	AV3	14		42	58	AV2	12
38	106	AV3	18		42	58	AV3	15
38	106	AV5	14		42	63	AV4	17
38	106	AV6	13		42	66	AV3	14
39	17	AV3	23		42	66	AV4	15
39	17	AV4	21		42	67	AV3	11
39	17	AV5	15		44	22	AV5	16
39	17	AV6	30		44	102	AV4	13
39	20	AV4	13		45	22	AV5	12
39	26	AV2	21		45	40	AV3	20
39	35	AV3	20		45	40	AV4	17
39	35	AV4	19		45	40	AV5	19
39	35	AV5	14		45	40	AV6	15
39	63	AV3	12		45	46	AV2	13
39	66	AV3	17		45	46	AV3	16
39	66	AV4	15		45	46	AV4	12
39	66	AV5	15		45	48	AV2	20
39	102	AV2	14		45	48	AV3	26
39	102	AV5	12		45	49	AV2	24
39	104	AV4	10		45	49	AV3	28
39	104	AV5	22		45	61	AV4	16
40	19	AV4	11		45	61	AV5	21
40	19	AV5	19		45	62	AV3	31
40	19	AV6	13		45	62	AV4	30
40	20	AV2	12		45	63	AV3	28
40	20	AV3	13		45	63	AV4	16
40	30	AV5	21		45	82	AV4	14
40	35	AV4	12		45	85	AV4	12
40	97	AV3	15		46	25	AV4	10
40	100	AV5	15		46	25	AV5	14
40	101	AV5	11		47	26	AV5	19

(1) AV# – Location of AVB intersection with the tube (there are up to 6)

Vogtle 1 Steam Generator 3 AVB Wear Indications for 1R13 (continued)

Row	Column	Location (1)	% Depth		Row	Column	Location (1)	% Depth
40	102	AV2	17		47	35	AV4	15
40	102	AV6	13		47	38	AV4	27
40	104	AV4	16		47	45	AV2	15
41	19	AV3	15		47	45	AV4	18
41	19	AV4	13		47	95	AV6	8
41	19	AV5	21		49	92	AV5	13
41	21	AV4	11		49	96	AV6	14
41	21	AV5	15		50	86	AV2	14
41	102	AV2	12		51	55	AV4	14
41	102	AV3	33		51	82	AV4	28
41	102	AV4	19		51	82	AV5	24
42	21	AV4	20		53	84	AV3	21
42	21	AV5	19		53	84	AV4	27
42	23	AV4	13		53	84	AV5	15
42	27	AV4	13		54	88	AV1	15
42	27	AV5	27		54	88	AV6	14
42	28	AV2	12		55	81	AV2	11
42	28	AV4	13		58	52	AV6	17
42	29	AV4	17		59	68	AV6	14

(1) AV# – Location of AVB intersection with the tube (there are up to 6)

No tubes were plugged as a result of AVB wear.

Visual inspection in steam generator 2 identified oxide removal patterns on several tubes hypothesized to be a result of cavitation during ultrasonic energy cleaning. Wall loss information as a result of eddy current inspection is provided in the table below.

Vogtle 1 R13 Steam Generator 2 Shallow Wall Loss

Row	Column	Volts	% Depth	Location	Inch1
1	70	0.05	6	TSC(1)	11.00
1	70	0.09	10	TSC(1)	9.58
1	70	0.07	8	TSC(1)	8.38
1	78	0.10	10	TSC(1)	9.71
1	78	0.05	6	TSC(1)	8.42
1	82	0.05	5	TSC(1)	8.31

(1) TSC – Tubesheet region on CL side.

No tubes were plugged as a result of this shallow wall loss.

Number of Tubes Plugged

Tubes Plugged in 1R13

SG	Row	Column	Indication Type	Description
1	1	103	SCI	Circumferential ODSCC
1	3	103	SCI	Circumferential ODSCC
1	3	119	SCI	Circumferential ODSCC
2	2	109	SCI	Circumferential ODSCC
2	2	113	SCI	Circumferential ODSCC
2	39	46	VOL(1)	Loose Parts Wear
3	2	106	SCI	Circumferential ODSCC
3	5	118	SCI	Circumferential ODSCC
3	6	112	SCI	Circumferential ODSCC
4	4	107	SCI	Circumferential ODSCC
4	5	68	SAI	Axial ODSCC
4	6	105	MCI	Circumferential ODSCC
4	8	106	SCI	Circumferential ODSCC
4	8	108	MCI	Circumferential ODSCC
4	8	113	SCI	Circumferential ODSCC
4	9	107	SCI	Circumferential ODSCC
4	11	115	MCI	Circumferential ODSCC
4	22	84	SCI	Circumferential ODSCC
4	25	51	MCI	Circumferential ODSCC

(1) VOL – Volumetric indication

Total plugging in the SGs after 1R13 is as follows:

SG 1 – 9 tubes for a total of 0.16% tubes plugged
SG 2 – 14 tubes for a total of 0.25% tubes plugged
SG 3 – 25 tubes for a total of 0.44% tubes plugged
SG 4 – 26 tubes for a total of 0.46% tubes plugged

Chemical Cleaning

The chemical cleaning process applied to the Vogtle 1 SGs during 1R13 was recognized as part of the planned maintenance activities in the 1R13 Steam Generator Degradation Assessment. The compositions of the iron removal solutions were optimized based on the anticipated sludge and tube deposits inventories. As applied, this chemical cleaning operation incorporated elements of the EPRI/SGOG process and employed several phases, wherein temperature adjustments were made to facilitate dissolution in specific regions of the bundle, such as TSP crevices and the TTS sludge region. Residual iron stage chemicals were removed by multiple rinse operations prior to the copper removal phase of the cleaning process. The process was completed after similar rinse steps following the copper removal step. All 4 SGs were subjected to chemical cleaning during 1R13.

Condition Monitoring Results

No indications were found to exceed the condition monitoring limits specified in the Degradation Assessment.

For burst of a circumferential crack at $3\Delta P_{NO}$ at Vogtle 1, a percent degraded area (PDA) of 78% or a uniformly 100% through wall crack of 280° is required. The largest measured total crack angle for R8C108 is only nominally 216° or 250° at 95% probability. The nominal PDAs for this indication range from 17.3% for the WCAP-15573 methods to 25.5% for amplitude sizing, which bound the largest PDAs for all the indications including WCAP-15573 methods at the upper 95% probability. The measured angle at 95% probability is less than the 280° required for burst under the very conservative assumption that the crack is uniformly 100% deep. Similarly, the maximum PDA of 25.5% for any indication is much less than the acceptance limit of 78% required for burst of a circumferential crack. Consequently, it can be concluded that there is a negligible probability of burst for the Vogtle 1 circumferential cracks at $3\Delta P_{NO}$. Based on the above assessments, condition monitoring requirements are satisfied for all circumferential indications found in the 1R13 inspection. Additionally, the maximum circumferential indication voltage of 0.55 volts is less than the minimum voltage threshold of 1.31 volts for in situ testing in the EPRI Steam Generator In Situ Pressure Test Guidelines. Therefore, in situ testing with respect to the circumferential indications was not performed.

The single axial tubesheet indication assessed as ODSCC similarly did not exceed the in situ screening parameters for leak testing. Based on the evaluation of R5C68 for SLB leakage with crack opening constrained by the tubesheet, the SLB leak rate at 95% probability is 0.09 gpm (room temperature) with no leakage for the nominal estimate. Since tube burst is prevented by the tubesheet, it can be concluded that the condition monitoring tube integrity requirements with an allowable leak rate of 0.25 gpm (RT) at 95% probability are conservatively satisfied.

A tube pull during the 1R13 outage was not practicable due to issues regarding vendor crew and equipment availability. Tube pulls of ODSCC indications in future outages are being evaluated.

The foreign object-related wear on R39C46 in SG2 exceeded the plugging criteria, but its 42% depth estimate does not exceed the Condition Monitoring limit (as provided in the Degradation Assessment for 1.5" long uniform thinning). The axial length of the wear scar (0.32") and the circumferential extent (78 degrees) indicate that there is considerable margin as compared to the uniform thinning reference. Additional margin is inherent in the result, given that the tube area affected by the wear scar is less than 10% of the area assumed in calculation of the Structural Limit.

None of the AVB wear indications in either SG2 or SG3 exceed the plugging criteria. Therefore, they do not exceed the Condition Monitoring limits as given in the 1R13 Degradation Assessment. The growth rates are essentially negligible.

Evaluation of the indications found in the 1R13 inspection indicate that the condition monitoring requirements for structural and leakage integrity as specified in NEI-97-06 Revision 2 are satisfied.