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Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Sir / Madam:

Subject: VIRGIL C. SUMMER NUCLEAR STATION (VCSNS), UNIT 1
DOCKET NO. 50-395
OPERATING LICENSE NO. NPF-12
SPECIAL REPORT (SPR) 2014-006

Reference: Letter from S. A. Byrne (VCSNS) to Document Control Desk (NRC), "SPECIAL REPORT (SPR 2000-005)," dated November 8, 2000 [ML003769321]

South Carolina Electric & Gas Company (SCE&G) hereby submits the Steam Generator Tube Inspection Report pursuant to the requirements of Technical Specifications 6.9.1.12. This report summarizes the examination conducted during the 2014 Spring Refueling (RF-21) and the state of the three steam generators installed at V. C. Summer Nuclear Station (VCSNS), Unit 1.

In preparation for the RF-21 inspection, an error was identified. The referenced letter incorrectly identified the location of two of the three tubes that were plugged in 'A" Steam Generator during RF-12. This error has been corrected in Table 9 of the attached Steam Generator Tube Inspection Report. The error has been entered in the station's corrective action program. No tube plugging was required during RF-21.

Should you have any questions, please call Mr. Bruce Thompson at (803) 931-5042.

Very truly yours,

Thomas D. Gatlin

WLT/TDG/ts
Attachment

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A001
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Steam Generator Tube Inspection Report
VC Summer Nuclear Station
Jenkinsville SC 29065

RF-21 April 2014

1.0 Background

Commissioned in January 1984, VC Summer originally had three Westinghouse Model D3 steam generators. The original steam generators were replaced with Westinghouse Delta-75 steam generators in the fall of 1994.

Each of the replacement steam generators contains 6307 thermally treated alloy 690 tubes with an outside diameter of 0.6875 inches and a nominal wall thickness of 0.040 inches. Stress relief was performed during fabrication on the U-bends of the first 17 rows of tubing. The straight sections of the tubing are supported by nine tube support plates made of 1.125 inch thick, SA-240, Type 405 stainless steel. The tube support plates (TSP) have trefoil, broached holes which reduce dryout and the collection of impurities at the tube-to-support plate intersections. The u-bend sections of the tubing are supported by four sets of anti-vibration bars (AVB) made of SA-240, Type 405 stainless steel. A flow distribution baffle (FDB) plate is located between the tubesheet and the lowest support plate. The flow distribution baffle increases the secondary side flow velocity near the tubesheet, thus reducing the accumulation of sludge at the top of the tubesheet.

The D-75 steam generators contain a sludge collector above each primary separator which is designed to reduce the accumulation of sludge at the tubesheet. The tube-to-tubesheet joints are formed by a full depth hydraulic expansion and a weld to the primary cladding on the tubesheet.

2.0 Scope of Inspections Performed on Each Steam Generator (SG)

The RF-21 inspection program, as required by the EPRI PWR SG Examination Guidelines Revision 7, addressed the existing and potential degradation mechanisms for V. C. Summer. The defined scope for each steam generator included the following:

1) 55% (plus tubes with prior indications) full length bobbin inspection
2) U-bend +Point inspection of tubes that a bobbin probe would not pass through
3) 100% +Point inspection of peripheral tubes and at the tube lane (two tubes closest to the boundary in both cases) in the hot leg (HL) and cold leg (CL) from 3 inches above to 3 inches below Top of the Tubesheet (TTS)
4) 20% +Point inspection of non-peripheral tubes in hot leg from 3 inches above to 3 inches below TTS

5) 50% +Point inspection of all dents/dings ≥ 5 volts
6) +Point inspection of legacy loose parts
7) Special interest RPC (freespan signals without historical resolution, bobbin I-code indications, etc.)
8) 100% tube plug video inspection in HL and CL (8 tubes total)
9) Video scan of channel head bowl in HL and CL as recommended by Westinghouse Nuclear Safety Advisory Letter (NSAL) 12-1
10) TTS secondary side video inspection including Foreign Object Search & Retrieval (FOSAR)
11) Upper bundle video inspection in 'A' SG
12) Steam drum inspection

Tables 1 and 2 provide the RF-21 total eddy current examination scope.

Table 1: Base Scope Exam

Base Scope Exam Type	SG A	SG B	SG C
Cold Leg Full Length Bobbin	2889	2895	2885
Cold Leg Low Row Straight Section	619	545	322
Hot Leg Full Length Bobbin	0	80	298
Hot Leg Candy Cane	619	545	322
Cold Leg RPC Tubesheet Exams (Periphery and Interior)	680	679	678
Hot Leg RPC Tubesheet Exams (Periphery and Interior)	1832	1893	1882
TOTAL	**6639**	**6637**	**6387**

Table 2: +Point Diagnostic Exams for Bobbin Indications (Special Interest Additional Scope)

Exam Type	SG A	SG B	SG C
Hot Leg Bobbin Dent/Ding ≥ 5V	0	2	0
Hot Leg Bobbin I-Code Indications	6	1	4
Hot Leg PLP/VOL and Box In	18	14	0
Hot Leg Mag Bias Special Interest	0	1	2
Cold Leg Bobbin Dent/Ding ≥ 5V	34	47	31
Cold Leg Bobbin I-Code Indications	5	13	8
Cold Leg PLP/VOL and Box In	0	0	0
Cold Leg New Bobbin Wear	10	20	13
Cold Leg Mag Bias Special Interest	0	0	0
U-bend Bobbin I-Code Indications	0	0	2
Hot Leg U-Bend Dent/Ding ≥ 5V	2	2	0
Cold Leg U-Bend Dent/Ding ≥ 5V	1	1	0
TOTAL	**76**	**101**	**60**

3.0 Degradation Mechanisms Found

Existing degradation mechanisms are those mechanical or corrosive processes previously and/or currently observed in a Steam Generator. Based on this definition of existing degradation mechanisms and prior inspection results, there are three existing degradation mechanisms within the VC Summer replacement steam generators.

3.1 Tube Wear at AVBs

Wear related to tube interaction with AVB supports results from flow-induced vibration in the upper bundle. This mechanical process is related to the tightness of the upper bundle assembly as expressed in the distribution of tube-to-AVB gaps. Indications of AVB wear in the replacement steam generators were first reported during RF-12. Very few AVB wear indications were reported in subsequent inspections during RF-15 and RF-18. No new AVB wear indications were reported in RF-21. The deepest wear indication during RF-21 was 10% through-wall depth (TWD). To date, no tubes have been plugged for this mechanism.

3.2 Tube Wear at TSPs and FDB

Flow-induced vibration that causes tube wear at TSPs and the FDB is governed primarily by secondary side thermal hydraulic characteristics and the geometry (sizes of the tube-to-support gaps, TSP spacing, etc.). Tube wear at TSPs was first reported in the replacement steam generators during RF-15. The deepest TSP wear reported during RF-21 was 29% TW. One indication of tube wear at FDB was reported during RF-18. The FDB wear reported during RF-21 was 16% TW. Both wear mechanisms are located and sized using identical eddy current testing techniques. With TSP wear being significantly deeper than FDB wear, TSP wear bounds the condition monitoring analysis results for FDB wear. To date, no tubes have been plugged for this mechanism.

3.3 Tube Wear Due to Foreign Objects

Foreign objects may enter the SG through the feedwater stream and may cause tube wear. Foreign object wear was detected for the first time during RF-21 inspections. During the bobbin probe base scope inspection program, an indication was noted at the top of the hot leg baffle plate in two tubes. When these locations were tested with a rotating coil probe, small indications indicative of wear were noted above the baffle plate. It was surmised that the wear was caused by a transient loose part. The tube at row 32, column 89 was sized at 7% TWD and the tube at row 35, column 92 was sized at 10% TWD. A review of the eddy current data from surrounding tubes was conducted with no additional indications discovered. Due to the lack of similar indications reported during the inspection and the shallow nature of the indications, examination expansion was deemed unnecessary. No loose parts associated with this wear were found in the

vicinity of these indications during FOSAR activities so it is believed that the loose part no longer remains in the SG. No tubes were plugged for this mechanism.

4.0 Nondestructive Examination Techniques for Each Degradation Mechanism

Inspection programs and Examination Technique Specification Sheets (ETSS) identified in the Degradation Assessment for each degradation mechanism are identified in Table 3.

Table 3: SG Tube Degradation Mechanisms and Associated NDE Techniques

Degradation Mechanisms	Inspection Program % Sample	Detection Technique ETSS #	Sizing Technique ETSS #
Existing Mechanisms			
Wear at AVBs	55% Bobbin	96004.1	96004.1
Wear at TSPs and FDB	55% Bobbin, +Point Special Interest	96004.1 96910.1	96004.1 96910.1
Potential Mechanisms [1]			
Wear due to Foreign Objects	55% Bobbin, +Point Special Interest, TTS +Point of peripheral tubes in HL and CL	27091.2 21998.1 Alternate 2790X.3 [2]	 21998.1 Alternate 2790X.3 [2]
Diagnostic Inspection			
Inspection of Row 1-2 U-bends	55% Bobbin	96004.1	96004.1
ODSCC at HL TTS Expansion Transition	20% + Point HL TTS	I28424 I28425 21410.1	I28431 I28432 21410.1
ODSCC at Dings/Dents	55% Bobbin, 50% +Point dents/dings ≥ 5V	10013.1 24013.1 I28413 I28424 I28425 21410.1 22841.3	 I28431 I28432 21410.1

Note 1: Prior to RF-21, wear due to foreign objects was classified as a potential degradation mechanism.
Note 2: The applicable ETSS are numbered 2790X.3 where X is a variable between 1 and 7. Techniques and corresponding uncertainty used for sizing of foreign object wear is dependent on indication geometry.

5.0 Location, Orientation (if Linear), and Measured Sizes (if Available) of Service Induced Indications

Tables 4-8 provide the location and measured sizes of service induced indications. The majority of the indications were from tube wear by support structures. Two indications of wear due to a migratory loose part were detected in SG C.

Table 4: AVB Wear

SG	Row	Col	Supp	Inch	Depth
A	19	140	AV7	0.43	10
A	26	139	AV2	-0.75	7
A	26	139	AV7	0.75	9
C	26	3	AV2	-0.75	9

Table 5: SG A TSP Wear

Row	Col	Supp	Inch	Depth
17	2	05C	0.31	13
1	10	06C	-0.57	15
1	10	05C	0.00	20
1	10	04C	0.00	13
67	24	07C	0.41	12
91	28	07C	-0.70	11
1	60	03C	-0.43	8
1	60	03C	0.47	16
115	62	09H	0.45	12
2	77	08H	-0.43	26
2	77	07C	0.00	29
4	81	07C	0.52	10
4	99	05C	0.36	14
4	103	05C	-0.56	8
4	103	05C	0.45	10
77	122	07C	0.50	12

Table 6: SG B TSP Wear

Row	Col	Supp	Inch	Depth
1	2	06C	-0.63	15
1	2	06C	0.43	15
1	2	05C	-0.68	7
1	2	05C	0.38	14
34	9	06C	0.43	11
2	17	07H	0.49	11
1	28	07H	-0.55	14

Row	Col	Supp	Inch	Depth
1	28	07H	0.49	11
2	31	06C	0.58	12
2	31	05C	0.48	17
99	44	09C	0.43	10
94	45	09C	0.43	8
3	46	08C	-0.53	14
3	46	07C	-0.49	19
108	47	07H	-0.61	11
108	47	07H	0.41	11
3	54	06C	0.56	13
2	61	04C	-0.59	14
115	74	06H	0.43	12
6	75	07C	-0.54	13
114	75	04H	0.49	6
3	84	07C	0.47	16
5	84	07C	0.52	11
5	88	08C	-0.57	12
5	88	08C	0.48	12
5	88	07C	-0.54	18
5	88	07C	0.48	11
5	88	05C	-0.47	10
5	90	08C	0.50	13
5	90	07C	0.57	13
99	106	07C	-0.61	12
2	113	07C	0.47	15
2	113	06C	0.50	16
5	116	07C	0.43	14
39	120	08C	0.36	8
10	121	08C	-0.52	10
10	121	08C	0.58	7
54	121	07C	-0.61	13
20	139	03H	-0.58	11
1	140	06C	-0.58	10
1	140	06C	0.41	14

Table 7: SG C TSP Wear and FDB Wear

Row	Col	Supp	Inch	Depth
1	4	06C	0.38	11
1	8	07C	0.45	14
52	19	08C	0.47	10
25	36	07C	0.47	12
5	52	06C	-0.56	15
7	54	06C	-0.52	15

Row	Col	Supp	Inch	Depth
104	55	08C	0.38	25
110	73	08C	0.33	20
1	82	08H	0.53	14
114	83	09H	0.39	8
34	91	BPH	0.51	16
1	94	06H	0.59	21
6	107	05C	-0.45	9
1	112	06C	-0.52	19
1	112	06C	0.48	13
83	116	07C	-0.55	13
30	137	08C	0.43	12

Table 8: SG C Foreign Object Wear

Row	Col	Supp	Inch	Depth
32	89	BPH	0.42	7
35	92	BPH	0.50	10

6.0 Tubes Plugged during the Inspection Outage

No tube plugging was required during RF-21.

7.0 Number and Percentage of Tubes Plugged to Date

A total of eight (8) tubes have been removed from service by plugging in the VC Summer Steam Generators as shown in Table 9. The percentage of tubes plugged to date is less than 0.07% for each SG as shown in Table 10.

Table 9: List of all Plugged Tubes through RF-21

SG	Outage	Year	Row	Col	Ind	Plugging Attribute
A [1]	RF-12	2000	26	25	NTE	Anomalous tube-end expansion
A [1]	RF-12	2000	26	31	NTE	Anomalous tube-end expansion
A	RF-12	2000	94	51	NTE	Anomalous tube-end expansion
B	Factory	1994	76	123		Factory-installed weld plug
C	Factory	1994	104	41		Factory-installed weld plug
C	RF-12	2000	57	96	NTE	Anomalous tube-end expansion
C	Factory	1994	108	97		Factory-installed weld plug
C	RF-12	2000	99	100	NTE	Anomalous tube-end expansion

Note 1: Report RC-00-0345, dated 11/8/2000, incorrectly identified that the tubes at Row 25 Column 26 and Row 25 Column 31 were plugged in "A" Steam Generator during RF-12.

Table 10: SG Tube Plugging Percent

	SG A	SG B	SG C
Total Tubes	6307	6307	6307
Tubes Plugged	3	1	4
Effective Plugging Percentage	**0.048%**	**0.016%**	**0.063%**

8.0 Results of Condition Monitoring, Including Tube Pulls and In-Situ Testing

Condition monitoring results for each existing degradation mechanism is outlined in the sections that follow. Based on inspection data, no tube pulls or in-situ testing was required in RF-21. Condition monitoring concluded that SG performance criteria for leakage and structural integrity were satisfied for the preceding three cycle operating interval prior to RF-21.

8.1 Tube Wear at AVBs

The maximum AVB wear indication from RF-21 was 10% TWD. This observed wear is well within the predicted wear from the operating assessment performed in RF-18 (approximated to be 21% TWD).

ETSS 96004.1, Rev. 13, was utilized for sizing AVB wear. The ETSS correlation for true depth to indicated depth is:

$T = 0.98*I + 2.89$,
where T is predicted depth and I is the indicated depth from EC.

From this correlation, the predicted depth of the maximum indicated wear (10%) is 12.69%.

The standard deviation for the correlation, $\sigma = 4.19$. The multiplier on the standard deviation to achieve a 95% probability for a normal distribution is 1.645. Therefore, at 95% probability, the sizing uncertainty is 6.89% (1.645x4.19).

The EPRI Steam Generator Integrity Assessment Guidelines specifies a factor of 1.12 to adjust for analyst uncertainty; thus, the total uncertainty, Ut, for sizing at 95% probability is:

$Ut = 1.12 * 6.89\% = 7.72\%$

The potential maximum depth of the indication at a confidence level > 95/50 is:

Maximum Predicted Indication	12.69% TWD
NDE Sizing Uncertainty (95/50 CL)	7.72% TWD
Total (>95/50)	20.41% TWD
Structural Limit for AVB Wear	72% TWD

Since the maximum observed AVB wear indication of 20.41% TWD at 95% probability and 50% confidence is less than the structural limit of 72% TWD (defined in the RF-21 Degradation Assessment), the requirements for condition monitoring are met for AVB wear.

8.2 Tube Wear at TSPs and FDB

The maximum TSP and FDB wear indication from RF-21 was 29% TWD and 16% TWD, respectively. This observed wear is well within the predicted wear from the operating assessment performed at RF-18 (approximated to be 40% TWD and 24% TWD, respectively).

ETSS 96004.1, Rev. 13, was utilized for sizing TSP and FDB wear. The ETSS correlation for true depth to indicated depth is:

T = 0.98*I + 2.89,
where T is predicted depth and I is the indicated depth from EC.

From this correlation, the predicted depth of the maximum indicated wear (29%) is 31.31%.

The standard deviation for the correlation, $\sigma = 4.19$. The multiplier on the standard deviation to achieve a 95% probability for a normal distribution is 1.645. Therefore, at 95% probability, the sizing uncertainty is 6.89% (1.645 x 4.19).

The EPRI Steam Generator Integrity Assessment Guidelines specifies a factor of 1.12 to adjust for analyst uncertainty; thus, the total uncertainty, Ut, for sizing at 95% probability is:

Ut = 1.12 * 6.89% = 7.72%

The potential maximum depth of the indication at a confidence level > 95/50 is:

Maximum Predicted Indication	31.31% TWD
NDE Sizing Uncertainty (95/50 CL)	7.72% TWD
Total (>95/50)	39.03% TWD
Structural Limit for TSP and FDB Wear	66% TWD

Since the maximum observed TSP and FDB wear indication of 39.03% TWD at 95% probability and 50% confidence is less than the structural limit of 66% TWD (defined in the RF-21 Degradation Assessment), the requirements for condition monitoring are met for TSP and FDB wear.

8.3 Tube Wear Due to Foreign Objects

The maximum foreign object wear indication from RF-21 was 10% TWD.

ETSS 27903.3, Rev. 1, was utilized for sizing foreign object wear. The ETSS correlation for true depth to indicated depth is:

$T = 1.21*I + 26.3$;
where T is predicted depth and I is the indicated depth from EC.

From this correlation, the predicted depth of the maximum indicated wear (10%) is 38.4%. The standard deviation for the correlation, $\sigma = 4.99$. The multiplier on the standard deviation to achieve a 95% probability for a normal distribution is 1.645. Therefore, at 95% probability, the sizing uncertainty is 8.21% (1.645x4.99).

The EPRI Steam Generator Integrity Assessment Guidelines specifies a factor of 1.12 to adjust for analyst uncertainty; thus, the total uncertainty, Ut, for sizing at 95% probability is:

$Ut = 1.12 * 8.21\% = 9.19\%$

The potential maximum depth of the indication at a confidence level > 95/50 is:

Maximum Predicted Indication	38.4% TWD
NDE Sizing Uncertainty (95/50 CL)	9.19% TWD
Total (>95/50)	47.6% TWD
Structural Limit for Foreign Object Wear	65% TWD

Since the maximum observed foreign object wear indication of 47.6% TWD at 95% probability and 50% confidence is less than the structural limit of 65% TWD, the requirements for condition monitoring are met for foreign object wear.

9.0 References

9.1 Westinghouse Document SG-SGMP-14-1, V.C. Summer 1 RF21 (April 2014) Steam Generator Degradation Assessment, Rev. 2, April 2014.

9.2 Westinghouse Document SG-SGMP-14-15, V.C. Summer Unit 1 Steam Generator Cycle 21 Condition Monitoring and Cycles 22, 23, and 24 Operational Assessment, Rev. 0, May 2014.

9.3 V.C. Summer U1 R21 SG Eddy Current Inspection Report, April 2014.