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

Re: St. Lucie Unit 1
Docket No. 50-335
Refueling Outage SL1-27
Steam Generator Tube Inspection Report

Attached is the St. Lucie Unit 1 Technical Specification 6.9.1.12 steam generator tube inservice inspection report for the fall 2016 refueling outage (SL1-27). This submittal was made within 180 days after the initial entry into hot shutdown following the completion of the steam generator inspection that was performed in accordance with TS 6.8.4.l, Steam Generator (SG) Program.

Please contact Ken Frehafer at (772) 467-7748 should you have any questions regarding this submittal.

Very truly yours,

Michael J. Snyder
Licensing Manager
St. Lucie Plant

MJS/KWF

Attachment: St. Lucie Unit 1 Steam Generator Tube Inspection Report for SL1-27

cc: USNRC Regional Administrator, Region II
USNRC Senior Resident Inspector, St. Lucie Nuclear Plant

Enclosure

SL1-27 Steam Generator Tube Inspection Report

Introduction:

The enclosed Steam Generator Tube Inspection Report for St. Lucie Unit 1 is submitted for the inspection of the replacement steam generators (RSGs) during refueling outage 27 (hereafter referred to as the SL1-27 inspection/outage), as required by plant Technical Specification section 6.9.1.12. Per the St. Lucie Unit 1 Tech Spec section 6.8.4.l.d.2, the second sequential period is 108 EFPMs. The inspection during SL1-27, performed in accordance with Tech Spec section 6.8.4.l.d, was the 2nd inspection of the RSGs in the second sequential period, and the 6th ISI inspection since installation of the RSGs in 1997.

The plant Tech Spec requirement to inspect 50% of the tubes by the refueling outage nearest the midpoint of the period was met by the SL1-25 inspection. No primary-side inspection was performed during the SL1-26 outage. At unit shutdown for the SL1-27 inspection, the RSGs had operated for approximately 16.51 EFPY (198.18 EFPM) since installation. This included operation for approximately 1.331 EFPY (15.97 EFPM) during Cycle 25 and 1.334 EFPY (16.00 EFPM) during Cycle 26. Initial entry into Hot Shutdown following completion of the SL1-27 inspection was made on November 3, 2016.

St. Lucie Unit 1 is a 2-loop Combustion Engineering designed NSSS with RSGs manufactured by B&W Canada. The RSGs were fabricated using Inconel composition Alloy 690 thermally-treated tubes. Each RSG contains 8,523 U-tubes arranged in 141 rows and 167 columns. The tubes have a nominal OD of 0.75", a nominal wall thickness of 0.045", and have a triangular pitch arrangement. The tube bundle is supported by 7 horizontal lattice grid supports (LGS) along the straight lengths of tubes; the U-bend region is also supported by 10 fan bar supports (FBS) and 2 connector bar supports, all fabricated of stainless steel. The primary-side channel head has a stay cylinder as well as divider plates which provides flow separation between the inlet and outlet plenums. Tubes in rows 2 & 3 have the smallest U-bend radii. The general arrangement of the tube bundle supports including the FBS, CBS and horizontal LGS is shown in Appendix B. References to historical SG Tube Inspection Reports are provided in Appendix A along with acronyms and abbreviations used in this report. The inspection of the RSGs during the SL1-27 outage met the inspection requirements of the St. Lucie Unit 1 Tech Specs, NEI 97-06 and the referenced EPRI Guidelines.

A. Scope of Inspections Performed on each SG

Primary-side:

- 100% full-length bobbin probe exam of all active tubes
- Array probe exam of peripheral tubes (high flow regions) in hot and cold legs (HL/CL) in each RSG, and low-row tubes (rows 1-4) along the tube free lane. (Peripheral tubes are defined as the 2 outermost tubes exposed to the annulus, all tubes in Rows 1-4 along the tube-free lane, and the innermost 2 tubes adjacent to the outermost edge of the stay cylinder.) The exam extent was from 01H to TTS-3".
- 30% tube sample of tight-radius U-bends of Rows 2 & 3 using the +Point™ probe. The U-bend test extent was the portion of tubing between the uppermost horizontal LGS. (The selected tube sample was different from the 30% sample which was inspected during SL1-25.)
- 100% of all previously-identified DNG/DNT indications in the U-bend and at hotleg horizontal LGS locations with +Point™; at least 50% of all previously-identified DNG/DNT indications > 5 Volts at HL freespan locations with +Point™; and all newly-reported DNG/DNT indications that meet the above reporting criteria for previously-identified DNG/DNT indications with +Point™.
- +Point™ and/or array probe exams of all tubes with previously-identified possible loose part (PLP) indications, from TTS ± 3 inches.

- Diagnostic +Point™ examination at other special interest locations as required based on the results of the bobbin coil and array coil data.
- Visual inspection of all installed tube plugs in each RSG.
- Channel head bowl scan visual inspection of each RSG per recommended actions in Westinghouse NSAL 12-1 "Steam Generator Channel Head Degradation" January 5, 2012.

Secondary-side:

- Visual inspection of the Steam Drum / Upper Internals was performed in SG 1A. This included a sample of the primary and secondary separators.

B. Active degradation mechanisms found

Wear at tube supports and historical PLP wear at the TTS were the active (existing) degradation mechanisms identified during the SL1-27 RSG inspection. Specifically, the degradation mechanisms were:

- Wear at fan bar supports (FBS)
- Wear at lattice grid supports (LGS)
- Historical PLP wear on 2 tubes at the HL TTS location

Wear at CBS locations was not found in SL1-27. No indication was identified that was due to a corrosion degradation mechanism. There was no new degradation from foreign objects.

C. Nondestructive examination techniques utilized for each degradation mechanism

Table 1 is a list of the EPRI Examination Technique Specification Sheets (ETSS) used for tube degradation detection and sizing, as needed, during the SL1-27 inspection.

Table 1

NDE Technique		Degradation Mechanism		ETSS
		Location/Description	Status	
1	Bobbin	Wear at Support Structures (LGS, FBS, CBS)	Existing	96004.1 Rev. 13 (differential mix channel)
2	Bobbin	Wear at Support Structures (LGS, FBS, CBS)	Existing	96004.2 Rev. 13 (absolute mix channel)
3	Bobbin	Foreign Object Wear (PLP) (Object not present)	Potential	27091.2 Rev. 2
4	+Point™	Wear at LGS Structures	Existing	96910.1 Rev. 10
5	+Point™	Wear at U-bend Supports (FBS, CBS)	Existing	10908.4, Rev. 1
6	+Point™	PLP Wear (morphology dependent)	Potential	27901.1 Rev 1, 27902.1 Rev 2, 27903.1 Rev 1, 27904.1 Rev 2, 27905.1 Rev 2, 27906.1 Rev 1, 27907.1 Rev 2
7	Array	PLP Wear (based on technique extension)	Potential	20400.1, Rev. 5

D. Location, orientation (if linear), and measured sizes (if available) of service induced indications

Listings of all service-induced indications identified during the SL1-27 inspections are provided below in Tables 2a, 2b and 2c.

Table 2a: Wear at Lattice Grid Supports (LGS):

SG	Row	Col	%TW	Location
A	64	11	15	04C -1.34
A	97	144	9	01C -1.58
A	97	144	23	02C -1.60
A	107	138	10	02C -1.51
A	116	37	14	06H -0.54
A	139	74	14	03H -0.92

SG	Row	Col	%TW	Location
B	1	146	12	06C -1.45
B	2	127	13	05C +0.48
B	107	138	12	05H +1.45
B	133	60	14	02C -1.39
B	139	92	16	04H -1.59

Table 2b: Wear at Fan Bar Supports (FBS):

SG	Row	Col	%TW	Location
A	67	92	11	F09 -2.41
A	82	105	11	F06 +0.80
A	86	91	14	F06 +1.32
A	87	94	12	F04 +1.27
A	87	94	14	F06 +1.34
A	87	94	14	F07 +1.47
A	101	74	14	F05 -0.89
A	101	74	14	F06 +1.82
A	104	79	12	F07 +1.36
A	118	61	11	F05 +0.93
A	118	61	11	F06 -0.95
A	118	61	15	F07 -1.21
A	118	61	11	F08 -1.31
A	121	66	12	F03 -1.09
A	121	66	11	F04 -1.06
A	121	66	12	F05 -0.54
A	121	66	18	F06 +1.45
A	121	66	11	F08 -1.11
A	121	66	11	F09 -1.26
A	126	83	13	F07 +1.27
A	126	83	11	F08 +1.36

SG	Row	Col	%TW	Location
B	93	90	15	F04 -1.26
B	102	67	11	F07 -1.12
B	108	91	10	F04 -1.23
B	108	91	12	F05 +1.05
B	108	91	12	F08 -1.36
B	123	94	12	F08 +0.81
B	132	65	10	F05 +1.11
B	132	65	11	F07 -1.14
B	137	64	11	F06 -0.85
B	137	64	11	F07 -0.91

Table 2c: Historical Wear due to PLP:

SG	Row	Col	%TW	Location
B	137	78	17	TSH +0.37
B	139	78	14	TSH +0.54

Apart from the items in Table 2c, there were no new degradation from PLP/foreign objects. As mentioned previously, wear at CBS locations was not found in SL1-27. No indication was identified that was due to a corrosion degradation mechanism.

E. Number of tubes plugged during the inspection outage for each active degradation mechanism

The number of tubes plugged for each active degradation mechanism is summarized below in Table 3:

Table 3 - Tubes Plugged[1] during SL1-27 inspection outage

Degradation Mechanism[2]	SG 1A	SG 1B	Total
Wear at Fan Bar Supports (FBS)	3	1	4
Wear at Lattice Grid Supports (LGS)	1	0	1
Wear at Connector Bar Supports (CBS)	0	0	0
Wear due to PLP/foreign objects	0	0	0
Total	4	1	5

1. The tubes plugged in SG 1A during SL1-27 were: R97C144, R87C94, R118C61 and R121C66. The tube at R108C91 was plugged in SG 1B.

2. No tube had wear which exceeded the Tech Spec limit (≥ 40%TWD). The tubes plugged were taken out of service to support the operational assessment until the next primary-side inspection in SL1-30. (A primary-side inspection is not planned for the SL1-28 or SL1-29 outages.)

F. Total number and percentage of tubes plugged to date

The total number and percentage of tubes plugged to-date in each SG is summarized below in Table 4:

Table 4 - Cumulative Tube Plugging Summary following the SL1-27 Inspection

SG	Total Plugged	% Plugged
1A	101	1.19%
1B	54	0.63%

G. The results of condition monitoring, including the results of the tube pulls and in-situ testing

All SG tubes inspected during the SL1-27 outage met the condition monitoring (CM) requirements for structural and leakage integrity. No evidence of corrosion degradation was detected. No primary-to-secondary leakage was noted since the last inspection. No indications were found to exceed the structural limits. The next inspection is planned for the SL1-30 outage. (A primary-side inspection is not planned for the SL1-28 or SL1-29 outages.)

1. The largest wear indications at lattice grid support (LGS) locations in each SG were 23%TWD and 16%TWD, in SG 1A and 1B, respectively. All detected LGS wear indications fell below the CM limit for burst and leakage. One (1) tube in SG 1A (none in SG 1B) was plugged due to wear at a LGS location to support the operational assessment to the next inspection. The list of LGS Wear indications in SL1-27 is provided in Table 2a.

2. The largest wear indications at fan bar support (FBS) locations in each SG were 18%TWD and 15%TWD, in SG 1A and 1B, respectively. All detected FBS wear indications fell below the CM limit

for burst and leakage. Three (3) tubes in SG 1A and one (1) tube in SG 1B were plugged due to wear at FBS locations to support the operational assessment to the next inspection. The list of FBS Wear indications in SL1-27 is provided in Table 2b.

3. No wear indications were found at U-bend connector bar support (CBS) locations. Two (2) historical PLP wear indications at the TTS in SG 1B measured 14% and 17% in SL1-27 using the +Point™ probe. There has been no growth in these 2 PLP wear indications since they were first reported. The list of historical PLP wear indications is provided in Table 2c.
4. During the Steam Drum / Upper Internal components inspection, no sign of damage, degradation, erosion or corrosion was observed.
5. No degradation was found during the visual inspection of the primary-side channel head bowl. No corrosion-related degradation was identified anywhere in the channel head of the SGs. All previously-installed tube plugs were confirmed to be in their correct locations, and showed no visible signs of leakage based on the visual examination. No degradation of the tube plugs was identified.

In summary, all wear indications detected in SL1-27 met CM requirements. As a result, no tubes required in-situ pressure testing for burst or leakage, and no tube pulls were required. Therefore, all tubes met the structural and leakage integrity requirements of the St. Lucie Unit 1 Tech Specs.

H. The effective plugging percentage for all plugging in each SG

No tube repair methods (i.e. sleeving) are approved for St. Lucie Unit 1 that would have an effect on the effective plugging percentages. Therefore, the applicable effective plugging percentage is synonymous with the “% Plugged” entries shown in “Item F” above.

APPENDIX A - Additional Information

References to historical SG Tube Inspection Reports

SG ISI #	EOC	Outage	NRC ADAMS Accession No.
1	EOC-15	SL1-16	ML003684169
2	EOC-16	SL1-17	ML012390098
3	EOC-18	SL1-19	ML053190206
4	EOC-21	SL1-22	ML091120207
5	EOC-24	SL1-25	ML14127A008
6	EOC-26	SL1-27	(current report)

Abbreviations and Acronyms

CBS	Connector Bar Support
CL	Cold Leg
CM	Condition Monitoring
DNG/DNT	Dings/Dents
EOC26	End-of-cycle 26 (or SL1-27 inspection)
EFPM	Effective Full Power Months
EFPY	Effective Full Power Years
EPRI	Electric Power Research Institute
ETSS	Examination Technique Specification Sheet
FBS	Fan Bar Support
HL	Hot Leg
ISI	In-service Inspection
LGS	Lattice Grid Support
NSSS	Nuclear Steam Supply System
OD	Outside Diameter
PLP	Possible Loose Part
RSG	Replacement Steam Generator
SG	Steam Generator
TSH	Tubesheet Hot
TTS	Top of Tubesheet
TWD	Through Wall Depth

APPENDIX B - General arrangement of St. Lucie Unit 1 RSG Tube Bundle Supports

Note: Seven horizontal lattice grid support (LGS) elevations are labeled sequentially from bottom to top as 01H to 07H (or 01C to 07C) according to the following table. There is no baffle plate.

	Horizontal LGS designation						
Tube Support	1	2	3	4	5	6	7
Hot Leg	01H	02H	03H	04H	05H	06H	07H
Cold Leg	01C	02C	03C	04C	05C	06C	07C