FPL

September 25, 2019
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U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-00001

Re: Turkey Point Unit 4
Docket No. 50-251
Steam Generator Tube Inspection Report

The attached Turkey Point Unit 4 Cycle 31 Refueling Outage Steam Generator Tube Inspection Report is submitted in accordance with Turkey Point Technical Specification, 6.9.1.8 and within 180 days after the initial entry to MODE 4 following completion of the inspections performed in accordance with Technical Specification 6.8.4.j, Steam Generator (SG) Program.

Should there be any questions, please contact Mr. Robert Hess, Licensing Manager, at (305) 246-4112.

Sincerely,

Robert Hess
Licensing Manager
Turkey Point Nuclear Plant

Attachments

cc: Regional Administrator, Region II, USNRC.
Senior Resident Inspector, USNRC, Turkey Point Plant

Enclosure

Turkey Point Unit 4
TP4-31 Steam Generator Tube Inspection Report

Introduction:

The enclosed Steam Generator Tube Inspection Report for Turkey Point Unit 4 is submitted for the inspection of the SGs during refueling outage 31 (hereafter referred to as the TP4-31 inspection or outage), as required by Technical Specification section 6.9.1.8. Per the Turkey Point Unit 4 Technical Specification section 6.8.4.j.d.2.c, the 4th ISI period is 72 EFPM. The inspection in TP4-31 was performed in accordance with Technical Specification 6.8.4.j.d.2.c, and was the 2nd (and last) inspection of the SGs in the 4th ISI period. The TP4-30 outage was a SG inspection "skip". At unit shutdown for the TP4-31 inspection, the SGs had operated for approximately 28.53 EFPY (342.4 EFPM) since installation, including 46.6 EFPM in the 4th ISI period. Since the last SG inspection (TP4-29), the SGs operated for approximately 1.40 EFPY (16.77 EFPM) and 1.34 EFPY (16.12 EFPM) during fuel cycles 29 and 30, respectively, leading up to the TP4-31 inspection. Initial entry into Mode 4 following completion of the TP4-31 inspection was made on April 6, 2019.

Turkey Point Unit 4 is a Westinghouse 3-loop PWR with Model 44F steam generators. The SGs are U-tube heat exchangers with tube bundles fabricated using thermally treated Alloy 600 tubing. Each SG contains 3,214 tubes arranged in 45 rows and 92 columns, in a square-pitch configuration. Nominal tube OD is 0.875" with a 0.050" nominal wall thickness. Each SG tube bundle is supported by one drilled-hole flow distribution baffle (FDB) and 6 quatrefoil, broached-hole tube support plates (TSPs) all fabricated from stainless steel. Two (2) sets of anti-vibration bars (AVBs) in the U-bends also provide tube bundle support. The inspection of the SGs during the TP4-31 outage met the requirements of the Turkey Point Unit 4 Technical Specifications, EPRI SGMP: PWR Steam Generator Examination Guidelines Revision 8, and EPRI SGMP: Steam Generator Integrity Assessment Guidelines Revision 4.

Appendix A provides references to recent SG Tube Inspection Reports and acronyms used in this report. Appendix B provides a list of indications reported in TP4-31.

A. Scope of Inspections Performed on each SG

The inspection scope for TP4-31 met the requirements of Turkey Point Unit 4 Technical Specification 6.8.4.j. For all sample inspections, tube selection priority was given to the ones not inspected in TP4-29 to meet the sequential period requirements in Technical Specifications. Unless otherwise noted, the defined TP4-31 base inspection scope in all 3 SGs was:

Primary-side:

- 100% full-length bobbin probe examination of all active tubes except U-bends of Rows 1 and 2.
- 50% sample of tubes in the U-bends of Rows 1 & 2 using the +Point™ probe.
- Peripheral tubes (2 outermost tubes of each row) exposed to the annulus, and Rows 1 and 2 in the tube-free lane were inspected in the HL and CL using the array probe. The test extent was from the first broached TSP (designated 01H or 01C) to the tube-end (TEH or TEC).
- 50% sample of tubes in the HL tubesheet section from 01H to TEH using the array probe, including 50% of the BLG/OXP within the H* depth (TTS-18.11") of the tubesheet.
- 50% sample of Dings/Dents > 5V in the HL (freespan, TSPs), and the U-bend using the +Point™ probe.
- +Point™ probe inspection of a) all "high stress" (minus 2-sigma) tubes within the HL tubesheet section (TSH+3" to TEH), and b) 75% of "high stress" tubes at HL tube support structures and top CL TSP.
- +Point™ or array probe exam of all tubes adjacent to (1-tube bounding of) current and previously-reported PLP indications and foreign objects reported during FOSAR in TP4-29.
- Other special interest exams based on the results of bobbin coil exams including +Point™ probe inspection of all "I-codes" from bobbin or array probe.

Enclosure

- Visual inspection of all mechanical and welded plugs.
- Channel head visual inspection, and bowl scan per Westinghouse NSAL 12-1 Rev 1, “Steam Generator Channel Head Degradation,” October 2017.

  Inspection Expansion: No scope expansion was required based on the TP4-31 base exam scope.

Secondary-side:

- Upper bundle flush and top-of-tubesheet (TTS) Sludge Lancing in all SGs.
- TTS FOSAR performed in the annulus and tube-free lane of each SG. This included TTS in-bundle inspections in each SG.
- Upper tube-bundle visual inspection in SG-B at the top TSP (06H/06C).
- Upper steam drum visual inspection in SG-B. UT thickness measurements were also obtained at sample locations on the feedring T-box and all J-tubes.

B. Degradation Mechanisms Found

The following degradation mechanisms were identified during the TP4-31 inspection:

- Wear at anti-vibration bar (AVB) contact points.
- Wear at horizontal tube support structures (FDBs, TSPs).
- Foreign object wear at one location in SG-B at the TTS in the HL (reported as VOL).

No degradation was identified as a result of a corrosion damage mechanism.

Enclosure

C. NDE Techniques utilized for each Degradation Mechanism

Table 1a is the list of the EPRI ETSSs used for degradation detection during the TP4-31 ECT inspection.

Table 1a - NDE Detection Techniques for Degradation Mechanisms

Detection probe	ETSS used for Detection	Degradation Mechanism	Location / Applicability
Bobbin	I96041.1 Rev 6	Wear	AVB locations
	96004.1 Rev 13		Broached TSP locations
	I96042.1 Rev 4		Drilled supports (FDB)
	27091.2 Rev 2		Foreign object wear (with/without part present)
	96005.2 Rev 9	Pitting	In the freespan and sludge pile
	I-28411 Rev 4	Axial ODSCC	At FDBs locations
	I-28412 Rev 4 I-28413 Rev 5		In the freespan
	I-28413 Rev 5		At broached TSPs
	24013.1 Rev 2 10013.1 Rev 1		At Dents/Dings ≤ 5V
+Point™	I-28424 Rev 4 I-28425 Rev 4		At Dents/Dings > 5V
	10411.1 Rev 0 10411.2 Rev 0		All U-bends
	I28424 Rev 4		sludge pile/expansion transition
	20511.1 Rev 8	Axial PWSCC	At expansion transition
	I11524 Rev 0	Circ PWSCC	
	96511.1 Rev 16 96511.2 Rev 16	Axial/Circ PWSCC	In low row U-bends
	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	Wear	Foreign object wear (with/without part present)
Array	17901.1/ .3; 17902.1/ .3; 17903.1/ .3; 17904.1/ .3; 17905.1/ .3; 17906.1/ .3 [All Rev 0]		
	20400.1 Rev 5	Axial/Circ ODSCC	At expansion transition
	20500.1 Rev 4	Circ PWSCC	At expansion transitions / BLGs / OXPs
	20501.1 Rev 4	Axial PWSCC	

Table 1b is the list of the EPRI ETSSs used for degradation sizing based on the degradation mechanisms reported during the TP4-31 ECT inspection.

Table 1b - NDE Sizing Techniques for Degradation Mechanisms

Sizing probe	ETSS used for Sizing	Degradation Mechanism	Location / Applicability
Bobbin	I96041.1 Rev 6	Wear	AVB locations
+Point™	10908.4 Rev 1		
	96910.1 Rev 11		TSP and FDB locations
	27905.1 Rev 2		Just above or below TSP edges
	27902.1 Rev 2		Foreign object wear at TSPs
	27901.1 Rev 1		Foreign object wear (volumetric) at or slightly above TTS

Enclosure

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

For each SG, Attachment B provides the listing of service-induced indications identified during the TP4-31 inspection, including locations and measured sizes. Note:

For AVB wear, the indication depth as measured by the bobbin probe is provided.
For all other locations, the indication depth as measured by the +Point™ probe is provided.

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

Five (5) tubes were plugged based on the TP4-31 inspection; the tubes plugged for each degradation mechanism are summarized below in Table 2:

Table 2 – TP4-31 Tubes Plugged

SG	Tube	Degradation Mechanism	Notes
B	R38C58	AVB wear	Preventively plugged due to atypical AVB wear growth.
	R28C34, R28C35, R29C34, R29C35	No degradation reported at dent locations	Four (4) adjacent tubes reported dent signals (no wear) just above the TTS in the HL from a bounded legacy foreign object. The tubes were preventively plugged and stabilized.

F. Number and percentage of tubes plugged to date, and the effective plugging percentage in each steam generator

The number and percentage of SG tubes plugged to-date, and the effective plugging percentage in each SG are summarized in Table 3.

Table 3 - Tubes plugged to-date and effective plugging percentage

	SG-A	SG-B	SG-C	Total
Tubes Plugged	33	28	11	72
Percent Plugged	1.03%	0.87%	0.34%	0.75%

G. Results of Condition Monitoring, including the results of tube pulls and in-situ testing

All indications found in TP4-31 satisfy the condition monitoring (CM) requirements of NEI 97-06 and Turkey Point Technical Specifications for structural and leakage integrity. No indication exceeded the structural limits. The tubes identified for plugging were screened against the in-situ test selection criteria contained in the EPRI SGMP Steam Generator In-Situ Pressure Test Guidelines, Rev 5, and provided for Turkey Point Unit 4 conditions. None of the tubes identified for plugging met the requirements for in-situ pressure testing, and no tube pulls were performed. The TP4-31 inspection results validate the projections and conclusions of the Operational Assessment of the previous inspection at TP4-29.

1. Wear at AVB locations has been the dominant mode of degradation for the Turkey Point Unit 4 SGs and accounts for the majority of the indications reported (Attachment B). One tube showed an atypical growth rate history having reported indication growths of 8% and 10% TW at two AVB locations over the last 2 cycles, and was preventively plugged. The maximum observed AVB wear indication in TP4-31 for all SGs was 32% TW and meets the CM requirements

Enclosure

for burst and leakage integrity. The largest wear indications at TSP and FDB locations also fell well-below the CM limits.

2. A FO wear (volumetric) indication was reported in the HL at the TTS (tube R27C22) in SG-B. Since a FO was not detected in the vicinity of this indication, it was likely removed during bundle flush and sludge lancing. The NDE depth of the FO wear indication was 31% TW and met the performance requirements when evaluated against the ISPT screening charts for CM.

3. No degradation was detected during the +Point inspection of "high stress" tubes, and the DNG/DNT sample inspection scope. During the array probe inspection of tubes in the tubesheet, no indication was detected at locations where BLGs/OXPs were located. No corrosion degradation mechanisms were observed during the TP4-31 inspection. All wear reported at broached TSP and FDB locations fell well below the CM limits; therefore, these indications met the acceptance criteria of NEI 97-06 structural performance criterion for burst and leak integrity.

4. Channelhead Components Visual Inspection:
   - Tube Plug Inspection: During the inspection of tube plugs in TP4-31, all installed plugs were confirmed to be in their correct location. In addition, all plugs were found to be dry; no dripping plugs were identified. No degradation or visible signs of leakage were noted on the plugs during the visual inspection.
   - Other Channelhead Inspections: Visual inspection of various channelhead components were performed to identify degradation per guidance in Westinghouse NSAL 12-1 Rev 1, "Steam Generator Channel Head Degradation" and LR-ISG-2016-01, "Changes to Aging Management Guidance for Various Steam Generator Components." Areas inspected include the divider plate-to-channelhead weld, the weld at the top of the channelhead bowl drain tube, the channelhead-to-tubesheet girth weld seam region, the divider plate, and all cladded surfaces of the channelhead bowl and tubesheet. No degradation was found; the observed condition during the TP4-31 inspection is consistent with the manufacturing process.

5. Secondary-side Inspections and Maintenance:
   - A total of 116 lbs. of sludge was removed from the 3 SGs based on upper bundle flush and sludge lancing in TP4-31 (36, 31 and 49 lbs. in SGs A, B and C, respectively). The TTS locations of all legacy FOs were visually inspected, and 5 newly-identified objects were removed during TTS FOSAR. One newly-identified FO in SG-B (in the shape of a button-head bolt) could not be removed since it was fixed in place between 4 adjacent tubes. The object appears to have been in place since the SG was manufactured. ECT results also reported dent signals (but no degradation) on these tubes just above the TTS; these tubes were plugged and stabilized. The other FOs remaining in the SGs were mostly small sludge rocks, hard deposits and scale. An evaluation is in place for all irretrievable FOs that have the potential to cause tube damage. Upper tube-bundle visual inspection in SG-B at the top TSP reported no fouling/deposit material or abnormal conditions.
   - Upper Internals Inspection: Visual inspections performed in SG-B (for erosion/corrosion, mechanical damage, foreign material and unusual conditions) included the moisture separators, swirl vanes, feedring and J-nozzles. A light deposit material was noted on the surfaces of the steam drum. No fouling was observed in the flow holes of the moisture separators, and no erosion or corrosion was apparent on the separators or swirl vanes. A minimal amount of scouring was observed inside some of the J-tubes at the interface with the feedring; these have been noted previously and do not appear to have changed. The welds of all steam drum components were noted to be intact. Some wall-thinning (external) was noted based on UT thickness measurements taken on the feedring in SG-B in TP4-31. The condition appears to have been caused by impingement of feedwater as it discharges from the neighboring j-tube. This was entered in the corrective action program and repairs were performed in TP4-31 to address this condition.

Enclosure

H. Primary-to-secondary leakage rate observed in each SG during the previous cycle

No primary-to-secondary leakage was observed during the previous 2 fuel cycles (Cycles 29 and 30).

I. Calculated accident induced leakage rate

As described in the H* alternate repair criteria (ARC) for the Turkey Point Plant[1], the accident induced leakage rate from the portion of the tubes below 18.11 inches from the TTS is calculated from any observed normal operating leakage that cannot be attributed to a source other than the tubesheet expansion region. For Turkey Point Unit 4, the maximum operational primary-to-secondary leakage rate from the portion of the tubes below 18.11 inches from the top of the tubesheet is determined by multiplying any normal operating leakage by a factor of 1.82 to determine the accident induced leakage rate. Since no operational primary-to-secondary leakage has been observed (per section H of this report), the calculated accident induced leakage rate is zero.

J. Results of monitoring for tube axial displacement (slippage)

A condition for licensing H* was to monitor for tube slippage within the tubesheet region. Monitoring for tube slippage was completed during the TP4-31 inspections. No tube slippage was reported.

[1] Turkey Point Nuclear Generating Station Unit Nos. 3 and 4 - Issuance of Amendments Regarding Permanent Alternate Repair Criteria for Steam Generator Tubes (TAC NOS. ME8515 and ME8516); ADAMS Accession No. ML12292A342

Enclosure

APPPENDIX A - Additional Information

References to recent SG Tube Inspection Reports (SGTIR)

EOC #	Outage	ADAMS Accession No.
EOC-26	TP4-27	ML13277A358
EOC-27	TP4-28	Inspection “skip” (no SGTIR)
EOC-28	TP4-29	ML16298A391
EOC-29	TP4-30	Inspection “skip” (no SGTIR)

Abbreviations and Acronyms:

ARC	Alternate Repair Criteria
AVB	Anti Vibration Bar
BAC	Baffle plate cold
BAH	Baffle plate hot
BLG	Bulge
CL	Cold Leg
CM	Condition Monitoring
DNG	Ding
DNT	Dent
ECT	Eddy Current Testing
EFPM	Effective Full Power Months
EFPY	Effective Full Power Years
EPRI	Electric Power Research Institute
ETSS	Exam Technique Spec Sheet
FDB	Flow Distribution Baffle
FO	Foreign Object
FOSAR	Foreign Object Search and Retrieval
HL	Hot Leg
ISPT	In-Situ Pressure Test
NEI	Nuclear Energy Institute
NSAL	Nuclear Safety Advisory Letter
OD	Outside Diameter
OXP	Over-expansion
PLP	Possible Loose Part
PWSCC	Primary Water SCC
SCC	Stress Corrosion Cracking
SG	Steam Generator
SGMP	SG Management Program
TEC	Tube End Cold
TEH	Tube End Hot
TS	Tubesheet
TSC	Tubesheet Cold
TSH	Tubesheet Hot
TSP	Tube Support Plate
TTS	Top of Tube Sheet
TW	Through Wall
VOL	Volumetric indication (used to report FO-wear in TP4-31)

Enclosure

Appendix B – TP4-31 Listing of Indications

Note: Designation used for tube support structures: TSPs: 01H thru 06H on the HL; 01C thru 06C on the CL. FDB: BAH or BAC. AVBs: AV1 thru AV4

SG-A

ROW	COL	%TW	LOCATION
25	12	12	AV2 +0.26
26	20	7	AV1 +0.30
30	16	7	AV2 +0.16
30	30	7	AV3 +0.00
30	80	9	AV2 +0.18
31	77	13	AV1 +0.28
31	80	10	AV1 +0.30
		10	AV2 +0.24
32	74	15	AV1 +0.05
		14	AV2 +0.27
		12	AV3 +0.20
32	76	9	AV4 -0.14
33	72	14	AV3 -0.18
33	74	7	AV1 +0.14
35	67	10	AV4 -0.14
37	20	14	AV2 +0.26
		12	AV1 +0.30
37	65	17	AV3 +0.00
40	49	11	AV4 -0.05
42	63	7	AV3 +0.71
29	25	20	AV4 -0.11
33	72	20	AV1 +0.23
37	65	28	AV2 +0.00
		32	AV4 +0.00
37	71	26	AV2 +0.48
		20	AV3 +0.35

ROW	COL	%TW	LOCATION
4	58	6	02H +0.48
10	62	8	04H +0.48
11	86	7	04C +0.41
13	4	9	BAH -0.29
18	86	11	BAC -0.31
39	28	5	BAH +0.05

SG-B

ROW	COL	%TW	LOCATION
13	35	10	AV3 -0.93
13	42	10	AV1 -0.04
21	6	9	AV3 +0.23
23	50	13	AV3 +0.96
23	85	10	AV3 -0.10
26	64	17	AV2 +0.00
		18	AV3 +0.00
26	68	10	AV3 +0.00
26	71	8	AV2 +0.19
26	83	7	AV2 +0.25
27	72	16	AV2 +0.20
27	82	11	AV4 +0.18
30	65	14	AV2 +0.15
		8	AV3 +0.18
30	73	8	AV2 +0.00
		13	AV3 +0.00
		17	AV4 +0.00
31	13	12	AV2 +0.18
		10	AV3 -0.16
		9	AV4 +0.19
33	16	13	AV4 -0.07
33	62	11	AV2 -0.23
33	78	9	AV1 +0.18
		8	AV2 +0.17
34	46	13	AV1 +0.29
		12	AV2 +0.58
27	72	22	AV1 -0.11
34	46	27	AV2 -0.50
38	58	23	AV3 +0.23
		30	AV4 -0.21

ROW	COL	%TW	LOCATION
19	86	10	BAH -0.22
		8	BAH -0.27
35	70	9	BAH -0.40
40	26	8	BAH -0.32
		6	BAH +0.00
27	22	31	TSH -0.03
5	12	10	04H +0.43
5	86	8	01H +0.66
8	3	16	02H -0.57
9	80	5	02H +0.46
28	80	6	05H -0.54
31	60	17	02H -0.32

SG-B (cont'd)

ROW	COL	%TW	LOCATION
35	49	9	02H -0.37
40	25	6	01C +0.43
43	37	11	04C +0.56
43	39	10	04C +0.64
44	38	18	04C +0.53

SG-C

ROW	COL	%TW	LOCATION
12	4	13	AV4 +0.36
13	4	12	AV4 +0.37
22	7	8	AV2 +0.17
22	82	10	AV1 +0.33
22	83	11	AV4 +0.00
24	12	17	AV4 -0.09
26	82	13	AV1 +0.35
27	80	9	AV3 +0.25
27	81	9	AV1 +0.31
		8	AV4 +0.15
30	15	15	AV1 +0.35
30	75	13	AV2 +0.65
31	80	7	AV3 +0.14
32	16	18	AV2 +0.28
33	76	8	AV1 +0.26
34	17	7	AV1 +0.09
34	53	10	AV1 -0.22
		16	AV2 +0.22
34	75	15	AV4 +0.00
36	74	6	AV3 +0.02
37	71	9	AV1 +0.33
37	73	7	AV3 -0.27
39	69	7	AV2 -0.11
40	68	5	AV2 +0.20
32	70	24	AV1 +0.31
		22	AV3 +0.18
35	31	20	AV2 +0.31

ROW	COL	%TW	LOCATION
35	75	12	06H +0.29
28	82	7	BAH +0.51