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Engineering Report Cover Sheet

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Condition Monitoring and Operational Assessment of Indian Point 2 Steam Generator Tubing for Cycles 18 and 19

Engineering Report Type:

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ANO1	☐	ANO2	☐	ECH	☐	GGNS	☐	RBS	☐	WF3	☐		

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Revision Summary

Rev.	Description	Changes
0	Original Issue	n/a

1. Purpose

The purpose of this report is to evaluate the seventeenth refueling outage (2R17) inspection results and ensure the performance criteria contained in the Nuclear Energy Institute steam generator program guidelines (NEI 97-06) are satisfied. This includes evaluating any detected degradation for structural and leakage integrity. Consideration is mainly given to the previous cycle 17 operational assessment to determine the accuracy of the assessment based on the results to the 2R17 inspection findings. Additionally, the results are used to project the condition of the steam generators at the next scheduled inspection in 2R19 (2010) and demonstrate that the performance criteria will continue to be satisfied until that inspection.

2. Summary of Results

Twenty-three (23) tubes were found with new anti-vibration bar (AVB) indications of which 7 met the threshold for degradation (≥20%). Those seven tubes were removed from service with plugging. No other degradation was detected. The largest AVB indication was 28% through wall (TW) which is well below the condition monitoring limit of 63% TW. Therefore, the performance criteria was met for the previous two cycles.

Sludge lancing removed an average of 23 pounds per steam generator and numerous small foreign objects. Many of the foreign objects are likely to be attributed to the moisture separator reheater (MSR) modifications made in 2R16 to support stretch power uprate (SPU). Visual inspections performed at the top of the tubesheet found additional foreign objects of which the significant ones (i.e. one inch or greater) were removed. There was no evidence of tube damage from either the visual examinations or the eddy current inspections.

The top support plate in 23 and 24 steam generators were visually inspected via the inspection port. No anomolies other than those previously documented during fabrication were noted. There was no evidence of excessive sludge buildup in this area. In addition, there was no evidence of a wrapper shift noted when removing the handhole covers for sludge lancing. Structural integrity of the secondary side should continue until the next secondary side inspections in 2R19 (2010).

Going forward, it is likely that the AVB wear in the tubes left in service will continue to grow and that similar indications exist in the un-inspected tubes. This operational assessment projects that any additional wear will remain below the AVB structural limit (67.8%) of the SG tubing at the time of the next inspection in 2R19 (2010). The small foreign objects remaining in the steam generators are not likely to cause any detectable tube wear and should not challenge the structural limits for the tubing. Therefore, the steam generator tubing should satisfy the performance criteria at the next scheduled inspection in 2R19 (2010).

3. Background

The Indian Point 2 steam generators were replaced in 2000 with Westinghouse Model 44F units. At the time of the 2R17 inspection, the SGs had accumulated 60 effective full power months (EFPM) of service since replacement. The SG tubing material is Alloy 600TT and 2R17 marked the third refueling outage since replacement and the second ISI of the steam generators. During the first ISI (2R15) on the replacement steam generators the only degradation detected was AVB wear that affected 13 tubes. All 13 tubes were plugged during 2R15 and no degraded tubes were left in service.

The inspections performed in 2R17 were 43 calendar months and 39 EFPM since the previous inspection in 2R15. During 2R17, eddy current inspections were performed in all 4 steam generators including a full length bobbin exam of 50% of the tubes. In addition, all 4 SGs were sludge lanced at the top of the tubesheet followed by a visual foreign object search and retrieval (FOSAR). This FOSAR included the annulus, tubelane and approximately every fifth column in bundle.

Primary to secondary leakage during the previous operating period was less than 0.1 gpd.

4. Evaluation

4.1. Introduction

This evaluation follows guidance provided by the Nuclear Energy Institute (NEI) 97-06, "Steam Generator Program Guidelines[1]," for performing condition monitoring and operational assessments of steam generator tubing degradation. Additionally, guidance from the EPRI "Steam Generator Degradation Specific Management Flaw Handbook[2]" was also used.

A steam generator integrity program, which provides reasonable assurance that the steam generator tubes are capable of performing their intended safety function, has been developed by Entergy, using guidance from NEI. This includes establishing performance criteria commensurate with adequate tube integrity, programmatic considerations for providing reasonable assurance that the performance criteria will be met during plant operation, and guidelines for condition monitoring of the SG tubing to confirm that the performance criteria are met.

4.2. Steam Generator Design

IP2 is a four-loop plant with Model 44F steam generators. Operation with the new Model 44F Replacement Steam Generators (RSG) began with startup for cycle 15 on January 3rd, 2001. These steam generators include Alloy 600 thermally treated (A600TT) tubing, full-depth hydraulically expanded tubesheet joints, and broached-hole quatrefoil tube support plates constructed of stainless steel. The tubes are 7/8ths outside diameter by 0.050 inch wall thickness. The tubing pattern is on a square pitch. IP2 is currently in cycle 18, which is the fourth cycle of operations with the replacement steam generators.

4.3. Inspection Results

4.3.1. RF17 Scope

Eddy Current Scope

The following eddy current exams were performed in each of the four SGs:

1) 50% Bobbin 4 SG's full length except rows 1 & 2 (1515 tubes/SG)
2) 50% Bobbin 4 SG's straight lengths hot and cold legs rows 1 & 2 (92 tubes/SG)
3) 50% RPC U-Bend 4 SG's Rows 1 & 2 (92 tubes/SG)
4) RPC of tubes at top of tubesheet (TTS) ±3" in 4 SG's:
   - 20% patterned sample of hot leg TTS (±3") in 4 SG's (~648 tubes/SG)
   - Three tubes in from the annulus on the hot leg not covered in the 20% sample above. Purpose was for PLP (possible loose part) identification and loose part wear (~508 tubes)
   - All row 1 & 2 tubes on the hot leg not covered in two criteria above. Purpose was for PLP (possible loose part) identification and loose part wear (~124 tubes)
   - Three tubes in from the annulus on the cold leg Purpose was for PLP identification and loose part wear.
   - All row 1 & 2 tubes on the cold leg not covered in the criteria above: Purpose was for PLP identification and loose part wear. (~164 tubes)
5) RPC of selected dents/dings in the hot leg straight sections
   - 100% of dents/dings ≥5 volts identified in 2R15 (25 tubes total)
   - 20% sample of dents/dings ≥2 and <5 volts identified in 2R15 (46 tubes total)
   - Any new dents/dings ≥2 volts identified in 2R17
6) RPC of selected indications in hot leg tubesheet:
   - 20% sample of OXP, BLG and DNT
7) Special Interest Examinations:
   - Special interest exams of abnormal indications

Secondary Side Scope (Sludge lancing & Visual Inspections)

1) Sludge lanced the top of the tubesheet in all 4 SG's and the flow distribution baffle in 23/24 steam generators.
2) Performed foreign object search and retrieval (FOSAR) in 4 SG's (annulus and tube lane) post lancing
3) Performed TTS In-bundle visual inspection of approximately every 5th column of both hot and cold legs in 4 SG's post lancing
4) Visually inspected the Top Support Plate ("G" plate) visual inspection in 23/24 SG's including:
   - The underside of the tube U-bends
   - The top of the plate the full length of the tube lane
   - The length of 11 columns on both hot and cold legs from the tube lane to the wrapper
5) Collected sludge samples for future analysis

4.3.2. Inspection Results

The results of the RF17 inspection are listed in Table 4-1 below.

Table 4-1 RF17 Inspection Results (50% of Tubes Inspected)

Identification Code	SG21	SG22	SG23	SG24
Final "I" Codes	0	0	0	0
>=20%	2	2	0	3
IDV	0	0	0	0
DFS				
VOL	0	0	0	0
PVN	5	2	5	4
DNT	58	7	39	11
DNG	70	47	32	30
DNR	26	5	23	1
BLG	265	1	130	369
PDS				
IDC	0	0	0	0
MBM				
FSD	221	248	155	131
FSA	55	72	33	72
PLP	13	4	0	7
PLG				
INF	0	1	0	0
INR	114	54	73	139
TRA	0	0	0	0
Bobbin "S" Codes	1	0	0	2
NDD	3273	3520	3382	3247
Total	829	443	490	767

4.3.3. Loose Parts (CR-IP2-2006-02562, 02652, 02732, 02749)

The previous design of the moisture separator re-heaters included moisture separator re-heater demister pads that contain stainless steel wire components. Degradation of these pads resulted in small portions of the wire (0.12" diameter) migrating to the secondary side of the generator. These items were identified in previous outages with extensive efforts to find and remove them from the secondary side. There are no cases where this material has caused damage to the tubing. So this material was not documented when found.

Visual inspections were performed in all 4 SGs for foreign objects in the annulus and tube lane regions. Additionally, approximately every fifth column was inspected for cleanliness in all 4 SGs following sludge lancing. The presence of any foreign objects seen during the in-bundle inspections was documented as well. The following is a list of the foreign objects identified along with a status of whether or not the object was retrieved.

Table 4-2 SG 21 Foreign Object List

Object Number	Object Description	Object Location			Length	Height	Width/Dia.	Object Retrieved Yes/No
		Col.	Row	Leg				
21-001	Metal Object	72	2	HL	0.354	0.175	0.0625	Yes
21-002	Weld Slag	63	23	HL	1	0.25	0.3	Yes
21-003	Rod	63	27	HL	1.25	0	0.125	Yes
21-004	Machine Remnant	34	27	HL	1.75	0.25	0.125	Yes
21-005	Metal Object	37	44	HL	1	0.25	0.25	Yes
21-006	Metal Object	50	45	HL	0.25	0.125	0.125	Yes
21-007	Gasket	87	23	HL	0.5	0.125	0.125	No
21-008	Gasket	57	43	HL	0.75	0.125	0.125	Yes
21-009	Metal Object	70	38	HL	0.75	0.25	0.125	Yes
21-010	Rod	69	39	HL	1	0.062	0.062	Yes
21-011	Gasket	71	38	HL	0.625	0.125	0.125	Yes
21-012	Gasket	71	38	HL	1.25	0.125	0.125	Yes
21-013	Metal Object	71	38	HL	0.25	0.125	0.25	Yes
21-014	Gasket	41	44	HL	1.5	0.125	0.125	Yes
21-015	Wire	25	39	HL	0.625	0.125	0.125	Yes
21-016	Gasket	71	38	HL	0.375	0.125	0.125	No
21-017	Wire	48	44	HL	1	0	0.2	Yes
21-018	Metal Object	46	44	HL	0.5	0.125	0.3	No
21-019	Metal Object	45	43	HL	0.75	0.0625	0.3	Yes
21-020	Metal Object	40	43	HL	0.5	0.125	0.125	No
21-021	Metal Object	20	34	HL	0.300	0.062	0.032	No
21-022	Metal Object	15	31	CL	1.000	0.125	0.050	Yes
21-023	Metal Object	25	38	CL	0.300	0.125	0.100	No
21-024	Unknown	35	41	CL	0.250	0.250	0.250	No
21-025	Metal Object	40	44	CL	0.375	0.125	0.125	Yes
21-026	Metal Object	55	37	CL	0.500	0.125	0.030	Yes
21-027	Unknown Object	50	35	CL	0.300	0.125	0.200	Yes
21-028	Unknown Object		40	CL	0.354	0.125	0.100	Yes
21-029	Metal Object	44	9	HL	0.250	0.125	0.100	Yes
21-030	Wire	44	43	HL	0.500	0.125	0.000	Yes

Table 4-3 SG 22 Foreign Object List

Object Number	Object Description	Object Location			Length	Height	Width/Dia.	Object Retrieved Yes/No
		Col.	Row	Leg				
22-001	Weld slag	8	20	CL	3.000	0.200	0.100	Yes
22-002	Gasket	42	43	HL	0.750	0.050	0.188	Yes
22-003	Gasket	45	43	HL	0.500	0.050	0.188	Yes
22-004	Metal Object	47	44	HL	0.750	0.250	0.125	Yes
22-005	Gasket	55	44	HL	2.375	0.050	0.188	Yes
22-006	Metal Object	56	43	HL	0.750	0.125	0.250	Yes
22-007	Gasket	54	44	CL	1.000	0.050	0.188	Yes
22-008	Unknown Object	35	7	HL	0.300	0.038	0.125	Yes
22-009	Gasket	40	12	HL	0.354	0.050	0.188	No
22-010	Metal Object	45	16	HL	0.354	0.000	0.031	No
22-011	Metal Object	35	43	HL	0.300	0.200	0.125	Yes
22-012	Gasket	45	45	CL	0.500	0.050	0.188	Yes
22-013	Metal Object	80	22	HL	0.150	0.100	0.030	No
22-014	Gasket	60	41	CL	1.250	0.050	0.188	Yes
22-015	Weld Splater	60	44	CL	1.500	0.125	1.750	Yes

Table 4-4 SG 23 Foreign Object List

Object Number	Object Description	Object Location			Length	Height	Width/Dia.	Object Retrieved Yes/No
		Col.	Row	Leg				
23-001	Rock	40	31	HL	0.175	0.175	0.175	No
23-002	Gasket	30	33	CL	0.700	0.000	0.000	Yes
23-003	metal object	35	42	CL	0.700	0.125	0.354	Yes
23-004	Wire	45	42	CL	1.250	0.000	0.031	Yes

Table 4-5 SG 24 Foreign Object List

Object Number	Object Description	Object Location			Length	Height	Width/Dia.	Object Retrieved Yes/No
		Col.	Row	Leg				
24-001	Weld slag	45	45	CL	1.800	0.300	0.100	Yes
24-002	Wire	30	42	CL	8.000	0.100	0.100	Yes
24-003	Unknown/object	33	40	CL	0.250	0.250	0.125	No
24-004	Gasket	47	13	HL	1.000	0.125	0.050	No
24-005	Gasket	54	38	HL	0.300	0.125	0.050	Yes
24-006	Gasket	60	37	HL	0.250	0.250	0.125	Yes
24-007	Gasket	65	39	HL	0.500	0.125	0.125	No
24-008	Flake/Unknown	73	22	HL	0.300	0.125	0.125	No
24-009	Wire	80	28	HL	1.500	0.000	0.032	No
24-010	Gasket	55	41	HL	0.375	0.125	0.125	No
24-011	Metalic Object	55	25	HL	0.125	0.125	0.125	No
24-012	Gasket	23	32	HL	0.250	0.125	0.125	No
24-013	Gasket	30	39	HL	0.250	0.125	0.125	No
24-014	Wire	30	39	HL	1.000	0.000	0.062	Yes
24-015	Metal Object	30	25	HL	0.375	0.000	0.156	Yes
24-016	Metal Object	45	41	CL	0.100	0.250	0.500	Yes
24-017	Metal Object	29	26	HL	0.365	0.125	0.000	Yes

4.3.4. Potential Loose Parts (PLP)

Attempts were made to retrieve potential loose part from locations identified with eddy current data. In many cases retrieval was successful however in other cases the part broke into pieces or was not found at the designated location.

Table 4-6 Number of Potential Loose Parts Eddy Current Indications

	SG21	SG22	SG23	SG24
PLP Indications	13	4	0	7

4.3.5. Permeability Variation (CR-IP2-2006-02693)

There were thirteen tubes identified that had permeability variations (PVN). These tubes remain in service since no evidence of degradation has been identified in the area of interest in other tubes. Therefore it is believe PVN indication is not hiding degradation

Table 4-7 Tubes with PVN Indications

Tubes with PVN Indications for RF17		
SG	**Tube Row**	**Tube Column**
21	1	46
	12	45
	23	33
	27	13
	32	14
22	36	24
	41	59
23	2	43
	39	34
24	9	16
	12	50
	18	23
	25	10

4.3.6. AVB Wear (CR-IP2-2006-02562)

There were 23 tubes identified with Anti Vibration Bar (AVB) wear. All of the indications were new. Entergy administratively plugged all 7 tubes found with AVB wear indications ≥ 20% TW. The deepest indication was 28% TW.

Table 4-8 AVB Wear Identified in RF17

AVB Wear Identified in RF17							
SG	**Tube Row**	**Tube Column**	**AV1 %TW**	**AV2 %TW**	**AV3 %TW**	**AV4 %TW**	**Tube Status**
21	39	35	NR	21	NR	17	Plugged
	33	46	15	NR	NR	NR	In-Service
	34	60	13	13	NR	16	In-Service
	37	60	16	20	16	NR	Plugged
22	34	43	NR	20	15	NR	Plugged
	36	44	14	16	NR	NR	In-Service
	23	54	13	11	13	18	In-Service
	40	59	13	15	25	NR	Plugged
	30	67	NR	11	NR	NR	In-Service
23	37	39	13	16	19	NR	In-Service
	41	40	NR	18	14	15	In-Service
	39	56	15	NR	16	NR	In-Service
	40	58	NR	16	15	NR	In-Service
	34	64	14	NR	16	13	In-Service
	41	64	NR	13	NR	NR	In-Service
24	38	57	22	25	28	16	Plugged
	33	63	NR	15	11	NR	In-Service
	33	64	NR	NR	15	14	In-Service
	38	64	NR	25	16	NR	Plugged
	33	71	12	15	14	NR	In-Service
	35	71	NR	16	23	NR	Plugged
	36	71	14	15	11	NR	In-Service
	35	73	NR	NR	12	NR	In-Service
NOTES: all wear identified in IP2-R17 is new wear; all wear identified during the previous inspection was plugged. NR represents no recorded wear.							

4.3.7. Repairs

There were a total of 7 tubes repaired during RF17 due to AVB wear. These are listed in Table 4-9 below:

Table 4-9 RF17 Plugging List

AVB Wear Plugged in RF17							
SG	**Tube Row**	**Tube Column**	**AV1 %TW**	**AV2 %TW**	**AV3 %TW**	**AV4 %TW**	**Tube Status**
21	39	35	NR	21	NR	17	Plugged
	37	60	16	20	16	NR	Plugged
22	34	43	NR	20	15	NR	Plugged
	40	59	13	15	25	NR	Plugged
24	38	57	22	25	28	16	Plugged
	38	64	NR	25	16	NR	Plugged
	35	71	NR	16	23	NR	Plugged
NOTES: all wear identified in IP2-R17 is new wear; all wear identified during the previous inspection was plugged. NR represents no recorded wear.							

4.3.8. In-situ Testing

There were no in-situ pressure tests performed during this examination.

4.3.9. Repair History

Table 4-10 lists the number of the tubes plugged from pre-service to the present. There are no sleeves installed in the IP2 steam generators.

Table 4-10 Tube Repair History - Number of Tubes Plugged

Year	Outage	SG21	SG22	SG23	SG24	Total
1988	Fabrication	0	0	0	2	2
2000	Pre-service	0	0	0	0	0
2002	RF15	8	1	3	4	16
2004	RF16	0	0	0	0	0
2006	RF17	2	2	0	3	7
Totals		10	3	3	9	25
Percent Plugged		0.31%	0.09%	0.09%	0.28%	0.19%

4.4. Condition Monitoring

The following was taken from the SG Degradation Assessment for Indian Point 2 R17 Refueling Outage

Table 4-11 lists the condition monitoring limits that were taken from the previous degradation assessment/operational assessment:

Table 4-11
Condition Monitoring Limits

Degradation Mechanism	Location	Condition Monitoring Limit Based on Structural Limit; Technique and Analyst Uncertainty
Tube Wear (loose parts)	TTS periphery	36%TW
Tube Wear	AVB	63%TW
Tube Wear	TSP	36%TW
All ODSCC	Any location	Circ. PDA = 49% Axial Depth = 30%TW
OD Pitting	TTS	52%TW

4.4.1. AVB Wear Condition Monitoring

The deepest AVB wear indication is 28% of the tube wall thickness, which is well below the 63% condition monitoring limit developed in the degradation assessment. Therefore all AVB wear indications meet the condition monitoring structural integrity and leakage criteria.

4.4.2. Loose Parts Wear Condition Monitoring

Although loose parts were found as discussed in Section 4.3.3, no tube degradation due to the loose parts was found. Therefore there is no challenge to the tube integrity and leakage criteria due to loose parts.

4.4.3. Hardware Condition Monitoring

There were previously 18 tubes plugged. Two tubes were welded I-690 plugs in SG24 during fabrication. The leakage associated with this type of repair is zero. Sixteen I-690 ribbed plugs were installed during RF15. The leakage associated with this number of plugs is also zero. Seven newly installed I-690 ribbed plugs also have leakage of zero. All of the previously installed plugs were visually inspected in 2R17 and showed no signs of leakage. Therefore there is no challenge to the leakage criteria due to plugs.

4.4.4. Conclusion of Condition Monitoring

A total of 23 tubes with volumetric indications and 24 tubes with potential loose part indications were detected by NDE. All AVB wear indications had measured depths well below their respective structural and leakage condition monitoring limit. There was no tube degradation due to the loose parts was found. Therefore there is no challenge to the tube integrity and leakage criteria due to loose parts. Therefore all detected indications were determined to meet the performance criteria recommended in NEI 97-06, Revision 2. The Indian Point 2 Condition Monitoring for RF17 complies with the guidance of NEI 97-06, Revision 2, and demonstrates that the structural and leakage criteria for all steam generators are satisfied.

4.5. Operational Assessment

The operational assessment of the steam generators requires the consideration of growth of degradation to assess if the structural and leak integrity of the Indian Point 2 steam generators will be maintained during the next operation cycles. Since the wear rate is expected to show a significant decrease with operating time, it is reasonable to expect that the Indian Point 2 steam generator tube structural and leakage integrity requirements will be maintained through the next two operating cycles.

The Operational Assessment process of evaluating the condition of the steam generator tubes during the next 2 cycles of operation requires that the steam generator tubes meet specified performance criteria that provide reasonable assurance of adequate tube structural and leakage integrity at the end of the next inspection interval.

The operational assessment consists of four parts:

1. estimating the size of the largest flaws of each type that are present at the beginning of the next operating cycle.
2. estimating the size of the largest flaws that will be present at the end of the next inspection interval.
3. demonstrating that the largest flaw of each type will meet the structural integrity criterion at the next inspection.

4. demonstrating that at the end of the next inspection interval the total leakage at MSLB conditions will meet the leakage criterion.

This Operational Assessment of the IP2 steam generators is based on the inspection results summarized in Section 4.3 of this report. This assessment has been conducted in accordance with the requirements of NEI 97-06 Rev.2 and EPRI Tube Integrity Assessment Guidelines (References 1 and 6). This report provides a demonstration based on the NDE data acquired that the structural and leakage criteria will be maintained in all steam generators throughout the estimated 3.7 effective full power years of Cycles 18 and 19. This operational assessment was developed using the deterministic methodology.

4.5.1. Structural Limits

The structural limits for the steam generator tubing were calculated using the methodology outlined in draft Regulatory Guide 1.121. Those limits were updated for the more limiting proposed uprate conditions calculated in 2004 (Reference 14) for operation in cycle 14 and are listed below.

Table 4-12 SG Tube Wear Structural Limits

Location	Parameter	Limit
Straight Leg	t_{min} (inch)	0.024
	Structural Limit (%)	52.0
AVB (0.5")	t_{min} (inch)	0.016
	Structural Limit (%)	67.8
FDB (0.75")	t_{min} (inch)	0.020
	Structural Limit (%)	61.0
TSP (1.125")	t_{min} (inch)	0.022
	Structural Limit (%)	55.2

4.5.2. Deterministic Evaluation

The only degradation mechanism that currently exists in the replacement steam generators is AVB wear. Using industry experience there is the potential for the IP2 replacement steam generators to experience wear or damage from loose parts. Thermally treated Inconel 600 tubing has been in-service for greater than 20 years at several plants. To date Primary water stress corrosion cracking (PWSCC) has been found in three plants with Inconel 600TT tubing (Seabrook, Braidwood and Catawba). Given the limited service time on these IP2 steam generators, PWSCC is not considered a potential mechanism over the next inspection interval. AVB wear will be evaluated assuming the largest detected flaw and projected growth for two cycles of operation. This is the amount of time until the next scheduled inspection.

Wear

The following are the inputs used to evaluate AVB wear through the end of Cycle 19:

Method Used	Simplified Statistic
Structural Limit	1.121 analysis (67.8%TW)
Sizing Uncertainties	Mean of Regression Line + 1.28 sigma
Analyst Uncertainties	1.28 sigma
BOC Flaw Size	Largest Flaw from 2R17
Growth	Largest Flaw from 2R17 divided by 3.22 EFPY

Structural Limit	67.8 % TW
Sizing Technique Uncertainty[4]	5.74 % TW (90/50)
Analyst Uncertainties[10]	0.86 % TW x 1.28 = 1.1 % TW
BOC Flaw Size	28 % TW
Growth (3.7 EFPY)	32 % TW = (0.28x3.7/3.22)

The beginning of cycle depth of 28% was estimated based on the as-found results at Indian Point 2 during 2R17 given the inspection scope of 50% Bobbin.

For the purpose of this assessment, the projected AVB growth over two cycles period is assumed to be the highest seen in the current inspection estimate of 32% TW for two cycles (48 months). The current largest flaw of 28% grew over 3.22 EFPY or 8.7%/EFPY. The next inspection interval is 3.7 EFPY.

To calculate the end of cycle (EOC) maximum depth, the following equation is used:

(BOC flaw) + (SQRT [Sizing^2 + Analyst^2]) + (Growth) = EOC flaw

(28 %) + (SQRT [$5.74^2 + 1.10^2$)] + (32 %) = Maximum Depth at EOC.
(28 %) + (5.8 %) + (32 %) = Maximum Depth at EOC
(28 %) + (5.8 %) + (32 %) = 65.8 %

This result does not exceed the AVB wear tube structural limit of 67.8% TW, and is conservative since AVB wear growth generally slows down over time.

4.5.3. Loose Parts

The largest foreign object seen and not retrieved was a 1.5 inch piece of wire in 24SG. As mentioned earlier, there are small portions of the wire (1/64" diameter) that migrate to the secondary side of the generator. These items have been identified in previous outages with extensive efforts to find and remove them from the secondary side. There are no cases where this material has caused damage to the tubing. The potential loose part indications appear to be associated with deposits of sludge and/or scale on the outside diameter (OD) of the tubing. A detailed review of potential loose part intrusion was documented in IP2 Safety Evaluation 02-0528-PR-00-RS. The conditions that this evaluation was based on have not changed. The evaluation determined that objects at Indian Point 2 would not have an adverse affect on the generator. An analysis has also been performed to determine the effect on the tubes should the material begin to migrate and repeatedly contact the tubes (impacting only analysis). A conservative analysis was performed assuming that the maximum possible weight of the largest loose object is less than 0.1 lbs. This weight conservatively bounds the weight of any of the known objects remaining inside the S/Gs. The analysis has determined that the energy that the postulated loose object would impart on a tube during repeated collisions is sufficiently low that significant deformation of the tubes due to impacting only is not expected. It is not anticipated that damage from loose parts should be expected prior to the next inspection in RF19. The indications are tracked for evaluation in the next inspection.

4.5.4. Stress Corrosion Cracking

Many autoclave tests of stressed samples of alloy 600, 690, and 800 tubing materials have demonstrated that alloy 600TT consistently possesses equal or better corrosion and cracking resistance under aggressive environmental conditions than 600 mill annealed tubing. Mock-up specimens of thermally treated alloys 600, 690, and 800 with hydraulic expansion, typical of replacement steam generators, outperformed mill annealed alloy 600 with hard rolled or hydraulic expansions. Hard rolled, mill annealed alloy 600 suffered intergranular stress corrosion cracking (IGSCC) between 19 and 30 days. Hydraulically expanded, mill annealed alloy 600 suffered IGSCC between 21 and 132 days of testing. Historically, dependent on variables such as temperature and material properties, units with hard roll transitions have not initiated cracking in ~ 8-10 years of operation. Therefore, it is not anticipated that this form of degradation will initiate before the next inspection planned in 2010.

4.5.5. Secondary Side Integrity

The secondary tubesheet in all 4 SGs were sludge lanced during 2R17. Approximately 23 pounds of sludge per SG was removed along with debris such as small wires, pieces of spiral wound gasket and weld splatter. Visual inspections were performed of the annulus, tubelane and approximately every 5th column inbundle in all 4 SGs. More debris was noted during this inspection and the larger pieces were retrieved. There were no indications of tube damage seen during the visual inspections.

There was no evidence of the wrapper having shifted in any of the steam generators. Portions of the top support plate in 23 and 24 SGs were visually inspected via an inspection port. There was no evidence of sludge buildup and all the support structures examined such as wrapper blocks and wedges were intact. The upper internals of the steam generators were not inspected based on the results from prior inspections performed in the IP3 SGs and no evidence of degradation in that area in other Westinghouse Model 44F SGs in the industry.

Based on no evidence of secondary side degradation observed during the 2R17 visual inspections and similar experiences in other Westinghouse Model 44F steam generators it is acceptable to operate the steam generators for two cycles before the next scheduled secondary side inspections.

4.5.6. Conclusion of Operational Assessment

This operational assessment demonstrates that there is reasonable assurance that the observed degradation mode will not lead to a predicted flaw that would exceed its respective structural or leakage limit at the end of the next two operation cycles. The Indian Point 2 Operational Assessment for all four steam generators complies with the guidance of NEI 97-06, Revision 2, and demonstrates that the Indian Point 2 Steam Generators are expected to continue to meet the leakage and structural integrity performance criteria for the duration of Cycles 18 and 19.

5. Conclusions

Entergy Nuclear Operations has performed an investigation into the potential degradation of the replacement steam generators at IP2. The investigation was based on guidance based on NEI 97-06 for determining end of cycle conditions. The only expected potential condition with growth would be AVB wear. Using industry experience, it was evaluated that the IP2 steam generators will still meet their structural integrity requirements at the end of 9 effective full power years. Therefore, IP2 is considered safe to operate for 2 consecutive cycles without an inspection in the spring of 2008. The next inspection will be during the spring of 2010 (RF19).

6. References

1. NEI 97-06, "Steam Generator Program Guidelines", Revision 2
2. "Steam Generator Degradation Specific Management Flaw Handbook."
3. WCAP-15909, " Regulatory Guide 1.121 Analysis for the Indian Point Unit 2 Model 44F Replacement Steam Generators"
4. EPRI ETSS 96004
5. IP-RPT-05-00408, Revision 1 "Steam Generator Pre-Outage Degradation Assessment and Repair Criteria for 2R17 ER-IP2-20801".
6. EPRI TR-107621, "Steam Generator Integrity Assessment Guidelines"
7. Entergy Nuclear Northeast, "Evaluation of Foreign Objects in the SGs at IP2 RFO15", 02-0528-PR-00-RS, Revision 0, November 15, 2002
8. FMX-323-01, Westinghouse Electric Company, "Indian Point 2 Condition Monitoring Assessment and Operational Assessment RFO-15", Report number SG-SGDA-02-45, Revision 1, September 2003
9. Westinghouse CN-SGDA-02-128, Revision 2, "Regulatory Guide 1.121 Analysis for Indian Point Unit 2 Model 44R Replacement Steam Generators", December 2003
10. Harris, D.H., "Capabilities of Eddy Current Data Analysts to Detect and Characterize Defects in Steam Generator Tube", Proceedings 15th S/G NDE Workshop, EPRI Report TR107161, November 1996