Entergy

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Michael R. Kansler
President

March 31, 2004
NL-04-033

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

SUBJECT: Indian Point Nuclear Generating Unit No. 2
Docket No. 50-247
Response to NRC Request for Additional Information
Re: "Proposed Change to Technical Specifications:
One-Time Change to the Indian Point 2 Steam
Generator Tube Inspection Requirements (TAC No. MC1260)"

References:

1. Entergy Nuclear Operations, Inc. (ENO) letter to NRC, "Proposed Change to Technical Specifications: One-Time Change to the Indian Point 2 Steam Generator Tube Inspection Requirements ", dated October 21, 2003, NL-03-165.
2. NRC letter to Mr. Michael Kansler, "Request for Additional Information Regarding Application to Extend Steam Examination Interval, Indian Point Nuclear Generating Unit No. 2 (TAC No. MC1260)", dated February 19, 2004.
3. ENO letter to NRC, "Proposed Steam Generator Examination Program -2002 Refueling Outage (2R15)", dated August 21, 2002, NL-02-112.

Dear Sir:

By letter dated October 21, 2003, Reference 1, Entergy Nuclear Operations, Inc. (ENO) submitted a proposed amendment for a one-time change to the Indian Point Nuclear Generating Unit No. 2 (Indian Point 2) Technical Specifications (TS). The proposed TS change would allow for a one-time extension of the frequency for examination of steam generator tubes.

This letter provides ENO's response to the NRC's request for additional information (RAI) contained in Reference 2. Attachment I responds to the three questions of the RAI, except for the issue of whether the remaining eleven tubes showing some degree of anti-vibration bar (AVB) wear will be evaluated for stabilization. ENO did not discuss these eleven tubes in detail, in the proposed License Amendment request, because they had minimal wear and did not exhibit wear at all four AVB intersections. These eleven tubes will be evaluated for future stabilization within 90 days after the completion of the next scheduled steam generator inspection. Attachment I was prepared by Westinghouse and was reviewed and accepted by ENO.

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In addition, during a February 17, 2004 telephone call between ENO personnel and NRC staff, ENO stated that information pertaining to tube structural limits including the use of Reg. Guide 1.121 was submitted to the NRC in attachments to a letter dated August 21, 2002, Reference 3.

The commitment described in this letter is listed in Attachment II. If you have any questions, please contact Ms. Charlene Faison at 914-272-3378.

I declare under penalty of perjury that the foregoing is true and correct. Executed on 03/31/04

Very truly yours,

Michael R. Kansler
President
Entergy Nuclear Operations, Inc.

Attachments:

I. Response to NRC 02/19/04 RAI
II. Commitments

cc: Mr. Patrick D. Milano, Sr. Project Manager
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ATTACHMENT I

RESPONSE TO NRC 02/19/04 RAI RE:
PROPOSED CHANGE TO TECHNICAL SPECIFICATIONS:
ONE-TIME CHANGE TO THE INDIAN POINT 2 STEAM GENERATOR TUBE INSPECTION REQUIREMENTS

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 2
DOCKET NO. 50-247

Westinghouse

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Entergy PO: 4500528970
W Sales Order: 26809
Our ref: IPP-04-47

March 29, 2004

Reference: 1) US NRC letter, "Request for Additional Information Regarding Application to Extend Steam Generator Examination Interval, Indian Point Nuclear Generating Unit No. 2 (TAC NO. MC1260)" dated February 19, 2004.

Entergy Nuclear Northeast
Indian Point Unit 2
Response to RAIs Regarding Tube Stabilization and AVB Growth

Dear Mr. Ingram:

In response to a request from Entergy Indian Point 2, this letter provides responses to questions (RAIs) from the US NRC (Reference 1) regarding the Indian Point 2 application to extend the Steam Generator Examination interval. The specific NRC questions have been repeated in italics, and the response follows each question. References appropriate to the responses appear at the end of the text of the responses.

This letter and the attachment are non-Proprietary and may be furnished to the NRC.

If you have any questions on these matters, please contact Herm Lagally at 724-722-5082 or me. Thank you.

Very truly yours,

S. M. Ira
Customer Project Manager

cc: Herm Lagally

DOCUMENTUM REFERENCE: LTR-SGDA-04-43, Rev. 3

ATTACHMENT TO IPP-04-47

Entergy

ENTERGY NUCLEAR NORTHEAST
ENN-DC-149

VENDOR DOCUMENT REVIEW STATUS

☒ IPEC ☐ JAF ☐ PNPS ☐ VY

Document No.: 2-RPT-04-00008 Rev. No.: 0
Document Title: Response to RAIs Re Tube Stabilization
ER No.: IP2-03-19190 Purchase Order No.: 4500528970

STATUS NO:
1 ☒ ACCEPTED
2 ☐ ACCEPTED AS NOTED RESUBMITTAL NOT REQUIRED
3 ☐ ACCEPTED AS NOTED RESUBMITTAL REQUIRED
4 ☐ NOT ACCEPTED
5 ☐ FOR INFORMATION

Acceptance does not constitute approval of design details, calculations, analysis, test methods or materials developed or selected by the supplier and does not relieve supplier from full compliance with contractual negotiations.

Responsible Engineer: D. Curt Ingram / D Curt Ingram 3/30/04
Print Name Signature Date

1. *The licensee states that two of thirteen tubes found with anti-vibration bar (AVB) wear indications will be evaluated for stabilization prior to the next scheduled inspection. The licensee states that these two tubes had indications at all four AVB contact points and are not expected to wear to the point of causing tube to tube contact for the next four cycles. Provide a brief summary of the method used for performing this evaluation. State whether the remaining eleven tubes will also be evaluated for future stabilization? If not evaluated, discuss the reason?*

The methodology used was to compare the wear experienced at Indian Point 2 to another plant with Model F steam generators that experienced significant AVB wear early in life. Tube wear history is available since these tubes, initially plugged, were deplugged for plug replacement or the possible return to service. The progression of wear in these tubes provides a good perspective of the progression of AVB wear. What follows is a description of the background and a more in-depth discussion of the decision making process used to answer the above question. Also, the growth rate calculations, provided in response to Question 2 below, provide additional technical support.

During the RFO15 inspection of Indian Point 2, AVB wear was reported in thirteen tubes in the four SGs as shown on the following table.

Table 1-1
AVB Wear Depth Measurements

SG	Row	Col	AVB1 Wear Depth (%TW)	AVB2 Wear Depth (%TW)	AVB3 Wear Depth (%TW)	AVB4 Wear Depth (%TW)
21	44	43	-	-	9	10
	45	45	17	20	20	14
	38	47	-	13	16	-
	45	47	14	18	-	-
	28	50	-	-	10	14
	28	79	-	-	12	-
22	39	37	-	-	10	-
23	41	46	12	17	20	17
	41	61	-		13	-
24	41	41	-	14	15	16
	34	51	-	12		-
	36	64	-	-	11	12
	36	66	11	-	-	-

Indian Point 2 elected to administratively plug these tubes to maintain the option for an extended operating period until the next inspection of the SGs. Westinghouse recommended installation of a cable dampener in tubes 21-45/45 and 23-41/46 because these tubes had a higher potential for eventually requiring stabilization, but noted that the actual installation of the dampener was optional at that time.

AVB wear was identified in Reference 1 as a degradation mechanism with a potential to become a propagation mechanism after a tube is plugged. Tube wear at the AVBs can continue after a tube is removed from service due to AVB wear. De-plugging of tubes at D.C. Cook, Millstone and Diablo Canyon some years after the original plugging, for reasons unrelated to AVB wear, as evidenced by water contained in the tube and subsequent inspection showing that the AVB wear had progressed from a non-throughwall condition at the time of plugging to a throughwall condition at de-plugging. As a worst case, it is possible that an aggressively vibrating tube could wear through the tube section sufficiently so that the remaining section could break due to fatigue, and the tube ends become damage propagation mechanisms to adjacent, active tubes.

Westinghouse has performed Wear Projection analyses for a number of operating SGs to determine the need for installation of cable dampeners in tubes that were repaired for AVB wear. Although no wear projection analysis was performed for Indian Point 2, the experience from the prior analyses shows that tubes that are recommended for stabilization are usually those that are plugged early in life. This can readily be inferred from the driving mechanism of AVB wear – fluidelastic excitation of one, or more, spans of a tube. Fluidelastic excitation depends on both the fluid velocity in which the tubes operate, and the structure of the tube. The design of the AVBs is intended to preclude fluidelastic excitation by limiting the unsupported span length of the tubes by placement of the AVBs, to lengths that are not excited in the u-bend flow field. Practical limitations of SG assembly require that some clearance between the AVBs and the bundle be included in the design; consequently, because of the large number of tubes and AVBs in the bundle, a finite probability exists that not all AVBs will provide support to individual adjacent tubes. The result is a stochastic condition of support and non-support in the bundle. The longest, unsupported, fluidelastically unstable spans are those that will experience the most energetic vibration and the most rapid wear, and, therefore, are also those that will be plugged earliest in life. Tubes that are plugged for AVB wear after greater operating time exhibit lower wear rates. The experience from operating SGs with AVB wear supports this observation for all Westinghouse models of SGs. Since the support conditions are constant , i.e., the AVB assembly does not shift position due to thermal and flow effects, no significant changes in the AVB wear trends will be observed unless the fluid velocity conditions are changed, e.g., by up-rating of the plants. AVB wear is generally first observed near the outside of the tube bundle in the larger radius u-bends, progressing to shorter rows over a period of time.

Further, operating SG data show that the characteristics of the most aggressively wearing tubes are similar – they have significantly deep indications at all of the AVB contact points. Since these tubes are impacting at every AVB location, it can be inferred that little if any support is provided by any of the AVBs. These tubes are oscillating primarily in their fundamental mode, and will continue to wear at all locations.

Tubes that exhibit wear at only one, or several, AVB intersections most often experience "redistribution", that is, involvement of additional intersections. The primary effect is that the wear rate of the first, or several, intersections is initially less than that of a tube with involvement of all intersections, and will continue to wear at a slower rate due to the distribution of available energy over a greater number of intersections. This has been observed in every SG exhibiting AVB wear.

Table 1-2 provides a summary of AVB wear from a Model F plant that experienced significant AVB wear early in life. This plant chose to plug tubes below the plugging limit of 40% as a conservative measure. Later, after additional operating experience, those tubes were de-plugged for plug replacement, but also with the intent of restoring those tubes with wear less than the plugging limit to service. This database provides a good window on the progression of AVB wear.

Most of the tubes display redistribution. For example, tube no. 3 appeared to have a maximum growth rate of 33% in 2.43 EFPY. At the location of the apparent maximum growth rate, no change occurred over the next 4.64 EFPY, while a new intersection grew from zero to 22%. Further over the subsequent 2.66 EFPY, the maximum growth rate changed back to the original maximum growth rate site, but at 27% over that time interval. The change in boundary conditions, due to wear, over the last 2.66 EFPY appears to have reached an energetic fundamental mode which may continue to wear in this configuration, or may further redistribute to AVB1.

Tube no. 2 displays no change in wear over 4.64 EFPY, after an initial growth of 41% in 2.43 EFPY. This tube is very likely well supported at all AVB intersections except those that wore. The amplitude of oscillation appears to be limited to less than the new boundary conditions.

A key observation from these tubes is that the initial apparent growth rate on tubes which have not reached their fundamental vibration mode does not continue at the same location at the same rate. It may well be that these tubes will ultimately require stabilization, but the time to reach the point where stabilization is required is very long.

Another conclusion that can be inferred from the data is that a tube that has achieved a fixed mode of vibration due to boundary conditions may stop wearing after its amplitude limit has been reached, but that this limit may be large if the fundamental mode of vibration includes all of the AVB intersections.

Note that the data in Table 1-2 are from 11/16" diameter tubing and are, therefore, conservative when applied to the 7/8" diameter tubing of the IP2 SGs. Smaller diameter tubing is significantly more flexible for the same span length than larger diameter tubing; therefore, since the flow conditions are approximately the same in the u-bend area in both models of SGs, the vibration potential of the 11/16" tubing is greater than that for the 7/8" tubing of IP2.

Among the tubes at Indian Point 2 that exhibited AVB wear at RFO15, R45C45, SG-21 and R41C46, SG 23 are the tubes that could be considered to have achieved a stable mode of vibration. The data in Table 1-2 show that an incremental operating time of much greater than 6 EFPY (>72 calendar months [CM]) would not result in tube wear that approached a through-wall condition. Therefore, it is concluded that operating for 48 calendar months (< 48 EFPM) will not be an issue with respect to stabilization of any tube plugged for AVB wear at RFO15. Significantly greater margin in operating time is available before potential stabilization would be required, if it is shown to be required at all, for the 11 tubes that did not exhibit wear at all four AVB intersections at RFO15.

The observed wear at Indian Point 2 occurred under the initial (non-uprated) operating condition. Conservatively assuming that all of the wear occurred at the initial, non-uprated conditions, and applying the uprate wear multiplier of 1.46, the effective operating time to reach through-wall conditions would be greater than 49 EFPM (>72 CM/1.46). Note that this is the projected time to the through-wall condition, which has significant time margin to the tube-to-tube contact condition.

The criterion that has been used by Westinghouse for all wear projection evaluations performed over about ten years for stabilization recommendations is prevention of tube-to-tube contact as illustrated on Figure 1.1. At the point of tube to tube contact, wear would be expected to occur on the adjacent tube. However, this does not meet the definition of uncontrolled damage propagation, similar to the condition observed at TMI (Ref 1). For uncontrolled damage propagation, separation of the plugged tube is required, i.e., at the point of the AVB wear. Tube to tube contact occurs when the wear is approximately 35% through the cross-section of the tube. Significantly greater damage to the cross-section of the tube is required before separation of the tube due to fatigue would occur. Prior to that condition, wear on the adjacent active tube(s) would be observed.

In Summary:

1. Tubes with AVB wear can be categorized into greater or lesser need for stabilization by their wear characteristics (involvement of AVB contact points).
2. For the tubes with greatest potential to require stabilization during the lifetime of the SGs, a significant margin (>>4 EFPY) in time exists between first observation of wear leading to plugging and a throughwall wear condition, based on industry data.
3. Significant margin in time exists between the time a tube would wear from a throughwall condition to the through-section criterion defined for stabilization.
4. Significant margin on time exists between the stabilization criterion condition (tube to tube contact) and a condition that could result in separation of a worn tube and uncontrolled damage propagation.
5. Continued operation of the IP2 SGs for a cycle length of 4 years poses no challenge to any condition that could lead to uncontrolled damage propagation due to AVB wear.

Table 1-2

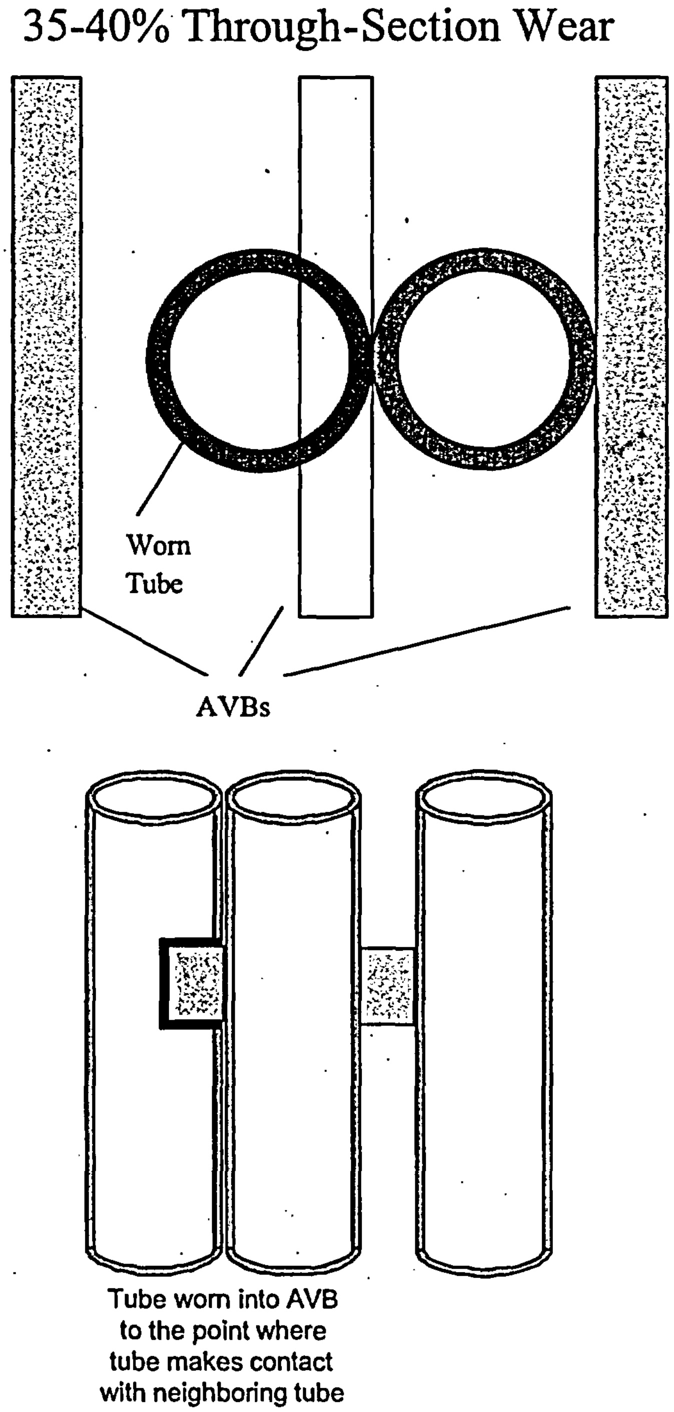
Wear Progression in a Model F SG

Tube	EFPY	AVB1	AVB2	AVB3	AVB4	AVB5	AVB6
1 Row 42	2.43			33	NDD	NDD	36
	7.07			34	NDD	NDD	30
	9.73			51	15	16	39
2 Row 44	2.43				41	40	
	7.07				41	38	
	9.73						
3 Row 44	2.43		NDD	26	33	NDD	21
	7.07		22	33	33	14	33
	9.73		37	58	60	30	35
4 Row 45	2.43		NDD	20	NDD	36	NDD
	7.07		NDD	34	NDD	37	NDD
	9.73		12	38	11	55	22
5 Row 45	2.43			NDD	NDD	30	24
	7.07			22	14	41	32
	9.73						
6 Row 47	2.43		24	29	NDD	NDD	30
	7.07		35	37	49	37	34
	9.73						
7 Row 47	2.43		NDD	NDD	31	NDD	NDD
	7.07		NDD	NDD	31	NDD	NDD
	9.73		16	22	46	19	18
8 Row 48	2.43	22	NDD	INR	56	28	NDD
	7.07	34	34	39	79	56	39
	9.73						
9 Row 48	2.43		24	18	33	NDD	19
	7.07		24	18	37	23	27
	9.73		30	37	57	18	31
10 Row 49	2.43		30	36	NDD	NDD	
	7.07		40	35	18	19	
	9.73						
11 Row 50	2.43			INR	34	24	25
	7.07			14	61	46	44
	9.73						

1. All tubes were plugged at 2.43 EFPY, de-plugged at 7.07 EFPY, and re-plugged at either 7.07 EFPY or 9.73 EFPY.
2. Values indicate wear depth in %-throughwall
3. NDD- No detectable degradation; INR- indication not reportable

Figure 1.1

Stabilization Criterion



2. *The licensee states that as a result of the implementation of a 1.4% power uprate, the amount of wear expected over a 40-year lifetime is 2 mils (4% of the tube wall thickness), which is less than the allowable 3 mils. Provide additional clarification on this estimate since it seems to be at odds with experience to date at IP2 where thirteen tubes exhibited wear ranging between 5% (the detection threshold) and 20% of the wall thickness after just one operating cycle. Presumably, there may be undetected wear flaws which grew by as much as 5% over the first operating cycle, prior to the 1.4% power uprate.*

The flow-induced vibration analysis results referenced in the uprate analysis addresses the expected wear of the general population of steam generator tubes given the construction tolerances, geometry, and flow characteristics of the steam generators. The fact that 13 out of 12,856 tubes (0.1% of the total population) exhibit wear in excess of what analysis predicts should not detract from the fact that the general population of tubes show no wear after one cycle of operation. It is not unexpected that some tubes may exist with local conditions that lie outside of expected parameters that will show wear outside of predicted limits. Although a few additional tubes with wear outside of the predicted performance may be anticipated, the wear conditions actually observed are expected to be the worst case from the initiation and growth perspective. The following discussion provides additional details in support of this position.

The driving mechanism for AVB wear, fluidelastic excitation of the u-bends resulting from cross-flow over the tubes, has been considered in the design of all models of Westinghouse steam generators, as evidenced the installation of anti-vibration bars (AVB) in the u-bend region. Nevertheless, the observation of significant AVB wear in the Model 51 SGs led to a detailed study in the early to mid-1980s of the conditions leading to the wear. This study concluded that the dimensions of the tubes and AVBs, together with the limitations of the assembly methods could lead to local conditions where the AVBs might not provide support at one, or more, tube to AVB intersections. Indeed, a field replacement of AVBs was implemented in numerous SGs, which eliminated as much of the clearance between the tubes and the AVBs as practicable. This field repair was very successful in eliminating AVB wear.

The same design objective – elimination, to the extent possible, of gap between tubes and AVBs – was implemented in second generation replacement steam generators. Although the design of the u-bend structure in the IP2 replacement SGs is nominally the same as that of the predecessor SGs, the key difference lies in the dimensions and tolerances of the AVBs and tubes, resulting in a design with very small theoretical gaps between the tubes and the AVBs. As in any design process, the performance predictions are based on conservative assumptions of tolerances for the limiting conditions of the design, since the actual conditions after manufacturing cannot be precisely anticipated. This performance prediction concluded that very limited wear would occur among all tubes in general for the design dimensions and tolerances of the IP2 replacement steam generators. The subsequent uprating report concluded that a 46% increase in the predicted wear could occur due to the uprated conditions, resulting in a final prediction of about 2 mils wear over the 40 year lifetime of the SGs. This conclusion applies for both the 1.4% and the future additional 3.26% uprate, for a total uprate of 4.7% (see response to Question 3, below).

Anecdotal data indicate that the extremely tight tolerances of the design led to unanticipated difficulties during u-bend assembly. Thus, it is not unexpected that some local conditions may exist where wear greater than predicted in the design performance predictions could occur. This is similar to the original steam generators in which the practical limitation of the manufacturing process resulted in local conditions conducive to wear in an overall successful design for the bulk of the tubes. Although a few additional occurrences of wear greater than the performance predictions may be anticipated, the wear conditions actually observed are expected to be the worst case from the initiation and growth perspective.

Consider a hypothetical case of AVB wear:

Undetected Indications:

The reliable detection threshold for AVB wear is about 5% TW. Wear above this value will be detected using the bobbin probe essentially 100% of the time.

Growth Rate:

The RFO15 data for IP2 show the maximum depth wear observed over one cycle (24 calendar months) was 20%. However, this cannot be assumed to be the applicable growth value for forward looking projections because the geometry of the tube changes as the wear progresses. The available impact energy from tube vibration is limited by the flow conditions and the vibration mode dictated by the boundary conditions of the tube. At the onset of wear, the impact energy is imparted at a single point, but as the wear progresses, the point becomes an area, due to the curvature of the tube, whose footprint continually increases until the wear eventually becomes throughwall wear. The proper model for wear growth is "constant volumetric growth rate." A unit width of wear can be assumed to reduce the calculation to an area calculation. Table 2-1 provides the area (volume) calculation for a unit width AVB as a function of percent throughwall wear.

While the volumetric wear rate is constant, the apparent depth growth rate calculation depends on the initial wear depth assumed. For example, if the initial depth is zero, as in the situation of a tube that has seen no prior service, the change in area (volume) equivalent to 20% depth is 0.001243 in.^{2}. However, if an initial, undetected depth is assumed, say 5% TW, the change in area (volume) is 0.001580 in.^{2} to progress to 25% depth. Since this violates the model assumption of constant volumetric wear, it is clear that definition of the initial condition for the wear is critical, and also, that the depth wear rate will decrease as the absolute wear depth increases.

Given that two facts are known;

1. The depth wear growth rate is 20%/cycle (24 months);
2. The detection limit for AVB wear is 5% throughwall depth,

The following is the projected wear for the planned 43 month operating cycle:

Reference volume growth rate, 24 months, 5% to 25% depth:	0.001580 in.^{3}
x Uprate Factor Multiplier (Ref 2):	1.46
= Reference 24 month growth rate at uprate conditions	0.002307 in.^{3}
x Cycle length multiplier (43/24):	1.79
= Extended cycle volumetric growth at uprate conditions:	0.004129 in.^{3}

The initial volume, equivalent to the undetected 5% wear is:	0.000156 in.^{3}
The incremental wear volume, from above, is:	0.004129 in.^{3}
The total worn volume after the extended operating cycle is:	0.004285 in.^{3}

From Table 2-1, the equivalent wear depth for this wear volume is approximately 45.8% TW.

Table 2-1
Wear Area (Volume) Equivalents to Throughwall Depths
(0.875 dia., 0.050 in wall thickness tubes)

Wear (thru wall)	Area (sq. in.)	Wear (thru wall)	Area (sq. in.)	Wear (thru wall)	Area (sq. in.)	Wear (thru wall)	Area (sq. in.)
1%	0.000014	26%	0.001840	51%	0.005034	76%	0.009118
2%	0.000039	27%	0.001947	52%	0.005182	77%	0.009296
3%	0.000072	28%	0.002056	53%	0.005331	78%	0.009476
4%	0.000111	29%	0.002167	54%	0.005482	79%	0.009658
5%	0.000156	30%	0.002279	55%	0.005634	80%	0.009840
6%	0.000205	31%	0.002394	56%	0.005787	81%	0.010023
7%	0.000258	32%	0.002510	57%	0.005942	82%	0.010207
8%	0.000315	33%	0.002628	58%	0.006098	83%	0.010393
9%	0.000376	34%	0.002748	59%	0.006255	84%	0.010579
10%	0.000440	35%	0.002870	60%	0.006414	85%	0.010767
11%	0.000508	36%	0.002993	61%	0.006574	86%	0.010956
12%	0.000578	37%	0.003118	62%	0.006735	87%	0.011145
13%	0.000652	38%	0.003245	63%	0.006897	88%	0.011336
14%	0.000729	39%	0.003373	64%	0.007061	89%	0.011528
15%	0.000808	40%	0.003503	65%	0.007226	90%	0.011720
16%	0.000890	41%	0.003635	66%	0.007392	91%	0.011914
17%	0.000975	42%	0.003768	67%	0.007559	92%	0.012109
18%	0.001062	43%	0.003903	68%	0.007727	93%	0.012305
19%	0.001151	44%	0.004039	69%	0.007897	94%	0.012502
20%	0.001243	45%	0.004177	70%	0.008068	95%	0.012699
21%	0.001337	46%	0.004316	71%	0.008240	96%	0.012898
22%	0.001433	47%	0.004457	72%	0.008413	97%	0.013098
23%	0.001532	48%	0.004599	73%	0.008588	98%	0.013299
24%	0.001633	49%	0.004743	74%	0.008763	99%	0.013500
25%	0.001736	50%	0.004888	75%	0.008940	100%	0.013703

NDE Uncertainties

A test program was performed (1998) to provide an improved database to evaluate AVB wear NDE sizing uncertainty. This program included 78 specimens, specifically simulating AVB wear in 11/16" diameter tubes. The specimens included several samples of two-sided wear and of tapered wear. The data for the samples were evaluated by 5 field analysts to obtain a statistically meaningful database for determining the total sizing uncertainty. The participating analysts were drawn from the population of field analysts participating in the inspections of several plants.

Although the results of these tests showed that the NDE sizing of tapered wear results in slight undercalls (about 2%) of the maximum depth of the wear, it was concluded that the results of the tests without tapered wear be utilized for the operational assessment since a study of tapered wear has led to the following conclusions:

1. The geometry of the AVB obviates a significant tapered wear condition. The corner radius of the AVB (0.060") is large compared to the depth of wear (50%TDW = 0.021"). Thus, wear of an AVB rotated out of plane relative to the tube would result approximately in a uniform notch with 0.060" radius, and not a longer, flat surface, inclined to the tube surface, that would lead to the NDE error. RPC evaluation of the largest indication observed during inspection of a Model F SG supports a flat wear scar of about the width of the AVB.

2. Field observations on AVBs removed from operating steam generators, including a Model F, show that the AVB also wears. Consequently, for relatively deep wear, approximating the current plugging limit of 40% TWD or larger, the wear surface tends to flatten out and approximate "flat" AVB wear.

3. Based on a burst test of a tapered wear specimen, the burst strength of a tube with tapered wear is significantly greater than that of a tube with flat wear having the same depth as the maximum of the tapered wear.

All of the 2-sided specimens evaluated resulted in conservative NDE calls (NDE sizing evaluation greater than the larger of the two wear scars). However, the differences between the 2-sided and the single wear scars are not significant until both wear sites of the 2-sided specimens are very deep (>80% depth). At that point, the NDE sizing becomes significantly conservative.

The uncertainty correlation shown on Figure 2.1 represents the total uncertainty of the technique and the analysts. It includes the 2-sided specimen data, but excludes the tapered data based on the rationale presented above. The correlation shows that the sizing technique tends to overestimate the actual depth slightly (<1%) over the entire range of depths tested. The 95% CL value of uncertainty is approximately 4.3% at a wear depth of 75% TW. Application of sizing uncertainties specified here are contingent upon use of 20%/40%/70% depth AVB wear scar standard for indications greater than about 50%TW. For wear depth less than about 50% TW, there is essentially no difference in uncertainties when using a

0/20/40 standard or using a 20/40/70 standard. For conservatism a 5% uncertainty will be used in this evaluation.

Although this correlation was developed for 11/16" diameter A600TT tubing, no significant differences would be expected for the 7/8" A600TT tubing at IP2.

Summary

The combined result for AVB wear, projected over a 43 month operating cycle, is:

Undetected Indication	5.0 % TW
Growth over 43 months	45.8 % TW
NDE Uncertainty (95%CL)	5.0 % TW
End of Cycle Depth	55.8 % TW

Since the structural limit specified for AVB wear is 67.8% TW (Reference 4), AVB wear does not represent a limiting condition for SG operation for 43 months.

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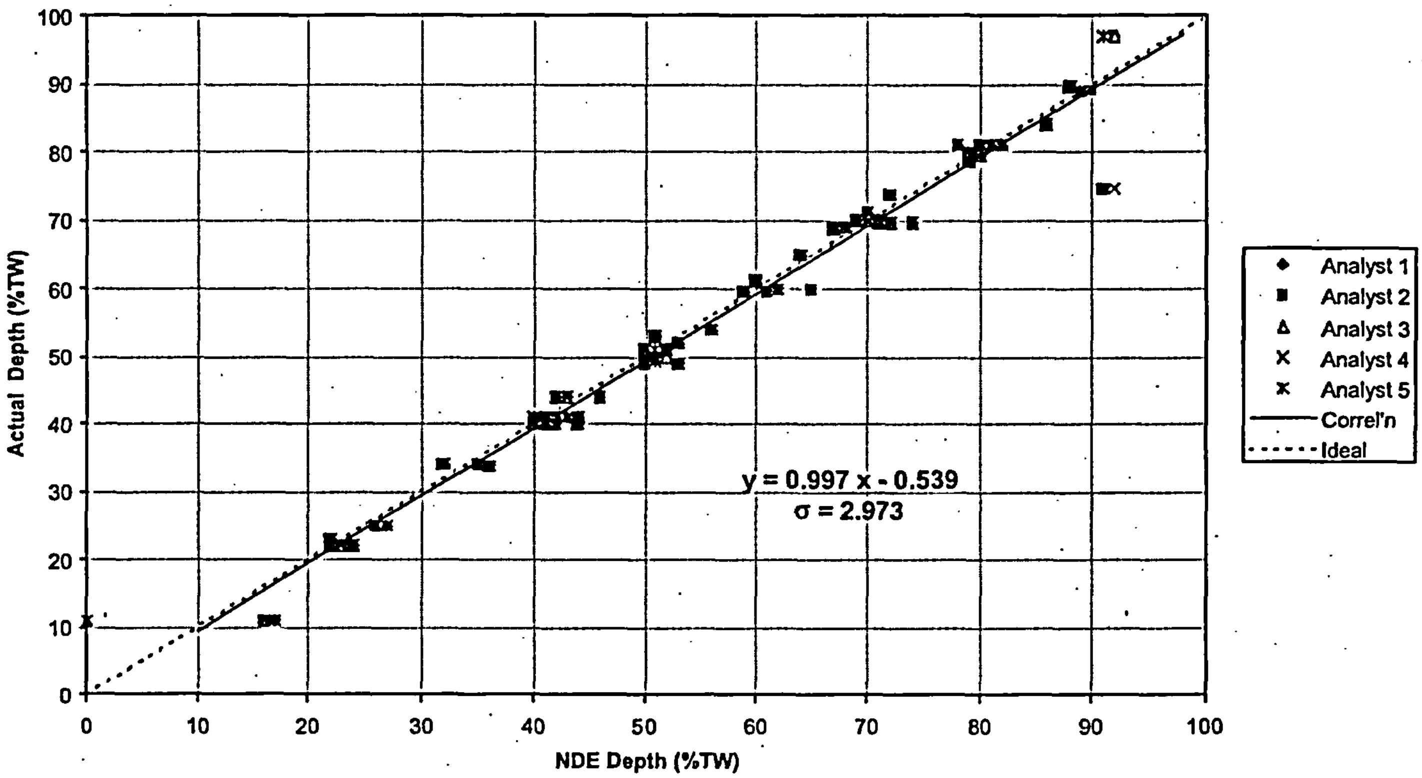
Figure 2.1

AVB Wear Sizing Correlation
(630/160 Differential Mix; 20/40/70 Standard)



3. *Provide the expected percentage increase in wear rate expected as a result of the projected 3.26% power uprate conditions anticipated in the future, and provide a summary description of the basis for this estimate.*

For each of the Uprates evaluated, 1.4% and 4.7% (a 3.26% increase), the same baseline condition is used. Therefore, a direct comparison of the effect of the uprate is possible based on the initial 100% power condition. It should be noted that the 1.4% uprate considered an upper plugging limit of 25% while the 4.7% uprate only considered a 10% plugging limit. The effect of increased tube plugging is to increase the relative wear factor ratio calculated. Since the IP2 replacement steam generators are new with an insignificant number of tubes plugged, the zero tube plugging condition can be said to exist. This would result in an uprate wear factor of 24% and 35% for the 1.4% and 4.7% uprates respectively.

When the maximum tube plugging limit is considered for each uprate, it can be expected that the 25% tube plugging condition would be more severe than if only 10% of the tubes are plugged for the same percent uprate. The calculated effect that the 4.7% uprate with a 10% plugging limit has on wear, based on the same baseline case used for the 1.4% uprate, was 46%. This increase in wear is the same as calculated for the 1.4% uprate with a 25% tube plugging limit. It is seen that the reduction of the tube plugging limit offset the effect that the increase in power has on the wear factor. Since the maximum uprate factor is conservatively used to determine the increase in wear resulting from the uprate, the uprate factor for the 4.7% uprate is the same as for the 1.4% uprate.

Uprate Wear Factor Calculation:

The work rate between the S/G tubes and the TSP or AVB can be defined as:

$$\dot{W} = Fd/t$$

where:

$\dot{W}$ = Work rate
F = Force
d = Sliding distance
t = Time

Since the change in the wear rate is being evaluated, the time to wear is the same. Both the force and the sliding distance between the two bodies are determined by the fluid flow around the tube. The forces acting on the tube are a result of the fluid actions on the tube. These forces are a result of the physical geometry and the fluid properties of density and velocity. With changes to these properties a determination of a corresponding change in the relative work rate can be made. The relative increase in the work rate can be evaluated as the ratio of the work-rate after Uprate to the work-rate prior to Uprate, or:

$$\dot{W}_{Uprate} / \dot{W}$$

The contact force is a function of the fluid forces, and the forces are a function of density and the fluid velocity squared, (ρV^2). In addition, the sliding distance is also a strong function of ρV^2. Therefore the relative increase in the work-rate can be written as:

$$\left(\rho_{Uprate} V_{Uprate}^2\right)^2 \Big/ (\rho V^2)^2$$

These are all known quantities that are calculated as part of the thermal-hydraulic evaluation performed to evaluate the thermal-hydraulic performance of the steam generators following uprate. Therefore, the density and velocity calculated within the tube bundle that formed the basis for the initial wear analysis is compared to those quantities calculated for the various uprate conditions postulated to determine the relative increase in the wear rate resulting from the uprate.

References:

1. LTR-SGDA-03-34;Westinghouse/CE Design Steam Generator Plugged Tube Mechanisms; EPRI Project Agreement EP-P8572/C4338; February 2002. (to be included in an EPRI report)
2. IPP-02-124; Final Input to the Indian Point 2 1.4% Measurement Uncertainty Recapture (MUR) Power Uprate Report; November 18, 2002
3. WCAP-16156-P; Indian Point Nuclear Unit 2 Stretch Power Uprate NSSS Engineering Report (Proprietary); February 2004
4. WCAP 15909-P; Regulatory Guide 1.121 Analysis for the Indian Point Unit 2 Replacement Steam Generators (Proprietary); August 2002

ATTACHMENT II

COMMITMENTS REGARDING PROPOSED CHANGE TO TECHNICAL SPECIFICATIONS: ONE-TIME CHANGE TO THE INDIAN POINT 2 STEAM GENERATOR TUBE INSPECTIONS REQUIREMENTS

ENTERGY NUCLEAR OPERATIONS, INC
INDIAN POINT NUCLEAR GENERATING UNIT NO. 2
DOCKET NO. 50-247

COMMITMENTS REGARDING PROPOSED CHANGE TO TECHNICAL SPECIFICATIONS: ONE-TIME CHANGE TO THE INDIAN POINT 2 STEAM GENERATOR TUBE INSPECTION REQUIREMENTS

Number	Commitment	Due Date
NL-04-033-01	Evaluate for future stabilization the eleven tubes that did not exhibit wear at all four AVB intersections.	Within 90 after the completion of the next scheduled steam generator inspection.