Duke Energy

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January 12, 2012

10 CFR 50.90

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Subject: Duke Energy Carolinas, LLC (Duke Energy)
Catawba Nuclear Station, Units 1 and 2
Docket Numbers 50-413 and 50-414
Proposed Technical Specifications (TS) Amendment
TS 3.4.13, "RCS Operational LEAKAGE"
TS 5.5.9, "Steam Generator (SG) Program"
TS 5.6.8, "Steam Generator (SG) Tube Inspection Report"
License Amendment Request to Revise TS for Permanent Alternate Repair Criteria

Reference: Letters from Duke Energy to NRC, same subject, dated June 30, 2011 and July 11, 2011

The reference letters comprise Duke Energy's request for an amendment to Catawba Facility Operating Licenses NPF-35 and NPF-52 and the subject TS. The proposed amendment constitutes a redefinition of the SG tube primary to secondary pressure boundary for Unit 2 and defines the safety significant portion of the tube that must be inspected or plugged. The technical justification for the amendment request is based in part on Westinghouse WCAP-17330-P, Rev. 1, "H*: Resolution of NRC Technical Issue Regarding Tubesheet Bore Eccentricity (Model F/Model D5)".

On January 5, 2012, the NRC electronically transmitted Requests for Additional Information (RAIs) associated with the amendment request. The purpose of this letter is to formally respond to these RAIs. Attachment 1 to this letter consists of the proprietary version of the RAI responses to Questions 1 through 11. Attachment 2 consists of the non-proprietary version of the RAI responses to Questions 1 through 11. Attachment 3 provides a copy of Westinghouse Authorization Letter CAW-12-3341 with Accompanying Affidavit, Proprietary Information Notice, and Copyright Notice. Attachment 4 consists of the RAI responses to Questions 12 and 13.

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As Attachment 1 contains information proprietary to Westinghouse Electric Company LLC, it is supported by the affidavit signed by Westinghouse, the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the NRC and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR 2.390. Accordingly, it is requested that the information that is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR 2.390. Correspondence with respect to the copyright or proprietary aspects of the information listed above or the supporting Westinghouse affidavit should reference the applicable CAW letter and should be addressed to J.A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, LLC, Westinghouse Electric Company LLC, Suite 428, 1000 Westinghouse Drive, Cranberry Township, PA 16066.

The original regulatory evaluation provided in support of the proposed amendment is unchanged as a result of this supplement.

There are no regulatory commitments contained in this letter.

In accordance with 10 CFR 50.91, Duke Energy is notifying the State of South Carolina of this license amendment request supplement by transmitting a copy of this letter (minus Attachment 1) to the designated state official.

Should you have any questions concerning this information, please contact L.J. Rudy at (803) 701-3084.

Very truly yours,

James R Morris

James R. Morris

LJR/s

Attachments

James R. Morris affirms that he is the person who subscribed his name to the foregoing statement, and that all the matters and facts set forth herein are true and correct to the best of his knowledge.

James R Morris

James R. Morris, Vice President

Subscribed and sworn to me: 1-12-2012
Date

Notary Public

My commission expires: 7-10-2012
Date

SEAL

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ATTACHMENT 2

Response to NRC Requests for Additional Information (Questions 1 through 11)
(Non-Proprietary)

Response to USNRC Request for Additional Information Regarding the Catawba License Amendment Request for Permanent Application of the Alternate Repair Criterion, H*

Westinghouse Electric Company LLC
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Cranberry Township, PA 16066, USA

References:

1. Duke Energy Letter," Duke Energy Carolina (Duke Energy) Catawba Nuclear Station, Units 1 and 2 Docket Numbers 50-413 and 50-414, Proposed Technical Specification (TS) Amendment, TS 3.4.13, "RCS Operational Leakage," TS 5.5.9, "Steam Generator (SG) Program," TS 5.6.8, "Steam Generator (SG) Tube Inspection Report," License Amendment Request to Revise TS for Permanent Alternate Repair Criteria, June 30, 2011.
2. E-mail from USNRC (Andrew Johnson) to Duke Energy (Jon Thompson) transmitting NRC letter, "Catawba Nuclear Station, Request for Additional Information Regarding the Steam Generator License Amendment Request to Revise Technical Specification for Permanent Alternate Repair Criteria," November 15, 2011.
3. Dominion letter, 11-403, "Surry Power Station Units 1 and 2 – License Amendment Request – Permanent Alternate Repair Criteria for Steam Generator Tube Inspection and Repair," July 28, 2011, ADAMS Accession No. ML112150144.
4. NRC Letter, Surry Power Station Units 1 and 2 Request for Additional Information Regarding the Steam Generator License Amendment Request to Revise Technical Specification for Permanent Alternate Repair Criteria," December 2012.
5. SG-SGMP-11-16, "H* Technical Basis Independent Review by MPR Associates: Technical Questions and Responses," April 2011.

Introduction

In Reference 1, Duke Energy submitted a license amendment request (LAR) for permanent application of the alternate repair criterion H* at Catawba Unit 2. Reference 2 transmitted the NRC request for additional information (RAI) regarding the Duke Energy LAR for a permanent H* for Catawba Unit 2.

Subsequent to the Duke Energy LAR for Catawba, Dominion Generation also submitted a LAR for permanent application of H* at Surry Units 1 and 2 (Reference 3). Whereas the Catawba technical justification is contained in WCAP-17330-P, Revision 1, the Surry technical justification is contained in WCAP-17345-P, Revision 2. Although the questions in Reference 2 and Reference 4 are quite similar, some of them require different numerical information for Catawba and Surry. Consequently, the responses contained in this document are specific to WCAP-17330-P, Revision 1 and do not contain the necessary information to completely respond to the questions regarding WCAP-17345-P, Revision 2. A separate response will be provided for the questions contained in Reference 4.

LAR submittals by several utilities for the permanent application of H* for the Model F steam generators (SGs) are anticipated. The Model F SG technical justification is also contained in WCAP-17330-P, Revision 1. Because the need for the Catawba responses to Reference 2 is immediate, the responses may not be sufficient for the Model F SGs. Should this be the case, a revision to these responses will be issued that provides the complete information for the Model F SGs.

Questions 1 through 11 from Reference 2 are reproduced below, followed by the responses. Questions 12 and 13 will be addressed by Duke Energy,

Question 1:

> *WCAP-17330-P, Revision 1 - The footnote on page 3-53 states that Figure 3-36 shows the same data as Figure 3-32 in Revision 0 of the WCAP, but without the data that correspond to negative tubesheet CTE variation. The footnote states that while only a few percent of the data shown in Figure 3-32 of Revision 0 reflect negative values of tubesheet CTE, these cases do result in upward scatter, but must be included to properly represent the top 10% of the Monte Carlo rank order results. This being the case, why does Figure 3-32 in Revision 1 properly represent the top 10% of the Monte Carlo rank order results? Why are the minimum H* values in Figure 3-36 of Revision 1 substantially different from those in Figure 3-32 of Revision 0?*

Response:

The footnote on page 3-53 of WCAP-17330-P, Revision 1 erroneously states that Figure 3-36 in WCAP-17330-P, Revision 1 and Figure 3-32 in WCAP-17330-P, Revision 0 are from the same database. The title of Figure 3-36 in WCAP-17330-P, Revision 1 is correct; it applies to the Model D5 SG at normal operating conditions. Figure 3-32 in WCAP-17330-P, Revision 0 applies to the Model F SGs at normal operating (NOP) conditions. Because the figures apply to different models of SGs, the H* values are also different.

A prior NRC staff question (Ref: February 2011 meeting with the NRC staff) challenged the data scatter in Figure 3-32 in WCAP-17330-P, Revision 0 and other similar figures, specifically in the context of the efficacy of the "break-line" concept. Figure 3-36 in WCAP-17330-P, Revision 1 shows the value of H* against the value of alpha (α), the square root of the sum of the squares of the component pairs of Monte Carlo selected values of coefficients of thermal expansion of the tubesheet and the tube.

The footnote on page 3-53 of WCAP-17330-P, Revision 1 correctly notes that scatter in the Revision 0 figures is the result of the Monte Carlo process that results in samples with negative variations of the tubesheet coefficient of thermal expansion with corresponding large negative variations in tube coefficient of thermal expansion (CTE). It is known from the prior work that the maximum values of H* are likely to occur at positive variations of tubesheet CTE and negative variations of tube CTE. In the Monte Carlo analysis, described further in the response to Question 3, approximately half of the H* values include a negative variation of tubesheet CTE and a corresponding large negative variation of tube CTE; however, the frequency of occurrence in the rank order range of interest is low

As noted above, the probabilistic response surface is presented in terms of the combined variable α, the square root of the sum of the squares of the individual tube and tubesheet

(TS) CTE components. The RSS combination of tube and tubesheet variables negates the sign of the negative variation of both the tube and TS CTE and artificially inflates the value of α, resulting in the upward data scatter shown on Figure 3-32 in WCAP-17330-P, Revision 0.

To address this issue in the H* analysis, Monte Carlo picks with a negative variation in TS CTE were assigned an H* value corresponding to a TS CTE variation of zero but with the Monte Carlo selected value of tube CTE. The complete process used for these points, discussed in the response to Question 3, results in a conservative value of H*.

Question 2:

> *WCAP-17330-P, Revision 0 - Provide copy of the "response surface" (i.e., H* relationship to coefficients of thermal expansion (CTE) variability for the tube and tubesheet) discussed for Model D5 steam line break (SLB) at the top of page 3-49. Confirm that this response surface applies to a radial location of 26.703 inches. Is this a full response surface or "partial" response surface of the type discussed in Revision 1 of WCAP-17330-P, page 3-58?*

Response:

The data for the requested response surface is provided in Table 2-1, below. It applies to a radial location of 26.703 inches for the bounding Model D5 plant at steam line break (SLB) condition. Note that the response surface considers only positive variations in the tubesheet CTE and negative variations in the tube CTE over a wide range of standard deviations, based on the prior experience of which parameters lead to the extreme values of H*. Hence, the name "reduced response surface."

Table 2-1
Reduced Response Surface; Model D5, 26.703 inches Radius

a,c,e

Case #	TS CTE n σ	T CTE n σ	H*+BET (in)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			

40			
41			
42			
43			
44			
45			

a,c,e

Question 3:

> *WCAP-17330-P, Revision 1 - Provide copy of the "reduced" response surfaces for bounding Model D5 SLB case discussed on page 3-58. Explain how the reduced response surfaces are used in the Monte Carlo analysis. If for a particular Monte Carlo iteration a negative variation of tubesheet CTE is randomly generated, what is done with this value (e.g., is tubesheet CTE assumed to have nominal value)? Why doesn't the use of a reduced response surface bias the rank ordering above 90% in the non-conservative direction?*

Response:

Table 3-1 provides the data for the requested response surface for the Model D5 SGs at the critical tubesheet radius of [ ]^{a,c,e} inches. Note that the change in the maximum value of H* (see Case 45) at the critical radius of [ ]^{a,c,e} inches from the prior critical radius of 26.703 inches shown in the response to Question 2 is only 0.03 inch.

The utilization of a reduced response surface as shown in Tables 2-1 and 3-1 does not bias the rank ordering in a non-conservative direction; it simply limits the effort to develop a response surface to the region in parameter space where the limiting values of H* are most likely located. The interpolation method for the reduced response surface permits calculation of H* values with the thick-shell equation, which is the underlying calculation basis of the response surface. The Monte Carlo process randomly samples, including variances in the region excluded from the reduced response surface by means of the interpolation scheme. In approximately half of the cases, the sampling results have negative tubesheet CTEs. Because the ultimate objective is to define specific combinations of tubesheet and tube CTEs that represent a specific rank order of H* values for input to the C^2 model, the salient question is how points with negative tubesheet CTEs are treated in the probabilistic calculation of H* using the C^2 model.

Each of the 10,000 simulations in the general Monte Carlo procedure uses the following process:

1. Pick a random normal deviate to represent the tubesheet CTE variation.
2. Pick a random normal deviate for each tube in the steam generator to represent the tube CTE variation.
3. For each tube, assign an H* value corresponding to the current tubesheet CTE variation and the tube's CTE variation by interpolating an H* value on the response surface. If the tubesheet CTE variation is negative, interpolate as though the tubesheet CTE variation is zero (i.e., mean value).
4. Apply sector ratios as discussed in LTR-SGMP-09-100 P Attachment, Rev. 1.
5. Store the largest H* value along with the corresponding tube and tubesheet CTE variations. Note that negative tubesheet CTE variations are retained, although the H* assigned to them is conservative by step 3.

Steps 1-5 represent one iteration of the Monte Carlo process. This process is repeated 10,000 times, and the results sorted in ascending order by H* value.

Step 3 of the process slightly distorts the rank order of the H* values because artificially higher values of H* are assigned to the combination of randomly selected CTEs when the selected tubesheet CTE is negative. The true H* rank order of these cases is lower than the apparent value of H* for these cases. The effect is to displace the rank order of H*s with positive values of tubesheet CTE to lower positions in the H* vector.

The manner in which these values are used in the subsequent step of the H* calculation process with the C^2 model ensures a conservative H* value. For instance, in order to obtain, the 95/50 full bundle H* value, the 9500th value in the H* rank order is chosen. In the event that the 9500th value contained a negative tubesheet CTE variation, the next higher rank order value with a positive tubesheet CTE was chosen. In practice, only one or two rank orders needed to be traversed to find an H* with a positive tubesheet variation. The parameters associated with this value were used in the calculation of H* with the C^2 model. Since higher rank orders are more conservative (larger H* distance), the process of using the first higher rank order with a positive tubesheet CTE variation is conservative.

Table 3-1
Reduced Response Surface; Model D5, [ ]^{a,c,e} inches Radius

a,c,e

Case #	TS CTE n σ	T CTE n σ	H*+BET (in) ([ ]^{a,c,e}Radius)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
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21			
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26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			

39			
40			
41			
42			
43			
44			
45			

a,c,e

Question 4:

> *WCAP-17330-P, Revision 1, Table 3-28 - Provide a similar table applicable to the Model D5 SLB case, from the 9526 to 9546 rank orders.*

Response

Table 4-1 provides the requested information.

Table 4-1
Variation of CTEs over a Range of Rank Order Statistics for Model D5

Rank	H*	Tube CTE	Tubesheet CTE	Alpha(1)
9526				
9527				
9528				
9529				
9530				
9531				
9532				
9533				
9534				
9535				
9536				
9537				
9538				
9539				
9540				
9541				
9542				
9543				
9544				
9545				
9546				

a,c,e

Notes:

1. Defined as SQRT((Tube CTE)^2 + (Tubesheet CTE)^2)

Question 5:

> *WCAP-17330-P, Revision 1, Table 3-29 - Provide C2 H* values for rank orders 9888 and 9892. This will lend additional confidence to inferences drawn from this table on page 3-58. In addition, provide a similar table applicable to the Model D5 SLB case.*

Response:

[Analysis code note: The structural code employed for the prior H* calculations was ANSYS "Workbench", Version 11. Version 12.1 of ANSYS "Workbench" was released following the issue of WCAP-17330-P, Revision 1. The updates to this version of ANSYS Workbench include changes to the contact modelling and solver options. Westinghouse has benchmarked and configured this version of the ANSYS code and has verified the results and conclusions of the previous H* analyses obtained with Version 11. However, there are minor numerical differences in the results. The net difference of applying version 12.1 of the ANSYS code compared to version 11 of the ANSYS code is a slight variation in the average circumferential contact pressure, typically on the order of ± 40 psi. Version 11 generally produces the lower contact pressures. Consequently, there may be small differences in the values provided for points already included in WCAP-17330-P, Revision 1.]

Table 5-1 provides the requested additional probabilistic Model F NOP results at a [ ]^{a,c,e} inch radius for rank orders 9888 and 9892. Table 5-2 provides the requested probabilistic Model D5 SLB results at an [ ]^{a,c,e} inch radius for rank orders from 9533 through 9539.

Table 5-1: Model F NOP Results at [ ]^{a,c,e} inches

Variation Input			
MC	T CTE	TS CTE	C^2 H*
#	$n\sigma$	$m\sigma$	in.
9888	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]^{a,c,e}
9892	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]^{a,c,e}

Table 5-2: Model D5 SLB Results at [ ]^{a,c,e} inches

Variation Input			
MC	T CTE	TS CTE	C^2 H*
#	$n\sigma$	$m\sigma$	in.
9533	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]^{a,c,e}
9534	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]^{a,c,e}
9536	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]$^{a,c,e(1)}$
9538	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]^{a,c,e}
9539	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]^{a,c,e}
Notes: (1) Refer to LTR-SGMP-11-58, "WCAP-17330-P Revision 1 Erratum"			

Although the uncertainty in the narrow range of rank order H* values for the Model D5 (Table 5-2) is slightly larger than the uncertainty for the Model F (Table 5-1 and Table 3-29 of WCAP-17330-P Rev. 1), the inferences drawn from these data on page 3-56 of WCAP-17330-P, Rev. 1 remain valid. It is expected that small variations will occur due to factors such as variation in extremely small absolute values of the structural displacements (e.g., due to round-off effects) that are the inputs to the C^2 model. This uncertainty is on the order of 2% of the final H* value, which is more than adequately covered by other conservatisms in the H* value that are discussed in the responses to the other questions.

Question 6:

> *WCAP-17330-P, Revision 1, Figure 3-45 - Should the data corresponding to the two open symbols be labeled as "data used in probabilistic analysis" (consistent with Figure 3-44) instead of "reduced data?" Why does this figure show only two open symbols rather than three as are given in Figure 3-44?*

Response

For clarity, the two (three) open symbols on Figure 3-45 of WCAP-17330-P, Revision 1, should be labelled the same as the three open symbols in Figure 3-44 of the report. No differentiation of meaning was intended in the current labelling.

On Figure 3-45 of WCAP-17330-P, Revision 1, the two apparent open symbols are, in fact, three open symbols. Two of the points are closely overlaid, leading to the impression that there are only two points. For clarity, the Table 6-1 provides the coordinates of the three points on Figure 3-45 of WCAP-17330-P. Figure 6-1 is an update of Figure 3-45 of WCAP-17330, Revision 1 that shows the previously overlaid data points as an open triangle and a dark grey square.

Table 6-1
Coordinates of Three Open-symbol Points on Figure 3-45 of WCAP-17330-P, Revision 1

Rank	H*	Tube CTE	Tubesheet CTE	Alpha
9149	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]^{a,c,e}	3.513
9500	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]^{a,c,e}	3.750
9536	[ ]^{a,c,e}	[ ]^{a,c,e}	[ ]^{a,c,e}	3.733

a,c,e

Figure 6-1
Update of Figure 3-45 of WCAP-17330, Revision 1

Question 7:

> *WCAP-17330-P, Revision 1, Tables 3-35 to 3-48 - The numerical methods used to generate the accumulated pullout loads in these tables appear to contain two sources of non-conservatism. One, the distance below the top of the tubesheet (TTS) where the contact pressure transitions from zero to a positive non-zero value is assumed to be the lowermost elevation for which a C2 calculation was performed and yielding a zero value contact pressure. The staff believes a more realistic and more conservative estimate of the contact pressure zero intercept value can be obtained by extrapolating the C2 results at lower elevations to the zero intercept location. Two, the method used to interpolate the H* distance between specific locations where C2 analyses were performed assumes that the distribution of contact pressure between these locations is a constant value equal to average value between these locations. For Table 3-35, the staff estimates that elimination of the non-conservatisms increases the calculated H* by 0.34 inches. For Tables 3-46 and 3-48, H* increases by 0.15 inches. These are not trivial differences. The staff estimates that the pullout loads corresponding to the H* distances in Figures 3-35, 3-46, and 3-48 are overestimated by 17%, 6%, and 8%, respectively. Provide revisions to Tables 3-35 to 3-48, if and as needed, to address the staff's concern.*

Response

Linear extrapolation of data points to determine a presumed zero contact pressure intercept, while conservative, is not realistic. The addition of a number of data points in the Model D5 contact pressure curve showed that extrapolation of data points provided in WCAP-17330-P, Revision 0 was unrealistically conservative. While a higher point density would always provide more certainty in the result, the current density of points was judged adequate by Westinghouse and (implicitly) by MPR in their independent review of H* methodology based on the minor effect on H*. In response to this question, another point was added to the contact pressure curve (Figure 3-20 of WCAP-17330-P, Revision 1) between the last zero point and the first non-zero point; the result is shown in Figure 7-1, below. Figure 7-1 shows that the extrapolation proposed by the question is unrealistically conservative and that such an extrapolation is also inconsistent with the behavior of a real structure. A sharp break in the contact pressure curve would not be expected in the physical structure; rather, a smooth transition from zero to non-zero contact pressure would be expected. Figure 7-1 shows that addition of even more points would simply further define the smooth transition in the curve as would be expected.

a,c,e

Figure 7-1

Calculation of Conservatism in CTE Variances Used in Probabilistic Analysis

The CTE variances used in the probabilistic analysis were derived from a large set of heterogeneous data across a broad range of temperatures. Since the issuance of the first H* report, further analysis of CTE data at specific temperatures has been performed in LTR-SGDA-11-87 in response to a question from the independent review by MPR Associates (Reference 5). (LTR-SGDA-11-87 is Reference 3-17 in WCAP-17330-P, Revision 1 and is provided as Appendix A in this document.) The additional statistical analysis was performed on the data to extract instrumentation uncertainty contributions (at high-confidence levels). Table 7-1 compares the values used in the analysis with the values from the more recent statistical analysis. Values are listed at 300° and 600°, the values pertinent to the Model F and D5 limiting conditions. As can be seen, the more accurately calculated values are significantly lower than those used in the current technical justification of H*.

The effect of applying the more realistic CTE variations on H* can be estimated by considering the ratio by which the standard deviations have been reduced. Since the difference between the mean H* and the probabilistic H* is entirely based on CTE differences, a first-order approximation to the reduction in H* length that would result from using the refined CTE variances can be obtained by multiplying the difference between the current mean and probabilistic H*'s by the above ratio. For conservatism, the more limiting of the tube/tubesheet CTE variance ratios from Table 7-2 were used.

Table 7-4 shows the effects of applying the improved CTE variability values to the H* analysis. Note that the H* values in Table 7-4 do not include crevice pressure or Poisson contraction because neither of these are related to CTE. As can be seen from Table 7-4, the existing H* length for the Model F's is conservative by approximately [ ]^{a,c,e} inches and the H* length for the Model D5's is conservative by about [ ]^{a,c,e} inch. This shows that the conservatism inherent in the current H* calculations are adequately conservative to account for small differences in judgment on the calculation process even without considering the major conservatisms identified previously (i.e., neglecting residual contact pressure). Additional conservatism to further support this conclusion is identified below.

Table 7-1
CTE Values Without Instrumentation Error

Temperature (°F)	**Tube CTE SDs, %**		
	As Used in WCAP-17330,Rev. 1	**Improved 50% Confidence**	**Improved 95% Confidence**
300	2.33	[ ]^{a,c,e}	[ ]^{a,c,e}
600	2.33	[ ]^{a,c,e}	[ ]^{a,c,e}

Temperature (°F)	**Tubesheet CTE SDs, %**		
	As Used in WCAP-17330,Rev. 1	**Improved 50% Confidence**	**Improved 95% Confidence**
300	1.62	[ ]^{a,c,e}	[ ]^{a,c,e}
600	1.62	[ ]^{a,c,e}	[ ]^{a,c,e}

Table 7-2
Ratio of CTE Variances (Refined/Used in Current H*)

Temperature (°F)	Tube CTE SDs Ratios	
	50% Confidence	95% Confidence
300	[ ]^{a,c,e}	[ ]^{a,c,e}
600	[ ]^{a,c,e}	[ ]^{a,c,e}

Temperature (°F)	Tubesheet CTE SDs Ratios	
	50% Confidence	95% Confidence
300	[ ]^{a,c,e}	[ ]^{a,c,e}
600	[ ]^{a,c,e}	[ ]^{a,c,e}

Table 7-3
Summary of H* Lengths from WCAP-17330, Revision 1

Model/Case	Mean H* (inches)	Probabilistic H* (inches)	Difference, Probabilistic – Mean	Limiting σ Ratio from Table 7-2
F, 95/50 Whole Bundle	[			
F, 95/95 Whole Plant				
D5, 95/50 Whole Bundle				
D5, 95/95 Whole Bundle				]

a,c,e

Table 7-4
Estimate of Conservatism of H* Length Related to CTE Variance

Model/Case	Difference x Limiting Ratio	New Probabilistic H*	Difference (Licensed H* - New Probabilistic H*)
F, 95/50 Whole Bundle	[		
F, 95/95 Whole Plant			
D5, 95/50 Whole Bundle			
D5, 95/95 Whole Bundle			]

a,c,e

Question 8:

> *WCAP-17330-P, Revision 1, Figures 3-48 and 3-49 - These figures were generated with the thick shell model. Were "spot checks" performed with the C2 model to determine whether adjustments to the curves in these figures are needed to approximate what the curves would look like if entirely generated with the C2 model? If not, why are the curves in their present form conservative?*

Response

The Model D5 contact pressure results reported for the steam line break (SLB) condition in WCAP-17330-P are conservative with respect to the crevice pressure distribution. The contact pressure distributions developed in WCAP-17330-P assume that the crevice pressure is distributed over the full depth of the tubesheet. No "spot checks" were performed to test if the crevice pressure correction distribution, determined by the thick shell equations (shown in Figures 3-48 and 3-49 of WCAP-17330, Revision 1), required an adjustment when applied to the C^2 results. The adjustment to the final H* length in Tables 3-50 and 3-51 of WCAP-17330-P, Revision 1 was made to be consistent with the methodology described in WCAP-17072-P.

The contact pressure results based on application of the C^2 model already represent a practical worst case with respect to crevice pressure, therefore, any further adjustment to the H* value using the curves shown in Figures 3-48 and 3-49 of WCAP-17330-P is unnecessary. The basis of this conclusion is explained below.

As discussed in WCAP-17072-P, the crevice pressure distribution was proportionally adjusted through the thickness of the tubesheet to reflect the predicted H* tube length because the tube below any postulated 360°, 100% through-wall flaw, is assumed to be absent. The crevice pressure at, and below, the flaw depth is in equilibrium with the primary side pressure. Increasing the crevice pressure over the length of the predicted H*so that it is equal to the primary side pressure reduces the tube to tubesheet contact pressure and increases the length of H*. Conversely, reducing the crevice pressure over the length of H* increases the tube to tubesheet contact pressure and decreases the length of H*.

The current contact pressure results for the Model D5 SGs show that there is zero contact pressure for a short distance below the top of the tubesheet. The H* length and the leakage factors are calculated based on only the length of positive contact pressure. Therefore, the crevice pressure in the crevice below the top of the tubesheet to the point of departure from zero contact pressure experiences the full primary to secondary pressure differential because that length of crevice is at the secondary side pressure condition. During a Model D5 steam line break, this pressure differential is equal to 2560 psig, acting towards the tubesheet. Figure 8-1 shows a comparison of the unmodified crevice pressure distribution used in the C^2 analysis (i.e., the crevice pressure is distributed over the full depth of the tubesheet) and the crevice pressure distribution that has been adjusted to reflect the final contact pressure distribution reported in Table 3-48 in WCAP-17330-P, Revision 1 for the critical radius in the Model D5 SG. In effect, the normalization of the crevice pressure distribution must be based on the shorter distance defined by the distance between the point of departure from zero-contact pressure to the predicted H* length (i.e., the location of the assumed flaw).

When the normalization length of the crevice is decreased, the pressure differential across the tube over the H* length increases. The increased pressure differential results in a large increase in the contact pressure between the tube and the tubesheet at the upper portion of the tube in the C^2 analysis. This effect was not included in the current analysis for H* because including it required iterating the probabilistic contact pressure distribution at both ends of the tube portion within the tubesheet with positive contact pressure between the tube and the tubesheet. The double iteration significantly increases the time required to perform the analysis and it is conservative to neglect it. Including the effect of the increased pressure differential reduces the final H* distance by more than 1 inch for the Model D5 SGs.

Figure 8-2 is a plot of the contact pressure between the tube and the tubesheet using the probabilistic results from Table 3-41 in WCAP-17330-P and the adjusted crevice pressure distribution shown in Figure 8-1. The increase in contact pressure due to adjusting the crevice pressure at the top of the tubesheet occurs regardless of the predicted length of H* if the underlying contact pressure distribution includes a length of zero contact pressure at the top of the tubesheet. Therefore, neglecting the crevice pressure distribution adjustment in the zero contact pressure length for any predicted H* length provides additional margin to the calculation of H*. The conservative application of crevice pressure distribution in the current analysis results in an under-prediction of the actual tube to tubesheet contact pressure by about 20% and in an overestimate of the H* length by more than 1 inch, before the additional crevice pressure adjustment from Figure 3-49 in WCAP-17330-P, Rev. 1 is added.

Figure 8-3 shows that no adjustment to the final probabilistic contact pressure distribution for crevice pressure distribution is necessary. The probabilistic contact pressure distribution is the contact pressure profile that is determined by the C^2 model when the probabilistic values of inputs (CTEs, displacements) are input to the C^2 model. The unadjusted (for crevice length) crevice pressure differential distribution, when applied to the probabilistic contact pressure distribution, results in a near-worst-case result for H* because the contact pressure is much less sensitive to crevice pressure variations than it is to variations of the other input parameters such as temperature and pressure.

For example, at the critical radius in the Model D5 tubesheet ([$]^{a,c,e}$ inch), if the applied tubesheet displacements and temperatures throughout the tubesheet depth are kept the same as shown in Table 3-10 in WCAP-17330-P, Rev. 1, but the crevice pressure differential is held constant at 1 psi throughout the depth of the tubesheet (i.e., primary pressure in the full length of the crevice), the result is the "DP=1 psi" curve in Figure 8-3. Similarly, if the C^2 model inputs are kept the same, but the crevice pressure differential is held constant at 2560 psi throughout the depth of the tubesheet (i.e., secondary pressure in the crevice), the result is the "DP=2560 psi" curve in Figure 8-3. These are the bounding conditions for crevice pressure. It is not possible for variation in crevice pressure differential to produce a contact pressure distribution less than, or greater than, the space bounded by these two curves. The current probabilistic contact pressure distribution, with the unmodified crevice pressure differential, is also shown on Figure 8-3. The difference between the contact pressure distribution with the unmodified crevice pressure distribution used in WCAP-17330-P, Rev. 1, and the contact pressure distribution with the worst-case assumption of a 1 psi differential, is essentially negligible.

When the modified crevice pressure differential distribution (i.e., based on the shorter crevice length) is applied, the result is increased contact pressure as illustrated in Figure 8-4. Increased contact pressure results in a reduced H* value. However, for consistency with the H* calculation process established in WCAP-17072-P, , the H* distance is increased by 1.51 inches for crevice pressure distribution in the current analysis methodology, not decreased as it should be from the results shown in Figure 8-4. Therefore, the 1.51 inches from the current crevice pressure adjustment shown in Figure 3-49 in WCAP-17330-P, Rev. 1 represents excess conservatism, and further refinement of the crevice pressure adjustment curve as it is applied in the C^2 analysis methodology is not required.

a,c,e

Figure 8-1: Plot of Crevice Pressure Differential acting towards the tubesheet on the inner diameter of the tube wall as a function of depth into the tubesheet. The zero (0) elevation is the top of the tubesheet.

a,c,e

Figure 8-2: Plot of tube-to-tubesheet contact pressure for the modified and unmodified crevice pressure differential distributions shown in Figure A. The zero (0) elevation is the top of the tubesheet.

a,c,e

Figure 8-3: Plot of tube-to-tubesheet contact pressure as a function of crevice pressure distribution. The zero (0) elevation is the top of the tubesheet.

a,c,e

Figure 8-4 Composite plot showing the effect on contact pressure of adjusting crevice pressure distribution to account for zero contact pressure near the top of the tubesheet.

Question 9:

> *In addition to the potential non-conservatisms in the H* estimate discussed in Question 7 above, there is uncertainty associated with the computed probabilistic H* values calculated with the C2 model as illustrated in Table 3-29. Depending on the response to question 8 above, there also may be some uncertainty associated with the H* adjustments for the crevice pressure distribution. What change to the proposed H* value of 14.01 inches is needed to ensure that it is a conservative value?*

Response:

The responses to RAI 7 and RAI 8 indicate that no adjustments to the Model D5 probabilistic SLB H* estimate are necessary to account for the uncertainty associated with the C^2 model results shown in Table 3-29 of WCAP-17330-P, Rev. 1. The current H* estimate of 14.01 inches is conservative by approximately 3.5 inches compared to the technically justifiable value even without accounting for the significant conservatism of neglecting residual contact pressure and other conservatism identified previously.

The probabilistic H* value, <u>before any adjustments</u>, cited in Table 3-49 in WCAP-17330-P, Rev. 1 is [ ]^{a,c,e} inches. The probabilistic H* value for the contact pressure distribution shown in the response to Question 8, Figure 8-2, is [ ]^{a,c,e} inches.

Table 9-1 summarizes the adjustments to the probabilistic H* estimate compared to the adjustments that are demonstrated above in the current technical basis for H*. It is seen from Table 9-1 that a margin of [ ]^{a,c,e} inches exists in the currently recommended H* length of 14.01 inches (for the Model D5 SGs) when the conservatism in the crevice pressure adjustment and the measurement error in the CTE data are quantified and the proper adjustments are made. This previously un-quantified conservatism significantly exceeds the potential increase in the H* length if different judgments are made in the details of the H* calculation as suggested in Questions 7, 8 and 9. Based on this, it is concluded that no adjustment to the recommended probabilistic H* value of 14.01 inches for the Model D5 SGs is necessary and that the H* length recommended in WCAP-17330-P, Revision 1 is significantly conservative.

Table RAI 9-1
Conservatism in Current Model D5 H* Calculation

a,c,e

Source	WCAP-17330-P, Rev 1	Refined Calculations
	in	in
Unmodified H* Value		
Adjustments		
Poisson Correction		
Crevice Pressure and BET Adjustment		
CTE Uncertainty Adjustment (RAI 7)		
Total Adjustments		
Final Probabilistic H*	**14.01**	[ ]^{a,c,e}

Notes:

(1) Recalculated for [ ]^{a,c,e} inches H* based on Figure 8-2.

(2) Crevice pressure margin ([ ]^{a,c,e} inch) plus BET adder of 0.3 inch included in Pcrev correction (Figure 3-49 of WCAP-17330, Rev. 1)

(3) See response to question 7.

Question 10:

> *Westinghouse letter LTR-SGMP-10-95 P - Attachment, Revision 1 - The staff is able to reasonably reproduce the numbers in Table 5 for Exp-2 and Power-2. It is the staff's understanding that Table 4 contains intermediate results leading to the results in Table 5. However, the staff cannot reproduce the numbers in Table 4 based on the information provided. Is Table 4 correctly titled? Provide a precise definition of the parameters that are listed in Table 4. Provide one example of how the parameter values were calculated, say for one segment at a tubesheet radius of 18.139 inches for SLB.*

Response:

Table 4 in LTR-SGMP-10-95, Revision 1 is labelled correctly with regard to the definition of the loss coefficient function but it is based on the contact pressure results from the Thick-Shell model. Its inclusion in LTR-SGMP-10-95, Revision 1 is the result of a transcription error.

Table 10-1, below, provides the local loss coefficients in units of (in^{-4}) for the "Power-2" function based on the contact pressure data contained in Table 3 of LTR-SGMP-10-95, Revision 1. The contact pressures in Table 3 of LTR-SGMP-10-95, Revision 1 are the average contact pressures over each segment length. The values on Table 10-1 are the solution for K from the "Power-2" function.

Table 10-2, below, shows the segment resistances in units of (lbf-sec/in^2) calculated from the local loss coefficients in Table 10-1, adjusted for units conversion and segment length. The segment lengths are shown on both Tables 10-1 and 10-2. Table 10-2 is the solution to the resistance equation, $R = 12\mu Kl$, but neglecting the constant because it divides out in the calculation of the resistance ratios.

Table 10-1
Local Loss Coefficient For Power 2 (K=0.15*(Pc)$^{4.5}$)

Segment Lengths from BTS to TTS	Tubesheet Radius					
	4.437	10.431	18.139	26.703	42.974	49.825
	Local K - NOP					
2.00	5.1313E+15	3.6865E+15	2.3659E+15	1.2689E+15	1.0700E+14	1.5672E+13
2.00	3.0747E+15	2.1831E+15	1.3670E+15	7.8175E+14	9.6690E+13	2.4449E+13
2.00	1.6627E+15	1.1207E+15	7.2723E+14	4.3233E+14	9.1542E+13	3.6160E+13
4.515	5.0019E+14	2.9683E+14	2.1225E+14	1.3996E+14	7.8376E+13	7.3598E+13
6.386	1.7653E+13	7.5284E+12	6.7741E+12	8.3479E+12	5.1448E+13	1.7803E+14
2.129	6.0972E+09	9.2123E+08	1.8742E+09	4.8467E+10	3.0885E+13	2.7622E+14
1.00	2.8981E+00	5.2512E-02	1.2442E-02	6.6444E+07	4.1304E+12	1.0078E+14
1.00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	8.3625E+09	3.7119E+12
	Local K -SLB					
2.00	5.5942E+16	4.9018E+16	3.4632E+16	2.0108E+16	2.2119E+15	2.3001E+14
2.00	2.5365E+16	2.2641E+16	1.6093E+16	9.3208E+15	1.2097E+15	1.8243E+14
2.00	9.6846E+15	8.8889E+15	6.3912E+15	3.7879E+15	6.2174E+14	1.4254E+14
4.515	1.0293E+15	1.0557E+15	7.8702E+14	5.3297E+14	1.7396E+14	9.0305E+13
6.386	3.1277E+12	4.0461E+12	3.2101E+12	2.8085E+12	1.5655E+13	7.4616E+13
2.129	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.0516E+12	9.0654E+13
1.00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	4.0011E+11	1.2318E+14
1.00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	6.2667E+11	2.0023E+14

Table 10-2

Segment Resistance Based on Viscosity in (lbf-sec/in^2) Units for Power 2 $(K=0.15*(Pc)^{4.5})$

Segment Lengths from BTS to TTS	Tubesheet Radius					
	4.437	10.431	18.139	26.703	42.974	49.825
	Normal Operating Conditions					
2.00	1.19E+08	8.55E+07	5.49E+07	2.94E+07	2.48E+06	3.64E+05
2.00	7.13E+07	5.07E+07	3.17E+07	1.81E+07	2.24E+06	5.67E+05
2.00	3.86E+07	2.60E+07	1.69E+07	1.00E+07	2.12E+06	8.39E+05
4.515	2.62E+07	1.56E+07	1.11E+07	7.33E+06	4.11E+06	3.86E+06
6.386	1.31E+06	5.58E+05	5.02E+05	6.19E+05	3.81E+06	1.32E+07
2.129	1.51E+02	2.28E+01	4.63E+01	1.20E+03	7.63E+05	6.82E+06
1.00	3.36E-08	6.09E-10	1.44E-10	7.71E-01	4.79E+04	1.17E+06
1.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.70E+01	4.31E+04
	Steam Line Break Conditions					
2.00	3.06E+09	2.69E+09	1.90E+09	1.10E+09	1.21E+08	1.26E+07
2.00	1.39E+09	1.24E+09	8.82E+08	5.11E+08	6.63E+07	9.99E+06
2.00	5.31E+08	4.87E+08	3.50E+08	2.07E+08	3.41E+07	7.81E+06
4.515	1.27E+08	1.31E+08	9.73E+07	6.59E+07	2.15E+07	1.12E+07
6.386	5.47E+05	7.08E+05	5.61E+05	4.91E+05	2.74E+06	1.31E+07
2.129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.13E+04	5.29E+06
1.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E+04	3.37E+06
1.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E+04	5.48E+06

Question 11

> *Westinghouse letter LTR-SGMP-10-95 P - Attachment, Revision 1 – This report spells out the definition of Exp-2 and Power-2 in Table 5. Provide definitions of the other functions considered in the table.*

Response:

The following is a complete list of the functions with their definitions that were considered in LTR-SGMP-10-95, Revision 1. K is the loss coefficient as defined in Figure 1 of LTR-SGMP-10-95, Revision 1. As noted in LTR-SGMP-10-95, Revision 1, these functions are not mathematical fits to the data; rather, they are functions developed to represent various interpretations of the loss coefficient data.

Function	Definition:	Note
Exp-1	$K = 1E+12*\exp(1.5E-03*P_c)$	
Exp-2	$K = 3.5E+12*\exp(5E-04*P_c)$	
Exp-3	$K = 2E+12*\exp(2E-04*P_c)$	
Exp-4	$K = 6E+11*\exp(8E-05*P_c)$	Lower Bound Horizontal
Exp-5	$K = 1.1E+14*\exp(1.8E-04*P_c)$	Upper Bound Horizontal
Linear	$K = 6.5E+9*P_c$	
Power-1	$K = 1E+4*P_c\hat{}3$	
Power-2	$K = 0.15*(P_c)^{4.5}$	Diagonal Bound
Logarithmic	$K =1E+12*\ln(P_c)+4E+08$	

Appendix A
LTR-SGMP-11-87
(Reference 3-17 of WCAP-17330-P, Revision 1)

To: G. W. Whiteman
B. J. Bedont
C. D. Cassino

Date: May 5, 2011

cc:

From: A. O. Roslund
Ext: 724-722-6473
Fax: 724-722-5889

Your ref:
Our ref: LTR-SGDA-11-87

Subject: High-Confidence Variances for Tube and Tubesheet CTE for H*

References:

1. WCAP-17071-P, Revision 2, "H*: Alternate Repair Criteria for the Tubesheet Expansion Region in Steam Generators with Hydraulically Expanded Tubes (Model F)".
2. LTR-0026-0087-2, "Independent Technical Review of H* Steam Generator Tube Alternate Repair Criterion," MPR Associates, April 11, 2011.
3. SG-SGMP-11-16, "H* Technical Basis Independent Review by MPR Associates: Technical Questions and Responses," April 2011.

The purpose of this letter is to document the methodology by which high confidence variances for tube and tubesheet CTE for H* were calculated in response to questions from MPR in the independent review of H*.

Electronically Approved*
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Introduction

The calculation of H* at high probability and confidence in Reference 1 entails the use of standard deviations for the coefficient of thermal expansion (CTE) for the tube and tubesheet, both of which are modeled as normal distributions. The justification for modeling them as normal and the means and standard deviations of the CTEs are contained in Appendix B of Reference 1. The standard deviations used for the tube and tubesheet were 2.33% and 1.62%, respectively. These standard deviations are essentially best estimate (50% confidence) from the data used. During the independent review of the H* technical basis (References 2 and 3), it was requested that Westinghouse calculate high-confidence variances of the standard deviations for the CTEs to show that the values used were conservative. The data used in the following analysis were from tests that Westinghouse contracted ANTER to perform as documented in Reference 1, Appendix B.

Methodology

ANTER tested 30 alloy 600 TT CTE specimens and 40 SA-508 tubesheet specimens. The results were given as CTEs in 25°F increments from 100°F to 700°F. The tubesheet data are in Table 1 through Table 4. The tube data are in Table 5 through Table 7. In order to determine the instrumentation error, one specimen each of the tube and tubesheet material was run ten times. These results are shown in Table 8 and Table 9.

Best estimate (50% confidence) standard deviations were calculated from the standard formula,

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(\bar{x} - x_i)^2}{n-1}}$$

High confidence (95%) standard deviations are obtained by the standard Chi-Squared adjustment:

$$\sigma_{95} = \sigma_{50}\sqrt{\frac{n-1}{\chi^2_{n-1,0.95}}}$$

Results for the tube and tubesheet are in Table 10 and Table 11. Results for the tube and tubesheet instrumentation error (multiple runs) are in Table 12 and Table 13. Note that a higher CTE variance is conservative for the purposes of calculating H*, while a lower instrumentation variance is conservative. Therefore, the above equation is used for adjusting material standard deviations, which results in a higher standard deviation at high confidence. For instrumentation variance, the above equation is used with a 0.05 instead of 0.95, which results in a high-confidence lower bound. The standard formula below was used to calculate a high confidence standard deviation for the tube and tubesheet without instrumentation error:

$$\sigma_{95,Material} = \sqrt{\sigma_{95,total}^2 - \sigma_{95,instrumentation}^2}$$

Results are in Table 14. As can be seen, the standard deviation values used in the H* analyses (2.33% for the tube and 1.62% for the tubesheet) are conservative compared to the true high-confidence standard deviations at temperatures of 200°F and greater. The range of temperatures applicable to the operating conditions of population of H* candidate plants is between 200°F and 650°F.

Table 1
Tubesheet CTEs (µin / in °F)

a,c,e

Temp (°F)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
100										
125										
150										
175										
200										
225										
250										
275										
300										
325										
350										
375										
400										
425										
450										
475										
500										
525										
550										
575										
600										
625										
650										
675										
700										

Table 15
Tubesheet CTEs (μin / in °F)

Temp (°F)	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18	Sample 19	Sample 20
100										
125										
150										
175										
200										
225										
250										
275										
300										
325										
350										
375										
400										
425										
450										
475										
500										
525										
550										
575										
600										
625										
650										
675										
700										

a,c,e

Table 16
Tubesheet CTEs (µin / in °F)

a,c,e

Temp (°F)	Sample 21	Sample 22	Sample 23	Sample 24	Sample 25	Sample 26	Sample 27	Sample 28	Sample 29	Sample 30
100										
125										
150										
175										
200										
225										
250										
275										
300										
325										
350										
375										
400										
425										
450										
475										
500										
525										
550										
575										
600										
625										
650										
675										
700										

Table 17

Tubesheet CTEs (μin / in °F)

Temp (°F)	Sample 31	Sample 32	Sample 33	Sample 34	Sample 35	Sample 36	Sample 37	Sample 38	Sample 39	Sample 40
100										
125										
150										
175										
200										
225										
250										
275										
300										
325										
350										
375										
400										
425										
450										
475										
500										
525										
550										
575										
600										
625										
650										
675										
700										

a,c,e

Table 18

Tube CTEs (Model F) (μin / in °F)

a,c,e

Temp (°F)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
100										
125										
150										
175										
200										
225										
250										
275										
300										
325										
350										
375										
400										
425										
450										
475										
500										
525										
550										
575										
600										
625										
650										
675										
700										

Table 19
Tube CTEs (Model D5) (μin / in °F)

Temp (°F)	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18	Sample 19	Sample 20
100										
125										
150										
175										
200										
225										
250										
275										
300										
325										
350										
375										
400										
425										
450										
475										
500										
525										
550										
575										
600										
625										
650										
675										
700										

a,c,e

Table 20
Tube CTEs (Model 44F) (μin / in °F)

Temp (°F)	Sample 21	Sample 22	Sample 23	Sample 24	Sample 25	Sample 26	Sample 27	Sample 28	Sample 29	Sample 30
100										
125										
150										
175										
200										
225										
250										
275										
300										
325										
350										
375										
400										
425										
450										
475										
500										
525										
550										
575										
600										
625										
650										
675										
700										

a,c,e

Table 21

Tube CTEs (Multiple runs on same specimen) (μin / in °F)

a,c,e

Temp (°F)	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
100										
125										
150										
175										
200										
225										
250										
275										
300										
325										
350										
375										
400										
425										
450										
475										
500										
525										
550										
575										
600										
625										
650										
675										
700										

Table 22

Tubesheet CTEs (Multiple runs on same specimen) (μin / in °F)

a,c,e

Temp (°F)	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
100										
125										
150										
175										
200										
225										
250										
275										
300										
325										
350										
375										
400										
425										
450										
475										
500										
525										
550										
575										
600										
625										
650										
675										
700										

Table 10
Mean and Standard Deviation, Tube Material

Temperature (°F)	Mean (µin/in°F)	Best Estimate Standard Deviation (%)	95% Confidence Standard Deviation (%)
100	6.95	3.40	4.35
125	7.03	2.84	3.64
150	7.10	2.38	3.04
175	7.16	2.00	2.55
200	7.23	1.69	2.16
225	7.28	1.45	1.86
250	7.34	1.27	1.63
275	7.39	1.14	1.46
300	7.43	1.05	1.35
325	7.48	0.99	1.27
350	7.52	0.95	1.21
375	7.56	0.92	1.17
400	7.59	0.89	1.14
425	7.63	0.87	1.12
450	7.66	0.86	1.10
475	7.69	0.85	1.08
500	7.72	0.84	1.07
525	7.76	0.83	1.07
550	7.79	0.83	1.06
575	7.82	0.82	1.05
600	7.85	0.81	1.03
625	7.88	0.79	1.01
650	7.91	0.77	0.98
675	7.94	0.74	0.95
700	7.97	0.72	0.92

Table 11
Mean and Standard Deviation, Tubesheet Material

Temperature (°F)	Mean (μin/in°F)	Best Estimate Standard Deviation (%)	95% Confidence Standard Deviation (%)
100	6.11	2.71	3.34
125	6.23	2.30	2.83
150	6.35	1.96	2.42
175	6.45	1.69	2.08
200	6.55	1.48	1.82
225	6.63	1.31	1.62
250	6.71	1.19	1.46
275	6.79	1.09	1.35
300	6.85	1.02	1.26
325	6.91	0.97	1.19
350	6.97	0.92	1.14
375	7.02	0.89	1.10
400	7.07	0.86	1.06
425	7.12	0.84	1.03
450	7.16	0.82	1.01
475	7.20	0.80	0.99
500	7.24	0.79	0.97
525	7.28	0.77	0.95
550	7.32	0.76	0.94
575	7.35	0.76	0.93
600	7.39	0.75	0.92
625	7.43	0.74	0.92
650	7.48	0.75	0.92
675	7.52	0.76	0.93
700	7.57	0.78	0.96

Table 12
Standard Deviation for Instrumentation Error, Tube Material

Temperature (°F)	Best Estimate Standard Deviation (%)	95% Confidence Standard Deviation (%)
100	2.28	1.66
125	2.01	1.46
150	1.77	1.29
175	1.57	1.14
200	1.39	1.01
225	1.24	0.91
250	1.12	0.81
275	1.01	0.74
300	0.92	0.67
325	0.85	0.62
350	0.79	0.58
375	0.75	0.55
400	0.71	0.52
425	0.69	0.50
450	0.67	0.49
475	0.66	0.48
500	0.65	0.48
525	0.65	0.47
550	0.64	0.47
575	0.63	0.46
600	0.62	0.46
625	0.61	0.44
650	0.59	0.43
675	0.56	0.41
700	0.53	0.38

Table 13
Standard Deviation for Instrumentation Error, Tubesheet Material

Temperature (°F)	Best Estimate Standard Deviation (%)	95% Confidence Standard Deviation (%)
100	2.08	1.52
125	1.82	1.32
150	1.59	1.16
175	1.40	1.02
200	1.25	0.91
225	1.13	0.82
250	1.03	0.75
275	0.95	0.69
300	0.89	0.65
325	0.85	0.62
350	0.82	0.60
375	0.79	0.58
400	0.78	0.57
425	0.78	0.57
450	0.77	0.56
475	0.78	0.57
500	0.79	0.57
525	0.79	0.58
550	0.79	0.58
575	0.80	0.58
600	0.80	0.59
625	0.80	0.58
650	0.79	0.57
675	0.77	0.56
700	0.74	0.54

Table 14
High-Confidence Tube and Tubesheet Standard Deviations with Instrumentation Error Removed

a,c,e

Temperature (°F)	Tube (%)	Tubesheet (%)
100		
125		
150		
175		
200		
225		
250		
275		
300		
325		
350		
375		
400		
425		
450		
475		
500		
525		
550		
575		
600		
625		
650		
675		
700		

ATTACHMENT 3

Westinghouse Authorization Letter CAW-12-3341 with Accompanying Affidavit, Proprietary Information Notice, and Copyright Notice

Westinghouse

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Cranberry Township, PA 16066
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
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Proj letter: DPC-12-2

CAW-12-3341

January 5, 2012

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-SGMMP-11-28 P-Attachment, "Response to USNRC Request for Additional Information Regarding the Catawba License Amendment Request for Permanent Application of the Alternate Repair Criterion, H*" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-12-3341 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by Duke Energy.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference CAW-12-3341 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company LLC, Suite 428, 1000 Westinghouse Drive, Cranberry Township, PA 16066.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance

Enclosures

CAW-12-3341

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

Before me, the undersigned authority, personally appeared J. A. Gresham, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

J. A. Gresham, Manager
Regulatory Compliance

Sworn to and subscribed before me
this 5th day of January 2012

Cynthia Olesky
Notary Public

Cynthia Olesky, Notary Public
My Commission Expires July 16, 2014

(1) I am Manager, Regulatory Compliance, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of

Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390; it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in LTR-SGMMP-11-28 P-Attachment, "Response to USNRC Request for Additional Information Regarding the Catawba License Amendment Request for Permanent Application of the Alternate Repair Criterion, H*" (Proprietary), dated January 2012, for submittal to the Commission, being transmitted by Duke Energy Letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse for Catawba Unit 2, is that associated with the technical justification of the H* Alternate Repair Criteria for hydraulically expanded steam generator tubes and may be used only for that purpose.

This information is part of that which will enable Westinghouse to:

(a) License the H* Alternate Repair Criteria.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of the information to its customers for the purpose of licensing the H* Alternate Repair Criteria.

(b) Westinghouse can sell support and defense of the H* criteria.

(c) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical justification and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.390 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

12. BET measurements for Catawba 2, documented in Westinghouse letter LTR-SGMP-09-111 P-Attachment, Revision 1, range to a maximum of 0.65 inches and appear not to be a factor affecting the H* and leak rate ratio calculations. Apart from tubes with this reported range of BETs, are there any non-expanded or partially expanded tubes at Catawba 2? If so, provide revisions to the proposed technical specifications which exclude such tubes from the proposed H* provisions.

Duke Energy Response:

In 2010, Duke Energy performed a one-time verification of the tube expansion to locate any significant deviations in the distance from the top of the tubesheet to the bottom of the expansion transition. Westinghouse was contracted to perform this effort. In the summary report for this effort (Westinghouse Letter DPC-10-25, "Transmittal of Catawba Unit 2: Position of the Bottom of the Tubesheet Expansion Transition"), Westinghouse noted that tube R30C12 in Steam Generator B was found to be unexpanded on the cold leg side. This tube had been previously removed from service in April of 2006. No evidence exists of any additional unexpanded or partially expanded tubes in any of the steam generators.

13. Proposed TS 5.6.8.h through j – The proposed changes contain more words than seem necessary, reducing the clarity of the proposed reporting requirements. For example, the proposed wording refers to "an inspection performed after each refueling outage" which doesn't seem to make sense. The staff believes the proposed requirements can be stated more clearly and concisely as follows:

    h. For Unit 2, ~~following completion of an inspection performed during End of Cycle 17 Refueling Outage (and any inspections performed during subsequent Cycle 18 operation),~~ the primary to secondary LEAKAGE rate observed in each steam generator (if it is not practical to assign the leakage to an individual SG, the entire primary to secondary leakage should be conservatively assumed to be from one SG) during the cycle preceding the inspection which is the subject of the report,

    i. For Unit 2, ~~following completion of an inspection performed during the End of Cycle 17 Refueling Outage (and any inspections performed during subsequent Cycle 18 operation),~~ the calculated accident induced leakage rate from the portion of the tubes below ~~20~~ **14.01** inches from the top of the tubesheet for the most limiting accident in the most limiting SG. In addition, if the calculated accident leakage rate from the most limiting accident is less

ATTACHMENT 4

Response to NRC Requests for Additional Information (Questions 12 and 13)

than 3.27 times the maximum primary to secondary LEAKAGE rate, the report shall describe how it was determined, and

j. For Unit 2, ~~following completion of an inspection performed during the End of Cycle 17 Refueling Outage (and any inspections performed during subsequent Cycle 18 operation),~~ the results of monitoring for tube axial displacement (slippage). If slippage is discovered, the implications of the discovery and corrective action shall be provided.

Provide revisions to the proposed reporting requirements as necessary to clarify their intent.

Duke Energy Response:

The requested re-marked up TS pages are enclosed.

5.6.8 Steam Generator (SG) Tube Inspection Report (continued)

h. For Unit 2, ~~following completion of an inspection performed during the End of Cycle 17 Refueling Outage (and any inspections performed during subsequent Cycle 18 operation),~~ the primary to secondary LEAKAGE rate observed in each SG (if it is not practical to assign leakage to an individual SG, the entire primary to secondary LEAKAGE should be conservatively assumed to be from one SG) during the cycle preceding the inspection which is the subject of the report,

i. For Unit 2, ~~following completion of an inspection performed during the End of Cycle 17 Refueling Outage (and any inspections performed during subsequent Cycle 18 operation),~~ the calculated accident leakage rate from the portion of the tubes below ~~20~~ 14.01 inches from the top of the tubesheet for the most limiting accident in the most limiting SG. In addition, if the calculated accident leakage rate from the most limiting accident is less than 3.27 times the maximum primary to secondary LEAKAGE rate, the report shall describe how it was determined, and

j. For Unit 2, ~~following completion of an inspection performed during the End of Cycle 17 Refueling Outage (and any inspections performed during subsequent Cycle 18 operation),~~ the results of monitoring for tube axial displacement (slippage). If slippage is discovered, the implications of the discovery and corrective action shall be provided.