Vogtle Electric Generating Plant Units 1 and 2
License Amendment Request to Revise Technical Specification (TS)
Sections 5.5.9, "Steam Generator (SG) Program" and TS 5.6.10,
"Steam Generator Tube Inspection Report" for Temporary Alternate Repair Criteria

Enclosure 11

LTR-SGMP-10-33 P-Attachment, "H* Response to NRC Questions Regarding Tubesheet Bore Eccentricity," September 13, 2010. (Non-Proprietary)

H*: Response to NRC Questions Regarding Tubesheet Bore Eccentricity

September 2010

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H*: Response to NRC Questions Regarding Tubesheet Bore Eccentricity

References (for introduction and responses):

1. USNRC Letter, "Vogtle Electric Generating Plant, Units 1 and 2- Transmittal of Unresolved Issues Regarding Permanent Alternate Repair Criteria for Steam Generators (TAC Nos. ME1339 and ME 1340)," November 23, 2009
2. USNRC Letter, "Vogtle Electric Generating Plant, Units 1 and 2- Summary of January 20, 2010, Public Meeting with Southern Nuclear Operating Company, Inc (SNC) on the Unresolved Issues Regarding the Permanent Alternate Repair Criteria for Steam Generators (TAC No. ME3003 and ME3004).
3. SM-94-58, Rev. 1, "Doel 4 Elevated Tubesheet Sleeve – ASME Code Evaluation and Effect of Tubesheet Rotations on Contact Pressures," December 14, 1995.
4. USNRC Letter, "Vogtle Electric Generating Plant-Audit of Steam Generator H* Amendment Reference Documents (TAC Numbers ME3003 and ME3004)," July 9, 2010.
5. SNC letter NL-09-1375, August 28, 2009, responding to VEGP RAI No. 4, NRC ADAMS Accession No. ML092450333 and transmitting Westinghouse letter SGMP-09-109-P Attachment "Response to NRC Request for Additional Information on H*; RAI # 4; Model F and Model D5 Steam Generators," August 25, 2009, NRC ADAMS Accession Nos. ML092450334 (Proprietary) and ML092470144 (Non-Proprietary).
6. WCAP-17072-P, "H*: Alternate Repair Criteria for the Tubesheet Expansion Region in Steam Generators with Hydraulically Expanded Tubes (Model D5)," May 2009

Introduction:

This document is provided in response to the NRC questions regarding tubesheet bore eccentricity provided in Reference 1. The questions are numbered the same as they are in the NRC letter transmitting the questions (Reference 1). In a meeting on January 20, 2010, Westinghouse presented a plan for resolution of the issue of eccentricity (Reference 2). The NRC did not comment on the plan but reiterated that responses to the questions as asked in Reference 1 are required. This document is the response to a number of the questions as-asked. As a result of an audit of the H* calculations in June of 2010, responses to several of the remaining questions have been determined no longer to be necessary by the NRC staff (Reference 4). Those questions are also included in this document.

Two sets of references are provided: those that are included in the NRC letter transmitting the questions and those that pertain to the responses. The references pertaining to the responses are provided above, prior to the responses. The references pertaining to the questions are included after all of the responses.

Question 1

Provide a complete description of the model used to develop the relationship between eccentricity and scale factor in Section 6.3 of Reference 1. This description should address, but not be limited to addressing, the following questions:

Response:

A description of the slice model is provided below prior to the responses to the specific subparts of RAI 1.

For consistency, please note that the terms "slice model," "scale factor model," and "old model" are synonymous in these responses.

Model Description:

To respond to comments and questions raised by a customer in 1994 on a sleeving report, a study was performed (Reference 3) to determine the effect of hole out-of-roundness on the contact pressures between the sleeve and tube and between the tube and the tubesheet. The study consisted of a series of finite element models such as shown in Figure RAI1-1 with varying degrees of eccentricity in the inner diameter of the tubesheet collar. In this application, eccentricity is defined as the difference between the major and minor axes ($D_{MAX} - D_{MIN}$) of the ellipse modeled.

The structural analysis elements used were the plane stress quadratic version of the 2-D isoparametric quadrilateral (STIF53) of the *WECAN Plus* code. Interface elements (STIF 12) were placed between all the nodes of the sleeve outer diameter and the tube inner diameter and between all the nodes of the tube outer diameter and the hole inner diameter as illustrated in Figure RAI1-2. These elements are used to calculate the radial stresses between the structural components (sleeve, tube and collar).

In the unloaded condition, the sleeve OD was assumed to be in contact with the tube ID and the tube OD was in contact with the tubesheet simulant (collar) ID at, at least, one point. Loading of the sleeve and tube within the elliptical hole was accomplished by applying a 500°F temperature increase on the entire model, while setting the coefficient of thermal expansion of the tubesheet collar to zero, and the coefficient of thermal expansion for the sleeve and tube to their proper ASME Code mean values at temperature. Five cases were considered in the development of Table RAI4-2: A reference case with a round hole ($D_{MAX} - D_{MIN}$) = 0.0) plus four other cases with ($D_{MAX} - D_{MIN}$) = 0.0002, 0.0004, 0.0006 and 0.0008 inch. For example, Figure RAI1-3 shows the resultant displacement of the slice model at a ($D_{MAX} - D_{MIN}$) = 0.0 inches. For comparison, Figure RAI1-4 shows the resultant displacement of the slice model at ($D_{MAX} - D_{MIN}$) = 0.0008 inches. The dashed lines represent the original position of the tube, sleeve and collar.

The boundary conditions of the model are set to permit ±x-translation of the nodes at the x-axis and ±y-translation of the nodes at the y-axis. The nodes at the x-axis are constrained from y-motion and the nodes at the y-axis are constrained from x-motion. The x- and y- axes are the flat faces of the model.

Table RAI4-2 lists the mean radial stress at the sleeve and tube outer diameters for each of the cases identified above, plus the ratios between the elliptical cases and the reference case. The deltas in Table RAI4-2 refer to the maximum deviation from a constant value of the linearized radial stress around the

a,c,e

[ ]

Figure RAI1-1 Finite Element Model for Elliptical Hole Study (Slice Model)

a,c,e

Figure RAI1-2 Locations of Non-Linear Interface/Contact Elements in Slice Model

a,c,e

Figure RAI1-3 Slice Model Displacement at D_{MAX}-D_{MIN} = 0.0 after Application of 500°F Temperature Increase (note the uniform radial displacement)

[ ] a,c,e

Figure RAI 1-4 Slice Model Displacement at D_{MAX}-D_{MIN} = 0.0008 in after Application of 500°F Temperature Increase (note the non-uniform radial displacement)

*a. **Provide a complete description of Table RAI [request for additional information] 4-3 in Reference 2. Give complete details of the role of the "slice model" in the development of this table. Give complete details of the role of the 2-D lower SG shell axisymmetric model in the development of this table.***

Response:

Table RAI4-3 was developed based on five 90 degree slice models – one for each "Initial" hole eccentricity (first column). The initial eccentricity for each model was established by setting the radius of the node at the inside surface of the hole at 90 degrees equal to the radius of the node at the inside radius of the hole at 0 degrees plus the eccentricity (i.e., 0, 0.0002, 0.0004, 0.0006, or 0.0008). Nodes on the inside surface of the hole between 0 and 90 degrees follow an elliptical coordinate system. The initial shapes of the sleeve and tube were circular in each of the 5 separate models created. Contact elements were placed between all nodes on the outside surface of the sleeve and inside surface of the tube, and between all nodes on the outside surface of the tube and inside surface of the hole.

The 2-D lower SG shell axisymmetric model was not used to develop any of the information on Table RAI4-3 of Reference 2.

Figure RAI1-5 is a flowchart that shows how the data in Table RAI4-3 of Reference 5 was developed. The following provides a word description of the process.

The second column of Table RAI4-3 of reference 5 is the final value of eccentricity as defined above after the models have been loaded by application of the 500°F temperature increase. The final eccentricity is the difference between the columns labeled (2) and (3).

The columns labeled (2) and (3) are the changes in the initial hole diameter for each model after it has been loaded by application of the 500°F temperature increase.

The columns labeled (4) and (5) are the respective contact pressures between the sleeve and tube and between the tube and the collar using the thick-shell equations discussed in the respective WCAP reports. For each different value of initial eccentricity (i.e., for each of the 5 different models), the ΔD input for the thick-shell equations was calculated based on a range of assumed scale factors shown in the column labeled (1). Also shown in the column labeled (5) are the minimum, maximum and average contact stresses between the structural components of the model using a scale factor of [ ]a,c,e, [ ]a,c,e and [ ]ac,e for the minimum, average and maximum cases , respectively (see Equation RAI4-1 of Reference 5).

The column labeled (6) is the ratio of the contact stresses calculated for each case of assumed scale factor (SF) value to the average contact stress value (i.e., scale factor = [ ]a,c,e) from the base case.

In summary, Table RAI4-3 of Reference 5 is used only to provide a database for choosing the proper scale factor value to match a desired value of stress ratio. The desired values of stress ratio are given on Table RAI4-2 of Reference 5 which relates the contact stresses calculated with the slice model under various assumed conditions of initial eccentricity (D_{max} –D_{min}). The ratios on Table RAI4-2 are the results for the assumed (D_{max} –D_{min}) divided by the results from the case where (D_{max} –D_{min}) equals zero.

Regarding the contact pressures shown in Column 5 of Table RAI4-3 of Reference 6, the NRC staff observed that the results shown are counter-intuitive. That is, it would be expected that, with increasing eccentricity, the predicted contact pressures should incrementally decrease instead of the slight incremental increase shown on the table. Question 2 of Reference 1 deals with the prototypicality of the slice model as originally presented in Reference 3. The response to question 2 includes a revision of the model that includes removal of the sleeve from the model. The same process of calculations shown in Figure RAI1-5 were repeated with the updated model (sleeve removed) using the same methods (*WECAN*) as used previously. Two principal conclusions resulted from this:

1. The predicted contact pressures decrease with increasing eccentricity (D_{max} –D_{min}) as expected as shown on Table RAI1-1 of this document.
2. The effect of removing the sleeve from the slice model on the predicted value of the mean H* was insignificant. This is discussed further in the response to Question 2.

In summary, the apparent non-intuitive results from the scale factor calculations provided in Reference 5 and the inclusion of the sleeve in the original model are inconsequential to the predictions of H* and therefore, contact pressures.

In regard to the difference in the predicted contact pressures shown on Table RAI4-2 of Reference 5 and those shown on Table RAI4-3 of Reference 5, the values on Table RAI4-2 were calculated using the slice model and the contact pressure values on Table RAI4-3 were calculated using the thick-shell equations based on displacement inputs shown in columns 2 and 3 of Table RAI4-3. A principal reason for the differences in magnitudes between the radial stress calculated using the *WECAN*/Plus results versus using the contact pressures calculated using the thick shell equations is the interface elements (STIF 12). The interface elements are placed between all of the nodes of the sleeve outer diameter and the tube inner diameter and between all of the nodes of the tube outer diameter and the tubesheet hole inner diameter as illustrated in Figure RAI1-2. These elements are used to calculate the radial forces between the structural components (sleeve, tube and collar). An initial gap of 0.0001 inch between the sleeve and tube and between the tube and collar was used to define the orientation of each of the contact elements. The contact elements with the initial gaps are judged to have over-predicted the radial stress. When the model was modified to eliminate the sleeve, leaving only the tube and the collar, the predicted contact stresses were reasonably in line with the results from the thick-shell equations. An independent model based on the *ANSYS* code also predicted contact stresses reasonably in line with the thick-shell equation results (see Table RAI1-2 in this document). The results from the original slice model are not actually used in the calculation of H* but are used only to define the scale factor relationship. The over-prediction of contact pressure by the original slice model is compensated for by using the ratios of contact pressure reduction as a function of tubesheet hole eccentricity in the final development of the scale factor versus eccentricity relationship which utilizes the results from the thick-shell equations.

Table RAI1-1

Eccentricity Results for D5 SG with Temperature = 500°F

Eccentricity (inch)	S11 Avg (psi)	Hole Delta D(1)	Hole Delta D (90 Deg) (2)	T/TS Contact Pressure(3)	Max/Min Factor(4)
[					]

a,c,e

Notes:
(1) $2UX_{338}$ of tubesheet hole at 0 degrees.
(2) $2(UY_{430} + \varepsilon_0)$ of tubesheet hole at 90 degrees.
(3) Contact pressure calculated using Max/Min factor in last column.
(4) Scale factor that results in the ratio of the calculated contact pressure for a given ε to that calculated for ε=0 which is the same as the ratio for the corresponding S11 Avgs.

Figure RAI1-5

a,c,e

b. ***Confirm the relevancy of each of the input parameters listed at the top of the table. For example, if the table is entirely based on the "slice model" results, then the assumed shell and channel head temperatures do not seem to be relevant to the results of Table RAI4-3.***

Response:

The input parameters at the top of the table are a carry-over from the original calculation spreadsheet and are not all relevant to Table RAI4-3. The only parameter used is the tubesheet change in temperature, which determines the temperature-dependent material properties of the sleeve, tube, and tubesheet and the thermal expansion of the sleeve and tube.

c. ***Explain why there are two values listed for the tube/tubesheet interaction values listed at the top of Table RAI4-3? Explain the differences between the two values in detail. Explain why one of the values is negative.***

Response:

Because the slice model discussed in Reference 5 includes both a sleeve and a tube within the collar, the interaction coefficients are the matrix values resulting from simultaneous solution of the thick shell equations as shown below for the sleeve, tube and collar. The interaction coefficients are the entries in the [a]-matrix in the formulation of the solution shown immediately above the example at the end of this response. The values and signs of these coefficients are those that result when the specific problem is solved. (Note that the sleeve has been removed from the model in its current application.)

Thick shell equations in combination with the hole expansions calculated from the finite element model displacements are used to calculate the contact pressures between the sleeve and tube, and between the tube and tubesheet in the slice model.

The unrestrained expansion of the sleeve outer diameter (OD) for an intact tube (end cap load carried by the tube) is given by:

[ ] a,c,e

Where

P_i	=	Internal pressure, psi
P_o	=	External pressure, psi
a	=	Inside radius of sleeve, in.
b	=	Outside radius of sleeve, in.
α_s	=	Coefficient of thermal expansion of sleeve in/in °F
v	=	Poisson's Ratio (0.3)
E_s	=	Modulus of Elasticity of sleeve, psi

Ts = Temperature of the Sleeve, °F

The unrestrained expansion of the tube I.D. for an intact tube is given by:

[ ] a,c,e

Where

b = Inside radius of tube, in.

c = Outside radius of tube, in.

α_t = Coefficient of thermal expansion of tube in/in °F

E_t = Modulus of Elasticity of tube, psi

T_t = Temperature of the tube, °F

The unrestrained expansion of the tube OD for an intact tube is given by:

[ ] a,c,e

The expansion of the hole inside diameter (ID) produced by pressure is given by:

[ ] a,c,e

Where

E_{TS} = Elastic modulus of the tubesheet, psi

d = Equivalent outside radius of a tubesheet unit cell, in.

If the unrestrained expansion of the sleeve OD is greater than the expansion of the ID of the tube, then the sleeve and the tube are in contact. The thick cylinder equations above can be used to determine the contact pressure between the sleeve and the tube. The inward radial displacement of the outside surface of the sleeve produced by the contact pressure between the sleeve and tube is given by:

[ ] a,c,e

The radial displacement of the inside surface of the tube is given by:

[ ] a,c,e

Where

P_1 = Contact pressure between sleeve and tube, psi

P_2 = Contact pressure between tube and tubesheet, psi

One equation for the contact pressures P_1 and P_2 is thus obtained from:

[ ] a,c,e

Where the ΔRs are given for an intact tube by:

[ ] a,c,e

If the unrestrained expansion of the tube OD is greater than the expansion of the tubesheet hole, then the tube and the tubesheet are in contact. The inward radial displacement of the outside surface of the tube produced by the contact pressures is given by:

[ ] a,c,e

The radial displacement of the inside surface of the tubesheet hole produced by the contact pressure between the tube and hole is given by:

[ ] a,c,e

The second equation for the contact pressures P_1 and P_2 is obtained from:

[ ] a,c,e

Where,

ΔR_{ROT} = Hole expansion produced by tubesheet rotations obtained from finite element results (Equation RAI4-1 of LTR-CDME-09-109 P-Attachment divided by 2 because the results are given in terms of diameter).

For a tube assumed to have no degradation, the ΔRs are:

[ ] a,c,e

Therefore,

[ ] a,c,e

[ ] a,c,e

where the appropriate expressions are used for the ΔRs.

The resulting equations are of the form:

[ ] a,c,e

which have the solution:

[ ] a,c,e

By way of example, the tube to-tubesheet (T/TS) contact pressure, P_2, of [ ]a,c,e psi for an initial "eccentricity" of E=0.0002 inch (D_{max} = 0.0020545 in, D_{min} = 0.001513 in) and an assumed scale factor of 0.53 in Table RAI 4-3 is calculated substituting the following input values from Table RAI 4-3 into the equation for P_2 above:

[ ] a,c,e

Where:

[ ] a,c,e

d. ***Given that the final eccentricity values shown in Table RAI4-3 were obtained from the slice model and that the only load considered in the analysis was a temperature loading of the tube and sleeve, explain how it is physically possible for the final eccentricity to be larger than the initial eccentricity. Might this result indicate that the slice model is not valid and, if not, why not?***

Response:

The final eccentricity is two times the difference between the radii of the nodes at 90 degrees and 0 degrees after the sleeve and tube have expanded into the tubesheet hole. If the tubesheet collar was rigid, the final eccentricity would be the same as the initial eccentricity. Since the tubesheet collar is elastic, it deforms due to the expansion of the sleeve and tube. Refer to the boundary conditions of the model discussed earlier which permit the structure to deform freely under the applied loading from the tube and sleeve. A final eccentricity larger than the initial eccentricity indicates that the radial deflection of the inside of the hole was greater at 90 degrees than at 0 degrees in the loaded condition. This is clearly shown in Figure RAI1-4 of this response. The dashed lines represent the original position of the sleeve, tube and collar.

The original slice model and the modified slice model (sleeve removed) were created in *WECAN*. An entirely new model was independently created in the current issue of *ANSYS* (see Figure RAI1-6). The new model was built with the same parameters as the modified original model and loaded in the same manner to provide a completely independent check on the original analysis. The predicted contact pressures from the *ANSYS* model were essentially the same as those predicted with the *WECAN* model (see Figure RAI1-7) The final eccentricity after loading the *ANSYS* model was essentially the same as the initial eccentricity (see Table RAI1-2).

Interpretation of the validity of the model depends on its application in the final analysis, that is, calculation and justification of H*. While it can be argued that the results of the slice model as presented in References 3 and 5 are counterintuitive to a degree, the contact pressure reduction ratios used to define the resultant scale factor versus eccentricity polynomial relationship decrease as tubesheet hole eccentricity increases and the application of the model provides substantially conservative results for the prediction of H*. The parallel approach of calculating H* using the square cell model is expected to support this conclusion.

[ ] a,c,e

Figure RAI1-6
ANSYS Model D5 Slice Model

[ ] a,c,e

Figure RAI1-7
Model D5 Contact Pressure Results for DT =142^{o}F, Eccentricity =0.0005 in

Table RAI1-2
RESULTS FROM ANSYS SLICE MODEL for Model D5 SG

Applied Load	Initial Collar Dimensions			Relative Displacement		Final Collar Dimensions		Eccentricity		Contact Pressure		
ΔT	Nominal Radius	90°(Top)	0° (Bottom)	90° (Top)	0° (Bottom)	90° (Top)	0° (Bottom)	Initial	Final	Max (2)	Min (2)	Average (1)
°F	in	in	in	in	in	in	in	in/in	in/in	psi	psi	psi

a,c,e

(1): Average taken as a function of circumference around the quarter section of tube and collar.
(2): Zero and Positive values for contact pressure indicate a loss of contact in the radial coordinate system used to calculate the contact pressure.
(3): Eccentricity is defined as $(D_{MAX} - D_{MIN}) / D_{NOM}$

e. ***1. Why are the listed contact pressures in Table RAI4-3 different from those in [Table] RAI4-2 for the same level of initial eccentricity?***
2. What method of analysis was used to calculate the contact pressures in Table RAI4-3?
3. What coefficient of thermal expansion (CTE) was assumed for the tubesheet when determining the final eccentricities and contact pressures in Table RAI4-3?
4. If greater than zero, why weren't consistent assumptions for tubesheet CTE used for developing both Table RAI4-2 and Table RAI4-3, and
5. Why does the use of a non-zero value for CTE produce conservative values of scale factors in Table RAI4-4?

Response:

e1. The contact pressures in Table RAI4-2 were the mean of the radial stresses in the elements on the outside surface of the sleeve and tube from the slice models. The contact pressures in Table RAI4-3 were obtained using the thick shell interaction equations as discussed in (c) above with the ΔDs from the slice models. The thick shell interaction equations assume intimate and continuous contact across the interfaces whereas a gap is initially present in the slice model analysis (tube and sleeve starts out circular) for the eccentric cases. Therefore, it is expected that the contact pressures in Tables RAI4-2 and RAI4-3 would differ.

e2. The contact pressures in Table RAI4-3 were obtained using the thick shell interaction equations as discussed in (c) above with the ΔDs from the slice models. The scale factors in Table RAI4-3 were selected so that the ratios of the contact pressures for the eccentric cases to the non-eccentric contact pressures matched the corresponding ratios in Table RAI4-2.

e3. The CTE for the tubesheet collar was set to zero for all slice models and for developing Tables RAI4-2 and RAI4-3.

e4. The CTE for the tubesheet collar was set to zero in the calculations for both Tables RAI4-2 and RAI4-3.

e5. Table RAI4-4 is simply a summary of the scale factors from Table RAI4-3 that are necessary to match the contact pressure ratios from Table RAI4-2. For example, the stress ratio in Table RAI4-2 for an initial eccentricity of 0.0002 is [ ]^{a,c,e}. From Table RAI4-3, for an initial eccentricity of 0.0002, the scale factor that produces a contact pressure ratio of [ ]^{a,c,e} is [ ]^{a,c,e}. On Table RAI4-4, for an "Initial Delta Dia." of 0.0002, the scale factor , [ ]^{a,c,e}, and the pressure ratio, [ ]^{a,c,e}, are transcribed from Table RAI4-3. The eccentricity columns on Table RAI4-4 are true eccentricity values [$(D_{max}-D_{min})/D_{nom}$] based on the initial and final eccentricity values from Table RAI4-3. D_{nom} = [ ]^{a,c,e} inch.

f. ***Item five near the top of page 18 of Reference 2 states that the slice model provides the input for using the scale factor relationship (eqn. RAI4-1). This differs from the NRC staff's understanding from Section 6.3 of Reference 1 that it is the eccentricities and delta Ds from the 3-D finite element analyses (or the axisymmetric model in previous analyses) that are actually used as input in eqn. RAI4-1. Please clarify this apparent discrepancy.***

Response

The slice model results are the input for the correlation between eccentricity and scale factor. That correlation was then used to determine the scale factor to be used in calculating contact pressure in the H* calculator spreadsheet (see Figure 1-1 of Reference 6) based on the input eccentricities and ΔDs from the 3-D finite element analyses.

Question 2

On page 9 of Reference 2, it is stated that the polynomial fit between initial eccentricity and scale factor (old eccentricity model) was appropriate for the conditions for which it was developed, but leads to physically impossible results when extrapolated significantly outside its "data basis" such as was in the case for the steam line break (SLB) conditions for the Model D-5 SGs. This apparently refers to the fact that the old eccentricity model was based on the application of a temperature loading of 500 degrees F to the slice model whereas the tube and the tubesheet temperatures during SLB for Model D5 SGs is substantially less than this value. The NRC staff has the following questions: (in italic, following the "General Response)

General Response:

In aggregate, the following sub-questions challenge if the scale factor model is prototypic of any SG design and are applicable to any SG at any condition. The scale factor model was created as an Engineering approximation to address a generic question: "How does tubesheet bore eccentricity affect the contact pressure between an expanded sleeve and the tube, compared to a non-deformed tubesheet bore?" No attempt was made to prototypically represent an SG other than to simulate a tubesheet unit cell with tube and sleeve included and to utilize an assumed range of bore eccentricity (defined as $D_{max} - D_{min}$) that might be expected in the tubesheet under all operating conditions. While responses to the specific sub-questions are provided below, it is important to recognize that the scale factor model is only a mechanism to evaluate the effect of bore eccentricity on contact pressure. The scale factor model is, in fact, a collection of models that differ only in their unloaded geometry, with the base model being a circular sleeve in a circular tube in a circular tubesheet collar. The only link to a prototypic SG is the range of assumed initial eccentricity, although the dimensions of the tubesheet collar (relatively unimportant for the intended purpose) were chosen to simulate the stiffer tubesheet compared to the tube and sleeve.

a. The slice model used to develop Table RAI4-2 considered a 500 degree F expansion of the tube and the sleeve, but no temperature expansion of the tubesheet. The NRC staff notes that this is not prototypical for either model SG under any condition. What is the rationale for saying the SLB temperatures for Model D5 SGs are outside the "data basis" for the old eccentricity model, but that the normal operating temperatures for the Model F and D5 SGs and SLB temperature for Model F SGs are consistent with the data basis? This question references Table RAI4-2 only, since the staff is unclear about what tubesheet temperature expansion was assumed in Table RAI4-3 (see question 1.e above).

Response:

As noted in the response to question 1 above, the CTE for the tubesheet was zero for all slice models and for developing Tables RAI4-2 and RAI4-3. However, the appropriate values for Modulus of Elasticity (E) of the tube/sleeve <u>and tubesheet</u> at 570°F are used in the determination of contact pressures in Tables RAI4-2 and RAI4-3.

The assumptions used to develop contact pressures using the slice model are not intended to be prototypical of any SG condition. The sole purpose of the development of the slice model was to determine the effect on contact pressure between the sleeve and tube, and between the tube and tubesheet of tubesheet tube bore "out-of-roundness." This consisted of generating a series of finite element (FEA) models (slice models) with varying degrees of eccentricity in the inner diameter of the tubesheet hole. (Note that the OD of the collar remained circular for all cases of eccentric ID.) A benchmark for contact pressures was established using these slice models for various assumed values of initial eccentricity (D_{max}-D_{min}). (Initial eccentricity refers to the geometry of the unloaded model.) The benchmark values of contact pressure and their ratios to the zero-eccentricity case are shown on Table RAI4-2.

By varying the assumed scale factors (see Equation RAI4-1) and using the "thick-shell" equations that are used in the H* calculations, a set of contact pressures and contact pressure ratios to the zero-eccentricity case are calculated that relate the scale factors to contact pressure ratios (Table RAI4-3). By matching the contact pressure ratios from the thick-shell equations to those from the slice model, the appropriate scale factor is determined for each value of initial eccentricity (D_{max}-D_{min}). The applicable scale factors that match the stress ratios on Table RAI4-1 of Reference 5 are then fit as a polynomial so that the appropriate scale factor can be selected for any input value of eccentricity. A third-order polynomial provided the best fit. The resulting scale factors are used in the H* calculation spreadsheet (See Figure 1-1 of Reference 6) for use in calculating the final contact pressures. The effect of eccentricity, resulting from tubesheet bow, is subtracted from the effect of pressure and temperature on tube-to-tubesheet contact pressure that is calculated through the use of the thick shell equations in the H* calculation spreadsheet (See Figure 1-1 of Reference 6).

Neither the original axisymmetric FEA model nor the 3-D FEA (tubesheet complex structural model) results for ΔD and eccentricity at different condition specific temperatures were used directly as inputs to the original scale factor model (sleeve, tube and collar) relationships. The scale factor curve was developed using the original slice model and assuming a set of displacements (ΔD) that represented the expected range of these parameters from the axisymmetric model of the tubesheet complex. As noted above, the slice model was not intended to prototypically represent the actual tubesheet conditions; rather, the slice model was intended to provide the input data to determine the scale factor relationship with various levels of ΔD and eccentricity.

The original scale factor model (slice model) was revised following receipt of the NRC questions (Reference 1) as follows:

- the sleeve was removed from the model;
- the loading conditions were changed from a single temperature increase (500°F) to multiple temperature increases that cover the expected range of normal operating and accident condition for the SGs that are H*candidates;
- an increased range of eccentricity was applied in the development of the scale factor relationship to test the limits of applicability of the model.

Because the original scale factor calculations were based on only a single loading condition, a 500°F temperature increase on the model as discussed in the response to Question 1, additional loading conditions representative of expected normal operating procedure (NOP) and design basis accident (DBA) temperature conditions were considered with the scale factor models to determine the sensitivity

of the model to the loading conditions. The calculations were made using the revised scale factor model, e.g., the sleeve was removed from the model.
Separate scale factor relationships were developed for each model SG (D5, F, 44F, 51F) using the following loading conditions:

Initial D_{max}-D_{min} (in.)	ΔT (°F)					
	142	230	350	430	530	558
0	x	x	x	x	x	x
2.00E-04	x	x	x	x	x	x
4.00E-04	x	x	x	x	x	x
1.00E-03	x	x	x	x	x	x
2.00E-03	x	x	x	x	x	x
4.00E-03	x	x	x	x	x	x
1.00E-02	x	x	x	x	x	x

These loading conditions envelop the temperature conditions developed during all plant conditions as well as the range of tubesheet bore hole eccentricity calculated using the 3-D finite element analysis of the tubesheet.

Figure RAI2-1 (below) provides a comparison of the original scale factor relationship curve (sleeve included in the model) to the scale factor relationship using the revised scale factor model (sleeve removed from the model) at several temperatures (628°F, 600°F, 500°F, 420°F, 300°F and 212°F) using the final eccentricity. (Final eccentricity refers to the eccentricity after the model has been loaded.) As is shown in Figure RAI2-1, for the same final eccentricity, the scale factors increase at lower temperatures. The scale factor model approach fails above certain eccentricities at the different temperatures because complete loss of contact pressure around the circumference of the tube is calculated to occur. The calculated scale factors begin to decrease when loss of contact pressure is predicted by the model. For this reason, the curves in Figure RAI2-1 are truncated at the highest point of average contact pressure around the tube circumference. Only the data points for which positive contact pressure is predicted are used for determining the scale factor equations for the curved shown in Figure RAI2-1. The maximum eccentricities as a function of temperature for applicability of the scale factor model to the Model D5 SG are shown in Figure RAI2-2. Similarly, the maximum eccentricities as a function of temperature for applicability of the scale factor model to the Model D5 SG are shown in Figure RAI2-3.

(It is noted that loss of contact pressure around the circumference of the tube is shown not to occur when using the more realistic square cell model originally discussed in Section 6.2.5 of Reference 6).

a,c,e

Figure RAI2-1 Revised D5 Scale Factor vs. Final Eccentricity Relationship

a,c,e

Figure RAI2-2 Scale Factor Model Applicability Limits on Final Eccentricity – Model D5 SG

[ ]a,c,e

Figure RAI2-3 Scale Factor Model Applicability Limits on Final Eccentricity – Model F SG

Tables RAI2-1 through RAI2-3 show the results for contact pressure and cumulative force using the revised scale factor versus eccentricity relationship (based on the model without the sleeve as shown in Figure RAI2-1). Tables RAI2-1, 2-2 and 2-3 are provided to permit a direct comparison of the revised scale factor versus eccentricity relationship on tube-to-tubesheet contact pressure as a function of tube bundle radius and elevation (Tables 6-25, 6-26 and 6-27 of Reference 6).

Table RAI2-4 provides a comparison of the predicted H* lengths based on the use of the revised scale factor model compared to the original scale factor model. The results on this table assume that the H* calculations are performed exclusively using the scale factor approach (i.e., the square cell model is <u>not</u> used); thus, the SLB condition is the apparent limiting condition for the Model D5 SG. However, when the limits of applicability of the scale factor approach are considered (see above), the scale factor approach implies lack of contact, in other words, it relies on a point to the right of the inflection point on the scale factor vs. eccentricity curve (Figure RAI 2-1) which is not considered to be physically possible. (Application of the square cell model shows that there is no loss of contact pressure, thus confirming the defined limit of applicability of the scale factor model.)

Referring to Table RAI2-4 in this document and Table 6-25 of Reference 6, changing the scale factor versus eccentricity relationship to remove the presence of the sleeve and to apply a temperature specific condition results in a maximum increase in H* length at normal operating conditions of less than 4.3% ([ ]^{a,c,e} inch). This is also the case for the postulated FLB condition (Table RAI2-4, and Table 6-27 of Reference 6) where the maximum increase in mean H* length is [ ]^{a,c,e} inch (9.2%). The most significant effect is for the postulated SLB event (Table RAI 2-4, and Table 6-26 of Reference 6) for which the maximum increase in mean H* length is [ ]^{a,c,e} inch (15.2%) at a radial position removed from the limiting radial position. When considering the radial location of the limiting H* values (i.e., at 26.703 inches radius), the absolute increases in the predicted H* length with the revised scale factor model are very small, approximately [ ]a,c,e inch for the apparent limiting condition (SLB) when only the scale factor approach is considered. It is concluded that the presence of the sleeve in the original scale factor model is not significant even if it is assumed that application of the scale factor model for all conditions is appropriate.

Table RAI2-1: Revised Scale Factor Model; Model D5 Mean Contact Pressure Distributions for NOP, Low T_{avg} Condition

	P	Q	R	S	T	U	V	
4	**Elevation**	**Pressures (psi) at TS Radii (in). w/o Residual**						
5	(Top to Bottom)	4.437	10.431	18.139	26.703	42.974	49.825	a,c,e
6	0.000							
7	2.000							
8	4.000							
9	6.000							
10	10.515							
11	16.901							
12	19.030							
13	20.030							
14	21.030							
15								
17	**Forces Accumulated from Top of Tubesheet**							
18		**Normal Forces (lbs.)**						
19		4.437	10.431	18.139	26.703	42.974	49.825	a,c,e
20	Delta P Force (lbs.)							
21	Force Req (lbs.)							
22	Pull Out Test (lb/in)							
23								
24	**Elevation (from top)**	**Cumulative Force from Top of Tubesheet**						
25	0.000							a,c,e
26	0.500							
27	1.000							
28	2.000							
29	3.000							
30	4.000							
31	6.000							
32	8.000							
33	10.515							
34	12.000							
35	16.901							
36	19.030							
37	20.030							
38	21.030							
	H* w/BET							

Table RAI2-2: Revised Scale Factor Model: Model D5 Mean Contact Pressure Distributions for SLB Condition

a,c,e

	AF	AG	AH	AI	AJ	AK	AL
4	**Elevation**	**Pressures (psi) at TS Radii (in). w/o Residual**					
5	**(Top to Bottom)**	4.437	10.431	18.139	26.703	42.974	49.825
6	0.000						
7	2.000						
8	4.000						
9	6.000						
10	10.515						
11	16.901						
12	19.030						
13	20.030						
14	21.030						
15							
16							
17	**Forces Accumulated from Top of Tubesheet**						
18		**SLB Forces (lbs.)**					
19		4.437	10.431	18.139	26.703	42.974	49.825
20	Delta P Force (lbs.)						
21	Force Req (lbs.)						
22	Pull Out Test (lb/in)						
23							
24	**Elevation (from top)**	**Cumulative Force from Top of Tubesheet**					
25	0.000						
26	0.500						
27	1.000						
28	2.000						
29	3.000						
30	4.000						
31	6.000						
32	8.000						
33	10.515						
34	12.000						
35	16.901						
36	19.030						
37	20.030						
38	21.030						
	H* w/BET						

a,c,e

a,c,e

Table RAI2-3: Revised Scale Factor Model: Model D5 Mean Contact Pressure Distributions for FLB, Low T_{avg} Condition

	P	Q	R	S	T	U	V	
4	**Elevation**	**Pressures (psi) at TS Radii (in). w/o Residual**						a,c,e
5	**(Top to Bottom)**	4.437	10.431	18.139	26.703	42.974	49.825	
6	0.000							
7	2.000							
8	4.000							
9	6.000							
10	10.515							
11	16.901							
12	19.030							
13	20.030							
14	21.030							
15								
17	**Forces Accumulated from Top of Tubesheet**							
18		Normal Forces (lbs.)						
19		4.437	10.431	18.139	26.703	42.974	49.825	a,c,e
20	Delta P Force (lbs.)							
21	Force Req (lbs.)							
22	Pull Out Test (lb/in)							
23								
24	**Elevation (from top)**	**Cumulative Force from Top of Tubesheet**						
25	0.000							a,c,e
26	0.500							
27	1.000							
28	2.000							
29	3.000							
30	4.000							
31	6.000							
32	8.000							
33	10.515							
34	12.000							
35	16.901							
36	19.030							
37	20.030							
38	21.030							
	H* w/BET							

Table RAI2-4: Comparison of Calculated Mean H* Lengths between Original Scale Factor Relationship and Revised Scale Factor Relationship (Model D5 SG)

Model D5 SG	Calculated H* Lengths (w/o BET) in. (Note 1)					
	Tubesheet Radius (in)					
	4.437	10.431	18.139	26.703	42.974	49.825
Old Ecc NOP H* (Low Tavg)						
New Ecc NOP H* (Low Tavg)						
Increase in H* Length (inch)						
Old Ecc SLB H*						
New Ecc SLB H*						
Increase in H* length (inch)						
Old Ecc FLB H*						
New Ecc FLB H*						
% Increase in H* Length (inch)						
Notes: 1. Calculated mean H* values for the Model D5 SGs 1. "Old Ecc"= Original Slice Model including sleeve; "New Ecc"=Revised Slice Model without sleeve						

a,c,e

Figures RAI2-4 and RAI2-5 show that the range of eccentricities evaluated for the different plant conditions for the model D5 SGs are generally within the limits of the scale factor model for eccentricity for the mean H* case. The data shown in Figures RAI2-4 and RAI2-5 apply for the worst sector of the bundle (see Section 6.2.3 of Reference 6) over all tubesheet radii and all depths through the tubesheet taken from the analysis of record. From Figures RAI2-4 and RAI2-5, for both normal operating conditions and SLB conditions for the Model D5 SG, the maximum eccentricity that occurs is approximately [ ]^{a,c,e} in/in. Referring to Figure RAI2-2, the maximum eccentricity for application of the scale factor model is [ ]^{a,c,e} in/in at 300°F and approximately [ ]^{a,c,e} in/in at 600°F, respectively. For each temperature condition, the calculated eccentricities are tightly clustered. Therefore, the actual predicted maximum eccentricity for the Model D5 at both SLB conditions (300°F) and normal operating conditions (600°F) are within the defined limit of applicability of the scale factor model.

Figures RAI2-6 and RAI2-7 show the range of eccentricity evaluated for the different plant conditions for the Model F SGs. For the Model F SG, for normal operating conditions, the range of eccentricities (maximum of [ ]^{a,c,e} in/in) is within the limiting value of approximately [ ]^{a,c,e} in/in. For the Model F SLB case, the maximum eccentricity exceeds the applicable range of the scale factor model ([ ]^{a,c,e} in/in > [ ]^{a,c,e} in/in).

Summary of Question 2(a) Response

The impact of the presence of the sleeve and the use of a temperature dependent scale factor on the H* analysis has been evaluated and has been determined to be very small. Table RAI2-4 provides a comparison of the calculated H* lengths as a function of tubesheet radius between the original scale factor versus eccentricity relationship (with sleeve present) and the revised relationship (sleeve removed) for the Model D5 SGs for NOP, SLB and feedline break (FLB) conditions. The absolute change in the H* length is small; the largest change in H* length occurs for the "colder" SLB condition for the Model D5 steam generators.

These results are based on application of only the scale factor models with, and without, the sleeve in the model. It is anticipated that application of the square cell model, modified from the original discussion of it in Reference 6 to address the questions raised by the NRC regarding it, will show that the results of applying the scale factor model are conservative. The square cell model is considered to be the best available calculation method for contact pressure between the tube and the tubesheet.

The scale factor model results become unrealistic above certain eccentricities at different temperatures because loss of contact pressure around the circumference of the tube is predicted to occur. The scale factor correlations start to decrease at approximately this point. For the Model D5 SG, for normal operating conditions, the range of eccentricities are within the limits of the scale factor model approach for eccentricity for the mean H* case ([ ]^{a,c,e} in/in < [ ]^{a,c,e} in/in). This is also the case for the "colder" SLB conditions, where the maximum eccentricity that occurs is approximately [ ]^{a,c,e} in/in at the top of the tubesheet surface which is less than the limiting eccentricity of [ ]^{a,c,e} in/in. For the Model F SG, for normal operating conditions, the range of eccentricities (a maximum of [ ]^{a,c,e} in/in) is within the limiting value of approximately [ ]^{a,c,e} in/in. For the SLB case, the maximum eccentricity exceeds the applicable range of the scale factor model ([ ]^{a,c,e} in/in > [ ]^{a,c,e} in/in). The actual eccentricity values are taken from the analysis of record, that is, the calculation spreadsheets that support the technical justification contained in WCAP-17072-P.

a,c,e

Figure RAI2-4 Model D5 Eccentricity Distribution – NOP Low T_{avg}

a,c,e

Figure RAI2-5 Model D5 Eccentricity Distribution - SLB

a,c,e

Figure RAI 2-6 Model F Eccentricity Distribution – NOP

a,c,e

Figure RAI2-7 Model F Eccentricity Distribution – SLB

b. The data basis for the old eccentricity model does not include pressure loadings. What is the rationale for concluding that actual pressure conditions do not represent an extrapolation significantly outside the data basis?

Response:

It is correct that the old eccentricity model (included in the current licensing basis) does not include pressure loading as discussed in the response to part (a) of this question. Because the intent of the slice model is only to provide a method for assessing the effect of eccentricity on contact pressure, with no intent to prototypically represent the actual SG conditions, application of pressure in the model is not necessary.

The tubesheet structure is massive and relatively rigid compared to the tube. The equivalent material properties approach for the perforated plate includes both temperature and pressure conditions on the tubesheet, but does not consider tube internal pressure loading. Section 6.2.4 of Reference 6 discusses the tubesheet bore deformation under various conditions of tube internal pressurization (i.e., plugged tubes surrounding an active tube) and concludes that the limiting case is that in which all tubes are active and pressurized. Given that each tube bore is surrounded by six other tube bores, little bore dilation/eccentricity would be expected if tube internal pressure were applied. Calculations with the axisymmetric model (and later, the 3D FEA model) showed that the principal source of tubesheet deflection was thermal loading and that application of pressure loading, in comparison, did not significantly increase the local deflections. From this, it was judged that the tube internal pressure induced loading could be ignored for the purpose of defining the scale factors.

c. The old eccentricity model considered a sleeve to be present, which is not the case for the plants in question. The assumed presence of a sleeve is tantamount to considering a tube which has twice the radial stiffness of an un-sleeved tube. What is the rationale for concluding that the use of the actual radial stiffness of the un-sleeved tubes does not represent an extrapolation significantly outside the data basis?

Response:

Please see the response to item (a) of this question.

The sleeve has been removed from the slice model and new scale factors for a range of temperatures and an increase range of eccentricities were calculated. The revised scale factors were applied in the re-analysis of the mean H* for the Model D5 SGs (see Table RAI2-4) as presented in the plan of approach during the January meeting (Reference 2).

The results from the revised slice model (sleeve removed) for the Model D5 SGs demonstrate a negligible impact on the mean H* distance as well as contact pressure during all plant conditions. A maximum increase in mean H* length of [ ]^{a,c,e} inch occurs at a non-limiting tubesheet radius (49.825 inches) occurs at NOP conditions. A maximum increase in mean H* length of [ ]^{a,c,e}inch at radius 26.7 inches occurs during a postulated SLB.

d. The old eccentricity model, including the third order polynomial expression for scale factor, was developed for eccentricity values ranging to a maximum as given in Table 6-20 of Reference 1. This value comes close to bounding the maximum eccentricities calculated by the 3-D finite element models for Model D5 under normal operating and SLB conditions. However, this value is less than half of the calculated eccentricities from the 3-D finite element analysis for the Model F SGs. Whereas the maximum scale factor for Model D5 SGs for SLB just slightly exceeds the maximum value in the "data basis", Table 6-20 in Reference 1, and the maximum value of scale factor for the Model F SLB case is well beyond the "data basis." Why do such wide extrapolations from the data basis for Model F SGs lead to conservative results?

Response:

Similar relationships for scale factor versus eccentricity as presented above for the Model D5 SG have been developed for the Model F SG as a function of temperature. Figure RAI2-8 shows that approximately the same limits of applicability apply for the Model F SGs as those that apply to the Model D5 SGs. For the Model F, the limits of applicability of the scale factor model are eccentricities up to 2E-3 in/in for normal operating conditions and [ ][a,c,e] in/in for SLB conditions (See Figure RAI 2-8). As reported in Table RAI4-1 in the response to question 4 below, the maximum eccentricity that occurs in the limiting Model F plant in the H* fleet during NOP conditions is calculated to be [ ][a,c,e] in/in and [ ][a,c,e] in/in for SLB conditions, located at the bottom of the tubesheet

a,c,e

Figure RAI2-8 F Tube/Tubesheet Scale Factor as a Function of Temperature (sleeve removed from model)

Question 3

Reference 2 at the top of page 19 states, "The results from the "slice" model cannot be linearly scaled to lower temperatures because the method of superposition has been shown during the development of the current H* analysis to not apply to the non-linear combination of materials and loading in the lower SG complex." Is the old eccentricity model entirely based on the slice model and not the axisymmetric model of the lower SG complex? Assuming the NRC staff's understanding is correct; explain why the results of the slice model are not scalable to lower temperatures.

Response:

As noted in the response to NRC Question 1(a) above, the old eccentricity model is entirely based on the slice model and not the axisymmetric model of the lower SG complex.

Temperature dependent relationships between scale factor and eccentricity have been developed for the Model D5 and Model F SG based on the slice model. [See Figure RAI2-1 (Model D5 SG) and Figure RAI2-8 (Model F SG)]. These figures show that the characteristics of the scale factor relationships at different temperatures are different. If the results were scalable in temperature, a series of parallel curves would be expected.

As discussed previously, the limit of applicability of the slice model varies by temperature. As temperature is reduced, the degree of tubesheet bore hole eccentricity that can be accommodated by the scale factor model is also reduced.

Question 4.

Table RAI4-1 in Reference 2 is accompanied by the "original Table RAI4-4." Explain the differences between these two tables. For example, the original Table RAI4-4 shows an average eccentricity for Model F SGs for normal operating conditions which appear different from the average eccentricity data in Table RAI 4-1.

Response:

To clarify the information provided in Tables RAI4-1 and RAI4-4, the definitions of the headings with calculated values in each table are provided below:

Definition of Table RAI4-1 Column Headers	
Table RAI4-1 Header	Definition
Avg. Eccentricity Data	Represents the average value of eccentricity of all the tubesheet holes along a line perpendicular to the divider plate at a constant axial elevation (i.e., the bottom tubesheet surface (0.0"), the neutral axis (10.515"), and the top of the tubesheet surface (21.03")). Each individual tubesheet hole eccentricity is equal to the difference between the maximum change in tubesheet hole diameter, D, which may occur in either the radial (ΔD, 0°) or circumferential (ΔD, 90°) direction and the minimum change in tubesheet hole diameter, D, which also may occur in either the radial (ΔD, 0°) or circumferential (ΔD, 90°) direction, at a radius, R, from the center of the tube bundle. This difference is then divided by the nominal tubesheet hole diameter. The average eccentricity data is calculated for both normal operating and SLB conditions.
Max. Eccentricity Data	Represents the maximum value of eccentricity that is calculated for all the tubesheet holes along a line perpendicular to the divider plate at a constant axial elevation (i.e., the bottom tubesheet surface (0.0"), the neutral axis (10.515"), and the top of the tubesheet surface (21.03")). The maximum eccentricity data is provided for both normal operating and SLB conditions at the identified elevations.
Avg. ΔD	Represents the average value of all of the radial (ΔD, 0°) and circumferential expansions (ΔD, 90°) of the tubesheet holes of diameter, D, at a constant elevation (i.e., the bottom tubesheet surface (0.0"), the neutral axis (10.515"), and the top of the tubesheet surface (21.03")). The average value is provided for both normal operating and SLB conditions at the identified elevations.
Max. ΔD	Represents the maximum value of all of the radial (ΔD, 0°) and circumferential expansions (ΔD, 90°) of the tubesheet holes of diameter, D, at a constant elevation (i.e., the bottom tubesheet surface (0.0"), the neutral axis (10.515"), and the top of the tubesheet surface (21.03")). The maximum value is provided for both normal operating and SLB conditions at the identified elevations.
Eccentricity, e (in/in)	Represents the maximum, minimum and average values of eccentricity of all

	the tubesheet holes along a line perpendicular to the divider plate at the top of the tubesheet surface (21.03") at both normal operating and SLB conditions. Each individual tubesheet hole eccentricity is equal to the difference between the maximum change in tubesheet hole diameter, D, which may occur in either the radial (ΔD, 0°) or circumferential (ΔD, 90°) direction and the minimum change in tubesheet hole diameter, D, which also may occur in either the radial (ΔD, 0°) or circumferential (ΔD, 90°) direction, at a radius, R, from the center of the tube bundle. This difference is then divided by the nominal tubesheet hole diameter.
ΔD, 0°	Represents the maximum, minimum and average values of all radial (ΔD, 0°) expansions of the tubesheet holes of diameter, D, at the top of the tubesheet surface (21.03")).
ΔD, 90°	Represents the maximum, minimum and average values of all circumferential (ΔD, 90°) expansions of the tubesheet holes of diameter, D, at the top of the tubesheet surface (21.03")).

The source of the values on Tables RAI4-1 and RAI4-4 are the H* calculations of record for the Models F and D5 steam generators. In the process of transferring the data to the tables, transcription errors occurred on both tables. On Table RAI4-1, the only value that changed is shown in bold type.

Table RAI4-1: Summary of Model D5 and Model F NOP and SLB Eccentricity Results

SG Model	Elev.	Avg. Eccentricity Data		Max. Eccentricity Data		Avg. Δ D		Max. Δ D	
-	Above BTS[1]	NOP	SLB	NOP	SLB	NOP	SLB	NOP	SLB
-	in	in/in	in/in	in/in	in/in	in	in	in	in
F									
F									
F									
D5									
D5									
D5									
F									
D5									

a,c,e

An updated "Original Table RAI4-4" from Reference 5 is provided as the following table:

Revised "Original Table RAI4-4" from Reference 6					
			Eccentricity, *e*	Δ D, 0º	Δ D, 90º
Plant	Condition	Value	inch/inch	inch	inch
Byron	SLB	MAX			
Byron	SLB	MIN			
Byron	SLB	AVG			
Millstone	SLB	MAX			
Millstone	SLB	MIN			
Millstone	SLB	AVG			
Byron	NOP	MAX			
Byron	NOP	MIN			
Byron	NOP	AVG			
Millstone	NOP	MAX			
Millstone	NOP	MIN			
Millstone	NOP	AVG			
Data source: Analysis spreadsheets of record for Model F and Model D5 SGS (1) Tubesheet hole in the radial direction is reduced					

a.c.e

Referring to Tables RAI4-1 and Table RAI4-4, only the data at the 21.03 inch elevation above the bottom of the tubesheet can be compared. Also, only the data in columns labeled Avg. Eccentricity Data, Max. Eccentricity Data, and Max. ΔD in Table RAI 4-1 can be directly compared with the data included in Table RAI 4-4.

Concerning the difference cited by the NRC staff between the original Table RAI4-4 which shows an average eccentricity for Model F SGs for normal operating conditions which is different from the average eccentricity data in Table RAI 4-1, Table RAI4-1 contains eccentricities from more than one elevation within the tubesheet (21.03 inches from the bottom of the tubesheet (BTS), 10.515 inches from the BTS, and at the bottom of the tubesheet). The "original Table RAI4-4" provides results for only a single elevation, i.e., the TTS.

The maximum tubesheet bore distortions occur at the top of the tubesheet (21.03 inches above the bottom of the tubesheet). The "Original Table RAI4-4" is a summary of the maximum, minimum and average eccentricities for Byron/Braidwood (Model D5) and Millstone (Model F) as calculated based on the radial deflection of the tubesheet (U_R) result from the 3-D lower SG complex model <u>at the top of the tubesheet only</u>.

For example, the average Millstone (Model F SG) eccentricity value of [ ]^{a,c,e} in/in for normal operating conditions included in "revised Table RAI4-4" is the tubesheet radial average eccentricity value that occurs at the top of the tubesheet elevation only. On Table RAI4-1, the average NOP eccentricity value for the Model F SGs ([ ]^{a,c,e}) represents the average of the average eccentricities that occur at the elevations 21.03 inches from the BTS, 10.515 inches from the BTS and at the BTS ([ ]a,c,e in/in+[ ]a,c,e in/in+[ ]a,c,e in/in)/3=[ ]a,c,e in/in).

The data in the column labeled as Avg. ΔD in Table RAI4-1 cannot be compared with the average ΔD values in Table RAI4-4 because the data in the column labeled Avg ΔD in Table RAI4-1 represents the combined average of the ΔD values that occur in both the radial and circumferential directions. The average ΔD values included in Table RAI4-4 are calculated separately for the radial and circumferential directions.

Question 5

Regarding Table RAI 4-5 of Reference 2:

- ***a.*** ***What are the temperature inputs (step five) for each case?***
- ***b.*** ***What are the displacements of the horizontal and vertical edges of the cell model after each of the steps four through nine?***
- ***c.*** ***Are the E-bar displacements added to the displacements existing after step five, or do the applied E-bar displacements replace the displacements existing after step five? Why aren't the applied E-bar displacements over-restraining the model? The NRC staff notes that the applied E-bar displacements do not allow for further displacement of the upper and lower edges during steps seven through nine, tending to maximize the contact stresses. Would it be more realistic to apply force boundary conditions (rather than displacement boundary conditions) to the horizontal edges of the cell models to achieve the desired eccentricity?***
- ***d.*** ***What are the displacement boundary conditions (applied after step six) that are applied to the sides of the square cell? Free to displace? Zero displacement?***
- ***e.*** ***Provide an expanded version of Table RAI 4-5 which shows the average, maximum and minimum contact pressures as a function of E-bar for steps five through nine as defined in Figure RAI 4-2.***
- ***f.*** ***Contact pressure seems to reach essentially zero for eccentricity values that are only one-fourth of the maximum values calculated by the 3-D finite element model, as shown in Table RAI 4-1, for Model F SGs and one-third for Model D5 Sgs. Why does this not apply as a loss of contact between the tube and the tubesheet at locations where the 3-D finite element model is predicting relatively high eccentricities? A related question pertains to item two on page 21 of Reference 2 which states that eccentricities from the unit cell model are "generally comparable" to those from the 3-D finite element analysis model. Explain the apparent discrepancy between the words "generally comparable" and how the unit cell eccentricities in Table RAI 4-5 actually compare to 3-D FEA eccentricities. Explain how the unit cell model adequately addresses the actual eccentricities of the 3-D FED Model.***

Response:

As requested in Reference 4, the final description of the square cell model in support of a permanent H* amendment will address the fundamental concerns identified in this RAI.

Question 6

Provide information as needed to reconcile Table RAI4-6 with Table RAI4-1 in Reference 2. For example, the eccentricities in line one of Table RAI4-6 for Model F don't match eccentricities in Table RAI4-1. The NRC staff has the same question about the average delta Ds in the two tables, although in this case the differences are minor. Also, explain why the average contact pressures in line two of RAI 4-6 do not match those in Table 6-25 of Reference 1.

Response:

The title of Table RAI4-6 states that the table is based on the H* calculation process as shown in Figure 1 of Reference 3, which includes the scale factor model. The table is, in fact, based on both analysis using the 3D FEA Model and the unit cell model.

The results provided in Table RAI4-6 of Reference 2 (i.e., NRC Reference 2) were all calculated at 2 inches below the top of the tubesheet. The values of ΔP account for the region of interest at the top of the tubesheet where the maximum eccentricity in the tubesheet is expected and where the crevice fluid is transitioning from crevice conditions to the secondary side fluid conditions. The region roughly 2 inches below the top of the tubesheet is also where a significant portion of the T/TS contact pressure develops; therefore, it is a good indicator of trends in the effect that different operating conditions have on the contact pressure. Therefore, for consistency, all values for eccentricity, average contact pressure, and average ΔD included in Table RAI4-6 were provided for a distance 2 inches below the top of the tubesheet.

Eccentricities and ΔDs are not provided in Table RAI4-1 at an elevation 2 inches below the top of the tubesheet. It is not expected that the values of eccentricities and ΔDs on these tables should match.

In regard to the correspondence of values between Table 6-25 of Reference 1 (i.e., NRC Reference 1) and Line 2 of Table RAI4-6, please note that the values match for the same location. For example, the values for contact pressure provided in line 2 of Table RAI4-6 correspond to the values provided in Table 6-25 (Limiting Radius – Model F – Ref. 6-15). The values in Table 6-25 of WCAP-17071-P at two inches below the top of the tubesheet are 1698.4 psi for NOP conditions and 2427.4 psi for SLB conditions, respectively.

Question 7

The bullet at the bottom of page 19 of Reference 2 states, "To address if tube to tubesheet contact continues for all assumed tubesheet displacements, the appropriate reference condition is the initialized condition (after step four) of the model that simulates a tube expanded in the tubesheet bore." Please clarify this sentence. Is it based on a premise that the residual contact pressures (introduced through steps one through four) are to be ignored? If not, explain why the statement is true? The NRC staff notes that the test of whether tube to tubesheet contact is maintained is whether positive contact pressure is maintained all around the circumference of the tube.

Response:

The square cell model was originally developed to demonstrate that the outer tube diameter surface maintains contact with the inner tubesheet bore surface during a wide range of conditions. The Model F operating conditions and geometry were used because they resulted in the lowest contact pressure estimates among all of the SG models under consideration. A variety of boundary conditions were applied to the model; the most limiting boundary conditions on the edges were used to determine the resulting contact pressure distribution around the circumference of the outer diameter of the tube. The most limiting contact pressures were those that kept the sides of the square cell even and the corners of the cell at 90 degrees without allowing for an inward reaction when forces were applied to achieve the desired displacement on the square cell edges. In other words, the sides of the square were not allowed to displace due to a Poisson contraction and the square cell was forced to remain in a rectangular shape (e.g., all corners maintained at right angles).

In the context of the original intent of the square cell model, that is, to demonstrate circumferential contact between the tube and the tubesheet as stated above, step 4 is the appropriate initial condition. The SGs are assembled at room temperature without a pressure differential across the tubesheet. Thus, the true initial condition for comparing effects of tubesheet deformations (i.e., bore deformations) is the post-hydraulic-expansion condition of the tubesheet. A number of conservative assumptions are included in this assessment, including the assumption of lower than specified expansion pressure and the assumptions noted above. It is physically not possible to have a zero post-expansion contact pressure, even assuming worst-case material properties and expansion properties. Variations in material conditions are limited by the material specifications; thus the extreme conditions considered in the probabilistic assessment are virtually impossible. Nevertheless, even if the material condition is assumed to be at the limits of the specifications, the expansion process still assures that the tube and tubesheet have some level of residual contact pressure. Therefore, it is true that the proper reference condition for the physically real condition is that condition after the expansion of the tube in the tubesheet.

The statement "To address if tube to tubesheet contact continues for all assumed tubesheet displacements, the appropriate reference condition is the initialized condition (after step four) of the model that simulates a tube expanded in the tubesheet bore" is not based on the premise that initial contact pressures (introduced through steps one through four) are to be ignored. The contact pressure studied in the square cell model that is included in the current licensing basis is generated by the residual installation effects and the applied pressure differential acting on the inside surface of the tube as well as differential thermal expansion between the tube and the tubesheet. The residual contact pressure generated by the hydraulic expansion process does not occur until the end of step 4. The unit cell model was initialized by simulating the tube expansion process in steps 1 through 4. The expansion process was conservatively simulated by applying a low value of expansion pressure (28000 psi) inside the tube, resulting in initial tube-to-tubesheet contact and an average residual contact pressure of 372 psi around the circumference of the tube. The loading at the end of step 4 is the same as in step 1, that is, no displacement or pressure load is applied to the model.

A separate square cell model will be developed as part of the plan presented to the NRC during the January 10, 2010 meeting that does not include any effects from tube expansion into the tubesheet. The results from this analysis will be provided at a later date and are expected to confirm that positive contact pressure is maintained around the entire circumference of the tube for the maximum bore eccentricities that are calculated to occur during all plant conditions using the 3D FEA Model.

Question 8

The bullet at the top of page 20 states, "To compare the results of the unit cell model with the 3-D FEA model, the appropriate reference condition of the unit cell model is the initial model (step zero) without the tube expansion simulated and thermal loads must be included." Please clarify this sentence. Does this statement refer to the bore diameter displacements and eccentricities, or does it refer to some other parameter? Do the bore displacements from step one to at least step five (if not step nine, depending the response to question 5.b above) of the unit cell model reflect the tube expansion process in steps one through four? If not, why? Is it primarily steps five and six that are intended to replicate the finite element analysis? If not, why? If yes, then why is step four not the appropriate reference condition for comparing the displacements from step six for purposes of comparison with the 3-D FEA displacements?

Response:

As noted in Reference 4, no additional work on this question is required.

Question 9

Figures RAI 4-5 for Model F and RAI 4-6 for Model D5 SGs shows the relationship between applied E-bar displacement and the resulting eccentricity of the tubesheet bore. The slope of the relationship changes sharply above the third data point and actually becomes negative for SLB. The discussion of these figures on page 20 of Reference 2 needs to be clarified or expanded to allow the NRC staff to understand the reason for these trends. For example, for the case of the SLB, explain how the increase in applied E-bar displacement can lead to a decrease in tubesheet bore eccentricity when all other variables, including temperature and pressure are held constant. This explanation should include the unit cell displacement diagrams showing both the E-bar displacements and the bore displacements for incrementally different values of E-bar above the third data point.

Response:

As noted in Reference 4, information provided to date is sufficient.

Question 10

Item one on page 21 of Reference 2 states, "The delta Ds from the 3D FEA model are significantly less than the corresponding delta Ds from the unit cell model from the unloaded to fully loaded condition...." Explain how this supports the conclusion in item one that the unit cell model displacement and contact pressure results conservatively represent the 3D FEA results. The NRC staff notes that the delta Ds from the unit cell model include the effects of pressure acting on the inside surface of the tube, whereas the 3-D FEA results do not. How do the incremental bore delta Ds from steps five and six of the unit cell model compare with the results of the 3-D FEA analysis? Does the comparison support the conclusion in item one?

Response:

The 3D FEA model applies an accepted technique for a perforated plate of applying equivalent material properties to represent the entire tubesheet without consideration of the presence of the tubes. In contrast, the unit cell model evaluates the local structure over the entire range of conditions that affect the interface between the tube and the tubesheet, including the expansion of the tube into the tubesheet (for results included in the current licensing basis). It is not realistically possible to compare the local displacements from the unit cell model with the global displacements from the 3D FEA models. The models are uniquely different for different purposes, with the purpose of the unit cell being to evaluate the local effects that cannot practically be included in the larger 3D FEA model. Therefore, direct numerical comparison between the 3D FEA and the unit cell model cannot be made.

From the results of the unit cell model it is evident that the contact pressures between the tube and the tubesheet are inversely related to tubesheet bore deformation: The larger the bore deformation, the smaller the contact pressure. If deformations predicted by the unit cell model are larger than those predicted by the 3D FEA model, one would conclude that the unit cell model is a conservative representation of the overall results from the 3D FEA model. Because the 3D FEA model is the underlying structural model for the H* analysis, the tubesheet bore deformations from this model are the fundamental basis of the analysis. Because the local 3D FEA deformations are smaller than those predicted by the unit cell model for a realistic representation of the local tube structure, it is concluded that the unit cell results must be a conservative prediction of the contact pressures. In addition, the original application of the square cell model did not include thermal effects but considered only the room temperature case. Because the tube expansion is demonstrably greater than the tubesheet expansion, excluding the temperature effect is inherently conservative.

Question 11

Should the words "bore eccentricities" in the first line of the last paragraph on page 28 of Reference 2 read "E-bar displacements"? If not, why not?

Response:

The NRC staff is correct; "bore eccentricities" should be replaced with "E-bar displacements."

Question 12

From the bottom of page 28 to page 33, of Reference 2, the text appears to discuss a new eccentricity analysis. This question does not need a response for Model F, Model 44F, and Model 51F SGs, provided this new eccentricity analysis will continue to play no role in the H* analysis for these SG models. The NRC staff has the following questions concerning this analysis.

- ***a. What are the specific objectives of this analysis?***
- ***b. Specifically, how is the analysis different from the analysis performed in the D5 White Paper (Reference 4)?***
- ***c. Describe the analysis in detail.***
- ***d. Provide a table of the results similar to RAI 4-5 in Reference 2, but expanded to include the information requested in question 5.e above.***
- ***e. The assumed delta T at the top of page 29 for the case of the Model D5 SLB does not appear to be consistent with what is assumed in the reference analysis in Reference 3 or what is assumed in Reference 4. Explain the apparent discrepancy.***
- ***f. Why does the analysis discussed in the first paragraph on page 29 consider a location 2 inches below the top of the tubesheet rather than the top of the tubesheet where eccentricities are generally higher? Why is consideration of the 2-inch location conservative from the standpoint of evaluating the eccentricity effect?***
- ***g. The term ""Figure RAI 4-10" is used for two different figures; on page 31 and page 32. This RAI will refer to the figure on page 32 as Figure 4-10a for clarity. The second paragraph on page 29 refers to Figure RAI 4-8 which appears to be an incorrect figure number. Is Figure 4-9 the correct figure number?***
- ***h. Regarding Figure RAI 4-9, it is unclear what the horizontal axis represents since the terms "relative tubedsheet displacement, e" is ambiguous. Is it eccentricity, D_{max}-D_{min}, or E-bar?***
- ***i. Is it correct that in the legend for Figure RAI 4-9, "H* Results – Old Fit" refers to the old eccentricity model discussed in Section 6.3 of Reference 1, "H* Results- New Fit" refers to the new eccentricity model discussed in Reference 4, and "Model D5 FEA Trend" refers to the most recent model discussed on pages 28 to 34 of Reference 2? If incorrect, provide the correct information.***
- ***j. The third paragraph on page 19 states that Figure RAI 4-9 shows contact pressure ratio as a function of E-bar. Should "RAI 4-9" read "RAI 4-10"?***
- ***k. Explain in detail how each of the curves in Figures RAI 4-9 and RAI 4-10 were determined.***

Response:

As noted in Reference 4, no additional work on this question is required.

Question 13

Provide an updated version of Table RAI 4-7 (Reference 2) showing the contact pressure reduction and final contact pressure as a function of eccentricity based on the "old eccentricity model" (Reference 1,

Section 6.3), "new eccentricity model" (Reference 4), and the latest eccentricity model (Reference 2). The table should include both Model F and model D5 SGs for normal operating and SLB conditions. The eccentricity cases should be those that can be cross-referenced with the updated versions of RAI 4-5 of Reference 2 requested in questions 5.e and 12.d above.

Response:

As noted in Reference 4, information provided to date is sufficient.

Question 14

The calculated H* distances in Reference 1 took no credit for residual contact pressure due to the hydraulic tube expansion process. Although calculated H* distances for the case where credit is taken for the residual contact pressure was provided in Reference 5, the NRC staff did not rely on these calculations when approving the interim H* amendment in Reference 6. Is it necessary to take credit for residual contact pressure to support a conclusion that the tubes remain in contact with the tubesheet for the full circumference of the tubes at all locations for normal operating and accident conditions? If so, provide rationale that there is sufficient residual contact pressure to support such a conclusion.

Response:

As noted in the response to Question 7, it is physically not possible to have zero residual contact pressure as a result of the limiting material and assembly process specifications. Nevertheless, this highly conservative assumption was made in the development of the H* structural justification in which no credit is taken for residual contact pressure in the determination of the H* lengths.

When considering the more local question of circumferential distribution of contact forces around the circumference of the tube, the physically realistic, but very conservative, initial condition was used in the assessment. This approach addressed a prior NRC question regarding strain hardening of the tubes during expansion. The initial condition utilized in the local contact pressure analysis effectively achieves the strain hardened condition of the tube in the tubesheet but also results in a modest, analytically determined, residual contact pressure. It does not seem appropriate to force physically unrealistic assumptions onto even the local sub-models intended to address specific prior concerns.

Nevertheless, continuing development of the models is in progress to assess the effect on circumferential contact pressure distribution of applying the physically unrealistic assumption of no initial contact pressure to the C^2 model. Also, it is not practicable to respond to both the issue of including tube strain hardening and to exclude any residual contact pressure.

References: (for NRC Questions)

1. Southern Nuclear Operating Company, Inc. (SNC), letter NL-09-0547, "Vogtle Electric Generating Plant License Amendment Request to Revise Technical Specification (TS) Sections 5.5.9, "Steam Generator (SG) Program" and TS 5.6.10, "Steam Generator Tube Inspection Report" for Permanent Alternate Repair Criteria," May 19, 2009, NRC ADAMS Accession No. ML091470701. This letter also transmitted Westinghouse Electric Company report, WCAP-17071-P (Proprietary) and WCAP-17071-P (Non-Proprietary), Rev. 0, "H*: Alternate Repair Criteria for the Tubesheet Expansion Region in Steam Generators with Hydraulically Expanded Tubes (Model F)," April 2009; NRC ADAMS Accession Nos. ML091470699 (Introduction through Chapter 5 – Proprietary), ML091470700 (Chapter 6 to end – Proprietary), and ML091470698 (Non-Proprietary)..
2. SNC letter NL-09-1375, August 28, 2009, responding to VEGP RAI No. 4, NRC ADAMS Accession No. ML092450333 and transmitting WEC letter SGMP-09-109-P Attachment "Response to NRC Request for Additional Information on H*; RAI # 4; Model F and Model D5 Steam Generators," dated August 25, 2009, NRC ADAMS Accession Nos. ML092450334 (Proprietary) and ML092470144 (Non-Proprietary)..
3. Westinghouse Electric Company report, WCAP-17072-P and WCAP-17072-NP, Rev. 0, "H*: Alternate Repair Criteria for the Tubesheet Expansion Region in Steam Generators with Hydraulically Expanded Tubes (Model D5)," May 2009, NRC ADAMS Accession Nos. ML091670159 (Introduction through Section 6.2.2.2.2 – Proprietary), ML091670160 (Section 6.2.2.2.3 through Section 6.2.5.3 – Proprietary), ML091670161 (Section 6.2.6 though Appendix), and ML091670172 (Non-Proprietary). This report was submitted by Luminant Generation Company LLC letter CP-200900748, June 8, 2009, NRC ADAMS Accession No. ML091670154..
4. Westinghouse report, LTR-09-66-P, LTR-09-66-NP, "White Paper: Low Temperature Steam Line Break Contact Pressure and Local Bore Deformation Analysis for H*," May 13, 2009, NRC ADAMS Accession Nos. ML092610441 (Proprietary) ,and ML092610440 (Non-Proprietary).
5. SNC letter NL-09-1265, August 28, 2009, responding to VEGP RAIs and transmitting WEC letter LTR-SGMP-09-100-P and LTR-SGMP-09-100-NP,"Response to NRC Request for Additional Information on H*; Model F and D5 Steam Generators," dated August 12, 2009, NRC ADAMS Accession Nos. ML092450102 (Proprietary) and ML092450101 (Non-Proprietary)..
6. NRC letter to Southern Nuclear Operating Company, "Vogtle Electric Generating Plant, Units 1 and 2, Issuance of Amendments Regarding Technical Specification (TS) Section 5.5.9, "Steam Generator Program," and TS 5.6.10, "Steam Generator Inspection Report," for Interim Alternate Repair Criteria," September 24, 2009 ADAMS Accession No. ML092170782.

Vogtle Electric Generating Plant Units 1 and 2
License Amendment Request to Revise Technical Specification (TS)
Sections 5.5.9, "Steam Generator (SG) Program" and TS 5.6.10,
"Steam Generator Tube Inspection Report" for Temporary Alternate Repair Criteria

Enclosure 12

Westinghouse Electric Company LLC LTR-CAW-10-2955, "Application for Withholding Proprietary Information from Public Disclosure"

Westinghouse

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CAW-10-2955

September 20, 2010

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-SGMP-10-33 P-Attachment, "H*: Response to NRC Questions Regarding Tubesheet Bore Eccentricity*" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-10-2955 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 Southern Nuclear Operating Company.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-10-2955, and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Enclosures

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

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 and Plant Licensing

Sworn to and subscribed before me
this 20th day of September 2010

Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Cynthia Olesky, Notary Public
Manor Boro, Westmoreland County
My Commission Expires July 16, 2014
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory Compliance and Plant Licensing, 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-SGMP-10-33 P-Attachment, "H*: Response to NRC Questions Regarding Tubesheet Bore Eccentricity," (Proprietary) dated September 2010, for submittal to the Commission, being transmitted by Southern Nuclear Operating Company (SNC) Letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with 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

Southern Nuclear Operating Company

Letter for Transmittal to the NRC

The following paragraphs should be included in your letter to the NRC:

Enclosed is:

1. __ copies of LTR-SGMP-10-33 P-Attachment, "H*: Response to NRC Questions Regarding Tubesheet Bore Eccentricity" (Proprietary)

2. __ copies of LTR-SGMP-10-33 NP-Attachment, "H*: Response to NRC Questions Regarding Tubesheet Bore Eccentricity" (Non-Proprietary)

Also enclosed is the Westinghouse Application for Withholding Proprietary Information from Public Disclosure CAW-10-2955, accompanying Affidavit, Proprietary Information Notice, and Copyright Notice.

As Item 1 contains information proprietary to Westinghouse Electric Company LLC, it is supported by an 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 Commission and addresses with specificity the considerations listed in paragraph (b)(4) of Section 2.390 of the Commission's regulations.

Accordingly, it is respectfully requested that the information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the copyright or proprietary aspects of the items listed above or the supporting Westinghouse affidavit should reference CAW-10-2955 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.