UNITED STATES
NUCLEAR REGULATORY COMMISSION
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January 6, 2010

Mr. David A. Heacock
President and Chief Nuclear Officer
Virginia Electric and Power Company
Innsbrook Technical Center
5000 Dominion Boulevard
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SUBJECT: SURRY POWER STATION, UNIT NOS. 1 AND 2 (SURRY UNITS 1 AND 2) – REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING THE PERMANENT ALTERNATE REPAIR CRITERIA LICENSE AMENDMENT REQUEST (TAC NOS. ME1783 AND ME1784)

By letter dated July 28, 2009 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML092150464), Virginia Electric and Power Company (the licensee), submitted a license amendment request to revise the technical specifications (TSs) of Surry Power Station, Unit Nos. 1 and 2. The request proposed changes to the inspection scope and repair requirements of TS Section 6.4.Q, "Steam Generator (SG) Program," to the reporting requirements of TS Section 6.6.A.3, "Steam Generator (SG) Tube Inspection Report," and to TS Sections 4.13 and 3.1.C, "RCS [Reactor Coolant System] Operational Leakage." The proposed changes would have established permanent alternate repair criteria for portions of the SG tubes within the tubesheet.

On September 2, 2009, in a teleconference between the staff and industry personnel including the licensee, the staff stated that an issue relating to the treatment of tubesheet bore eccentricities had not been resolved to the staff's satisfaction and that there was insufficient time to resolve this issue and evaluate the permanent amendment request for the fall 2009 refueling outages at Surry Unit 2 and other units. By letter dated September 30, 2009 (ADAMS Accession No. ML092800358), the licensee revised its amendment request to be an interim change applicable to Surry Unit 1 during Refueling Outage 23 (fall 2010) and the subsequent operating cycle, and to Surry Unit 2 during Refueling Outage 22 (fall 2009) and the subsequent operating cycle.

In its September 30, 2009, letter (ADAMS Accession No. ML092800358), the licensee requested that the NRC staff provide the specific questions concerning the tubesheet bore eccentricity issue which must be resolved to support a permanent amendment. Accordingly, the NRC staff has prepared the enclosed request for additional information concerning the eccentricity issue. This information is needed in order to complete the review of any future requests for a permanent amendment.

Sincerely,

Karen Cotton, Project Manager
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-280 and 50-281

Enclosure:
RAI

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REQUEST FOR ADDITIONAL INFORMATION (RAI)

REGARDING PERMANENT H* ALTERNATE REPAIR CRITERIA

FOR STEAM GENERATOR INSPECTIONS

SURRY POWER STATION, UNIT NOS. 1 AND 2

DOCKET NOS. 50-280 AND 50-281

Background:

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On September 2, 2009, in a teleconference between the staff and industry personnel including the licensee, the staff stated that an issue relating to the treatment of tubesheet bore eccentricities had not been resolved to the staff's satisfaction and that there was insufficient time to resolve this issue and evaluate the permanent amendment request for the fall 2009 refueling outages at Surry Unit 2 and other units. By letter dated September 30, 2009 (ADAMS Accession No. ML092800358), the licensee revised its amendment request to be an interim change applicable to Surry Unit 1 during Refueling Outage 23 (fall 2010) and the subsequent operating cycle, and to Surry Unit 2 during Refueling Outage 22 (fall 2009) and the subsequent operating cycle. The licensee requested that the staff provide the specific questions concerning the eccentricity issue which must be resolved to support a permanent amendment.

The staff has prepared the enclosed request for additional information (RAI) concerning the tubesheet bore eccentricity issue. This information is needed in order for the staff to complete its review of any future request for a permanent amendment.

Requested Information:

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:

    a. Provide a complete description of Table RAI4-3 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.

Enclosure

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 (as stated by the author of the Westinghouse SM-94-58, Rev. 1 analysis at the August 17-18, 2009, meeting), then the assumed shell and channel head temperatures do not seem to be relevant to the results in Table RAI4-3.

c. Explain why there are two values listed for 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.

d. Given that the final eccentricity values shown in Table RAI4-3 were obtained from the slice model (as stated by the Westinghouse author of the analysis in SM-94-58, Rev. 1 during the August 17-18, 2009, meeting) 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?

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

f. Item 5 near the top of page 112 of Reference 2 states that the slice model provides the input for using the SF relationship (eqn. RAI4-1). This differs from the 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 to eqn. RAI4-1. Please clarify this apparent discrepancy.

2. On page 102 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 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 tubesheet temperatures during SLB for Model D5 SGs is substantially less than this value. The staff has the following questions:

   a. The slice model used to develop Table RAI4-2 considered a 500 degree F expansion of the tube and sleeve, but no temperature expansion of the tubesheet. The staff notes that this is not prototypical for either model SG under any condition. What is the rationale for saying that 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).

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?

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 unsleeved tube. What is the rationale for concluding that use of the actual radial stiffness of unsleeved tubes does not represent an extrapolation significantly outside the data basis?

d. The old eccentricity model, including the third order polynomial expression for scale factor, was developed for eccentricity values ranging to a maximum value 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 SGs 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), 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?

3. Reference 2 states at the bottom of page 112, "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." However, it is the staff's understanding, based on statements made by the author of the Westinghouse SM-94-58, Rev. 1 analysis at the August 17-18, 2009, meeting, that the old eccentricity model is entirely based on the slice model and not the axisymmetric model of the lower SG complex. Assuming the staff's understanding is correct, explain why the results of the slice model are not scalable to lower temperatures.

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 appears different from the average eccentricity data in Table RAI4-1. Expand Table RAI4-1 in Reference 2 to include data for Model 44F and 51F.

5. Regarding Table RAI4-5 of Reference 2:

   a. What are the temperature inputs (step 5) for each case?

   b. What are the displacements of the horizontal and vertical edges of the cell model after each of the steps 4 through 9?

   c. Are the E-bar displacements added to the displacements existing after step 5, or do the applied E-bar displacements replace the displacements existing after step 5? Why aren't the applied E-bar displacements over-restraining the model? The staff notes that the applied E-bar displacements don't allow for further displacement of the upper and lower edges during steps 7 through 9, tending to maximize the contact stresses. Wouldn't it be

more realistic to apply force boundary conditions (rather than displacement boundary conditions) to the horizontal edges of the cell models such as to achieve the desired eccentricity?

d. What are the displacement boundary conditions (applied during step 6) that are applied to the sides of the square cell? Free to displace? Zero displacement?

e. Provide an expanded version of Table RAI4-5 which shows the average, maximum and minimum contact pressures as a function of E-bar for steps 5 through 9 as defined in Figure RAI4-2.

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 RAI4-1, for Model F SGs and one third for Model D5 SGs. Why does this not imply a loss of contact between the tube and tubesheet at locations where the 3-D finite element model is predicting relatively high eccentricities? A related question pertains to item 2 on page 115 of Reference 2 which states that eccentricities from the unit cell model are "generally comparable" to those from the 3-D FEA [finite element analysis] model. Explain the apparent discrepancy between the words "generally comparable" and how the unit cell eccentricities in Table RAI4-5 actually compare to 3-D FEA eccentricities. Explain how the unit cell model adequately addresses the actual range of eccentricities from the 3-D FEA model.

g. Table RAI4-5 does not provide unit cell results for the Model 44F and 51F SGs. Provide these results, if available. If not available, discuss whether the unit cell eccentricities, contact pressures, and average delta Ds for the Model 44F and 51F SGs are within the envelope of those for the Model F and D5 SGs.

6. Provide information as needed to reconcile Table RAI4-6 with Table RAI4-1 in Reference 2. For example, the eccentricities in line 1 of Table RAI4-6 for Model F don't match eccentricities in Table RAI4-1. The staff has the same question about the average delta Ds in the two tables, although in this case the differences are minor.

7. The bullet at the bottom of page 113 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 4) 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 during steps 1 through 4) are to be ignored? If not, explain why the statement is true. The staff notes that the test of whether tube-to-tubesheet contact is actually maintained is whether positive contact pressure is maintained all around the circumference of the tube.

8. The bullet at the top of page 114 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 0) 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? Don't the bore displacements from step 1 through at least step 5 (if not step 9, depending on the response to question 5.b above) of the unit cell model reflect the tube expansion process in steps 1 through 4 or, if not,

why not? Isn't it primarily steps 5 and 6 that are intended to replicate the FEA or, if not, why not? If yes, then why is step 4 not the appropriate reference condition for comparing the displacements from step 6 for purposes of comparison with the 3-D FEA displacements?

9. Figures RAI4-5 for Model F and RAI4-6 for Model D5 SGs show the relationship between the 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 NOP [normal operating pressure]. The discussion of these figures on page 114 needs to be clarified or expanded to allow the staff to understand the reason for these trends. For example, for the case of NOP, explain how an increase in the 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.

10. Item 1 on page 115 of Reference 2 states, "The delta Ds from the 3-D 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 1 that the unit cell model displacement and contact pressure results conservatively represent the reference 3-D FEA results. The 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 5 and 6 of the unit cell model compare with the results from the 3-D FEA analysis? Does this comparison support the conclusion in Item 1?

11. The words "bore eccentricities" in the first line of the last paragraph on page 122 of Reference 2 should read "E-bar displacements," correct? If not, why not?

12. From the bottom of page 122 to page 127 of Reference 2, the text appears to discuss a new eccentricity analysis. The staff has the following questions concerning this analysis. [This question does not need a response for Model F, 44F, and 51F SGs provided, this new eccentricity analysis will continue to play no role in the H* analyses for these SG models.]

    a. What are the specific objectives of the analysis?

    b. Specifically, how is the analysis different from the analyses performed in the Model D5 White Paper (Reference 3)?

    c. Describe the analysis in detail.

    d. Provide a table of results similar to RAI4-5 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 123 for the case of Model D5 SLB [steam line break] does not appear be consistent with what is assumed in the reference analysis in Reference 1 or with what is assumed in Reference 3. Explain this apparent discrepancy.

    f. Why does the analysis discussed in the first paragraph on page 123 consider a location 2 inches below the top of the tubesheet rather than the top of the tubesheet where the

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 RAI4-10" is used for two different Figures; on page 125 and page 126. This RAI will refer to the figure on page 126 as Figure RAI4-10a for clarity. The second paragraph on page 123 refers to Figure RAI4-8 which appears to be an incorrect figure number. Is Figure RAI 4-9 the correct figure?

h. Regarding Figure RAI 4-9, it is unclear what the horizontal axis represents since the terms "relative tubesheet displacement, e (in)" is ambiguous. Is it eccentricity, Dmax – Dmin, or Ebar?

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 3, and "Model D5 FEA Trend" refers to the most recent model discussed on pages 122 to 127 of Reference 2? If incorrect, provide the correct information.

j. The third paragraph on page 113 states that Figure RAI4-9 shows contact pressure ratio as a function of Ebar. Should "RAI4-9" read "RAI 4-10?"

k. Explain in detail how each of the curves in Figures RAI 4-9 and RAI 4-10 were determined?

13. Provide an updated version of "preliminary Table RAI4-5," which was discussed at the August 17-18, 2009, meeting, 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 3), 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 RAI4-5 of Reference 2 requested in questions 5.e and 12.d above.

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 2, the staff did not rely on these calculations when approving the interim H* amendments in Reference 4, 5, and 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.

References:

1. Westinghouse Electric Company (WEC) Report, WCAP-17092-P (Proprietary) and WCAP 17092-NP (Non-Proprietary), Rev. 0, "H*: Alternate Repair Criteria for the Tubesheet Expansion Region in Steam Generators with Hydraulically Expanded Tubes (Model 51F)," June 2009, NRC ADAMS Accession No. ML092150462. This report was submitted by Virginia Electric and Power Company (Dominion) letter 09-455, July 28, 2009, NRC ADAMS Accession No. ML092150464.

2. WEC letter LTR-SGMP-09-108 P-Attachment and NP-Attachment, "Response to NRC Request for Additional Information on H*; Model 44F and 51F Steam Generators," August 27, 2009, NRC ADAMS Accession No. ML092660616. This report was submitted by Dominion letter 09-455A, September 16, 2009, NRC ADAMS No. ML092660615.

3. WEC letter LTR-SGMP-09-66, "White Paper: Low Temperature Seam Line Break Contact Pressure and Local Tube Bore Deformation Analysis for H*," May 13, 2009, NRC ADAMS Accession No. ML092610440.

4. NRC letter to Dominion, "Surry, Unit 1, Issuance of Amendment Regarding Proposed License Amendment Request - Interim Alternate Repair Criteria for Steam Generator Tube Repair," April 08, 2009, NRC Accession No. ML090860735.

5. NRC letter to Dominion, "Surry Power Station, Unit 1 - Issuance of Amendment Regarding Modified Interim Alternate Repair Criteria for B Steam Generator Tube Repair," May 07, 2009, NRC Accession No. ML091260386.

6. NRC letter to Dominion, "Surry Power Station, Unit 2 - Issuance of Exigent Amendment Regarding Interim Alternate Repair Criteria for Steam Generator Tube Repair," May 16, 2008, NRC Accession No. ML081340068.

In its September 30, 2009, letter (ADAMS Accession No. ML092800358), the licensee requested that the NRC staff provide the specific questions concerning the tubesheet bore eccentricity issue which must be resolved to support a permanent amendment. Accordingly, the NRC staff has prepared the enclosed request for additional information concerning the eccentricity issue. This information is needed in order to complete the review of any future requests for a permanent amendment.

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/RA/

Karen Cotton, Project Manager
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

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RAI

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