UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 17, 2009

Mr. Charles G. Pardee
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: BRAIDWOOD STATION, UNITS 1 AND 2, AND BYRON STATION, UNIT NOS. 1 AND 2 - TRANSMITTAL OF UNRESOLVED ISSUES RELATED TO STEAM GENERATOR PERMANENT ALTERNATE REPAIR CRITERIA (TAC NOS. ME1613, ME1614, ME1615, AND ME1616)

Dear Mr. Pardee:

By letter to the Nuclear Regulatory Commission (NRC) dated June 24, 2009 (Agencywide Documents Access and Management System (ADAMS) Package No. ML091770543), as supplemented by letters dated August 14, 2009, and August 31, 2009 (ADAMS Package Nos. ML092320375 and ML092460588, respectively), Exelon Generation Company, LLC (the licensee) proposed to revise Technical Specification (TS) 5.5.9, "Steam Generator (SG) Program," and TS 5.6.9, "Steam Generator (SG) Tube Inspection Report," for Braidwood Station (Braidwood), Units 1 and 2, and for Byron Station (Byron), Unit Nos. 1 and 2. The proposed changes would have established permanent alternate repair criteria for portions of the steam generator (SG) tubes within the tubesheet of the Model D5 SGs for Braidwood, Unit 2, and for Byron, Unit No. 2.

On September 2, 2009, in a teleconference between the NRC staff and industry personnel, including the licensee, the NRC staff stated that an issue relating to the treatment of tubesheet bore eccentricities had not been resolved to the NRC 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. By letter dated September 15, 2009 (ADAMS Package No. ML092600168), the licensee revised its amendment request to be an interim change applicable to Braidwood, Unit 2, during Refueling Outage 14 (fall 2009) and the subsequent operating cycle, and to Byron, Unit No. 2, during Refueling Outage 15 (spring 2010) and the subsequent operating cycle. By letter dated October 16, 2009 (ADAMS Accession No. ML092520512), the NRC staff approved the requested amendments for an interim alternate repair criteria for Braidwood and Byron.

In its September 15, 2009, letter, the licensee requested that the NRC staff provide the specific questions concerning the tubesheet bore eccentricity issue, which must be resolved to support an amendment for permanent alternate repair criteria.

Accordingly, enclosed are the specific questions that are currently identified and remain unresolved concerning the eccentricity issue. This information would be needed for the NRC staff to complete its review of any future request for an amendment for permanent alternate repair criteria. If you have any questions, please contact me at (301) 415-1547.

Sincerely,

Marshall J. David, Senior Project Manager
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. STN-456, STN-457,
STN 50-454, and STN 50-455

Enclosure:
As stated

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UNRESOLVED ISSUES REGARDING

PERMANENT ALTERNATE REPAIR CRITERIA FOR STEAM GENERATORS

BRAIDWOOD STATION, UNITS 1 AND 2

AND BYRON STATION, UNIT NOS. 1 AND 2

DOCKET NOS. STN 50-456, STN 50-457

STN 50-454, AND STN 50-455

Background:

By letter to the Nuclear Regulatory Commission (NRC) dated June 24, 2009 (Agencywide Documents Access and Management System (ADAMS) Package No. ML091770543), as supplemented by letters dated August 14, 2009, and August 31, 2009 (ADAMS Package Nos. ML092320375 and ML092460588, respectively), Exelon Generation Company, LLC (EGC, the licensee) proposed to revise Technical Specification (TS) 5.5.9, "Steam Generator (SG) Program," and TS 5.6.9, "Steam Generator (SG) Tube Inspection Report," for Braidwood Station (Braidwood), Units 1 and 2, and for Byron Station (Byron), Unit Nos. 1 and 2. The proposed changes would have established permanent alternate repair criteria for portions of the SG tubes within the tubesheet of the Model D5 SGs for Braidwood, Unit 2, and for Byron, Unit No. 2.

On September 2, 2009, in a teleconference between the NRC staff and industry personnel, including the licensee, the NRC staff stated that an issue relating to the treatment of tubesheet bore eccentricities had not been resolved to the NRC 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. By letter dated September 15, 2009 (ADAMS Package No. ML092600168), the licensee revised its amendment request to be an interim change applicable to Braidwood, Unit 2, during Refueling Outage 14 (fall 2009) and the subsequent operating cycle, and to Byron, Unit No. 2, during Refueling Outage 15 (spring 2010) and the subsequent operating cycle. The licensee requested that the NRC staff provide the specific questions concerning the eccentricity issue, which must be resolved to support an amendment for a permanent alternate repair criteria.

Below are the specific questions that are currently identified and remain unresolved concerning the tubesheet bore eccentricity issue. This information is needed in order for the NRC staff to complete its review of any future request for an amendment for a permanent alternate repair criteria.

Unresolved Issues:

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-dimentional lower SG shell axisymmetric model in the development of this table.

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 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 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 Table 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 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 (bore dilations) from the 3-dimentional (3-D) finite element analyses (FEAs) (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 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 the case for the steamline break (SLB) conditions for the Model D5 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 NRC 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 NRC 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 NRC 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 FEA 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 FEA 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 top of page 19, "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 based entirely on the slice model and not the axisymmetric model of the lower SG complex? Assuming this 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 D5 SGs for normal operating conditions, which appears different from the average eccentricity data in Table RAI4-1.

5. Regarding Table RAI4-5 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 don't allow for further displacement of the upper and lower edges during steps seven through nine, 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 six) 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 five through nine 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 FEA 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 FEA model is predicting relatively high eccentricities? A related question pertains to Item 2 on page 21 of Reference 2, which states that eccentricities from the unit cell model are "generally comparable" to those from the 3-D FEA 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.

6. Provide information as needed to reconcile Table RAI4-6 with Table RAI4-1 in Reference 2. For example, the eccentricities in line three of Table RAI4-6 for Model D5 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 six of Table RAI4-6 do not match those in Table 6-25 of Reference 1.

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 during 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 actually maintained is whether positive contact pressure is maintained all around the circumference of the tube.

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 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 one through at least step five (if not step nine, depending on 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? Isn't it primarily steps five and six that are intended to replicate the FEAs? 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?

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] conditions. 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 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 above the third data point.

10. Item 1 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 1 that the unit cell model displacement and contact pressure results conservatively represent the reference 3-D 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 from the 3-D FEA analysis? Does this comparison support the conclusion in Item 1?

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?

12. From the bottom of page 28 to page 33 of Reference 2, the text appears to discuss a new eccentricity analysis. The NRC staff has the following questions concerning this analysis.

    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 29 for the case of Model D5 SLB 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 29 consider a location two 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 31 and page 32. This RAI will refer to the figure on page 32 as Figure RAI4-10a for clarity. The second paragraph on page 29 refers to Figure RAI4-8 which appears to be an incorrect figure number. Is Figure RAI4-9 the correct figure?

h. Regarding Figure RAI4-9, it is unclear what the horizontal axis represents since the terms "relative tubesheet displacement, e (in)" is ambiguous. Is it eccentricity, Dmax – Dmin, or E-bar?

i. Is it correct that in the legend for Figure RAI4-9, "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 28 to 34 of Reference 2? If incorrect, provide the correct information.

j. The third paragraph on page 19 states that Figure RAI4-9 shows contact pressure ratio as a function of E-bar. Should "RAI4-9" read "RAI4-10?"

k. Explain in detail how each of the curves in Figures RAI4-9 and RAI4-10 were determined?

13. Provide an updated version of Table RAI4-7 (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 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 were provided in Reference 4, the NRC staff did not rely on these calculations when approving the interim H* amendment in Reference 5. 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-17072-P (Proprietary) and WCAP-17072-NP (Non-Proprietary), 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 No. ML091770546 (Non- Proprietary). This report was submitted by EGC letter RS-09-071, June 24, 2009, NRC ADAMS Accession No. ML091770545.

2. WEC letter, LTR-SGMP-09-109-P (Proprietary) and LTR-SGMP-09-109-NP (Non-Proprietary), "Response to NRC Request for Additional Information on H*; RAI #4; Model F and D5 Steam Generators," August 25, 2009, NRC ADAMS Accession No. ML092460590 (Non-Proprietary). This letter was submitted by EGC letter RS-09-117, August 31, 2009, NRC ADAMS Accession No. ML092460590.

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. WEC letter, LTR-SGMP-09-100-P (Proprietary) and LTR-SGMP-09-100-NP (Non-Proprietary) "Response to NRC Request for Additional Information on H*; Model F and D5 Steam Generators," August 12, 2009, NRC ADAMS Accession No. ML092320377 (Non-Proprietary). This letter was submitted by EGC letter RS-09-108, August 14, 2009, ADAMS Accession No. ML092320377.

5. NRC letter to EGC, "Braidwood Station, Units 1 and 2, and Byron Station, Unit Nos. 1 and 2 - Issuance of Amendments Re: Revision to Technical Specifications for the Steam Generator Program," October 16, 2009, NRC ADAMS Accession No. ML092520512.

Accordingly, enclosed are the specific questions that are currently identified and remain unresolved concerning the eccentricity issue. This information would be needed for the NRC staff to complete its review of any future request for an amendment for permanent alternate repair criteria. If you have any questions, please contact me at (301) 415-1547.

Sincerely,

/RA/

Marshall J. David, Senior Project Manager
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. STN-456, STN-457,
STN 50-454, and STN 50-455

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