May 1, 2009

MEMORANDUM TO: Mirela Gavrilas, Chief
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FROM: Andrew B. Johnson, Materials Engineer ***/RA/***
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SUBJECT: SUMMARY OF THE APRIL 3, 2009, CATEGORY 2 PUBLIC MEETING WITH U.S. NUCLEAR INDUSTRY REPRESENTATIVES TO DISCUSS STEAM GENERATOR H* ISSUES

The U.S. Nuclear Regulatory Commission (NRC) staff met with the Nuclear Energy Institute (NEI), Westinghouse, and licensees on April 3, 2009, at the NEI offices in Washington DC. The purpose of the meeting was to discuss the status of issues related to the technical basis for limiting the extent of inspections in the tubesheet region (H*) in units with thermally treated Alloy 600 steam generator tubes. Enclosure 1 provides a list of those in attendance. This meeting was noticed as a public meeting and the meeting agenda is available in the NRC Agencywide Documents Access and Management System (ADAMS) under accession no. ML090680667. Other than industry representatives, no members of the public were present.

Information presented by the industry during the meeting is available in ADAMS under accession no. ML091130583.

Background: Westinghouse has developed structural and leakage models to support future license applications for an alternate repair criteria (ARC) amendment applicable to the tube-to-tubesheet joints in steam generators (SGs). Westinghouse has termed this ARC “H*.”

The following summarizes the meeting discussions.

- Westinghouse presented an overview of the structural analysis, section 6 of the forthcoming H* report. The overview included discussion of the bounding plants for the different types of SGs that are part of the potential H* population; the current analysis methodology for calculating the mean H* value, excluding the probabilistic analysis; an overview of the significant changes to the analysis methodology that have occurred since 2007, and a review of the conservatisms in the current analysis.

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During this discussion, the staff asked questions related to the current structural analysis and provided a list of editorial comments on portions of the draft report to Westinghouse. The staff indicated that they would summarize all of their comments and provide them to Westinghouse in the near term. The list was provided to Westinghouse on April 9, 2009, and a copy of the list is attached to this summary.

- Westinghouse presented an overview of the probabilistic analysis, section 8 of the forthcoming H* report. The overview included discussion of the two probabilistic methods used, which were the square root of the sum of the squares and the Monte Carlo simulation using biased influence factor distributions, and the results of a whole bundle analysis performed to a probability of 95 percent and confidence level of 50 percent (95/50). A whole bundle analysis contains all the tubes in one SG. Also discussed were the sensitivity analyses, which assess modeling results from changes in variables, and a review of the conservatisms in the current analysis. The staff indicated that while we did not have any comments on the probabilistic analysis at this time, we still needed to review the approach in more detail.

In a January 9, 2009, public meeting on H*, Westinghouse indicated that they would provide the following analyses separately from the report:

1. The H* distance that would ensure the safety factor of 1.4 is met at 95/95 based on a whole bundle analysis.

2. The H* distance that would ensure the safety factor of 3.0 is met at 95/95 based on an analysis of all the tubes in the unit, rather than a whole bundle analysis.

3. The H* distance that would ensure the safety factor of 3.0 is met at 95/50 based on an analysis of all the tubes in the unit, rather than a whole bundle analysis.

Westinghouse provided the 95/50 analyses for all the tubes in a unit during the April 3, 2009, public meeting. The staff and Westinghouse discussed the whole bundle and whole plant 95/95 analyses and Westinghouse reiterated its commitment to provide the analyses, and stated that they expected the results of the analyses to have no impact on the analyses performed to date.

- The independent expert panel that has been reviewing the H* analysis and providing feedback to Westinghouse, presented a summary of the work they have performed over the previous 15 months.

- Westinghouse stated that they would submit the appropriate affidavit for proprietary information, along with proprietary and non-proprietary versions of the slides used during the meeting. Westinghouse provided these documents to the NRC on April 28, 2009, Accession No. ML091190168.

- Westinghouse stated that they would provide the finished H* report to the first licensee in early May 2009. The various licensee representatives who were present at the meeting indicated that they would submit seven license amendment requests, for permanent SG alternate repair criteria, starting in June 2009. These license amendment requests would be needed to support refueling outages in fall 2009.

- Westinghouse reviewed the tube pull-out testing that they have been performing in an effort to evaluate the actual residual contact pressure that is generated during hydraulic expansion of the tubes into the tubesheet. They reviewed issues they encountered in the manufacture of the test specimens and new insights they had gained during resolution of issues identified during prior pull-out tests. In addition, they presented load displacement curves they had generated from the testing.

- The NRC staff and industry agreed that it may be useful to discuss the proposed wording for incorporating the H* methodology into the Technical Specifications.

Project No. 689

Enclosures:
1. Attendance List
2. Section 6 Comments

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ATTENDANCE LIST

April 3, 2009, Meeting with NEI and Industry

Industry
Mike Melton, NEI
Herm Lagally, Westinghouse
Damian Testa, Westinghouse
Russ Cipoola, Intertek-APTECH Engineering
Jim Begley, AREVA
Pete Ricardella, Structural Integrity Assoc.
Chung Tran, Luminant Power
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Richard Hall, Exelon
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Russell Lieder, FPL Energy Seabrook
Don Gerber, Dominion
Dan Mayes, Duke Energy

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Jay Smith, Exelon

NRC
Ken Karwoski
Emmett Murphy
Tim Lupold
Andrew Johnson

ENCLOSURE 1

1. The mean H* depth on page 2 is different from that in Table 6-24 on page 99.

2. Regarding Table 6-6, Summary of H* Millstone 3 Mean Input Properties, this Table needs considerable clarification. For example:
   a. What does "SLB TS delta T" mean? For this parameter, what does "350 degrees F mean?" Is this the amount that the tubesheet (TS) temperature increases from the normal operating value, or is it the assumed TS temperature under SLB conditions?
   b. What does "FLB Primary delta T Hi" mean?
   c. What does "-54 degrees F" mean? Relative to what?
   d. What is "Cold Leg delta T?"
   e. What is "Cold Leg delta P?"

3. Regarding Figure 6-19,
   a. Where are the radial displacements being calculated? At TTS? At BTS?
   b. What is the radius of the outer edge of the support ring? Can the Figure be extended to show TS radial displacement out to the edge of the support ring?
   c. What does Figure 6-19 look like for the "no-support ring" case?
   d. Do the conclusions of Section 6.2.2.2.3 hold for the no-support ring case?

4. Regarding page 36, are the scaling factors (between linear and modified temperature distributions) a function of tubesheet radius? If so, is this reflected in the FEA analysis? For the thermal FEA analysis, why not run the FEA with the modified temperature distribution rather than the more approximate scaled linear distribution?

5. Equation 1 on page 43 and much of the discussion through page 48 appear to ignore the fact that tubesheet bore displacement is a function not just of crevice pressure but is also a function of primary pressure inside the tube. For the general case of uncracked tubes, the crevice pressure will have a different value than the primary pressure. Why is this not relevant to the discussion on these pages? Are the calculated TS cylinder outer diameters at the inner, middle, and outer tube locations conservative for the case where only the tube of interest contains a through-wall crack and all other tubes are uncracked for the different patterns of plugged and unplugged tubes assumed in the analysis? Some clarifying words on these pages which address these questions would be helpful.

6. Equation 2 seems to ignore the fact that the displacements of the bore surface (which vary around the circumference of the bore) and of the bore centerline are vector, not scalar quantities. In general, the direction of the bore surface displacements may be different than the direction of the bore centerline displacements. Thus, it seems that Equation 1 should be in vector form.

7. Pg. 45, paragraph 2 – Ref [1] is cited as the reference that was used to submit crevice pressure testing data to the NRC; Ref [1] is NEI 97-06.

8. Pg. 45, paragraph 4 – Part of a sentence states, "…revealed that the reduction in tube-to-tubesheet contact pressure due to tubesheet bore ID expansion was decreased…" A decrease in a reduction is the same as an increase, which is not what I think is trying to be said here…clarify.

9. Pg. 45, paragraph 4, last sentence – “crevice pressure” is used in the sentence but I think it should say “contact pressure.”

10. 6.2.4.5, pgs. 50 - 57 – In these pages, it is repeatedly stated that tube bore translation due to thermal growth is excluded from the models and the translation effects are not shown in the graphs. Then, in the last paragraph (pg. 57), the translation effects are brought into the final calculation. Why are there no graphs showing the effects of translation, since in Section 6.2.3 it was stated that translation due to thermal growth led to decreased pull out resistance?

11. Regarding discussion of tube conformance to the TS bore on page 55, do we necessarily have conformance when crevice pressure equals primary pressure?

12. Regarding Figure 6-23, does “composite” refer to “scaled linear?” If so, we suggest consistent terminology be used.

13. Regarding Figure 6-28, clarifications would be helpful regarding which edges correspond to planes of symmetry, tube lane, and support ring, and which edges are free. It would also be helpful if this figure showed the displacement boundary conditions for each edge.

14. Figs. 6-37 - 6-42 – These figures have the y-axis labeled as total deformation of tube hole, yet the paragraph on pg. 51 references tube hole dilation, not deformation. The use of deflection, dilation, and deformation appears to be inconsistent between written paragraphs and graphs.

15. Regarding step 5 on page 66, how do we have thermal loads without thermal expansions as is stated on page 67?

16. 6.2.5.2, last paragraph pg. 67 – A statement is made that limiting movement in the X direction (while the cell is being deformed in the Y direction) is the worst case condition because it keeps contact pressure on the side of the tube low (in contrast to allowing the strain around the tube to redistribute via the Poisson effect, which would allow the tubesheet to pinch the tube). However, the pressures shown in Table 6-18 for Step 7 (NOP conditions) seem to dispute this statement. Runs S.2.4, S.2.5, and S.2.6 (which allow for the Poisson effect) have lower Average, Maximum, and Minimum values than runs S.1.4, S.1.5, and S.1.6 (which do not allow for the Poisson effect). For Step 6 in Table 6-18, the same is true for runs S.2.5 and S.2.6 when compared to runs S.1.5 and S.1.6. Step 6 simulates pressure conditions with a crack in the tube.

17. Equation 2 on page 64 should be Equation 4. Equation 3 on page 65 should be Equation 5.

18. The definition of “d” needs to be clarified. “d” is defined as:

    a. the TS collar outer radius in Equation 1
    b. the TS collar outer diameter in Figure 6-46
    c. the TS collar thickness in Figure 6-47

19. Pg. 104 also states that rates of increase of the combined tubesheet displacements for the SLB case are greater than the rate of slope increase of the combined tubesheet

displacement during NOP. However, the values shown in Figs. 6-77 and 6-78 indicate a greater change for NOP than SLB, from the TTS to the BTS.

20. Pg. 104 also states that Figs. 6-77 and 6-78 show that the tubesheet is tighter at SLB conditions than at NOP conditions. However, Figs. 6-77 and 6-78 show that SLB displacements are greater than NOP combined radial displacements.

21. Figs. 6-78 and 6-80 seem to contradict each other.

22. It is confusing to have Figs. 6-77 through 6-80 showing TTS at 20" (which is backwards from traditional convention) and to then have TTS at 0" on Fig. 6-81.

23. Section 6.4.8, pg. 106 – 1st paragraph cites Reference 1 (NEI 97-06) as the reference that was used to submit the H* crevice pressure testing data to the NRC.