December 19, 2008

MEMORANDUM TO: Allen L. Hiser, Jr., Chief
Steam Generator Tube Integrity and
Chemical Engineering Branch
Division of Component Integrity
Office of Nuclear Reactor Regulation

FROM: Andrew B. Johnson **/RA/**
Steam Generator Tube Integrity and
Chemical Engineering Branch
Division of Component Integrity
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF THE NOVEMBER 19, 2008 CATEGORY 2 PUBLIC MEETING WITH THE NUCLEAR ENERGY INSTITUTE (NEI) AND INDUSTRY TO DISCUSS MODELING ISSUES PERTAINING TO THE STEAM GENERATOR TUBE-TO-TUBESHEET JOINTS

The Nuclear Regulatory Commission's (NRC) staff met with the Nuclear Energy Institute, Westinghouse, and licensees on November 19, 2008, at Westinghouse's Waltz Mill Site in Madison, Pennsylvania. The purpose of the meeting was to discuss the different approaches taken by Westinghouse and Argonne National Laboratory (ANL) to model the structural and leakage behavior of steam generator (SG) tube-to-tubesheet joints, to assess the consistency of the model predictions for design basis conditions, and to reconcile any differences. The Enclosure 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 Number ML083060005. 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 Numbers ML083290362, ML083290363, and ML083290366. Information presented by ANL is available in ADAMS under Accession Numbers ML083290367 and ML083290369.

Background: The Westinghouse models are being developed to support future license applications for an alternate repair criterion (ARC) applicable to the tube-to-tubesheet joints. This ARC is termed "H*." The ANL models are being developed under contract to the NRC's Office of Nuclear Regulatory Research to evaluate the behavior of the joints under severe accident conditions; however, the ANL models can also be used to evaluate the joint behavior under design basis conditions.

CONTACT: Johnson B. Andrew, DCI/CSGB
301-415-1475

The following summarizes the information presented during the meeting and the accompanying comments, observations, and action items that resulted. Industry started the meeting by reviewing the key technical issues that were resolved and that remained in establishing the technical basis for H*; by reviewing the estimated schedule for completion of the H* report; and by reviewing the status of the open requests for additional information (RAIs). Industry then provided updates to the structural and leakage analyses in response to issues raised in the industry meeting on October 29 and 30, 2008 (Summary provided in ADAMS under Accession Number ML083300422). The first issue addressed was the varying axial distribution of tube-to-tubesheet contact pressure when changing from normal operating conditions (NOP) to steam line break (SLB) conditions. Industry showed that the contact pressure distribution analysis is sensitive to input parameters and crevice pressure assumptions, and that when absolute maximum and minimum reference values from different plants are combined in one analysis, results that are non-intuitive can result. However, industry showed that even when non-intuitive contact pressure distributions are used as inputs in the structural analysis, the resulting H* distances are less than the minimum being proposed by industry.

Next, industry addressed the model being used for crevice pressure distribution in the H* analysis. To date, industry has been using constant median crevice pressures (one for NOP and a different one for SLB conditions) that were obtained from industry testing. Industry showed that either a depth-dependent crevice pressure model (also calculated from an average of industry test results) or a constant median crevice pressure model, resulted in calculated H* distances that were smaller than the minimum H* distance being proposed for use by industry.

Industry then presented an overview of the 3D finite element model and how the tubesheet displacements vary between the 3D model and the axial linear superposition model (ALSP). This discussion also included a comparison of the sub-modeling strategies in the 3D model and the ALSP model.

Lastly, industry reviewed the modified B* approach and addressed two issues discussed in the October 29, 2008, public meeting. The first issue was whether the loss coefficient remained constant when changing from NOP to SLB conditions. Industry performed a detailed evaluation of leakage test data and concluded that there is not a significant relationship between contact pressure and leakage loss coefficient. To address leakage during a design basis accident (DBA), industry discussed two options: (1) defining an increased inspection depth into the tubesheet that is intended to limit the increase in primary-to-secondary leakage to a factor of two (when compared to normal operating leakage) during a DBA, and (2) using an increased leakage factor in the leakage equation, and then using a reduced primary coolant activity when calculating the dose consequences.

The second issue was how to account for the contact pressure changes between NOP and SLB conditions if the analysis showed that contact pressure is reduced when changing from NOP to SLB conditions. To address this issue, the industry developed a model that involves introducing a “sub-factor” for loss coefficient into the leakage equation that determines the overall leakage factor.

Argonne personnel presented an overview of how the industry leak rate data compared with the SG tube-to-tubesheet interface model developed at ANL. They reviewed their leak rate models, which include factors that account for surface roughness and two phase flow, unlike the current industry model. The predicted results of the ANL model gave good agreement with three sets of industry test data (for the SLB condition) from one specimen (i.e., specimen 8); however, the

test data from a second industry specimen in the SLB condition (specimen 7) was not predicted as well by the ANL model, but were still in general agreement. Industry test data from the same two specimens tested in NOP conditions again showed reasonable agreement to the ANL model's predicted results for specimen 8, but not for specimen 7. When ANL analyzed the industry leak rate data, a fairly consistent trend between loss coefficient and contact pressure was observed that was in reasonable agreement with the ANL model predictions. The pressure profile tests suggested that differential pressure, whether calculated between primary and exit pressure or primary and saturation pressure, did not provide good modeling of two phase flow through tight contacts. The ANL rough surface model predicted reasonable pressure profiles, but it did not account for corrosion effects and therefore might overestimate leak rate through tight contacts.

Two different coefficients of thermal expansion (CTE) were modeled by ANL to compare differences in the calculated joint contact pressures. The difference was approximately 1 ksi during NOP and insignificant during SLB conditions (when tubesheet bowing is ignored). A separate ANL model indicated that the addition of a 2-inch solid rib (to approximate the tubesheet tube lane) to the tubesheet resulted in a change to the calculated transverse displacement during SLB conditions of approximately 0.1 inches. Due to the somewhat scattered leak rate results that were presented by ANL at the October 29, 2008, meeting, improved iterative solution steps were run on the ANL model to obtain convergence of the model leak rate solutions. These results were presented during the meeting, and showed that leak rates during NOP and SLB were comparable and that the predicted leak rates from the ring-assembly model were reasonable (when tubesheet bowing is ignored). A comparison of the axial distribution of crevice pressure between the ANL model results and industry test data results showed reasonable agreement, with the ANL model providing mostly an upper bound to the industry data.

The action items that came out of the meeting were as follows:

1. The NRC staff indicated their concern that appropriate performance standards are used to ensure that the technical specification performance criteria (a factor of 3 for NOP conditions and a factor of 1.4 for the worst case DBA) are met. This includes the proposed use of a 95/50 probability and confidence limit (rather than 95/95) for satisfying the performance criteria and the proposal to base the performance standard for NOP on the tube population for an individual SG rather than the entire tube population at the plant. The NRC staff stated it may be useful to provide the sensitivity of H* to the assumed performance standards. Industry expressed concern for establishing a new precedent and indicated that they would provide the information in a separate document from the formal H* report.

2. The NRC staff indicated that it may be useful to have the final report specifically address the potential for anisotropic CTE behavior of the tube after strain hardening in the radial direction during hydraulic expansion. Industry reiterated that this issue had been fully resolved and that it would be addressed in the final report.

3. Industry and the NRC agreed to cancel the planned December public meeting. Additional meetings may be scheduled prior to the next planned meeting on February 17, 2009, if needed. (Subsequent to the November 19, 2008, meeting, the planned December 17, 2008, meeting was held at the Westinghouse Waltz Mill Site and a meeting has been tentatively scheduled for January 9, 2009.)

4. The NRC staff stated that if contact pressure during DBA conditions is greater than that for NOP conditions, then it is reasonable to calculate the accident-induced leakage by applying a factor (termed the accident leakage ratio) to the NOP leakage rate (i.e., option 2).

5. The NRC staff indicated that it believes it is important to understand the modeling differences that lead to ANL's model predicting loss of contact at the top three inches of the tubesheet during a SLB while the mean input H* case presented by the industry model does not predict a loss of contact. One approach for assessing these differences was discussed. This includes having ANL provide Westinghouse with displacements as a function of depth into the tubesheet from the ANL model. Westinghouse could then insert these values into their subroutine and see if they get similar results. To accomplish this, Westinghouse would need to provide ANL with a list of input data required for this operation.

6. The NRC staff indicated that leakage specimen 7, from the testing performed by Westinghouse in 2005, appeared to exhibit an anomalous trend in crevice pressure and that such a trend may warrant the data being deleted from the model.

7. The NRC staffed indicated that the H* models are complex and such complexity may warrant consideration of adding additional margin in the final H* distance.

Project No. 689

Enclosure:
Attendance List

4. The NRC staff stated that if contact pressure during DBA conditions is greater than that for NOP conditions, then it is reasonable to calculate the accident-induced leakage by applying a factor (termed the accident leakage ratio) to the NOP leakage rate (i.e., option 2).

5. The NRC staff indicated that it believes it is important to understand the modeling differences that lead to ANL's model predicting loss of contact at the top three inches of the tubesheet during a SLB while the mean input H* case presented by the industry model does not predict a loss of contact. One approach for assessing these differences was discussed. This includes having ANL provide Westinghouse with displacements as a function of depth into the tubesheet from the ANL model. Westinghouse could then insert these values into their subroutine and see if they get similar results. To accomplish this, Westinghouse would need to provide ANL with a list of input data required for this operation.

6. The NRC staff indicated that leakage specimen 7, from the testing performed by Westinghouse in 2005, appeared to exhibit an anomalous trend in crevice pressure and that such a trend may warrant the data being deleted from the model.

7. The NRC staffed indicated that the H* models are complex and such complexity may warrant consideration of adding additional margin in the final H* distance.

Project No. 689

Enclosure:
Attendance List

DISTRIBUTION:

DCI R/F
EWong
RidsNrrAdes
RidsNrrDpr
PUBLIC
CHarris
DTerao
RidsNrrOD
GMakar
KKarwoski
KGruss
RidsOgcMailCenter
RidsNrrDci
MMelton(mam@nei.org)

ADAMS ACCESSION NO.: Pkg. ML083540700, Memo ML083540708

OFFICE	NRR/DCI/CSGB	DCI/CSGB	DCI/CSGB
NAME	AJohnson /RA/	EMurphy /RA/	AHiser /RA/
DATE	12/12/2008	12/12/2008	12/19/2008

OFFICIAL RECORD COPY

ATTENDANCE LIST

November 19, 2008 Meeting with NEI, SGTF, and Industry to Discuss H*/B* Issues

SGTF/Industry
Jay Smith, Exelon
Steve Leshnoff, Exelon
Dave Czufin, Exelon
Richard Mullins, Southern Nuclear
Daniel Mayes, Duke Energy Corporation
Gary Boyers, Florida Power & Light
Mike Melton, NEI
Herm Lagally, Westinghouse
Chris Cassino, Westinghouse
Gary Whiteman, Westinghouse
Cheryl Hammer, Westinghouse
Damian Testa, Westinghouse
Chris Hoffmann, Westinghouse
Joe Kandra, Westinghouse
Patrick Fabian, Public Service Enterprise Group
Terry Garrett, Wolf Creek Nuclear Operating Corporation
Don Gerber, Dominion
Russ Cipolla, APTECH Engineering
Jim Begley, AREVA
Pete Riccardella, Structural Integrity Associates

ANL/NRC
Bill Shack, ANL
Saurin Majumdar, ANL
Allen Hiser, NRC
Kenneth Karwoski, NRC
Emmett Murphy, NRC
Andrew Johnson, NRC
Charles Harris, NRC

ENCLOSURE