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June 5, 2003

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
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Washington, DC 20555-0001

Ladies & Gentlemen:

ULNRC-04861
TAC No. MB6478

DOCKET NUMBER 50-483
CALLAWAY PLANT
UNION ELECTRIC COMPANY
REVISION TO TECHNICAL SPECIFICATION 5.5.9
"STEAM GENERATOR (SG) TUBE SURVEILLANCE PROGRAM"

Ameren UE

References: 1) ULNRC-04745 dated October 3, 2002
2) NRC letter to G. L. Randolph dated February 4, 2003

Reference 1 transmitted a license amendment request per the guidance of Administrative Letter 98-10, This amendment request was submitted to address the use of Rotating Pancake Coils (RPC) exams at the top of the tube sheet. RPC is used to supplement bobbin coil exams to ensure structural integrity in accordance with NEI 97-06. Following several teleconferences with the Staff, NRC issued References 2 which transmitted requests for additional information (RAI).

Attachment 2 provides responses to the RAIs transmitted by Reference 2. Several of the RAIs deal with the Technical Specification changes proposed in Reference 1. Since the treatment of tube inspections in plant technical specification has become a generic industry issue we propose that this amendment request be held until generic technical specification language has been developed and accepted. We will provide a follow-on submittal to update the Callaway Technical Specification at that time.

Attached are:

2 copies of LTR-SGDA-03-129, "Responses to NRC RAIs on Partial-Length RPC Inspection of the Tube Sheet Region of the Callaway Plant Steam Generators" (Proprietary)

2 copies of LTR-SGDA-03-130, "Responses to NRC RAIs on Partial-Length RPC Inspection of the Tube Sheet Region of the Callaway Plant Steam Generators" (Non-proprietary)

2 copies of WCAP-15032-NP, Rev. 1, "Improved Justification of Partial Length RPC Inspection of Tube Joints of Model F Steam Generators of AmerenUE Callaway Plant" (Proprietary)

2 copies of WCAP-15932-P, Rev. 1, "Improved Justification of Partial Length RPC Inspection of Tube Joints of Model F Steam Generators of AmerenUE Callaway Plant" (Non-Proprietary)

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Also attached are Westinghouse authorization letters, CAW-03-1649 and CAW-03-1650 accompanying affidavits, Proprietary Information Notice (Attachment 4) and Copyright Notice (Attachment 5).

As Items 1 and 3 contain information proprietary to Westinghouse Electric Company, it is supported by affidavits signed by Westinghouse, the owner of the information. The affidavits set 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 2.790 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 2.790 of the Commission's regulations.

Correspondence with respect to the copyright or proprietary aspects of the items listed above or the supporting Westinghouse Affidavits should reference CAW-03-1649 or CAW-03-1650 and should be addressed to H.A. Sepp, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

If you have any questions on this amendment application, please contact Mr. Dave Shafer at (314) 554-3104.

Very truly yours,

David Shafer

David Shafer
Acting Manager, Regulatory Affairs

DES/mlo

Attachments: See List on Next Page

Attachments

1) Affidavit

2) a. Callaway RAI Responses
   b. Westinghouse RAI Responses LTR-SGDA-03-129 (Proprietary Class 2)
   c. Westinghouse RAI Responses LTR-SGDA-03-130 (Non-Proprietary Class 3)
   d. Proprietary Affidavit CAW-03-1649

3) a. Westinghouse Topical Report WCAP-15932-P, Rev. 1 (Proprietary Class 2)
   b. Westinghouse Topical Report WCAP-15932-NP, Rev. 1 (Non-Proprietary Class 3)
   c. Proprietary Affidavit CAW-03-1650

4) Proprietary Information Notice

5) Copyright Notice

6) RAI 54
   The eddy current data for 5 tubes mentioned in RAI 54 and calibration runs (optical disk). Also included are the standard drawings and setups for the various cal groups. A copy of the analyst guidelines are also included.

7) RAI 32
   A copy of the Appendix H Technique Qualification Report is included as requested by RAI 32.

8) RAIs 52
   A list of indications in all steam generators located below -0.3 inches is also included as part of the answer to RAI 52, I8.a, and 65.

9) RAI 63.c
   The calibration sheet for the in-situ flow meter is included to answer RAI 63.c.

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STATE OF MISSOURI	)	
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CITY OF ST. LOUIS	)	

David Shafer, of lawful age, being first duly sworn upon oath says that he is Acting Manager, Regulatory Affairs, for Union Electric Company; that he has read the foregoing document and knows the content thereof; that he has executed the same for and on behalf of said company with full power and authority to do so; and that the facts therein stated are true and correct to the best of his knowledge, information and belief.

By David Shafer
David Shafer
Acting Manager, Regulatory Affairs

SUBSCRIBED and sworn to before me this 5th day of June, 2003.

Melissa L. Orr

MELISSA L. ORR
Notary Public - Notary Seal
STATE OF MISSOURI
City of St. Louis
My Commission Expires: June 23, 2003

REQUEST FOR ADDITIONAL INFORMATION

RELATED TO STEAM GENERATOR TUBE INSPECTION LICENSE AMENDMENT

UNION ELECTRIC COMPANY

CALLAWAY PLANT, UNIT 1

DOCKET NO. 50-483

The information requested by the NRC staff is on the licensee's application dated October 3, 2002, in which the licensee proposed changes to TS 5.5.9, "Steam Generator (SG) Tube Surveillance Program," to add a requirement for using the rotating pancake coil (RPC) to the H* depth in the SG tubesheet. Of the following questions, questions 1 to 5 are on the Callaway Technical Specifications (TSs), and questions 6 to 73 are on the proprietary Westinghouse Topical Report (TR) WCAP-15932-P, "Improved Justification of Partial-Length RPC Inspection of Tube Joints of Model F Steam Generators of Ameren-UE Callaway Plant," Revision 0, dated September 2002, which was submitted with the application.

Questions on the TSs:

1. Discuss if the TSs should also specify that the H* depth inspection is applicable to hot leg tubes only so as to be consistent with the technical basis in the Westinghouse TR. The proposed TS wording implies that the H* depths can be applied to the cold leg tubes also.

   Response:

   The Callaway license change is requested to be placed on hold based on submittal of the steam generator generic license change package. Callaway plans to submit a license change package based on the industry developed language and final NRC acceptance of generic technical specification changes.

2. Provide the following: (1) confirm that the primary-to-secondary leakage in the Callaway TSs is 150 gallons per day (gpd) per steam generator, and (2) describe the current plant administrative procedures regarding operator actions when a steam generator tube leakage occurs.

   Response:

   (1) TS 3.4.13.e states "RCS operational leakage shall be limited to: 150 gallons per day primary to secondary LEAKAGE through any one steam generator.
   (2) The administrative procedure governing primary to secondary leakage and operator action is in accordance with the EPRI Primary to Secondary Leakage Guidelines. The procedure recommends plant shutdown at 75 gallons per day leakage. Callaway uses several methods for primary to secondary leakage detection. They are N-16 monitors on the main steam lines, steam generator blowdown (SGBD) Heat Exchangers Outlet Header Gamma Detector, and a Condenser Air Discharge Radiation Detector.

3. The proposed phrase to be added to TS 5.5.9.d.1.h, "Tube Inspection," states that the tube inspection includes "inspection with rotating pancake coil (or equivalent) from the tube expansion transition at the top of the tubesheet to the H* depth as specified in TS Table 5.5.9-4." Discuss what is the starting point (or reference point) of the H* depth measurement, including the following:

   a. The TR mentioned that the starting point for the H* depth is the top of tubesheet whereas the proposed TS wording implies that the starting point is the expansion transition. If the top of the tubesheet is the starting point, then consideration should be made in the TS wording for cases where the expansion transition is located above or below the top of tubesheet. If the starting point is the expansion joint point, then the TS requirement is not consistent with the TR. If the starting point is from the expansion joint, then is the H* depth measured from the top of the expansion transition joint or from the bottom of the expansion transition joint? The starting point of the H* depth should be clarified.

   b. In general, when inspecting the top of tubesheet, licensees also inspect the tube above the top of tubesheet (e.g., three inches above the top of the tubesheet). How many inches above the top of the tubesheet is proposed to be inspected?

   Response:

   The Callaway license change is requested to be placed on hold based on submittal of the steam generator generic license change package. Callaway plans to submit a license change package based on the industry developed language and final NRC acceptance of generic technical specification changes.

4. Address whether there should be a TS requirement for future inspection of H* tubes, including if each H* tube must be inspected during each steam generator tube inspection to assure that there are no indications in the H* distance.

   Response:

   The Callaway license change is requested to be placed on hold based on submittal of the steam generator generic license change package. Callaway plans to submit a license change package based on the industry developed language and final NRC acceptance of generic technical specification changes.

5. The proposed TS wording describes the H* inspection distance and probe; however, the TS has no requirement stating that if any indication is found within the H* distance it must be repaired or plugged (i.e., plug on detection) and if any indication is found below the H* distance in the tube in the tubesheet it may remain in service. Discuss this issue.

   Response:

   The Callaway license change is requested to be placed on hold based on submittal of the steam generator generic license change package. Callaway plans to submit a license *change package based on the industry developed language and final NRC acceptance of generic technical specification changes.*

Questions on Westinghouse Report WCAP-15932-P:

6. Page 2-2. One of the assumptions for the H* criterion is that tube cracking within the tubesheet is primary water stress corrosion cracking (PWSCC). This implies that the H* criterion will not be applicable to tubes with other degradation mechanisms such as outside diameter stress corrosion cracking (ODSCC). If this is the correct interpretation, then TS 5.5.9.h needs to limit the H* criterion to PWSCC only.

   Response:

   Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

7. Page 2-2. One of the assumptions states that bobbin coil eddy current testing (ECT) is capable of detecting circumferential crack and deep axial indications within the tubesheet. It is not clear in the TR that the bobbin coil is qualified for these indications. Describe the qualification of the bobbin coil for these types of indications.

   Response:

   Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.s.

8. Page 2-1. It is stated that any indication in the tube region below the H* distance in the tubesheet may remain in service. It is not clear whether a severely degraded indication (e.g., 100 percent through-wall crack) may remain in service even if the indication is located below the H*distance. Address the disposition strategy for the through-wall indications below the H* distance.

   Response:

   Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

   The following is provided for additional clarification:

   All positive indications will be removed from service below the H distance.*

9. Page 3-1, 4th paragraph. It is stated that the maximum practical primary-to-secondary leakage during normal operation is 75 gpd. On page 3-4, it is stated that the plant will shut down when the leak rate is above 75 gpd. Discuss if the 75 gpd leakage limit is an analytical condition of the H* depth criterion, and if the limit should be included in the proposed TS requirement for the H* criterion.

   Response:

   Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

   The following is provided for additional clarification:

For normal operation, the plant has administrative guidelines in accordance with the EPRI PWR Primary-to-Secondary Leakage Guidelines, which recommend plant shutdown at 75 gpd. The technical specification allowable leakage limit is 150 gpd.

10. Page 3-3, 5th paragraph. It is stated that +point, Vpp > 3 volt, would be used within the tubesheet and below the RPC inspection depth. Address the following:

    a. Why the peak-to-peak voltage is specified to be greater than 3 volts for the +point probe.

    b. It is the staff's understanding that within the H* depth, the RPC (i.e., +point) would be used and below the H* depth, a bobbin coil would be used; however, the statement in the 5th paragraph implies that a +point would be used below the H* depth, not the bobbin coil. Explain the discrepancy.

    Response:

    Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

11. Page 3-3, 6th paragraph. It is stated that all of the tubes in the 50 percent program of the opened steam generators would be inspected to the H* depth. Describe the "50 percent program." It is not clear to the staff whether the inspection strategy is consistent with the inspection strategy on page 3-3 in the TR. Clarify and describe the inspection strategy.

    Response:

    Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

    The following is provided for additional clarification:

    Callaway will inspect the H regions in accordance with WCAP-15932 Revision 1. The inspection scope will be in accordance with the Steam Generator Examination Guidelines for active degradation at the top of the tubesheet. Callaway has historically performed a 100% top of tubesheet examination with RPC.*

12. Page 3-5, 4th paragraph. It is stated that the H* values do not contain any margin for non-destructive examination (NDE) uncertainty in elevation of the crack features. Regulatory Guide 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes," recommends measurement uncertainties (i.e., measurement error and analyst variability) in the eddy current inspections. Provide justification for not including measurement uncertainties

    Response:

    Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

13. Page 3-5, 5th paragraph. It is stated that the H* values are grouped in four zones based on

the tubesheet upward bending during normal operation and during the limiting accident condition. It is not clear if the zones were calculated based on the limiting conditions and if the radii for each zone include any statistical/calculational errors. Address these issues.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

14. Page 5-1. Provide the following: (1) how many test tubes were assembled in the leak test program, and (2) how many tests were performed at room temperature, normal operating temperature, or accident event temperature.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

15. Page 6-1. It is stated a,c.e that the tubesheet constraints the crack opening area and that the constraining effect for axial cracks is taken into account in the leakage calculation by using an effective crack length that is less than the actual length. However, during an accident, the tubesheet bows and the tubesheet bore expands, and the expansion of the tubesheet bore would reduce the constraint effect. Address how the tubesheet bore expansion was taken into consideration in the leakage or tube pull-out calculations, including the impact of the bore expansion on the leak rate and pull-out force (e.g., the percentage of the leak rate or pull-out force caused by the bore expansion).

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

16. Section 7.0. In its structural analysis, Westinghouse used carbon steel material properties for the tubesheet; however, there is a stainless steel (or nickel-based alloy) cladding on the top of the tubesheet. Address how the material properties of cladding were considered in the tubesheet structural analysis, including the effect of the cladding, if any, on the H* depth and on the leakage calculations.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

17. Address how a leakage model with a through-wall circumferential crack having a 360 degree extent below the H* depth in the tubesheet has been considered, including what would be the leak rate of such a crack. Considering the worst scenario leakage from H* tubes, address how many tubes can be applied with the H* criterion without exceeding TS primary-to-secondary leakage limit.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

18. In the proposed TS Table 5.5.9-4, the H* depth for inspection depth zone A is proposed to be 2.38 inches. This H* depth is smaller than the H* depth proposed for zones B, C, and D, and can be viewed as not as conservative in terms of tube structural and leakage integrity. In general practice, licensees inspect 3.0 to 6.0 inches below the top of the tubesheet using the RPC. Address the differences in the proposed H* depths by inspection depth zone, and include the following:

    a. Describe the history of indications detected within 2.38 inches below the top of the tubesheet at Callaway.

    b. Describe the structural and leakage integrity of a tube with an H* depth of 2.38 inches.

    Response:

    Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

    The following is provided for additional clarification:

    Callaway has identified several indications in the tubesheet region. However, most of the Indications discovered in the steam generators are located at the expansion transition, as expected. The H distances were revised prior to the issuance of the RAI's. The H* depth for Zone A was revised from 2.38" to 3.46". The reference 2.38" is taken to apply to the revised value of 3.46". Callaway first identified stress corrosion cracking in Refuel 7. Question 52 lists the indications found 0.30 inches below the top of the tubesheet in all steam generators.*

19. Discuss the length(s) of the test tube inside the tubesheet collar in the mock-up tests, including if the distance of 2.38 inches was modeled in the test. Discuss whether the test tube was severed at the 2.38 inch location inside the tubesheet. It should be pointed out that the TR discussed only perforated locations in the tube, not a severed tube.

    Response:

    Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

20. In its review, the staff found that the description of the inspection depth zones A, B, C, and D in proposed TS Table 5.5.9-4, by listing the range of radii of the zone from the vertical centerline of the tube sheet, is not as descriptive as Figure 3-6 in the TR. Address whether Figure 3-6 in the TR should be included in the Callaway TSs (i.e., can the proprietary information in the figure be omitted to allow it to be placed in the TSs?).

    Response:

    The Callaway license change is requested to be placed on hold based on submittal of the steam generator generic license change package. Callaway plans to submit a license change package based on the industry developed language and final NRC acceptance of *generic technical specification changes.*

21. In the conference call on October 17, 2002, a Westinghouse representative stated that all tubes with indications in the H* distance region would be plugged as shown by Figure 2-1 of the TR, because the RPC would not be able to size the indications. However, a Union Electric representative stated that tubes with some indications detected in the H* distance may not be plugged and thus would remain in service, and that tube plugging would be based on the TS 5.5.9 tube plugging criteria of 40 percent through-wall, because the RPC can size the indications in the H* region. Address the discrepancy between these statements.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

The following is provided for additional clarification:

All tubes found with degradation, whether in the H region or below will be repaired.*

22. Abstract:

a. Page vii, Abstract. Explain the engagement distances of 0.30 inch and 1.4 inches with respect to the P* distance.

b. Page vii, Abstract. It is stated that "...P* is to show the acceptability of a tube separation below the P* distance for about 95% of the operating tubes in the bundle..." Discuss whether tube separation would be acceptable in terms of structural and leakage integrity for the remaining 5 percent of the tubes in the bundle.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

23. Section 1.0:

a. It is stated that PWSCC has been identified in the region between the bottom of the hydraulic expansion transition and the 3-inch depth in the Callaway steam generators. Provide the historical data of tube indications (circumferential and axial) found in the tubesheet. Specify the maximum distance measured from the top of the tubesheet into the tubesheet that PWSCC indications have been detected.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

See response to Question 52. The maximum distance measured from the top of the tubesheet into the tubesheet for PWSCC indications is 10.58 inches.

b. Discuss the disposition of an indication that is detected by a RPC probe that is not within the H* distance, but is within the expansion transition zone (e.g., above the top of the tubesheet) or below the H* distance. Include in the discussion if the disposition would be in terms of the requirements specified in TS 5.5.9.

Response part b:

Any indication of degradation found in the expansion transition, above or below the H distance, will be repaired. Callaway has not licensed an Alternate Repair Criteria (ARC), therefore, any indication of degradation is repaired based on a repair-on-detection criteria. Wear is the only indication that may be left in-service based on applying the technical specification criteria of 40% through wall.*

24. Section 2.0:

Page 2-1, 4th paragraph. It is not clear why P* distance is not specified in the Callaway TSs as an inspection requirement because the P* distance is related to the H* distance. It is stated in the TR that, "... the initiation of inspection to H* depths also initiate the use of P*..." Discuss if this recommendation will be adopted at Callaway and included in the TSs.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

25. Section 5.0:

a. Page 5-1, Section 5.1.1. Provide information on the test collars, i.e., the number of collars used in the test, the dimension of the collars (1.63 inches in outside diameter?), and the number of tube specimens in any one collar. Discuss whether the test program included testing of the tubesheet bowing effect.

b. The summary of the tests is addressed on page 5-4. In the summary, there is no mention of fatigue (mechanical or thermal) testing. The mechanical fatigue testing would include cyclic load testing, and the thermal fatigue testing would consider the thermal expansion and contraction (during heatup and cooldown) of the tube length between the top of the tubesheet and the tube support plate(s) where the tube may be constraint by either denting or deposits. Discuss why these tests were not considered.

c. Page 5-4. It is not clear in the TR whether the H* distances were modeled in the test mock-ups. Discuss if this was done, and provide the length of the tube in the tubesheet for the tube pull-out and leakage tests.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

26. Section 6.0:

a. Page 6-2, 3rd paragraph. The report discussed the proprietary DENTFLO computer code in calculating leak rate of an axial crack and the effective crack length in the leak rate calculations; however, there is no discussion of a leak rate calculation for a circumferential crack. It is not clear how the effective crack length of a circumferential crack is modeled in the leak rate calculation. Provide a discussion on the leak rate calculation for a circumferential crack.

b. Page 6-3, 1st paragraph. It is stated in the TR that a through-wall circumferential crack of 180 degree extent was considered in the leak rate calculation. Discuss why a through-wall circumferential crack of 360 degree extent is not the worst scenario crack and was not considered in the leak rate calculation. See Question 17.

c. Page 6-3, 2nd paragraph. Provide leak rate results of a single axial and circumferential crack under steam line break conditions and normal operational conditions.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

The following is provided for clarification:

The Westinghouse RAI *response is inconsistent as to the number of axial cracks located ~0.3 inches below the top of the tubesheet. A review of the historical indications reveal that two axial indications have been identified. However, these indications do not affect the SLB leakage calculation included in WCAP-15932 Rev.1. Refer to Question 72.*

27. Section 7.0:

a. Page 7-1, 4th paragraph. The report discussed a previously developed finite element model for the model F steam generator. Discuss if this model was developed for Callaway and provide the reference for this model.

b. Page 7-2. It is not clear whether the tube bores were included in the finite element model. In addition, the tubesheet bores are not evident in the finite element model as shown in Figure 7-1. The TR stated that an equivalent ligament efficiency, modified modulus of elasticity, and modified Poisson's ratio were used to simulate the tubesheet bore. However, it is not clear how the ligament efficiency is input in the finite element model to simulate the tubesheet bore in the finite element model. Discuss how the ligament efficiency can simulate the tubesheet bore, including the previous sentences.

c. Pages 7-3 and 7-4. The TR cited References 9.21, 9.22, 9.23, 9.24 (e.g., on page 7-12, Reference 9.28 was cited); however, these references could not be found in the reference section of the report. Explain the discrepancy.

d. Page 7-3, 2nd paragraph. The TR discussed a previous calculation performed with a 3-D finite element model of a model D-4 steam generator. Provide the reference of this analysis.

e. Pages 7-8 and 7-9. Discuss whether the pressure and temperature parameters for the feedline break, steamline break, and loss-of-coolant accident (LOCA) events were specifically taken from the Callaway design basis accident analysis or from a generic accident analysis. On the basis of the references cited in the TR, it seems that the pressure and temperature parameters used in the Callaway analysis may be generic values. Discuss if this is correct, and confirm whether the generic pressure and temperature parameters used in the H* analysis bound the values in the accident analysis of the Callaway plant.

f. Pages 7-23 and 7-24; Tables 7.2-2a and 7.2-2b. Explain the significance of Psec = 893 psig and Psec = 955 psig, and why there is no Psec value in Table 7.2-3?

g. Page 7-26. Discuss whether the P* analysis in Section 7.3 was benchmarked with testing data. It is the staff's understanding that the purpose of the P* distance is to provide assurance that if a tube having a H* distance less than P* distance is pulled out from the tubesheet, that tube would be confined by the adjacent row tube without damaging other tubes. However, absence of a valid verification of the P* methodology, the shortest H* distance should be made to be greater than P* distance to assure that if a tube is pulled out, it would not impinge on any tubes. Discuss this.

h. Discuss how the tubesheet bowing is considered in the structural and leakage integrity calculations, providing the following: (1) the maximum and minimum values of the tubesheet bowing, (2) the locations of the maximum and minimum tubesheet bowing, and (3) the maximum and minimum values of tubesheet bore expansion.

i. Discuss whether the finite element model has been benchmarked with the actual test results to verify the accuracy of the analytical method of calculating tubesheet bowing.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

28. In the proposed TSs, the inspection extent references the expansion transition. Given how the testing was performed, clarify whether the proposed TSs should be modified to reference from the bottom of the expansion transition or the top of the tubesheet, whichever is lower.

There are several references in the TR indicating that H* is reckoned from the top of the tubesheet and assumes a conservative distance between the bottom of the hydraulic expansion transition and the top of the tubesheet. Discuss the reference point for the H* distances provided in the TSs.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

The Callaway license change is requested to be placed on hold based on submittal of the steam generator generic license change package. Callaway plans to submit a license change package based on the industry developed language and final NRC acceptance of generic technical specification changes.

29. Discuss the role of P* in determining the H*distances in the proposed amendment. If P* is relied upon in determining the proposed H* distances, address the following:

   a. Discuss why P* is limited to non-stayrod and non-patchplate area tubes, including if this is because there are no nearby neighbors or are there other reasons?

   b. The basis for assuming that tube separation below the P* distance for approximately 95 percent of the tubes in the bundle.

   c. How have the effects of degraded tubes been accounted for in the P* analysis?

   d. Describe the test data supporting the analytical calculations with respect to neighboring tubes limiting the extent of tube pull-out.

   e. Discuss how sliding of the tubes and distortion (bending) of the tubes were accounted for in the analysis.

   f. Discuss the effects of one tube impacting another tube assuming the tube "impacted" is degraded to the steam generator performance criteria by the most limiting damage mechanism.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

30. Clarify the meaning of the statement on page 1-2 in the TR: "a similar approach has been demonstrated to be acceptable for use in cases of tube weld damage due to loose parts." Provide the data which demonstrates that leakage during normal operation can be related to leakage during postulated transients. Discuss the relationship, including how ligament tearing is accounted for in this relationship and how the scatter in the data is accounted for in the H* methodology.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

31. Assumptions regarding the location of the bottom of the expansion transition were

made in the TR. For Callaway, if the inspection distances are from the top of the tubesheet, provide the maximum distance from the top of the tubesheet to the bottom of the expansion transition (i.e., ones below the top of the tubesheet). Discuss how this distance is used in relation to the H* distances provided in the TS and how the NDE uncertainty in determining the top of the tubesheet, the bottom of the expansion transition, and the inspection distance is accounted for in the analysis. List the assumptions made and provide the basis for the assumptions.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

The following is provided for additional clarification:

Westinghouse as-built manufacturing data suggests the maximum depth measured is 0.28". Callaway has added a distance of 0.30 inches to all H distances. Callaway increased the H* distances for each zone by more than 1 inch to account for axial encoder uncertainty and add conservatism to all distances. The RPC inspection is performed from 2" above the top of the tubesheet to at least 1 inch below the calculated H* depths. The axial encoder uncertainty was determined by primary eddy current vendor prior to the Refuel 12 inspection by mocking up the conditions at Callaway. Several trials were performed which determined an axial encoder uncertainty to be 0.08 inches for the tubesheet inspection.*

The Callaway license change is requested to be placed on hold based on submittal of the steam generator generic license change package. Callaway plans to submit a license change package based on the industry developed language and final NRC acceptance of generic technical specification changes.

32. Several assumptions were made in establishing the H* and P* distances in Section 2.2 of the TR. List the assumptions and provide the technical basis and data for each of the assumptions (with the exception of the assumption regarding the 1.0 gpm leakage limit during steam line break (SLB) and the primary side makeup capacity). Discuss whether the inspection techniques have been qualified in accordance with the Electric Power Research Institute (EPRI) guidelines and provide the qualification data. Discuss whether the EPRI guidelines are being followed with respect to the frequency of inspection for plants with mill annealed Alloy 600. If not, provide the technical justification for the deviation.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

The following is provided for additional clarification:

The bobbin probe is not qualified for use in the tubesheet at Callaway. The RPC probe used at Callaway is qualified in accordance with the Steam Generator Examination Guidelines, Appendix H. The qualification report for Refuel 12 is attached.

Callaway inspects 100% of the tubesheet region in all four steam generators every *outage (18 months) with an RPC probe. This is in accordance with the Steam Generator Examination Guidelines for Westinghouse steam generators.*

33. It was indicated that past experience with circumferential cracks inside the tubesheet for another type of tube joint indicated that leakage is low and that the same trend is expected for Callaway. Discuss the relationship between the contact pressures at Callaway to these other plants. Discuss the extent to which these indications were subjected to the full range of normal operating, transient, and accident conditions.
Response:

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

34. It was assumed in Section 3.1.2.2 of the TR that the pull-out distances associated with the normal operating pressure (NOP) values could be ignored since the plant will shut down because of leakage. Discuss the basis for this assumption. As indicated above, past experience indicates that leakage is low from circumferential cracks. Discuss the possibility that no leakage may be observed from a joint that is totally severed at some distance or has a through-wall crack. In determining the steam line break pull-out distance, discuss how the lower temperature during the break was accounted for in determining the inspection distance.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

35. In determining the acceptance limits, the most limiting primary-to-secondary differential pressure during normal operation should be used (most limiting would equate to the maximum differential pressure that can be observed during normal operation for the life of the steam generator). In performing the testing, it would appear that the lowest differential pressure should be used, since it would result in a lower contact pressure. Discuss the basis for performing the tests at 1900 psi, which is considerably higher than normal operating differential pressure. Discuss how the lowest normal operating pressure was accounted for in determining the H* inspection distance, and provide the data associated with the determination of the resistance to pull-out as a result of the hydraulic expansion.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

36. Describe how the roughness of the collars used during the testing program compare to the roughness of the tubesheet bore. Describe any data confirming the as-built roughness of the tubesheet bore. Discuss if the lowest possible value of roughness was used, and, if not, how was this accounted for in determining the inspection distances.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

37. In performing the leak rate tests, discuss why a 100 percent through-wall circumferential crack was not assumed at the H* distance. If based on some qualification data, discuss the potential for a partial through-wall flaw to "pop" through-wall during a steam line break or to grow from partial through-wall at one inspection to through-wall during the next inspection.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

38. It was indicated in Section 5.1.4.1 of the TR that wall thinning calculations were performed to determine the effect of tack rolling. Discuss the reason for this section of the TR. Also, discuss if the tack rolling was at the tube end in the field, and, if so, if the test specimens also had this tack rolling and whether the tack roll performed on the test specimens had the lowest contact pressure that could be observed in the field. Provide the basis (including applicable data) for your answer.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

39. With respect to the test specimens, it was indicated that segmented expansions were performed. Discuss the various configurations tested, including, for example, were all tests segmented or were some tests fully expanded for the entire region of the tubesheet? Discuss also the basis for concluding that the test specimens were representative of the expansions in the field, including, for the segmented samples, is it possible that the tack roll assumed a greater percentage of the load than the hydraulically expanded region and, if so, discuss the need to repeat the test to account for the fact that this area is below the H* distance. In addition, discuss the basis for assuming the pull out force is evenly distributed along the length of the tube in contact with the tubesheet.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

40. In Section 5.3.2 of the TR it was indicated that: "in the 600°F pullout tests, the lowest value for 'first slip' or 'breakaway' force was 3000 lbs." This section then indicates that the results were conservative because of the lack of the additional resistance to pull-out due to the differential pressure tightening between the tube and the tube hole surface which would be present in the plant. Discuss at what pressure were these tests run and how was the tube/tubesheet heated.

Response:
Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

41. Provide a comparison of the results of the leak tests provided in Section 5.3.1 of the TR to the predictions from the proprietary DENTFLO computer code.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

42. Section 6.3, page 6-2. It is not clear why degradation of various depths was assumed in the leakage analysis. Given the potential for a tube to be circumferentially severed below the H* distance (or near severance at the time of inspection), it would appear appropriate to assume every active tube is severed at the H* distance. Discuss this discrepancy.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

43. A finite element model was used in determining tubesheet hole dilations. Discuss the basis for the assumptions in this model, or compare the differences between this model and that used for other plants with similar repair criteria which have been approved (e.g., Diablo Canyon W* criteria).

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

44. Discuss whether the H* distances in the TSs are based on a feedline break or an SLB. In the TR, the acceptance criteria is more restrictive than a feedline break; however, the transients are different. Discuss whether an analysis was performed to confirm that the more conservative inspection distance was determined.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

45. With respect to the TSs, given that the test program was done on non-degraded tubing, discuss why the TSs should not specify that any tube with detected degradation below the expansion transition and within the H* distance should be plugged, including the technical basis for assuming pull-out is not affected by tube degradation.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

The Callaway license change is requested to be placed on hold based on submittal of the steam generator generic license change package. Callaway plans to submit a license change package based on the industry developed language and final NRC acceptance of generic technical specification changes.

46. Discuss how the dynamic effects associated with steam generator blowdown during a SLB or feedline break are modeled in the determination of the H* distance (e.g., are there increased loads placed on the tubes as a result of the blowdown of the steam generator?).

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

47. Discuss any test data supporting the magnitude of the pressure and temperature effects on contact pressure. Because the corrections in the TR appear to be analytical rather than experimental in nature, discuss whether mockup tests have been performed on specimens at room temperature and at operating temperature (or at ambient and operating pressure), and, if so, discuss whether the results of these tests support the contact forces for these effects used in the analysis. If testing of hydraulically expanded tubes is not available, discuss whether tests from other types of expansions (e.g., WEXTEX, hardroll) are applicable and the results of any testing on these specimens. The staff notes that resistance to pull-out in the peripheral tubes appears to be controlled mainly by the effects of pressures and temperature rather than by hydraulic expansion.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

48. The first 10 rows of the Callaway steam generator tubes were fabricated with thermally treated Alloy 600 material and the rest were fabricated with mill-annealed Alloy 600 material. Discuss whether there is any difference in the pull-out capacity and leakage resistance between the thermally treated Alloy 600 tubes and mill-annealed Alloy 600 tubes, because it seems that the test specimens, leakage and pull-out calculations discussed in the TR were based on mill-annealed Alloy 600 material properties only.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

49. Discuss whether in TS 5.5.9, there should be a requirement that limits the application of the proposed H* depths to the original steam generators, because this requirement is to assure that the H* depths will not be inadvertently applied to future replacement steam generators, such as a statement in the Bases for Surveillance Requirement 3.4.13.2.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

The Callaway license change is requested to be placed on hold based on submittal of the steam generator generic license change package. Callaway plans to submit a license change package based on the industry developed language and final NRC acceptance of generic technical specification changes.

50. Discuss the need to modify the pull-out length to account for differences in the thermal treatment process between the low row (less than row 10) and the high row tubes.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

51. In several places, references are made to documents for which no references are listed (e.g., what is reference 9.21 cited in Section 7.1.2?). This needs to be clarified in the TR.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

52. Tube flaws may remain in service at the end of the next operating cycle for the following reasons: (a) they were knowingly left in service at the beginning of cycle (since they were below the H* distance and sized with a qualified technique as being less than 40 percent through-wall), (b) a region of the tubesheet area was not inspected with a qualified probe so indications were not detected at the beginning of cycle (e.g., below the H* distance circumferential flaws would not be detected), (c) they initiated during the cycle, and (d) they were missed during the inspection and continued to grow. The methodology for predicting leakage from flaws in the tubesheet area was provided in the TR, based in part on the computer code DENTFLO. Describe the methodology to be used to determine the number, severity, and location (depth within the tubesheet) of flaws for purposes of determining the amount of leakage (using the DENTFLO code) during postulated accident conditions, including the following information for flaws that are found, in the steam generators, to extend below the bottom of the expansion transition:

a. the outage in which the flaw was found,

b. the orientation of the flaw (axial and circumferential indications),

c. the location of the indication with respect to the bottom of the expansion transition and the top of the tubesheet,

d. the size of the flaw to include the method of sizing (by plus-point, bobbin, or RPC), length (axial and/or circumferential), depth, and percent degraded area (for the circumferential indications), and

e. the H* zone (A, B, C, or D) where the flaw is located.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

See the attached list of indications found in the Callaway steam generators. All indications are referenced from the top of the tubesheet.

53. Based on the discussion of "turbo mix" in the telecon held on October 19, 2002, with Union Electric staff, explain the use of the "turbo mix" with the bobbin coil indications in (1) the bobbin coil inspection of the steam generator tubes in the then current refueling outage, and

(2) determining indications of circumferential cracks previously found by use of the pancake coil in the tube inspections in the same outage.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

Response:

Part 1:

A bobbin coil consists of two circumferentially wound coils (primary and secondary), separated axially on the probe. Bobbin coil data is obtained at four separate frequencies (630, 320, 160, and 30 KHz for Callaway) by the primary coil. Data at each frequency is obtained on two channels, one "absolute", the other "differential", providing eight total channels of data. The absolute channel is the primary coil data compared to a reference coil located in a perfect sample of tubing (reference standard). The differential channel is the primary coil data compared to the secondary coil. The eight channels of data are used in various ways to determine the condition of the tube wall.

The lower the frequency, the greater radial distance the coil can see. For example, the 30 KHz is used to look "outside" the tube for sludge and foreign objects. A typical "mix" used in eddy current analysis consists of two frequencies. For example, a high frequency (630 KHz) is typically mixed with a lower frequency (160 KHz), whose signal is then "subtracted" from the first. This eliminates the effect of the support plate and allows the tube located within that support plate to be analyzed without the interference of the support plate signal.

A "turbo" mix is a mix of more than two frequencies. It was developed jointly several years ago by Framatome (actually Conam or Rockridge at the time) and Zetec. It is another tool used by analysts. It is not a particularly reliable method of analyzing data, but can sometimes be used to find a potential flaw that is not apparent using other bobbin coil analysis techniques. The problem with the bobbin coil is not how to analyze the data, it is the limited amount of data it can obtain. At best, a bobbin coil is capable of flagging a potential [cracklike] indication. It is not capable of providing any useful data about that indication. It is, however, an excellent tool for finding and sizing volumetric flaws such as wear.

Steam generator eddy current inspections are governed by the EPRI PWR Examination Guidelines, and must be performed by techniques qualified in accordance with the guidelines. Appendix H governs the qualification of techniques. At Callaway, the site specific Examination Technique Specification Sheet (ETSS) used for the bobbin coil examination meets the requirements of EPRI ETSS' 96001.1, 96004.3, 96005.2, 96007.1 and 96008.1. This ensures our bobbin coil inspection meets all the requirements of the guidelines.

During Refuel 12, the bobbin ETSS at Callaway required the use of the four absolute and differential channels as described above, plus four mixes to be used as further *analysis tools. These mixes were designated as channels P1 - P4. P1, P2, and P4 were standard two-frequency mixes used primarily to suppress the support plate signal. The fourth mix, P3, was a 3-channel mix (turbo) used to suppress the support plate and also to suppress the tubesheet signal in the hot and cold leg tubesheets. Instructions on the ETSS directed the analysts to scroll each tube (through the hot and cold leg tubesheets) with P1 and P3. Therefore, all the tubes were scanned with the turbo mix through the tubesheet.*

Part 2

Scanning of the tubesheet region with the turbo mix (and P1) yielded no indications requiring further attention. After the rotating probe examination, the lead Level III analyst and Independent Level III reviewed the bobbin data for the deep tubesheet indications. According to lead Level III, they were able to see the large circumferential indication in 'C' steam generator after the fact (even going back to previous outage data). However, the signal was so insignificant that an analyst would not (and, of course, had not) identified it as a potential defect on initial review. It was only with knowledge (from RPC) that the flaw existed that allowed the analysts to recognize it for what it was. Most of the other defects had no signal at all on the bobbin data. Callaway does not employ this as a normal analysis technique because the RPC techniques are the "qualified techniques" for use in the tubesheet and expansion transition.

54. In a telecon on November 19, 2002, the licensee discussed several circumferential tube flaws that were detected in the tubesheet region of the Callaway steam generators during the Fall 2002 inspection. Provide the bobbin coil and rotating probe inspection data for the following tubes in the associated Callaway steam generators:
SG A--R25C71; SG C--R18C77; SC C--R21C101; SC C--R29C69; and SG D--R42C57. Include with this data the appropriate calibration runs, a drawing of the standards, and the setups from the various calibration groups. Also provide a copy of the eddy current data analysis guidelines.

Response:

The requested information is included.

55. On page 12 of the Westinghouse report, "RPC Inspection Lengths for Tube-To-Tubesheet Joints In the Callaway Steam Generators," SG-SGDA-02-47, the licensee indicated that the in-situ pressure test included a 360 degree, through-wall circumferential indication. The licensee stated that the circumferential indication did not leak under the SLB condition during the in-situ pressure test. The indication may not have leaked because (a) it was not as severe as eddy current data indicated, (b) the in-situ pressure test may be limited in its ability to provide results representative of an SLB, and/or (c) it does not represent the worst-case scenario. The staff notes that if a full- length tube pressure test is performed at a pressure of three times the normal operating pressure, it may result in simulating three times the axial loads; however, it also increases the interface pressure between the tube and the tubesheet as a result of pressure by 3 times. In addition, the in-situ pressure test does not include the effect of tubesheet bow. Ideally, the test should result in the more limiting of the following conditions: (a) imparting 3 times the axial loads on the tube at

normal operating pressure and temperature with a hole dilation consistent with that observed during normal operation; or (b) imparting 1.4 times the axial loads on the tube at SLB differential pressures and temperature with a hole dilation consistent with that observed during an SLB.

a. Discuss whether the appropriate end-cap loads and contact loads between the tube and the tubesheet, as a result of pressure, are simulated during the test (i.e., if the interface pressure due to the tube's internal pressure is increased by a factor of three during the test, it would not appear that the test is providing useful information).

Response part a:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

b. Provide a description of the test apparatus (including whether it was a partial or full length tube test; if a partial test, address the location of the sealing bladders with respect to the top of the tubesheet).

Response part b.

The in-situ pressure tests performed at Callaway in the most recent Refueling (12) were full length tube pressure tests. A constant high volume pump with a capacity of 4.5 gpm was used with digital flow meters capable of measuring 0.001 to 4.5 gpm at main steam line break conditions. A sealing probe was inserted into each end of the tubes to be tested below the flaw on the hot leg side of the steam generator channelhead. The system is capable of achieving 7000 psi.

c. Provide an analysis demonstrating the in-situ test conditions bound the conditions observed during normal operation and an SLB as a result of tubesheet bow.

Response part c.

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

d. Discuss whether the in-situ testing performed at Callaway can be used to assess the structural and leakage integrity of tubes with flaws in the tubesheet region. If the in-situ test does not provide information regarding the integrity of the indications in the tubesheet region, discuss the implications of these results.

Response part d.

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

56. The licensee investigated the location of the bottom of the expansion transition in relation to the top of the tubesheet. The licensee included a value of 0.30-inch in the H* distances based on an understanding of the expansion method and a review of data from other units. Based on an assessment of the eddy current data at Callaway, provide the maximum

distance that the bottom of any of the expansion transitions is from the top of the tubesheet.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

The following is provided for additional clarification:

Callaway did not perform an eddy current review to determine the bottom of the expansion transition. Callaway did add 0.3 inches to each H calculated distance to account for variation in the top-of-tubesheet to bottom of expansion transition distances. Another 0.25 inches was added to the calculated H* distances to account for axial encoder uncertainty in determining the top of the tubesheet. Therefore, a total of 0.55 inches was added to the inspection distance. Additional margin was added by performing inspections in accordance with the chart below.*

Zone	*Calculated H**	*Inspection Depth*	*Margin*
A	*3.46 inches*	*5 inches*	*1.54 inches*
B	*5.91 inches*	*7 inches*	*1.09 inches*
C	*7.45 inches*	*9 inches*	*1.55 inches*
D	*7.99 inches*	*9 inches*	*1.01 inches*

The primary eddy current vendor performed mockup testing of the RPC inspection to determine axial encoder uncertainty. The maximum error determined in mockup testing was 0.08 inches.

57. In evaluating the potential for leakage from reactor vessel head penetrations which have an interference fit (similar to the steam generator tubes), the industry's Materials Reliability Program (MRP-75) analyses include the fact that a leak into the annulus region between the nozzle and the head results in application of pressure on the outside of the nozzle and inside of the hole in the vessel head. This change in boundary condition from the as-designed configuration increases the pressure dilation of the vessel head (pressure applied to a larger diameter than the inside of the nozzle) and eliminates the pressure deflection of the nozzle. The net effect of the leakage into the gap is therefore to increase the gap opening. Discuss whether the analyses performed in support of determining the pull-out distance and the leakage from a steam generator tube account for this phenomena. If the model doesn't account for this effect, please perform an analysis to determine the need to account for this effect.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

58. Provide the "no-contact" length for each of the steam generator zones for both normal operating and postulated accident conditions (including the factors of safety for both conditions).

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

59. On page 9 of the Westinghouse report, SG-SGDA-02-47, Westinghouse stated that it made several modifications to the leakage analysis in the TR:

a. It removed room temperature tests from the analysis data.

b. It revised the crack opening area model to account for the fact that pressure acting on the flanks of the cracks is compressive relative to the material adjacent to the crack plane. This reduced the crack opening area by 50 percent.

c. The revised leakage analysis considered the tube material below the crack whereas in the original analysis the tube material below the crack was not considered.

Provide a more detailed description of the revised model and its basis, including:

a. A description of the testing program used to develop the loss coefficient. Provide the data acquired and the data used in the correlation.

b. A description of the testing program used to develop the flow through a crack. Provide the data acquired and the data used in the correlations.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

60. It was noted in the Westinghouse report, SG-SGDA-02-47, that all of the test specimens in the test program exhibited leakage at both room and elevated temperature conditions with higher leak rates being measured at room temperature. Although this general trend is expected because of the lower contact pressures at room temperature, discuss whether the magnitude of the differences in leak rates is consistent with what would be expected given the models used for accounting for the effects of temperature on contact pressure. If the trends cannot be quantitatively explained, discuss the need to perform additional testing to ensure there is a fundamental understanding of all key parameters.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

61. If the loss coefficients are lower at lower temperatures and an SLB results in temperatures less than 600°F, discuss the need to obtain a loss coefficient corresponding to the temperatures actually observed during an SLB. If no data is available from realistic SLB temperatures, discuss the need to use the room temperature test data to ensure the condition is bounded.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

62. On page 7 of the Westinghouse report, SG-SGDA-02-47, the licensee postulated a theory regarding why the loss coefficient may increase with the initial introduction of primary water into the crevice. Regarding this theory, please address the following:

a. Discuss whether the corrosion products or the primary water in the crevice would result in a loss of contact pressure above the joint and whether this effect was considered in the analysis. For example, suppose corrosion of the tubesheet resulted in the accumulation of corrosion products between the tube and the tubesheet, would the corrosion products result in a loss of contact pressure (due to a phenomenon such as denting)? In addition, suppose a tube was leaking from a crack in the tubesheet region, discuss the potential for loss of contact pressure as a result of the leakage. Provide the technical basis for the answers.

b. During the leak rate testing program as discussed in Westinghouse report, SG-SGDA-02-47, it was noted that when repeat tests were performed on a specimen at elevated temperature, there was an increase in the loss coefficient (with few exceptions). Please describe these exceptions and assess the key parameters that may explain why these exceptions occur (e.g., specimens with lower contact pressures, more severe flaws, random, etc.). Given the results of this analysis, discuss whether similar conditions occur in the field.

c. Discuss the extent to which the same phenomenon (increase in loss coefficient as a result of leakage) would occur in the field given that the water chemistry in the plant is different than the pressurizing medium used during the tests. Also discuss the handling of the specimens between these tests. Discuss whether the loss coefficient is increasing with time simply as a result of different environments and handling (the lab specimens are probably exposed to much more oxygen than would be present in a steam generator during operation).

d. Given that the tubesheet collar used in the test is a different material than that used in the field and was primarily selected to simulate the rigidity of the tubesheet, discuss whether different results may be obtained if the actual tubesheet material was used.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

63. On page 8 of the Westinghouse report, SG-SGDA-02-47, Westinghouse stated that the leak rate can be measured by the pressure drop during the in-situ pressure test and that if there is no detected drop in the pressure during a hold period, there has been zero leakage. Westinghouse also stated that the in-situ testing equipment is capable of measuring leak rates as small as 0.001 gpm.

a. The staff understands that the holding period for the maximum pressure is usually two minutes. If the holding period is extended to a longer period of time such as the duration of a steam line break event, the tube may leak because the crack opening area may enlarge. Discuss the potential for the tube to leak when the holding period is extended.

Response part a:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

b. Describe how the leak rate was measured in the in-situ pressure tests.

Response part b:

The leak rate was measured with a digital flow meter. The system is closed and is comprised of a positive displacement pump. The system is pressurized and is operated under a static head. Any displacement of water is detected by the flow meters and output to a digital display and acquisition system.

c. Assuming the in-situ test can simulate the conditions of an SLB, please provide the basis for the statement that the in-situ testing equipment is capable of measuring leak rates as small as 0.001 gpm.

Response part c:

See the attached calibration sheet for the low flow meter. The meter calibration sheets shows a capability of measuring 0.0007 gpm.

d. With respect to the statement that the detection capability is improved if pressure is monitored, discuss the sensitivity of this technique for the standard hold times used during in-situ tests. Provide the basis for this answer.

Response part d:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

64. The licensee indicated that the flaws in the tubesheet may grow deeper without getting appreciably longer. The basis for this conclusion is not obvious. It may simply mean that the stresses at the deepest part of the flaw were the highest with somewhat lower stresses elsewhere. The profile could indicate a deep section with a shallower extent around the remaining portion of the circumference (below the detection threshold). If this were the case, all flaws could eventually grow to be 360 degrees in circumferential extent and 100 percent through-wall. Discuss the need to obtain field data to confirm the expectation.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

65. Regarding Figure 14 in the Westinghouse report, SG-SGDA-02-47, and the determination of

the distribution of indications below the inspected region, it is not apparent that the methodology presented supports the conclusion that the distribution of indications below the H* distance is uniform, for the following reasons:

a. If one were just interested in the most severe indications, it would appear that only the data from 3" to the H* distance should be included in the Figure since the first 3 inches of the tube were inspected during prior outages (since circumferential indications in the first 3-inches had been removed from the population during past inspections).

b. Given that eventually all indications below the H* distance will become severe since they will not be detected nor repaired, it would seem appropriate that all indications should be assessed (i.e., not just the most severe).

c. Given that each zone is potentially inspected to a different distance, it would appear appropriate to evaluate whether there is differences between the various zones.

Provide a list of all indications, the outage in which they were detected, their severity (circumferential extent, average depth, maximum depth, percent degraded area), their elevation with respect to the top of the tubesheet (e.g., TSH-2.5 inches), and the zone in which they were found.

Replot Figure 14 based on all indications (regardless of severity, zone, or outage in which they were detected) and also with all indications in specific zones to assess whether the uniform distribution assumption still holds.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

For a list of indications found, see Question 52.

66. Regarding the theory that the flaws are a result of local expansions of the tube material into manufacturing depressions within the drilled holes in the tubesheet:

a. Discuss the basis for this theory.

b. Are these manufacturing depressions evident from bobbin coil or rotating pancake coil inspections?

c. Discuss whether the flaws observed were contained within the area "bounded" by the depression in all cases.

d. Discuss why flaws have not been observed in Zone A given the postulated cause of cracking (presumably the frequency of these manufacturing depressions would be the same from one zone to the next).

e. Given these observations, discuss the need to modify the leakage assessment for Refueling 12 and subsequent outages to address cracks that may be occurring in Zone A and other zones.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

Response part e:

The SG leakage calculation included in WCAP-15932, Rev. 1 projected the number of indications in the tubesheet RPC inspection region in all SGs (in each zone) and determined the expected primary to secondary leakage to be approximately 0.44 gpm. Calculated leakage for Refuel 12 did incorporate postulated tubesheet indications below the H distance. The leakage was based on Revision 0 of the WCAP. The total postulated leakage due to the WCAP revision is still under the 1 gpm requirement. Therefore, there is no need to revise the prediction.*

67. To evaluate the leakage through a 360 degree circumferential extent, 100 percent through-wall circumferential flaw, the maximum crack opening area was determined from an analysis which considers either (a) the primary pressure acting on the crack flanks with a tube material acting as a spring to resist parting of the crack faces, or (b) from extrapolating the areas obtained from analyzing a series of circumferential cracks up to about 270 degree in circumferential extent. Please provide a more detailed description of how this was done, its basis, and any data supporting the predictions from this model.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

68. With respect to the assumption in the leakage model that the leak rate from a circumferential crack is the same as the leak rate from an axial crack if the crack opening areas of the two cracks are identical, the staff agrees to a first approximation that this is true when the ratio of wall thickness to crack opening displacement is not large (e.g., ratio <10). However, when this ratio is large, it is not clear whether this assumption would hold true. As a result, discuss the need to account for differences in leak rates when the wall thickness to crack opening displacement is large. Discuss whether the leakage model considered cases when the wall thickness to crack opening displacement is large (e.g., ratio > 10).
Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

69. The staff notes that there are uncertainties associated with many aspects of the leakage evaluation. There are uncertainties in the number of flaws, the locations of the flaws, the size of the flaws and whether they grow in circumferential extent, the loss coefficient, and the constraining effect the tubesheet has on crack opening. Given the uncertainties in the

evaluation, a leakage model similar to that developed for NRC Generic Letter 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," should be considered to ensure the leakage estimates provided by the model represents a 95th percentile value at a 95 percent confidence when accounting for all of the uncertainties. Discuss how uncertainties are treated in the leakage model.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

70. The leak rates for various crack sizes are plotted in Figure 19 in the Westinghouse report, SG-SGDA-02-47. This figure represents the leak rate for indications at the boundary between Zones B and C. It would seem that similar data would need to be developed for all Zones unless there is no potential for circumferential cracks in those other zones such as Zones A and D.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

71. The staff understands that tube inspections are frequently performed beyond the specified inspection extent (e.g., three inches). Without understanding more details of what indications were found, where they were found, and when they were found, the staff is unable to draw any conclusions regarding whether a conservative prediction of the number of flaws that could be present below the H* distance is being determined. Please clarify the data in Tables 1, 2, and 3 in the Westinghouse report SG-SGDA-02-47. Also, the information in Tables 1, 2, and 3 do not appear to match the description in the text. For example, the text indicated that the number of indications found for all of the steam generators was 46, but the corresponding table entry (based on staff's interpretation) indicates the number is 52.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

72. The Callaway inspection results have shown that circumferential and axial cracks may develop within the H* distance during an operating cycle. At the time of plant startup, there will be no detected degradation within the H* distance. During the course of the cycle, a flaw could initiate within the H* distance of this tube. This flaw may affect the pull-out resistance of the joint. In addition, there is a potential that 360 degree, 100 percent through-wall flaws at or below the H* distance may occur.

   a. Discuss the need to expand the inspection distance of the rotating pancake coil probe to account for the initiation/growth of flaws within the H* distance during the course of the cycle.

   b. Provide data supporting the ability to assess the impact of degradation within the

H* distance on the pull-out resistance of the joint.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

For additional clarification

The Westinghouse letters state that only one axial indication exists –0.3 inches below the top of the tubesheet, however, a review of the historical indications reveal that two axial indications have been identified.

The impact of the presence of an additional axial indication in tube R47 C61 at an elevation of -0.81 inches from the top of the tubesheet in SG A during RF10 on the projected SLB leakage calculated in WCAP-15932, Rev. 1 of 0.44 gpm is addressed below.

The SLB leakage model considers both the effect of the depth in the tubesheet and the radial location from the center of the tubesheet in calculating postulated SLB leakage. The total projected number of circumferential indications at the end of the next cycle of operation have been grouped by elevation and by distribution of severe indication crack angles in order to calculate SLB leakage.

Therefore, a conservative prediction of the potential total leak rate for the Callaway steam generators has been made assuming:

1. *All of the indications are in one SG*
2. *The distribution of indications in H* are representative of each respective depth in the tubesheet*
3. *The distribution of crack angles for all indications at each elevation interval are consistent with the distribution of severe indication total angles.*
4. *All of the indications are through-wall at their respective depths.*
5. *All of the indications leak.*

The presence of an additional axial indication in tube R47 C61 at an elevation of -0.81 inches from the top of the tubesheet in SG A during RF10 does not adversely impact the SLB leakage projection provided in WCAP-15932, Rev. 1 as no axial indications are considered in the calculation of SLB leakage. This is the case as only two axial indications have been identified below -0.3 inches from the top of the tubesheet in the Callaway SGs. The SLB leakage calculation is conservative and remains a bounding calculation.

73. On page 13 of the Westinghouse report, SG-SGDA-02-47, it states that, "...the stress from the pressure on the flanks is 0.214 of the stress that would result from an end cap pressure load for the same pressure..." Provide the technical basis for the 0.214.

Response:

Refer to Westinghouse letters LTR-SGDA-03-129 and LTR-SGDA-03-130.

Westinghouse

To: P.J. McDonough, D.E. Peck, J. Gambino

Date: 6-2-03

cc: R.J. Sterdis, D. Merkovsky, T.A. Pitterle, B.A Bell, D.J. Ayres, A.L. Thurman, M. Hu, J.G. Thakkar, J.X. Jenko, G.P. Pierini, K.J. Romanko, S.L. Ellenberger

From: Steam Generator Design and Analysis
Ext: 724-722-5584
Fax: 724-722-5909

Your ref:
Our ref: LTR-SGDA-03-130

Subject: **Transmittal of Responses to NRC RAIs on Partial-Length RPC Inspection of the Tubesheet Region of the Callaway Plant Steam Generators to AmerenUE Callaway (Class 3 Document)**

Please find attached for transmittal to AmerenUE responses to NRC requests for additional information (RAIs) related to the justification of partial-length rotating pancake coil (RPC) inspection of the tubesheet region of the Callaway steam generators (SGs). Several discussions have been held between AmerenUE and the NRC staff personnel during the time period between mid-October 2002 and the present aimed at resolving technical concerns for the RPC inspection lengths proposed for the tube-to-tubesheet joints in the Callaway SGs. These discussions have revolved around a series of 73 questions posed by the NRC staff to AmerenUE. The RAIs concentrate on seeking additional information regarding the implementation of the inspection scope increases, information regarding the testing and analyses performed to determine the structural capability of a hydraulic expansion joint, and information regarding the testing and analyses performed to ascertain the leak resistance of a joint during both normal and postulated accident conditions related to the proposed partial length RPC inspection.

If there any questions or comments, contact G.Whiteman or L.Nelson.

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5/30/03
Request for Additional Information
Callaway Steam Generator Tube Inspection Amendment Request

The information requested is on the licensee's application dated October 3, 2002. Questions 1 to 5 are on the Callaway Technical Specifications, and Questions 6 to 73 are on the WestinghouseWCAP-15932-P, Rev. 0, " Improved Justification of Partial-Length RPC Inspection of Tube Joints of Model F Steam Generators of Ameren-UE Callaway Plant," dated September 2002 which was submitted with the application.

Questions on the Technical Specifications (TSs):

1. *Discuss if the TSs should also specify that the H* depth inspection is applicable to hot leg tubes only so as to be consistent with the technical basis in the Westinghouse report, WCAP-15932-P, "Improved Justification of Partial-Length RPC Inspection of Tube Joints of Model F Steam Generators of Ameren-UE Callaway Plant." The proposed TS wording implies that the H* depths can be applied to the cold leg tubes also.*

Ameren-UE to provide response.

2. *Provide the following: (1) confirm that the primary-to-secondary leakage in the Callaway TSs is 150 gallons per day (gpd) per steam generator, and (2) describe the current plant administrative procedures regarding operator actions when steam generator tube leakage occurs.*

Ameren-UE to provide response.

3. *The proposed phrase to be added to TS 5.5.9.d.1.h, "Tube Inspection," states that the tube inspection includes "inspection with rotating pancake coil (or equivalent from the tube expansion transition at the top of the tubesheet to the H* depth as specified in TS Table 5.5.9-4." Discuss what is the starting point (or reference point) of the H* depth measurement, including the following:*

A. WCAP-15932-P mentioned that the starting point for the H depth is the top of tubesheet whereas the proposed TS wording implies that the starting point is the expansion transition. If the top of the tubesheet is the starting point then consideration should be made in the TS wording for cases where the expansion transition is located above the top of tubesheet. If the starting point is the expansion joint point, then the TS requirement is not consistent with WCAP-15932. If the starting is from the expansion joint, then is the H* depth measured from the top of the expansion transition joint or from the bottom of the expansion transition joint? The starting point of the H* depth should be clarified.*

Ameren-UE to provide response.

B. In general, when inspecting the top of tubesheet, licensees also inspect the tube above the top of tubesheet (e.g., 3 inches above the top of the tubesheet). How many inches above the top of the tubesheet is proposed to be inspected?

Ameren-UE to provide response.

4. Address whether there should be a TS requirement for future inspection of H tubes, including if each H* tube must be inspected during each steam generator tube inspection to assure that there are no indications in the H* distance.*

Ameren-UE to provide response.

5. The proposed TS wording describes the H inspection distance and probe; however, the TS has no requirement stating that any indication found within the H* distance must be repaired or plugged (i.e., plug on detection), and any indication found below the H* distance in the tube in the tubesheet may be remain in service. Discuss this issue.*

Ameren-UE to provide response.

Questions Regarding Westinghouse Report WCAP-15932-P:

6. Page 2-2 of the report. One of the assumptions for the H criterion is that tube cracking within the tubesheet is primary water stress corrosion cracking (PWSCC). This implies that the H* criterion will not be applicable to tubes with other degradation mechanisms such as outside diameter stress corrosion cracking (ODSCC). If this is the correct interpretation, then TS 5.5.9.h needs to limit the H* criterion to PWSCC only.*

Response: The assumption of PWSCC is made because ODSCC would not be an expected damage mechanism below the expansion. However, the criterion applies to degradation irrespective of the surface of origin.

7. On page 2-2 one of the assumptions states that bobbin coil eddy current testing (ECT) is capable of detecting circumferential crack and deep axial indications within the tubesheet. It is not clear in the report that the bobbin coil is qualified for these indications. Describe the qualification of the bobbin coil for these types of indications.

Response: All indications identified by bobbin probe below the H* distance in the Callaway SGs will be further investigated by RPC in order to characterize them and separate them from potential false positives (e.g. expansion anomalies). All positive indications will be removed from service below the H* distance.

Westinghouse has evaluated the reliability of bobbin probe detection for conditions at the limit of acceptance with respect to structural integrity of the tubes. [

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The evaluations were conducted using [

]a,c,e

8. *On Page 2-1 it is stated that any indication in the tube region below the H* distance in the tubesheet may remain in service. It is not clear whether a severe degraded indication (e.g., 100% through wall crack) may remain in service even if the indication is located below the H* distance. Address the disposition strategy for the through wall indications below the H* distance.*

Response: It is assumed that the reference to indications below the H* depth is with regard to Figure 2-1 on Page 2-3 rather than the discussion on Page 2-1. As noted in response to 7 above, all indications identified by bobbin probe below the H* distances will be further investigated by RPC in order to characterize them and separate them from potential false positives (e.g. expansion anomalies).

9. *On page 3-1, 4th paragraph, it is stated that maximum practical primary-to-secondary leakage during normal operation is 75 gallons per day (gpd). On page 3-4, it is stated that the plant will be shut down when the leak rate is above 75 gpd. Discuss if the 75 gpd leakage limit is an analytical condition of the H* depth criterion, and whether the 75 gpd leakage limit should be included in the proposed TS requirement for the H* criterion.*

Response: No the 75 gpd leakage limit is not an analytical condition of the H* criterion. For normal operation, the plant will operate as long as the leak rate stays within the technical specification allowable leakage limit of 150 gpd and within the administrative guidelines of the EPRI report on PWR Primary-to-Secondary Leakage Guidelines.

The bellwether approach for limiting primary-to-secondary accident condition leakage based on monitoring NOP leakage has been determined not to be necessary in support of the future operation of Callaway Unit 1 with potential cracking occurring below the H* distances in the SG tubesheet. Based on plant operating experience and laboratory test results discussed in Section 6.0 of WCAP-15932, Rev. 1 significant leakage is not anticipated during normal operating or accident conditions. For the distribution of indications anticipated at the end of the next operating cycle of Callaway, leakage during a postulated SLB event is calculated to be less than 0.44 gpm.

10. *On page 3-3, 5th paragraph, it is stated that +point, Vpp > 3 volt, would be used within the tubesheet and below the RPC inspection depth. Address the following:*

Response: The WCAP-15932 has been revised and this discussion no longer appears on page 3-3. However, a response is provided anyhow to clarify the type of eddy current inspection that will occur below the H* distances within the tubesheet.

A. Why the peak-to-peak voltage is specified to be greater than 3 volts for the +point probe.

Response: The intent of the paragraph is with regard to the likelihood for bobbin detection of large axial flaws. A +Point amplitude 3 Vpp corresponds to the response for a flaw that should be detectable by the bobbin. This is further clarified by the response to the next query.

B. It is the staff's understanding that within the H depth, the RPC (i.e., +point) would be used and below the H* depth, a bobbin coil would be used; however, the statement in the 5th paragraph implies that a +point would be used below the H* depth, not the bobbin coil. Explain the discrepancy.*

Response:

The bobbin probe will be used below the H* inspection depth to identify potential sites of severe degradation, i.e., very deep axial indications. These sites would be interrogated using RPC in order to characterize the indication.

See the response to Question 7 which addresses bobbin probe detection capability for the tubesheet region of the steam generators.

11. *Page 3-3, 6th paragraph. It is stated that all of the tubes in the 50 percent program of the opened steam generators would be inspected to the H* depth. Describe the "50 percent program." It is not clear to the staff whether the inspection strategy is consistent with the inspection strategy on Page 3-3 in WCAP-15932-P. Clarify and describe the inspection strategy.*

Response: The WCAP has been revised and this discussion no longer appears on page 3-3. Ameren-UE to provide a response to further clarify and describe the inspection strategy after implementation of the RPC inspection lengths.

12. On *page 3-5, 4th paragraph, it is stated that the H* values do not contain any margin for non-destructive examination (NDE) uncertainty in elevation of the crack features. Regulatory Guide 1.121 recommends measurement uncertainties (i.e., measurement error and analyst variability) in the eddy current inspections. Provide justification for not including measurement uncertainties.*

Response: The resultant H* depths will include margins for measurement error in elevation of the crack features (See Section 3.2.1 of the WCAP). A value for the measurement error is not identified in the WCAP. However, an uncertainty of 0.1 inch has been conservatively defined by AmerenUE. RG 1.121 discusses analyst measurement error and technique uncertainty for localized throughwall degradation due to wastage, not measurement error associated with determining crack elevation.

13. *On page 3-5, 5th paragraph, it is stated that the H* values are grouped in four zones based on the tubesheet upward bending during normal operation and during the limiting accident condition. [A] It is not clear if the zone was calculated based on the limiting conditions and [B] if the radii for each zone include any statistical/calculational errors. Address these issues.*

Response: The WCAP has been revised and this discussion no longer appears on page 3-5.

Part A Revised Response 11/13/02:

The H* distances are defined by the lengths of hydraulic expansion that are necessary to preclude tube pull out from end cap loads resulting from a pressure differential of 3 times normal operating pressure differential across the tubesheet.

Part B Response:

The zone boundaries were drawn per the tubesheet "map" and were conservatively drawn such that a particular tube was within the longer-H* zone if any part of it was. The location of Zones A, B, C, and D are a deterministic result. There is no statistical/calculation error to address.

14. *Regarding page 5-1, provide the following: (1) how many test tubes were assembled in the leak test program, and (2) how many tests were performed at room temperature, normal operating temperature, or accident event temperature?*
(Note: Even though this question was not on the list of RAIs we discussed during the 10/22/02 telecon with the NRC needed additional work, a couple of lines were added here.)

W Response:

A total of [

]a,c,e

The lower bound leakage resistance distribution for the collars with the nominal tubesheet hole diameter was used in the present leakage evaluation. This lower bound leakage resistance was made using data for the test conditions shown in the table below.

a,c,e

[

]

* 1000 psi pressure differential equates to 790 psi contact pressure.

15. *On page 6-1 it is stated that the tubesheet constrains the crack opening area and that the constraining effect for axial cracks is taken into account in the leakage calculation by using an effective crack length that is less than the actual length. However, during an accident, the tubesheet bows and the tubesheet bore expands and the expansion of the tubesheet bore would reduce the constraint effect. Address how the tubesheet bore expansion was taken into consideration in the leakage or tube pull-out calculations, including the impact of the bore expansion on the leak rate and pull out force (e.g., the percentage of the leak rate or pull out force caused by the bore expansion).*

Response: The effect of tubesheet bore expansion on the leakage during accident conditions was taken into account by calculating the effect of the tube hole expansion on the tube-to-tubesheet contact pressure. As described in Section 7.0 of WCAP 15932-P, detailed calculations were performed using a finite element model to determine the tubesheet hole dilations from thermal expansions of the tube and the tubesheet and by the deflections resulting from the primary-to-secondary pressure differential. The results also provided the tube-to-tubesheet contact pressure distribution from the top to bottom of the tubesheet used for tube pull-out calculations.

The results of the prior tests to measure the constraining effect of the tubesheet on leakage from axial cracks provided a correlation for the effective (free span) crack length as a function of the tube-to-tubesheet contact pressure. The contact pressure distribution for the Callaway-specific normal operating and accident conditions was used to determine the effective crack length utilized in leakage calculations. The lowest contact pressure along the crack length, which occurs at the upper tip for an axial crack, was used to determine the effective crack length.

W Later comment (10/24/02):

The tube-to-tubesheet contact pressure strongly affects the leak resistances of the crack and the tubesheet crevice above the crack. The results of leakage tests described in Section 5.0 of WCAP 15932-P provided a correlation for the tubesheet crevice resistance as a function of the contact pressure.

The DENTFLO code was used to calculate the leakage from a crack below the H* distance taking into account the flow resistances of both the crack and the tubesheet crevice above it. The tubesheet crevice leakage model in DENTFLO is benchmarked against the leakage tests described in Section 5.0 of WCAP-15932-P. For crack leakage, DENTFLO uses the model developed for the CRACKFLO code that is very similar to other industry codes like PICEP. The CRACKFLO model is valid for a free span axial crack and is benchmarked against test data. The leakage from a crack within the tubesheet is expected to be significantly less than that of a free span crack of the same length due to the tubesheet constraining effects. The effect of tubesheet constraint on the crack flow resistance for axial and circumferential cracks was determined as follows:

Axial Cracks

The constraining effects of the tubesheet on leakage from axial cracks were taken into account by using an effective crack length that is less than the actual length in a free span crack leakage model. Results of tests conducted in support of the W* program provided a correlation for the effective (free span) crack length as a function of the tube-to-tubesheet contact pressure. The effective crack length varies with depth from the top of the tubesheet and radial location of the tube within the tubesheet. The contact pressure distribution for the Callaway-specific normal operating and accident conditions was used to determine the effective crack length utilized in leakage calculations. The lowest contact pressure along the crack length, which occurs at the upper tip for an axial crack, was used to determine the effective crack length.

Circumferential Cracks

The equations for the opening area of a circumferential crack presented in the standard handbooks like EPRI Ductile Fracture Handbook do not account for the restriction on out-of-plane bending and other constraints such as guiding the tube within tubesheet. Also, below the H* distance there is no axial stress due to the end cap load on the tube. Therefore, the equations in the EPRI handbook were modified to remove the contribution of the axial stress and tube bending on the crack opening area. With the crack opening area known, the leakage from a circumferential crack in a given tube at a given depth from the top of tubesheet was determined by looking at tabular data of leak rate vs. crack opening area for an axial crack at the same location (same depth and radial location within the tubesheet) established using the DENTFLO code.

16. *Per Section 7.0, in its structural analysis, Westinghouse used carbon steel material properties for the tubesheet; however, there is a stainless steel (or nickel based alloy) cladding on the top of the tubesheet. Address how the material properties of cladding were considered in the tubesheet structural analysis, including the effect of the cladding, if any, on the H* depth and on the leakage calculations.*

Response: This question was resolved during the NRC/AmerenUE/Westinghouse telecon conducted on 10/17/02, there is no cladding on the top of the tubesheet.

17. *Address how a leakage model with a throughwall circumferential crack having a 360 degree extent below the H* depth in the tubesheet has been considered, including what would be the leak rate of such a crack. Considering the worst scenario leakage from H* tubes, address how many tubes can be applied with the H* criterion without exceeding TS primary-to-secondary leakage limit.*

Response: As noted in Section 6.2 of WCAP Report 15932, Rev. 1, an analysis procedure has been developed for dealing with the occurrence of a 360° throughwall crack. Prior discussions were based on postulating that the tube material below the crack ceased to exist and only the tube-to-tubesheet crevice resisted flow. In reality, the crack faces will part slightly and the crack will provide a resistance to primary-to-secondary leakage. The leak rates predicted for 360°

cracks at elevations of 8, 12 and 16 inches deep in the tubesheet are [

]a,c,e respectively during a postulated SLB accident. This translates into about 96, 271 or 465 throughwall and leaking 360° cracks at the 8, 12 and 16 inch elevation are necessary to achieve leak rates of 1.0 gpm during a postulated SLB event. Nearly half of the cracks are about 125 ° in azimuthal extent and the respective number needed to be throughwall and leaking would be 449, 1052, and 1095. The results for SG A show an expectation of about 77 cracks in the range of 7 to 16 inches below the top of the tubesheet and 43 in the range of 16 to 21 inches below the top of the tubesheet.

Overall, it is unlikely that the combination of a large number of throughwall indications would be capable of leaking in combination with the circumferential lengths necessary to provide meaningful leakage would be present.

18. *In the proposed Table 5.5.9-4, the H* depth for inspection depth zone A is proposed to be 2.38 inches. This H* depth is smaller than the H* depth proposed for zones B, C, and D, and can be viewed as not as conservative in terms of tube structural and leakage integrity. In general practice, licensees inspect* ***3.0*** *to* ***6.0*** *inches below the top of tubesheet using the RPC. Address the differences in the proposed H* depths by inspection depth zone, and include the following:*

The values for H distance have been revised to range from 5.0 to 9 inches from the top of the tubesheet.*

A. Describe the history of indications detected within 2.38 inches below the top of tubesheet at Callaway.

Response: Callaway has experienced degradation within 2.38 inches below the top of the tubesheet.

Response: **To be developed by Callaway. Ancillary information below.**

Callaway has experienced degradation within 2.38 inches below the top of the tubesheet. The response to RAI number 35 details the repeat of an analysis that establishes values of H* based on directly meeting the normal operation performance criterion in addition to the accident condition performance criterion. The result of the analysis is that the minimum H* depth was determined to be 3.46 inches for Zone A. Callaway has chosen to inspect to a depth of at least 5.0 inches to comply with this value.

B. Describe the structural and leakage integrity of a tube with H depth of 2.38 inches.*

Response:

(Note: The change from using accident conditions for the determination of H* based on end cap loads corresponding to 3 times normal operating pressure differential conditions has been incorporated in this response.)

a) Structural

As discussed in Section 7.2 of WCAP-15932, Rev. 1, testing has been performed on full depth hydraulic expansions of 11/16 diameter tubes [

]a,c,e

Analyses were performed to determine the minimum axial length between the tube and tubesheet, beginning at the TTS and extending down into the tubesheet, that is sufficient to resist the pullout loads under bounding conditions. The minimum contact length for the NOP at a radius of 58.3" from the bundle vertical centerline (Zone A) is 3.46 inch. This length, along with pressure tightening, thermal tightening and addressing tubesheet bow considerations provides resistance to tube pull out equal to the end cap load resulting from 3 times the normal operating pressure differential across the tubesheet.

b) Leakage

The leakage potential of a tube with a throughwall crack below the H* distance is strongly dependent on the magnitude of the tube-to-tubesheet contact pressure distribution near the top of tubesheet. Because of the manner in which the tubesheet bows due to the primary-to-secondary differential pressure, [

]a,c,e

The leakage resistances of both the crack and the tubesheet crevice (axial interface length) above the crack increase significantly with the contact pressure. The estimated leakage from a throughwall crack located at 3.46 inches below the top of tubesheet in Zone A [

]a,c,e

19. *Discuss the length(s) of the test tube inside the tubesheet collar in the mock-up tests, including if the distance of 2.38 inches was modeled in the test. Discuss whether the test tube was severed at the 2.38 inch location inside the tubesheet, including, it should be pointed out, that the WCAP report discussed only perforated locations in the tube, not a severed tube.*

Response: The response to RAI number 35 details the development of a revised minimum H* value of 3.46 inches for Zone A. Therefore, the reference to 2.38 inches in the RAI is taken to apply to the revised value of 3.46 inches. The response to RAI 35 also provides a detailed discussion of the tests and tables of the test data. An expanded engagement length of 3.46 inches was not specifically tested. The expansion lengths tested were [

]a,c,e

20. *In its review, the staff finds that the description of the inspection depth zones A, B, C, and D in proposed Table 5.5.9-4, by listing the range of radii of the zone from the vertical centerline of the tube sheet, is not as descriptive as Figure 3-6 in WCAP-15932-P. Address whether the WCAP Figure 3-6 should be included in the Callaway TSs (i.e., can the proprietary information in the figure be omitted to allow it to be placed in the TSs).*

Response: Callaway does not feel that it is appropriate or necessary to add Figure 3-6 to the TS. The figure contains the same information that is contained in Table 5.5.9-4.

21. *In the conference call on October 17, 2002, a Westinghouse representative stated that all tubes, with indications in the H* distance region, would be plugged as shown by Figure 2-1 of WCAP-15932 because the RPC would not be able to size the indications. However, a Callaway representative stated that tubes, with some indications detected in the H* distance, may not be plugged and thus would remain in service in that tube plugging would be based on the TS 5.5.9 tube plugging criteria, of 40% through wall, because the RPC can size the indications in the H* region. Address the discrepancy between these statements.*

Response: Any indication determined to be a crack will require the associated tube to be plugged based on detection criteria. Any indication such as wear that can be sized with a level of certainty will have the plugging criteria specified in TS 5.5.9.f applied to the affected tube.

22. *Question on Abstract:*

A. Page vii, Abstract. Explain the engagement distances of 0.30 inch and 1.4 inches with respect to the P distance.*

W Response

The intent of including the P* analysis in the justification document was to demonstrate qualitatively and quantitatively a "defense in depth" associated with the application of H*. P* is not included in the operating license by way of the Technical Specification.

The engagements referred to are with regard to the length of tube remaining within the tubesheet if the tube were to become severed during operation. The P* distance is 3.0 inches, thus if there were an upward movement of a severed tube of 2.7 inches the remaining engagement within the tubesheet would be 0.3 inches.

B. Page vii, Abstract. It is stated that ...P is to show the acceptability of a tube separation below the P* distance for about 95% of the operating tubes in the bundle..." Discuss whether tube separation would be acceptable in terms of structural and leakage integrity for the remaining 5% of the tubes in the bundle.*

W Response

The intent of including the P* analysis in the justification document was to demonstrate qualitatively and quantitatively a "defense in depth" associated with the application of H*. All of the H* distances now exceed the P* distance. P* is not intended to be included in the operating license by way of the Technical Specification.

P* is based on identifying features that would prevent a severed tube from exiting the top of the tubesheet during normal or postulated accident conditions. Such features only exist for 95% of the tubes in the bundle. The hypothetical separation of a tube may not be acceptable for the other 5% depending on the location of the tube in Zone A, B, C or D.

23. *Questions on Section 1.0:*

A. It is stated that primary water stress corrosion cracking (PWSCC) has been identified in the region between the bottom of the hydraulic expansion transition and the 3 inch depth in the Callaway steam generators. Provide historical data of tube indications (circumferential and axial) found in the tubesheet. Specify the maximum distance measured from the top of the tubesheet into the tubesheet that PWSCC indications have been detected.

Response: To be provided by AmerenUE.

B. Discuss the disposition of an indication that is detected by a rotating pancake coil (RPC) probe that is not within the H distance but is within the expansion transition zone (e.g., above the top of the tubesheet) or below the H* distance. Include in the discussion if the disposition would be in terms of the requirements specified in TS 5.5.9.*

Response: To be provided by AmerenUE. As noted in the responses to questions 5, 7 and 8 above, Callaway implements a plug based on detection criteria.

24. *Questions on Section 2.0*

A. Page 2-1, 4th paragraph. It is not clear why P distance is not specified in the Callaway Technical Specifications as an inspection requirement because the P* distance is related to the H* distance. It is stated in the topical report that "... the initiation of inspection to H* depths also initiate the use of P*..." Discuss if this recommendation will be adopted at Callaway, and included in the Technical Specifications.*

Response: The intent of including the P* analysis in the justification document was to demonstrate qualitatively and quantitatively a "defense in depth" associated with the application of H*. P* is not included in the operating license by way of the Technical Specification. Also, it is not related to H*. The intent was only to relate P* to a typical RPC inspection depth of 3 inches below the tubesheet top.

25. *Questions on Section 5.0*

A. Page 5-1, Section 5.1.1. Provide information on the test collars, i.e., the number of collars used in the test, the dimension of the collars (1.63 inches in outside diameter), the number of tube specimens in any one collar. Discuss whether the test program included testing of tubesheet bowing effect.

W Response:

Section 5.1.1 provides a description of collars used to simulate the effect of the tubesheet. A total of [

]a,c,e

B. The summary of tests is addressed on page 5-4. In the summary, there is no mention of fatigue (mechanical or thermal) testing. The mechanical fatigue testing would include cyclic load testing, and the thermal fatigue testing would consider the thermal expansion and contraction (during heatup and cooldown) of the tube length between the top of tubesheet and the tube support plate(s) where the tube may be constraint by either denting or deposits. Discuss why these tests were not considered.

W Response:

Based on previous testing, Westinghouse has concluded that there is no need for cyclic load testing for this type of configuration. All of the full depth expansion processes used by Westinghouse close the gap between the tube and the tubesheet to virtually zero. For an F* plant, the axial load applied to the samples for fatigue testing was calculated using both pressure and temperature components. Thermal loads were calculated assuming the tube became fixed at the top of the tubesheet due to crevice crud. Upon shutdown, a tensile load is applied between the fixity locations due to thermal growth mismatch. For pressure effects the tube is assumed to be loaded due to the end cap load at operating conditions, which is tensile, and the tensile load is maintained during shutdown. The combined effects of pressure end cap loading and thermal growth were summed to determine the fatigue load to be applied for leak rate testing.

Of the samples leak tested prior to cycling, the average leak rate from all samples tested at 615 ° F at a pressure differential of 2650 psi was 1.2 drops per minute. The average leak rate of only those samples which leaked was 3.3 dpm.

Following application of over 29000 fatigue cycles, the average leakage of the leakers was 3.6 dpm while the average of all samples was 1.8 dpm.

The consistency of these results suggests that the H* region will not be adversely affected by fatigue.

C. Page 5-4. It is not clear in the topical report whether the H distances were modeled in the test mock-ups. Discuss if this was done, and provide the length of the tube in the tubesheet for the tube pullout and leakage tests.*

W Response:

This question appears to be the same as Question 19. It was pointed out that it was unnecessary to model the exact H* lengths; joint strength and leakage resistance were calculated based on tests of joints of approximately the axial extents of the tubesheet in the plant.

26. *Questions on Section 6.0*

A. Page 6-2, 3rd paragraph. The report discussed the proprietary DENTFLO computer code in calculating leak rate of an axial crack and the effective crack length in the leak rate calculations; however, there is no discussion of a leak rate calculation for a circumferential crack. It is not clear how the effective crack length of a circumferential crack is modeled in the leak rate calculation. Provide a discussion on the leak rate calculation for a circumferential crack.

W Response:

See response to Question 17. The WCAP has been revised and this discussion no longer appears on page 6-2. It now appears in Section 6.2 of WCAP-15932, Rev. 1.

B. Page 6-3, first paragraph. It is stated in the report that a throughwall circumferential crack of 180 degree extent was considered in the leak rate calculation. Discuss why a throughwall circumferential crack of 360 degree extent is not the worst scenario crack and was not considered in the leak rate calculation. See previous Question 17.

W Response:

The WCAP has been revised and this discussion no longer applies. See response to Question 17. Axial cracks are not considered because none were observed in the distribution of indications below –0.3 inches from the top of the tubesheet in the Callaway SGs..

C. Page 6-3, 2nd Paragraph. Provide leak rate results of a single axial and circumferential crack under steam line break conditions and normal operational conditions.

W Response:

The WCAP-15932 has been revised. The prediction of leak rates is discussed in Section 6.2 of the report. The leak rate from a 360 ° crack at elevations of 8, 12, 16 inches deep into the tubesheet during a postulated steam line break accident is calculated to be [ ] a,c,e , respectively. These leak rates are predicted at the worst radial location for the elevations considered. With the crack opening area known, the leakage from a circumferential crack in a given tube at a given depth from the top of the tubesheet can be determined by looking at tabular data versus crack opening area for an axial crack. Modeling of future leak rates is a function of the number of circumferentially oriented cracks that are in the SGs at elevations below the H* distances. The calculated SLB leakage at the end of the next cycle of operation at Callaway is determined to be 0.44 gpm.

27. *Questions on Section 7.0*

A. Page 7-1, 4th paragraph. The report discussed a previously developed finite element model for the model F steam generator. Discuss if this model was developed for Callaway, and provide the reference for this model.

W Response:

The Callaway steam generators are Westinghouse Model F SGs.

This response was okayed during the NRC/AmerenUE/Westinghouse telecon conducted on 10/24/02.

B. Page 7-2. It is not clear whether the tube bores were included in the finite element model. In addition, the tubesheet bores are not evident in the finite element model as shown in figure 7-1. The report stated that an equivalent ligament efficiency, modified modulus of elasticity, and modified Poisson's ratio were used to simulate the tubesheet bore. However, it is not clear how the ligament efficiency is input in the finite element model to simulate the tubesheet bore in the finite element model. Discuss how can the ligament efficiency simulate the tubesheet bore, including the previous sentences.

W Response:

The tube bores are included in the finite element model [

]a,c,e This is a standard modeling technique that has been used for 30 years by all vendors in a number of industries.

This response was okayed during the NRC/AmerenUE/Westinghouse telecon conducted on 10/24/02.

C. Pages 7-3 and 7-4. The report cited References 9.21, 9.22, 9.23, 9.24 (e.g., on page 7-12, Reference 9.28 was cited); however, these references could not be found in the reference section of the report. Explain the discrepancy.

W Response:

The references on pages 7-3 and 7-4 were erroneously in the pre-publication version of the WCAP. These were observed and removed from the published WCAP. Reference 9.28 on Page 7-12 was not observed in the pre-publication version and is erroneously in the WCAP.

This response was okayed during the NRC/AmerenUE/Westinghouse telecon conducted on 10/24/02.

D. Page 7-3, 2nd paragraph. The report discussed a previous calculations performed with a 3-D finite element model of a model D-4 steam generator. Provide the reference of this analysis.

W Response:

The references for the 3-D finite element model of a Model D-4 steam generator come from Westinghouse Reports WNET-142, Vol. 4, titled, "Model D4-2 Steam Generator Stress Report Tubesheet and Shell Junction Analysis" and WNET-120, Vol. 5, titled, "Model D2/D3 Steam Generator Stress Report Tubesheet and Shell Junction Analysis". The reason for the comparison of the D-4 steam generator to the Model F steam generator is that the ligament efficiencies are almost identical, i.e. 0.2796 for Model F and 0.2805 for Model D-4. Also both tubesheets have the same thickness (i.e. 21.18 inches) and diameter to the secondary shell inner diameter (i.e. 129.38 inches).

E. Pages 7-8 and 7-9. Discuss whether the pressure and temperature parameters for the feedline break, steamline break, and loss-of-coolant accident (LOCA) events were specifically taken from the Callaway design basis accident analysis or from a generic accident analysis. On the basis of the references cited in the report, it seems that the pressure and temperature parameters used in the Callaway analysis may be generic values. Discuss if this is correct, and confirm whether the generic pressure and temperature parameters used in the H analysis bound the values in the accident analysis of the Callaway plant.*

W Response:

The pressure and temperature parameters for the feedline break, steamline break, and loss of coolant accident (LOCA) events were from a generic accident analysis. The generic temperature and pressure parameters used in the structural analysis bound the values used in the accident analyses of the Callaway plant. The H* SLB leakage analysis is completed at plant conditions (2560 psi, 600 ° F) similar to that used by the industry and approved by the NRC for steam generator tube alternate repair criteria.

This response was okayed during the NRC/AmerenUE/Westinghouse telecon conducted on 10/24/02.

F. Pages 7-23 and 7-24. Tables 7.2-2a and 7.2-2b. Explain the significance of Psec = 893 psig and Psec = 955 psig, and why there is no Psec value in Table 7.2-3?
W Response:

The Psec values of 893 and 955 psig are in Tables 7.2-2a and 7.2-2b for the two normal operating conditions that envelope the Callaway plant for minimum and maximum steam temperature and pressure. These Psec values are from the latest steady state, normal operation conditions that are applicable to the Callaway plant. Table 7.2-3 applies to the steamline break condition where Psec is 0 psig.

This response was okayed during the NRC/AmerenUE/Westinghouse telecon conducted on 10/24/02.

G. Page 7-26. Discuss whether the P analysis in Section 7.3 was benchmarked with testing data. It is the staff's understanding that the purpose of the P* distance is to provide assurance that if a tube, having a H* distance less than P* distance, is pulled out from the tubesheet that tube would be confined by the adjacent row tube without damage to other tubes. However, absence of a valid verification of the P* methodology, the shortest H* distance should be made to be greater than P* distance to assure that, if a tube is pulled out, it would not impinge on any tubes. Discuss this.*

Response: The intent of including the P* analysis in the justification document (now included as Appendix A in WCAP-15932, Rev. 1) was to demonstrate qualitatively and quantitatively a "defense in depth" associated with the application of H*. P* is not included in the operating license by way of the Technical Specification.

H. Discuss how the tubesheet bowing are considered in the structural and leakage integrity calculations, providing the following: (1) the maximum and minimum values of the tubesheet bowing, (2) the locations of the maximum and minimum tubesheet bowing, and (3) the maximum and minimum values of tubesheet bore expansion. See the previous Question 15, which is related to the impact of the tubesheet bore expansion on the pullout and leakage tests.

W Response:

Loads are imposed on the tube as a result of the tubesheet bowing under various pressure and temperature conditions. The finite element analysis of the [

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I. Discuss whether the finite element model has been benchmarked with the actual test results to verify the accuracy of the analytical method of calculating tubesheet bowing.

W Response:

The finite element model has not been benchmarked with actual test results. However, the [

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28. *In the proposed technical specifications, the inspection extent references the expansion transition.*

A. Given how the testing was performed, clarify whether the proposed technical specifications should be modified to reference from the bottom of the expansion transition or the top of the tubesheet, whichever is lower.

B. There are several references in WCAP-15932 indicating that H is reckoned from the top of the tubesheet and assumes a conservative distance between the bottom of the hydraulic expansion transition and the top of the tubesheet. Discuss the reference point for the H* distances provided in the Technical Specifications.*

Response to [A] and [B]: AmerenUE should develop the final wording of this response and may chose to trim much of the background discussion. It is included here for completeness and to familiarize Callaway personnel with the technical details.

The technical specifications reference the H* distance from the top of the tubesheet. The values specified for H* include consideration of the potential for a crevice to exist between the tube and the tubesheet at the top of the expansion. A conservative estimate of the maximum crevice depth was identified as 0.15 inch based on initial available information regarding the fabrication of the SGs. The analysis determined that the adjustment needed to be added to the H* value calculated for Zones A and B. This is because the length of the region with zero contact pressure is greater than that distance in the other two zones, hence, the adjustment has no real bearing on the measurement of H*. Initially, the maximum crevice depth value was added to the values determined for the other zones strictly for consistency in developing the table in the WCAP. Subsequent determinations of H* based on the normal operation performance criterion support the conclusion that the maximum crevice depth to be expected in Zones C and D (during SLB) is less than the estimated length of loss of contact at the top of the tubesheet. Therefore, the H* length for Zone A has been determined to be 3.46 inches and the H* distance for Zone B has been determined to be 5.93 inches to resist pullout.

The original manufacturer engineering specification for the distance from the top of the tubesheet to the bottom of the expansion transition, referred to as crevice depth, was for a maximum acceptable value of [

]a,c,e

29. *Discuss the role of P* in determining the actual distances in the proposed amendment, including the following:*

Response: The intent of including the P* analysis in the justification document was to demonstrate qualitatively and quantitatively a "defense in depth" associated with the application of H*. P* is not included in the operating license by way of the Technical Specification. Therefore responses to the following additional requests for information are not needed.

A. Discuss why P is limited to non-stayrod and non-patchplate area tubes, including if this is because there are no nearby neighbors or are there other reasons.*

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a,c,e

B. The basis for assuming that tube separation below the P distance for approximately 95% of the tubes in the bundle.*

C. How have the effects of degraded tubes been accounted for in the P analysis.*

D. Describe the test data supporting the analytical calculations with respect to neighboring tubes limiting the extent of tube pullout.

E. Discuss how sliding of the tubes and distortion (bending) of the tubes was accounted for in the analysis.

F. Discuss the effects of one tube impacting another tube, assuming the tube "impacted" is degraded to the steam generator performance criteria by the most limiting damage mechanism.

30. *Clarify the meaning of the statement on page 1-2 in WCAP-15932: "a similar approach has been demonstrated to be acceptable for use in cases of tube weld damage due to loose parts".*

A. Provide the data which demonstrates that leakage during normal operation can be related to leakage during postulated transients.

W Response: No leakage is anticipated during normal operating conditions in the Callaway SGs. See response to Question 32 [A] 2.

B. Discuss the relationship, including how ligament tearing is accounted for in this relationship and how the scatter in the data is accounted for in the H methodology*

W Response:

(Note: Westinghouse has renumbered the parts of the question by making [A] be the clarification…, [B] being the providing of data…, and [C] being the "discuss the relationship…ligament tearing…, and [D] being the accounting for scatter in the relationship…

Response to [A] and [B]: The WCAP-15932 has been revised. Please see Section 6.2 and the responses to Questions 17 and 26.

Part [C]

It is assumed that the intent of the query relative to ligament tearing is based on a concern that there could be part-throughwall cracks present that are stable during normal operation but could be unstable when exposed to the higher primary side pressures postulated to occur during accident conditions such as SLB or FLB. The formulation of the H* RPC inspection length is based on end-cap forces produced by a primary-to-secondary pressure difference equal to $3 \cdot \Delta P$, i.e., three times the differential pressure of 1342 psi (see the response to RAI number 35). Therefore, in reality, the end cap load is not transmitted to tube material that is below about 1/3 of the H* distance. The pressure differences associated with postulated accident conditions are less than about twice the normal operating pressure difference, thus the end cap load is not transmitted to material below about 2/3 of the H* distance. In conclusion, the only force acting to open a circumferential crack below the H* distance is the force due to pressure acting on the flanks of the crack acting to open the crack. Since the tube is captured within the tubesheet, there are additional forces acting on the tube in the vicinity of the crack, these are:

- Differential thermal expansion between the tube and tubesheet – The expansion of the tube is greater than that of the carbon steel tubesheet, thereby placing the tube below the H* length in compression.

- Friction – The tube is expanded within the tubesheet producing a contact pressure between the tube and tubesheet.

- Poisson effect – The effect of the pressure on the crack flanks attempts to push the tube out of the tubesheet. This results in an expansion of the tube where the force is being applied, thereby increasing the contact pressure between the tube and tubesheet.

A scoping evaluation can be performed by [

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31. *Assumptions regarding the location of the bottom of the expansion transition were made in the WCAP.*

A. For Callaway, if the inspection distances are from the top of the tubesheet, provide the maximum distance from the top of the tubesheet to the bottom of the expansion transition (i.e., ones below the top of the tubesheet).

B. Discuss how this distance is used in relation to the H distances provided in the Technical Specifications and how the NDE uncertainty in determining the top of tubesheet, the bottom of the expansion transition, and the inspection distance is accounted for in the analysis.*

C. List the assumptions made, and provide the basis for the assumptions.

W Response:

[A] See the response to Question 28 and the addition of measurement error will be addressed by Ameren-UE.
[B] "

[C] "

W Note: As stated in the WCAP, the distance of the bottom of the expansion transition is approximately 0.15 inch below the TTS. This was later conservatively changed to 0.30 inch.

W Note: Part of the response to this question is the same as shown in the response to Question 13A.

During normal operating conditions, the tubes do not contact the tube sheet hole surface within a minimum distance of 0.30 inches from the top of the tubesheet due to tube hole dilation resulting from tubesheet bending in Zones C and D. Therefore, the 0.30 inch distance which was superimposed on the H* distances for Zones A and B was not applied in Zones C and D.

32. *Several assumptions were made in establishing the H* and P* distances in Section 2.2 of the WCAP. [A] List the assumptions and provide the technical bases and data for each of the assumptions (with the exception of the assumption regarding the 1.0 gpm leakage limit during SLB and the primary side makeup capacity). [B] Discuss whether the inspection techniques have been qualified in accordance with the EPRI guidelines and provide the qualification data. [C] Discuss whether the EPRI guidelines are being followed with respect to the frequency of inspection for plants with mill annealed Alloy 600. If not, provide the technical justification for the deviation.*

W Response:

Response to Part A: Assumptions used for establishing H* and P* were listed in the WCAP in Section 2.2. Amplification of each is provided in the following paragraphs. It should be noted that many of the assumptions are clarifying in nature and are not technically necessary to demonstrate the validity of the H* results.

1. *Bobbin coil ECT is capable of detecting deep axial indications (+Point with a peak-to-peak voltage amplitude, Vpp, >3 V) within the tubesheet.*

   See response to Question 7.

2. *Some potential normal operation (NOP) leakage from a separated tube is acceptable because such a severe crack would not be expected to appear suddenly, and, hence, the leak rate would start small, would be detectable, and would only gradually reach the maximum practical NOP leakage of 75 gpd.*

   There is no correlation between normal operation and accident condition leakage for cracked tubes located within the tubesheet at the Callaway plant. The evaluation of prior test data strongly support the conclusion that a small amount of oxidation of the tubesheet in the vicinity of a throughwall crack will significantly narrow the effective crevice area and is expected to prevent meaningful primary-to-secondary leakage during normal operating conditions. There has been no significant primary to secondary leakage during operation of the Callaway plant.

   See also Section 6.0 of WCAP-15932, Rev. 1 for further explanation of expected leakage during normal operating conditions and a postulated SLB event.

3. *Tube cracking within the tubesheet is PWSCC.*

   The assumption of PWSCC is made because ODSCC would not be an expected damage mechanism below the expansion. However, the criterion applies to degradation irrespective of the surface of origin.

4. *The separated tube condition for H* and P* is a low probability event for hydraulic expanded Alloy 600 mill annealed (MA) and thermally treated (TT) tubing.*

   A distribution of the location of cracks below the top of the tubesheet is illustrated on Figure 6.14 of WCAP-15932, Rev. 1. It is concluded that the number of cracks outside of the H* distances can be made using a uniform distribution. The distribution of angles of cracks is approximately linear between 30 and 150°, however, there was one with an angular extent of about 220° and one with an angular extent of 360°. The distribution is in keeping with expectations of the cause of the cracking is postulated to be residual stresses from local expansions of tube material into manufacturing depressions within the drilled holes in the tubesheet. It is expected that the cracking would progress to a significant depth without necessarily extending 360° circumferentially. In other words, the large crack angles appear to be exceptions and most cracks would be expected to be in the range of less than 150°.

5. *H* distances will prevent tube movement for all of the hot leg (HL) tubes for the limiting condition, the accident (SLB) condition and will control leakage to the FSAR accident limit for multiple tubes based on controlling NOP leakage to the practical NOP limit.*

   For the H* distances established in WCAP-15932, Rev. 1, H* is determined semi-empirically and coupled with thermal and pressure tightening effects the tube resistance to pullout (or pushout) exceeds the pullout (or pushout) load by the required margin. Analyses have been performed to determine the minimum axial lengths between the tube and tubesheet that will meet a critical end cap level of 1900 lbs. These distances are defined in Table 7.2-24 of WCAP-15932, Rev. 1.

   From Section 6.7 of WCAP-15932, Rev. 1, modeling of leak rates is a function of the number of cracks that are in the SGs at elevations below H*. An examination of the inspection data for the Callaway SGs was used to determine the SG with the most indications as a function of time, and then to predict the number of indications below H* that would exist at the end of the next operating cycle. The result of the calculation for Callaway was a total predicted leak rate of 0.44 gpm during a postulated accident condition.

6. *P* distances will prevent the probability of tube disengagement from the tubesheet hole in the case of separation and translation, based on the three-inch RPC inspection depth.*

   As discussed in later responses, P* questions are moot because P* will not be part of the license amendment request and do not need to be answered.

7. *Crack growth is manageable over the inspection interval (two cycles – based on examining the tubes in two of the four SGs each refueling or inspection outage and a 50% RPC program in the HL of each of the opened SGs).*

   The discussion of the Callaway inspection program has been removed from WCAP-15932, Rev. 1.

8. *The maximum allowable primary-to-secondary side leakage during the limiting accident condition, i.e., Steamline Break (SLB), through the affected SG is 1.0 gpm in the affected SG.*

   The accident analyses assumption of 1.0 gpm during a postulated SLB is consistent with the licensing basis of the Callaway plant.

9. *The plant primary side makeup capacity is on the order of 100 gpm.*

   This assumption is reasonably standard within the industry, some plants have significantly greater capability. The assumption is not essential to the analysis.

Part B Note: AmerenUE to do this.

Part C Note: AmerenUE to do this.

33. *It was indicated that past experience with circumferential cracks inside the tubesheet for another type of tube joint indicated that leakage is low and that the same trend is expected for Callaway Plant.*

A. Discuss the relationship between the contact pressures at Callaway to these other plants.

B. Discuss the extent to which these indications were subjected to the full range of normal operating, transient, and accident conditions.

Response to Part [A] and [B].

In this response, it is assumed that this question pertains to the same type of operating conditions for the Callaway plant and the other plant, i.e., a plant with the WEXTEX tube joint. The tube-to-tubesheet contact pressures (CPs) resulting from the application of the WEXTEX installation process are compared with the Callaway CPs at NOP resulting from hydraulic expansion. The tube-to-tubesheet CPs resulting from the application of the WEXTEX installation process at NOP are comparable to the Callaway CPs at NOP. It is reasoned that circumferential crack leakage would be low due to the tubesheet hole surface preventing tube bending, and therefore crack opening from that mechanism. It is also reasoned that anchorage of the tube in the tubesheet due to the H* axial extent above it should essentially prevent crack opening due to axial strain. With little crack opening, leakage from circumferential cracks is expected to be small.

(Note: The comparison will be on the basis of CPs in the largest-tubesheet-hole-dilation portion of the tubesheet, resulting solely from combination of the beneficial effects of thermal growth mismatch and differential pressure tightening and the detrimental effects of tubesheet bowing as the plant goes from room temperature to NOP; it makes no use of the potential as-manufactured residual CP of the tube expansion process.)

WEXTEX has 2 zones. Zone B covers approximately half of the tubesheet and is roughly comparable to the combination of Zones C and D in Callaway. For WEXTEX NOP condition on the hot leg, the limiting CP is 0 psi (for the tube location closest to the tubesheet vertical centerline) at the TTS and extending to a depth of approximately 2.91 inches and ranges to 713 psi at 8 inches below the TTS. The comparable CPs for Callaway for the limiting case (Zone D, P_{SEC} = 908 psia) at NOP – hot leg are from 0 psi, from the TTS to a depth of approximately 2.58 inches, the zero-CP extent, and from that point to approximately 765 psi at 8 inches down.

Response to Part [B]:

The leak rate evaluation for circumferential cracks examined leakage during normal operating conditions, steam line break and feed line break conditions. The results showed that the steam line break leakage bounds leakage during other conditions. Hence, only steam line break leakage results are presented in WCAP-15932, Rev. 1.

34. *It was assumed in Section 3.1.2.2 that the pullout distances associated with the normal operating pressure (NOP) values could be ignored since the plant will shutdown because of leakage. Discuss the basis for this assumption. As indicated above, past experience indicates that leakage is low from circumferential cracks. Discuss the possibility that no leakage may be observed from a joint that is totally severed at some distance or has a through-wall crack. In determining the steam line break pullout distance, discuss how the lower temperature during the break was accounted for in determining the inspection distance.*

W Response: WCAP-15932, Rev. 1 has been revised and the bellwether approach is no longer used to monitor structural integrity and leak tightness. The H* distances calculated provide tube structural integrity and leaktightness which meets the steam generator performance criteria of NEI 97-06 during subsequent plant operation even if no leakage is observed during normal operating conditions.

Also, see response to Question 61.

35. *In determining the acceptance limits, the most limiting primary to secondary differential pressure during normal operation should be used (most limiting would equate to the maximum differential pressure that can be observed during normal operation for the life of the steam generator). In performing the testing, it would appear that the lowest differential pressure should be used since the lowest differential pressure would result in a lower contact pressure.*

A. Discuss the basis for performing the tests at 1900 psi which is considerably higher than normal operating differential pressure.

B. Discuss how the lowest normal operating pressure was accounted for in determining the H inspection distance.*

C. Provide the data associated with the determination of the resistance to pullout as a result of the hydraulic expansion.

W General Response:

See the response to Question 34. The H* distances are established based on the limiting performance criteria of each tube having a pull out capability of 3 times the end cap load associated with the normal operating pressure differential and that SLB leakage will not exceed the accident analysis leakage assumption of 1.0 gpm. No leakage is anticipated during normal operating conditions. SLB leakage calculations assume a primary-to-secondary pressure differential of 2560 psi and a primary side temperature of 600 ° F.

Response to question [A]: As noted in Section 5.2.1 the test pressure of 1900 psi was selected to keep the water above the saturation pressure for the high temperature tests. Since the pressure is significantly greater than the normal operating pressure the leak rate values would be expected to be conservative relative to normal operation.

Response to question [B]: The lowest normal operating pressure of import is the lowest secondary side pressure. This results in the largest applied pullout load. The analysis described at the start of the response to this RAI used the largest differential pressure to calculate the $3 \cdot \Delta P$ value to be used in the determination of the normal operation H* values.

Response to question [C]: A key element in estimating the strength of the tube-to-tubesheet joint during operation or postulated accident conditions is the residual strength of the joint stemming from the expansion preload due to the manufacturing process, i.e., hydraulic expansion. During operation the preload increases because the thermal expansion of the tube is greater than that of the tubesheet and because a portion of the internal pressure in the tube is transmitted to the interface between the tube and the tubesheet. However, the tubesheet bows upward leading to a dilation of the tubesheet holes at the top of the tubesheet and a contraction at the bottom of the tubesheet when the primary-to-secondary pressure difference is positive. The dilation of the holes acts to reduce the contact pressure between the tubes and the tubesheet. The H* lengths are based on the pullout resistance associated with the net contact pressure during normal or accident conditions. The calculation of the residual strength involves a conservative approximation that the strength is uniformly distributed along the entire length of the tube. This leads to a lower bound estimate of the strength and relegates the contribution of the preload to having a second order effect on the determination of H*.

Two series of test data are available for the determination of the residual strength of the joint. Data were obtained from a fabrication shop test program which was performed to investigate the various manufacturing steps associated with the tube-to-tubesheet joint relative to the use of Alloy 600 and Alloy 690 tube material. A second series of tests was performed to investigate the integrity of the tube-to-tubesheet joints as a consequence of extensive tube end foreign object damage being experienced at a plant with Model F SGs.

The data from both test programs were reviewed by Westinghouse in order to develop the response to this RAI. An error was found in the initial analysis relative to the determination of the residual strength of the joint. The value of the residual strength reported in Section 7.2 of the WCAP was to be 119 lbf/in. The calculation of this value was based on using an engagement length of 25.24 inches and a slip force of 3000 lbf. There were two errors associated with this calculation:

1) The specimen length came from the first series of tests and the slip force came from the second series of tests. Since the specimen length for the Series 1 tests was about 50% greater than for the Series 2 tests, the approach yields a conservative value.

2) The slip force was from a series of tests that were performed at 600°F, and thus included a differential thermal expansion contribution to the joint strength. Since the result was used as though it came from a room temperature test, the approach yields a non-conservative value.

The net impact on the overall analysis is not significant to the result. This will be discussed further in what follows.

The data from both series of pullout tests are listed in Table 1, below. The first six tests were part of the Series 1 tests, the remainder of the tests results are from the Series 2 tests. Two (2) of the Series 2 tests were performed at room temperature and six (6) were performed at 600°F. A comparison of the implied net contact pressure, "Net P", from the two series of tests can be effected by looking at the values in the last column. These include a correction factor to account for the increase in interface pressure, "Thermal P", due to the increased thermal expansion of the tube relative to the TS simulant. The results from both test series are quite similar, i.e., the average difference is less than about 50 psi. It is noted that the Series 2 data exhibit more scatter and one specimen does exhibit an apparently anomalous result. If that data point is removed the difference is about 90 psi, and both standard deviations are on the order of 75 to 80 psi.

Data were also obtained relative to [

]a,c,e

a,c,e

a,c,e

36. *Describe how the roughness of the collars used during the testing program compare to the roughness of the tubesheet bore. Describe any data confirming the as-built roughness of the tubesheet bore. Discuss if the lowest possible value of roughness was used, and, if not, how was this accounted for in determining the inspection distances.*

W Response:

The bore roughness for the tubesheet collars was specified on the drawing to be the same as the factory roughness, [ ][a,c,e]. Compliance with the requirement was verified by the quality assurance (QA) organization at the fabrication shop.

37. *In performing the leak rate tests, discuss why a 100% through-wall circumferential crack was not assumed at the H* distance. If based on some qualification data, discuss the potential for a partial through-wall flaw to "pop" throughwall during a steam line break, or to grow from partial through-wall at one inspection to throughwall during the next inspection.*

W Response:

WCAP-15932, Rev. 1 has been revised. See the leak rate discussion in response to Questions 17, 26 and 31.

38. *It was indicated in Section 5.1.4.1 of WCAP-15932 that wall thinning calculations were performed to determine the effect of tack rolling. Discuss the reason for this section of the WCAP. Also, discuss if the tack rolling was at the tube end in the field, and, if so, if the test specimens also had this tack rolling and whether the tack roll performed on the test specimens had the lowest contact pressure that could be observed in the field, providing the basis (including applicable data) for your answer.*

W Response:

This detail was important only to the fabrication of the test assemblies (for fitup for welding the primary side end of the test assembly and was completely inconsequential to the leakage tests. The perforations in the tube were above the minor roll expansion. Refer to the bottom picture in Figure 5-1.

39. *With respect to the test specimens, it was indicated that segmented expansions were performed. [A] Discuss the various configurations tested, including, for example, were all tests segmented or were some tests fully expanded for the entire region of the tubesheet. [B] Discuss also your basis for concluding that the test specimens were representative of the expansions in the field, including, for the segmented samples, is it possible that the tack roll assumed a greater percentage of the load than the hydraulically expanded region and, if so, discuss the need to repeat the test to account for the fact that this area is below the H* distance. [C] In addition, discuss the basis for assuming the pull out force is evenly distributed along the length of the tube in contact with the tubesheet.*

W Response:

Parts A and B:

Refer to Page 5-3 of Section 5.1.1 for the following excerpts:

Yes. The test samples are representative of the expansions in the field. The hydraulic expansion range for the Callaway steam generators was approximately [ ]a,c,e

This value conservatively bounds the lower pressure limit used for the Callaway steam generators.

The majority of the test samples were [ ]a,c,e A tube expansion schematic is shown in Figure 5-2.

A small group of the test samples was fabricated using [ ]a,c,e

The tack roll was inconsequential for pull-out testing. The tacking operation has no sealing function, being intended only to expand a tube into contact with the tube bore to facilitate the welding to the cladding on the tubesheet face.

The resistance to pull-out can be determined for any elevation in the tube joint, above or below the H* depth.

See Appendix B, "Tube-to-Tubesheet Joint Strength Analysis" of WCAP-15932, Rev.1 for further discussion of the test results.

Part C:

Distribution of the pull-out resistance uniformly throughout the axial extent of the joint is an adequate technical approach. It recognizes that short joints should have smaller pullout resistances and longer joints should have larger resistances. It is a minor contributor to joint strength for short H*'s such as 3.46 inches for Zone A, at only [ ]^{a,c,e}

40. *In Section 5.3.2 it was indicated that: "in the 600 °F pullout tests, the lowest value for 'first slip' or 'breakaway' force was 3000 lbs." This section then indicates that the results were conservative because of the lack of the additional resistance to pullout due to the differential pressure tightening between the tube and tube hole surface which would be present in the plant. Discuss at what pressure were these tests run and how was the tube/tubesheet heated.*

W Response:

The samples were not pressurized. Refer to the response to Question 35 for a complete explanation of the pull-out tests. The tubesheets for the test samples were heated by resistance heaters and covered with insulation.

41. *Provide a comparison of the results of the leak tests provided in Section 5.3.1 to the predictions from the proprietary DENTFLO computer code.*

W Response:

The DENTFLO code calculates leakage from a crack within the tubesheet by simulating the hydraulic resistances of both the crack and the tubesheet crevice above it. The code utilizes an empirical relationship to calculate the tubesheet crevice leak resistance. A second empirical relationship is used to model the constraining effect of the tubesheet on the crack leak resistance. Therefore, the tubesheet crevice and crack resistances used in DENTFLO are validated individually. The data that provided these two empirical correlations were obtained in two separate tests; one test simulated the tubesheet crevice only, and the other test simulated a crack within the tubesheet without tubesheet crevice resistance. There are no test data available under conditions where the leakage is controlled by both the crack and the tubesheet crevice resistances.

42. *In Section 6.3, Page 6-2, it is not clear why degradation of various depths was assumed in the leakage analysis. Given the potential for a tube to be circumferentially severed below the H* distance (or near severance at the time of inspection), it would appear appropriate to assume every active tube is severed at the H* distance. Discuss this discrepancy.*

W Response:

See leak rate calculation discussion in response to Questions 17, 26 and 31, which address expected crack morphology and expected number of cracks by elevation.

43. *A finite element model was used in determining tubesheet hole dilations. Discuss the basis for the assumptions in this model, or compare the differences between this model and that used for other plants with similar repair criteria which have been approved (e.g., Diablo Canyon W* criteria).*

W Response:

The secondary side pressure was assumed to penetrate the tube/tubesheet crevice and act on the outside surface of the tube and the surface of the tubesheet hole through the full depth of the tubesheet. This is clearly conservative in most cases, as the tightening produced by the tube internal pressure and differential thermal expansion between the tube and tubesheet is usually greater than the secondary side pressure, thus preventing its penetration through the tubesheet.

Tubesheet bowing complicates this somewhat with a reduction in contact pressures in the top half of the tubesheet when the primary pressure is greater than the secondary side pressure. Depending on the magnitude of the pressure differential, the secondary side pressure may penetrate the top few inches of the tube/tubesheet crevice. Rather than change the way the secondary side pressure is treated in the crevice when the calculated contact pressure is greater than the secondary pressure, it is conservative to apply the secondary pressure throughout the full depth of the tubesheet.

When the secondary pressure is greater than the primary pressure (i.e. LOCA or Leak Test), this assumption is appropriate.

An assumption was also made that the axial load from the end cap forces is present over the full length of the tube. This assumption is appropriate for the tube in the upper part of the tubesheet, but within a few inches of the neutral axis the end cap force will have been absorbed by the resistance to pull out afforded by the contact pressure between the tube and tubesheet. Thus, the tube in the lower part of the tubesheet will not experience the end cap load. Including the effect of the end cap load is clearly conservative.

44. Discuss whether the H distances in the Technical Specifications are based on a feed line break or a steam line break. In the WCAP, the acceptance criteria is more restrictive than a feedline break; however, the transients are different. Discuss whether an analysis was performed to confirm that the more conservative inspection distance was determined.*

W Response (Revised):

H* is based on the performance criteria that pull out resistance must exceed 3 times the end cap load resulting from normal operating pressure differential. Refer to Section 7.1.3. An analysis was performed to determine the limiting case; refer to Figures 7.2-2a through 7.2-3b.

45. With respect to the Technical Specifications, given the test program was done on non-degraded tubing, discuss why the Technical Specifications should not specify that any tube with detected degradation below the expansion transition and within the H distance should be plugged, including the technical basis for assuming pullout is not affected by tube degradation.*

Response: See the response provided for RAI Question # 5.

46. Discuss how the dynamic effects associated with steam generator blowdown during a steam line break or feed line break are modeled in the determination of the H distance (e.g., are there increased loads placed on the tubes as a result of the blowdown of the steam generator).*

W Response:

Those types of transients involve tube loads (most notably U-bend drag) which act at different times than when the maximum end cap loads act and therefore do not need to be added to the end cap loads.

47. [A] Discuss any test data supporting the magnitude of the pressure and temperature effects on contact pressure. Because the corrections in the WCAP appear to be analytical rather than experimental in nature, discuss whether mockup tests been performed on specimens at room temperature and at operating temperature (or at ambient and operating pressure), and, if so, discuss whether the results of these tests support the contact forces for these effects used in the analysis. If testing of hydraulically expanded tubes is not available, discuss whether tests from other types of expansions (e.g., WEXTEX, hardroll) are applicable and the results of any testing on these specimens.

B. The NRC notes that resistance to pullout in the peripheral tubes appears to be controlled mainly by the effects of pressures and temperature rather than by hydraulic expansion.

W Response:

There are test data for as-fabricated roll expanded joint contact pressures; these joints have higher contact pressures than hydraulically expanded joints. The tests are generally performed at RT with the differential pressure tightening (DPT), thermal growth mismatch tightening (TGMT) and tubesheet bending effects applied analytically. The calculations are all based on the application of the standard theory of elasticity and no plastic deformations are involved. Therefore, the results of the calculations do not require independent verification by additional testing.

Response to Part [B]: Based on the current analysis approach, the NRC Staff observation is correct, i.e., the peripheral tubes appear to rely mostly on contact pressure caused by the differential pressure and differential thermal expansion . This is an artifact of conservatively calculating the pullout resistance as though it were uniformly distributed along the tube. The net effect is a significant underestimate of the actual contact pressure from the installation process. If the test data were analyzed with an accounting of the actual distribution of pullout resistance, higher at the top, the tube-to-tubesheet joint would be demonstrated to be significantly stronger than it is given credit for in the determination of H*. This is a conservatism of the analysis and results in conservatively calculated values for H*.

48. *The first 10 rows of Callaway steam generator tubes were fabricated with thermally treated Alloy 600 material and the rest were fabricated with mill-annealed Alloy 600 material. Discuss whether there is any difference in the pullout capacity and leakage resistance between the thermally treated Alloy 600 tubes and mill-annealed Alloy 600 tubes, because it seems that the test specimens and leakage and pullout calculations discussed in WCAP-15932 were based on mill-annealed Alloy 600 material properties only.*

W Response:

There is no difference in the structural properties between the mill annealed and thermally treated A600. Therefore, either MA or TT tubes could have been used in the test; the results are equally valid for both the MA and TT tubes.

49. *Discuss whether, in TS 5.5.9, there should be a requirement that limits the application of the proposed H* depths to the original steam generators, because this requirement is to assure that the H* depths will not be inadvertently applied to future replacement steam generators, such as a statement in the Bases for Surveillance Requirement 3.4.13.2.*

Response: TS Table 5.5.9-4 has been revised to indicate that the H* depths are applicable to only the Model F Steam Generators.

50. *Discuss the need to modify the pullout length to account for differences in the thermal treatment process between the low row (less than row 10) and the high row tubes.*

W Response:

As discussed in the response to Question 48 above, the thermal treatment process did not change the structural properties of the A600. Therefore, the testing, performed with mill annealed Alloy 600 tubes (A600MA), provided results which are equally valid for A600 MA or Alloy 600 thermal treated (A600TT) tubes. There is no need to treat the plant mill annealed tubes differently from the plant thermal treated tubes and H* is independent of the MA or TT effect.

51. *In several places, references are made to documents for which no references are listed (e.g., what is reference 9.21 cited in Section 7.1.2). This needs to be clarified in the WCAP.*

W Response:

See previous explanation (Question 27.C) plus the following, the references on pages 7-3 and 7-4 were erroneously in the pre-publication version of the WCAP. These were observed and removed from the published WCAP. Reference 9.28 on Page 7-12 was not observed in the pre-publication version and is erroneously in the WCAP.

- Section 7.1 of the prepublication document: Reference 8.X is Ref. 8.3 of the WCAP
- Section 7.1.1 of the prepublication document: Reference 8.Z is Ref. 8.4 of the WCAP
- Section 7.1.1: Reference 9.20 should be 8.5
- Section 7.1.2: References 9.21 and 9.22 in the prepublication version of the WCAP were unnecessary and were removed in the published WCAP.
- Section 7.2: Reference to 9.28 should be 8.1

52. *Tube flaws may remain in service at the end of the next operating cycle for the following reasons: (a) they were knowingly left in service at the beginning of cycle (since they were below the H* distance and sized with a qualified technique as being less than 40% through-wall), (b) a region of the tubesheet area was not inspected with a qualified probe so indications were not detected at the beginning of cycle (e.g., below the H* distance, circumferential flaws would not be detected), (c) they initiated during the cycle, and d) they were missed during the inspection and continued to grow. The methodology for predicting leakage from flaws in the tubesheet area was provided in WCAP-15932-P, based in part on the computer code DENTFLO. Describe the methodology to be used to determine the number, severity, and location (depth within the tubesheet) of flaws for purposes of determining the amount of leakage (using the DENTFLO code) during postulated accident conditions, including the following information for flaws that are found, in the steam generators, to extend below the bottom of the expansion transition:*

A. the outage in which the flaw was found.

B. the orientation of the flaw (axial and circumferential indications).

C. the location of the indication with respect to the bottom of the expansion transition.

D. the size of the flaw to include the method of sizing (by plus-point, bobbin, or RPC), length (axial and/or circumferential), depth, and percent degraded area (for the circumferential indications).

E. the H zone (A, B, C, or D) where the flaw is located.*
W Response:

See the response to Questions 17, 26 and 31.

53. *Based on the discussion of "turbo mix" in the conference call held on October 19, 2002, with the Callaway staff, explain the use of the "turbo mix" with the bobbin coil indications in (1) the bobbin coil inspection of the steam generator tubes in the then current refueling outage and (2) determining indications of circumferential cracks previously found by use of the pancake coil in the tube inspections in the same outage.*

Ameren-UE Response.

54. In a phone call on November 19, 2002, the licensee discussed several circumferential tube flaws that were detected in the tubesheet region of the Callaway steam generators during the fall 2002 inspection. Provide the bobbin coil and rotating probe inspection data for the following tubes in the associated Callaway steam generators: SG A--R25C71; SG C--R18C77; SG C--R21C101; SG C--R29C69; and SG D--R42C57. Include with this data the appropriate calibration runs, a drawing of the standards, and the setups from the various calibration groups. Also provide a copy of the eddy current data analysis guidelines.

Ameren-UE Response

55. *On page 12 of the Westinghouse report, "RPC Inspection Lengths for Tube-To-Tubesheet Joints In the Callaway Steam Generators," SG-SGDA-02-47, the licensee indicated that the in-situ pressure test included a 360 degree, through-wall circumferential indication. The licensee stated that the circumferential indication did not leak under the SLB condition during the in-situ pressure test. The indication may not have leaked because (a) it was not as severe as eddy current data indicated, (b) the in-situ pressure test may be limited in its ability to provide results representative of an SLB, and/or (c) it does not represent the worst-case scenario. The staff notes that if a full- length tube pressure test is performed at a pressure of three times the normal operating pressure, it may result in simulating three times the axial loads; however, it also increases the interface pressure between the tube and the tubesheet as a result of pressure by 3 times. In addition, the in-situ pressure test does not include the effect of tubesheet bow. Ideally, the test should result in the more limiting of the following conditions: (a) imparting 3 times the axial loads on the tube at normal operating pressure and temperature with a hole dilation consistent with that observed during normal operation; or (b) imparting 1.4 times the axial loads*

on the tube at SLB differential pressures and temperature with a hole dilation consistent with that observed during an SLB.

A. Discuss whether the appropriate end-cap loads and contact loads between the tube and the tubesheet, as a result of pressure, are simulated during the test (i.e., if the interface pressure due to the tube's internal pressure is increased by a factor of three during the test, it would not appear that the test is providing useful information).

W Response:

There are two reasons for performing in situ tests. To ascertain whether or not condition structural requirements are met by degraded tubes and whether or not condition monitoring leak rate requirements were met by those same degraded tubes. For degradation within the tubesheet the structural requirements are inherently satisfied and the only purpose of such testing is with regard to leak rate requirements. For circumferential degradation the in situ tests may be performed with the intent of demonstrating compliance with structural and/or leak rate requirements. If the degradation is located below the specified H* distance there is no rationale for performing in situ tests aimed at demonstrating structural adequacy because structural adequacy has already been demonstrated in determining the value to be used for H*.

For circumferential degradation located above the H* elevation within the tubesheet the demonstration of structural adequacy can best be affected by determining the circumferential extent of the degradation and calculating the strength of any remaining ligaments. Structural in situ tests should only be considered in the unlikely event that the analysis fails to confirm that the structural requirement was met.

The dilation of the tubesheet holes during a postulated SLB is a function of the location on the tubesheet and elevation below the top of the tubesheet. The holes experiencing the most dilation tend to be [

]a,c,e

Please see Appendix D to WCAP-15932, Rev. 1.

B. *Provide a description of the test apparatus (including whether it was a partial or full length tube test; if a partial test, address the location of the sealing bladders with respect to the top of the tubesheet).*

[Ameren-UE Response]

C. Provide an analysis demonstrating the in-situ test conditions bound the conditions observed during normal operation and a SLB as a result of tubesheet bow.

W Response:

See the response to 55 a) above.

D. Discuss whether the in-situ testing performed at Callaway can be used to assess the structural and leakage integrity of tubes with flaws in the tubesheet region. If the in-situ test does not provide information regarding the integrity of the indications in the tubesheet region, discuss the implications of these results.

W Response:

See also Appendix D , "In Situ Testing of Tube Indications Located In the Tubesheet" in WCAP-15932, Rev. 1.

56. *The licensee investigated the location of the bottom of the expansion transition in relation to the top of the tubesheet. The licensee included a value of 0.30-inch in the H* distances based on an understanding of the expansion method and a review of data from other units. Based on an assessment of the eddy current data at Callaway, provide the maximum distance that the bottom of any of the expansion transitions is from the top of the tubesheet.*

W Response:

See the response to Question 28. A limiting value of [

]^{a,c,e}

57. *In evaluating the potential for leakage from reactor vessel head penetrations which have an interference fit (similar to the steam generator tubes), the industry's Materials Reliability Program (MRP-75) analyses include the fact that a leak into the annulus region between the nozzle and the head results in application of pressure on the outside of the nozzle and inside of the hole in the vessel head. This change in boundary condition from the as-designed configuration increases the pressure dilation of the vessel head (pressure applied to a larger diameter than the inside of the nozzle) and eliminates the pressure deflection of the nozzle. The net effect of the leakage into the gap is therefore to increase the gap opening. Discuss whether the analyses performed in support of determining the pull-out distance and the leakage from a steam generator tube account for this phenomena. If the model doesn't account for this effect, please perform an analysis to determine the need to account for this effect.*

W Response:

This phenomena is not considered for the following reason. If a through-wall crack developed during operation, the loss coefficient would likely increase significantly with the introduction of primary water into the crevice between the tube and the tubesheet. A very small amount of primary water would be involved and any oxidant present would be quickly consumed by surface reactions with the tubesheet wetted by the flow. This means that the exposed microscopic crevices between mating surfaces would be expected to narrow due to the expansion of the oxides formed; the oxides associated with corrosion in a SG occupy more space than the parent metals. There would be no meaningful further corrosion because of the lack of a mechanism for oxidant replenishment.

An observation from the leakage testing program was that subsequent tests on the same specimen at the same test pressures at elevated temperatures with few exceptions demonstrated an increase in the loss coefficient with test number. This same effect was not observed on specimens for which repeated tests were run at room temperature using the same pressurizing medium, deionized water. Thus, supporting the argument that a small amount of oxidation takes place at elevated temperatures and leads to closing or narrowing of the microscopic pathways between the tube and the tubesheet. This argument also explains why none of the in situ tests of tubes with likely through wall cracks at Callaway resulted in detectable leakage In the laboratory testing, at temperature exposures of test units were very short (typically < 1 day) while at Callaway the at-temperature leakage may have occurred for hundreds of days before decreasing to less than detectable. Additionally, the presence of boric acid in the reactor coolant would result in slightly higher low-alloy steel corrosion rates that would further accelerate blocking of the crevice to the point that flow would be limited.

The impact of boric acid attack on the tubesheet due to the presence of a through-wall flaw in a SG tube is provided in WCAP-11228, Rev. 1. "Tubesheet Region Plugging Criterion for the South Carolina Electric and Gas Company V.C. Summer Units 1 and 2 Steam Generators", October 1986 which has been submitted to the NRC staff.

See section 6.0 of WCAP-15932, Revision 1 for further discussion.

58. P*rovide the "no-contact" length for each of the steam generator zones for both normal operating and postulated accident conditions (including the factors of safety for both conditions).*

W Response:

The no contact length is the axial length over which dilation of the tubesheet causes the mechanical interference contact pressure between the tube OD and the tubesheet hole surface to reduce to zero. There is no safety factor included in the determination of the no contact lengths.

a,c,e

[

]

59. *On page 9 of the Westinghouse report, SG-SGDA-02-47, Westinghouse stated that it made several modifications to the leakage analysis in the TR:*

A. It removed room temperature tests from the analysis data.

B. It revised the crack opening area model to account for the fact that pressure acting on the flanks of the cracks is compressive relative to the material adjacent to the crack plane. This reduced the crack opening area by 50 percent.

C. The revised leakage analysis considered the tube material below the crack whereas in the original analysis the tube material below the crack was not considered.

Provide a more detailed description of the revised model and its basis, including:

A. A description of the testing program used to develop the loss coefficient. Provide the data acquired and the data used in the correlation.

W Response:

The tube-to-tubesheet crevice loss coefficient was determined using [

]a,c,e

Leak rate test data are provided in Table Q59-1.

B. A description of the testing program used to develop the flow through a crack. Provide the data acquired and the data used in the correlations.

See Appendix C of WCAP-15932, Rev. 1.

W Response:

The leakage analyses reported in both WCAP 15932 and SG-SGDA-02-48 take credit for the tube material located below the crack. Both analyses consider the leakage resistances of the crack as well as the tube-to-tubesheet interface downstream. The two analyses differ to the extent that a more realistic approach is used in SG-SGDA-02-48 to obtain the tube-to-tubesheet leakage resistance and to estimate crack opening area. A description of the revised crack opening model used in SG-SGDA-02-48 is provided in Appendix C of WCAP-15932, Rev. 1.

a,c,e

[ ]

a,c,e

a,c,e

The test data used to generate the revised correlation for loss coefficient for leakage through the tube-to-tubesheet interface is [

]^{a,c,e}

Flow through the crack portion of the leakage path is modeled using [

]^{a,c,e} The same fluid mechanics model has been used in a number of other studies in the past involving crack leakage and is described in several reports submitted to NRC (for example, in Section 6.0 of WCAP-15573, "Depth-Based SG Tube Repair Criteria for Axial PWSCC at Dented TSP Intersections – Alternate Burst Pressure Calculation").

60. *It was noted in the Westinghouse report, SG-SGDA-02-47, that all of the test specimens in the test program exhibited leakage at both room and elevated temperature conditions with higher leak rates being measured at room temperature. Although this general trend is expected because of the lower contact pressures at room temperature, discuss whether the magnitude of the differences in leak rates is consistent with what would be expected given the models used for accounting for the effects of temperature on contact pressure. If the trends cannot be quantitatively explained, discuss the need to perform additional testing to ensure there is a fundamental understanding of all key parameters.*

W Response:

Although the trends in leakage between room temperature and elevated temperature cannot be quantitatively explained, it is judged that a fundamental understanding of key parameters exists and that there is not need for additional testing. As stated in section 6.2 of WCAP-15932, Rev. 1, the data base for the curve fitting of the crevice loss coefficient as a function of the contact pressure has been reviewed in detail. The examination of the test data has revealed a bias to lower loss coefficients from tests performed at room temperature relative to tests performed at 600°F. In addition, it was found that crevice resistance increased for subsequent tests using the same specimens. An examination of the data from the tests performed at room temperature revealed that the leak rate was constant with time, even though the repeated tests were performed using the same test equipment and the same test specimens. The consistent explanation for the behavior of the elevated temperature results is that slight oxidation of the tubesheet simulant at elevated temperature resulted in a narrowing of the flow paths within the tube-to-tubesheet interface. The same effect would be expected to occur in the tubesheet of an operating plant and supports the observation of no leakage from any of the in situ tests of cracks that were surely throughwall in the Callaway SGs.

The resistance to leakage through the tube-to-tubesheet interface arises from imperfect contact between the tube OD and tubesheet hole. Both microscopic roughness asperities and a small degree of ovality limit the extent of physical contact. An increase in contact pressure produces increased contact by tightening the interference fit of hill-and-valley asperities, by overcoming ovality interference and by elastically and plastically deforming the asperities on the tube and tubesheet hole, which in turn increases the resistance for leakage through the joint.

Temperature has a major influence on the leakage resistance of the tube-to-tubesheet interface joint. Since the tube expands more than the tubesheet hole, the contact pressures at normal operating and accident conditions temperatures are expected to be significantly higher than at room temperature for the same primary-to-secondary pressure differential, which increases the resistance for leakage. For a given contact pressure, increasing temperature facilitates deformation of roughness asperities and tightens the interference fit between the tube and tubesheet. Furthermore, primary fluid flashing at elevated temperatures reduces the effective pressure differential available to drive the flow, which manifests as increased flow resistance. Therefore, at a given contact pressure the leakage resistance is expected to be significantly higher at the normal operating and accident conditions temperatures relative to room temperature condition. This is clearly evident from the test conducted using simulated Model F tubesheet joints.

Leak rate evaluations to predict leakage under normal operating and accident conditions utilize an empirical correlation for leakage loss coefficient. The development of this correlation is described in SG-SGDA-02-48. The correlation is based on tests conducted at 600°F, which represents normal operating and accident conditions. There are 29 data points in the correlation and the coefficient of regression is 75%. Therefore, the loss coefficients used in the leakage calculations are based on a sound database, and no additional tests are deemed necessary.

See Appendix D of WCAP-15932, Rev. 1.

61. *If the loss coefficients are lower at lower temperatures and an SLB results in temperatures less than 600°F, discuss the need to obtain a loss coefficient corresponding to the temperatures actually observed during an SLB. If no data is available from realistic SLB temperatures, discuss the need to use the room temperature test data to ensure the condition is bounded.*

W Response:

The generic temperature and pressure parameters used in the H* structural analysis bound the values in the accident analysis of the Callaway plant. The H* SLB leakage analysis is completed at plant conditions (2560 psi, 600 ° F) similar to that used by the industry and approved by the NRC for steam generator alternate repair criteria.

62. *On page 7 of the Westinghouse report, SG-SGDA-02-47, the licensee postulated a theory regarding why the loss coefficient may increase with the initial introduction of primary water into the crevice. Regarding this theory, please address the following:*

A. Discuss whether the corrosion products or the primary water in the crevice would result in a loss of contact pressure above the joint and whether this effect was considered in the analysis. For example, suppose corrosion of the tubesheet resulted in the accumulation of corrosion products between the tube and the tubesheet, would the corrosion products result in a loss of contact pressure (due to a phenomenon such as denting)? In addition, suppose a tube was leaking from a crack in the tubesheet region, discuss the potential for loss of contact pressure as a result of the leakage. Provide the technical basis for the answers.

W Response:

As noted in section 6.0 of WCAP-15932, Rev. 1, if a through-wall crack developed during operation, the loss coefficient would likely increase significantly with the initial introduction of primary water into the crevice between the tube and the tubesheet. A very small amount of primary water would be involved and any oxidant present would be quickly consumed by surface reactions with the tubesheet material wetted by the flow. This means that the exposed microscopic crevices between material surfaces would be expected to narrow due to the expansion of the oxides formed; the oxides associated with the corrosion in a SG occupy more space than the parent metals. There would be no meaningful further corrosion because of lack of a mechanism for oxygen replenishment. In addition, any microscopic particulates that were transported through the crack would likely further narrow the crevice and retard the flow. An observation from the leak rate testing program was that subsequent tests on the same specimen at the same test pressures at elevated temperatures for the most part demonstrated an increase in loss coefficient with test number. The same effect was not demonstrated on specimens for which repeated tests were run at room temperature using the same pressurizing medium, deionized water. Thus, supporting the argument that a small amount of oxidation takes place at elevated temperatures and leads to a closing or narrowing of the microscopic pathways between the tube and the tubesheet. This argument also explains why none of the in situ tests with likely through-wall cracks at Callaway resulted in detectable leakage and implies that there would be no leakage during a postulated accident.

B. During the leak rate testing program as discussed in Westinghouse report, SG-SGDA-02-47, it was noted that when repeat tests were performed on a specimen at elevated temperature, there was an increase in the loss coefficient (with few exceptions). Please describe these exceptions and assess the key parameters that may explain why these exceptions occur (e.g., specimens with lower contact pressures, more severe flaws, random, etc.). Given the results of this analysis, discuss whether similar conditions occur in the field.

W Response:

The repeat tests were conducted in succession on the same day. For a given sample, the leakage data at the NOP condition, 1900 psi (nominal) were recorded first, followed by the data at the accident condition pressure differential, 2650 psi (nom.). Finally, the data at the pressure exceeding the accident condition, 3100 psi (nom.), were recorded. At this point, the sequence was repeated.

There were [

]^{a,c,e} The leakage flow reduced in eight of the 11 pairs of tests. In the remaining tests of the pairs of data points, the leakage flow increased. Another case involved only one data point at each pressure differential for a sample. Hence, there weren't two leakage flows for the same pressure differential to compare for that sample.

It was concluded that the results of sample fabrication variables, such as hydraulic expansion pressure effects on the resulting tube-to-tubesheet contact pressure, were minimal due to maintaining good control of the processes.

It is concluded that the laboratory fabrication processes produced joints which were conservative to, or the same as, the processes used to make the tube-to-tubesheet joints in the factory. The main conservatism was the use of the low end of the factory hydraulic expansion pressure range to make the laboratory samples.

C. Discuss the extent to which the same phenomenon (increase in loss coefficient as a result of leakage) would occur in the field given that the water chemistry in the plant is different than the pressurizing medium used during the tests. Also discuss the handling of the specimens between these tests. Discuss whether the loss coefficient is increasing with time simply as a result of different environments and handling (the lab specimens are probably exposed to much more oxygen than would be present in a steam generator during operation).

See response to Question 63 a).

D. Given that the tubesheet collar used in the test is a different material than that used in the field and was primarily selected to simulate the rigidity of the tubesheet, discuss whether different results may be obtained if the actual tubesheet material was used.

W Response:

It is Westinghouse's engineering judgment that the slight oxidation in the tubesheet simulant at elevated temperature results in a narrowing of the flow paths in the tube-to-tubesheet crevice. This same effect would be expected to occur in the tubesheet of an operating plant.

As stated in WCAP-11228, Rev. 1, "Tubesheet Region Plugging Criterion for the South Carolina Electric and Gas Company V.C. Summer Units 1 and 2 Steam Generators", October 1986. corrosion testing showed that high temperature exposure of tubesheet material resulted in steel corrosion rates of about 1 mil per year. This rate is higher than would be expected in the steam generator since no attempt was made to completely remove the oxygen from the autoclave during heatup. Even with this amount of corrosion, the leak rate is still a factor of nine less than the corrosion rate observed during low temperature exposure. This differential corrosion rate observed between high and low temperature exposure was expected because of the decreasing acidity of the boric acid at high temperatures and the corrosive effect of the high oxygen at low temperatures.

These corrosion tests are considered to be very conservative since they were conducted at maximum boric acid concentrations, in the absence of lithium hydroxide, with no special precaution to deaerate the solutions , and they were of short duration. The latter point is very significant since parabolic corrosion rates are expected in these types of tests, which leads one to overestimate actual corrosion rates when working with data of short duration. Previous testing by Westinghouse has shown that the presence of lithium hydroxide reduces corrosion of Inconel Alloy 600 and steel in a borated solution at operating temperatures.

63. *On page 8 of the Westinghouse report, SG-SGDA-02-47, Westinghouse stated that the leak rate can be measured by the pressure drop during the in-situ pressure test and that if there is no detected drop in the pressure during a hold period, there has been zero leakage. Westinghouse also stated that the in-situ testing equipment is capable of measuring leak rates as small as 0.001 gpm.*

A. *The staff understands that the holding period for the maximum pressure is usually two minutes. If the holding period is extended to a longer period of time such as the duration of a steam line break event, the tube may leak because the crack opening area may enlarge. Discuss the potential for the tube to leak when the holding period is extended.*

W Response:

In accordance with the EPRI Guideline document on In Situ Testing, for leakage testing, indications which leak have a 5 to 10 minute hold period. If the leak rate decays during the test interval, the maximum leak rate value is reported. If the leak rate is increasing, the trending information should be reported over the 10 minute testing period. If no leakage is measured, the minimum hold period is 2 minutes.

Callaway has performed a number of in situ tests of circumferential tube crack indications located within the tubesheet and has found none that exhibited any leakage. The in situ testing equipment is capable of measuring leak rates as small as 0.001 gpm or about 75 drops per minute. Therefore, the hold times were limited to 2 minutes.

See also Appendix D of WCAP-15932, Rev. 1 for a discussion of the use of in situ test data for the Callaway PLRPC inspection criteria..

B. Describe how the leak rate was measured in the in-situ pressure tests.

Ameren-UE to Respond.

C. Assuming the in-situ test can simulate the conditions of an SLB, please provide the basis for the statement that the in-situ testing equipment is capable of measuring leak rates as small as 0.001 gpm.

W Response:

Ameren-UE Response.

C. With respect to the statement that the detection capability is improved if pressure is monitored, discuss the sensitivity of this technique for the standard hold times used during in-situ tests. Provide the basis for this answer.

W Response:

See the response to Question 63 a).

64. *The licensee indicated that the flaws in the tubesheet may grow deeper without getting appreciably longer. The basis for this conclusion is not obvious. It may simply mean that the stresses at the deepest part of the flaw were the highest with somewhat lower stresses elsewhere. The profile could indicate a deep section with a shallower extent around the remaining portion of the circumference (below the detection threshold). If this were the case, all flaws could eventually grow to be 360 degrees in circumferential extent and 100 percent through-wall. Discuss the need to obtain field data to confirm the expectation.*

W Response:

See response to Question 66.

65. *Regarding Figure 14 in the Westinghouse report, SG-SGDA-02-47, and the determination of the distribution of indications below the inspected region, it is not apparent that the methodology presented supports the conclusion that the distribution of indications below the H* distance is uniform, for the following reasons:*

A. If one were just interested in the most severe indications, it would appear that only the data from 3" to the H distance should be included in the Figure since the first 3 inches of the tube were inspected during prior outages (since circumferential indications in the first 3-inches had been removed from the population during past inspections).*

B. Given that eventually all indications below the H distance will become severe since they will not be detected nor repaired, it would seem appropriate that all indications should be assessed (i.e., not just the most severe).*

C. Given that each zone is potentially inspected to a different distance, it would appear appropriate to evaluate whether there is differences between the various zones.

Provide a list of all indications, the outage in which they were detected, their severity (circumferential extent, average depth, maximum depth, percent degraded area), their elevation with respect to the top of the tubesheet (e.g., TSH-2.5 inches), and the zone in which they were found.

Replot Figure 14 based on all indications (regardless of severity, zone, or outage in which they were detected) and also with all indications in specific zones to assess whether the uniform distribution assumption still holds.

W Response to [A], [B], and [C]:

Tables 6.2 and 6.3 of WCAP-15932, Rev. 1 represent a projection of the number of cracks to be present in all the steam generators and the number in the most seriously affected SG, i.e., SG A based on the number of indications. The projections have been made based on a lognormal distribution function. The first cracks were observed in the Callaway SGs in 1995 after 8.6 effective full power years of operation. The cumulative distribution of circumferential cracks within the tubesheet are illustrated on Figure 6-16 for all the SGs and Figure 6-17 for SG A. A summation of the leak rates to be expected from each indication in Table 6.3 has been made using the distribution of angles as listed in Figure 6.15 and likely depths from the distribution of all indications found during the outage in combination with the prediction curves of Figure 6.19. Moreover, the SLB leakage calculation conservatively assumes that all indications are located in one SG. The calculated SLB leakage is determined to be 0. 44 gpm which is within the accident analyses assumption of 1.0 gpm included within the Callaway UFSAR.

A tubesheet map of Callaway non-axial tubesheet indications below -0.3 inches from the top of the tubesheet is provided in Figure Q65-1. The plot supports a determination that the indications are distributed uniformly in the radial direction outside the thermally treated portion of the tube bundle and part of Zone A. Figure 6.14, "Distribution of Severe Indication Locations" of WCAP-15932, Rev. 1 supports a uniform distribution along the elevation of the tubesheet.

66. *Regarding the theory that the flaws are a result of local expansions of the tube material into manufacturing depressions within the drilled holes in the tubesheet:*

Regarding the theory that the flaws are a result of local expansions of the tube material into manufacturing depressions within the drilled holes in the tubesheet:

A. Discuss the basis for this theory.

W Response:

Discussion:

Primary water stress corrosion cracking (PWSCC) was first observed at the tubesheet expansion region in operating steam generators in which the tube-to-tubesheet crevice closure had been effected by full-depth roll expansion. Somewhat unexpectedly, the cracking occurred not at the expansion transition at the top of the tubesheet, where the residual stresses are known to be high, but rather appeared to be randomly distributed within the tubesheet. A close review of the manufacturing records from the tubesheet drilling operation, which included manual gauging of the drilled tubesheet holes to locate and disposition drilling anomalies, indicated a strong correspondence between the drilling anomalies and the tube cracking locations.

The conclusion from this assessment was that these drilling anomalies represent locations at which the residual stresses are high as a consequence of the mechanical rollers expanding the tubing over ledges and into gouges in the tubesheet hole ID surfaces. A significant number of mockups were tested, using relatively short-length collar simulants intentionally drilled to contain irregular ID surfaces. Tubes were then roll-expanded into the collars. Most of these mockups used surrogate stainless steel tubes rather than Alloy 600 tubes, and were used to index the relative residual stress level by means of the familiar boiling $MgCl_2$ test. Invariably the times-to-crack were shorter at the ID surface irregularities than at the roll expansion transitions.

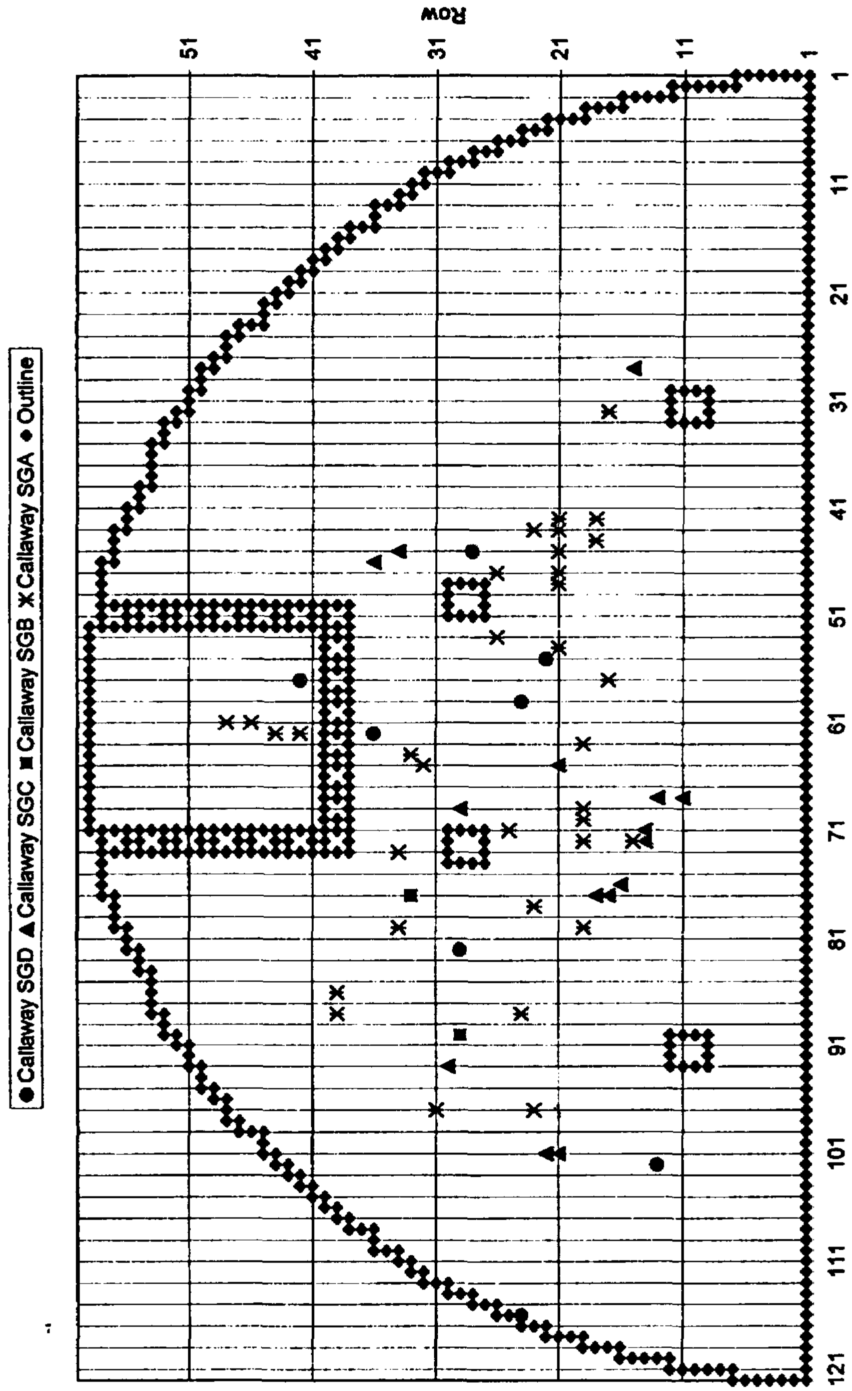

Figure Q65-1
Callaway Non-axial Tubesheet Indications (Below –0.3" from TTS)

Similar observations were also noted in the "skip roll repair" program. When full-depth roll expansion was first implemented, ID profilometry indicated the existence of unexpanded regions where the step-wise rolling equipment had missed a step and left a small portion of the tube unexpanded. This created an internal "expansion transition"; these locations proved in testing to represent a region of high residual stress where cracking occurred preferentially. A solution to this was to re-roll the nonexpanded region - i.e., to "skip roll repair" the sites - using specially designed rolling equipment. Eventually, it turned out that the overlap regions between original roll expansions and subsequent roll-repairs represented locations of high residual stress, and first-cracking initiated at those sites. While not duplicating the conditions of the present concern, this experience did provide additional support to the judgment that internal regions of high residual stress could in fact lead to premature stress corrosion cracking.

When explosive-expansion was adopted as the means for closing the tube-to-tubesheet crevice, it was common to find the earliest signs of degradation within the tubesheet, well away from the expansion transitions at the top of the tubesheet. While it is likely that the residual stresses at ID surface irregularities are lower for explosive (or hydraulic) expansion than for roll-expansion, the local residual stresses are apparently sufficiently high that initial cracking occurs there.

Since most of these sites, well removed from the top surface of the tubesheet, do not represent a safety concern, the qualification and adoption of such alternate repair criteria as L*, F* and W* provided significant relief to the utilities in that unnecessary plugging was avoided.

An indirect confirmation of the judgment that the local ID surface irregularities are the source of the problem is available from the results of a study performed in 1992 for EPRI to characterize the resistance to PWSCC of hydraulic tube-tubesheet expansions (Ref. 1). For this program, both hydraulic and mechanical (roll) expansion mockups were prepared and tested in a highly accelerated 400°C doped steam test environment. These mockups used smooth-bore cylindrical collars - i.e., they contained no ID surface irregularities. All cracking in the test mockups - both the roll-expansion mockups and the hydraulic expansion mockups - occurred at the expansion transitions at the top and bottom of the collars; no cracking occurred within the smooth-bored regions. This suggests that, lacking ID surface irregularities, degradation would not be expected to occur within the tubesheet. The obverse proposition, therefore, is that the occurrence of cracking within the tubesheet regions strongly suggests the existence of ID surface irregularities at the sites of the degradation.

B. *Are these manufacturing depressions evident from bobbin coil or rotating pancake coil inspections?*

W Response:

The manufacturing depressions and other features may be referred to as anomalies or signals and have been detected in both bobbin coil and rotating pancake coil inspections.

C. *Discuss whether the flaws observed were contained within the area "bounded" by the depression in all cases.*
W Response:

In the testing programs mentioned in Response A above, degradation was observed to be both axial and circumferential in orientation. This was interpreted to indicate that, depending on the nature of the surface irregularity/condition causing the local high residual stress, the stress may be exaggerated either in the hoop or in the axial direction. The former would promote axial cracking, whereas the latter would encourage circumferentially-oriented degradation. Logically, it would be expected that circumferential cracking would be more likely to be confined to the region adjacent to the source of the stress, whereas the axial crack might extend somewhat away from the stress source until it reached a region where the residual-plus-operating stress was insufficient to continue to drive the crack extension.

The thrust of the previous work was not to study and carefully characterize the cracking, but rather to elucidate means to avoid it. Hence, exhaustive physical examinations of all degradation locations was not performed.

D. Discuss why flaws have not been observed in Zone A given the postulated cause of cracking (presumably the frequency of these manufacturing depressions would be the same from one zone to the next).

W Response:

A circumferential indication has been observed in Zone A of the Callaway SGs.

E. Given these observations, discuss the need to modify the leakage assessment for Refueling 12 and subsequent outages to address cracks that may be occurring in Zone A and other zones.

The SG leakage calculation included in WCAP-15932, Rev. 1 projected the number of indications in the tubesheet RPC inspection region in all SGs (in each zone) and determined the expected primary to secondary leakage to be approximately 0.44 gpm.

Reference:

1. *Characterization of the Resistance to PWSCC of Hydraulic Tube-Tubesheet Expansions*, Final Report for Project S406-12, EPRI TR-100865, July 1992.

67. *To evaluate the leakage through a 360 degree circumferential extent, 100 percent through-wall circumferential flaw, the maximum crack opening area was determined from an analysis which considers either (a) the primary pressure acting on the crack flanks with a tube material acting as a spring to resist parting of the crack faces, or (b) from extrapolating the areas obtained from analyzing a series of circumferential cracks up to about 270 degree in circumferential extent. Please provide a more detailed description of how this was done, its basis, and any data supporting the predictions from this model.*

W Response:

See Appendix C of the revised WCAP-15932, Rev. 1 entitled "Crack Opening Area for Circumferential Cracks in the Tubesheet".

68. *With respect to the assumption in the leakage model that the leak rate from a circumferential crack is the same as the leak rate from an axial crack if the crack opening areas of the two cracks are identical, the staff agrees to a first approximation that this is true when the ratio of wall thickness to crack opening displacement is not large (e.g., ratio <10). However, when this ratio is large, it is not clear whether this assumption would hold true. As a result, discuss the need to account for differences in leak rates when the wall thickness to crack opening displacement is large. Discuss whether the leakage model considered cases when the wall thickness to crack opening displacement is large (e.g., ratio > 10).*

W Response:

The presence of the tubesheet prevents the tube segments above a crack from bending, which limits the crack opening area for circumferential cracks. Similarly, the tubesheet limits crack flanks opening for axial cracks. The ratio of wall thickness to crack opening displacement is greater than 10 for all crack sizes considered in this study.

Fluid mechanics models used in the industry to compute crack leakage treat the leak path as a slit of constant area or varying linearly in the direction of flow. Using analogy with flow through a pipe, leakage flow rate is determined by equating the pressure difference available to drive leakage with pressure losses due to a large number turns in the leakage path due to irregular geometry (tortuosity), expansions and contractions, and wall friction, as well as due to effects of flashing of liquid to vapor. In such a model, the crack orientation, axial vs. circumferential, is not important. If the effective crack area and factors affecting pressure drops (i.e., tortuosity and surface roughness) are the same, then the leakage from an axial crack would be the same the leakage from a circumferential crack.

69. *The staff notes that there are uncertainties associated with many aspects of the leakage evaluation. There are uncertainties in the number of flaws, the locations of the flaws, the size of the flaws and whether they grow in circumferential extent, the loss coefficient, and the constraining effect the tubesheet has on crack opening. Given the uncertainties in the evaluation, a leakage model similar to that developed for NRC Generic Letter 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," should be considered to ensure the leakage estimates provided by the model represents a 95th percentile value at a 95 percent confidence when accounting for all of the uncertainties. Discuss how uncertainties are treated in the leakage model.*

W Response:

See the response to Question 65.

70. *The leak rates for various crack sizes are plotted in Figure 19 in the Westinghouse report, SG-SGDA-02-47. This figure represents the leak rate for indications at the boundary between Zones B and C. It would seem that similar data would need to be developed for all Zones unless there is no potential for circumferential cracks in those other zones such as Zones A and D.*

W Response:

There is a potential for leakage from Zones A, B, C and D. The SLB leakage model has been revised to consider both the effect of depth into the tubesheet and radial location from the center of the tubesheet in establishing postulated SLB leakage. The total projected number of indications at the end of the next operating cycle have been grouped by elevation in the tubesheet and by distribution of severe indication crack angles in order to calculate SLB leakage. Moreover, the SLB leakage calculation assumes all indications are located in one steam generator. The projected SLB leakage is calculated to be 0.44 gpm which is significantly less that the 1.0 gpm assumed in the Callaway UFSAR accident analyses.

71. *The staff understands that tube inspections are frequently performed beyond the specified inspection extent (e.g., three inches). Without understanding more details of what indications were found, where they were found, and when they were found, the staff is unable to draw any conclusions regarding whether a conservative prediction of the number of flaws that could be present below the H* distance is being determined. Please clarify the data in Tables 1, 2, and 3 in the Westinghouse report SG-SGDA-02-47. Also, the information in Tables 1, 2, and 3 do not appear to match the description in the text. For example, the text indicated that the number of indications found for all of the steam generators was 46, but the corresponding table entry (based on staff's interpretation) indicates the number is 52.*

W Response:

The total number of significant indications found in the Callaway steam generators within the H* distance is 12 as defined in Table 6.1. The numbers of severe circumferential indications for H* < Depth and H* < depth < 16" are projected numbers.

Table 6.1 has been revised as follows to correct an error in the scaling factors. This change is described in WCAP-15932, Rev. 1 and is summarized below.

Table 6.1: Distribution of Severe Circumferential Indications in Callaway SGs and H* Zone

SG	Depth < H*		H* < Depth		H* < Depth < 16"	
	Zone B	Zone C	Zone B	Zone C	Zone B	Zone C
A	3	0	6	0	4	0
B	0	0	0	0	0	0
C	4	3	8	4	6	3
D	2	0	4	0	5	0
Totals	9	3	18	4	15	3

Hence, the total number of severe indications in the Callaway SGs is projected to be 52.

Also, Tables 6.2 and 6.3 have been modified to be consistent with the text in WCAP-15932, Rev. 1. These tables represent a projection of all circumferential indications in the tubesheet region of the Callaway SGs below -0.3 inches from the top of the tubesheet and all circumferential indications located in that same region in SG A.

72. *The Callaway inspection results have shown that circumferential and axial cracks may develop within the H* distance during an operating cycle. At the time of plant startup, there will be no detected degradation within the H* distance. During the course of the cycle, a flaw could initiate within the H* distance of this tube. This flaw may affect the pull-out resistance of the joint. In addition, there is a potential that 360 degree, 100 percent through-wall flaws at or below the H* distance may occur.*

A. Discuss the need to expand the inspection distance of the rotating pancake coil probe to account for the initiation/growth of flaws within the H distance during the course of the cycle.*

B. Provide data supporting the ability to assess the impact of degradation within the H distance on the pull-out resistance of the joint.*

W Response:

The plant data only shows that circumferential cracks occur below -0.3 inches from the top of the tubesheet in the Callaway SGs. With one exception, axial cracks occur above this elevation in the crevice region. This one exception, tube R46 C61 in SG A, had a Multiple Axial Indication

(MAI) on the tube at an elevation of -0.75 inches and a Single Circumferential Indication (SCI) at an elevation -0.74 inches from the top of the tubesheet.

Addressing the need to expand the inspection distance of the RPC probe to account for initiation and growth of flaws within the H* distances during the course of a cycle, the Callaway plant currently has no repair criteria for degradation found in the steam generators that would allow a tube with any type of indication other than wear to remain in service. Callaway follows the industry practice as defined in the EPRI Guideline document for SG Inservice Inspection of plug-based-on-detection. Plugging of the defective tubes is intended to ensure that tubes remaining in service will meet the integrity performance criteria until the next scheduled tube inspection.

From a structural standpoint, based on the occurrence of cracking within the Callaway steam generators, it is expected that at most only a single crack would be present in the H* distance and that the crack would be limited in azimuthal extent. It is judged that the presence of a single crack within the H* distance would not significantly affect the stiffness of the tube in the hoop direction during all plant conditions and the integrity of the joint would not be compromised.

Concerning primary-to-secondary leakage, no through-wall cracks are expected. In the unlikely occurrence of a through-wall crack in the H* distance, leakage would be expected to be negligible during all plant conditions due to the small circumferential extent of the crack.

73. On page 13 of the Westinghouse report, SG-SGDA-02-47, it states that, "...the stress from the pressure on the flanks is 0.214 of the stress that would result from an end cap pressure load for the same pressure..." Provide the technical basis for the 0.214.

W Response:

This is the ratio of the material area of the tube based on the thickness relative to the total area of the tube based on the OD. Ratio of $2 \cdot \pi \cdot r_m \cdot t$ to $\pi \cdot r_o^2$.

ATTACHMENT 2d
ULNRC 04861
CALLAWAY PLANT

Westinghouse

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Our ref: SCP-03-52

June 3, 2003

AmerenUE
CALLAWAY PLANT
Responses to NRC RAIs on Partial-Length RPC Inspection of the Tube Sheet Region of the Callaway Plant Steam Generators

Dear Mr. Corder:

This letter transmits 10 copies of proprietary (LTR-SGDA-03-129) and non-proprietary (LTR-SGDA-03-130) versions of "Responses to NRC RAIs on Partial-Length RPC Inspection of the Tube Sheet Region of the Callaway Plant Steam Generators," dated May 2003 for your submittal to the NRC for review and approval.

In addition to the proprietary and non-proprietary letter reports, there are four other enclosures for your use:

1. Information which should be included in your NRC transmittal letter.

2. Proprietary Information Notice to be attached to your NRC transmittal letter.

3. Copyright Notice to be attached to your NRC transmittal letter.

4. Westinghouse letter, "Application for Withholding Proprietary Information from Public Disclosure" (CAW-03-1649) with Affidavit CAW-03-1649.

Please transmit the original of Item 4 to the NRC in your transmittal.

If you have any questions, please do not hesitate to contact us.

Sincerely,

WESTINGHOUSE ELECTRIC COMPANY LLC

P. J. McDonough
Customer Project Manager

Enclosures

cc:	M. S. Evans	Callaway
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Our ref: CAW-03-1649

June 3, 2003

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-SGDA-03-129, "Responses to NRC RAIs on Partial Length RPC Inspection of the Tube Sheet Region of the Callaway Plant Steam Generators" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-03-1649 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 2.790 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by AmerenUE.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-03-1649 and should be addressed to the undersigned.

Very truly yours,

H. A. Sepp, Manager
Regulatory Compliance and Plant Licensing

Enclosures

cc: S. J. Collins
D. Holland
B. Benney

CAW-03-1649

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared H. A. Sepp, 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:

H. A. Sepp, Manager
Regulatory Compliance and Plant Licensing

Sworn to and subscribed
before me this 3rd day
of June, 2003

Sharon L. Fiori
Notary Public

SHARON L. FIORI COMMONWEALTH OF PENNSYLVANIA NOTARY PUBLIC

Notarial Seal
Sharon L. Fiori, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires January 29, 2007
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 the Westinghouse Electric Company LLC.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Electric Company LLC 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 2.790 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 2.790, 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-SGDA-03-129, "Responses to NRC RAIs on Partial-Length RPC Inspection of the Tube Sheet Region of the Callaway Plant Steam Generator," (Proprietary) dated May 2003. The information is provided in support of a submittal to the Commission, being transmitted by the AmerenUE letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted for use by Westinghouse Electric Company LLC for the Callaway Plant is expected to be applicable for other licensee submittals in response to certain NRC requirements for justification of a reduction of rotating pancake coil (RPC) inspection length of Model F steam generator tubes within the tubesheet from full-length to partial length.

This information is part of that which will enable Westinghouse to:

(a) Justify the use of the H* criterion as a basis for limiting the length of eddy current inspection of hydraulically expanded tubes in the tubesheet region of steam generators.

(b) Discuss analysis and testing programs used in support of the development of the H* criterion.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for licensing documentation.

(b) Westinghouse can sell support and defense of this information to its customers in the licensing process.

(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 licensing support documentation 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 2.790 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 2.790(b)(1).

COPYRIGHT NOTICE

AmerenUE

Letter for Transmittal to the NRC

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

Enclosed are:

1. 2 copies of LTR-SGDA-03-129, "Responses to NRC RAIs on Partial-Length RPC Inspection of the Tube Sheet Region of the Callaway Plant Steam Generators" (Proprietary)

2. 2 copies of LTR-SGDA-03-130, "Responses to NRC RAIs on Partial-Length RPC Inspection of the Tube Sheet Region of the Callaway Plant Steam Generators" (Non-proprietary)

Also enclosed are a Westinghouse authorization letter, CAW-03-1649, accompanying affidavit, Proprietary Information Notice, and Copyright Notice.

As Item 1 contains information proprietary to Westinghouse Electric Company, 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 2.790 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 2.790 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-03-1649 and should be addressed to H. A. Sepp, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.