Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37384-2000

Proprietary information submitted
under 10 CFR 2.390

March 9, 2005

SQN-TS-03-06 10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

In the Matter of) Docket Nos. 50-328
Tennessee Valley Authority)

SEQUOYAH NUCLEAR PLANT (SQN) - UNIT 2 - LICENSE AMENDMENT CHANGE NO. SQN-TS-03-06 - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) (TAC NO. MC5212)

Reference: 1) TVA letter to NRC dated December 2, 2004, "Sequoyah Nuclear Plant (SQN) - Unit 2 - Technical Specifications (TS) Change 03-06 - Change Inspection Scope for Steam Generator (SG) Tubes"

2) TVA letter to NRC dated February 15, 2005, "Sequoyah Nuclear Plant (SQN) - Unit 2 - Technical Specifications (TS) Change 03-06 - Change Inspection Scope for Steam Generator (SG) Tubes - Revised Request"

TVA submitted TS Change 03-06, Reference 1, to NRC by letter to revise the steam generator tube inspection portion of the Sequoyah Unit 2 technical specifications.

AP01

Subsequent discussions with NRC indicated that additional information regarding the proposed TS change was needed. Accordingly, the TS change request was revised and submitted to NRC as shown in Reference 2. This letter addresses the remaining questions that were not provided in Reference 2.

Enclosure 1 provides the responses to the remaining questions. The revised pages and figures are included in the revised Westinghouse letter Nos. LTR-CDME-04-147 and LTR-CDME-04-148, which are included in Enclosures 3 and 4.

Enclosure 2 provides the application for withholding and affidavits (CAW-04-1908) signed by Westinghouse, the owners of the information, as well as the proprietary information notice and copyright notices. The applications for withholding and the affidavits set forth the basis on which the information may be withheld from public disclosure by NRC and address the considerations listed in 10 CFR 2.390 (b)(4).

Accordingly, it is respectfully requested that the information that is proprietary to Westinghouse, (Enclosure 3), be withheld from public disclosure in accordance with 10 CFR 2.390.

Correspondence, with respect to the copyright or proprietary aspects of the subject reports or the supporting Westinghouse affidavits, should reference CAW-05-1955 and/or CAW-05-1956 and should be addressed to:

J. A. Gresham
Manager, Regulatory Compliance and Plant Licensing
Westinghouse Electric Company
LLC, P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355

There are no commitments contained in this letter. If you have any questions concerning this change, please contact me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 9th day of March, 2005.

Sincerely,

P. L Pace
Manager, Site Licensing
and Industry Affairs Manager

Enclosures
1. Response to Request for Additional Information (RAI), Technical Specification (TS) Change 03-06
2. Westinghouse Electric Company Application For Withholding and Affidavit, CAW-05-1956
3. Westinghouse Proprietary Class 2, Application of W* to Sequoyah Unit 2 Steam Generator Tubes, LTR-CDMW-04-148, Revision 1, February 2005
4. Westinghouse Non-Proprietary Class 3, Application of W* to Sequoyah Unit 2 Steam Generator Tubes, LTR-CDMW-04-147, Revision 1, February 2005

cc: See page 4

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ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 2
DOCKET NO. 328

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI)
TECHNICAL SPECIFICATION (TS) CHANGE 03-06

In review of TS Change 03-06, the NRC asked questions to complete its review of the application and responses to the questions are provided:

Question 1

Your current proposal involves modifying Technical Specification 4.4.5.2.e to require a "100 percent rotating coil probe inspection of the hot leg tubesheet W distance". Given the staff position in Generic Letter 2004-01, "Requirements for Steam Generator Tube Inspections," it is not clear why a specific probe (rotating coil probe) is being listed within the technical specifications. Although the proposal is very specific, it removes your flexibility in selecting appropriate probes and may result in using multiple probe types to examine the hot-leg tubesheet W* distance. For example, non-rotating probe technology (e.g., an array probe) could not be used to satisfy this technical specification. In addition, it would appear that under certain circumstances it may require use of multiple probes to examine this portion of the tube (e.g., in the event that a form of degradation occurring (or postulated to occur) in the tubesheet region within the W* distance is not reliably detectable with a rotating coil probe). Please clarify.*

Response 1

The reference to probe type was removed in the revised TS change request submitted on February 15, 2005.

Question 2

In your proposed technical specifications, you indicate that tubes with service induced degradation identified within the W distance shall be plugged on detection. However, your leakage model implies that only degradation below 8-inches from the top-of-the-tubesheet will be left in service. Given that the W* distance can be less than 8-inches (and therefore degradation between the inspection distance and 8-inches can be left in service), discuss your plans for modifying your technical specification proposal to* *be consistent with your proposed leakage model. For example, changes to the Plugging Limit and/or the Tube Inspection definitions may be needed.*

Response 2

The definition of W* distance in the technical specification (TS) has been changed to define the distance as 8″ below the top of the tubesheet or the distance defined in the WCAP, whichever is more conservative. The change was included in the revised TS change request submitted on February 15, 2005.

Question 3

Enclosure 5 of your submittal provides the leakage model to be applied in the tubesheet region. Enclosure 5 implies that the amendment request is for one cycle of operation (refer to Section 1.0). Similarly, Enclosure 1 (page E1-3) indicates that site specific data detailed in Enclosure 5 will be used for the first inspection in which these criteria are implemented. Given that you are requesting a permanent change to your technical specifications (rather than a one-cycle application), please provide the methodology to be used for projecting (a) the number of indications in the tubesheet region (between 8 and 12 inches below the top of the tubesheet) and (b) the amount of leakage from these indications for all future operating cycles with the currently installed steam generators.

Response 3

Westinghouse letter No. LTR-CDME-04-147 has been changed, see Enclosure 3 Section 1.0. This request is for a permanent amendment. Enclosure 1 has been modified by the revised TS change request submitted on February 15, 2005, to be clearer so that the methodology used for projections for the upcoming inspection will be used in the future unless it is proven to be nonconservative. Corrective actions will be discussed, as required by the revised TS change request, in the 90-day report if the projections are not conservative

Question 4

Please clarify the intent of the statement on page E1-5 that "... without the potential for tube burst, there is no need for the leak-before-burst leakage limit." The staff notes that the operational leakage limit (1) does not ensure a tube will leak before it breaks (however, it does provide some defense-in-depth), and (2) limits the radiological dose to the public and plant operating personnel. The staff is aware that tube burst will not *occur as a result of defects located a certain distance below the top of the tubesheet TTS; however, it is not clear that excessive leakage could be tolerated from these defects while still meeting radiological dose limits.*

Response 4

The statement on E1-5 has been changed and is included in the revised TS change request submitted on February 15, 2005, to state that the current 150 gallons per day operational leakage limit is not affected.

Question 5

In Note 2 on page 3/4-14a of your technical specifications, there is a reference to GL 90-05. Should this be referring to GL 95-05?

Response 5

This was a typographical error from an earlier submittal that has been corrected in the revised TS change request submitted on February 15, 2005.

Question 6

Please discuss your plans to modify your technical specifications to include the following information relative to implementation of the W criteria in your 90-day report: the number of indications, the location of the indications (relative to the bottom of the WEXTEX transition (BWT) and TTS), the orientation (axial, circumferential, skewed, volumetric), the severity of each indication (e.g., near through-wall or not through-wall), the side of the tube from which the indication initiated (inside or outside diameter), and an assessment of whether the results were consistent with expectations with respect to the number of flaws and flaw severity (and if not consistent, a description of the proposed corrective action).*

In addition, discuss your plans to provide in the report the cumulative number of indications detected in the tubesheet region as a function of elevation within the tubesheet (e.g., 12 indications at the expansion transition or TTS, 6 indications within 1 inch of TTS, 4 indications from 1 inch to 2 inches below the TTS, etc.).

Please discuss your plans to supply in the report the amount of leakage from each source (e.g., W alternate repair criteria) in addition to the aggregate amount from all sources.*

Response 6

The requested information is included in the requirements for reporting in the TS 4.4.5.5.e. in the revised TS change request submitted on February 15, 2005.

Question 7

On page 5 of 61 in Enclosure 5, the accident induced leakage rate limit is quoted as being 0.1 gallons per minute (gpm) at a temperature of 600 degrees F. Please clarify the basis for these values. For example, is the 0.1 gpm based on the plant-specific design basis, a typographical error, or an administrative limit?

Response 7

Page 5 of the Westinghouse letter No. LTR-CDME-04-147 included unnecessary information that has been deleted, including the discussion of the leakage limit. See page 4 of Enclosure 3 for the revised discussion.

Question 8

Please confirm that the steam generator tubesheet bore roughness used to develop WCAP-14797 is applicable to the Sequoyah Unit 2 tubesheet holes.

Response 8

The WCAP was developed to be generic to all Model 51 SGs with WEXTEX expansions. The WCAP is applicable to SQN Unit 2 tubesheet holes.

Question 9

Given the potential long-term application of this amendment, please discuss what controls will be placed on primary temperature and steam generator secondary side pressure to ensure that it stays within the bounds of (or remains conservative with respect to) the generic analysis. For example, if the steam pressure is greater than that assumed in the generic analysis, the pressure tightening effect will be less. Similarly, if the steam pressure is lower than that assumed in the generic analysis, the amount of tubesheet bow would be affected.

Response 9

As discussed in Section 3.2 of Enclosure 5 of the December 2, 2004, submittal, the generic analysis is based on a limiting minimum reactor coolant system full power hot leg temperature of 590 degrees F for evaluation of thermal tightening effects, a maximum full power secondary side steam pressure of 900 psia for evaluation of pressure tightening effects, and a minimum full power steam pressure of 760 psia for evaluation of tubesheet bow effects. As part of the implementation of the proposed TS change, these limits will be added to the plant licensing and design basis for the Model 51 SGs. Any subsequent design or operating changes which have the potential to alter the full power primary system temperature or full power secondary side steam pressure will be reviewed for compliance with these limits as part of the plant design change process.

Design studies performed by TVA have established that reactor coolant system hot leg temperature reductions lower than 600 degrees F will not support the current full power output rating without a nuclear steam supply system power uprate. Similarly, studies of full power steam generator performance for the current nuclear steam supply system rating have established a best estimate Model 51 maximum operating pressure of 855 psia (assuming a 6 percent tube plugging level) and a minimum operating pressure of 795 psia (assuming the maximum design basis 15 percent tube plugging). Given the amount of margin between these values and the limits established by the generic analysis and the fact that significant plant modifications (performed in accordance with the plant modification process) are required to challenge the limits, no additional controls on primary system temperature and secondary system pressure are required.

Question 10

On page 11 of 61 of Enclosure 5, it was indicated that 3 circumferential indications were reported at the end of cycle (EOC) 8 in 1997. This value does not match that in Table 5-1 on page 29 of 61. Please verify the correct value and provide any update to the number of projected indications at the EOC13 (2005). Please confirm the end date for U2C12 (Table 5-1 indicates 2002 whereas the text on page 12 indicates it ended in 2003).

Response 10

The information on page 11 is correct. There were three circumferential indications reported at the EOC-8. The table on page 30 has been corrected to include two additional circumferential indications, one in SG No.1 and one in SG No. 2. The indications that were included on the table were indications that had available sizing information. The data in Table 5-2 is the sizing information from past inspections. Two of the circumferential indications identified in 1997 were not sized. This change does not affect the projections. Table 5-2 also had an incorrect date referenced for U2C12. The table has been corrected to refer to 2003. See Enclosure 3, page 30 for the revised table.

Question 11

Many of the plots and tables refer to primary water stress corrosion cracking (PWSCC) indications. Please confirm that no outside diameter stress corrosion cracking (ODSCC) has occurred below the top of the tubesheet. If ODSCC has been detected below the top of the tubesheet, please discuss why it was not included in your analyses.

Response 11

There has been no ODSCC detected within the tubesheet on SQN Unit 2.

Question 12

The projected number of new indications for EOC 13 appears to be based on a mean regression curve. Please discuss the basis for using the mean regression curve rather than a conservative (e.g., 95% prediction interval) regression curve for determining the number of new indications expected to be identified during the inspection.

Response 12

The projection of the number of indications was modeled using the same methodology as employed for projecting the number of indications in the Beaver Valley SGs. Long-term tracking of indication totals for PWSCC mechanisms shows the mechanism to be much more predictable than ODSCC mechanisms. The most recent inspection results at a similar plant, performed earlier in 2005, exhibited a PWSCC indication tally well below the value predicted by the mean regression.

The PWSCC initiation distribution as a function of elevation below the top of the tubesheet (TTS) is similar for currently operating Model 51 SGs. The trend shows that there is a reduced initiation frequency at lower elevations below the top of the tubesheet. Residual stresses in explosive and hydraulically expanded tubesheet conditions are expected to be compressive in the hoop direction, thus tensile residual stresses which act as the initiation sites must be associated with an external source, such as a drilling anomaly. Since the tubesheets are drilled from the primary face towards the secondary face, the frequency of drilling anomalies could be expected to increase as the secondary face of the tubesheet is approached based on fabrication considerations. Thus, the initiation frequency can be expected to be related to elevation below the TTS, decreasing with depth in accord with the field observations. The developed methodology uses a fit to this data to estimate the number of indications at any particular elevation below TTS.

Since the tensile residual stresses that act to initiate indications are believed to result from manufacturing variations, increasing operating length exposure would not be expected to result in a steadily increasing number of indications, such as is often observed with ODSCC mechanisms where secondary side environment may be the main contributing factor upon initiation. In other words, the number of initiation sites is expected to be finite. Penetration through wall would also be self limiting due to the level of tensile residual stress. Thus, it is reasonable to conclude that the number of tube indications that could develop within the 8 to 12 inch TTS range below the TTS would not vary significantly with time and that only a small percentage of these indications would develop to a 100-percent throughwall (TW) condition. The applied methodology assumes that the number of tube indications within 8- to 12-inch range below the TTS is related to the total observed population, thus increases to the total indication count due to initiation in high stress areas such as the TTS expansion transition result in an increase in the assumed initiation population between 8 and 12 inches below the TTS. The leakage methodology assumes all initiated indications are represented by a 100-percent TW, 360 degree circumferential separation of the tube. In conclusion, the methodology is conservative.

Question 13

In determining the leak rate assigned to degradation located between 8 and 12 inches within the tubesheet region, an average contact pressure was used to relate the test conditions to the field conditions. It was indicated that there are many conservatisms in the analyses and therefore the leak rate being *used is acceptable. In addition, an assessment that correlates the leak rate to both the crevice length and the contact pressure (presumably the average contact pressure) indicates that the leak rate should be low. In a previous review, the staff questioned whether it was appropriate to use the average or maximum contact pressure in assessing leakage from this region. The staff agrees that many of the assumptions in the analyses are conservative; however, it is difficult for the staff to quantitatively conclude that these conservatisms will ensure that the leak rate applied to degradation between 8 and 12 inches below the top of the tubesheet is conservative.*

As a result, please discuss whether there is any quantitative information to support the conservatism in the leakage value applied to degradation in the 8 to 12 inch range. For example, can a quantitative argument be provided that assesses the effect of consistently accounting for the secondary side pressure in determining the maximum and average contact pressure in the test and in the field (since for the field, a crevice pressure of 800 psi was assumed while for the test, no crevice pressure was assumed)? Additionally, discuss any insights into the relative roles of maximum contact pressure and average contact pressure on the leak rate.

Please clarify the statement on page 16 of 61 which indicates that with assumed secondary side pressures within the crevice, the contact pressures for the 3 inch nominal specimens could be as low as 1514 pounds per square inch (psi). In particular, please clarify what assumptions are made such that the contact pressure varies and discuss the effects of varying these assumptions on the contact pressure.

Please discuss where the neutral plane of the tubesheet is for Sequoyah Unit 2 (i.e., the point at which the tubesheet hole no longer dilates due to tubesheet bow).

Response 13

(A) The bounding model employed for application at SQN is based on considering only the data obtained from the tube-to-tubesheet interface (TTIF) tests, a.k.a. crevice tests, reported in WCAP-14797. Application of this model ignores any resistance to flow through the actual crack, i.e., the tube is considered to be severed and the ends separated. Data from another type of tests were also reported in WCAP-14797. Those tests consisted of testing axial cracks in constraining collars wherein the tip of the crack was aligned with a circumferential groove within the collar, in effect, simulating aligning the crack with the top of the collar. Thus, an alternate bounding model using the constrained crack data could be developed using only the constrained crack data and ignoring the resistance of the TTIF. Such an analysis was performed in response to NRC RAIs with regard to the application of W* at another plant. The results of the analysis of those data indicate that the leak rate from specimens with a TTIF length of 0.6 inch is comparable to that from the constrained axial cracks for similar contact pressures, e.g., about 2000 psi including the residual from the installation of the tube in the tubesheet and 1300 psi without considering the residual contact pressure. Moreover, the leak rate from specimens with a TTIF length of 1.3 inches is comparable to that from constrained axial cracks for contact pressures in the range of 2700 psi. This means that the resistance of short crevices is similar to that of short cracks. The axial cracks tested were on the order of 0.33 to 0.6 inch long. The simulated length of the circumferential crack in the crevice tests was 2.8 inches. Given the constraints provided by the tubesheet to radial deflection and crack opening displacement, the flow area of axial and circumferential cracks would not be expected to be radically different. The implication is that a relatively short crevice provides significantly more resistance to flow than the crack itself. However, conservatively considering them to be comparable and ignoring the fact that the length of the crevice in the tubesheet is significantly greater than that actually tested, leads to the conclusion that the leak rate from the crevice test model is at least a factor of two greater than would be obtained if actual cracks were tested in series with the crevice.

(B) This part of the RAI is assumed to be the result of a concern previously expressed by the staff associated with the use of the average contact pressure over the crevice length as opposed to the maximum contact pressure over a short length. The purpose of this discussion is to present a development of the physical model of the interface. There is no true crevice between the tube and the tubesheet. The true interface is an interference fit between two microscopically rough surfaces, the OD of the tube being less rough than the ID of the tubesheet hole. The interface pressure is concentrated at those locations where there is actual material contact and the flow is through those areas where there is not material contact. The leak path consists of the torturous route between mating peaks. Testing has demonstrated that water can be forced between the mating tube and tubesheet surfaces when the internal pressure is less than the contact pressure from the interference fit; hence, there must be a path for the flow when the net contact pressure is greater than zero. In order for flow to occur, a finite area flow path must exist between the outside surface of the tube and the inside surface of the tubesheet.

Both the tube and tubesheet can be characterized as having rough surfaces on a microscopic scale with the OD of the tube being much smoother than that of the ID of the tubesheet hole. The physical nature must be that of two rough surfaces being pressed together so that 100 percent intimate material contact does not occur until unusually high contact pressures are reached. The leak path is then between irregular mating of the surface asperities. If the tube and tubesheet surfaces were perfectly smooth and in intimate contact, there could be no flow through the interface because there would be no flow area. This would be true even in the event that the pressure internal to the tube was greater than the contact pressure. For example, flat rubber stoppers in open drains effectively prevent flow simply due to the weight of the water pressing on the upper surface. Leakage is prevented because the material of the stopper comes into intimate contact with the material of the sink and the rubber deforms to fill any superficial irregularities. When the smooth tube is forced into contact with the rougher tubesheet, the tube material does not flow to fill the gaps between asperities. This physical model explains the leakage phenomenon and is why the Darcy model for the flow was selected initially to quantify the calculation of the leak rate. Because there is an inhomogeneous physical interface between the tube and the tubesheet that is in contact, it is to be expected that there would be a meaningful relationship between the resistance to flow and the contact pressure. Consideration of the effect of the geometry of the interface leads to the expectation of a nonlinear microscopic deformation behavior that could be described using a logarithmic scale. The force needed to close off the crevice gaps would be expected to increase disproportionately and the resulting relationship on a logarithmic scale could be weak. That is, as the contact pressure increases, the resistance to further deformation at the interface also increases at the same time as the reduction in flow area decreases. Such a relationship was observed in plotting the loss coefficient against the contact pressure in WCAP-14797. Hence, the model implies that the resistance to flow would be significant over the length of the leak path and not be limited by any limited extent location of maximum contact pressure.

Moreover, there are outcomes that would be expected if the maximum contact pressure was the dominant factor in determining the magnitude of the resistance to flow. Specifically, the frequency of occurrence of maxima of the contact pressure would be expected to increase with an increase in length of the joint. For example, the frequency of occurrence of a local contact pressure matching the maximum over a specified length of joint would be expected to double on average if the joint length doubled. This means that the resistance to leakage would still be expected to be significantly dependent on the total length of the joint, a phenomenon which is evident from the test data. Thus, consideration of either scenario leads to a similar conclusion with regard to overall contact length.

(C) The calculation of contact pressures for the SG tubes assumed that a secondary pressure of 800 psia was present in the tube to tubesheet crevice. This reduces the overall or average contact pressure calculated for the SG tubes. The overall or average contact pressure of the leak test specimens was calculated assuming that no secondary pressure is present in the crevice; thus, the calculated contact pressures for the leakage samples are conservative for observed leakage.

The selection of a specific set of leakage data, i.e., the 1.25-, 2-, or 3-inch nominal crevice length specimens, to an elevation region of the tube in tubesheet was accomplished by matching the SG tube contact pressure (with the assumed crevice pressure) to the leakage specimen contact pressure (with no assumed crevice pressure). In other words, a region in the tubesheet with a higher contact pressure was associated with the leak rate from a specimen with a lower contact pressure. The upper end of the tube in tubesheet region was used to select the set of leakage data. As the contact pressure increases with increasing depth below the top of tubesheet, additional conservatism is provided for the leak rate associated with postulated indications that approach the lower end of the tube in tubesheet. Furthermore, the SG tube contact pressure used for selection of a set of leakage data was based upon the tube in the SG with the most severe tubesheet hole dilation associated with tubesheet bow. With increasing tube location radius based on the center of the SG, the contact pressure as a function of depth below top of tubesheet is increased.

The value of 1514 psi sited in the RAI was to illustrate the impact of an assumed crevice pressure on the leakage specimen contact pressure.

(D) The neutral plane in the tubesheet would be at the center of the tubesheet if the rim were simply supported and only bending stresses were present, i.e., an imposed moment on the rim. The tubesheet is actually supported on its periphery by the thicker part of the tubesheet forging and the attached cylindrical shell and channel head. In addition, the loading is due to the primary to secondary differential pressure. This means that in addition to pressure-induced bending stress, tensile toward the top of the tubesheet, a radial membrane stress is also developed. The addition of the membrane stress counters the compressive stress that would be developed below the centroid of the tubesheet if no membrane stress was present and shifts the location where the radial stress is zero toward the bottom of the tubesheet. The amount of the shift depends on primary to secondary differential pressure, the radial distance from the center of the tubesheet because the forging, etc., restrains rotation at the periphery. The tubesheet is 21.03-inches thick with a 0.15- to 0.25-inch thick layer of cladding on the bottom side. The net thickness is then about 21.2 to 21.3 inches. Without the membrane stress, the neutral plane would be at a distance of 10.515 inches below the top of the tubesheet. When the tubesheet is loaded, the neutral plane appears to be about 11 inches below the top of the tubesheet. This is based on visual examination of finite element analysis plots and is not based on a detailed examination of the analysis output.

Question 14

On page 16 of 61, there is a statement that at approximately 9.1 inches below the top of the tubesheet, the resultant radial contact pressure is 2500 psi. Please clarify this statement since it does not appear to match Figure 4.7. Is this apparent discrepancy because the WEXTEX expansion contact pressures are not included in the plot or because a different time during the transient was assumed (i.e., not 4200 seconds into the transient).

Response 14

The staff observation is correct. The value of 2500 psi includes the residual contact pressure of 693 psi and the information plotted on the figure does not include the residual contact pressure. The text on page 16 has been revised. See Enclosure 3.

Question 15

On page 16 of 61, it was indicated that for the 1.25 inch nominal crevice test case, an actual crevice length of 0.6-inch was provided. It was further indicated that the corresponding tube would have a crevice of 5.3 inches with positive contact pressure for 3.5 inches. Please clarify how these latter values were determined (i.e., are these values evident from Figure 4.7?).

Response 15

The figure has been changed to Figure 4.8 and the text on page 16 has been corrected. See Enclosure 3.

Question 16

Please clarify whether a leakage value of $4.5x10^{-3}$ or $4.6x10^{-3}$ will be used in assessing leakage for indications between 8 and 12 inches below the TTS (refer to pages 15 and 16 of 61).

Response 16

The value of $4.5x10^{-3}$ is correct. The value of $4.6x10^{-3}$ is a typographical error. The former value was and will be used in the calculations, and the enclosure has been corrected. See Enclosure 3, pages 15, 16, and 17 for the corrected information.

Question 17

Please clarify how the last 2 values in Section 4.3 of Enclosure 5 were determined (refer to page 19 of 61). These values do not appear to match those in Figure 4.7 (the 2nd figure 4.7).

Response 17

The values being referred to are in the sentence that reads the "calculated median leak rate per tube used with the assumption all of the tubes in the SG are severed is reduced from, $5x10^{-6}$ to $6.1x10^{-8}$ gpm per tube." An examination of Figure 4.8, actually labeled as a second Figure 4.7, reveals that the value of $5x10^{-6}$ was read at a depth of 2.2 instead of 2.3 inches. The correct number is $4x10^{-6}$ gpm. The value of $6.1x10^{-8}$ gpm was read from the curve corresponding to the nominal engagement length of 3 inches instead of the actual engagement length of 2.3 inches. The correct number, as read from the curve, is about $4.3x10^{-7}$ gpm. The inclusion of the sentence in the original discussion was based on reading the values from the figure and was intended only to further illustrate the reduction in leak rate that is to be expected by increasing the complexity of the model. In this case, the true reduction in the median leak rate for a contact length of 2.3 inches is a factor of 9.3 or almost an order of magnitude. The enclosure has been corrected to ensure this is clear. See Enclosure 3, page 19 for the corrected information.

Question 18

The results of the W leak rate testing do not appear to be consistent with leak rate tests performed on other explosively expanded joints (i.e., Combustion Engineering (CE) explosively expanded joints). For example, the WEXTEX testing indicated that at elevated temperatures changing from normal operating to steam line break differential pressures yields an essentially constant leak rate whereas the leak rate tests for the CE joints yields a leak rate which increases with differential pressure. In addition, the WEXTEX testing indicated that elevated temperature leak rates were approximately 100 times less than room temperature leak rates; however, this trend does not appear to be what was observed in the testing of the CE joints. Please discuss any insights on the differences in the behavior of the joint types (e.g., effects of different test setups, etc.).*

Response 18

There are two approaches to the evaluation of the question.

1) Expectation Considerations

The fact that Westinghouse Model 51 SGs and Combustion Engineering (CE) SGs used an explosive tube expansion process does not imply that performance of the two joints should be consistent. The following table presents a listing of the differences between the two designs and the associated specimen configurations. It may be that the CE explansion process results in an expanded tube condition that is meaningfully different from the WEXTEX expansion. The increased tube stiffness could prevent the tube from "flowing" or deforming according to the limitations of the tubesheet hole ID during the forming process. Elevated temperature pull force testing for the WEXTEX expansions shows the axial load capacity for a 2-inch expansion is about three times the room temperature axial load capacity (760 lb_f room temperature vs. 2000 lb_f at 600 degrees F). The explansion elevated temperature pull force testing results are about 50 percent greater than the room temperature results. Both designs use a similar tubesheet bore roughness. However, analysis of the relative stiffness of the joints results in similar changes in contact pressure from ambient to elevated temperature conditions, i.e., at SLB conditions the increases in contact pressure are 2480 and 2515 psi for the CE and Westinghouse assemblies, respectively.

The Model 51 tubesheet is significantly radially stiffer than the CE tubesheet, but the CE tube is stiffer than the Model 51 tube. The interface pressure increases by about 1 psi/°F for the Model 51 assembly and 1.2 psi/degree F for the CE assembly. Increasing the pressure in the tube results in about 75 percent and 70 percent of the pressure being transmitted to the interface for the Model 51 and CE assemblies respectively. In summary, while fabrication difference may be speculated to lead to meaningful changes in the leak rate as a function of temperature, the contact pressure changes do not lead to a strength of materials explanation.

Comparison of Westinghouse and CE Tube-to-Tubesheet Joints			
Parameter	Model 51	CE	Comment
Tube OD	0.875 inch	0.750 inch	CE tube is more stiff in radial direction
Tube Wall Thickness	0.050 inch	0.048 inch	
Tube R/t Ratio	8.25	7.31	
Test Collar OD	2.25 inch	1.63 inch	CE tubesheet is less stiff in the radial direction.

2) Potential Phenomenological Considerations

A result from the linear regression analyses in which the pressure is added as a variable to the analysis of the logarithm of the leak rate on the length of the joint is that the dependence on the driving pressure is small. Thus, it is possible that the difference is due to a change in the location within the joint where the leakage flashes to steam. Westinghouse has learned that the WEXTEX samples appear to provide higher contact pressures than the C* samples. One could infer from this that the pressure drop through the WEXTEX joint is greater because of a smaller net crevice cross section area, admitting the possibility the leakage is flashing to steam within the WEXTEX joint and developing choked flow within the joint. If choked flow is developed within the joint, increasing the pressure differential does not lead to an increase in mass flow. Hence, it might seem that the leak rate would be independent of pressure differential because the pressure differential that is reported for W* is the difference between the primary side and the secondary side of the sample; but the true pressure differential for W* is that between the primary side pressure and the saturation pressure of the choked flow.

Another potential effect could be that the effective diameter of the crevice leak path is smaller in the W* specimens than in the C* specimens. This would be in concert with the observation that the installed contact pressures appeared to be greater. This means that the relative decrease in effective diameter could be bigger in the W* specimens as the result of an increase in the contact pressure with temperature. For example, suppose the as-installed WEXTEX sample joint had a leakage path with an effective diameter of 105 angstroms and the C* samples were 200 angstroms. The C* and W* samples used the same materials. Suppose that differential thermal expansion at elevated temperature reduces the effective diameter of the leak path by 100 angstroms. At elevated temperatures, C* would then be 100 angstroms (a factor of 2 from room temperature) and W* would be 5 angstroms (a factor of 20 from room temperature). Since the Poiseuille equation applies, the flow rate is proportional to the square of the diameter of the effective flow path and the reduction in flow for the W* specimens would be a factor of 100 more than the reduction for the C* specimens for the example conditions.

Although neither discussion leads to an explanation for the observed differences, there should be no bearing on the evidence from the test data for the Model 51 SG tubes. The data from the crevice and the constrained crack tests are consistent.

<u>Question 19</u>

Even though indications within the W distance will be plugged on detection, it is likely that indications below the threshold of detection will be missed or new indications will develop during the course of an operating cycle. Depending on the severity of these indications, they may affect the structural and leakage integrity of the steam generator. On page 53 of 61, there is a discussion that if axial degradation was observed within the W* distance and was judged to be 100% through-wall, then the accident induced leakage assessment would account for these indications. Based on the text on page 53, it was not clear whether Sequoyah 2 planned on performing this assessment. Please discuss your plans for assessing the amount of leakage from axial or circumferential flaws that are judged to contain 100% through-wall penetration within the W* distance in both your condition monitoring and operational assessment. In addition, please discuss whether these "new" indications could affect the pullout resistance of the tube (since these new indications are within the W* distance) or alternatively discuss your plans for assessing the effect of these indications on the pullout resistance (including the supporting database for this assessment).*

Response 19

The original discussion in the SQN submittal was based on experiences with the SG tubes at another plant site. That plant did not have any severe new indications. The discussion on page 53 of the submittal also included consideration of the length of the indications and pointed out the limited magnitudes associated with the cumulative population of indications. The indications are believed to initiate at locations where there are anomalies in the tube surface, which led to points of high residual stress and that the residual stress field is of limited extent. Thus, significant growth is only expected in the rarest of instances. There have been no observed indication large growth values found in the W* indication population. If newly initiated severe indications of cracking are found, an assessment of their potential leak rate for the condition monitoring report must be performed, along with an analysis of the impact of potential future indications in the operational assessment and in the degradation assessment preceding the next inspection. Based on the experiences at a plant implementing the full W* criteria, the likelihood of new indications affecting the leak rate or pullout resistance is small. Therefore, plant procedures will require an assessment to be performed at SQN if newly initiated severe indications of cracking are identified.

Question 20

On page 54 of 61 (Section 5.3.8), it was indicated that taking into account the actual pressure and temperature conditions during the steam line break transient that the contact pressures in the field would be greater than the contact pressures present in the laboratory specimens used in the determination of the leak rates (based on comparing the field contact pressure to the "average" contact pressure for the laboratory specimens). Ignoring the effects of contact pressure, the leakage through a flaw changes with temperature as a result of such variables as water density and viscosity. Given the complex situation in a tubesheet joint where the temperature can change the leak rate by affecting the joint tightness as well as other variables such as the liquid density, please discuss what effect lowering the temperature would have on the leak rate if the contact pressures remained the same. In other words, given equal joint contact pressures but different primary water temperatures, would identical leak rates be expected?

Response 20

During the oral discussion of the comments with the staff, it was requested that the long-term behavior of the event also be described. The steam line break (SLB) event is a rapid cooldown event. During the blowdown of the secondary side of the SG, the reactor coolant system (RCS) fluid rapidly reduces in temperature. This cooldown causes a primary pressure reduction of the RCS because of the contraction of the primary fluid. The long-term response of the plant to a postulated SLB event would be expected to result in a recovery of RCS temperatures to near 600 degrees F. This is due to residual heat within the core and RCS components and RCS pressure approaching the pressurizer safety value setpoint of 2575 psia. Short-term effects of reduced RCS temperature would be compensated by the reduced RCS pressure and a conservative assumption of: the number of degraded tubes, the degradation circumferential extent, and the degradation progression through wall. This assumption is contrary to the intent of the Emergency Operating Procedures, which is to cool and depressurize the RCS as rapidly as possible.

Lowering the temperature of the fluid, while keeping the contact pressure constant, increases both the viscosity and the density on the fluid. The Darcy equation describes volumetric flow as does the test data. Thus, the same volume at the lower temperature would have a greater density and hence more mass and would occupy more volume when cooled to ambient conditions. The leak rate data presented in WCAP-14797 are in units of gpm at ambient conditions, i.e., at 70 degrees F the density is 62.3 lb/ft^3.

The volumetric flow of fluid through a crevice is directly proportional to the inverse of the viscosity of the fluid. For the same pressure conditions, the viscosity increases approximately linearly by 143 percent in going from 610 to 460 degrees F (using the fourth edition of the ASME steam tables). At the same time, the density of water increases by 122 percent. Under these conditions, the volume of water collected over time and cooled to 70 degrees F would be expected to decrease because the resistance to flow is increasing faster than the density. Such conditions could not be expected to occur in the SG.

ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 2

WESTINGHOUSE ELECTRIC COMPANY
APPLICATION FOR WITHHOLDING AND AFFIDAVIT
(CAW-05-1956)

Westinghouse

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Our ref: CAW-05-1956

February 17, 2005

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-CDME-04-147, Rev. 1, "Application of W* Alternate Repair Criteria to Sequoyah Unit 2" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-05-1956 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 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by Tennessee Valley Authority.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-05-1956, and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Enclosures

cc: B. Benney
L. Feizollahi

bcc: J. A. Gresham (ECE 4-7A) 1L
R. Bastien, 1L (Nivelles, Belgium)
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RCPL Administrative Aide (ECE 4-7A) 1L, 1A (letter and affidavit only)
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R. F. Keating, Waltz Mill
W. K. Cullen, Waltz Mill
L. A. Nelson, Waltz Mill

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared J. A. Gresham, 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:

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Sworn to and subscribed
before me this 17th day
of February, 2005

Sharon L. Fiori
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 Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 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 Westinghouse 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 2.390 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 2.390, 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-CDME-04-147, Revision 1, "Application of W* Alternate Repair Criteria to Sequoyah Unit 2" (Proprietary) dated February 17, 2005. The information is provided in support of a submittal to the Commission, being transmitted by Tennessee Valley Authority letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted for use by Westinghouse for Sequoyah Unit 2 is expected to be applicable for other licensee submittals in support of implementing the W* inspection methodology addressing service induced degradation in the tube joint region of steam generators.

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

(a) Provide documentation of the analyses, methods, and testing for the implementation of the W* tube inspection methodology.

(b) Provide evaluation of the required W* engagement lengths for Sequoyah Unit 2.

(c) Provide a bounding W* potential steam line break leakage evaluation for Sequoyah Unit 2.

(d) Assist the customer to respond to NRC requests for information.

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 2.390 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 2.390(b)(1).

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