TVA

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March 2, 2000

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

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

SEQUOYAH NUCLEAR PLANT (SQN) - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING TOPICAL REPORT WCAP-15128, "DEPTH-BASED SG TUBE REPAIR CRITERIA FOR AXIAL PWSCC AT DENTED TSP INTERSECTIONS"

References:

1. NRC letter to TVA dated February 2, 2000, "Sequoyah Nuclear Plant, Units 1 and 2 - Request for Additional Information on Topical Report WCAP-15128, 'Depth-Based SG Tube Repair Criteria for Axial PWSCC at Dented TSP Intersections' (TAC Nos. MA6434, MA7895, and MA7899)"

2. TVA letter to NRC dated February 24, 2000, "Sequoyah Nuclear Plant (SQN) - Westinghouse Electric Company Topical Report WCAP-15128, Revision 2"

3. TVA letter to NRC dated February 23, 2000, "Sequoyah Nuclear Plant, Units 1 and 2 - Clarification of Technical Specification (TS) Change No. 99-12, 'Alternate Repair Criteria (ARC) for Steam Generators (S/G)'"

Enclosure 1 to this letter provides the additional information requested by Reference 1. A revised Topical Report (WCAP-15128, Revision 2 [Reference 2]) and TS Change 99-12 (Reference 3) have been provided under separate letters to support responses to the RAI questions.

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An additional telephone conversation with NRC on February 25 and 28, 2000, illustrated a need to further clarify the WCAP. This clarification has been provided in Enclosure 2. We currently plan to issue Revision 3 to WCAP-15128 which will incorporate only these clarifications.

In addition, as requested by NRC during a February 9, 2000 meeting on this subject, Enclosure 3 provides our commitment to pull a tube which meets the leakage criteria in WCAP-15128.

Enclosure 4 provides revised clean technical specification pages. They reflect the additional constraints of the proposed license amendment (Reference 3).

Please direct questions concerning this issue to me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

Sincerely,

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ENCLOSURE 1

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
REGARDING WCAP-15128, "DEPTH-BASED SG TUBE REPAIR CRITERIA FOR AXIAL PWSCC AT DENTED TSP INTERSECTIONS"
SEQUOYAH NUCLEAR PLANT (SQN)

Background

By letter dated February 2, 2000, NRC requested additional information to support staff review of Westinghouse Electric Company Topical Report WCAP-15128, Revision 2. This topical report provides the basis for TVA Technical Specification (TS) Change 99-12 for SQN. The following information is provided in response to the staff's questions:

CHAPTER 3.0 PULLED TUBE AND LABORATORY SPECIMEN DATABASE

NRC Request

1. Discuss how you treated the uncertainties associated with the destructive examination measurements.

TVA Response

The destructive exam reports do not include uncertainties in the measurements and the measurement uncertainties are not directly used in the evaluations. Equipment used in the laboratory for pulled tube examinations is required to have updated certifications and calibrations. Determination of the uncertainties would require a significant increase in the scope of the exam while the uncertainties that can be well defined, such as instrument and measurement error, are negligibly small. Burst tests of identical specimens will vary by a few hundred pounds per square inch (psi) from unknown causes. The principal review of a burst test is to review the crack opening to determine if significant crack extension has occurred to assure that the test is a complete burst. Leak tests can vary by up to about 20 percent over time in a single test and between repeat tests at the same pressure. Because the measurement error in the burst pressures and leak rates are not explicitly accounted for during the destructive examination, the effects are implicitly accounted for in the burst and leak rate correlations. The net effect is an increase in the standard deviation of the residuals, thereby reducing the calculated burst pressures and leak rates for values below the mean prediction of the regression equation.

Measurements of crack depths are expected to be within a few mils with the principal variables for a burst crack face being corrections for thinning due to plastic deformation and whether or not the photography is perpendicular to the crack face. This error would be expected to randomly oscillate plus and minus from point to point along the profile. On average, this should result in a net elimination of the effect of the destructive exam error. Overall, the uncertainties are generally small for the applications to tube integrity, and are not adequately defined to treat the uncertainties with adequate confidence in the uncertainty values.

NRC Request

2. The tube pulls from Diablo Canyon Power Plant (DCPP) and SQN were included in the development of the nondestructive examination (NDE) techniques that you will apply in the implementation of this alternate repair criteria (ARC). Discuss the availability of tube pulls from other plants to supplement your database. Discuss the limitations of these NDE techniques if applied to a plant other than DCPP or SQN.

TVA Response

The requirements to include pulled tubes in the NDE development were that the field data include plus point coil measurements and that the destructive examination include determination of the depth profile for the burst crack face. None of the older tube exams for axial primary water stress corrosion cracking (PWSCC) at dented tube support plate (TSP) intersections in plants such as Surry and North Anna included these requirements and could not be used in this program. There are no recently pulled tubes for PWSCC that met these requirements other than DCPP. SQN has pulled a tube for PWSCC; however, it was not included in the correlation because no plus point data was collected. SQN will commit to pull an intersection with PWSCC during the outage with a scheduled tube pull for outer diameter stress corrosion cracking (ODSCC) if an indication is identified during the inspection that meets the criteria identified in the WCAP.

The crack morphology for axial PWSCC at dented TSP intersections is relatively simple compared to other degradation mechanisms such as ODSCC at TSP intersections.

The dented TSP morphology consists predominantly as one or two dominant cracks, and when two cracks exist, the cracks are 180° apart at the minor axes of an ovalized tube. Secondary cracks are a few minor microcracks close and parallel to the dominant crack. Given the well defined crack morphology for axial PWSCC, the NDE techniques can be expected to be applicable to any plant with dented TSP intersections. However, at this time, the application of the ARC for dented TSP intersections is expected to be limited to the SQN and DCPP steam generators (SGs).

NRC Request

3. The database of pulled tube specimens and laboratory specimens used for the NDE qualification effort is scattered amongst nine tables, each of which provides different and often extraneous information about the specimens. This inhibits our review of the database upon which you developed your NDE techniques. To facilitate our review, provide one table that contains every specimen used in the development of the bobbin and plus point NDE techniques. Include in the table the specimen identification, how the specimen was used (i.e., for training, for Appendix H qualification, for performance testing), provide destructive examination data (i.e., length, maximum depth, average depth), dent voltage, burst pressure (if available), and leak rate (if available).

TVA Response

A table including the requested information has been included in new Section 3.6 of the Revision 2 report.

CHAPTER 4.0 NDE DEVELOPMENT

NRC Request

1. The probability of detection developed for the bobbin technique applied for detection of PWSCC at TSPs may be overly optimistic and not truly representative because of the very high overcall rate. The staff believes this aspect of the NDE is extremely demanding of the bobbin coil technique for this application. The limitations of this technique can be minimized if analysts continue to call very conservatively in the field. Discuss how this can be ensured. Discuss also what technique modifications you plan to pursue to improve the detection capability of the bobbin coil probe.

TVA Response

All site analysts are trained on the bobbin detection techniques prior to each inspection. This training includes specific examples of the flaw signal characteristics expected to be called for additional plus point inspections. Emphasis in the training is placed on making conservative calls and identifying signals as a potential indication if in doubt. The field analysts are tested on the bobbin detection techniques as part of the Site Specific Performance Test to demonstrate their understanding of the calling criteria. The field analyst training is consistent with that given to the analysts participating in the NDE Performance Test and is expected to result in field analyst probability of detections (PODs) consistent with that obtained from the performance test.

At this time, there are no programs in place to improve the detection capability of the bobbin coil probe. The bobbin inspection has been conservatively limited to small dents of ≤ 2 volts although the data support detection to higher dent voltages. The specimens with < 5-volt dents utilized in the NDE Performance Test (Table 4-4) included 8 specimens with dents between 2 and 3 volts, 3 specimens between 3 and 4 volts, and 2 specimens between 4 and 5 volts. All indications in these dents were detected. The indications not detected had dents < 2 volts (3 out of 21 indications in < 2-volt dents not detected by at least one team) and flaws with < 30 percent average depth and < 50 percent maximum depth. Bobbin detection with the techniques in place has been demonstrated to be adequate to support the PWSCC ARC. The plus point confirmation rates for the U1C10 and U1C11 inspection will be included in the 120-day report.

NRC Request

2. Discuss if indications not detected with the bobbin coil and which would be detected with the plus point coil, if they were inspected, could be considered significant flaws. Discuss whether the pulled tube and laboratory specimen data support the statement that significant indications (in terms of leakage or burst probability) can be expected to be detected by the bobbin coil and confirmed by the plus point coil. Discuss whether the data support the observation that indications detected by the bobbin coil and not confirmed through the plus point coil inspection are insignificant.

TVA Response

The response to this RAI has been incorporated into Sections 4.5.1 and 4.5.2 of WCAP-15128, Revision 2. The development of detailed PODs as a function of depth have been deleted from Revision 2.

NRC Request

3. The temperature correction used to combine the SQN and DCPP growth rates used an "Arrhenius equation with a propagation Q value of 32.5 kcal/mol . . . ." Provide the details of the specific equation used to adjust the growth rates for operating temperature. Provide the technical basis for the propagation Q value of 32.5 kcal/mol. Discuss the advantages and disadvantages of each plant using their own plant-specific growth rates. Using growth rates based on plant-specific numbers would be consistent with the approach taken in the ARC ODSCC at TSPs (i.e., Generic Letter 95-05). Discuss also why there is no data from SQN Unit 2. This approach of combining the data from SQN Unit 1 and DCPP Units 1 and 2 appears conservative for DCPP to use (assuming the temperature correction), but it is not conservative for SQN.

TVA Response

The discussion of the Arrhenius equation is expanded in Section 4.7.1 of Revision 2 to the WCAP, including reference to an EPRI report to support the Q value of 32.5 kcal/mol. The growth rate discussion is included in the revised Sections 4.7.4 and 4.7.5. The WCAP has been revised to require that SQN growth data be applied for SQN ARC analyses and the combined SQN and DCPP growth data for DCPP analyses.

NRC Request

4. You stated that the destructive examination profiles are averaged over the plus point coil "effective coil field average" of 0.16 inch for comparison with NDE data. Where did this number come from?

TVA Response

EPRI Appendix H, Section H2.2.1g recommends the use of destructive exam results averaged over the coil field length, which is the running average used this WCAP. The method for determining the effective coil field length or effective scan field width (ESFW) is defined in the EPRI inservice inspection (ISI) guidelines, Appendix H, Section H1.3.3.1.1 for bobbin probe qualification. The guidance provided in this section also applies to other types of coils. Westinghouse obtained ESFW measurements for the plus point coil following the guidance of the ISI guidelines.

The measurement of effective scan field width is accomplished by measuring the apparent length of a 100% through-wall EDM notch perpendicular to the coil preferred direction. The notch is 0.008 inch wide and a minimum length equal to the coil width + 1.0 inch in length; the notch length employed was 1.25 inches. The measurement was performed for the examination frequency and mode of coil operation as specified in the Acquisition Technique Sheet (ACTS), 400 kHz absolute mode. With the maximum amplitude set at 20 volts, the apparent length over which the response from the notch is reduced to an appropriate fraction of the maximum is recorded; the Effective Scan Field Width at this degree of attenuation is the difference between the measured length and the actual notch length. The ESFW is similar if not identical to the length measurement error, depending upon the convention, i.e., the fractional attenuation of the amplitude, used to identify the endpoints in the voltage profile.

The plus point EFSW values from the 100% notch were -0.02 inch at 50% attenuation, 0.136 inch at 75%, and 0.248 inch at 90%. It is seen that the value increases as the degree of attenuation used is increased. The common analytical practice for identifying the endpoints of a flaw depend upon observing departure from null; this is effectively equivalent to making the length measurement in the 75% - 90% attenuation range. Evaluation of the data supporting ETSS#96703 (axial PWSCC in dented TSPs) shows a length error of 0.13" after correction, confirming the approach. The data supporting ETSS#96702, for detection and sizing circumferential PWSCC at expansion transitions, yields a 21° azimuthal arc length measurement error; converting to linear dimensions for 0.875 diameter tubing yields 0.16 inch. The overall data for EFSW and length errors support a range of 0.13 to 0.16 inch for the effective coil field length. The arc length value had been used extensively in an EPRI circumferential crack evaluation for comparisons of NDE and destructive exam data, and the selection of 0.16 inch for WCAP-15128 was chosen for consistency with this previous work.

<u>**NRC Request**</u>

5. The specimens used in your qualification database did not encompass a wide range of dent voltages nor were crack lengths much longer than 1 inch. Discuss the limits you placed on your plus point qualification to address the fact that few specimens were more than 5.0 volts in size or greater than 1 inch in length. Discuss also the limits you placed in the guidelines in general with respect to dent size and geometry, flaw locations and flaw morphology (e.g., multiple versus separate single axial indications), etc.

TVA Response

Qualification of the plus point coil for detection was not an objective of this program since detection had previously been qualified per Appendix H of the EPRI ISI guidelines. This program focused on plus point sizing development. The plus point coils are spring loaded to achieve surface riding coils. Dents have relatively smoothly varying diameter changes as compared to expansion transitions. The ovalization from denting typically spans the TSP thickness and frequently extends outside the TSP. Local indentations that may be superimposed on the ovalized tube are generally short spanning a few tenths of an inch or less. Based on profilometry results, local indentations tend to be a few mils while ovalization tends to dominate the reduction in the tube diameter due to denting. Responses of the surface riding coils are not strongly influenced by the modest rate of diameter change for the ovalized tubes, particularly at the minor axes where PWSCC is found. The local indentations, which might have more influence on the coil response due to liftoff effects, tend to be short in length and would not be expected to be a strong function of dent size. For the specimens used to develop the sizing uncertainties, about 2/3 of the specimens were less than 2 volts and the remaining 1/3 spanned the range of 2 to 6.3 volts. As expected, the plus point sizing results show no apparent dependence upon dent size for these specimens. Since the dent must pass a 720 mil plus point probe, very large dent deformations are excluded from ARC applications. Because of the surface riding coils and the expected similarities of local indentations across varying dent sizes, the plus point sizing uncertainties should not be significantly dependent upon dent size.

The specimens used for sizing included 3 specimens with lengths between 1.0 and 1.5 inches and 6 specimens between 1.5 and 2.6 inches (see Table 4-8). These indications are longer than found in the field and are believed to provide an adequate sample of long indications. The longer cracks were principally part of the first phase of this program (Reference 8-4) which emphasized sizing of structurally challenging indications. The first phase indications have a prefix P for the specimen labels of this report.

The axial PWSCC morphology found at dented TSP intersections is that of a single crack or two cracks typically about 180° apart at the minor axes. Minor microcracking is sometimes found adjacent to the dominant axial indication. Multiple axial indications (MAIs) 180° apart have no affect on plus point sizing of the individual indications. The minor microcracks are present in some of the laboratory specimens as well as pulled tubes with no apparent affect on sizing accuracy.

Based on the above considerations, no limits are placed on plus point sizing for dent voltages, crack lengths, or MAI versus single axial indication (SAI). For leaving indications in service based upon plus point sizing, flaw locations are limited to dented TSP intersections although the sizing uncertainties are expected to apply to all axial PWSCC locations except potentially hardroll expansion transitions. No limits are placed on flaw locations within or adjacent to TSP intersections. SQN ETSS for the plus point inspection of dents ≥ 2 volts includes a warning to the analysts to be very sensitive to dents causing lift-off. If lift-off occurs, the tube will be identified as "RBD" (retest bad data).

NRC Request

6. Provide the staff with the final analyst guidelines and training manual that will be used in the field. Confirm that these guidelines were identical to those used for the NDE performance testing. If not, discuss the differences and their probable effect on the outcome of the performance testing. The guidelines provided in Reference 8-1 of the WCAP topical report provided conflicting information. Appendix A3 has three different examination technique specification sheets (ETSSs) and they differed from one another in significant ways (e.g., cable lengths, frequencies used, rotation settings).

TVA Response

Field analyst guidelines will be provided on a plant specific basis. As noted in the response to this question and to Question 7 below, limited flexibility is permitted in the guidelines, and the field guidelines do not have to be "identical" to those used for the NDE performance testing. The ETSS items, Appendix A-2 and Appendix A-4, represent the then existing Appendix H qualified techniques on which the subject work relied upon for precedent. The examination procedures, Appendix A-1 and Appendix A-3, integrated the site-specific instructions employed at DCPP and at SQN to implement the Appendix H techniques. Differences between the guidelines in Appendix A3 represent some differences in how data were collected and analyzed during various parts of the program. Plus point sizing analyses are limited to the use of the 720-mil probe evaluated at 300kHz. The acceptability of the minor changes was demonstrated at Westinghouse and these differences were found acceptable for ARC applications.

NRC Request

7. The staff notes that a common standard does not appear to be mandated by the analyst guidelines. The staff believes that the analyst guidelines should specifically describe the standard to be used and that this standard should be optimized for this application. Such an optimized standard would include 20, 40, 60, 80 and 100 percent internal diameter (ID) notches. The phase rotation of the plus point coil is currently set at approximately 40° on the 100 percent notch for all frequencies. Because the phase rotation changes with frequency, the phase rotation should be set at the proper value for each frequency. This is critical for shallow ID defects, and thus should be set on a shallow ID notch, such as the 20-percent notch. The phase shift is approximately linear with depth, and the 20-percent phase should be set at about 20 percent of the 100 percent notch. Clarify your position on the calibration standard and the standard set up for these techniques.

TVA Response

Since the depth versus phase relation for ID notches is close to linear, it is not necessary to require calibration standards with 20, 40, 60, 80, and 100 percent ID notches. Standards with any three of these notch depths are acceptable. A requirement for five ID notches would unnecessarily lead to replacement of acceptable field standards.

Depth sizing with the plus point coil is performed at 300 kHz, and calibration curves for other frequencies are not required for ARC applications. It is acceptable to set the phase for the 100 percent slot, such as about 40°, or set the phase for the 40 percent notch, such as about 15°. These setups are considered to be equivalent. However, Section 4.2.1 of WCAP-15128, Revision 2 has included a requirement that the 40% notch be set at 15° and that a minimum of three points be used to establish the depth versus phase calibration curve including the 40% and 100% notch depths. It is preferred to draw the curve from the actual data points for the slots on the standard rather than forcing a linearity by setting the phase of a 20 percent notch at 1/5 of the phase of a 100 percent notch. The use of a 20 percent notch for the setup is not considered appropriate for field applications. The signal phase is too close to the horizontal, and signal-to-noise for a 20 percent notch may not be acceptable.

NRC Request

8. From our review, it appears that the best probe in the study was the 0.080-inch-high frequency shielded pancake coil. In fact, the Westinghouse report recommended using this coil when the dent signals are minimal, and the DCPP ETSSs also stated that some small defects cannot be detected by the plus point and that the 0.080-inch-high frequency pancake coil must be used. Clarify your position on the use of this coil. It appears to the staff that its use should be mandated when the dent sizes are small, and clear guidelines should be developed as to its usage.

TVA Response

The 80-mil coil may have marginal improvement for detection and sizing over the plus point coil under limited conditions such as small dents. The plus point coil was selected as the reference coil due to overall performance including large dents and deposits for which the elimination of symmetric signals can be advantageous. The use of the plus point coil for ID defects is then also common to its use for OD defects. The limited advantages of the 80-mil coil do not justify complicating the analysis by requiring selected use of two coils. The development of NDE sizing uncertainties was based on the use of the plus point coil and only this coil can be used for ARC sizing analyses.

The 80-mil coil may be optionally used for detection as a supplement to the plus point coil, but its use is not mandatory for the ARC. One of the indirect advantages of an ARC development program is the demonstration that undetected small signals have no impact on tube integrity.

NRC Request

9. From our review, it appears also that the use of a high frequency (i.e., 800 kHz) plus point probe improves the detectability of small ID flaws. The use of the plus point is preferred over the 0.080-inch coil discussed in the previous question for larger dent sizes. Because the low frequencies of the mid-range plus point probe are not being used, the staff recommends using the high frequency plus point over the mid range plus point to allow better detectability. Clarify your position on the use of the high frequency plus point probe.

TVA Response

The 800 kHz plus point probe may improve detection of small ID flaws under limited conditions. However, the data quality at 800 kHz is generally not consistent and often produces low signal to noise problems. The standard plus point probe used in inspections includes the mid-range plus point, 80 mil and 115 mil coils. The limited use of the high frequency plus point coil does not justify inspections with a second probe and there are no plans for implementing this coil for ARC applications.

CHAPTER 5.0 BURST PRESSURE ANALYSES

NRC Request

1. Section 5 is difficult to follow as a stand-alone documentation of the burst pressure analysis methodology since it presumes intimate familiarity on the part of the reader with past topical reports on voltage based repair limits for ODSCC and with much of the other background information discussed. Revisions to Section 5 to better explain the background material will facilitate the staff's review by reducing the need for reviewing the source documents of the background material. In addition, it would be helpful to expand the discussion in the bottom paragraph of page 5-6 and continuing on through the first full paragraph on page 5-7 to expedite understanding of how the statistic model was developed.

TVA Response

The sections were amplified in Revision 2 to provide the requested information. Additional material was added to clarify the evaluations performed and the details of performing those analyses.

NRC Request

2. Westinghouse stated during the January 19, 2000, public meeting that it intended to delete Sections 5.4 and 5.5 of the topical report. The staff believes that the topics covered in these sections are an integral component of the proposed methodology and should continue to be addressed in the revised report. Sections 5.1, 5.2 and 5.3 say very little about how uncertainties in the "final predictive equation" (bottom of Page 5-5) were modeled, other than to note that Figure 6 confirms that the residuals of the

logarithm of the pressure do not contradict the assumption of being from a normal distribution. A complete description of the statistical modeling used to account for the parameter uncertainty of the "final predictive equation" and of the variability or scatter of the measured normalized burst pressures about the regression line indicated by the equation are needed. Sufficient information is needed to allow one to reproduce the results produced by the model. In addition, a benchmark for comparing results, such as that provided by Figure 5-8 is needed.

TVA Response

Sections 5.4 and 5.5 were retained in the WCAP. Discussions of the statistical and simulation methodologies were added to facilitate the review by the staff.

NRC Request

3. Describe or reference the basis for the adjustment term for the part-through-wall (PTW) expression given on page 5-6. (Note, equation numbers would be helpful.)

TVA Response

Equation numbers have been added to the discussion. The adjustment term is based on the Cochet model of ligament tearing. The derivation of the Cochet model has been included in the report along with the specifics of deriving the adjustment factor to account for the presence of pressure on the flanks of the crack.

NRC Request

4. Regarding the database used to develop the regression analysis in Section 5.0, confirm that the model predicted burst pressure for the following points is correctly defined in the database: San Onofre 2 R061C111-09, San Onofre 2 R094C032-07, and Arkansas Nuclear One 2 R016C056. If these values are misrepresented in the database, reevaluate the regression analysis.

TVA Response

The burst pressure values for the San Onofre 2 R061C111-09 and R094C032-07, and Arkansas Nuclear One 2 R016C056 tubes were 3515, 5300, and 3200 psi, respectively. The corresponding burst prediction values from the theoretical model were 2402, 5363, and 3352 psi. These are the values used in the analysis.

NRC Request

5. Regarding the application of a probabilistic Monte Carlo-based analysis to evaluate the burst behavior of the indicated flaws:

   A. Provide a detailed explanation of how the Monte Carlo program operates. Include in this an explanation of how the distributions for each variable will be developed.

TVA Response

A listing of the steps performed in the Monte Carlo simulations has been added to the discussion of Section 5.4.

NRC Request

B. Provide a flow diagram and written description which shows how the depth NDE uncertainty, length NDE uncertainty, and growth rates are incorporated into the analysis. Explain how the distributions for these parameters will be developed and applied. Demonstrate that the application of these factors in the Monte Carlo analysis is not order dependent, or that the order in which they are applied is conservative.

TVA Response

The depth and length uncertainty statistics are included in Section 4 of the report. A description of how the length/depth uncertainties and growth are added to the NDE depth profile in the Monte Carlo analysis is given in Section 7.7 (Operational Assessment). The applications of some of the factors in the Monte Carlo simulations are order dependent. The simulation of the NDE uncertainty relative to depth does not depend on the length, nor does the length uncertainty depend on the depth. The growth does not depend on either the depth or the length. These latter three uncertainty adjustments are additive and may be applied in any order. The uncertainties associated with the length, depth and growth must be simulated before the calculation of the normalized burst pressure. The simulation of the material strength does not depend on any of the other variables and may be calculated at any time in the process.

NRC Request

C. Explain how the random numbers are generated in the Monte Carlo analysis and how the random number generator is qualified for this application.

TVA Response

The Monte Carlo simulation involves the generation of random numbers from the normal, or Gaussian, and Chi-squared distributions. In general, the procedure for both calculations is based on the generation of uniform random numbers. For example, uniform random numbers between 0 and 1 are generated to represent the cumulative distribution function (CDF) of a variable. The inverse transformation of the CDF value is used to obtain a variate corresponding to the distribution of interest. For example, a uniform random number of 0.825 (82.5 percent) leads to a standardized normal deviate of 0.935. This is multiplied by the standard deviation of the sample distribution and added to the mean prediction from the regression equation to obtain a random value of the simulated variable. Similarly, a uniform random number of 0.063 leads to a standardized normal deviate of -1.50.

Uniform random numbers are generated using a published pseudo-random number generator (Numerical Recipes in Fortran, Cambridge Press, 1992). The period of the random number generator is $2 \cdot 10^{18}$, hence repeating the sequence of random numbers within the same simulation is a practical impossibility. The random number generator is qualified for the application.

CHAPTER 6.0 STEAMLINE BREAK (SLB) LEAK RATE ANALYSIS

NRC Request

1. Section 6.2.2 states that material properties including flow stress for the data sets were only sometimes available; otherwise mean properties for I-600 were used. Given that operational assessment are intended to produce conservative estimates of total SG leak rate (e.g., "95/95" estimates), what is the justification for use of mean properties rather than a more conservative assumption (presumably upper bound properties)?

TVA Response

Response is incorporated into the 2nd paragraph in Section 6.2.2. An overall discussion of methods and uncertainties relative to their increasing or decreasing the conservatism in the leakage analyses has been included in Section 6.5 of WCAP-15128, Revision 2.

NRC Request

2. Concerning your note in Section 6.2.3, that various combinations of mean or through-wall crack length can be used with varying values of tortuosity and surface roughness to develop the leak models as long at it is normalized to the available data, confirm that the crack morphologies on which the available data were developed are consistent with the flaws found in service. This similarity is necessary to conclude that the choice of modeling parameters will not effect the applicability of the model.

TVA Response

Response is incorporated into the 3nd paragraph in Section 6.2.2. An overall discussion of methods and uncertainties relative to their increasing or decreasing the conservatism in the leakage analyses has been included in Section 6.5 of WCAP-15128, Revision 2.

NRC Request

3. The statistical modeling of leak rate uncertainties for a given crack size is not discussed in great detail in Section 6. Sufficient information should be provided, if it hasn't been already, to allow the staff to reproduce the model predictions. Of particular interest to the staff is how well the slope and intercept uncertainty of the regression fit has been modeled.

TVA Response

Uncertainties in the ANL ligament tearing model are included in the analysis as discussed in Section 6.4.3 of Revision 2. Uncertainties in the regression parameters (slope, intercept) of the leak rate correlation are included in the analysis, as well as the correlation uncertainty as discussed in Section 6.4.4.

CHAPTER 7.0 OVERVIEW OF ARC AND SUPPORTING ANALYSES

NRC Request

1. In the first paragraph of Section 7.5.1, the report states that no leakage is expected for a maximum crack depth less than 85 percent. Provide the basis for this statement, including any implicit assumptions.

TVA Response

The discussion of the 85 percent maximum depth has been modified in Revision 2 to emphasize that this discussion is a scoping estimate to demonstrate the expected acceptability of the 40 percent depth repair limit. It is noted that a crack length of about 0.6 inch at 85 percent average depth is required for ligament tearing and potential leakage. For a maximum depth of 85 percent, an 85 percent average depth over 0.6 inch is very unlikely. In either case, it is noted that the operational assessment performed to assess the need for tube repair includes the freespan crack analysis and would be the final basis for demonstrating the acceptability of the 40 percent depth repair limit.

NRC Request

2. Section 7.5.5: The last sentence in the first paragraph appears inconsistent with the last sentence of the second paragraph and with the approach in NRC Generic Letter 95-05. Clarify the approach to be used and justify it to the extent that it is different from that used in generic letter.

TVA Response

The following sentence has been added after the last sentence of the first paragraph to clarify the intent to follow the approach of the generic letter for application of growth rates. "However, data cannot be deleted from the last two cycles of growth data since it is necessary to utilize the largest growth distribution over the last two cycles of operation in the operational assessment."

NRC Request

3. Section 7.5.6: Reference is made to a "separate PG&E submittal for licensing considerations." It would be helpful to state that the submittal pertains to a voltage-based ARC for ODSCC at tube support plates.

TVA Response

The requested statement is included in Section 7.5.6 of Revision 2, as well as a reference to the submittal letter.

NRC Request

4. Section 7.5.6, FLB or SLB +SSE: It is stated that compressive stress has the capability to reduce burst capability if stress is sufficiently large, presumably above the yield

strength. Given the possibility that the tubes are locked at the tube support plates, what is the potential, if any, for axial compressive stress approaching the yield strength due to differential thermal expansion between the tubes and the shell?

TVA Response

Stress analyses for tubes under locked conditions have been reported in WCAP-14707. The results in this report demonstrate that the tube stress remain below the yield strength under locked tube conditions including power operation and hot standby conditions.

NRC Request

5. Justification for use of the Cecco probe as part of the implementation of the proposed ARC should be provided. Alternatively, the Cecco should be eliminated as an inspection option from WCAP-15128.

TVA Response

The optional use of the Cecco probe for the ARC has been deleted from Revision 2 of the WCAP and is no longer applicable to the ARC.

NRC Request

6. If Cecco is used for detection in lieu of the bobbin, what is the basis for not inspecting all TSP intersections as would be the case if bobbin is used? In addition, there seems to be a circular inconsistency between the plus point and Cecco inspection requirements. Plus point inspections are to include, in part, all TSP intersections having > 2 volt dents up to the highest TSP for which PWSCC has been detected (by Cecco, presumably) in the prior and current inspection. Ceccos are to be performed for all dented TSP intersections up to the highest TSP for which axial PWSCC has been confirmed by plus point in the prior and current inspections.

TVA Response

The optional use of the Cecco probe for the ARC has been deleted from Revision 2 of the WCAP and is no longer applicable to the ARC.

NRC Request

7. Section 7.7: The first sentence refers to an optional SLB burst probability calculation, which can be performed for indications predominantly inside the TSP. The proposed

acceptance criteria would need to be included in the topical report and in the Technical Specification Bases. It is stated that sufficient Monte Carlo samples will be performed to obtain adequate statistical confidence in the SG SLB burst probability. What constitutes an acceptable level of confidence?

TVA Response

This response has been included in Section 7.8, Condition Monitoring Assessments, of Revision 1 to the WCAP. The acceptance criterion is stated as a SLB tube burst probability of 1.0×10^{-2} at 95 percent probability and 50 percent confidence.

NRC Request

8. Section 7.7, first paragraph: The discussion on in-situ pressure tests needs to be clarified to indicate that in-situ pressure testing is not able to demonstrate that the total crack length (inside and out of the TSP) meets 1.43xSLB.

TVA Response

This response has been included in Section 7.8 of Revision 1 to the WCAP. The use of in situ tests is explicitly limited to the freespan length evaluations.

NRC Request

9. Section 7.7, second paragraph: The seven samples referred to in this paragraph do not appear to convincingly demonstrate that all cracks with maximum depths exceeding 98 percent through wall can be expected to be predicted 100 percent through wall by NDE analysis. Further, it cannot seem to be precluded that PWSCC with a maximum depth of 98 percent cannot break through and leak under main steamline break (MSLB) conditions. Staff estimates show that even a 95 percent through-wall crack, 0.25-inch long can pop through and leak under MSLB differential pressure. Finally, it is not clear in view of the above concerns and given the depth measurement uncertainties reported in Section 4 of the WCAP how a 90 percent depth call with the plus point provides an adequate threshold for performing a detailed leakage assessment.

TVA Response

This statement has been deleted from Revision 2 of the WCAP and is no longer applicable to the ARC. A breakthrough model is now applied for the SLB leakage analysis as described in Revision 2, Section 6.4.2.

NRC Request

10. Section 7.7, page 7-11, last sentence of first full paragraph: This last sentence states that methods described below are applied for condition monitoring assessment if the structural limits of Section 7.4 are exceeded for any indication. It is the staff's understanding that the structural limits in Section 7.4 are not sufficient to fully evaluate burst margins for a given crack profile. This sentence also seems to conflict with the methodology summary given at the bottom of page 7-12 and top of page 7-13 and with the flow chart handed out at the January 19, 2000, public meeting.

TVA Response

This statement and the structural limits of Section 7.4 have been deleted from Revision 2 of the WCAP and are no longer applicable to the ARC. The Revision 2 methodology and flow charts given in Sections 7.7 and 7.8 for operational and condition monitoring assessments are consistent with that presented at the January 19 meeting.

NRC Request

11. Revisions to the technical specification amendment package are needed to reflect agreements reached at the public meeting on January 19, 2000, to facilitate staff review to support the TVA need date. These include limiting application of the proposed ARC to axial PWSCC indications, or portions thereof, located within the thickness of dented tube support plate. In addition, the proposed maximum depth limit as described in the proposed TS Bases and in WCAP-15128 is to be used for screening purposes only. The proposed TS Bases and WCAP-15128 should be revised to state that for indications where the maximum depth limit is satisfied, the repair bases are then obtained by projecting the crack profile to the end of the next operating cycle and determining the burst pressure and the potential accident-induced leak rate associated with the projected profile based on a detailed structural and leakage analysis of that profile. The WCAP should be revised to include a description of the leakage evaluation. The projected accident leak rate for the subject indication is included in the operational assessment as part of the calculation of total accident induced leak rate (from all indications and degradation mechanisms). Both the burst pressure margins and total accident leakage rate must be acceptable for the subject indication to be left in service.

TVA Response

Section 7.7 (Operational Assessment) of Revision 2 of the WCAP has been revised to reflect that both burst pressure and SLB leakage associated with the projected EOC profile are based on a detailed structural and leakage analysis of that profile. A description of the breakthrough model for leakage is included in Section 6.4 of Revision 2. Both burst pressure and leakage requirements given in Section 7 of the revised WCAP must be satisfied to leave the subject indication in service. The operational assessment leakage calculation is performed for all indications, which eliminates the need for a maximum depth screening criterion. The SLB leak rate for axial PWSCC is based on a total SG Monte Carlo analysis. The projected accident leak rate for each SG is included in the operational assessment as part of the calculation of total accident induced leak rate (from all indications and degradation mechanisms). Both the burst pressure margins and total accident leakage rate must be acceptable for all indication left in service. If the total accident induced leak rate from the operational assessment for all degradation mechanisms exceed the allowable limits, additional indications with the largest leak rates that otherwise satisfy structural limits will be repaired until the leakage limits are satisfied.

NRC Request

12. The WCAP should be revised to indicate that accident induced leakage should be evaluated at 95/50 and 95/95 for condition monitoring and operational assessment, respectively, for both total crack length and free span crack length.

TVA Response

The requirements that both leakage and burst be evaluated at 95% probability at 50% confidence for condition monitoring and 95% probability at 95% confidence for operational assessment have been included in Section 7 of Revision 2. It is expected that these confidence levels may be further assessed as part of the NRC/industry reviews for implementation of NEI 97-06. If these reviews lead to changes from these confidence levels, it is the intent that the agreed upon values for NEI 97-06 implementation will be also applied to the PWSCC ARC.

ENCLOSURE 2

PRIMARY WATER STRESS CORROSION CRACKING (PWSCC)
ALTERNATE REPAIR CRITERIA (ARC)
RESOLUTION OF FINAL NRC ISSUES

Part I

NRC Request

1. Page 2-5, Section 2.1.6 - Reporting requirements state a 90-day report. Elsewhere it is a 120-day report. Clarify that 120 days is correct.

TVA Response

SQN will submit a report to the NRC 120 days after the inspection. Chapter 7 of WCAP-15128, Revision 2 and SQN's submitted technical specifications (TS) change state that the report is due 120 days after the inspection. However, Chapter 2 states that the report is due 90 days after the inspection. Chapter 2 will be changed to include the 120-day report in Revision 3.

NRC Request

2. Page 4-19, top of the page, just before Section 4.7.2 - ". . . of indications in each growth bin and the cumulative probability distribution function for the combined SQN and Diablo Canyon Power Plant (DCPP) growth data sets." This implies you combine SQN and DCPP data. Later you write that SQN must use SQN data only.

TVA Response

SQN will use SQN-specific growth data and DCPP will use the combined growth data. This is stated on page 4-21 of WCAP-15128, Revision 2. Changes will be made to clarify this in Section 4.7.2 and on page 7-7 in Revision 3.

NRC Request

3. Clarify the growth data set you will use for SQN and confirm you will assess what you have now for Cycles 8 and 9 with data from 10 and use the most conservative in the same manner as Generic Letter 95-05. Further, clarify that growth data from most recent cycle will be included in operational assessment for next end-of-cycle.

TVA Response

SQN will use the following plan for growth rate updates for Unit 1 Cycle 10 (U1C10) and Unit 1 Cycle 11 (U1C11) inspections.

OBJECTIVE

Selected evaluation of growth rates during the inspection process is necessary to minimize the risk that the operational assessment performed during the outage could be significantly nonconservative. That is, an increase in growth rates for the completed cycle could lead to additional tubes requiring repair compared to evaluations based upon the growth distribution available entering the outage. Therefore, it is desirable to monitor growth rates during the inspection process to minimize the risk of leaving indications in service that might require repair with inclusion of growth data from the current inspection in the growth rate distributions. The steam generators (SG) inspection tends to be part of the critical path for the outage, and depth profiling of PWSCC indications requires considerable analyst time. Development of growth rates for all indications found in the inspection prior to defining indications requiring repair would extend the outage time. A plan to selectively evaluate growth rates during the inspection is defined below that minimizes the potential for both an outage schedule impact and the risk of not identifying indications requiring repair.

SELECTIVE DEVELOPMENT OF GROWTH RATE DATA DURING THE INSPECTION

During the Sequoyah U1C9 outage, about 54 indications were left in service based upon the maximum depth of the indication less than 40%. These indications were all sized during the U1C9 inspection, and growth rates can be obtained upon inspection and sizing of the U1C10 data without reanalysis of the U1C9 data. The U1C10 inspection plan calls for these indications to be plus point inspected early in the outage. Therefore, growth data for these indications will be available as soon as the U1C10 plus point data are sized. Upon obtaining these growth results, the data will be added to the existing growth distribution as described below.

The potential exists that new indications could grow to sizes at U1C10 comparable to the known indications left in service. When new indications are found and sized, the indication depths and lengths will be compared to the sizes of indications found for the tubes left in service at U1C9. If the new indications are found to have average or maximum depths comparable to the largest indications found for the U1C9 indications left in service, growth rates will be obtained for these new indications based on reevaluation and sizing of the U1C9 data. Upon obtaining these growth results, the data will be added to the existing growth distribution as described below.

EVALUATION OF NEW GROWTH DATA FOR INCLUSION IN OPERATIONAL ASSESSMENT FOR TUBE REPAIR

When new growth data are obtained, the data will be added to the growth distribution available entering the outage. Prior to the U1C10 outage, there are about 95 data points in the Sequoyah growth distribution to be used for the U1C10 outage operational assessment during the U1C10 outage. The new growth data obtained in the U1C10 outage will be added to the prior growth distribution. The prior and updated growth distributions will be compared as cumulative probability distributions comparing probability of occurrence as a function of growth per effective full power years. If the updated distribution above 90% probability is found to be more conservative (e.g., larger depths at same probability) than the prior distribution, the updated distribution will be used for the operational assessment for tube repair decisions. These growth distribution comparisons are to be made for average depth, maximum depth, and length. If the updated data is more conservative for any of the three growth distributions, all updated growth distributions will be used in the operational assessment.

REPORTING OF GROWTH DATA IN 120-DAY PWSCC ARC REPORT

Following the outage inspection, growth rates are to be obtained for all indications found in the inspection. The complete growth data from the U1C10 inspection are then used to update the growth distribution. This updated distribution must then be compared to the growth distribution used to define the indications requiring repair at the U1C10 outage. If the updated growth distribution is more conservative above 90% probability than the distribution applied at U1C10, the operational assessment for U1C10 will be revised using the updated growth data. These growth distribution comparisons are to be made for average depth, maximum depth, and length. If the updated data is more conservative for any of the three growth distributions, all updated growth distributions will be used in the revised operational assessment. The comparisons of growth distributions and any revised operational assessment results, if required, are to be included in the 120-day PWSCC ARC report.

<u>NRC Request</u>

4. Please commit that the use of ARC is contingent on tube support plates (TSPs) being uncracked. Please commit to evaluating the bobbin data to demonstrate absence of TSP ligament cracks.

TVA Response

The PWSCC ARC is based on the assumption that the TSPs are not present during a steam line break (SLB). Consequently, the presence of a crack in the TSP does not impact application of the ARC repair limits. Under normal operating conditions, the ARC applies the presence of the TSP to prevent burst as the basis for applying the 1.4ΔPNO deterministic structural limit for the total crack length. The presence of a crack in the TSP would not prevent the TSP from constraining the crack to prevent burst. A missing ligament in the TSP could permit a burst under normal operating conditions and indications should not be left in service with a missing TSP ligament. As a part of the general inspection plan, SQN uses the bobbin coil to inspect for TSP ligament cracks each outage. This inspection will identify the overall condition of the TSPs relative to cracking. Since denting has been arrested at SQN, it is anticipated that the future inspections will not identify new indications in the TSPs.

Although only a missing ligament impacts the ARC, an indication will be repaired if a bobbin coil indication of a TSP anomaly is confirmed by plus point or pancake coil evaluation as a crack or missing ligament at the TSP intersection with the indication. This exclusion criterion will be added to Revision 3 of the WCAP.

NRC Request

5. Regarding Section 7.5.3 of the WCAP, please clarify your intention to perform operational assessment of PWSCC inside TSP even if it is ≤ 40 percent maximum depth. Note such an operational assessment is called for by NEI 97-06, Revision 1b.

TVA Response

SQN will perform an operational assessment on all axial PWSCC degradation at TSP intersections including indications left in service ≤ 40 percent maximum depth. In Revision 3 of the WCAP, the flow chart in Section 7 and the text in Section 7.5.3, will be revised to include this requirement.

NRC Request

6. WCAP Section 7.5.4 states that total constrained leakage (i.e., total PWSCC cracks, outer-diameter stress corrosion cracking at TSPs, and W*) must be less than the TSs allowable leakage limit per GL 95-05 guidelines. Freespan leakage from all degradation mechanisms including PWSCC must be less than 1 gallons per minute (gpm). Is the allowable limit really stated in the TSs? Irrespective, the above is subtly different from NEI 97-06, Revision 1b. Please commit that the accident leakage rate for the most limiting postulated accident, other than SG tube

rupture, shall not exceed the leakage rate assumed in the licensing basis accident analysis in terms of total leakage rate for all SGs and leakage rate for an individual SG. [Note, this criteria applies to the summation of confined and freespan leakages.] [Presumably, SLB has been determined to be the limiting accident for SQN]. In addition, freespan accident leakage from all degradation mechanisms is not to exceed 1 gpm. [This second sentence is consistent with what you already have in the WCAP].

SQN's accident leakage calculation for constrained indications is based on total leakage of 8.5 gpm from all SGs and 8.2 gpm from the faulted SG. The total freespan leak rate is 1 gpm per SG. SLB is the limiting event for SQN and is limited to the faulted loop. SLB analyses for the postulated faulted SG will be compared to the 8.2 and 1 gpm/SG limits. If future analyses for the nonfaulted SGs should indicate a potential for the leak rate to exceed the 150 gallons per day (gpd) (≈0.1 gpm) operating limit requiring plant shutdown in the nonfaulted loops, an evaluation against the total leakage of 8.5 gpm from all SGs would be performed. It is expected that the 150 gpd shutdown limit will bound leakage per SG for the non-faulted loops, and only the faulted SG analysis would be required. This clarification will be documented in Revision 3 of the WCAP.

TVA Response

Revision 3 of the WCAP will change the reference for the constrained leak rate limit from the TSs to the licensing basis as given in other parts of Section 7.

Part II

The following items were discussed between the staff and Westinghouse Electric Company as the staff prepared the safety evaluation report. Necessary additional information was provided to the staff and the following changes were requested for Revision 3 of the WCAP.

NRC Request

1. Update the burst model database in Table 5-1 to 117 data points to resolve differences between Sections 5 and 3.

TVA Response

SQN will use the burst model updated to include 119 data points for the ARC application. Sections 3 and 5 will include the 119 points and will be in agreement on the indications included in the burst correlation in Revision 3 of the WCAP.

NRC Request

2. Document the new regression analysis in Tables 5-4 and 5-5.

TVA Response

NRC-requested changes were included in the burst regression analysis. This new regression analysis will be used at SQN for U1C10 and U1C11 inspections. The new regression will be documented in Revision 3 of the WCAP.

NRC Request

3. Specifically state in Chapter 5 that the uncertainty in the non-destructive examination (NDE) depth measurement and the growth factor are based on average depth for the burst modeling.

TVA Response

The NDE uncertainties in Chapter 5 are based on average depth. In WCAP-15128, Section 5.4, Revision 2, the use of average depth for NDE uncertainties is explicitly stated in Step 3 of the Monte Carlo simulation description. The use of average depth for growth is implied by the discussion in Step 5 of the description stating ". . .creating a self-similar profile at the final average depth." The use of average depth for these parameters is also described in Section 7.7. Additional clarification will be added to Chapter 5 in Revision 3 of the WCAP.

NRC Request

4. Specifically state in Chapter 6 that the uncertainty in the NDE depth measurement and the growth factor are based on maximum depth data for the leakage rate modeling.

TVA Response

In the leakage model that will be used for calculations during the SQN U1C10 and U1C11 inspections, NDE measurement uncertainties and growth are based on maximum depth data. This clarification will be incorporated into the Monte Carlo leakage method discussion of Section 6.4.1 in Revision 3 of the WCAP.

NRC Request

5. Include the values used for all parameters in Chapter 6 necessary to perform the leak rate modeling work for the ARC.

TVA Response

The assumed values used in the thermal hydraulic modeling in WCAP Revision 2 will be the same values used for the calculations performed during the SQN U1C10 and U1C11. The constants will be documented in Revision 3 of the WCAP.

NRC Request

6. Cite in Section 6.2.2 the distribution of throughwall crack lengths that were used in the database for leak rate model development.

TVA Response

The distribution of throughwall crack lengths for the specimens used in the correlation of test results to CRACKFLO predictions is given in Figure 1 of this letter. The throughwall lengths range from 0.03 inch to 0.6 inch. Figure 1 includes only the largest throughwall length for each specimen. A number of the PWSCC specimens include more than one throughwall crack. These secondary cracks were dominantly < 0.1 inch with a few up to 0.15 inch. The leak rate calculations sum the leak rate from all throughwall cracks for comparison with the test results. This discussion will be added to Revision 3 of the WCAP.

NRC Request

7. The leak rate data from Tube 11-3, Crack 1 (2.14 gpm) was not included in the leak rate database. A justification as to why its inclusion is not necessary in the short term has been discussed with the staff.

TVA Response

WCAP 15128, Revision 2 leak rate correlation work had been completed before the data were available for specimen 11-3. Calculations of the leak rate for this specimen applying the Argonne National Laboratory ligament tearing model have been performed. The calculated leak rate with ligament tearing exceeds the measured 2.14 gpm. Consequently, if indications like the profile for specimen 11-3 are found in the field analyses, the leak rate would be conservatively predicted. The current leak rate correlation of measurement with prediction is based on corrosion throughwall lengths and does not include the ligament tearing throughwall length. The current model is very conservative when the breakthrough lengths are used with the current correlation.

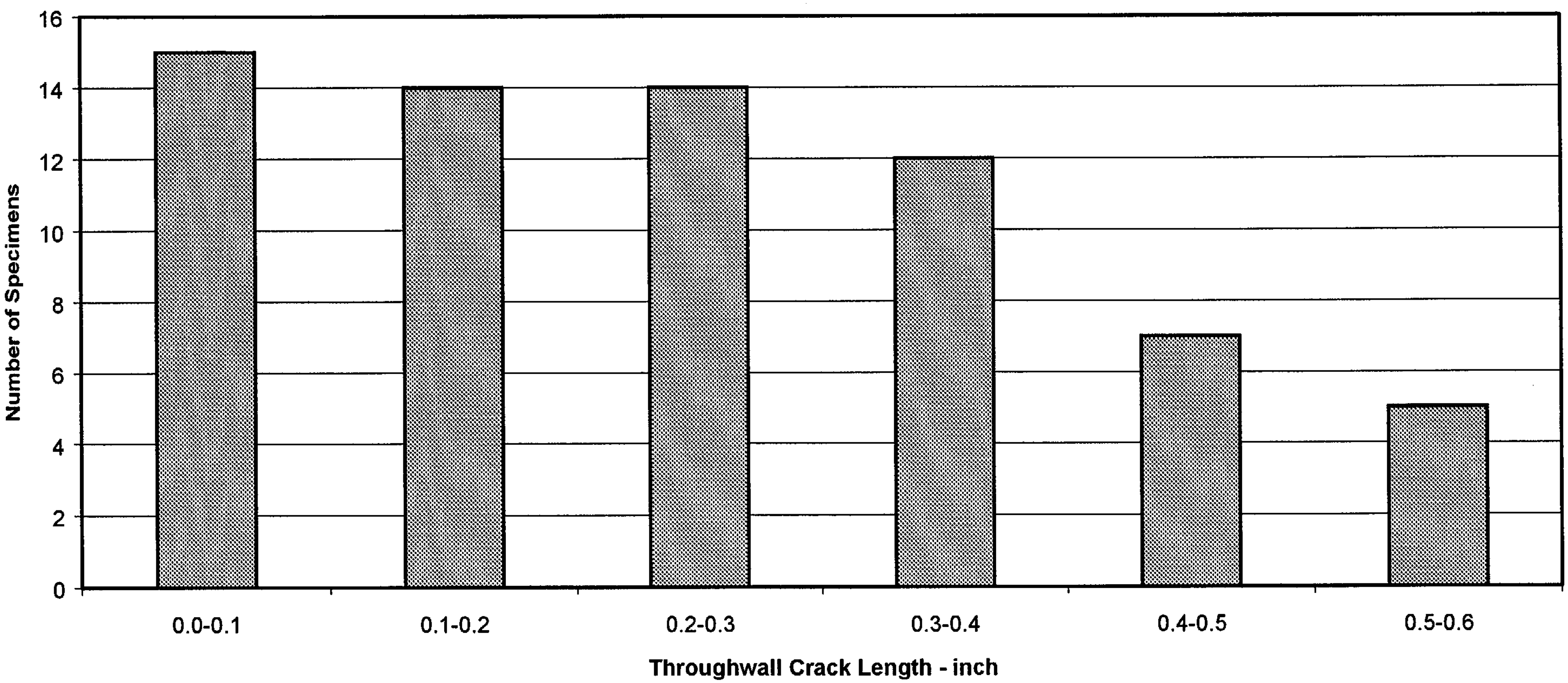
NRC Request

8. Change the wording in Section 6.4.2 starting from the paragraph on the bottom of page 6-13 to state that the program searches for the sub-crack which has a ligament tearing pressure just less than (not more than) the critical pressure. Also, change the wording to state that the leakage crack front search now identifies the longest section predicted to break through under SLB conditions (the "principle leak") and then goes back to find the largest other sub-regions either above or below the "principle leak" which would also be predicted to break through.

TVA Response

The leakage model used by SQN during U1C10 and U1C11 inspections will identify the longest section predicted to break through for any pressure less than or equal to SLB conditions (the "principle leak"). The search is then repeated to find the longest other sub-regions either above or below the "principle leak" which would also be predicted to break through. The wording in Section 6.4.2 will be changed in WCAP Revision 3.

Figure 1. SLB Leak Correlation Specimens
Number of Specimens vs Throughwall Length



ENCLOSURE 3

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING WCAP-15128, "DEPTH-BASED SG TUBE REPAIR CRITERIA FOR AXIAL PWSCC AT DENTED TSP INTERSECTIONS" SEQUOYAH NUCLEAR PLANT

COMMITMENT

In conjunction with the next outer diameter stress corrosion cracking tube pull required by TVA's commitment to Generic Letter 95-05, TVA will pull one tube with primary water stress corrosion cracking (PWSCC) that meets the leakage criteria in WCAP-15128. This commitment will remain in effect only for the time that the proposed technical specification change (99-12) will remain in effect. That is, it is limited to Cycles 11 and 12 operation of Sequoyah Units 1 and 2. The intent of this pull is to enhance the PWSCC database and is contingent upon the implementation of the proposed alternate plugging criteria.

ENCLOSURE 4

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
REGARDING WCAP-15128, "DEPTH-BASED SG TUBE REPAIR
CRITERIA FOR AXIAL PWSCC AT DENTED TSP INTERSECTIONS"
SEQUOYAH NUCLEAR PLANT

REVISED TECHNICAL SPECIFICATION (TS)
PAGES FOR TS 99-12

3. A tube inspection (pursuant to Specification 4.4.5.4.a.8) shall be performed on each selected tube. If any selected tube does not permit the passage of the eddy current probe for a tube inspection, this shall be recorded and an adjacent tube shall be selected and subjected to a tube inspection.

4. Indications left in service as a result of application of the tube support plate voltage-based repair criteria shall be inspected by bobbin coil probe during all future refueling outages. R226

c. The tubes selected as the second and third samples (if required by Table 4.4-2) during each inservice inspection may be subjected to a partial tube inspection provided:

1. The tubes selected for these samples include the tubes from those areas of the tube sheet array where tubes with imperfections were previously found.

2. The inspections include those portions of the tubes where imperfections were previously found.

NOTE: Tube degradation identified in the portion of the tube that is not a reactor coolant pressure boundary (tube end up to the start of the tube-to-tubesheet weld) is excluded from the Result and Action Required in Table 4.4-2. R193

d. Implementation of the steam generator tube/tube support plate repair criteria requires a 100 percent bobbin coil inspection for hot-leg and cold-leg tube support plate intersections down to the lowest cold-leg tube support plate with known outside diameter stress corrosion cracking (ODSCC) indications. The determination of the lowest cold-leg tube support plate intersections having ODSCC indications shall be based on the performance of at least a 20 percent random sampling of tubes inspected over their full length. R226

e. Inspection of dented tube support plate intersections will be performed in accordance with WCAP 15128, Revision 2, dated February 2000 as supplemented by TVA's letter to NRC dated March 2, 2000. This alternate repair criteria is applicable to Cycle 11 and 12 operation.

The results of each sample inspection shall be classified into one of the following three categories:

Category	Inspection Results
C-1	Less than 5% of the total tubes inspected are degraded tubes and none of the inspected tubes are defective.
C-2	One or more tubes, but not more than 1% of the total tubes inspected are defective, or between 5% and 10% of the total tubes inspected are degraded tubes.
C-3	More than 10% of the total tubes inspected are degraded tubes or more than 1% of the inspected tubes are defective.

Note: In all inspections, previously degraded tubes must exhibit significant (greater than 10%) further wall penetrations to be included in the above percentage calculations.

R226

where:

V_{URL}	=	upper voltage repair limit
V_{LRL}	=	lower voltage repair limit
V_{MURL}	=	mid-cycle upper voltage repair limit based on time into cycle
V_{MLRL}	=	mid-cycle lower voltage repair limit based on V_{MURL} and time into cycle
Δt	=	length of time since last scheduled inspection during which V_{URL} and V_{LRL} were implemented
CL	=	cycle length (the time between two scheduled steam generator inspections)
V_{SL}	=	structural limit voltage
Gr	=	average growth rate per cycle length
NDE	=	95-percent cumulative probability allowance for nondestructive examination uncertainty (i.e., a value of 20-percent has been approved by NRC)

R226

Implementation of these mid-cycle repair limits should follow the same approach as in TS 4.4.5.4.a.10.a, 4.4.5.4.a.10.b, and 4.4.5.4.a.10.c.

Note 1: The lower voltage repair limit is 1.0 volt for 3/4-inch diameter tubing or 2.0 volts for 7/8-inch diameter tubing.

Note 2: The upper voltage repair limit is calculated according to the methodology in GL 90-05 as supplemented. V_{URL} may differ at the TSPs and flow distribution baffle.

11. Primary Water Stress Corrosion Cracking (PWSCC) Tube Support Plate Plugging Limit is used for the disposition of an Alloy 600 steam generator tube for continued service that is experiencing predominantly axially oriented PWSCC at dented tube support plate intersections as described in WCAP 15128, Revision 2, dated February 2000 as supplemented by TVA's letter to NRC dated March 2, 2000. This alternate repair criteria is applicable to Cycle 11 and 12 operation.

The mid-cycle equation of SR 4.4.5.4.a.10.e should only be used during unplanned inspection in which eddy current data is acquired for indications at the tube support plates.

SR 4.4.5.5 implements several reporting requirements recommended by GL 95-05 for situations which NRC wants to be notified prior to returning the S/Gs to service. For SR 4.4.5.5.d., Items 3 and 4, indications are applicable only where alternate plugging criteria is being applied. For the purposes of this reporting requirement, leakage and conditional burst probability can be calculated based on the as-found voltage distribution rather than the projected end-of-cycle voltage distribution (refer to GL 95-05 for more information) when it is not practical to complete these calculations using the projected EOC voltage distributions prior to returning the S/Gs to service. Note that if leakage and conditional burst probability were calculated using the measured EOC voltage distribution for the purposes of addressing GL Sections 6.a.1 and 6.a.3 reporting criteria, then the results of the projected EOC voltage distribution should be provided per GL Section 6.b(c) criteria. R226

Wastage-type defects are unlikely with proper chemistry treatment of the secondary coolant. However, even if a defect should develop in service, it will be found during scheduled inservice steam generator tube examinations. Plugging will be required for all tubes with imperfections exceeding the repair limit defined in Surveillance Requirement 4.4.5.4.a. R226 The portion of the tube that the plugging limit does not apply to is the portion of the tube that is not within the RCS pressure boundary (tube end up to the start of the tube-to-tubesheet weld). R193 The tube end to tube-to-tubesheet weld portion of the tube does not affect structural integrity of the steam generator tubes and therefore indications found in this portion of the tube will be excluded from the Result and Action Required for tube inspections. It is expected that any indications that extend from this region will be detected during the scheduled tube inspections. Steam generator tube inspections of operating plants have demonstrated the capability to reliably detect degradation that has penetrated 20% of the original tube wall thickness.

Tubes experiencing outside diameter stress corrosion cracking within the thickness of the tube support plate are plugged or repaired by the criteria of 4.4.5.4.a.10. R226

The steam generator tube repair limits for primary water stress corrosion cracking (PWSCC) of SR 4.4.5 represents a steam generator tube alternate repair criteria for greater than or equal to 40 percent deep PWSCC indications which are located within the thickness of tube support plates. The repair bases for PWSCC are not applicable to other types of localized tube wall degradation located at the tube-to-tube support plate intersections.

The ARC includes completion of a condition monitoring assessment to determine the end-of-cycle (EOC) condition of the tube bundle. An operational assessment is completed to determine the need for tube repair on a forward-fit basis. The ARC is based on the use of crack depth profiles obtained from Plus Point analyses. Burst pressures and leak rates are calculated from depth profiles by searching the total crack length for the partial length that results in the lowest burst pressure and the longest length that would tear through-wall at steam-line break conditions. The repair bases for PWSCC at dented TSP intersections is obtained by projecting the crack profile to the end of the next operating cycle and determining if the projected profile meets the requirements of WCAP 15128, Revision 2, dated February 2000 as supplemented by TVA's letter to NRC dated March 2, 2000. The following provides the limits and bases for repair established in the WCAP analyses:

Freespan Indication Repair Limits

The tube will be repaired if the crack length outside the dented TSP is ≥40% maximum depth.

Crack Length Limit for ≥40% Maximum Depth

The crack length limit for ≥40% maximum depth indications is defined as 0.375 inch from the centerline of the TSP. This limit defines the edges of the TSP thickness of 0.75 inch for Model 51 S/Gs. It is acceptable for the crack to extend to both edges of the TSP as long as the maximum depth of the crack outside the TSP is <40% maximum depth and the requirements for EOC conditions are acceptable.

Operational Assessment Repair Bases

If the indication satisfies the above maximum depth and length requirements, the repair bases is then obtained by projecting the crack profile to the end of the next operating cycle and determining the burst pressure and leakage for the projected profile. The burst pressure and leakage is compared to the requirements in WCAP 15128, Revision 2, dated February 2000 as supplemented by TVA's letter to NRC dated March 2, 2000. Separate analyses are required for the total crack length and the length outside the TSP due to differences in requirements. If the projected EOC requirements are satisfied, the tube will be left in service.

The results of the condition monitoring and operational assessments will be reported to the NRC within 120 days following completion of the inspection.

Whenever the results of any steam generator tubing inservice inspection fall into Category C-3, these results will be promptly reported to the Commission pursuant to Specification 6.6.1 prior to resumption of plant operation. Such cases will be considered by the Commission on a case-by-case basis and may result in a requirement for analysis, laboratory examinations, tests, additional eddy-current inspection, and revision of the Technical Specifications, if necessary. R40

R226

1. All nonplugged tubes that previously had detectable wall penetrations (greater than 20%).

2. Tubes in those areas where experience has indicated potential problems.

3. A tube inspection (pursuant to Specification 4.4.5.4.a.8) shall be performed on each selected tube. If any selected tube does not permit the passage of the eddy current probe for a tube inspection, this shall be recorded and an adjacent tube shall be selected and subjected to a tube inspection.

4. Indications left in service as a result of application of the tube support plate voltage-based repair criteria shall be inspected by bobbin coil probe during all future refueling outages. R213

c. The tubes selected as the second and third samples (if required by Table 4.4-2) during each inservice inspection may be subjected to a partial tube inspection provided:

1. The tubes selected for these samples include the tubes from those areas of the tube sheet array where tubes with imperfections were previously found.

2. The inspections include those portions of the tubes where imperfections were previously found.

Note: Tube degradation identified in the portion of the tube that is not a reactor coolant pressure boundary (tube end up to the start of the tube-to-tubesheet weld) is excluded from the Result and Action Required in Table 4.4-2. R181

d. Implementation of the steam generator tube/tube support plate repair criteria requires a 100 percent bobbin coil inspection for hot-leg and cold-leg tube support plate intersections down to the lowest cold-leg tube support plate with known outside diameter stress corrosion cracking (ODSCC) indications. The determination of the lowest cold-leg tube support plate intersections having ODSCC indications shall be based on the performance of at least a 20 percent random sampling of tubes inspected over their full length. R213

e. Inspection of dented tube support plate intersections will be performed in accordance with WCAP 15128, Revision 2, dated February 2000 as supplemented by TVA's letter to NRC dated March 2, 2000. This alternate repair criteria is applicable to Cycle 11 and 12 operation.

The results of each sample inspection shall be classified into one of the following three categories:

Category	Inspection Results
C-1	Less than 5% of the total tubes inspected are degraded tubes and none of the inspected tubes are defective.

R213

where:

V_{URL}	=	upper voltage repair limit
V_{LRL}	=	lower voltage repair limit
V_{MURL}	=	mid-cycle upper voltage repair limit based on time into cycle
V_{MLRL}	=	mid-cycle lower voltage repair limit based on V_{MURL} and time into cycle
Δt	=	length of time since last scheduled inspection during which V_{URL} and V_{LRL} were implemented
CL	=	cycle length (the time between two scheduled steam generator inspections)
V_{SL}	=	structural limit voltage
Gr	=	average growth rate per cycle length
NDE	=	95-percent cumulative probability allowance for nondestructive examination uncertainty (i.e., a value of 20-percent has been approved by NRC)

R213

Implementation of these mid-cycle repair limits should follow the same approach as in TS 4.4.5.4.a.10.a, 4.4.5.4.a.10.b, and 4.4.5.4.a.10.c.

Note 1: The lower voltage repair limit is 1.0 volt for 3/4-inch diameter tubing or 2.0 volts for 7/8-inch diameter tubing.

Note 2: The upper voltage repair limit is calculated according to the methodology in GL 90-05 as supplemented. V_{URL} may differ at the TSPs and flow distribution baffle.

11. Primary Water Stress Corrosion Cracking (PWSCC) Tube Support Plate Plugging Limit is used for the disposition of an Alloy 600 steam generator tube for continued service that is experiencing predominantly axially oriented PWSCC at dented tube support plate intersections as described in WCAP 15128, Revision 2, dated February 2000 as supplemented by TVA's letter to NRC dated March 2, 2000. This alternate repair criteria is applicable to Cycle 11 and 12 operation.

b. The steam generator shall be determined OPERABLE after completing the corresponding actions (plug all tubes exceeding the plugging limit and all tubes containing through-wall cracks) required by Table 4.4-2.

results in the lowest burst pressure and the longest length that would tear through-wall at steam-line break conditions. The repair bases for PWSCC at dented TSP intersections is obtained by projecting the crack profile to the end of the next operating cycle and determining if the projected profile meets the requirements of WCAP 15128, Revision 2, dated February 2000 as supplemented by TVA's letter to NRC dated March 2, 2000. The following provides the limits and bases for repair established in the WCAP analyses:

Freespan Indication Repair Limits

The tube will be repaired if the crack length outside the dented TSP is ≥40% maximum depth.

Crack Length Limit for ≥40% Maximum Depth

The crack length limit for ≥40% maximum depth indications is defined as 0.375 inch from the centerline of the TSP. This limit defines the edges of the TSP thickness of 0.75 inch for Model 51 S/Gs. It is acceptable for the crack to extend to both edges of the TSP as long as the maximum depth of the crack outside the TSP is <40% maximum depth and the requirements for EOC conditions are acceptable.

Operational Assessment Repair Bases

If the indication satisfies the above maximum depth and length requirements, the repair bases is then obtained by projecting the crack profile to the end of the next operating cycle and determining the burst pressure and leakage for the projected profile. The burst pressure and leakage is compared to the requirements in WCAP 15128, Revision 2, dated February 2000 as supplemented by TVA's letter to NRC dated March 2, 2000. Separate analyses are required for the total crack length and the length outside the TSP due to differences in requirements. If the projected EOC requirements are satisfied, the tube will be left in service.

The results of the condition monitoring and operational assessments will be reported to the NRC within 120 days following completion of the inspection.

Whenever the results of any steam generator tubing inservice inspection fall into Category C-3, these results will be promptly reported to the Commission pursuant to Specification 6.6.1 prior to resumption of plant operation. Such cases will be considered by the Commission on a case-by-case basis and may result in a requirement for analysis, laboratory examinations, tests, additional eddy-current inspection, and revision of the Technical Specifications, if necessary.

R213