January 8, 2008

10 CFR 50.90

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

Gentlemen:

In the Matter of	)	Docket No. 50-328
Tennessee Valley Authority	)	

SEQUOYAH NUCLEAR PLANT (SQN) RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING UNIT 2 TECHNICAL SPECIFICATION CHANGE 06-06, PROBABILITY OF PRIOR CYCLE DETECTION (POPCD) (TAC NO. MD4110)

Reference: NRC letter to TVA dated November 20, 2007, "Sequoyah Nuclear Plant, Unit 2 - Request for Additional Information Regarding Revised Probability of Prior Cycle Detection Model (TAC No. MD4110)"

Enclosed are the TVA responses to the staff's request for additional information from the reference letter. TVA's responses were discussed with your staff during telephone conference calls on November 27 and December 18, 2007. TVA's responses support staff review of the subject TS change for SQN Unit 2.

Enclosure 1 provides the TVA responses to the staff's questions. Enclosure 2 provides reformatted TS pages for TS Change 06-06 that support TVA's response to NRC question No. 1. Please note that the TS pages provided by Enclosure 2 supersede the TS pages previously provided by TVA's January 12, 2007 letter. Enclosure 3 provides a TVA commitment associated with implementation of the subject TS change.

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

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 8th day of January, 2008.

Sincerely,

James D. Smith
Manager, Site Licensing and
Industry Affairs

Enclosures
1. TVA Reponses to NRC's Request for Additional Information
2. Reformatted TS and Bases page markups for TSC 06-06
3. TVA Commitment

cc (Enclosures):

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ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY (TVA)
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 2

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) FOR SQN TECHNICAL SPECIFICATION (TS) CHANGE 06-06, PROBABILITY OF PRIOR CYCLE DETECTION (POPCD)

NRC Question 1

Regarding your proposed reporting requirements for implementation of the POPCD methodology, please update your proposal to reflect your new SG technical specification format. In addition, please discuss your plans to clarify when the report would be submitted since as currently written, you would be required to submit a report 90-days after the SGs were returned to service regardless of whether SG tube inspections were performed. For example, you could specify that consistent with Technical Specification 6.9.1.16.1 the report would be submitted 90-days after the initial entry into MODE 4 following completion of an inspection performed in accordance with Specification 6.8.4.k, "Steam Generator (SG) Program."

Please note that the discussion in Section 2.0 of Enclosure 1 to your January 12, 2007, submittal does not match the wording in your proposed Technical Specifications in Enclosure 2. The staff assumed that the proposed wording in the Technical Specifications is what you intended to propose.

TVA response

Enclosure 2 of this submittal provides reformatted TS and Bases markup pages that supersede the markups previously provided in TVA's January 12, 2007 submittal. It may be noted that the wording in Section 2.0 of TVA's January 12, 2007, submittal did contain typographical errors that resulted in a mismatch with the wording provided in Enclosure 2. The proposed TS wording provided in Enclosure 2 was the intended wording.

NRC Question 2

Regarding the changes you intend to make to your Bases, the NRC does not have a copy of the Westinghouse letter that is referenced. As a result, it can not comment on whether this change is appropriate. The NRC expects that if the POPCD methodology is approved that it would be implemented consistent

with the methodology provided to the staff to support its approval. The methodology in the referenced Westinghouse letter may have been modified as a result of responses to the NRC staff's request for additional information. Please discuss your plans to ensure that the Bases reflect the actual POPCD methodology that is approved by the NRC staff.

TVA Response

TVA has revised the Bases pages to reflect the actual POPCD methodology approved by the NRC staff. (Note: Enclosure 2 of this submittal contains the Bases page markups with the references that include the NRC letter that approves the POPCD methodology for SQN Unit 2.)

NRC Question 3

On pages E1-5 and E4-14 of Enclosure 1 to your January 12, 2007, submittal, you indicated that if an indication grows by an extreme amount (i.e., an outlier) that you will implement a methodology intended to address this issue. Given the text on these two pages are different, it is not clear whether the methodology would be submitted for NRC approval. Please confirm that this outlier methodology would be submitted for NRC approval prior to implementation. The NRC staff notes that its previous approval of POPCD relied on (1) modifications to the inspection and repair criteria to limit the potential for indications with high voltage growth; (2) other calculations performed by the licensee; and (3) additional reporting requirements that essentially require an assessment if the under predictions were significant (as discussed in the technical specifications).

TVA Response

The outlier method would be submitted for NRC approval prior to implementation consistent with page E4-14 of Enclosure 4.

NRC Question 4

On pages E1-5 and E4-15 of Enclosure 1 to your January 12, 2007, submittal, you indicated that you performed rotating probe inspections of bobbin indications greater than 1.5 volts and no indications exceeded the 1.9 volt threshold for preventive repair. Since the actual practices in prior inspections may affect the potential for large voltage growth rates, please discuss whether any indications were preventively repaired as a result of these inspections (i.e., regardless of whether they exceeded the 1.9 volt threshold). If indications were repaired (to address the potential for large voltage growth rates),

discuss whether similar practices will be employed in all future inspections.

TVA Response

During the end-of-cycles (EOCs) 12 and 13 inspections, 13 indications were preventively plugged at least in part as a result of the rotating pancake coil (RPC) inspection of indications over 1.5 volts. These indications were the largest RPC confirmed indications less than two bobbin volts. During the EOC-14 inspection, the indications above 1 volt were RPC tested. A small number of tubes (five indications) were preventively plugged. No specific guideline for preventive tube plugging was applied. The considerations for plugging included RPC volts, bobbin growth rates, number of RPC indications, etc.

TVA will continue to review large bobbin voltage, RPC confirmed indications for preventive tube plugging that do not exceed the 1.9-volt RPC volt threshold for repair. The option for preventive tube plugging will continue to be judgmental based on the overall NDE responses.

NRC Question 5

You indicated that the number of high voltage indications in the POPCD database for SQN-2 does not satisfy the minimum requirements specified by the industry. As a result, you compared the SQN-2 database to the industry database. Please discuss what the effect would be on the SQN-2 POPCD curve if the SQN-1 [Sequoyah Nuclear Plant, Unit 1] and SQN-2 POPCD databases were combined. Although there may be differences in the noise levels (e.g., from denting) between the two units, there may be some insights gained on potential performance for higher voltage level indications.

In addition, please provide an enlarged view of the data above 1.0 volt in Figure 5.

Your justification for using the SQN-2 POPCD curve instead of the more limiting of the composite POPCD or SQN-2 POPCD curve is largely qualitative and relies on the "small" differences between the curves. Since the POPCD curve is used to calculate the probability of burst under steam line break conditions and the amount of leakage under steam line break conditions, it would appear that a more appropriate comparison would be to evaluate the effects of the different POPCD curves on the structural and leakage integrity of the SG tubes. Please provide this assessment.

Since this is a one-time assessment, please discuss your plans to submit a similar analysis until a sufficient number of "high" voltage data points are present at SQN-2. Alternatively, discuss your plans for using the most limiting of the POPCD curves.

TVA Response

The large number of dents and high dent voltages at SQN-1 preclude meaningful combination of data from SQN-1 into POPCD for SQN-2. The addition of the SQN-1 data would not contribute meaningful data for application of POPCD and would significantly degrade the SQN-2 POPCD.

An enlarged view above 1.0 volt in Figure 5 is provided as Figure 5-1 (see page E1-30). The SQN-2 POPCD curve at the lower 95 percent is conservative relative to the industry curve while the nominal regression curves are nearly identical. The smaller number of data points in the SQN-2 POPCD data compared to the industry data lead to the larger uncertainties for the SQN-2 POPCD. However, the differences are small and have negligible influence on burst probability and leakage analyses.

The conclusion that small changes in POPCD have a negligible influence on burst and leakage is based on prior experience with POPCD analyses rather than "qualitative" judgment. See response to RAI-19 for examples of burst and leakage sensitivity to small changes in POPCD. In Table 19-1 (see page E1-24), the probability of burst and leakage are compared for the Addendum 5 POPCD and the SQN-2 POPCD. All other inputs are identical. The computation considered 250,000 Monte Carlo Trials. In both cases, the results are conservative relative to the as-found indications at end of cycle (EOC)-13. Although the probability of burst (POB) values are small, there are significant differences between the POB values computed using the two different POPCD functions. A test was run to determine if this difference was a consequence of the small number of Monte Carlo trials relative to the POB values. Table 19-1A (see page E1-25) shows the comparable results using 1 million Monte Carlo trials. Table 19-1B (see page E1-25) shows that the percent difference between the POB using the two different POPCD curves is significantly less when a larger number of trials is used. This is because the Monte Carlo results are more reliable when more bursts are predicted. Similarly, it is expected that for cases where the probability of burst is greater, the difference in POB for slightly different POPCD curves will be small.

A sufficient number of "high" voltage data points to satisfy the criteria for a plant-specific POPCD is expected to be present when the EOC-14 POPCD is evaluated at the EOC-15 inspection. The earliest that POPCD can be implemented is the EOC-15 inspection. Accordingly, implementation of POPCD on SQN-2 will be based on plant specific data with no need to assess the more limiting of the plant specific and industry POPCD distributions.

NRC Question 6

On page E4-6 (1st bullet), you indicate that the end of cycle (EOC) inspection EOC_n bobbin voltages are "generally" based on the inspection records for the EOC_n. Please discuss your plans to report (in the 90-day report) any instances in which sizing is based on a reanalysis of the voltages previously reported. The staff notes that detection will always be based on past inspection records (as indicated in the first bullet).

TVA Response

In any instance for which sizing is based on a reanalysis of the voltages previously reported, a description of the change and the basis for the change would be discussed in the 90-day report. No reanalyses have been applied to the POPCD data through the EOC-12 evaluations reported in the submittal. The option for reanalysis is included primarily to permit review of a EOC_n missed indication with a very high EOC_{n+1} voltage for use in growth rate assessments.

NRC Question 7

On page E4-6 (2nd bullet), you indicate that the EOC_n voltage for new EOC_{n+1} indications will be based on lookback analyses when the EOC_n voltages are not available from the inspection record. Please clarify "when" an EOC_n voltage would be available for a flaw not reported in EOC_n (or should the "when" in this sentence really be "since"). In addition (if "when" is the correct word in this sentence), please discuss why it is acceptable (in this case) not to confirm that the reported EOC_n voltage actually corresponds to the flaw reported at EOC_{n+1}.

TVA Response

The word "when" in the sentence should be changed to the word "since." The use of the word "since" will provide improved clarity for the 2nd bullet on page E4-6.

NRC Question 8

On page E4-7, you indicated that data supporting the adequacy of using the square root sum of the squares method for determining the inferred bobbin voltage from multiple rotating probe indications at a tube support plate was provided by another utility (in an August 18, 2004 letter). Since this information

was specific to this utility, please provide a similar plot demonstrating that the approach is currently adequate for SQN-2 (future assessments will be provided in the 90-day report).

TVA Response

Figure 8-1 (see page E1-31) shows the inferred bobbin voltage from multiple +Point indications compared to the measured bobbin voltages. The inferred bobbin volts are obtained as the square root of the sum of squares of the bobbin volts obtained for each +Point indication from the correlation of bobbin volts to +Point volts. It is seen that the inferred bobbin volts are conservative compared to the measured bobbin volts for nearly all measurements. The conservatism results from the relatively high bobbin volts obtained from the correlation with +Point volts as shown in Figure 8-2 (see page E1-31), which represents the correlation updated to include EOC-14 data. The polynomial fit to the 95 percent confidence on the mean regression line is used to infer the bobbin volts. It is seen that the bobbin volts inferred from the +Point volts is always greater than unity such that the multiple +Point indication correlation leads to bobbin volts greater than 1.5. Figure 8-2 is further discussed in RAI-9.

NRC Question 9

Figure 2 provides a correlation for assigning an inferred bobbin voltage to indications detected only with a rotating probe. A similar curve is provided in Figure 3-13 of your March 20, 2007 letter, which submitted the SQN-2 Cycle 14 90-day SG report. Please discuss the differences in these curves. Please discuss if there have been significant changes in this correlation with time. If so, discuss whether a composite curve is more appropriate or whether a conservative lower bound to any single cycle data is appropriate. In addition, please confirm that there are no data from axially oriented outside diameter stress corrosion cracking indications not detectable by bobbin (AONDBs) such that an assessment of the adequacy of this correlation can currently be assessed. The staff notes that it appears that the prior practice was to plug AONDBs on detection (page E4-17).

TVA Response

Figure 2 applies bobbin voltages inferred from the 95 percent confidence on the mean regression correlation of bobbin with +Point volts. This is consistent with Section 10.1 of Addendum 6 to the alternate repair criteria (ARC) database (Reference 1) and prior licensed POPCD applications. Figure 3-13 of the 90-day report infers bobbin voltages from the 95 percent prediction interval of the correlation, which yields more conservative bobbin voltage predictions.

Figure 8-2 (see page E1-31) shows a revision of the submittal's Figure 2 bobbin to +Point volt correlation for SQN-2 EOC-14 data. The +Point data for this correlation includes the single axial indication (SAI) data from the EOC-14 inspection.

Upon approval for POPCD implementation, the 95 percent confidence on the mean bobbin to +Point voltage correlation will be applied to obtain inferred bobbin voltages consistent with Figure 2 of the transmittal and Figure 8-2 (see page E1-31) of this response. The adequacy of the correlation cannot be assessed since the prior practice was to plug the indications.

If/once an AONDB becomes detectable by bobbin, a comparison of the actual bobbin voltage to what would be expected based on the inferred bobbin voltage from the prior inspection and typical voltage growth will be included in the 90-day report.

NRC Question 10

On page E4-9, you indicated that if the p-value is greater than 5 percent, you will propose an alternate probability of detection (POD) model and submit the recommendation to the NRC for approval. Given that it may take time for the NRC to review any changes to the POD model, please discuss the model to be used in the interim pending staff review of the alternate model. The NRC staff notes that it previously accepted the use of a default value of 0.6 for POD as an acceptable alternative.

TVA Response

A default value of 0.6 for POD would be used as an alternative POD in the event that the p-value for a POPCD analysis is greater than five percent. However, the likelihood of the p-value increasing from less than 2.9×10^{-7} to 0.05 as more data is accumulated in the database is extremely low.

NRC Question 11

On page E4-15, you indicate that an assessment for the onset of voltage dependent growth "should" be performed and the methods of Reference 1 applied when growth rates show a dependence on the beginning of cycle voltage. Please confirm that this assessment "will" be performed. In addition, discuss whether there are any differences in the voltage dependent growth methodology discussed in Reference 1 and the methodology approved by the NRC staff in prior POPCD approvals. If there are any differences, please justify them.

TVA Response

Assessments for the onset of voltage dependent growth (VDG) will be performed and documented in each 90-day report. There are no differences between the VDG methods of Section 10.3 of Reference 1 and the methodology approved by the NRC staff in prior POPCD approvals. It can be noted that Section 10.3 includes examples based on applying the methods to the plant having a previously approved POPCD.

NRC Question 12

On page E4-16, you indicated that a rotating probe (+Point) inspection would be performed for +Point confirmed indications at EOC_n that are not detected by bobbin at EOC_{n+1}. Please confirm that this is Note 1 in Table 1 (rather than Note 3 in Table 1 as indicated in the text).

TVA Response

It is correct that Note 1 in Table 1 should have been referenced on page E4-16 rather than Note 3.

NRC Question 13

On page E4-17, you indicate that you assign a through-wall depth (i.e., a percent code) to bobbin indications confirmed with a rotating probe to be volumetric indications. Please confirm that this applies only to volumetric wear indications and thinning/wastage indications rather than to volumetric indications attributed to intergranular attack or closely spaced cracks. Please confirm that the voltage based repair criteria are applied to volumetric outside diameter cracking indications (including intergranular attack). If not, please confirm that these indications are plugged on detection.

TVA Response

It is correct that depth assignments for volumetric indications are only made for indications attributed to wear and thinning/wastage indications. The voltage based repair criteria are applied to intergranular attack or volumetric interpretations for outside diameter cracking indications.

NRC Question 14

On page E4-18, you indicated that no reevaluation was performed of the EOC 9 data for a 2.03 volt indication that was detected at EOC 10. Please confirm that future assessments of POPCD that use previous data will be re-evaluated to determine the voltage of the potentially missed indication. In addition, please discuss what growth rate was assigned to this indication if the previous data were not reviewed (this is important from a benchmarking standpoint).

TVA Response

A review of the EOC-10 90-day report showed no 2.03 volt indication at SG 3, R32C17 H01 as stated on page E4-18. Supporting documentation for that report noted that the 2.03 volt indication at SG 3, R32C17 H01 which was originally reported as a distorted support indication (DSI) was RPC tested and determined to be an ID flaw, and thus it was eliminated from the axial outer-diameter stress corrosion cracking (ODSCC) analysis. Therefore, no look back to determine an ODSCC growth rate was performed. This information however was not received by the person developing the POPCD. As described on page E4-18, the average growth rate of 0.1 volt was assigned to this indication to obtain a 1.93 volt missed indication at EOC-9, which is the largest undetected indication in the POPCD database. This remains as a small conservatism in the SQN-2 POPCD. The benchmark predictive calculations for EOC-11 in Table 8 consider the 0.1 volt growth rate for this indication. The largest growth in the EOC-11 predictive analysis is 0.7 volts/effective full-power year.

TVA confirms that future assessments of POPCD that use previous data will be reevaluated to determine the voltage of the potentially missed indication.

NRC Question 15

On page E4-18, you indicate the composite POPCD data contains 11 indications found only with a rotating probe (Column F of Table 4) although there were only six occurrences. You further indicate that the rotating probe only detections are counted as missed indications in two successive cycle POPCD evaluations even though they were repaired on detection. Please clarify this discussion. If an indication was initially detected at EOC_{n+1} and subsequently plugged, it does not appear (to the staff) that the indications should be counted twice based on a review of Table 1.

TVA Response

When the indication is found only by RPC at Cycle n+1, the indication is included as a missed bobbin indication at Cycle n (e.g., most frequently bobbin no degredation detected [NDD] indication bobbin NDD intersection [BND] w/o RPC in Table 1) and entered in Column F in Table 4. When Cycle n+2 is completed, the indication is included as a missed bobbin indication at Cycle n+1 (Cycle n BND w/RPC detected [RDD] in Table 1). In most cases, the indication remains bobbin NDD and RPC detected at EOC n+2 (column F of Table 4) although the indication could be a new indication in Column E or D of Table 4. Since these indications were preventively plugged when found at SQN-2, the indication is missed at Cycle n+1 based on BND w/RDD and plugged as shown in Table 2 for Cycle n.

NRC Question 16

Please provide an enlarged view of the data above 1.0 volt in Figure 4. In addition, please discuss what POPCD curve is required to be used in the assessments given that the POD above 1.0 volt for the cycle 12 data is less than the corresponding POD for the composite dataset.

TVA Response

Figure 16-1 (see page E1-32) provides the requested data above 1.0 volt from Figure 4 of the transmittal.

On page E4-19 of TVA's January 12, 2007 transmittal, it is noted that the multi-cycle POPCD is considered more appropriate for future operational assessments than any one cycle of POPCD data. On page E4-23, first bullet, it is noted that differences between the multi-cycle POPCD and the last cycle should be assessed in the 90-day report relative to the potential for significant changes in detection capability. Recognizing the number of data points for any one cycle of POPCD is considered to be too small to control the expected POPCD for the next cycle, if there are "significant" negative trends in POPCD, appropriate adjustments will be made to POPCD to ensure reliable projections continue to be made. If there are "significant" negative trends in POPCD, other corrective actions may also be necessary (e.g., chemical cleaning to reduce noise, other actions to reduce noise in the ECT, . . .).

NRC Question 17

Regarding Table 7, please confirm that the number of data points in the POPCD curve for EOC 7 through 12 is only slightly greater than the number of datapoints from EOC 12. Since a number of datapoints should be present from year to year, the staff would

have expected a large number of data points for the EOC 7 through 12 composite curve and a significantly less number of datapoints for any one cycle (unless a significant number of new indications were identified in EOC 13).

TVA Response

As noted in the following paragraph, there is a large difference in the number of data points between EOC-7 to EOC-12 and only EOC-12. However, Table 7 has erroneously entered the POPCD parameters for EOC-8 to EOC-12 for EOC-12 parameters. The "Corrected Table 7" is attached (see page E1-24) and shows the correct differences in the number of points as discussed below. The POPCD plot for EOC-12 in Figure 4 of the submittal is correct.

The number of data points for EOC-7 to EOC-12 (Table 4 of submittal) is 4524 for detection at EOC_n and 1869 for no detection at EOC_n where the corresponding values for only EOC-12 (Table 6 of submittal) are 1494 and 361. These data represent a large number of data points for the EOC-7 to EOC-12 data and a significantly smaller number of data points for Cycle 12 alone.

NRC Question 18

Please confirm that no adjustment to the voltage growth rate distribution is performed when the average growth rate decreases from one cycle to the next.

TVA Response

As noted in Section 4.2, page E4-15 of the POPCD submittal, the incremental increase in average growth rate will be implemented when the average growth rate shows an increase for the just completed cycle. The intent of this statement is that the adjustment is made only when the average growth rate increases from one cycle to the next, and no adjustment is performed when the average growth rate decreases. This is further noted in the step-by-step description of developing growth rates given in the response to RAI-22.

NRC Question 19

In the benchmark analysis, you used the composite POPCD curve from Cycle 7 through 12. This does not appear to be appropriate since some of the data was not present at the time of the inspections (and using "future" data to predict past trends would normally be expected to provide reasonable results). As a result, please repeat the benchmark analysis with POPCD data

available at the time the inspections were performed (use of the latest burst and leakage correlations and actual cycle lengths is acceptable). In addition, this benchmarking should not include the datapoint that exhibited "extreme voltage growth" since actions were taken to limit the possibility of such extreme voltage growths and inclusion of this datapoint can skew the results. This datapoint should not be included in the beginning of cycle voltage distribution or the growth rate data (i.e., the average growth rate or the distribution of growth rates). As part of this benchmarking analysis, please include an analysis of the EOC 14 inspection data completed in Fall 2006. Please include in this response the database used for assessing the integrity of the tubes, the actual cycle length, and the cycle length assumed in the benchmarking analysis. Lastly, discuss whether there has been any significant preventive plugging of tubes such that the benchmarking analysis (or growth rate distributions) may have been skewed.

TVA Response

As discussed in page E4-20 of the submittal, the SQN-2 composite POPCD was used for all prior cycles since the industry POPCD for these cycles (required per Section 3.3, pages E4-10 and E4-11 when inadequate plant specific data are available) is essentially the same as the Sequoyah POPCD. Figure 19-1 (see page E1-33) shows the comparison of the industry Addendum 5 POPCD with the SQN-2 POPCD. It is seen that these two distributions are essentially the same with the larger uncertainties in the SQN-2 POPCD leading to a lower 95 percent POPCD slightly smaller than the industry POPCD below about 0.2 volt and a slightly higher POPCD above about 0.3 volt. Page E4-39, Figure 5 compares the SQN-2 POPCD with the industry POPCD updated to the time of the SQN-2 POPCD submittal. In this case, the lower 95 percent SQN-2 POPCD is in excellent agreement with the industry POPCD. It is noted in Table 7-4 of the January 12, 2007 TVA submittal that there is essentially no change in the industry POPCD data between Addenda 4 and 5. Since the industry POPCDs for Addenda 4 to 6 and the SQN-2 POPCD are essentially the same and burst pressures or leak rates are not sensitive to small changes in POD, there was no need to change the POPCD distribution between the projected EOC-11 to EOC-13 predictions in Table 9, page E4-33.

To numerically demonstrate the negligible influence of small differences in POD, the EOC-13 projections were repeated using the Addendum 5 POPCD. The results are shown in the lower part of Table 19-1 (see page E1-33), where the projected leak rates, number of indications, and maximum volts are essentially unchanged by the change in POPCD. Small differences are seen in the burst probabilities with the SQN-2 POPCD yielding slightly lower burst probabilities, which is likely due to the modest increase in the SQN-2 POPCD above about 0.3 volt. For benchmarking, the objective is to demonstrate margins over the as-found conditions. This objective is satisfied by both the SQN-2 and Addendum 5 POPCD distributions. The use of the SQN-2 POPCD is thus more realistic than using the Addendum 5 POPCD since it yields slightly smaller burst probability margins. The Addendum 5 POPCD would be the required benchmarking POD for EOC-13 projections if there were significant differences from the SQN-2 POPCD. The Addenda 4 and 5 industry POPCDs would have been the required POPCD distributions for projecting Cycles 11 and 12, respectively. The negligible differences in burst pressures and leak rates between applying the Addendum 5 POPCD and the SQN-2 Cycles 7-12 POPCD together with the negligible differences in POPCD between Addendum 4 and Cycles 7-12 support the use of the Cycles 7-12 POPCD for all benchmarking analyses in Table 8 of the submittal. The actual cycle length in EFPD is compared to the length of time in the analyses in Table 19-5 (see page E1-27). EOC-11 used the actual time, and the other cases used the times that were used in the predictions in the respective 90-day reports.

The benchmarking analyses for Cycles 13 and 14 are performed including and not including the one large growth rate of 5.67 volts/effective full power year found for Cycle 12 for a comparison of the resulting POB and leakage. It is appropriate to exclude the large growth rate because of the preventive measures discussed in RAI-4. In this case, the bobbin voltages grew at modest rates from 1.06 volts at EOC-7 to 1.98 volts at EOC-11. The indication was not +Point inspected prior to the large 9.76 volts found at EOC-12. The indication would have been +Point inspected at EOC-11 based on the preventive repair guideline currently being applied to inspect all bobbin DSI indications greater than 1.7 volts. It is not clear that a +Point inspection at EOC-11 would have led to a +Point amplitude greater than 1.9 volts that would have required repair. The results are shown at the bottom of Table 19-1 (see page E1-24). It is seen that exclusion of the high growth rate value reduces the burst probabilities and leak rates although the EOC-13 projections remain conservative compared to the as-found results.

Table 19-2 (see page E1-26) provides the EOC-14 projections and as-found results at EOC-14 for projections with and without the large growth rate found in Cycle 12. The columns in the table identify the ARC burst and leak rate correlations, the growth rate used, and the POPCD used in the analyses. The EOC-14 projections with the large growth rate included are the projections given in Table 9 of the submittal. The projections are based on a Cycle 14 length of 545 days where the actual cycle length was 537.1 days. The observations from the comparison are as follows:

1) The number of indications is underpredicted when POPCD is used. The extent of the underprediction is shown in Table 19-3A (see page E1-26).

2) Using POPCD, leakage is conservatively predicted for all SGs. The results using the reduced growth rate are much closer to the as-found results.

3) Using POPCD and the large growth rate due to the large indication at EOC-12, POB is conservatively predicted for all SGs.

4) Using POPCD and the growth rate obtained by ignoring the large indication at EOC-12, POB is conservatively predicted for SGs 1, 2, and 3, and is underpredicted by 1.11×10^{-4} using the reported DSIs. This is an underprediction of one tenth of the value for considering method revision (0.001) in the Diablo Canyon TS as approved by NRC.

Based on these observations, the underprediction of the number of indications was investigated. It was noted that the definition of what would be called a DSI was changed in the EOC-14 inspection from the definition used previously. In EOC-14, a bobbin indication that appeared to be inside diameter (ID), and was either RPC inspected and found to be NDD or was reviewed by history to be unchanged and previously RPC tested as NDD, that indication was considered to be a DSI and included in the indication count and the integrity and leakage analysis. Table 19-3B (see page E1-26) shows what the indication count at EOC 14 would have been if the definition of a DSI were unchanged from EOC-13. This table shows that the underprediction would be significantly less, and within the limits specified (15 percent or 150 indications) in the Diablo Canyon TS as approved by NRC. The probability of burst and leakage were recomputed for EOC-14 results using the revised indication population. It is seen in Table 19-4 (see page E1-27) that the results are slightly but not significantly more favorable. This is because the probability of burst and leakage are very dependent on the largest indications which were not affected by the revision.

It is expected that this change in definition will result in a one-time step change in the number of indications so the predictions for EOC-16 and beyond will not continue to show this level of underprediction. The projections of record for EOC-15 were made in the 90-day report using the approved POD of 0.6. Projections are planned to be made for EOC-15 for benchmarking purposes using the approved POPCD prior to EOC-15. It is expected that POPCD may be used for the projections of record from EOC-16 forward.

There were only 13 tubes preventively plugged at EOC-12 and EOC-13. These are properly treated as plugged tubes in the benchmark projections and the EOC actuals include the influence of all plugging at the prior EOC. The growth rate from EOC_{n-1} to EOC_n includes the growth for all tubes plugged at EOC_n. The growth rate from EOC_n to EOC_{n+1} would not include the growth for any tubes plugged at EOC_n.

NRC Question 20

Regarding your continuing assessment of the inspection results, please confirm that an assessment will be performed for any underpredictions in order to assess the probable cause. As currently written, it is not clear to the staff whether the assessments would only be performed when the quantitative criteria listed in Section 7.0 of your submittal are exceeded. In addition, please confirm that the assessment of the underprediction of the number of indications will include the potential need to increase the number of indications regardless of whether the indications that need to be increased are low or high voltage. Lastly, please confirm that you will provide an update (based on the results of your inspection) to Table 7 for the composite and one-cycle POPCD curve for SQN-2 in your 90-day report.

TVA Response

As noted in the first bullet of Section 7.0, page E4-22, an assessment of the probable cause for any underpredictions, including potential corrective actions and potential changes to probability of detection and or growth methodology, will be included in the 90-day report. This assessment is expected to be qualitative and no changes in ARC analysis methods are expected to be immediately implemented in operational assessments. An assessment of the potential need to revise the ARC analysis methods will be performed if the underpredictions in burst probability or leak rate exceed the values given in the second bullet in Section 7.0. This assessment is expected to include quantitative evaluations of proposed changes to the analysis methods that might be immediately implemented in the operational assessment.

As noted in the third bullet of Section 7.0, an assessment will be made of the need to increase the number of predicted low voltage indications if the total number of as-found indications is underestimated by greater the 15 percent or by greater than 150 indications. This guidance is based on the small influence of low voltage indications on burst probability and leak rates. An underprediction of high voltage indications leading to an underprediction of burst probability or leak rate would lead to the assessments of growth rates and POD required by the first or second bullet of Section 7.0.

TVA will provide an update (based on the results of each inspection) to Table 7 for the composite and one-cycle POPCD curve for SQN-2 in the 90-day report.

NRC Question 21

On page E1-5, you indicate that upon approval of the POPCD methodology the growth rates used in the operational assessments will be obtained as the bounding growth rate of the SGs and the composite average growth over the last two cycles of operation. Please clarify this statement. For example, is the composite average growth, the composite from all SGs over one cycle (or two cycles)? If the composite is from all SGs, discuss whether it is necessary to assess whether the average growth rate from one SG is increasing at a rate greater than the other SGs (implying that this SG may need a larger increase in the average growth rate than the "composite" growth rate would suggest).

TVA Response

The average growth rates for each SG for the past three cycles are shown in Table 21-1 (see page E1-28). Several observations can be made. First, the average growth rates are small, with one exception below 0.1 volt/EFPY; second, growth rates increase and decrease for each SG; and third, the SG with the largest average growth in one cycle is not the one with the largest average growth in the next cycle. The increase in average growth rate for each SG based on Table 21-1 is shown in Table 21-2 (see page E1-28). It is seen that the increase in average growth rate between Cycles 12 and 13 is negative for three of the four SGs. The increase in average growth rate between Cycles 13 and 14 is positive, but less than 0.1 volts/EFPY, for all four SGs. It may also be noted that SG 3 that had the highest increase in average growth in Cycle 13 had the lowest increase in growth in Cycle 14.

The benchmark cases run for RAI-19 did not add a growth rate adjustment ("Delta Volts Adjustment") because the average increase in growth rate was so small. In order to evaluate the impact of a small growth rate adjustment, the prediction for SG 4 EOC-14 was recalculated with a growth rate adjustment of 0.1 volts/EFPY which bounds the increases in Table 21-2. The comparison of the results reported in Table 19-2 (see page E1-26) and those with the growth rate adjustment is shown in Table 21-3 (see page E1-28). The POB for this case has increased with this adjustment to a conservative prediction relative to the as-found results.

Because the average growth rates are small, but variable, the bounding approach to developing the growth rate distribution to be used for predictive analyses is considered appropriate for SQN-2. An approach which will increase the likelihood of a conservative prediction is to add the growth rate adjustment prior to determining the bounding growth rate distribution.

The SQN-2 guidelines for developing growth rates are changed from those given in Section 4-2 (page E4-15). Upon implementation of POPCD, if the average growth rate for any SG shows an increase for the just completed cycle compared to the prior cycle, the incremental increase in average growth per EFPY will be added to each point in the growth rate distribution for that SG.

A bounding curve that envelopes the adjusted growth rate distributions for each SG for the last two cycles is the bounding growth rate distribution to be used for the operational assessment predictions. As discussed in RAI-22, voltage dependent growth (VDG) will be applied on a SG specific basis for the SGs showing VDG (only when it is conservative) with the bounding growth distribution (determined from SGs without VDG) applied for the other SGs. Similarly, if one SG develops a significantly greater growth rate than the others, a SG specific growth rate distribution will be used for this SG with the bounding growth rate distribution of the other SGs applied to the other SGs. This approach will provide a conservative growth rate distribution, without the excessive conservatism of applying the bounding growth rate adjustment to the bounding growth rate distribution.

NRC Question 22

Please provide a step-by-step description of the rationale that will be used for selecting the growth rate distribution and the POPCD curve used in the EOC projections. Please confirm that this methodology was used in performing the benchmarking analysis. If not, please justify any differences. Please confirm that voltage dependent growth is assessed on a SG basis rather than just a composite of all SGs.

TVA Response

The step-by-step process to be applied for developing the growth rate distribution used in EOC projections upon NRC approval for implementing POPCD is given below:

1. Prepare cumulative probability distribution function (CPDF) curves for each SG for each of the last two cycles. When POPCD is applied, then either steps 1a or 1b are applicable:

a. If the NRC has not approved the extreme growth modeling, then all growth rate data from the last two cycles will be included in the assessment.

b. If the NRC has approved the extreme growth modeling, than any growth rates greater than 5 volts/EFPY are to be excluded from these distributions and included in the extreme growth distribution, subject to possible future NRC limitations on the extreme growth methods.

2. For each curve selected from Step 1, analyze the growth curve for signs of VDG. In general, only the last cycle growth rates need to be evaluated for VDG since the prior cycle would have previously been evaluated for VDG.

   a. Plot the individual growth data on a "scatter" chart with beginning of cycle (BOC) voltages on the x-axis and voltage growth rates on the y-axis. Perform a simple linear regression on these data. If the slope is greater than about 0.1, then VDG should be considered in the operational assessment projection for the next cycle. If the slope is less than or equal to zero, then there is no evidence of VDG. If the slope is only slightly positive (between 0.0 and 0.1), then engineering judgment should be used to determine if VDG needs to be included in the analyses. Engineering judgment decisions should consider the results of the previous POB and leak rate predictions to determine appropriate actions if underpredictions occur, and should consider the affects of potential preventative plugging below the repair limit. In some cases, it may be necessary to perform POB and leak rate sensitivity calculations to determine which growth curve is limiting (voltage dependent or independent).

   b. For each curve in which VDG is apparent, determine how many growth bins to use and the appropriate breakpoints by performing piecewise regression analysis in accordance with Section 10.3 of the ARC database Addendum 6 (Reference 1).

3. When POPCD is applied, determine the need for a growth rate adjustment ("Delta Volts Adjustment") to account for potentially increasing growth rates, per the following steps:

   a. Determine the average growth rate for each SG. If there is VDG, the average growth rate for each cycle on VDG growth bin should be determined. This process is applied for the last two cycles (Cycles n and n-1). When determining the average growth rates, it is acceptable to include the negative growth rates (in lieu of setting the negative growth rates to zero).

b. If an extreme voltage growth rate (greater than 5 volts/EFPY) has occurred during either cycle, it should be included or not included as discussed in Step 1.

c. If the average Cycle n growth is greater than the average Cycle n-1 growth for any SG or any VDG bin, then the difference should be added to each of the individual growth rates in the growth rate distribution and any VDG distributions for any VDG distribution for that SG if found necessary from Step 2.

d. If the average Cycle n growth is less than the average Cycle n-1 growth, then no adjustment is performed.

4. For SGs that do not show VDG, select a growth curve that bounds all SG curves including the “Delta Volts Adjustment” for the last two cycles. Since the curve bounds all other growth rates for the last two cycles of operation, it will be the limiting curve relative to projecting leakage and probability of burst for these SGs. In some cases, however, Step 2 may show that it may be necessary to perform analyses for voltage-dependent growth to determine which growth curve is limiting for an SG. In such cases with VDG, it may also be necessary to perform POB and leak rate sensitivity calculations using the different growth curves to determine which curve is limiting. VDG will be applied on a SG specific basis for the SGs showing VDG (only when it is conservative) and a bounding growth distribution (determined from the SGs without VDG) applied for the other SGs as discussed in 3.c above. Similarly, if one SG develops a significantly greater growth rate than the others, a SG specific growth rate distribution will be used for this SG and the bounding growth rate distribution determined from the other SGs applied to the other SGs. For this guideline, the conservative approach of selecting the limiting growth curve regardless of the number of indications in the SG-specific growth distribution is applied so ARC guidelines on minimum numbers of indications in a growth curve do not need to be applied.

5. If multiple calculations are performed using different growth rate distributions or POPCD distributions, then the 90-day report should specify the “calculation of record.”

The above steps were considered for developing the growth rates used in the benchmarking analyses. No VDG has been experienced on SQN-2 and the growth rate adjustments are negligible for the benchmark cases run, except as described in RAI-21.

Since the SQN-2 POPCD database will satisfy all requirements for applying a plant-specific POPCD at the next inspection, including EOC-14 data in the POPCD database, the multi-cycle SQN-2 POPCD from EOC-7 to the last completed POPCD update (e.g., POPCD for EOC-14 when the EOC-15 inspection is completed) will be used for operational assessment projections of burst probability and SLB leak rate except if significant trends in POPCD occur. In this case, appropriate adjustments will be made to the POPCD to ensure conservative projections continue to be made. The step-by-step process for updating POPCD for operational assessments is only to update the multi-cycle POPCD to include POPCD analyses from the last completed inspection. As discussed in the response to RAI-19, the SQN-2 POPCD through EOC-12 was used for EOCs-11 through EOC-14 projections since there are negligible differences in the industry Addenda 4 to 6 POPCDs and the SQN-2 POPCD through EOC-12.

NRC Question 23

You indicate that you will address POPCD uncertainties by either applying POPCD at the lower 95 percent confidence level or including an uncertainty analysis for POD in the operational assessment (Section 8.0 of your January 12, 2007 letter). Please clarify whether the "uncertainty analysis for POD in the operational assessment" is equivalent to the uncertainty analysis approved for use at Diablo Canyon (in their approval to use POPCD). If not, please clarify this statement.

In addition, since the POPCD curve is used to calculate the probability of burst under steam line break conditions and the amount of leakage under steam line break conditions, it would appear that an assessment of the adequacy of using the lower 95 percent confidence level to address uncertainty (rather than the Monte Carlo approach approved for use at Diablo Canyon) would be to evaluate the effects of the different approach for modeling uncertainty in the POPCD curves on the structural and leakage integrity of the SG tubes. Please provide this assessment.

Since this is a one-time assessment, please discuss your plans to submit a similar analysis in each of your 90-day reports. In the event that the results using the lower 95 percent confidence level are non-conservative, discuss your plans to use the uncertainty modeling approach approved for Diablo Canyon.

TVA Response

The uncertainty analysis methods applied to obtain the lower 95 percent POD are identical to the uncertainty methods approved for use at Diablo Canyon.

The requested comparison of applying directly the lower 95 percent confidence for the POD with performing the Monte Carlo analysis allowing for variability in the POD and then selection of the 95 percent results should never be necessary and is not included in this RAI response or planned for future 90-day reports. The primary purpose for performing Monte Carlo analyses is to reduce the conservatism in applying individual lower confidence values (deterministic analyses) in the analyses for burst pressures and leak rates. Without this established reduction in conservatism, Monte Carlo calculations would rarely or never be performed. Since the POPCD uncertainties are small due to the large number of data points, the effects of including POPCD uncertainties on burst pressures and leak rates, even at the conservative lower 95 percent POD, are negligible.

In order to illustrate the uncertainties in the SQN-2 POPCD, Figure 23-1 (see page E1-34) shows the POPCD curves for the 50 percent confidence, the 95th percentile lower bound, and the 99th percentile lower bound POPCD for volts greater than 1 volt. It is seen that the curves are quite close. To assess the effect of these differences on probability of burst and leakage, the SG 4 example case which was run with 1 million trials is rerun with the 50 percent confidence and with the 99-percent lower-bound POPCD curves. The results are shown in Table 23-1 (see page E1-28). It is seen that compared to the 50 percent confidence POPCD, the 95 percent confidence POPCD results in a slight increase in the number of indications, leak rate and POB. However, compared to the 95 percent confidence POPCD, the 99 percent confidence POPCD results in a small increase in the number of indications, no increase in the leak rate, and a small decrease in the POB. From these results, it is seen that the POPCD uncertainties have a negligible effect on the burst and leakage predictions; and therefore, a refinement in the methodology to include the POPCD uncertainties in the Monte Carlo process is unwarranted.

The Industry POPCD curve presented in Figure 1 and Figure 5 and expanded in Figure 5-1 (see page E1-30) is not the Addendum 5 curve used in the benchmark analyses. The Figure 1 curve is described in the submittal as "essentially the same as reported in Addendum 6." Later, Figure 5 curve (the same as Figure 1) is described as "industry POPCD updated to the time of the Sequoyah 2 POPCD submittal." The Addendum 5 curve is shown in Figure 19-1, and described as "Figure 19-1 shows the comparison of the industry Addendum 5 POPCD with the SQN-2 POPCD. It is seen that these two distributions are essentially the same with the larger uncertainties in the SQN-2 POPCD leading to a lower 95 percent POPCD slightly smaller than the industry POPCD below about 0.2 volt and a slightly higher POPCD above about 0.3 volt. "

An expanded view of Figure 19-1 is shown as Figure 19-2 (see page E1-34). Figure 19-2 shows that the POPCD used in the benchmark analyses for 95th percentile Addendum 5 is slightly more conservative than the 95th percentile SQN-2 specific curve. Note that in Table 19-1A, the leakage and number of indications are very slightly more conservative for the Addendum 5 cases indicating that the Addendum 5 curve is a slightly more conservative POPCD.

The POB values, because they are so small, are somewhat variable because of the Monte Carlo analysis process.

Therefore, it is not inconsistent that the slightly lower POPCD curve results in a slightly more conservative result.

Compared to the PWSCC ARC that was implemented for Diablo Canyon, the application of a 95th percentile POPCD is very different. For example, consider a 3-volt indication and assume the indication was plugged. As seen in Figure 23-1 (see page E1-34), the mean POPCD is 0.97, and the 95th percentile is 0.96. A POD of 0.97 in the ARC analysis means that for every 100 Monte Carlo trials of the population in the SG, there will be 3 indications that are to be included in the analysis. If uncertainties are applied (symmetric about the mean), sometimes the POD will be a little higher and sometimes it will be a little lower. At the end of the analysis, the number of 3-volt indications considered will be 3/100 times the number of Monte Carlo trials.

At the 95th percentile level of POPCD, the POD is 0.96 which means that in the ARC analysis there will be 4 indications for every 100 Monte Carlo trials. Since this is constant, at the end of the analysis the number of 3-volt indications considered will be 4/100 times the number of Monte Carlo trials. The more 3-volt indications considered in the analysis, the more likely one will have a greater probability of burst and leakage, and the more frequently a larger number of large indications contribute to the total leakage. Therefore, it is apparent that using the 95th percentile POPCD is conservative compared to using the mean with uncertainties.

Given that the bases for performing Monte Carlo analyses is to reduce projected burst and leak rate results relative to deterministic analyses such as directly applying the lower 95 percent POPCD curve, there are no plans to include sampling of

POPCD uncertainties in operational assessments such as applied for Diablo Canyon.

Supplemental Information

Since the submittal was prepared, additional data was obtained from the EOC-14 inspection enabling the construction of POPCD which includes the latest data. This cumulative data is shown in Table 10 (see page E1-38) for the EOC-13 POPCD with data through EOC-14. The log-logistic data fit parameters are given in Table 11 (see page E1-39) and the comparison of the EOC-12 POPCD which has been used in the benchmarks and the EOC-13 POPCD are shown in Figure 25-1 (see page E1-35) with an expanded view in Figure 25-2 (see page E1-36). The EOC-13 POPCD is slightly lower than the EOC-12 POPCD because of the increased number of "new" indications in EOC-14 due to the change in the DSI definition.

Reference

1. EPRI Report NP 7480-L, Addendum 6, 2004 Database Update, "Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates Database for Alternate Repair Limits," October 2004.

Corrected Table 7. Sequoyah-2 and Industry POPCD Log Logistic Distribution Parameters

Parameter	Sequoyah-2 POPCD at EOC-7 to EOC-12	Sequoyah-2 POPCD At EOC-12	Industry POPCD 30 Inspections
Number of Data Points	6393	1845	46454
b_0 (Intercept)	1.9947	2.3727	1.9628
b_1 (Slope)	2.9920	2.6592	3.1433
V_{11}	3.530E-03	1.467E-02	3.742E-04
V_{12}	6.826E-03	2.767E-02	7.215E-04
V_{22}	1.728E-02	6.962E-02	2.077E-03

Table 19-1
Additions to Table 8. Sequoyah-2 Prior Cycle Benchmarking Results for POPCD

Projected Outage	SG	Projected Results POB	Projected Results Leak Rate	Projected Results No. Ind.	Projected Results Max. Volts(1)	As Found Results POB	As Found Results Leak Rate	As Found Results No. Ind.	As Found Results Max. Volts(1)	POB & Leak Rate Correlations	Growth Rate Used	POD Used
EOC-13 Projections Reported in Table 8 of POPCD Submittal, 250,000 trials												
EOC-13	1	1.05×10^{-3}	0.421	342	8.5	1.90×10^{-5}	0.0724	294	1.95	Addendum 5 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycles 11 & 12, Fig. 3-16, Ref. 8 including largest growth rate.	Seq.-2 POPCD
	2	1.02×10^{-3}	0.429	342	8.5	3.10×10^{-5}	0.0769	305	1.97			
	3	1.23×10^{-3}	0.574	406	8.7	5.26×10^{-5}	0.224	412	2.36			
	4	2.78×10^{-3}	1.230	969	8.8	9.24×10^{-5}	0.285	836	1.74			
EOC-13 Projections Revised for Changes in Growth Rate and POPCD, 250000 Trials												
EOC-13	1	9.72×10^{-5}	0.222	342	3.6	1.90×10^{-5}	0.0724	294	1.95	Addendum 5 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycles 11 & 12, Fig. 3-16, Ref. 8 without largest growth rate.	Seq.-2 POPCD
	2	9.72×10^{-5}	0.240	342	3.6	3.10×10^{-5}	0.0769	305	1.97			
	3	1.40×10^{-4}	0.355	406	3.8	5.26×10^{-5}	0.224	412	2.36			
	4	2.26×10^{-4}	0.722	969	3.9	9.24×10^{-5}	0.285	836	1.74			
EOC-13	1	1.30×10^{-4}	0.220	345	3.6	1.90×10^{-5}	0.0724	294	1.95	Addendum 5 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycles 11 & 12, Fig. 3-16, Ref. 8 without largest growth rate.	Add. 5 POPCD
	2	7.28×10^{-5}	0.238	345	3.6	3.10×10^{-5}	0.0769	305	1.97			
	3	2.17×10^{-4}	0.352	409	3.8	5.26×10^{-5}	0.224	412	2.36			
	4	2.67×10^{-4}	0.722	978	3.9	9.24×10^{-5}	0.285	836	1.74			

Notes:
1. Voltage where projected tail accumulates to 0.3 ind.

Table 19-1A
Additions to Table 8. Sequoyah-2 Prior Cycle Benchmarking Results for Additional Monte Carlo Trials

Projected Outage	SG	Projected Results				As Found Results				POB & Leak Rate Correlations	Growth Rate Used	POD Used
		POB	Leak Rate	No. Ind.	Max. Volts[1]	POB	Leak Rate	No. Ind.	Max. Volts[1]			
EOC-13 Projections Revised for 1 million trials												
EOC-13	1	8.65×10^{-5}	0.218	342	3.6	1.90×10^{-5}	0.0724	294	1.95	Addendum 5 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycles 11 & 12, Fig. 3-16, Ref. 8 without largest growth rate.	Seq.-2 POPCD
	2	7.33×10^{-5}	0.236	342	3.6	3.10×10^{-5}	0.0769	305	1.97			
	3	1.32×10^{-4}	0.348	406	3.8	5.26×10^{-5}	0.224	412	2.36			
	4	2.29×10^{-4}	0.715	969	3.9	9.24×10^{-5}	0.285	836	1.74			
EOC-13	1	7.66×10^{-5}	0.220	345	3.6	1.90×10^{-5}	0.0724	294	1.95	Addendum 5 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycles 11 & 12, Fig. 3-16, Ref. 8 without largest growth rate.	Add. 5 POPCD
	2	8.10×10^{-5}	0.236	345	3.6	3.10×10^{-5}	0.0769	305	1.97			
	3	1.57×10^{-4}	0.352	409	3.8	5.26×10^{-5}	0.224	412	2.36			
	4	2.16×10^{-4}	0.722	978	3.9	9.24×10^{-5}	0.285	836	1.74			

Notes:
1. Voltage where projected tail accumulates to 0.3 ind.

Table 19-1B
Additions to Table 8. Sequoyah-2 Prior Cycle Comparison of Results for Additional Monte Carlo Trials

Projected Outage	SG	1 Million trials			250,000 Trials		
		POB Seq-2 POPCD	POB Add 5 POPCD	Difference as % of Seq 2 POPCD POB	POB Seq-2 POPCD	POB Add 5 POPCD	Difference as % of Seq 2 POPCD POB
EOC-13	1	8.65×10^{-5}	7.66×10^{-5}	11.4%	9.72×10^{-5}	1.30×10^{-4}	-33.7%
	2	7.33×10^{-5}	8.10×10^{-5}	-10.5%	9.72×10^{-5}	7.28×10^{-5}	25.1%
	3	1.32×10^{-4}	1.57×10^{-4}	-18.9%	1.40×10^{-4}	2.17×10^{-4}	-55%
	4	2.29×10^{-4}	2.16×10^{-4}	5.7%	2.26×10^{-4}	2.67×10^{-4}	-18.1%

Table 19-2
Additions to Table 9. Sequoyah-2 EOC-14 Benchmarking Results for POPCD

Projected Outage	SG	Projected Results				As Found Results				POB & Leak Rate Correlations	Growth Rate Used	POD Used
		POB	Leak Rate	No. Ind	Max. Volts	POB	Leak Rate	No. Ind.	Max. Volts			
EOC-14 Projections Reported in Table 9 of POPCD Submittal												
EOC-14	1	$1.73x10^{-3}$	0.400	401	9.3	$8.76x10^{-5}$	0.108	438	2.36	Addendum 6 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycle 12, Fig. 3-16, Ref. 8 including largest growth rate.	Sequoyah-2 POPCD
	2	$1.80x10^{-3}$	0.409	412	9.3	$6.28x10^{-5}$	0.127	507	1.81			
	3	$2.23x10^{-3}$	0.667	531	9.6	$1.35x10^{-4}$	0.266	574	2.27			
	4	$4.57x10^{-3}$	1.12	1116	9.6	$3.55x10^{-4}$	0.484	1228	4.74			
EOC-14 Projections Revised for Changes in Growth Rate												
EOC-14	1	$1.35x10^{-4}$	0.160	401	3.7	$8.76x10^{-5}$	0.108	438	2.36	Addendum 6 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycle 12, Fig. 3-16, Ref. 8 without largest growth rate.	Sequoyah-2 POPCD
	2	$9.24x10^{-5}$	0.161	412	3.6	$6.28x10^{-5}$	0.127	507	1.81			
	3	$2.31x10^{-4}$	0.352	531	4.0	$1.35x10^{-4}$	0.266	574	2.27			
	4	$2.44x10^{-4}$	0.509	1116	4.0	$3.55x10^{-4}$	0.484	1228	4.74			

Table 19-3A

EOC-14 DSI Indications as Reported in 90 Day Report

SG	Reported DSI	Predictions with POD = 0.6 (90 Day Report)	Predictions with POPCD (Table 19-2)	Underpredicted by POPCD	Percent Underpredicted
1	438	489	401	37	8%
2	507	501	412	95	19%
3	574	680	531	43	7%
4	1228	1387	1116	112	9%

Table 19-3B

EOC 14 DSI Indications if EOC-13 Definition of DSI is Used

SG	Revised DSI	Predictions with POPCD	Under/ Over predicted by POPCD	Percent Under/Over predicted
1	403	401	2 under	<1% under
2	455	412	33 under	7% under
3	512	531	19 over	4% over
4	1161	1116	45 under	4% under

Table 19-4

EOC-14 As Found Results for SG 4			
POB	**Leak Rate**	**No. Ind.**	**Max. Volts**
EOC-14 As Reported in 90 Day Report			
$3.55x10^{-4}$	0.484	1228	4.74
EOC-14 Revised to EOC 13 Definition of DSI			
$3.24x10^{-4}$	0.451	1161	4.74

Table 19-5
Cycle Length for Benchmark Analyses

EOC Number	Actual Cycle length, EFPD	Analysis Cycle Length, EFPD
EOC-11	510.35	510.35
EOC-12	501.6	515
EOC-13	470.9	498
EOC-14	537.1	545

Table 21-1

Average Growth Volts/ EFPY			
SG	Cycle 12	Cycle 13	Cycle 14
1	0.0466	0.0456	0.0736
2	0.0699	0.0191	0.0893
3	0.0326*	0.0851	0.097
4	0.0517	0.0358	0.1179
Average	0.0501*	0.0451	0.1012

* Large growth indication removed

Table 21-2

Increase in Average Growth Volts/ EFPY			
SG	Cy12-13	Cy13-14	
1	-0.001	0.028	
2	-0.0508	0.0702	
3	0.0525	0.0119	
4	-0.0159	0.0821	
Average	-0.005	0.0561	

Table 21-3
Effect of Average Growth Addition

Projected Outage	SG	Projected Results				As Found Results				POB & Leak Rate Correlations	Growth Rate Used	POD Used
		POB	Leak Rate	No. Ind	Max. Volts	POB	Leak Rate	No. Ind.	Max. Volts			
EOC-14 Projection From Table 19-2												
EOC-14	4	2.44×10^{-4}	0.509	1116	4.0	3.55×10^{-4}	0.484	1228	4.74	Addendum 6 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycle 12, Fig. 3-16, Ref. 8 without largest growth rate.	Sequoyah-2 POPCD
EOC-14 Projection with 0.1V/EFPY adjustment												
EOC-14	4	3.99×10^{-4}	0.687	1116	4.1	3.55×10^{-4}	0.484	1228	4.74	Addendum 6 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycle 12, Fig. 3-16, Ref. 8 without largest growth rate, with 0.1V/EFPY adjustment	Sequoyah-2 POPCD

Table 23-1
Sensitivity of POPCD Uncertainties on Results
1 Million Trials

Projected Outage	SG	Projected Results				As Found Results				POB & Leak Rate Correlations	Growth Rate Used	POD Used
		POB	Leak Rate	No. Ind	Max. Volts	POB	Leak Rate	No. Ind.	Max. Volts			
EOC-13 Projections, 50% CL POPCD												
EOC-13	4	$2.09x10^{-4}$	0.701	954	3.9	$9.24x10^{-5}$	0.285	836	1.74	Addendum 5 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycles 11 & 12, Fig. 3-16, Ref. 8 without largest growth rate.	Sequoyah-2 POPCD, 50% confidence
EOC-13 Projections, 95% CL POPCD From Figure 19-1A												
EOC-13	4	$2.29x10^{-4}$	0.715	969	3.9	$9.24x10^{-5}$	0.285	836	1.74	Addendum 5 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycles 11 & 12, Fig. 3-16, Ref. 8 without largest growth rate.	Sequoyah-2 POPCD, 95% lower bound
EOC-13 Projections, 99% CL POPCD												
EOC-13	4	$2.05x10^{-4}$	0.715	975	3.9	$9.24x10^{-5}$	0.285	836	1.74	Addendum 5 ΔP_{SLB} = 2405 psi	All SGs: Bounding Cycles 11 & 12, Fig. 3-16, Ref. 8 without largest growth rate.	Sequoyah-2 POPCD, 99% lower bound

Figure 5-1. Sequoyah-2 and Industry 7/8" POPCD above 1.0 Volt

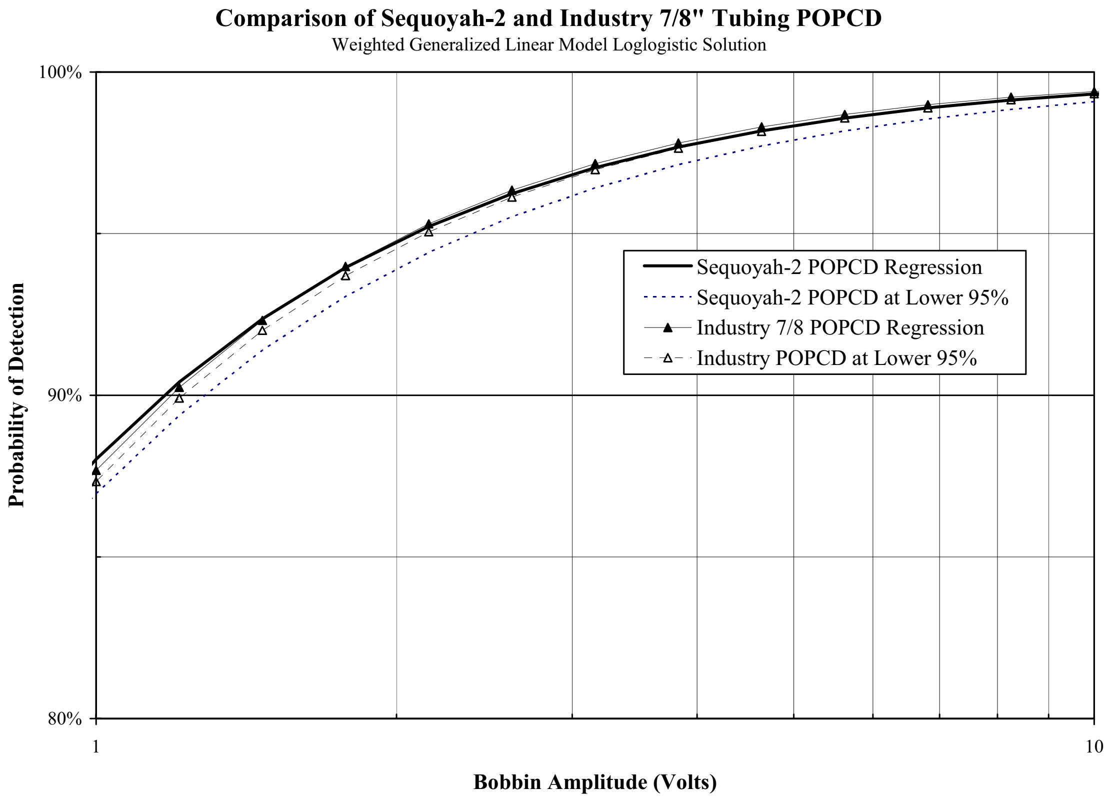


Figure 8-1.

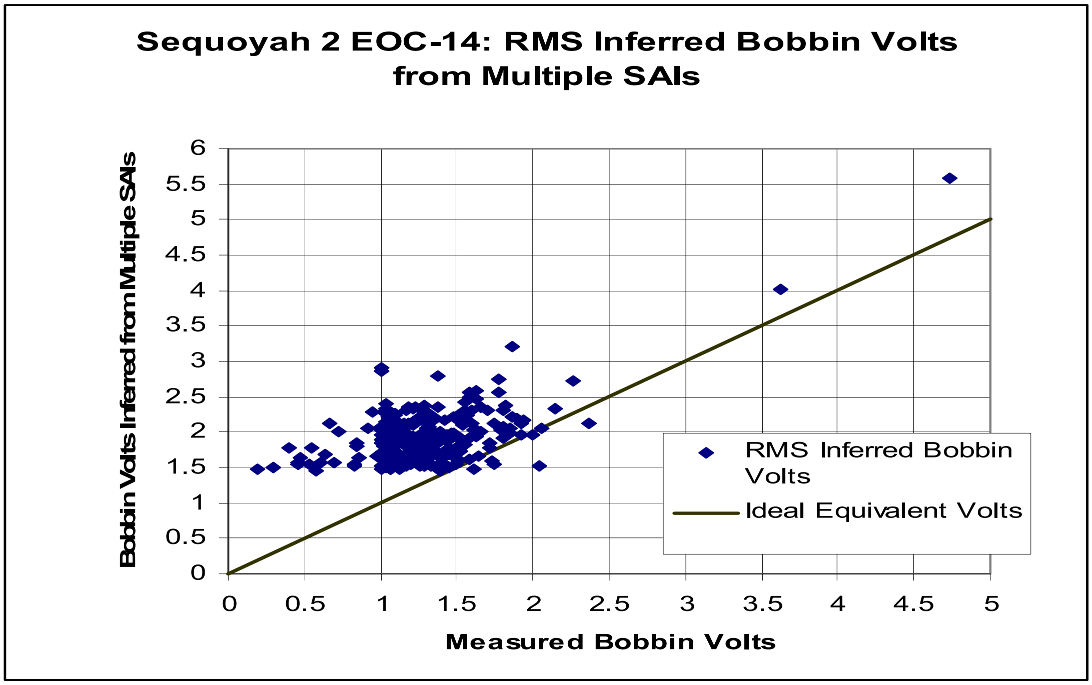


Figure 8-2.

Sequoyah Unit 2 EOC-14 Plus Point Volts to Bobbin Volts Correlation

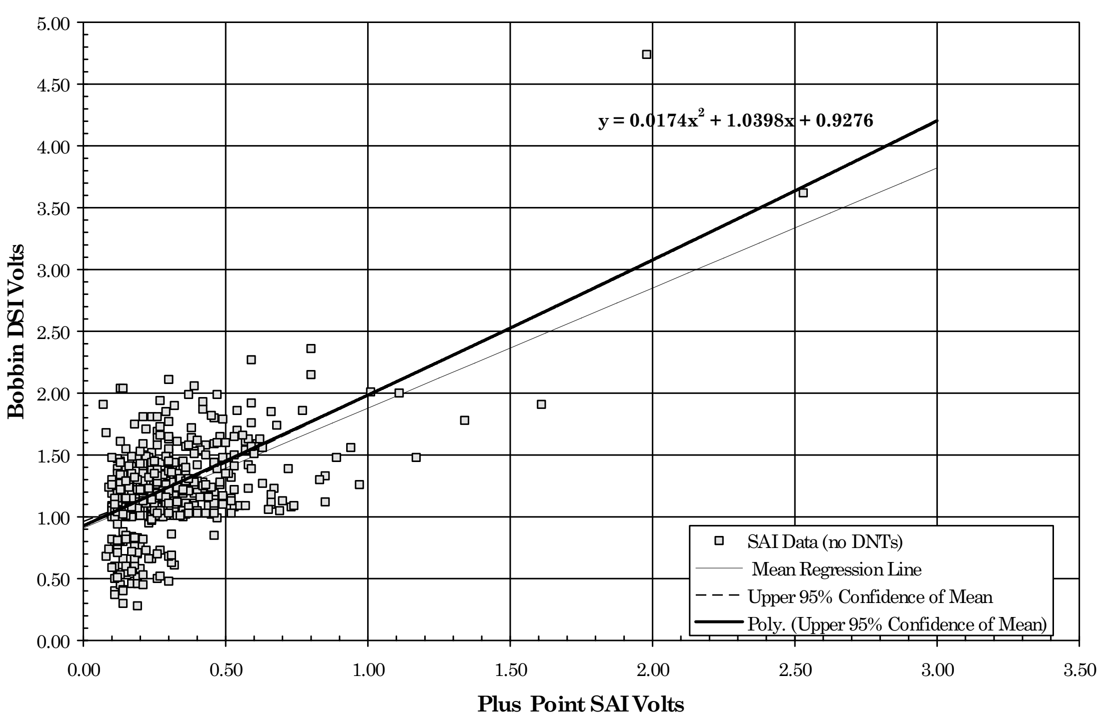


Figure 16-1. POPCD for Sequoyah-2 Cycles 7-12 and Cycle 12 above 1.0 Volt

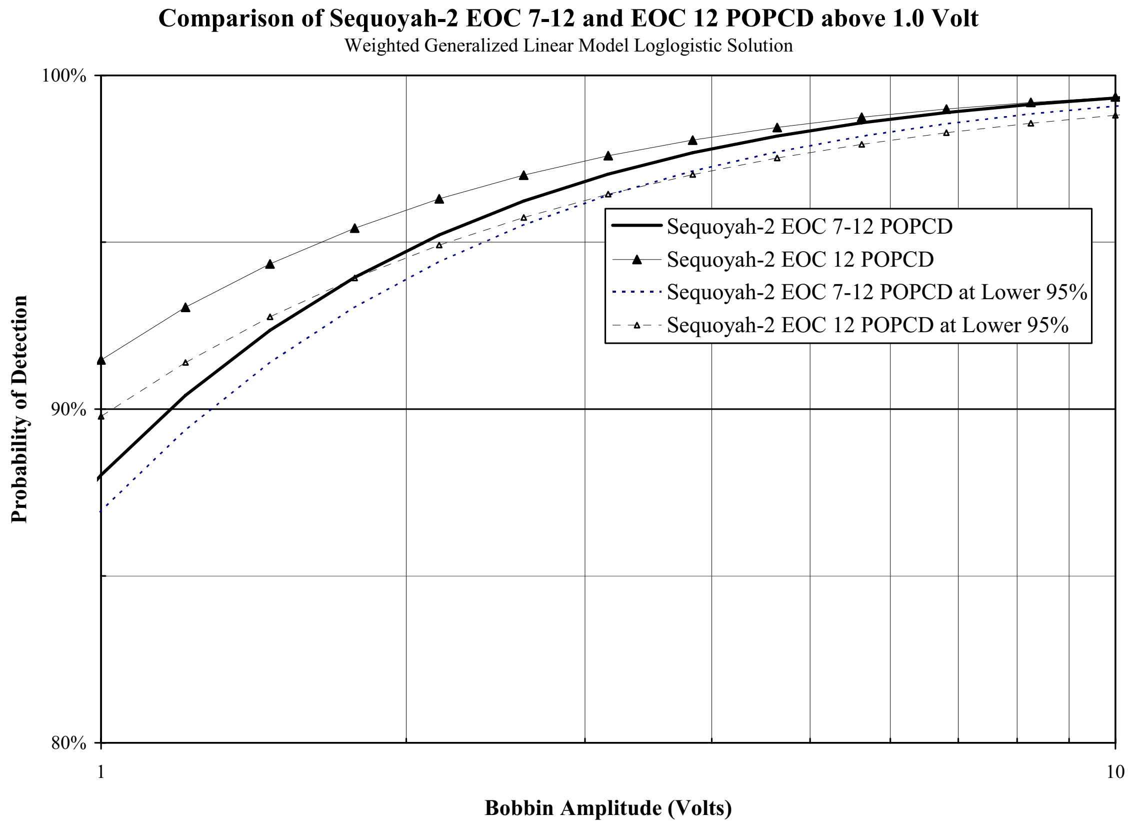


Figure 19-1

Comparison of Generic POPCD for 7/8" Add. 5 & Sequoyah-2 POPCD of Fig. 3

(Weighted Generalized Linear Model Loglogistic Solution - Fractional POD Data Shown for Information Only)

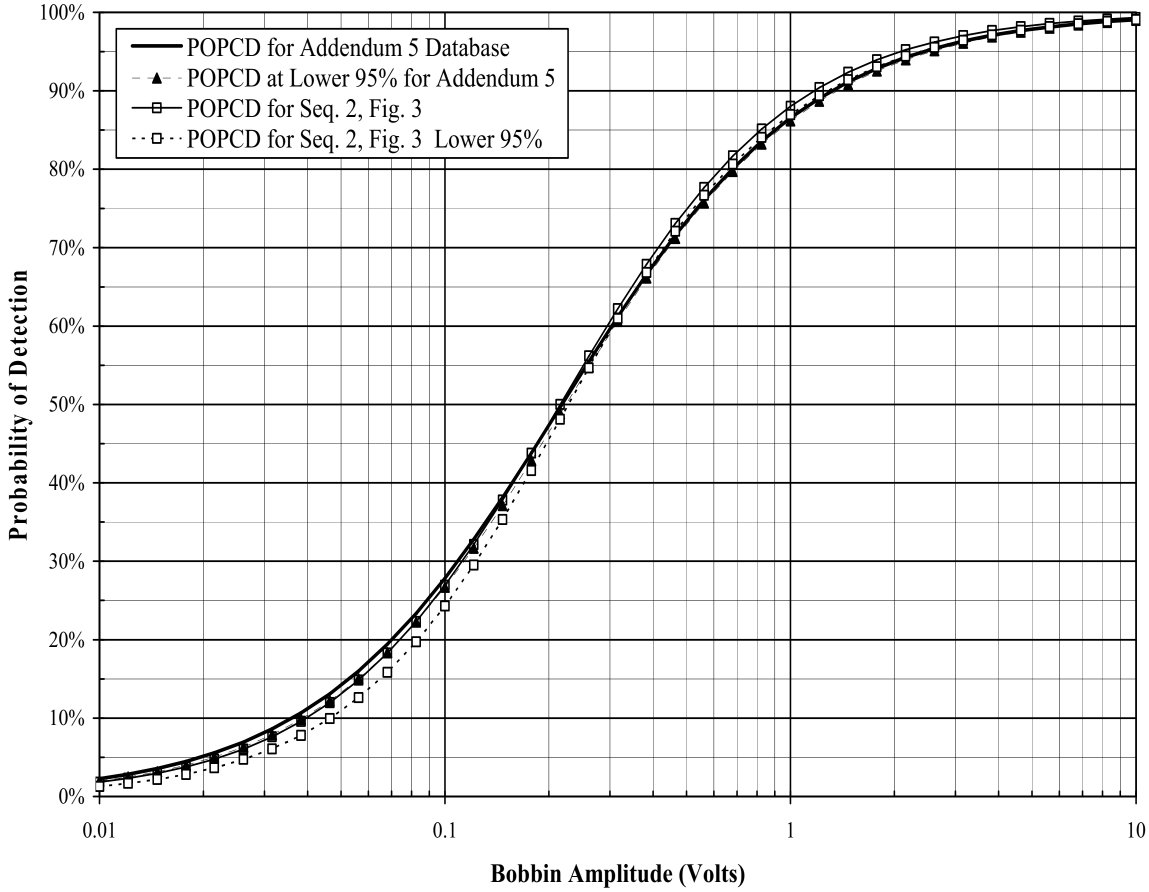


Figure 19-2 Expanded View of Figure 19-1

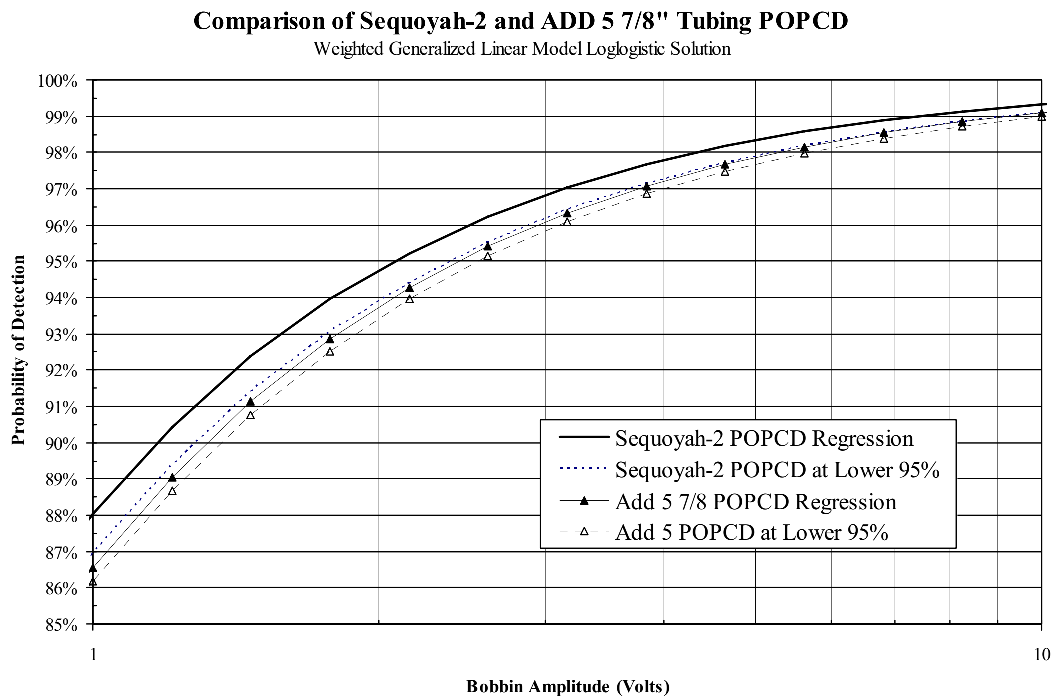


Figure 23-1

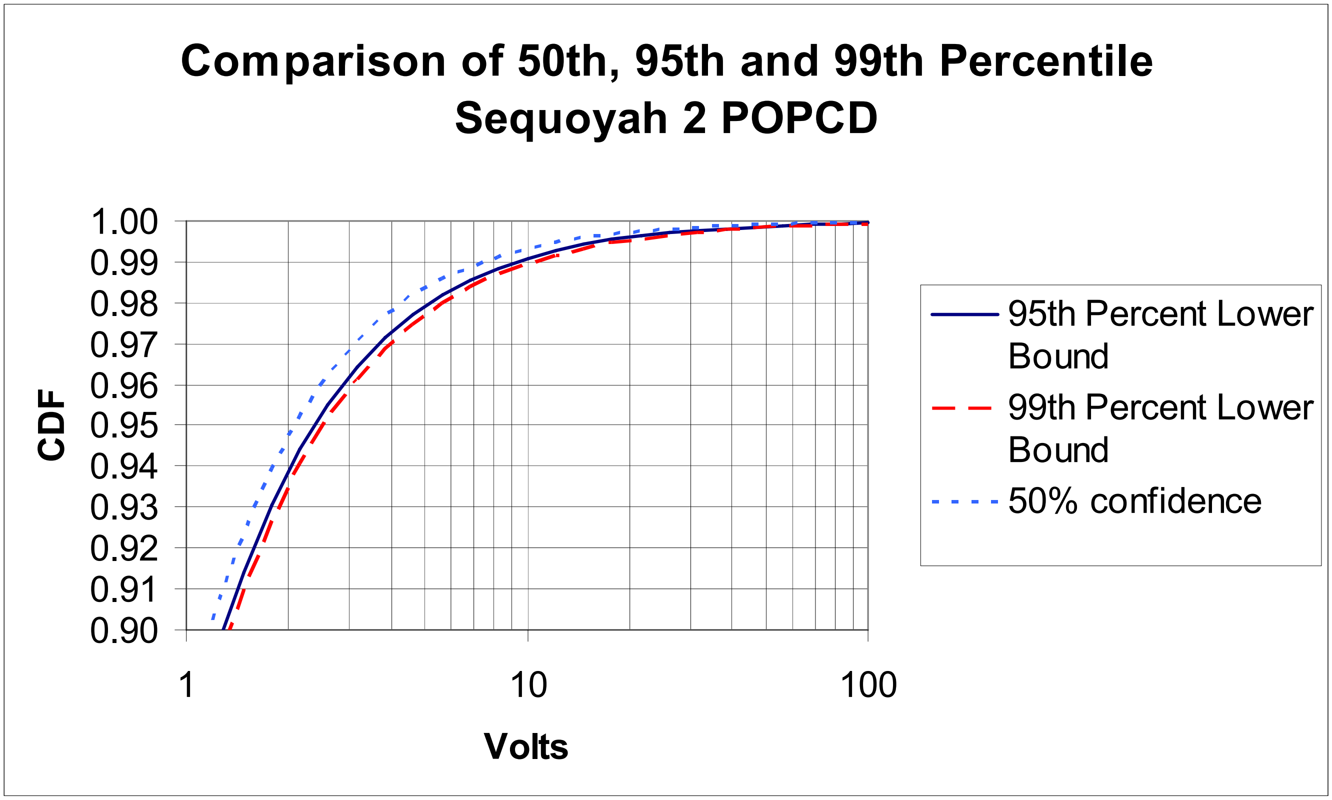
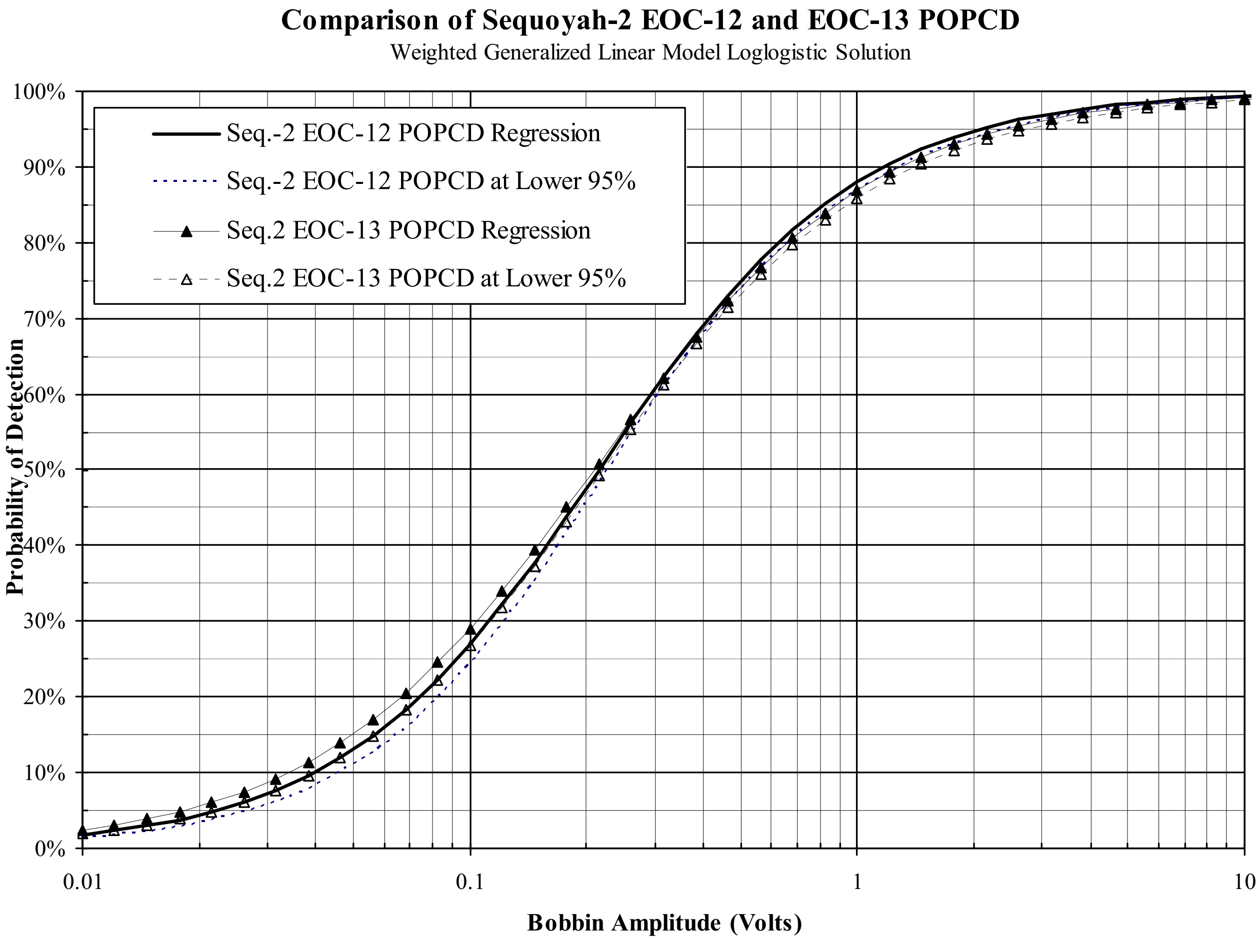

Comparison of 50th, 95th and 99th Percentile
Sequoyah 2 POPCD
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.90
CDF
1
10
100
Volts
95th Percent Lower Bound
99th Percent Lower Bound
50% confidence

Figure 25-1



Comparison of Sequoyah-2 EOC-12 and EOC-13 POPCD
Weighted Generalized Linear Model Loglogistic Solution
Seq.-2 EOC-12 POPCD Regression
Seq.-2 EOC-12 POPCD at Lower 95%
Seq.2 EOC-13 POPCD Regression
Seq.2 EOC-13 POPCD at Lower 95%
Probability of Detection
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.1
1
10
Bobbin Amplitude (Volts)

Figure 25-2

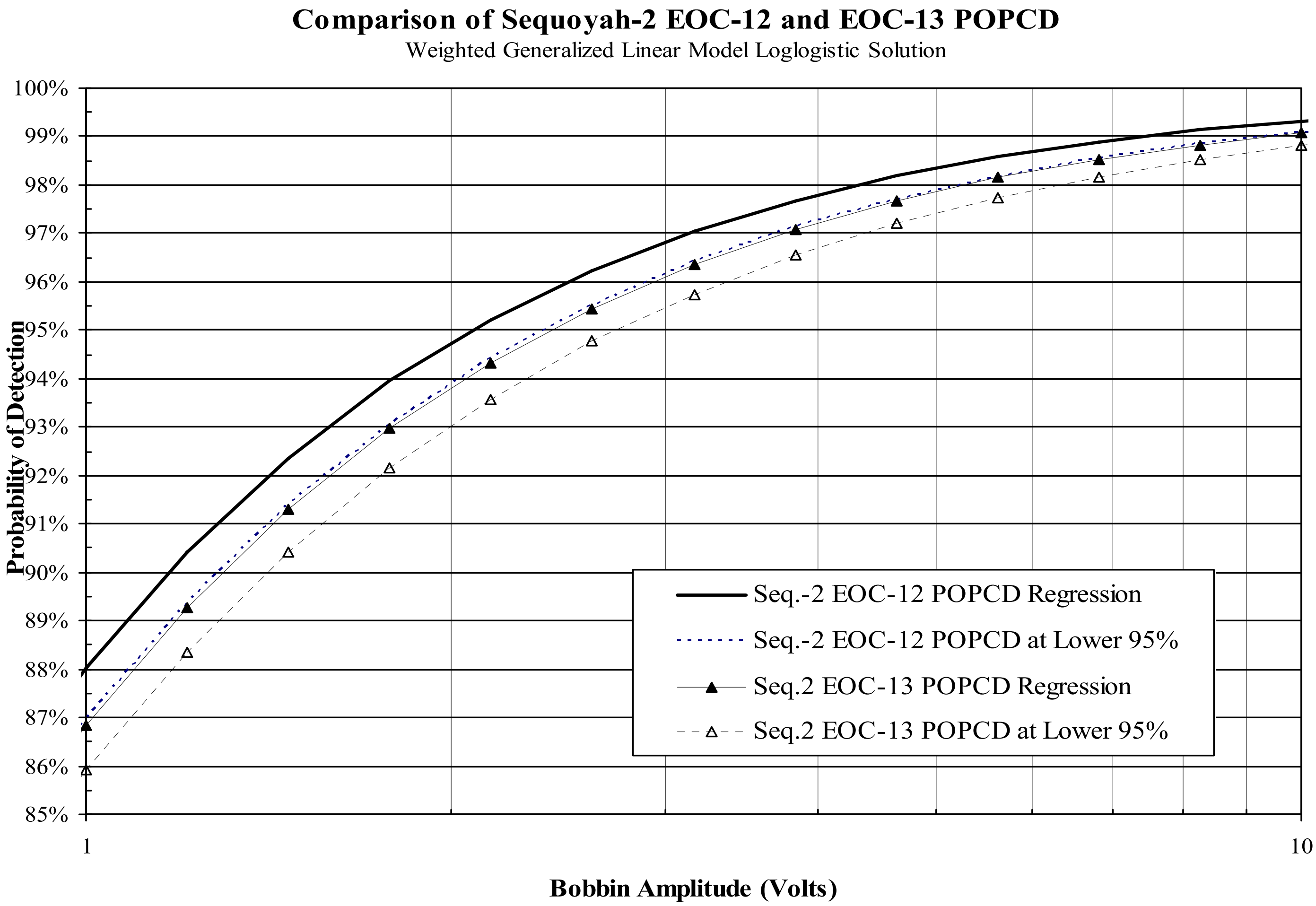

Comparison of Sequoyah-2 EOC-12 and EOC-13 POPCD
Weighted Generalized Linear Model Loglogistic Solution
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
89%
88%
87%
86%
85%
Probability of Detection
1
10
Bobbin Amplitude (Volts)
Seq.-2 EOC-12 POPCD Regression
Seq.-2 EOC-12 POPCD at Lower 95%
Seq.2 EOC-13 POPCD Regression
Seq.2 EOC-13 POPCD at Lower 95%

Table 10: Sequoyah-2 Composite POPCD Summary Evaluation for Results for EOC-7 (1996) thru EOC-14 (2006) for POPCD at EOC-6 thru EOC-13

Column	A	B	C	D	E	F	G	H	I	J	K
Sequoyah-2 Specific POPCD Data Table											
	Detection at EOC_n			No Detection at EOCn (New Indications)							
	EOC_n Bobbin Ind. RPC Confirmed at EOC_{n+1}	EOC_n Bobbin Ind. Not RPC Inspected at EOC_{n+1}	EOC_n Bobbin Ind. Repaired at EOC_n	New EOC_{n+1} Bobbin RPC Confirmed	New EOC_{n+1} Bobbin Not RPC Inspected	Ind. Found Only by RPC at EOC_{n+1} or at EOC_n & Plugged at EOC_n (3)	EOC_n RPC NDD Bobbin Indications (2)	Excluded from POPCD	Totals for POPCD Evaluation		
Voltage Bin	BDD / RDD → BDD / RDD BDD / RDD → BND / RDD BDD w/o RPC → BDD / RDD BDD w/o RPC → BND / RDD	BDD w/o RPC → BDD w/o RPC BDD / RDD → BDD w/o RPC	BDD / RDD → Plugged at EOCn BDD w/o RPC → Plugged at EOCn	BND w/o RPC → BDD / RDD BND / RDD → BDD / RDD BND / RND → BDD / RDD	BND w/o RPC → BDD w/o RPC BND / RDD → BDD w/o RPC BND / RND → BDD w/o RPC	BND w/o RPC → BND / RDD BND / RDD → BND / RDD BND / RND → BND / RDD BND / RDD → Plugged at EOCn	BDD / RND → BDD w/o RPC BDD / RND → BDD / RDD BDD / RND → BND / RDD	All RND AT EOC_{n+1} All BND w/o RPC at EOCn+1 BDD/RND/Plugged at EOCn	Detection at EOCn	No Detection at EOCn	POPCD for Voltage Bin Note (1)
0.01-0.10	0	4	0	3	35	0	0	2	4	38	0.095
0.11-0.20	6	181	1	11	330	0	0	71	188	341	0.355
0.21-0.30	20	667	7	28	501	0	5	147	694	534	0.565
0.31-0.40	25	1007	9	38	498	0	6	123	1041	542	0.658
0.41-0.50	34	1018	12	43	332	0	8	97	1064	383	0.735
0.51-0.60	44	824	11	49	226	1	6	90	879	282	0.757
0.61-0.70	62	672	5	41	151	0	10	60	739	202	0.785
0.71-0.80	94	454	5	23	71	3	6	54	553	103	0.843
0.81-0.90	107	298	5	25	49	2	1	47	410	77	0.842
0.91-1.00	99	163	5	22	25	1	9	32	267	57	0.824
1.01-1.10	105	70	1	13	10	1	4	19	176	28	0.863
1.11-1.20	85	44	2	9	6	2	6	19	131	23	0.851
1.21-1.30	55	20	1	4	1	1	1	15	76	7	0.916
1.31-1.40	30	11	2	5	0	1	3	14	43	9	0.827
1.41-1.50	27	8	2	6	0	0	0	8	37	6	0.860
1.51-1.60	18	5	3	0	1	1	1	1	26	3	0.897
1.61-1.70	15	4	1	0	0	1	0	1	20	1	0.952
1.71-1.80	4	1	3	0	0	0	0	1	8	0	1.000
1.81-1.90	2	0	0	0	0	0	0	5	2	0	1.000
1.91-2.00	4	2	1	1	0	0	0	1	7	1	0.875
2.01-2.10	0	0	4	0	0	0	0	2	4	0	1.000
2.11-2.20	0	0	1	0	0	0	0	0	1	0	1.000
2.21-2.30	0	0	1	0	0	0	0	0	1	0	1.000
2.31-2.40	0	0	1	0	0	0	0	0	1	0	1.000
2.41-2.50	0	0	2	0	0	0	0	0	2	0	1.000
2.51-2.60	0	0	0	0	0	0	0	0	0	0	
3.21-3.30	0	0	0	0	0	0	0	0	0	0	
3.31-3.40	0	0	1	0	0	0	0	0	1	0	1.000
3.41-3.50	0	0	0	0	0	0	0	0	0	0	
3.51-3.60	0	0	1	0	0	0	0	0	1	0	1.000
3.61-3.70	0	0	0	0	0	0	0	0	0	0	
9.61-9.70	0	0	0	0	0	0	0	0	0	0	
9.71-9.80	0	0	1	0	0	0	0	0	1	0	1.000
	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	
Total	836	5453	88	321	2236	14	66	809	6377	2637	0.707

Notes:
1) POPCD for each voltage bin calculated as (Detection at EOCn)/(Detection at EOCn + No Detection at EOCn). By column, POPCD = (A+B+C)/(A+B+C+D+E+F+G).
2) EOCn RPC NDD bobbin indications are treated as new indications per NRC request
3) Includes indications at EOCn plugged at EOCn and new indications at EOCn+1, not reported in the bobbin inspection, and found only by RPC inspection of dents, mixed residuals or other reasons for the RPC inspection.
4) BDD = Bobbin detected indication; BND = Bobbin NDD intersection; RDD = RPC detected indication; RND = RPC NDD intersection

Table 11 Sequoyah Unit 2 EOC-13 POPCD
Log-Logistic Distribution Parameters

Parameter	Sequoyah Unit 2 POPCD at EOC-13
Number of Data Points	9014
b_0 (intercept)	1.8865
b_1 (Slope)	2.7789
V_{11}	2.308E-03
V_{12}	4.489E-03
V_{22}	1.169E-02

ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY (TVA)
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 2

REFORMATTED TECHNICAL SPECIFICATION (TS) AND BASES PAGE MARKUPS FOR SQN TS CHANGE 06-06, PROBABILITY OF PRIOR CYCLE DETECTION

STEAM GENERATOR (SG) TUBE INSPECTION REPORT (continued)

a. The scope of inspections performed on each SG,

b. Active degradation mechanisms found,

c. Nondestructive examination techniques utilized for each degradation mechanism,

d. Location, orientation (if linear), and measured sizes (if available) of service induced indications,

e. Number of tubes plugged during the inspection outage for each active degradation mechanism,

f. Total number and percentage of tubes plugged to date,

g. The results of condition monitoring, including the results of tube pulls and in-situ testing, and

h. The effective plugging percentage for all plugging in each SG.

6.9.1.16.2 A report shall be submitted within 90 days after the initial entry into MODE 4 following completion of an inspection performed in accordance with the steam generator program (6.8.4.k) when voltage based alternate repair criteria have been applied. The report shall include information described in Section 6.b of Attachment 1 to NRC Generic Letter 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking."

6.9.1.16.3 For implementation of the voltage-based repair criteria for tube support plate (TSP) intersections, notify the staff prior to initial entry into MODE 4 following completion of an inspection performed in accordance with Specification 6.8.4.k, "Steam Generator (SG) Program," should any of the following conditions arise:

1) If circumferential crack-like indications are detected at the TSP intersections.

2) If indications are identified that extend beyond the confines of the TSP.

3) If indications are identified at the TSP elevations that are attributable to primary water stress corrosion cracking.

6.9.1.16.4 For implementation of W*, the calculated steam line break leakage from the application of TSP alternate repair criteria and W* inspection methodology shall be submitted within 90 days after the initial entry into MODE 4 following completion of an inspection performed in accordance with Specification 6.8.4.k, "Steam Generator (SG) Program." The report will include the number of indications within the tubesheet region, 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).

INSERT 1

INSERT 1

6.9.1.16.5 For implementation of the probability of prior cycle detection (POPCD) method, for the voltage-based repair criteria at tube support plate intersections, if the end-of-cycle conditional tube rupture probability for a postulated main steam line break, the projected primary to secondary leak rate during a postulated main steam line break, or the number of indications are under predicted by the previous cycle operational assessment, the following shall be reported to the Commission within 90 days after initial entry into MODE 4 following completion of inspection performed in accordance with specification 6.8.4.k, "Steam Generator Program."

1. The assessment of the probable causes for the under prediction, proposed corrective actions, and any recommended changes to probability of detection or growth methodology indicated by potential methods assessments.

2. An assessment of the potential need to revise the alternate repair criteria analysis methods if: the burst probability is under predicted by more than 0.001 (i.e., 10 percent of the performance criteria) or an order of magnitude; or the leak rate is under predicted by more than 0.5 gallon per minute (gpm) or an order of magnitude.

3. An assessment of the potential need to increase the number of predicted low voltage indications at the beginning of cycle if the total number of as-found indications in any SG are underestimated by greater than 15 percent or by greater than 150 indications.

INSERT 2

where V_{GR} represents the allowance for flaw growth between inspections and V_{NDE} represents the allowance for potential sources of error in the measurement of the bobbin coil voltage. Further discussion of the assumptions necessary to determine the voltage repair limit are discussed in GL 95-05.

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 are 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.

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. 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). 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.

The W* criteria incorporate the guidance provided in WCAP-14797, Revision 2, "Generic W* Tube Plugging Criteria for 51 Series Steam Generator Tubesheet Region WEXTEX Expansions." W* length is the length of tubing into the tubesheet below the bottom of the WEXTEX transition (BWT) that precludes tube pullout in the event of a complete circumferential separation of the tube below the W* length. W* distance is the distance from the top of the tubesheet to the bottom of the W* length including the distance from the top of the tubesheet to the BWT and measurement uncertainties.

Indications detected within the W* distance below the top-of-tube sheet (TTS), will be plugged upon detection. Tubes to which WCAP-14797 is applied can experience through-wall degradation up to the limits defined in Revision 2 without increasing the probability of a tube rupture or large leakage event. Tube degradation of any type or extent below W* distance, including a complete circumferential separation of the tube, is acceptable. As applied at Sequoyah Nuclear Plant Unit 2, the W* methodology is used to define the required tube inspection depth into the hot-leg tubesheet, and is not used to permit degradation in the W* distance to remain in service. Thus while primary to secondary leakage in the W* distance need not be postulated, primary to secondary leakage from potential degradation below the W* distance will be assumed for every inservice tube in the bounding steam generator.

INSERT 2

For the operational assessment, the Probability of Prior Cycle Detection (POPCD) voltage based probability of detection (POD) method, as ~~described in a September 15, 2006 letter from Westinghouse Electric Company to TVA (LTR-CDME-06-121, "Technical Support for Application of Probability of Prior Cycle Detection for Sequoyah Unit 2 Voltage Based Alternate Repair Criteria"),~~ is used to determine the beginning of cycle voltage distributions. The POPCD method is an exception to the GL 95-05 guidance that requires the application of a POD of 0.6 to all previous bobbin indications.

Approved by NRC letter dated _________________.

ENCLOSURE 3

**TENNESSEE VALLEY AUTHORITY (TVA)
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 2**

TVA COMMITMENT

TVA will revise SQN's steam generator program to incorporate the methodology for implementation of Probability of Prior Cycle Detection (POPCD) as described in Enclosure 1 of this submittal. The program revision will be completed within 45 days following NRC approval of the SQN Unit 2 POPCD TS Change 06-06.