Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

June 21, 2012

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ATTN: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Sequoyah Nuclear Plant, Unit 2
Facility Operating License No. DPR-79
NRC Docket No. 50-328

Subject: **Response to Request for Additional Information Regarding the 90-Day and 180-Day Steam Generator Tube Inspection Reports for Unit 2 - Cycle 17 Refueling Outage (TAC NO. ME7705)**

References:

1. Letter from NRC to TVA, "Sequoyah Nuclear Plant, Unit 2 - Spring 2011 Refueling Outage Steam Generator Tube Inspection Conference Call Summary," dated August 16, 2011 (TAC NO. ME7705)
2. Letter from TVA to NRC, "Unit 2 Cycle 17 - 90 - Day Steam Generator Report for Voltage-Based Alternate Repair Criteria and W* Alternate Repair Criteria," dated September 16, 2011
3. Letter from TVA to NRC, "Unit 2 Cycle 17 - 180-Day Steam Generator Inspection Report," dated December 13, 2011
4. Electronic Mail from NRC to TVA, "Sequoyah Nuclear Plant, Unit 2 - Cycle 17 180-Day Steam Generator Inspection Report (TAC NO. ME7705)," dated May 7, 2012

The purpose of this letter is to provide a response to the Nuclear Regulatory Commission (NRC) request for additional information (RAI) transmitted to the Tennessee Valley Authority (TVA) by electronic mail (email) on May 7, 2012 (Reference 4), regarding the Sequoyah Nuclear Plant (SQN), Unit 2, steam generator (SG) tube inspections performed during the spring 2011 Unit 2 Cycle 17 Refueling Outage (U2R17).

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In a conference call held on June 6, 2011, with the NRC staff, representatives from TVA provided information associated with the SQN U2R17 SG tube inspections as summarized in a letter dated August 16, 2011 (Reference 1). By letters dated September 16 and December 13, 2011 (References 2 and 3), TVA provided the 90-day and 180-day SG inspection reports, respectively, for SQN U2R17. On May 7, 2012, the NRC transmitted an RAI by email to TVA (Reference 4) concerning the SG tube inspections performed during SQN U2R17, and requested a response within 45 days.

The enclosure to this letter provides TVA's response to the RAI questions associated with the SG tube inspections performed during SQN U2R17 as requested by the NRC in the Reference 4 email.

There are no commitments contained in this letter. If you have any questions concerning this issue, please contact J. W. Proffitt at (423) 843-6651.

Respectfully,

J. W. Shea
Manager, Corporate Nuclear Licensing

Enclosure:
Response to Request for Additional Information

Enclosure
cc (Enclosure):

NRC Regional Administrator – Region II
NRC Senior Resident Inspector – Sequoyah Nuclear Plant

ENCLOSURE

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT, UNIT 2

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

NRC Question 1

Please discuss the scope and results of any secondary side inspections that were performed in the steam drum or upper bundle.

TVA Response

Foreign Object Search And Retrieval (FOSAR) was performed on all four steam generators (SGs) during the Unit 2 Cycle 17 Refueling Outage (U2R17) at Sequoyah Nuclear Plant (SQN). No other secondary side inspections were performed. An evaluation was performed to leave some of the loose parts discovered during FOSAR in the SGs.

In SG No. 1, at row 34-35 column 19-20 hot leg, there was a small metallic tube 0.19 inch diameter x 0.41 inch long. This part was unchanged from the Unit 2 Cycle 16 Refueling Outage (U2R16).

In SG No. 2, at row 18-19 column 47-48 hot leg top of tube sheet (HTS) +1.4, there was a piece of flexitallic gasket approximately 1.50 inches long x 0.25 inch wide x 0.03 inch thick, and a small piece of wire approximately 1.00 inches long x 0.02 inch diameter. At row 24 column 48 HTS +0.20, there was a loose thin wire approximately 0.02 inch diameter x 3.00 inches long.

In SG No. 3, at row 31 column 58 hot leg, there was a small piece of flexitallic gasket about 1.25 inches long x 0.25 inch wide.

In SG No. 4, there was shiny metallic debris and sludge deposits no larger than 0.50 inch in any direction identified at hot leg row 44 column 41-42, hot leg row 13-14 column 29, and hot leg row 20 column 17.

A 50.59 evaluation was performed, and a problem evaluation report (PER) was written for loose parts in SG Nos. 2, 3, and 4 (PERs 385513, 385526, and 382987).

The justification for leaving the loose parts in the SGs was provided in AREVA document CR Nos. 2011-4172, 2011-4173, 2011-4174, and 2011-4175. The fixed metallic object in SG No. 1 did not move from U2R16 to U2R17 and it is not likely that it will move. The flexitallic gasket material in SG Nos. 2, 3, and 4 (from U2R16) was previously evaluated by Westinghouse in document LTR-SGMP-09-185. The wire in SG No. 2 was determined to be small enough that even if it lifted in the flow and impacted the tubes, no appreciable wear would occur.

The sludge debris was determined to be commingled, packed sludge material (magnetite) and the debris is softer than the tubes and other metal components on the secondary side. Industry experience also shows that sludge rocks do not pose a threat to SG tube integrity. Based on the evaluation, the conclusion was that the sludge debris would not create any tube wear damage.

NRC Question 2

In your application of the in-situ screening criteria for several degradation mechanisms (e.g., axially oriented outside diameter stress corrosion cracking (ODSCC) in the freespan), you had several indications that exceeded the 0.5 volt "quick screen" criterion. In these cases, it appears that you determined that in-situ pressure testing was not needed since the flaw did not have a voltage of 0.4 volts for all the data points in any 0.6-inch portion of the flaw. Is this

interpretation correct? If so, it appears to be non-conservative since you could have a 0.6-inch flaw where all but one data point is 10 volts (or higher) and one data point is less than 0.4 volts and therefore would not need to be in-situ pressure tested. Please clarify.

TVA Response

The NRC's interpretation is correct, in that TVA had indications which exceeded the 0.5 volt "quick screen" criteria and concluded that in-situ pressure testing was not needed. However, additional screening is required to reach this conclusion. For axial ODSCC, indications with maximum voltages greater than 0.5 volt or greater than 0.4 volt for an axial length of greater than 0.6 inch must be further screened by length and depth. For SQN, Unit 2, all indications screened out on voltage except the 0.53 volt flaw in tube 33-58 in SG No. 2. The 0.43 volt flaw in the same tube screened out since it was less than 0.6 inch. The 0.53 volt flaw had to be further screened based on length and depth. It had an estimated depth of 34 percent Through-Wall (TW) and a length of 0.66 inch. The Condition Monitoring (CM) depth limit for a 0.66 inch long axial ODSCC flaw is greater than 50 percent TW. Since this flaw had a maximum depth of 34 percent TW, it did not require in-situ pressure testing. This screening criteria is consistent with the industry guidance provided in the Electric Power Research Institute (EPRI) *Steam Generator In-Situ Pressure Test Guidelines, Revision 3.* These guidelines are conservatively developed based on a combination of the following: 1) Non-Destructive Examination (NDE) results, such as eddy current plus analytical/semi-empirical calculations of burst pressures and leak rates, 2) laboratory burst and leak tests of pulled tubes with service-induced degradation, and 3) in-situ leak and/or proof testing of tube sections with eddy current indications of degradation. In the NRC's example, a hypothetical 10 volt (or higher) data point from an ODSCC freespan indication would be pressure tested based on the screening criteria of the EPRI *Steam Generator In-Situ Pressure Test Guidelines, Revision 3.*

NRC Question 3

In Section 4.6 of the September 16, 2011, letter, an assessment of the negative growth rates observed for axially oriented ODSCC in the tubes at the tube support plate elevations during the 2011 inspections were provided. In this discussion, it was indicated that a different frequency generator and a probe designed (and possibly manufactured) by a different vendor was used during the 2011 steam generator tube inspections. The negative growth rates were attributed to the difference in probe design.

The voltage-based alternate repair criteria for axially oriented ODSCC relies, in part, on representative/repeatable voltages being obtained for the flaws (at all plants and for the laboratory specimens). During the development of the repair criteria studies were performed to assess probes from different vendors. In addition, limits were placed on the design of the bobbin probe.

a. *Please discuss whether the bobbin probes used during application of the voltage-based repair criteria since implementation at SQN, Unit 2 are equivalent to what was used during the development of the criteria. For example, were the data in the databases obtained with Zetec designed probes similar to what was used in 2011 or the Westinghouse designed probes used during the three prior outages?*

TVA Response

a. The EPRI Report NP-7480-L, *Outside Diameter Stress Corrosion Cracking (ODSCC) of Steam Generator Tubing at Tube Support Plates - A Database for Alternate Repair Limits*, documents the equivalency between the Echoram and Zetec (720 MULC) 0.720 inch outside diameter bobbin coil probes when voltage normalization is performed the same, by the quote:

> "The use of probes from Echoram or Zetec has negligible influence on the data acquisition for tube repair limits."

Data sets that contained either the Zetec 720 MULC bobbin probe or the Echoram EC720BPRMS (Westinghouse 720LLMC) bobbin probes could be included in the alternate repair database (i.e., the laboratory/field results from one probe would be considered the same for the other probe).

The standard Zetec 720 MULC probe has been listed in various addenda added to the EPRI report NP-7480-L. Data sets in EPRI Appendix I ETSS I28411 lists the probe part number and the standard Zetec 0.720 inch outside diameter probe is well represented among the 0.875 inch x 0.050 inch wall tubing data sets (same tubing material/size as found in SQN Unit 2).

The coil design of the Zetec 720 MULC bobbin probe used during the SQN U2R17 SG inspection is considered the same coil design that is represented in the Alternate Repair Criteria (ARC) data sets, Appendix I (I28411), EPRI ETSS 96001.1 (Thinning at tube support plates (TSP) and Top of Tube Sheet), and EPRI ETSS 96012.2 (Detection of Primary Water Stress Corrosion Cracking at dented drilled tube support plate intersections).

Prior to Cycle 14, the Zetec 720 MULC probes were utilized. In Cycles 14 through 16, probes designed by Westinghouse and manufactured by either Corestar or Zetec were utilized. The probes were calibrated for wear criteria utilizing transfer standards owned by TVA. The voltages were normalized to these standards in accordance with the ARC. There are some inconsistencies in the documentation provided with these probes that were utilized by TVA. TVA has entered this into our Corrective Action Program and is reviewing the probe response data.

NRC Question 3

b. *Please discuss how the Westinghouse and Zetec designed bobbin probes were qualified for use during application of the voltage based repair criteria.*

TVA Response

b. Westinghouse probes used during U2R16 were listed on the certificate of conformance (COC) provided by CoreStar and Zetec. In addition, the probe wear monitoring procedure is included within Westinghouse procedure TVA-400-001 Revision 13, *Multifrequency Eddy Current Examination of Non-Ferromagnetic Steam Generator Tubing.*

A Zetec supplied COC was provided for each probe used during the SQN U2R17 inspection. In addition, the 720 MULC probes were required to satisfy paragraph 3.c.2 (NRC Generic Letter (GL) 95-05) before they were received for use. This Alternate Plugging

Criteria documentation is included in the final inspection/repair report submitted to TVA: *Report on Steam Generator Eddy Current Examination and Repair Sequoyah Nuclear Plant - Unit 2*, May 2011 - U2R17.

Detailed acquisition instructions on how to perform probe wear monitoring in accordance with GL 95-05 were outlined within the Sequoyah U2R17 bobbin examination technique specification sheet (ETSS), *BOB1, Revision 0.*

Through the probe manufacturing requirements set forth by EPRI, GL 95-05, and through the use of qualified acquisition and analysis techniques, the Zetec 720 MULC bobbin probes were qualified for use during the application of the U2R17 voltage based repair criteria.

NRC Question 3

c. *In the condition monitoring and operational assessment for axially oriented ODSCC in the portion of the tube passing through the tube support plates, the measured voltages from the Zetec designed probe were used. Since the previous operational assessment used voltages obtained from a Westinghouse designed probe (that gave higher voltages for similar flaws), it is not clear that it is appropriate to compare the previous operational assessment results with the current condition monitoring results. It would appear that some adjustment to the voltages would be needed to ensure that the 2011 results were consistent with expectations from the 2009 operational assessment. Please clarify.*

TVA Response

c. In order to clearly address this question, new "as-found" calculations were performed based on the 2011 inspection results. For these new calculations, both the voltages and the quantities of indications were adjusted. The adjustments were based on a review of the growth rate and flaw population trends for the last several cycles of operation. For Plant Operating Cycles (Cycles) 11, 12, 13, 15, and 16, the same bobbin coil probe design was used for both the Beginning Of Cycle (BOC) and End Of Cycle (EOC) examinations. For Cycles 14 and 17, different probe designs were used for the BOC and EOC inspections. Therefore, the growth rates from these two cycles are not considered to be representative of true growth. Considering only Cycles 11, 12, 13, 15, and 16, the highest growth rate occurred during Cycle 13 which had an average voltage change of 10.6 percent per Effective Full Power Year (EFPY). The largest increase in the number of indications occurred during Cycle 16 when 524 more indications were reported at the EOC-16 inspection than were reported at the EOC-15 inspection.

Based on an assumed bounding growth rate of 10.6 percent per EFPY, an adjusted as-found population of indications was obtained. Since the average measured voltage change during Cycle 17 was -7.4 percent, an adjustment of 19.4 percent would be needed to get to a voltage growth of 10.6 percent per EFPY [(1+0.106)/(1-0.074) = 1.194]. Since this value is normalized to 1 EFPY, it needs to be multiplied by the operating length of Cycle 17 (1.432 EFPY). This gives an increase of 27.8 percent. Therefore, the as-found EOC-17 voltages were conservatively adjusted upward by 30 percent. This effectively adjusts the measured voltages to values that would be expected if the flaws had grown by >10.6 percent per EFPY and the inspection probe had remained the same.

To account for the transient in the number of flaws detected, a probability of detection (POD) of 0.85 was applied to these new as-found leak rate and probability of burst calculations.

Under normal circumstances, a POD of 1 is used for the as-found calculations. In this case, however, since there was also an apparent transient in the number of new indications detected, a lower POD was used to artificially add more indications to the as-found population. Applying a POD of 0.85 artificially increases the as-found population to 4371 indications. This is 624 more than were detected during the EOC-16 inspection. This bounds the population increase of 524 indications observed from EOC-15 to EOC-16 as discussed above. This is very conservative since the POD is constant across all voltage ranges when, in reality, most of the postulated undetected indications will be in the lower voltage ranges (generally less than 1.0 volts).

Applying the 30 percent increase to the voltages and a POD of 0.85 yields new as-found results as shown in Table 1. As shown in the table, using the conservatively adjusted voltages and number of indications, the as-found leak rates and probabilities of burst are still less than those projected in the prior operational assessment.

Table 1: As-Found Results Using Adjusted Voltages and Quantities of Indications

		SG21	SG22	SG23	SG24
Number of Indications	Adjusted As-Found	757	842	1033	1739
	Cycle 16 OA Projection	1082	1172	1445	2455
Leak Rate Gallons Per Minute (gpm)	Adjusted As-Found	0.317	0.353	0.658	1.19
	Cycle 16 OA Projection	0.654	0.694	1.07	1.67
Probability of Burst (per cycle)	Adjusted As-Found	1.15×10^{-4}	1.11×10^{-4}	2.40×10^{-4}	6.41×10^{-4}
	Cycle 16 OA Projection	6.53×10^{-4}	7.25×10^{-4}	1.01×10^{-3}	1.80×10^{-3}

<u>NRC Question 3</u>

d. *The Westinghouse designed probe appeared to detect more degradation than the Zetec designed probe. As a result, one may postulate that there were more undetected flaws during the 2011 inspections than in the 2009 inspections (since the Zetec designed probe was used during the 2011 inspections and the Westinghouse designed probe was used during the 2009 inspections). If previous operational assessments with a 0.6 probability of detection resulted in non-conservative or marginally conservative results for the number of indications detected, it is not clear that using a 0.6 probability of detection for the operational assessment following the 2011 inspections is appropriate (since if a Westinghouse designed probe were used during the 2011 outage, more flaws would have been detected in the 2011 outage and this larger number of flaws would have resulted in even more flaws being predicted because of the 0.6 probability of detection). Please discuss why it is not appropriate to account for the potentially higher number of undetected flaws as a result of using a probe which appears to be less sensitive to degradation.*

TVA Response

d. Past inspection history at SQN Unit 2 supports the use of the 0.6 POD based on the quantities of indications reported at each inspection relative to the number projected with a POD of 0.6. Nonetheless, to adequately address the question and demonstrate the margin available in the analyses, new operational assessment (OA) calculations were performed using a reduced POD of 0.5. This value was selected so that the projected population of flaws at EOC-18 would bound the number projected if the average increase in number of indications detected (~500 more indications per cycle) were to have continued to EOC-17. If 500 more indications had been detected at EOC-17 than EOC-16, then 4247 indications would have been expected at EOC-17. If 4247 indications had been detected at EOC-17, then the OA projection for EOC-18 would have projected a maximum of 7078 indications (assuming that no indications were removed from service). Applying a reduced POD of 0.5 projects a total of 7358 indications at EOC-18 [(3747 indications / 0.5 POD) – 72 indications plugged]. As discussed in the previous response, reducing the POD in this manner is conservative since the POD is constant across all voltage ranges when, in reality, most of the postulated undetected indications will be in the lower voltage ranges (generally less than 1.0 volts).

In addition to the reduced POD, the as-found voltages were also adjusted upward by 30 percent as discussed in the response to the previous question. The growth rate used in these calculations is the same as used in the 90-Day ARC report which was the limiting measured growth distribution from the last three cycles.

The results of these new OA projections are provided in Table 2 below. As shown in the table, both the leakage and structural integrity performance criteria are still met with these conservative assumptions.

Table 2: Updated OA Projections Using Adjusted Voltages and Reduced POD

	SG21	SG22	SG23	SG24	Acceptance Criterion
Leak Rate (gpm)	0.99	1.08	1.82	2.84	3.7
Probability of Burst (per cycle)	7.67×10^{-4}	8.54×10^{-4}	1.32×10^{-3}	2.28×10^{-3}	1.0×10^{-2}

NRC Question 3

e. *The results presented for the voltage based repair criteria potentially have generic implications. It appears that two bobbin probes that have been identically calibrated can give different voltage readings for the same flaw. This would appear to draw into question any voltage-based sizing technique unless qualification was specific to the probe designer. What actions were taken to ensure appropriate sizing methods were applied during the 2011 inspections (i.e., the probe used to size degradation was equivalent to probe used during the development of the qualified technique).*

TVA Response

e. Numerous probe manufacturers have chosen to compare their bobbin coil probe to Zetec's bobbin coil probe when qualifying to EPRI PWR S/G Examination Guidelines: *Revision 6/7, Probe Manufacturing Quality Parameters* and *Appendix H1.3 Probe Characterization sections.*

Analysis techniques used for sizing ODSCC at TSPs during the U2R17 inspection were qualified in accordance with the applicable industry qualifications as delineated in the U2R17 degradation assessment and site validation document. Included in the instructions (bobbin examination technique specification sheet (ETSS)) were probe wear monitoring instructions, voltage normalization instructions, and resolution instructions, ensuring that the proper voltage normalization was performed and verified for each calibration group. The Independent Qualified Data Analyst (IQDA) was also instructed to verify that setups were being performed in accordance with the applicable ETSS, and to the accuracy of the reported indications. The IQDA would perform this monitoring throughout the eddy current inspection, ensuring the accuracy of the results.

NRC Question 3

f. Please discuss the basis for concluding that the frequency generator was not the cause of the negative growth rates.

TVA Response

f. There is documentation that supports the conclusion that changing the frequency generator, when the probe and normalization is performed the same, does not influence the voltage/phase of a specific signal. Zetec document 10020587 Revision F, *MIZ®-80iD Eddy Current Tester Implementation Document*, September 2006, and AREVA document 51-9147157-000, *MIZ-80iD to MIZ-30 Equivalency Report at Different MIZ-80iD Gain Settings*, October 2010, document that when only the instruments (frequency generators) are changed (i.e., change a MIZ-30 with a MIZ-80), as long as the same probe and normalization is performed, voltage value variances are negligible.

Raw voltages between the OMNI200 and the MIZ-80 instruments would be different. However, it is a reasonable assumption that if the same bobbin coil probe were to be calibrated the same using either the OMNI200 (U2R16) or the MIZ-80 (U2R17), the voltage measurements on any indication would be indistinguishable as to what instrument was used (as noted when comparing the MIZ-30 to the MIZ-80). The OMNI200 and the MIZ-80 were calibrated using the same technique.