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

July 3, 2013

10 CFR Part 50, App H, Section III.B.3

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

Sequoyah Nuclear Plant, Units 1 and 2
Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Subject: **Response to NRC Request for Additional Information Regarding Reactor Pressure Vessel Surveillance Capsule Withdrawal Schedule Revision (TAC Nos. MF0631 and MF0632)**

References:

1. TVA Letter to NRC, "Sequoyah Reactor Pressure Vessel Surveillance Capsule Withdrawal Schedule Revision Due to License Renewal Amendment," dated January 10, 2013 (ADAMS Accession No. ML13032A251)
2. NRC Letter to TVA, "Sequoyah Nuclear Plant, Unit 1 and 2 - Request for Additional Information Regarding Reactor Pressure Vessel Surveillance Capsule Withdrawal Schedule Revision," dated June 4, 2013 (ADAMS Accession No. ML13154A368)

By letter dated January 10, 2013 (Reference 1), Tennessee Valley Authority (TVA) submitted an application for the Nuclear Regulatory Commission (NRC) approval of a revision to the reactor vessel surveillance specimen withdrawal schedule for Sequoyah Nuclear Plant, Units 1 and 2. By letter dated June 4, 2013 (Reference 2), the NRC forwarded a request for additional information (RAI). The required date for the response is within 30 days of the date stated in the RAI, i.e., no later than July 5, 2013.

The enclosure to this letter provides TVA's response to the Reference 2 RAI. There are no new regulatory commitments contained in this submittal.

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NRR

Consistent with the standards set forth in 10 CFR 50.92(c), TVA has determined that the additional information, as provided in this letter, does not affect the no significant hazards considerations associated with the proposed application previously provided in Reference 1.

Please address any questions regarding this submittal to Henry Lee at (423) 843-4104.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 3rd day of July 2013.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosure: TVA Responses to NRC Request for Additional Information

cc (Enclosure):
NRC Regional Administrator – Region II
NRC Senior Resident Inspector – Sequoyah Nuclear Plant

ENCLOSURE

Tennessee Valley Authority
Sequoyah Nuclear Plant, Units 1 and 2 License Renewal

TVA Responses to NRC Request for Additional Information

RAI 1

<u>Issue:</u> *The American Society for Testing and Materials [ASTM] E 185-70 standard practice describes the withdrawal schedule in terms of the target fluence. The requested revision is written in terms of effective full power years (EFPY) instead of target fluence.*

<u>Request:</u> *Describe the withdrawal schedule (Tables 1 through 4) in terms of the fast neutron fluence (E> 1 million electron volts) in addition to the EFPY.*

<u>Response to RAI 1:</u>

The neutron fluence values needed to update Tables 2 through 4 of Sequoyah Nuclear Plant (SQN) Units 1 and 2 reactor pressure vessel surveillance capsule withdrawal schedule submittal are contained in Sections 2 and 7, and Appendix B of WCAP-17539-NP (Reference 1). Those tables have been recreated below with the appropriate neutron fluence values addressed. Note that Table 1 was a direct copy from the SQN Units 1 and 2 Final Safety Analysis Report (FSAR); therefore, it does not need to be updated and is not included in this enclosure. Because Capsules T, U, X, and Y have already been removed, the fluence values included in the revised Table 4 are the updated fluence values that were determined as part of the Time-Limited Aging Analysis (TLAA), Reference 1.

Table 2
Earliest Withdrawal Times
Capsule Relocation from the 4-degree to the 40-degree Azimuthal Location

Capsule S Relocation Time (EOC)	Capsule Time (EFPY) Corresponding to 60 Years of Operation (52 EFPY)	
	Unit 1[(a)]	Unit 2[(b)]
19	33.4	33.7
20	34.4	34.7

Notes:

(a)The target fluence, for Capsule S, at 60 years of operation at SQN Unit 1 is 2.66 x 1019 n/cm2 (E > 1.0MeV), as documented in Reference 1, Table 7-1.

(b)The target fluence, for Capsule S, at 60 years of operation at SQN Unit 2 is 2.57 x 10^{19} n/cm^2 (E > 1.0MeV), as documented in Reference 1, Table 7-2.

Table 3
Earliest Withdrawal Times
Capsule Relocation from the 4-degree to the 40-degree Azimuthal Location at EOC 19 and 20

Cycle	Unit 1 EFPY	Unit 1 Capsule Fluence (x 10^{19} n/cm², E > 1.0 MeV)		Unit 2 EFPY	Unit 2 Capsule Fluence (x 10^{19} n/cm², E > 1.0 MeV)	
		EOC 19	EOC 20		EOC 19	EOC 20
18	22.14[a]	1.14[a]	1.14[a]	22.97[a]	1.18[a]	1.18[a]
19	23.47[a]	1.20[a]	1.20[a]	24.34[a]	1.24[a]	1.24[a]
20	24.80[a]	1.40[a]	1.25[a]	25.70[a]	1.43[a]	1.30[a]
21	26.13[b]	1.59[b]	1.45[b]	27.07[b]	1.62[b]	1.49[b]
22	27.46[b]	1.79[b]	1.64[b]	28.43[b]	1.82[b]	1.69[b]
23	28.79[b]	1.98[b]	1.84[b]	29.80[b]	2.01[b]	1.88[b]
24	30.12[b]	2.18[b]	2.03[b]	31.16[b]	2.21[b]	2.07[b]
25	31.45[b]	2.37[b]	2.22[b]	32.53[b]	2.40[b]	2.27[b]
26	32.78[b]	2.57[b]	2.42[b]	33.89[b]	2.59[b]	2.46[b]
27	34.11[b]	2.76[b]	2.62[b]	**35.26[b]**	2.78[b]	2.65[b]
28	**35.44[b]**	2.96[b]	2.81[b]	36.62[b]	2.98[b]	2.84[b]
29	36.77[b]	3.15[b]	3.01[b]	37.99[b]	3.17[b]	3.04[b]
30	38.10[b]	3.35[b]	3.20[b]	39.35[b]	3.36[b]	3.23[b]
31	39.43[b]	3.55[b]	3.40[b]	40.72[b]	3.56[b]	3.43[b]
32	40.76[b]	3.74[b]	3.60[b]	42.08[b]	3.75[b]	3.62[b]

Notes:

(a) Reference 1, Tables B.1-2 and B.2-2

(b) Extrapolated from the EFPY and fluence values in Reference 1, Tables B.1-2 and B.2-2

Table 4
Proposed FSAR Reactor Vessel Capsule Removal Schedule

Capsule Number	Vessel Location	Lead Factor(c)		Withdrawal Time(c) (EFPY)		Neutron Fluence (x 10^{19} n/cm^2, E > 1.0 MeV)	
		Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
T	40°	3.15	3.11	1.07 (removed)	1.07 (removed)	0.241	0.244
U	140°	3.23	3.17	2.85(removed)	2.91 (removed)	0.693	0.654
X	220°	3.22	3.18	5.26 (removed)	5.36 (removed)	1.16	1.16
Y	320°	3.18	3.15	10.02 (removed)	10.55 (removed)	1.97	2.02
S	4°(a)	3.15	3.11	**EOC 28**	**EOC 27**	**2.66(d)**	**2.57(d)**
V	176°	0.90	0.94	Standby	Standby	N/A	N/A
W	184°(b)	3.22	3.18	Standby	Standby	N/A	N/A
Z	356°	0.90	0.94	Standby	Standby	N/A	N/A

Notes:

(a) Capsule S has been relocated from the 4-degree location to the 40-degree location
(b) Capsule W has been relocated from the 184-degree location to the 220-degree location
(c) Values taken from Reference 1, Tables 7-1 and 7-2
(d) Neutron fluence values shown are the 60-year peak reactor vessel values. The Capsule S fluence values at EOC 28 and 27 for SQN Units 1 and 2, respectively, will bound the 60-year peak reactor vessel fluence values assuming the capsules are relocated at either EOC 19 or 20, as shown Table 3.

RAI 2

Request: Provide a list of all materials included in Capsule S that the licensee plans to withdraw during the 28^{th} refueling outage (RFO) for Unit 1 and the 29^{th} RFO for Unit 2 along with any sister plants that could also use the test results from Capsule S. Do the remaining standby capsules contain the same materials that are found in Capsule S? If the answer is no, provide a list of all materials included in the standby capsules.

Response to RAI 2:

The reactor vessel materials in the SQN Units 1 and 2 reactor vessel radiation surveillance programs are documented in WCAP-8233 (Reference 2) and WCAP-8513 (Reference 3), which are the original baseline reports for both Units. The SQN Unit 1 surveillance capsules include tangential and axial test specimens from Lower Shell Forging 04 (SA508 Class 2, Heat No. 980919/281587). The surveillance weld metal was fabricated with SMIT 40 weld wire type, heat # 25295 and SMIT 89 flux type, lot # 1103, which is the same material as the Unit 1 reactor vessel beltline circumferential weld. The SQN Unit 2 surveillance capsules include tangential and axial test specimens from Intermediate Shell Forging 05 (SA508 Class 2, Heat No. 288757/981057). The surveillance weld was fabricated with Arcos weld wire type, heat # 4278 and SMIT 89 flux type, lot # 1211, which is the same material as the Unit 2 reactor vessel beltline circumferential weld. Tables 5 and 6 of this Enclosure document the reactor vessel materials present in each Unit's program. It is noted in these tables that all eight surveillance capsules at both Units contain Charpy, tensile, and Wedge-Open Loading (WOL) specimens from their respective vessel materials. Lastly, as documented in Section 3 and Appendix A of Reference 1, the SQN Units 1 and 2 reactor vessels do not have sister plant weld material with any other vessels.

Table 5
Number and Type of Specimens in the SQN Unit 1 Reactor Vessel Surveillance Capsules

Material (orientation)	Capsules S, V, W and X			Capsules T, U, Y, and Z		
	Charpy	Tensile	WOL	Charpy	Tensile	WOL
Lower Shell Forging 04 (tangential)	8	-	-	8	-	-
Lower Shell Forging 04 (axial)	12	2	4	12	2	-
Weld Metal (heat # 25295)	12	2	-	12	2	4
Heat-Affected Zone (HAZ)	12	-	-	12	-	-

Table 6
Number and Type of Specimens in the SQN Unit 2 Reactor Vessel Surveillance Capsules

Material (orientation)	Capsules S, V, W and X			Capsules T, U, Y, and Z		
	Charpy	Tensile	WOL	Charpy	Tensile	WOL
Intermediate Shell Forging 05 (tangential)	8	-	-	8	-	-
Intermediate Shell Forging 05 (axial)	12	2	4	12	2	-
Weld Metal (heat # 4278)	12	2	-	12	2	4
Heat-Affected Zone (HAZ)	12	-	-	12	-	-

RAI 3

Issue: Regarding the proposed new capsule schedule, the NRC staff noted that the licensee included WCAP-17539-NP, Revision 0, "Sequoyah Units 1 and 2 Time-Limited Aging Analysis on Reactor Vessel Integrity," March 2012, which addresses the applicant's technical bases for surveillance capsule schedule changes for the extended operation period. The NRC staff noted that Tables 7-1 and 7-2 list the fast neutron fluence values of the withdrawn surveillance capsules (T, U, X, and Y) for SQN, Units 1 and 2, respectively. However, these capsule fluence values are different from the capsule fluence values described in the applicant's previous capsule analysis reports such as WCAP-15224, Revision 0 and WCAP-15320, Revision 0. For example, the fast neutron fluence of Unit 1 Capsule Y reported in WCAP-17539-NP, 1.97E+19 neutrons (n)/centimeter^2 (cm^2), is less than the previously reported fast neutron fluence of the same capsule, 2.19E+19 n/cm^2 (WCAP-15224, Table 7-1).

Request: The NRC staff requests technical justification for why the fluence values of the withdrawn capsules reported for capsule schedule changes are different from those described in the previous capsule analysis reports.

Response to RAI 3:

A summary of the SQN Units 1 and 2 surveillance capsule and pressure vessel fluence calculations is provided below:

In 1999, calculations were completed to assess the neutron (E > 1.0 MeV) fluence received by surveillance capsules withdrawn and the pressure vessel wall of SQN Units 1 and 2. These 1999 calculations were documented in WCAP-15224 (June 1999) and WCAP-15320 (December 1999) for Units 1 and 2, respectively. These calculations were superseded in March 2012 (WCAP-17539) based on an updated neutron transport methodology as well as on additional fuel cycle specific plant operation. The following discussion describes the changes in the transport methodology over time and the additional operating data that was incorporated in the more recent analysis.

The methodology used for the 1999 calculations followed the guidance documented in Draft Regulatory Guide DG-1053 (later issued in March 2001 as Regulatory Guide 1.190 "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence"). In applying the methodology described in DG-1053, an adjoint neutron transport approach was used with a three-dimensional synthesis of the solution based on Equation 3 of the draft regulatory guide. The adjoint approach, along with the use of Equation 3 from Guide DG-1053, introduces the following three conservatisms into the analysis:

1. The use of the adjoint methodology does not allow cycle to cycle water density variations in the peripheral fuel assemblies, bypass region, or downcomer region. Therefore, in the analysis, water densities were chosen to conservatively envelope actual plant operation.
2. The use of Equation 3 from DG-1053 does not account for the flattening of the axial flux distribution that naturally occurs as a function of increasing distance from the reactor core. This tends to result in an overestimate in the high fluence areas of the surveillance capsule and pressure vessel.

3. The use of Equation 3 from DG-1053 does not account for the shielding effect introduced by the former plates located at several axial elevations between the core baffle plates and the core barrel.

The methodology used in the 2012 calculations follows the guidance of Regulatory Guide 1.190 and has been reviewed and approved by the NRC staff (see WCAP-16083). This updated methodology used a forward neutron transport approach with the three-dimensional synthesis of the solution based on Equation 4 of Regulatory Guide 1.190. The use of the forward transport methodology allows water density to be varied on a fuel cycle specific basis; while the use of Equation 4 from the regulatory guide explicitly accounts for changes in the axial neutron flux distribution as a function of radial position and also allows the shielding effect of the former plates to be included in the analysis.

Therefore, the use of the updated NRC-approved methodology for the 2012 analysis removed the three conservatisms listed above, resulting in a net reduction in the calculated fluence for surveillance capsules T, U, X, and Y at SQN Units 1 and 2.

In addition to the methodological changes noted above, the 2012 analysis accounted for several cycles of actual plant operation that were treated as projections in the 1999 calculations. The following table shows the differences in the analysis for both SQN Units:

Operating Periods	SQN Unit 1		SQN Unit 2	
	1999 Analysis	2012 Analysis	1999 Analysis	2012 Analysis
Cycle Specific	0 - 10.03 EFPY	0 – 22.1 EFPY	0 – 10.54 EFPY	0 – 21.6 EFPY
Projections	10.03 – 48 EFPY	22.1 – 52 EFPY	10.54 – 48 EFPY	21.6 – 52 EFPY
Projection Flux	Average Cy 5-9	Average Cy 16-18	Average Cy 5-9	Average Cy 15-17

The data in the above table shows that, for both Units, the amount of cycle specific operating time that was included in the analyses doubled from approximately 10 EFPY in the 1999 analysis to approximately 22 EFPY in the 2012 analysis. In addition, the neutron flux used to project the vessel and capsule exposures into the future was based on different fuel cycle averaging between the 1999 and 2012 calculations.

The new operational data listed in the table do not have any additional effect on the calculated neutron exposure of the previously withdrawn capsules. The assigned fluence for those capsules is affected only by the removal of conservatism due to change in methodology. However, while this reduction in conservatism also applies to the pressure vessel, additional changes to the pressure vessel exposure are brought about by the inclusion of operating fuel cycle data up to approximately 22 EFPY and by the choice of new updated power distributions for the future projected fluence.

References

1. Westinghouse Report, WCAP-17539-NP, Revision 0, "Sequoyah Units 1 and 2 Time-Limited Aging Analysis on Reactor Vessel Integrity," March 2012.

2. Westinghouse Report, WCAP-8233, Revision 0, "Tennessee Valley Authority Sequoyah Unit No. 1 Reactor Vessel Radiation Surveillance Program," December 1973.

3. Westinghouse Report, WCAP-8513, Revision 0, "Tennessee Valley Authority Sequoyah Unit No. 2 Reactor Vessel Radiation Surveillance Program," November 1975.