TVA

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

May 8, 2002

TVA-SQN-TS-02-05 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) - UNIT 2 - SUPPLEMENTAL INFORMATION TO SUPPORT EMERGENCY TECHNICAL SPECIFICATION (TS) CHANGE NO. 02-05, STEAM GENERATOR (SG) INSPECTION SCOPE - TAC NO. MB4994

Enclosed is supplemental information that is provided to support NRC review and approval of the subject TS change. The supplemental information is based on ongoing discussions with NRC staff and the staffs request regarding application of W* technology to the Unit 2 SGs.

Enclosure 1 provides supplemental information that contains a TVA commitment. As requested by NRC, the TVA commitment states that TVA will submit a SQN Unit 2 license amendment that applies W* methodology to the SQN Unit 2 SGs on a schedule to support SG inspections performed during the Unit 2 Cycle 12 refueling outage (the refueling outage is scheduled to begin October 26, 2003). Enclosure 2 provides supplemental information that provides a comparison of the SQN specific W* analysis (as contained in WCAP-13532, Revision 1) to the generic W* analysis (as contained in WCAP-14797, Revision 1). Enclosure 3 provides a revised TS page for the subject TS change.

D030

TVA has determined that the supplemental information does not affect the no significant hazards considerations associated with the subject TS change.

This emerging regulatory issue, as TVA understands it, concerns the NRC's opinion that additional rotating pancake probe inspections (below the top of tubesheet) are now a prerequisite for compliance with existing TS provisions, unless this TS change is granted. Nevertheless, since there is a common understanding that any tube degradation in this region, regardless of morphology, does not have a nexus to safety, TVA requests prompt approval of this amendment to avoid unnecessary restart delays. The current Mode 4 projection date remains as May 13.

There is a TVA commitment associated with this letter. This letter is being sent in accordance with NRC RIS 2001-05. If you have any questions about this change, please telephone me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

Sincerely,

James D. Smith
Site Licensing Supervisor

Subscribed and sworn to before me
on this 8th day of May

Notary Public

My Commission Expires October 9, 2002

Enclosures

ENCLOSURE 1

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

TVA COMMITMENT

TVA will submit a license amendment for SQN Unit 2 that will apply W* technology to the Unit 2 steam generators on a schedule that supports steam generator inspections performed during the Unit 2 Cycle 12 refueling outage (the refueling outage is scheduled to begin October 26, 2003).

ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
SEQUOYAH PLANT (SQN)
UNIT 2

WESTINGHOUSE COMPARISON OF SQN SPECIFIC W* ANALYSIS TO GENERIC W* ANALYSIS

Application of W* to Unit 2 Cycle 11 Sequoyah SG Tube Inspection

The Tennessee Valley Authority (TVA) is utilizing the W* analysis (Reference 1) forSequoyah Nuclear Plant (SQN) Cycle 12 operation to eliminate consideration of indications below a specified distance within the tubesheet, referred to as the W* distance. SQN is not implementing the W* alternate repair criteria, (i.e., indications will be repaired on detection instead of being allowed to remain in service). W* criteria were also developed for generic application to Westinghouse Series 51 steam generators (SGs) (Reference 2). These criteria were reviewed and approved by the NRC staff for application at another plant. The generic criteria that were developed are not numerically the same as in the document developed specifically for SQN. Moreover, the generic criteria differ in their scope of application.

The sections below discuss some of the features of the W* criteria and the effect of the differences between the generic development and the SQN-specific development. Detection of circumferential indications is the primary concern. A list of circumferential indications identified during the end of Cycle 11 inspection of the SQN SGs in and below the W* distance is provided in Table 1.

W* Background

W* is the length of sound engagement of the tube within the tubesheet such that the force resisting expulsion from the tubesheet balances the force applied to the end of a presumed severed tube. The value of W* is determined using applicable performance criteria relative to tube burst, expulsion from the tubesheet in this case, and relative to allowable leakage, relative to that established for alternate repair criteria (ARC). The structural performance criteria are that tube burst will not occur with a margin of 3 during normal operation and 1.4 during the most severe faulted event, a postulated steamline break (SLB) for SQN. The development of the W* criteria is based on balancing the forces resisting pull-out from the tubesheet, the cumulative reaction load, against the applied load from the internal pressure. These are explained further in the following paragraphs.

<u>Applied Load</u>

The applied force comes from the internal pressure in the tube. At the U-bend there is a component of the primary-to-secondary differential pressure acting in the axial direction. For the development of the criteria it is also assumed that the tube is severed in the tubesheet so that the differential pressure acts on the entire cross section area of the tube as calculated using the outside diameter (OD) of the tube. The applied force, F_A, is determined from the applied pressure, ΔP, and the outside diameter, D_o, area, A, as:

$$F_A = \Delta P\, A \ \text{ where, } \ A = \frac{\pi}{4} D_o^2 \qquad (1)$$

Here, ΔP is the difference between the primary, P_P, and secondary pressure, P_S, at the top of the tubesheet, (i.e., $P_P - P_S$).

Reaction Load

The reaction load in developing the W* length arises from friction between the tube and the tubesheet within the tubesheet hole. The friction force is the product of the normal force between the tube and the tubesheet and coefficient of friction between the tube and the tubesheet. The normal force arises or is affected by four sources:

1. The residual preload from the expansion process,
2. Differential thermal expansion between the tube and the tubesheet,
3. Internal pressure in the tube within the tubesheet, and
4. Dilation of the tubesheet holes from bowing of the tubesheet.

The first three items result in a compressive normal force between the OD of the tube and the ID of the tubesheet hole. The last item results in a reduction of the normal force near the top of the tubesheet and an increase in the normal force near the bottom of the tubesheet.

Determination of W* Length

The calculation performed is to find the length, W*, that makes the following equality true between the resisting force on the left and the applied force on the right,

$$\mu\left(N_X + N_T + N_P + N_D\right) = \Delta P\, A \qquad (2)$$

where
N_X = The residual normal force from the expansion process,
N_T = The normal force from the differential thermal expansion,
N_P = The normal force due to the internal pressure in the tube,
N_D = The normal force resulting from dilation of the tubesheet hole,
μ = The coefficient of friction between the tube and the tubesheet.

The resisting forces are due to the interface pressure between the tube and the tubesheet. The actual force is the product of the interface pressure times the effective area of contact, the circumference of the tube times the length of contact. Conservative uncertainty adjustments are then made to the length of contact to determine W*. The diameter of the tube is constant, so an expression for the force per unit length is used and solved for the length, L. This means that each force term must be replaced by force per unit length term.

The solution for W* is then,

$$W = \frac{\Delta P\, A}{\mu\left(F_X + F_T + F_P + F_D\right)} \qquad (3)$$

where W stands for the W* length and the letter F stands for the force per unit length of engagement. Each force per unit length term is then replaced by a corresponding pressure times circumference term, i.e.,

$$W = \frac{\Delta P\, A}{\mu\left(P_X + P_T + P_P + P_D\right)\pi D_o} \tag{4}$$

where D_o is the outside diameter of the expanded tube. Substituting for the cross section area yields,

$$W = \frac{\Delta P\, D_o}{4\mu\left(P_X + P_T + P_P + P_D\right)} \tag{5}$$

for the determination of W, sans adjustments for uncertainties in measurement and end effects where the assumption of a severed tube has been made. The following points are to be noted:

- The applied load term, the numerator is affected by changes in the operation of the plant. The value used for the generic document is larger than that for the plant specific application at SQN because of the use of a lower-bound secondary side pressure, hence the W* length would be expected to be less for SQN than that for the generic application.
- The residual expansion pressure, P_X, is not affected by changes in the operation of the plant. However, different values have been determined and used in the two different documents. A bounding lower value was selected for use in the generic document. This contributed to the calculation of a larger value of the W* distance than for application at SQN.
- The thermal expansion term, P_T, is affected by changes in the hot leg temperature, T_{hot}. The hot leg temperature at SQN is greater than the value used for the generic determination, hence the value of W* for use at SQN should be less than the generic value.
- The differential pressure term, P_P, is affected by changes in the primary or secondary pressure. The differential pressure term used for the SQN analysis is slightly smaller than the term used for the generic application for this term, assumed pressure in the crevice.
- The dilation term, P_D, is also affected by changes in the primary or secondary pressure. The differential pressure acting across the tube sheet was assumed to be greater in the generic report than for the SQN specific application because of the selection of lower-bound secondary side pressure value. The dilation loss is proportional to the differential pressure, hence the W* value determined for SQN would be expected to be less than the generic value.
- Finally, the coefficient of friction justified for the generic application is larger than that used for the SQN specific determination. Thus, the SQN determination is more conservative than the generic determination.

Conservatism in SQN Inspection Distance

- All indications identified are taken out of service by plugging.
- The 5.5" inspection length represents the most limiting length in the bundle. WCAP 13532, Rev. 1, allows for a shorter distance for the outer region of the SG bundle. SQN inspects all tubes in the bundle using the 5.5" length.
- The area of concern is the central region of the bundle where tubes would not be able to pull out without being restrained by contact with neighboring tubes, thus, the 5.1" pull out distance is very conservative.
- SQN Unit 2 has known denting at support plates which would further restrain tube pull out, and likely prevent the axial pressure load.
- A 0.7" tapered gap is assumed extending down from the bottom of the WEXTEX transition, which adds conservatism to the evaluation.
- Bobbin coil examinations were performed over the full length of each tube in the bundle.
- The circumferential cracks identified within the W* distance and below the W* distance during the inspection would satisfy the structural performance criteria even if evaluated as freespan indications.
- T_{hot} for Cycle 11 and planned for Cycle 12 is actually higher than the SQN-specific WCAP, which adds additional conservatism to the SQN determination ofW*.
- Actual secondary side pressure is within 1 pound of the SQN-specific WCAP.

Discussion

The effect of the differences in the application documents can be evaluated by considering each of the terms separately and by considering a combination of the terms. A listing of each of the terms and their expected effect is provided in Table 2. To consider the combination of the terms the ratio of a W* value developed for Sequoyah, W_S, to a W* value developed for generic application, W_G, can be evaluated by treating per the following expression,

$$\frac{W_S}{W_G} = \frac{\mu_G\left(P_{XG}+P_{TG}+P_{PG}+P_{DG}\right)}{\mu_S\left(P_{XS}+P_{TS}+P_{PS}+P_{DS}\right)}\frac{\Delta P_S}{\Delta P_G} \qquad (6)$$

where the subscript S stands for Sequoyah and G stands for generic. The combination of the terms makes this a difficult process. Therefore, alternate calculations were performed.

References 1 and 2 document the following evaluation steps. Section 3 determines the Axial loading a tube must withstand, the most conservative scenario is for normal operating conditions times a factor of 3. Section 4 of the WCAP documents report on the determination of the W* length based on the consideration that the radial contact pressure over the W* length times a static friction coefficient must equal the axial loading force determined above. The summation of four forces is used to determine the net radial contact pressure.

1. Residual radial contact force from the WEXTEX process.
2. Radial force from the difference in the coefficient for thermal expansion between the Alloy 600 tube and the low alloy tubesheet.
3. Radial contact force from the operating pressure difference the tube experiences during normal operation, (i.e., primary minus secondary side pressure).
4. The loss in interface pressure as a result of tubesheet hole dilation due to tubesheet flexure.

Both References add a 0.7-inch transition zone that goes from the bottom of WEXTEX transition. This derives from the analysis of the sample test specimens. A series of independent checking calculations of the required length of engagement were performed using a model originally developed for calculating the interface pressure when the radial interference was known. The results demonstrate reasonable consistency between the SQN specific and the generic calculation results. The qualitative effect of the changes are listed in Table 2. It is expected that the SQN specific W* should be less than the generic value because of the net effect of the changes. The independent considerations lead to the results similar to those presented in the WCAP. The conclusion is that the generic report should have reported results greater than those for SQN because ofconservatisms associated with a generic analysis.

Conclusions

The Reference 1 determination of the W* length of 5.1" for application to the SQNSGs is considered to be valid. The differences between the SQN specific and the generic calculation values is the result of the conservative assumptions associated with performing a generic calculation, (e.g., extremely low secondary side pressure, which increases the applied load and the dilation of the tubesheet holes), additional pressure considered in the crevice, and the use of a lower bound residual expansion pressure. This later effect is almost negated by the use of the higher coefficient of friction. Nevertheless, the application of W* to the SQN SG tubes per the Reference 1 guidance is considered to be justified.

References

1. WCAP-13532 (Proprietary) & WCAP-13533 (Non-Proprietary), Revision 1. *Sequoyah Units 1 and 2 W* Tube Plugging Criteria for SG Tubesheet Region of WEXTEX Expansions.* Westinghouse Electric Company, Madison, PA. November, 1992.
2. WCAP-14797 (Proprietary) & WCAP-14797 (Non-Proprietary), Revision 1. *Generic W* Tube Plugging Criteria for 51 Series Steam Generator Tubesheet Region WEXTEX Expansions.* Westinghouse Electric Company, Madison, PA. February, 1997.

Table 1: Circumferential Indications in or below W* distance Note: The BWT is assumed to be TTS-0.3", so the W* distance extends from the TTS-0.3" to TTS-5.5", including NDE uncertainties.					
	SG	Number of Indications	Type	Location	Comment
	2	1	ID Circ	TTS-6.41"	R37 C64 32° 64% MD
	4	5	ID Circ	TTS-0.36" TTS-3.59" TTS-3.55" TTS-3.64" TTS-2.67"	R12 C60 97° 82% MD R15 C60 69° 60% MD R18 C60 92° 85% MD R20 C45 48° 96% MD R24 C9 74° 89% MD

Table 2: Comparison of W* for Sequoyah SG Tubes Relative to Generic Information				
Item	Analysis Term & Description	Sequoyah WCAP-13532 Rev. 1	Generic WCAP-14797 Rev. 1	Application of the Result
1	ΔP, Applied Pressure	P_S = 882 psia	P_S = 760 psia	Sequoyah W* < Generic W*
2	P_X, Residual Pressure	P_R = 935 psi	P_R = 693 psi	Sequoyah W* < Generic W*
3	P_T, Thermal Tightening	T_{hot} = 608.5°F	T_{hot} = 590°F	Sequoyah W* < Generic W*
4	P_P, Pressure Tightening	P_S = 882 psia	P_S = 900 psia	Sequoyah W* < Generic W*
5	P_D, Dilation Loosening	SM-89-53	SM-96-39	Sequoyah W* < Generic W* (Higher ΔP for generic)
6	μ, Friction	0.152	0.210	Sequoyah W* > Generic W*

ENCLOSURE 3

TENNESSEE VALLEY AUTHORITY
SEQUOYAH PLANT
UNIT 2

TECHNICAL SPECIFICATION (TS) CHANGE 02-05
REVISED PAGE

4.4.5.4 Acceptance Criteria

a. As used in this Specification:

1. Imperfection means an exception to the dimensions, finish or contour of a tube from that required by fabrication drawings or specifications. Eddy-current testing indications below 20% of the nominal tube wall thickness, if detectable, may be considered as imperfections.

2. Degradation means a service-induced cracking, wastage, wear or general corrosion occurring on either inside or outside of a tube.

3. Degraded Tube means a tube containing imperfections greater than or equal to 20% of the nominal wall thickness caused by degradation.

4. % Degradation means the percentage of the tube wall thickness affected or removed by degradation.

5. Defect means an imperfection of such severity that it exceeds the plugging limit. A tube containing a defect is defective.

6. Plugging Limit means the imperfection depth at or beyond which the tube shall be removed from service and is equal to 40% of the nominal tube wall thickness. Plugging limit does not apply to that portion of the tube that is not within the pressure boundary of the reactor coolant system (tube end up to the start of the tube-to-tubesheet weld). This definition does not apply to tube support plate intersections if the voltage-based repair criteria are being applied. Refer to 4.4.5.4.a.10 for the repair limit applicable to these intersections. For Cycle 11 and 12 operation, this definition does not apply for axial PWSCC indications, or portions thereof, which are located within the thickness of dented tube support plates which exhibit a maximum depth greater than or equal to 40 percent of the initial tube wall thickness. Refer to 4.4.5.4.a.11 for the repair limits applicable to these intersections.

7. Unserviceable describes the condition of a tube if it leaks or contains a defect large enough to affect its structural integrity in the event of an Operating Basis Earthquake, a loss-of-coolant accident, or a steam line or feedwater line break as specified in 4.4.5.3.c, above.

8. Tube Inspection means an inspection of the steam generator tube from the point of entry (hot leg side) completely around the U-bend to the top support of the cold leg excluding the portion of the tube within the tubesheet below 5.5 inches (as measured from the top of the tubesheet).*

9. Preservice Inspection means an inspection of the full length of each tube in each steam generator performed by eddy current techniques prior to service to establish a baseline condition of the tubing. This inspection shall be performed prior to initial POWER OPERATION using the equipment and techniques expected to be used during subsequent inservice inspections.

*This exclusion is for Unit 2, Cycle 12 operation only.