May 3, 2005

Mr. Karl W. Singer
Chief Nuclear Officer and
Executive Vice President
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

SUBJECT: SEQUOYAH NUCLEAR PLANT, UNIT 2 — ISSUANCE OF AMENDMENT REGARDING CHANGES TO THE INSPECTION SCOPE FOR THE STEAM GENERATOR TUBES (TAC NO. MC5212) (TS-03-06)

Dear Mr. Singer:

The Commission has issued the enclosed Amendment No. 291 to Facility Operating License No. DPR-79 for the Sequoyah Nuclear Plant, Unit 2. This amendment is in response to your application dated December 2, 2004 (TVA-SQN-TS-03-06), as supplemented by letters dated February 15, March 9, and April 11, 2005.

The amendment revises portions of the Sequoyah Unit 2 Technical Specification Surveillance Requirement 4.4.5 to eliminate the requirement to inspect a portion of the tube within the tubesheet region. This will allow any flaws in the region, which is no longer inspected, to remain in service.

A copy of the Safety Evaluation is also enclosed. Notice of Issuance will be included in the Commission's biweekly *Federal Register* notice.

Sincerely,

/RA/

Douglas V. Pickett, Senior Project Manager, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-328

Enclosures:
1. Amendment No. 291 to License No. DPR-79
2. Safety Evaluation

cc w/enclosures: See next page

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cc:

Mr. Ashok S. Bhatnagar, Senior Vice President
Nuclear Operations
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Larry S. Bryant, General Manager
Nuclear Engineering
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Randy Douet
Site Vice President
Sequoyah Nuclear Plant
Tennessee Valley Authority
P.O. Box 2000
Soddy Daisy, TN 37384-2000

General Counsel
Tennessee Valley Authority
ET 11A
400 West Summit Hill Drive
Knoxville, TN 37902

Mr. John C. Fornicola, Manager
Nuclear Assurance and Licensing
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Fredrick C. Mashburn
Senior Program Manager
Nuclear Licensing
Tennessee Valley Authority
4X Blue Ridge
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Paul L. Pace, Manager
Licensing and Industry Affairs
ATTN: James D. Smith
Sequoyah Nuclear Plant
Tennessee Valley Authority
P.O. Box 2000
Soddy Daisy, TN 37384-2000

Mr. David A. Kulisek, Plant Manager
Sequoyah Nuclear Plant
Tennessee Valley Authority
P.O. Box 2000
Soddy Daisy, TN 37384-2000

Senior Resident Inspector
Sequoyah Nuclear Plant
U.S. Nuclear Regulatory Commission
2600 Igou Ferry Road
Soddy Daisy, TN 37379

Mr. Lawrence E. Nanney, Director
Division of Radiological Health
Dept. of Environment & Conservation
Third Floor, L and C Annex
401 Church Street
Nashville, TN 37243-1532

County Mayor
Hamilton County Courthouse
Chattanooga, TN 37402-2801

Ms. Ann P. Harris
341 Swing Loop Road
Rockwood, Tennessee 37854

TENNESSEE VALLEY AUTHORITY

DOCKET NO. 50-328

SEQUOYAH NUCLEAR PLANT, UNIT 2

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 291
License No. DPR-79

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Tennessee Valley Authority (the licensee) dated December 2, 2004, as supplemented by letters dated February 15, March 9, and April 11, 2005, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment and paragraph 2.C.(2) of Facility Operating License No. DPR-79 is hereby amended to read as follows:

(2) Technical Specifications

The Technical Specifications contained in Appendices A and B, as revised through Amendment No. 291, are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications.

3. This license amendment is effective as of its date of issuance, to be implemented no later than 45 days after issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Michael L. Marshall, Jr., Chief, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: May 3, 2005

ATTACHMENT TO LICENSE AMENDMENT NO. 291

FACILITY OPERATING LICENSE NO. DPR-79

DOCKET NO. 50-328

Replace the following pages of the Appendix A Technical Specifications with the attached pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

REMOVE	INSERT
3/4 4-11	3/4 4-11
3/4 4-13	3/4 4-13
3/4 4-14a	3/4 4-14a
3/4 4-14b	3/4 4-14b
3/4 4-14c	3/4 4-14c

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 291 TO FACILITY OPERATING LICENSE NO. DPR-79

TENNESSEE VALLEY AUTHORITY

SEQUOYAH NUCLEAR PLANT, UNIT 2

DOCKET NO. 50-328

1.0 INTRODUCTION

By application dated December 2, 2004 (Agencywide Documents Access and Management Systems accession number ML043490647), as supplemented by letters dated February 15 (ML050530319), March 9 (ML050740025), and April 11, 2005 (ML051190265), the Tennessee Valley Authority (the licensee) proposed an amendment to the Technical Specifications (TSs) for the Sequoyah Nuclear Plant (SQN) Unit 2. The supplemental letters provided clarifying information that did not change the initial proposed no significant hazards consideration determination.

The proposed amendment would revise the Sequoyah Unit 2 TSs to change the scope of the steam generator (SG) tube inspections required in the SG tubesheet region by applying a methodology referred to as W* (W-star). Specifically, the proposed amendment would revise SQN Unit 2 TS Surveillance Requirement (SR) 4.4.5.4.a.8 to exclude from inspection the bottom portion of the tube within the tubesheet region. That is, the new specification would require only an inspection of the upper portion of the tube within the hot-leg tubesheet region. The length of the tube required to be inspected is referred to as the W* distance. Currently, the TSs require, in part, an inspection of the entire portion of the SG tube within the hot-leg tubesheet region.

The proposed change will also (1) revise SR 4.4.5.4.a.6 on SG tube repair criteria, (2) revise SR 4.4.5.2.e to delete reference to alternate repair criteria for axial primary water stress corrosion cracking, which expired at the end of Cycle 12 operation, and replace it with a requirement to perform a 100-percent inspection of the tube in the tubesheet for the hot-leg W* distance, (3) correct a typographical error in 4.4.5.4.a.10, (4) revise 4.4.5.4.a.11 to delete reference to alternate repair criteria for axial primary water stress corrosion cracking, which expired at the end of Cycle 12 operation, and replace it with new W* terminology, and (5) revise 4.4.5.5.d.1 and 4.4.5.5.e to add new reporting criteria associated with implementation of the W* methodology.

The licensee’s proposed change requires that any tube with service-induced degradation within the W* distance to be plugged. The W* distance is the larger of the following distances as measured from the top of the tubesheet (TTS): (a) the top 8 inches of the portion of the tube below the TTS, or (b) 7 inches below the bottom of the WEXTEX transition plus the uncertainty associated with determining the distance below the bottom of the WEXTEX transition (approximately 0.12 inches).

2.0 REGULATORY EVALUATION

Because of the importance of SG tube integrity, the U.S. Nuclear Regulatory Commission (NRC) requires the performance of periodic inservice inspection (ISI) of SG tubes. These inspections detect, in part, degradation in the tubes as a result of the SG operating environment. ISIs may also provide a means of characterizing the nature and cause of any tube degradation so that corrective measures can be taken. Tubes with degradation that exceeds the tube repair limits specified in a plant's TSs are removed from service by plugging or are repaired by sleeving (if approved by the NRC for use at the plant). The plant TSs provide the acceptance criteria related to SG tube inspections.

The requirements for the inspection of SG tubes are intended to ensure that this portion of the reactor coolant system maintains its structural and leakage integrity. Structural integrity refers to maintaining adequate margins against gross failure, rupture, and collapse of the SG tubes. Leakage integrity refers to limiting primary-to-secondary leakage during normal operation, plant transients and postulated accidents to ensure that the radiological dose consequences are within acceptable limits.

In reviewing requests of this nature, the NRC staff verifies that the structural and leakage integrity of the tubes will continue to be maintained consistent with the plant design and licensing basis. This includes verifying that the applicable General Design Criteria (GDC) (e.g., GDC 14 and 32) of Appendix A to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, are satisfied and that the structural margins inherent in Regulatory Guide (RG) 1.121, "Bases for Plugging Degraded PWR [pressurized-water reactors] SG Tubes," dated August 1976, are maintained. This also includes verifying that a conservative methodology exists for determining the amount of primary-to-secondary leakage during design-basis accidents. The amount of leakage is limited to ensure that offsite and control room dose criteria are met. The radiological dose criteria are specified, in part, in 10 CFR Part 100 and in GDC 19 of Appendix A to 10 CFR Part 50.

The NRC previously approved similar, but not identical, license amendment requests for Diablo Canyon Power Plant, Unit Nos. 1 (NUDOCS accession number 9903030010) and 2 (ML021200166) in License Amendment Nos. 129 and 127, respectively, for two cycles of operation. In addition, the NRC approved a similar request for SQN, Unit 2 (ML021340595) in License Amendment No. 266 for one cycle of operation. Most recently, the NRC approved a similar request for Beaver Valley, Unit 1 (ML042730591) in License Amendment No. 262 for one cycle of operation.

3.0 TECHNICAL EVALUATION

As discussed above, the proposed amendment would revise the SQN Unit 2 TSs to change the scope of the steam generator (SG) tube inspections required in the SG tubesheet region by applying a methodology referred to as W*. In addition, the proposed amendment would make several administrative changes such as correcting a typographical error, deleting reference to alternate repair criteria for axial primary water stress corrosion cracking, which expired at the end of Cycle 12 operation, and deleting reference to a tubesheet inspection program, which expired at the end of Cycle 12.

3.1 Background

SQN Unit 2 is a 4-loop, Westinghouse-designed plant with Model 51 SGs. Each SG contains about 3400 tubes. The SG tubes are mill-annealed Alloy 600 with an outside diameter of 0.875 of an inch and a wall thickness of 0.050 of an inch. Each U-tube is roll-expanded for approximately 2.75 inches into the bottom of the tubesheet, then secured into the remaining portion of the tubesheet by an explosive expansion process referred to as the Westinghouse Explosive Tube Expansion (WEXTEX) process. The tubesheet is approximately 21-inches thick and each tube is expanded for essentially the full thickness of the tubesheet. Each tube is also welded to the primary side of the tubesheet near the tube end. This weld provides a leak-tight boundary and also provides resistance to tube pullout. The WEXTEX process forms an interference fit between the tube and tubesheet. The transition from the expanded portion of the tube to the unexpanded portion of the tube is referred to as the WEXTEX transition or the expansion transition. Each SG contains seven tube support plates to provide lateral support to the tubes. The tube supports are carbon steel plates with drilled holes through which the tubes are inserted.

The existing plant TSs do not take into account the reinforcing effect of the tubesheet on the external surface of the expanded tube. The presence of the tubesheet constrains the tube and complements tube integrity in that region by essentially precluding tube deformation beyond the expanded outside diameter of the tube. The resistance to both tube rupture and tube collapse is significantly enhanced by the tubesheet reinforcement. In addition, the proximity of the tubesheet to the expanded tube significantly reduces the leakage from any through-wall defect.

Based on these considerations, power reactor licensees have proposed, and the NRC has approved, alternate repair criteria for defects located in the SG tube contained in the lower portion of the tubesheet, when these defects are a specific distance below the expansion transition or the TTS, whichever is lower.

The W* methodology defines a distance, referred to as the W* distance, such that any type or combination of tube degradation below this distance is considered acceptable (i.e., even if inspections below this region identified degradation, the regulatory requirements pertaining to tube structural and leakage integrity would be met provided there were no flaws within the W* distance). The W* distance is determined by calculating the amount of undegraded tubing, termed the W* length, needed to address tube pullout and leakage concerns. This W* length is measured from the bottom of the WEXTEX transition region. One of the key considerations in determining the W* length is the amount of undegraded tubing necessary to prevent axial pullout of the tube from the tubesheet. Tube pullout could result from the internal pressure in the tube. In addition to the W* length, nondestructive examination (NDE) uncertainties must be accounted for to determine the W* distance. These uncertainties include, but are not limited to, the uncertainties in determining the location of the bottom of the WEXTEX expansion and the total inspection distance below this point (i.e., W* length). These uncertainties are addressed in the W* methodology and were discussed in the NRC staff's safety evaluation approving the W* repair criteria for Diablo Canyon Power Plant, Unit Nos. 1 and 2. To address leakage and structural integrity concerns, the W* distance is defined as the larger of the following two distances as measured from the TTS: (a) 8 inches below the TTS or (b) 7 inches below the bottom of the WEXTEX transition plus the uncertainty associated with determining the distance below the bottom of the WEXTEX transition (approximately 0.12 inches).

The generic W* analysis presented in Westinghouse Commercial Atomic Power report, WCAP-14797, Revision 2, “Generic W* Tube Plugging Criteria for 51 Series Steam Generator Tubesheet Region WEXTEX Expansions,” uses bounding or nonplant-specific values for secondary system pressure and primary temperature to determine the required W* length for two regions of the tube bundle. This analysis considered the forces acting to pull the tube out of the tubesheet (i.e., from the internal pressure in the tube) and the forces acting to keep the tube in place. These latter forces are a result of friction and the forces arising from (1) the residual preload from the WEXTEX expansion process, (2) the differential thermal expansion between the tube and the tubesheet, and (3) internal pressure in the tube within the tubesheet. In addition, the effects of tubesheet bow due to pressure and thermal differentials across the tubesheet were considered since this bow causes dilation of the tubesheet holes from the secondary face to approximately the midpoint of the tubesheet and reduces the ability of the tube to resist tube pullout. The amount of tubesheet bow varies across the tube bundle with tubes in the periphery (referred to as Zone A tubes) experiencing less bow than tubes in the interior of the SG tube bundle (referred to as Zone B tubes). In fact, the analysis provided indicates that the W* length for Zone A tubes is 5.2 inches and the W* length for Zone B tubes is 7.0 inches. In addition to the W* length, the analysis in WCAP-14797 also considered the uncertainties associated with NDE.

3.2 SQN Unit 2 Proposal

The licensee’s basis for inspecting from the TTS to the W* distance is documented in its license amendment request and in WCAP-14797, Revision 2. Operating conditions assumed in the generic WCAP analysis bound the operating conditions at SQN Unit 2 such that the W* distance calculated using plant-specific conditions would be less than the W* distance identified in WCAP-14797. For example, the generic analysis assumes a hot leg temperature of 590 ^{o}F, whereas the limiting hot leg operating temperature at SQN Unit 2 is approximately 609.5 ^{o}F. Therefore, the generic analysis provides less thermal tightening of the WEXTEX joint than would actually be present in the SGs. The secondary system pressure assumed for the generic analysis also provides for less pressure tightening of the WEXTEX joint compared to the plant conditions.

The proposal is also more conservative than that discussed in WCAP-14797 for other reasons. For example, the proposal requires all service-induced degradation in the W* distance to be plugged. In other words, axial cracks will not remain in service within the W* distance (i.e., the flexible W* length discussed in WCAP-14797 will not be applied). The proposal also uses a bounding leakage methodology based on tube-to-tubesheet contact pressures that differs from the DENTFLO Code leakage model presented in WCAP-14797. In addition, the licensee will conservatively apply the greater W* length calculated for Zone B tubes to all tubes in the SG.

Given that the operating conditions (e.g., pressure and temperature) can change at the plant, the licensee stated in their letter of March 9, 2005, that any subsequent design or operating changes that have the potential to alter the full power primary system temperature or full power secondary side steam pressure will be reviewed for compliance within the limits discussed in the WCAP as part of the plant design change process.

The following sections summarize the NRC staff’s evaluation of the proposed W* proposal in terms of maintaining SG structural and leakage integrity.

3.3 Tube Structural Integrity

The licensee's proposal will permit tubes with defects to remain in service; therefore, the licensee must demonstrate that the tubes returned to service using the W* methodology will maintain adequate structural integrity. Tube rupture and the pullout of a tube from the tubesheet are two potential modes of structural failure considered for tubes returned to service under the W* methodology.

In order for a tube to rupture due to flaws in the W* region, any known flaws remaining in service using the W* criteria would need to propagate above the tubesheet's secondary face. If the entire flaw remains within the tubesheet, the reinforcement provided by the tubesheet will prevent tube rupture. The proposed W* methodology requires an examination in the W* distance and the repair of any service-related degradation in the W* distance. Therefore, any known flaws remaining in service following the examinations will be located a minimum of 8 inches below the TTS. Industry operating experience shows flaw growth rates within the tubesheet over one cycle of operation are well below that necessary to propagate a flaw from 8 inches below the TTS to outside the tubesheet. Therefore, it's not likely that any of these flaws will grow in an axial direction and extend outside the tubesheet. Thus, tube burst is precluded for these flaws due to the reinforcement provided by the surrounding tubesheet.

In the event that flaws are located within the W* distance and are not detected during the inspection or if new flaws initiate in the W* distance in the operating cycle following the inspection, there is a potential that these flaws could grow in the axial direction and extend outside the tubesheet. As a result, the NRC staff considered the conditions that would be necessary to structurally fail a tube with this type of flaw. SG tube rupture is primarily a function of flaw geometry (e.g., length), the differential pressure across the tube wall, and the flaw location. In order to remove adequate margins for tube burst under all operating conditions, axial, through-wall tube flaws must exceed a certain length, typically on the order of 0.5 inch or longer, and have no external restraint (i.e., occur in the free span). Partially through-wall flaws would require additional length in order to become susceptible to spontaneous rupture based on empirical models for tube burst. Thus, these flaws would have to extend a significant distance above the tubesheet to degrade the margins of structural integrity for the affected tube (i.e., tubes with undetected flaws slightly below the TTS). In addition, restriction of a flaw on one end by the tubesheet would further elevate the burst pressure of this tube. Flaw growth rates necessary to reach a critical flaw size are unlikely to occur. Therefore, flaws remaining in service under either of the two scenarios described above should maintain adequate margins for tube burst.

The other postulated structural failure mode for tubes remaining in service, according to the W* methodology, is pullout of the tube from the tubesheet due to axial loading on the tube. Differential pressures from the primary side to the secondary side of the SG impart axial loads into each tube that are reacted at the tube-to-tubesheet interface. Axial tube loading during normal operating conditions can be significant. The peak postulated loading, however, occurs during events involving a depressurization of the secondary side of the SG (e.g., main steamline break (MSLB)). The presence of circumferentially oriented degradation within a SG tube under axial loading decreases the load-bearing capability of the affected tube. If a tube becomes sufficiently degraded, these loads could lead to an axial separation of the tube.

Resistance to tube pullout is provided by the interference fit created during the tube explosive expansion (i.e., WEXTEX process). In addition, increasing the temperature of the system and the internal pressure of the tube creates a tighter interference fit between the tube and the tubesheet to further resist tube pullout. The analysis supporting the licensee's proposed modifications to the plant TSs addressed the limiting conditions necessary to maintain adequate structural integrity of the tube-to-tubesheet joint. Specifically, the tube must not experience excessive displacement relative to the tubesheet under bounding loading conditions with appropriate factors of safety considered. The licensee's amendment proposal indicated all cracks within the W* distance (including those with circumferential orientation) will be repaired. To justify the acceptability of any type or combination of tube degradation below the W* distance, the licensee completed an assessment using analytical calculations and laboratory experiments. This assessment included pullout tests of prototypical SG tube-to-tubesheet joints to evaluate the length of sound tubing necessary to maintain the appropriate structural margins for tubes that may contain degradation within the tubesheet. The test specimens were subjected to internal pressurization and axial loadings at various temperature conditions in order to demonstrate acceptable structural capabilities under a range of loading conditions. Despite using configurations with lower structural capabilities than expected of actual in-service SG tubes, the test program demonstrated that tubes remaining in service according to the W* methodology resisted pullout from the tubesheet with margins meeting or exceeding those inherent in RG 1.121.

In summary, the W* repair criteria were established, in part, to limit the potential for the growth of cracks into the free span region above the tubesheet and to maintain adequate strength to resist tube pullout from the tubesheet. The confinement of the surrounding tubesheet for all flaws left in service using this proposed alternate repair criteria will prevent tube structural failure by tube burst. Repair of all service-induced degradation within the W* distance will ensure that tube pullout from the tubesheet under the limiting conditions is precluded. On these bases, the NRC staff has concluded that tubes returned to service using the W* repair criteria will maintain adequate structural integrity.

3.4 Tube Leakage Integrity

In assessing leakage integrity of a SG under postulated accident conditions, the leakage from all sources (i.e., all types of flaws at all locations and all non-leak tight repairs) must be assessed. The combined leakage from all sources is limited to below a plant-specific limit based on radiological dose consequences. The licensee's plant-specific limit is currently 3.7 gallons per minute (gpm). Since the W* methodology does not require inspections below the W* distance (i.e., 8 inches below the TTS or approximately 7.12 inches below the bottom of the WEXTEX expansion), there is a potential that flaws which could leak will exist below the W* distance. As a result, the licensee has developed a methodology, as part of the W* methodology, for determining the amount of accident-induced primary-to-secondary leakage from flaws in this region of the tubesheet. This methodology and the NRC staff's review of this methodology are discussed below.

A combination of laboratory leak test data and analytical models were used to determine the amount of leakage from flaws left in service using the W* criteria. In general, this information indicated the following relationships important to tube leakage assessment: leak rates decrease with increasing contact pressure; leak rates decrease with increasing crevice length; contact pressure increases with depth below the TTS.

The licensee's W* amendment proposal states that all service-induced degradation from the TTS to the W* distance or 8 inches, whichever distance is greater, will be repaired. Since the W* criteria permits all forms of degradation below the W* distance to remain in service, the licensee evaluated leakage from postulated indications below the W* distance. The proposed approach calculates total leakage from degradation below the W* distance by evaluating indications in two tube segments: (1) between 8 inches and 12 inches below the TTS, and (2) more than 12 inches below the TTS. This methodology requires a determination of the total number of indications within these two tube increments and the leak rate from these indications.

The licensee's leakage methodology approach relies on several relationships developed from data in WCAP-14797. Leak tests were performed on representative WEXTEX test specimens with holes drilled at various locations in order to produce 1.25-inch, 2-inch and 3-inch nominal crevice depths. An average contact pressure was determined for each of the drilled-hole leak rate specimens. These average contact pressures were then related to SG contact pressures calculated as a function of distance below the TTS, for the most limiting tube under the most limiting operating condition. That is, contact pressures were calculated assuming the limiting MSLB conditions, when tubesheet bow and accompanying tubesheet hole dilation effects are maximum. The licensee calculated leakage for tube indications between 8 and 12 inches below the TTS by applying an upper 90 percent prediction leak rate obtained from the 1.25-inch nominal crevice test specimens. The licensee applied the 1.25-inch crevice test leak rates to indications between 8 and 12 inches below the TTS since the contact pressure at 8 inches below the TTS was greater than the average contact pressure in the 1.25-inch crevice test specimens. In a similar manner, the licensee calculated leakage from indications located more than 12 inches below the TTS using the upper 90 percent prediction leak rate from the nominal 3-inch crevice depth leak rate specimens. The leak rate to be applied to indications at 8 inches is 4.5×10^{-3} gpm, and the leak rate to be applied to indications at 12 inches is 8.7×10^{-5} gpm.

In addition to determining the tube leak rate from an indication at a depth of 8 inches and 12 inches below the TTS, the licensee also developed a methodology for projecting the total number of indications below the W* distance in order to calculate the leakage from all indications. For determining the number of indications between 8 and 12 inches below the TTS at the next tube inspection, the licensee will (a) project the total number of additional indications it expects to find in the tubesheet region of all four SGs during the next inspection based on a regression fit of the number of indications as a function of outage, (b) determine the total number of indications it has detected in the tubesheet region in all four SGs since commencement of operation, and c) assume that 25 percent of the sum of the these two numbers will reside between 8 and 12 inches in each SG. The value of 25 percent is a conservative bound of the fraction of indications located between 4 and 8 inches within the tubesheet (i.e., a 4-inch band similar to the 8- to 12-inch band). Given that the 25 percent value is based on historical data, the licensee is required to provide an assessment of whether the results were consistent with expectations with respect to the number of flaws (e.g., the total number of indications in the 4- to 8-inch band is less than 25 percent of the total number of indications) and flaw severity. If the results are not consistent, the licensee is required to provide a description of their proposed corrective action. At 12 inches below the TTS, the licensee will assume that all tubes have indications at this location. The flaws at 8 and 12 inches below the TTS are assumed to be circumferentially oriented and 100 percent through-wall over the entire tube circumference (i.e., 360-degrees). In addition, the indications between 8 and 12 inches below the TTS are assumed to all be at 8 inches and the number of indications detected in all four SGs is used to project the number of indications in each SG. Although these indications would be expected to be spread over all four SGs, the licensee is conservatively assuming that all postulated indications within this range are located in each of the four SGs.

After determining the leak rates and the number of indications located (1) between 8 and 12 inches below the TTS, and (2) more than 12 inches below the TTS, the total leakage from indications in the tubesheet was obtained by multiplying the total number of indications at these elevations by the appropriate leak rates.

As discussed above, the NRC staff reviewed the licensee's leakage methodology that relates an average contact pressure from laboratory leak test specimens to contact pressures at certain tubesheet depths within the SG. This average contact pressure was calculated for each test specimen by dividing the calculated total contact pressure by the effective contact length, after accounting for end effects and tube staking. In order to assess the relative conservatism of the licensee's leakage methodology, the NRC staff compared the contact pressures at 8 inches and 12 inches below the TTS for the limiting design-basis accident conditions to the contact pressures for the 1.25-inch and 3-inch nominal crevice depth leak test specimens. For those indications greater than 12 inches below the TTS, the NRC staff considers use of the leak rates from the 3-inch crevice specimens to be acceptable, given the maximum contact pressure of the specimens, the actual crevice length of the specimens, and the assumption concerning the number and severity of flaws.

For the 1.25-inch crevice depth leak test specimens, which are used to estimate the leak rate for indications located approximately 8 inches below the TTS, WCAP-14797 indicates that the contact pressure at approximately 8 inches below the TTS is less than 100 pounds per square inch (psi) greater than the averaged contact pressure from the test specimens. Given NRC staff questions regarding whether the maximum contact pressure, rather than the average contact pressure, is the dominant factor that determines the leak rate, the licensee provided additional information to support their leakage model. Based on a review of this information, the NRC staff considers use of the leak rates from the 1.25-inch crevice specimens to be acceptable for determining the leak rate for those indications between 8 and 12 inches below the TTS, given the following:

1. Although the average (rather than the maximum) contact pressure was used in comparing the contact pressure of the test specimen to the contact pressure in the actual steam generator, the average contact pressure for the test specimen was determined assuming that there was no secondary side pressure. The contact pressure in the actual steam generator assumed that there was secondary side pressure. Since secondary side pressure reduces the contact pressure, both the maximum and average contact pressure of the specimens would be lower and closer (or less than) the contact pressure in the actual steam generator. For example, if a secondary side pressure was assumed for the 3-inch crevice specimens, the contact pressures could be as low as 1514 psi (as compared to contact pressures determined without consideration of secondary side pressures of 2100 to 2300 psi).

2. The leak rate applied at 8 inches is based on tests just simulating the crevice (or more precisely the interference fit) rather than both an interference fit and a crack. Tight cracks, such as those found in steam generator tubes, provide resistance to leakage (thereby limiting the total leak rate).

3. The assumption that all tubes postulated to have indications are assumed to have 360-degree, 100 percent through-wall flaws at 8 inches below the TTS. Historic inspection results indicate more limited flaw severity. In addition, in order to ensure a minimum, 8-inch inspection distance into the tubesheet, actual inspection distances will exceed 8 inches into the tubesheet.

4. Given that the leak path through the interference fit is most likely a tortuous route based on microscopic irregularities of the tube and the tubesheet surface, the maximum contact pressure would only be applied on a limited length of this path. In addition, unless the maximum contact pressure was significantly greater than the average contact pressure, the closing of the crevice (interference fit) between the tube and the tubesheet may be limited (since the resistance to further deformation is expected to increase as the contact pressure increases and the reduction in flow area is expected to decrease as the contact pressure increases).

5. The leak rate was determined based on the worst case tube in the steam generator (i.e., greatest hole dilation resulting in a lower contact pressure). All other radial positions within the steam generator would be expected to have lower leak rates due to higher contact pressures.

6. The crevice length of the test specimens used to determine the leak rate for cracks within the steam generator tube between 8 and 12 inches below the TTS was only 0.6 inches. A longer crevice in the steam generator is expected to reduce the leak rate.

7. The number of indications detected in all four steam generators is used to project the number of indications in each steam generator. Although these indications would be expected to be spread over all four SGs, the licensee is conservatively assuming that all postulated indications within this range are located in each of the four SGs.

To further evaluate the bounding leakage methodology approach presented by the licensee, the NRC staff also considered alternate ways of relating the leak test results to contact pressures within the SG tubesheet. From the data in WCAP-14797, the NRC staff plotted the WEXTEX drilled-hole leak rates as a function of test specimen average contact pressure. Using the calculated tube contact pressures at various depths during MSLB conditions, the NRC staff determined the corresponding leak rate using this plot. The leak rates presented by the licensee using the licensee's leakage method were either more conservative or similar to those obtained by the NRC staff using a direct relationship between test leak rates and test specimen contact pressures.

Accident-induced leakage from flaws located within the top 8 inches of the tubesheet is not anticipated since all flaws in this region are repaired upon detection. This limits the severity of the size of these flaws. Nonetheless, there is a potential that significant indications could arise.

To this end, the licensee stated in their letter of March 9, 2005, that it will perform an assessment if newly initiated severe indications of cracking are identified. This assessment will include an assessment of their potential leakage rate.

The licensee's application of the W* criteria and accompanying leakage methodology will be used to determine the amount of leakage from flaws below the W* distance (i.e., 8 inches below the TTS or 7.12 inches below the bottom of the WEXTEX expansion, whichever is lower within the tubesheet). This leakage will be combined with the leakage from all other sources to ensure that it is less than the plant-specific allowable limits. In addition, the licensee will be required to assess whether the results of the inspection were consistent with expectations with respect to the number of flaws and their severity. In the event that the results are not consistent, the licensee will be required to describe proposed corrective actions. On this basis, the NRC staff has concluded that the licensee has an acceptable methodology for assessing leakage below the W* distance, thereby ensuring leakage integrity can be maintained.

3.5 Reporting Requirements

As required by TS SR 4.4.5.5.e, within 90 days of returning the SGs to service (Mode 4), the licensee will report the following with respect to implementation of the W* inspection methodology: the calculated MSLB leakage, the total number of indications, the location of the indications (relative to the bottom of the WEXTEX transition and TTS), the indication orientation, the severity of each indication, the side of the tube from which the indication initiated, and an assessment of whether the inspection results were consistent with expectations regarding the number of flaws and their severity (and if not consistent, a description of the proposed corrective action). In addition, pursuant to TS SR 4.4.5.5.d, the staff shall be notified prior to returning the steam generators to service, if the total accident induced primary-to-secondary leakage exceeds the leak limit determined from the licensing basis dose calculation for a postulated MSLB for the next operating cycle.

3.6 Administrative Changes

In addition to the technical changes mentioned above, the licensee also proposed several administrative changes. For example, the licensee proposed deleting several references to alternate repair criteria for primary water stress corrosion cracking that was approved for Cycles 11 and 12 only. The staff considers these changes to the TSs acceptable since the approval period for these changes expired. In addition, the licensee proposed deleting reference to the extent of tubesheet inspections, which was approved for Cycle 12 only. The staff considers this change to the TSs acceptable since the approval period for this change expired. In addition, it is important to note that removal of these requirements results in more conservative inspection and repair requirements.

The licensee has also proposed to correct a typographical error in TS 4.4.5.4.a.10. This change replaces Generic Letter "90-05" with Generic Letter "95-05." Since Generic Letter 95-05 is the correct reference, the staff considers this change acceptable.

3.7 Summary

The NRC staff's approval of the licensee's proposal is based on the licensee demonstrating that applicable structural integrity and leakage integrity requirements will be met. This approval is based, in part, on inspections and conservative assumptions involving the licensee's implementation of the W* repair criteria including:

1. The licensee is performing inspections and repairing all service-induced degradation to a minimum depth of 8 inches below the TTS. The inspections are required to detect the forms of degradation occurring in this region.

2. The generic W* distance for the most limiting Zone B tubes (interior of tube bundle) will be applied to the entire SG, which is conservative for the Zone A tubes (peripheral tubes). The W* distance for Zone B tubes represents the most limiting W* tube length in the most limiting region of the SG and, therefore, bounds all other tubes in the SG.

3. The generic W* distances were determined using bounding parameters (i.e., secondary-side pressure and primary-side temperature) resulting in more conservative W* distances than would be obtained using plant-specific operating parameters. The generic W* distances were also determined from lower bound tube pull forces for WEXTEX expansions (based on a smooth tubesheet hole) in order to maximize the W* distance and bound the variability in WEXTEX expansions.

4. The most limiting region of the tube bundle is Zone B, which is in the interior of the tube bundle. If tubes in this region began to pull out of the tubesheet, they would be constrained by contact with neighboring tubes. As a result, the likelihood that a tube would pull out of the tubesheet is small. This effect was not considered in the development of the W* distance and adds conservatism to the evaluation.

5. The licensee's tubes are most likely experiencing denting at the tube support plates which would further restrain tube pullout and would likely prevent the axial pressure load necessary to cause tube pullout. This effect was not considered in the development of the W* distance and adds conservatism to the evaluation.

6. The licensee projects all postulated indications between 8 inches and 12 inches below the TTS are circumferential, 100 percent through-wall over 360°, and occur in one SG, which is a conservative assumption.

7. The licensee assumes all tubes remaining in service contain a 360° circumferential, 100 percent through-wall flaw located 12 inches below the TTS. This assumption is conservative given industry inspection results within the tubesheet region.

8. Flaws postulated below the W* distance are assumed to be leaking although industry operating experience has demonstrated negligible leakage under normal operating conditions, even when cracks are located in a tube-to-tubesheet expansion transition zone.

9. An 800 psi secondary-side pressure in the crevice was assumed when calculating SG tube contact pressures in WCAP-14797, but no secondary-side crevice pressure was assumed when calculating contact pressures for the WEXTEX leak rate test specimens.

The NRC staff concludes the licensee's proposed methodology for assessing structural and leakage integrity for flaws in the tubesheet region is acceptable. Therefore, the NRC staff concludes that the licensee's proposal to limit the tube inspection scope in the hot leg tubesheet is an acceptable approach. In addition, the NRC staff concludes that the administrative changes being proposed to the technical specifications to remove expired requirements and to correct a typographical error are acceptable.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Tennessee State official was notified of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 and changes SRs. The NRC staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration, and there has been no public comment on such finding (70 FR 2899). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

6.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

Principal Contributor: Kenneth Karwoski

Dated: May 3, 2005

Mr. Karl W. Singer
Tennessee Valley Authority

SEQUOYAH NUCLEAR PLANT

cc:

Mr. Ashok S. Bhatnagar, Senior Vice President
Nuclear Operations
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Larry S. Bryant, General Manager
Nuclear Engineering
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Randy Douet
Site Vice President
Sequoyah Nuclear Plant
Tennessee Valley Authority
P.O. Box 2000
Soddy Daisy, TN 37384-2000

General Counsel
Tennessee Valley Authority
ET 11A
400 West Summit Hill Drive
Knoxville, TN 37902

Mr. John C. Fornicola, Manager
Nuclear Assurance and Licensing
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Fredrick C. Mashburn
Senior Program Manager
Nuclear Licensing
Tennessee Valley Authority
4X Blue Ridge
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Paul L. Pace, Manager
Licensing and Industry Affairs
ATTN: James D. Smith
Sequoyah Nuclear Plant
Tennessee Valley Authority
P.O. Box 2000
Soddy Daisy, TN 37384-2000

Mr. David A. Kulisek, Plant Manager
Sequoyah Nuclear Plant
Tennessee Valley Authority
P.O. Box 2000
Soddy Daisy, TN 37384-2000

Senior Resident Inspector
Sequoyah Nuclear Plant
U.S. Nuclear Regulatory Commission
2600 Igou Ferry Road
Soddy Daisy, TN 37379

Mr. Lawrence E. Nanney, Director
Division of Radiological Health
Dept. of Environment & Conservation
Third Floor, L and C Annex
401 Church Street
Nashville, TN 37243-1532

County Mayor
Hamilton County Courthouse
Chattanooga, TN 37402-2801

Ms. Ann P. Harris
341 Swing Loop Road
Rockwood, Tennessee 37854