Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37379

June 27, 1995

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

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

SEQUOYAH NUCLEAR PLANT (SQN) - RESPONSE TO NRC GENERIC LETTER (GL) 95-03, "CIRCUMFERENTIAL CRACKING OF STEAM GENERATOR TUBES"

Reference: NRC letter to TVA dated April 28, 1995, "NRC Generic Letter 95-03: Circumferential Cracking of Steam Generator Tubes"

This letter provides the 60-day response required by the referenced GL 95-03 for SQN Units 1 and 2. TVA has implemented the requested actions from GL 95-03 as follows:

1. Evaluations of recent operating experience with respect to the detection and sizing of circumferential indications to determine applicability to SQN have been performed.

2. Based on the evaluation in Item 1 above, past inspections scope and results, susceptibility to circumferential cracking, threshold of detection, expected crack growth rates and other relevant factors, a safety assessment justifying continued operation until the next scheduled steam generator (S/G) tube inspections (Cycle 7 refueling outage) has been performed.

3. Plans for S/G tube inspections pertaining to detection of circumferential cracking have been provided.

SQN's S/G inspection program has established a defense in depth approach in the area of circumferential tube cracks. SQN has an administrative primary to secondary leak rate limit of 128 gallons per day to provide for leak before break protection. TVA has performed comprehensive examinations of SQN's S/G tubes and has utilized a rotating pancake coil (RPC) with three coils for examining regions susceptible to circumferential cracking. The examinations are performed in accordance with Electric Power Research Institute PWR Steam Generator Examination Guidelines and

D030

Westinghouse Electric Corporation Owners Group, Westinghouse Explosive Tube Expansion Subgroup Rotating Pancake Coil Inspection and Leakage Monitoring Guidelines. Shotpeening has been performed on SQN's S/G tubes within the tubesheet and tube expansion transition region to minimize susceptibility to cracking. In addition, heat treatment of SQN's Row 1 and 2 U-bend regions has been utilized as a tool in reducing susceptibility to cracking. SQN has performed RPC examinations on a sample of dented tube support plate intersections in response to the North Anna 1 Nuclear Plant findings; however, no circumferential cracks have been detected to date in this region. TVA is current with industry and technological advances in the prevention, detection, and mitigation of circumferential cracking.

Based on the above information, SQN's operating history, and a defense in depth approach, TVA considers these mitigation techniques and inspection methods adequate to provide a means of monitoring SQN S/Gs for circumferential cracks and for continued safe operation of both units.

Enclosure 1 provides a summary of SQN's S/G operating history and inspection results. Enclosure 2 provides detailed information relative to SQN's Unit 1 S/G tubes. Enclosure 3 provides detailed information relative to Unit 2. Enclosure 4 provides the SQN safety assessment justifying continued operation for both units. Enclosure 5 provides a summary of the inspection plans and a schedule for the upcoming Cycle 7 S/G inspections.

Please direct questions concerning this issue to D. V. Goodin at (615) 843-7734.

Sincerely,

R. H. Shell

R. H. Shell
Manager
SQN Site Licensing

Sworn to and subscribed before me
this 27th day of June 1995

Peggy M. Billingsley
Notary Public
My Commission Expires Oct. 21, 1998

Enclosures
cc: See page 3

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ENCLOSURE 1

SEQUOYAH NUCLEAR PLANT (SQN)

SUMMARY OF STEAM GENERATOR (S/G) TUBE

HISTORY AND INSPECTION FOR CIRCUMFERENTIAL CRACKING

SUMMARY

SQN's S/G inspection program currently provides a defense-in-depth approach in the prevention, detection, and mitigation of circumferential tube cracks.

No circumferential indications exceeding Regulatory Guide 1.121 tube burst recommendations have been found at either SQN Units 1 or 2. This applies to the Westinghouse Electric Corporation explosive tube expansion (WEXTEX) transitions, dented tube support plate intersections, and small radius U-bends. Since the initial 100 percent rotating pancake coil (RPC) inspections in 1991 (Unit 1), no WEXTEX circumferential indications exceeding RPC angles of 98 degrees have been found. The current operating cycle lengths and primary temperature are very similar to the past operating cycles for each unit.

Small crack angles found since 1991 demonstrate that the SQN S/G RPC inspections result in an adequate ability for detection and no structurally challenging indications have been left in service. SQN growth rates have been found to be on the order of 64 degrees per cycle, which is consistent with the lower range found for WEXTEX indications.

Shotpeening has been performed on SQN's S/G tubes within the tubesheet and tube expansion transition regions to minimize susceptibility to cracking. In addition, heat treatment of SQN's Row 1 and 2 U-bend regions has been utilized as a tool in reducing susceptibility to cracking. SQN has performed RPC examinations on a sample of dented tube support plate intersections in response to the North Anna 1 Nuclear Plant findings; however, no circumferential cracks have been detected to date in this region. In addition, an administrative primary-to-secondary leak rate limit of 128 gallons per day provides "leak-before-break" protection.

Based on: (1) the extensive RPC inspection programs performed in the SQN Units 1 and 2 tubes at the top of tubesheet elevation, (2) plugging of all detected circumferential indications, (3) a decreasing number of new indications, (4) low apparent growth rate, (5) secondary side chemistry control, (6) an administrative primary-to-secondary leak rate limit, and (7) ongoing S/G program elements described in the enclosures, it can be concluded that no SQN tubes are projected to challenge the structural integrity limits in the current operating cycle nor are circumferential indications expected to challenge tube integrity in future cycles. Accordingly, TVA considers SQN safe for operation to the upcoming Cycle 7 S/G inspections.

ENCLOSURE 2

SEQUOYAH NUCLEAR PLANT (SQN) UNIT 1

DETAILED HISTORY OF STEAM GENERATOR (S/G) TUBE

CIRCUMFERENTIAL CRACKING

Unit 1 Operating Parameters

SQN Unit 1 has Westinghouse Electric Corporation, Model 51 S/Gs with 7/8-inch outside diameter 0.050-inch wall Inconel Alloy 600 low temperature mill annealed tubing. The tubing was expanded full depth within the tubesheet by the Westinghouse explosive tube expansion (WEXTEX) method. Unit 1 will have approximately 7.2 effective full power years of operation at the next refueling outage (Unit 1 Cycle 7 scheduled for September 1995). SQN Unit 1 has a design reactor coolant system (RCS) T-hot of 610 degrees Fahrenheit (F), but operates at an average T-hot of approximately 607 degrees F.

SQN Unit 1 operates with all volatile treatment chemistry. During the first five operating cycles, SQN utilized ammonia for secondary side chemistry pH control. Morpholine was utilized for pH control for one operating cycle. Ethanolamine is now utilized for pH control. Boric acid addition was started in 1994 after the Cycle 6 refueling outage. Molar ratio control has also been implemented as of February 1995.

Areas Susceptible to Circumferential Cracking

SQN Unit 1 is susceptible to circumferential cracking in the following areas:

1. Top-of-tubesheet (TTS) expansion-transition region.
2. Dented tube support plate (TSP) intersections.
3. Low row U-bend region.

SQN Unit 1 tubes are not sleeved, therefore, the tubes are not susceptible to sleeve related circumferential cracking.

SQN Unit 1 is susceptible to TTS expansion-transition circumferential cracking. This is based on SQN Unit 1 inspections and on industry WEXTEX experience.

Industry experience with circumferential cracking at dented TSPs is currently limited to one nuclear unit (North Anna 1 Nuclear Plant). TVA has, in conjunction with Westinghouse, performed a comparison study with North Anna Unit 1 and found the SQN circumstances and tube conditions to be similar. SQN Unit 1 S/Gs 3 and 4 have a large number of TSP intersections, which are dented greater than or equal to 5 volts (from bobbin coil examinations). Numerous RPC examinations have been performed for outside diameter stress corrosion cracking detection. No circumferential cracking at TSP intersections have been detected to date.

SQN Unit 1 has detected low row U-bend region circumferential cracks. U-bend stress relief, performed during the Cycle 3 refueling outage, has been effective in precluding additional cracking of low row U-bends.

SQN Unit 1 has been analyzed by Westinghouse for the rapidly propagating fatigue cracking at the seventh TSP intersection due to unsupported U-bend regions (NRC Bulletin 88-02). All tubes identified as susceptible have been plugged on Unit 1. Therefore, Unit 1 is not susceptible to rapidly propagating fatigue cracking at the seventh TSP.

SQN Unit 1 Past Inspection Scope and Results

Attachment 1 contains the inspection scope and results pertaining to circumferential cracking for SQN Unit 1 Cycles 4, 5, and 6 refueling outages.

One circumferential crack was found during the Cycle 4 inspection. As a result of identifying TTS primary water stress corrosion cracking (PWSCC) during the Cycle 4 inspection, the recommendations from Westinghouse Owner Group (WOG) WEXTEX Subgroup (RPC Inspection and Leakage Monitoring Guidelines) were implemented during the Cycle 5 inspection. During the Cycle 5 inspection, 100 percent of the tubes were examined at TTS with rotating pancake coil (RPC). Due to the circumferential cracks found during the Cycle 5 inspection, ultrasonic testing (UT) examinations were utilized. UT examinations of the largest circumferential cracks determined that ligaments were present. Tube structural integrity, as required by RG-1.121, was thereby verified. During the Cycle 6 refueling outage, over 50 percent of the tubes were examined at TTS with RPC and 16 circumferential PWSCC cracks were detected. SQN, along with other WEXTEX plants, have been successful in managing circumferential cracking through the implementation of the WEXTEX guidelines.

During the Cycle 6 refueling outage, RPC examinations at dented TSPs were performed for the detection of stress corrosion cracking. All TSP intersection dented greater than or equal to 5 volts up to the fifth hot leg TSP were RPC examined (6,388) with no circumferential cracks detected.

Other Relevant Factors

Unit 1 S/G Rows 1 and 2 were U-bend stress relieved during the Unit 1 Cycle 3 refueling outage. U-bend stress relief has resulted in improved resistance to PWSCC in this region. The Unit 1 tubesheet regions were shotpeened during the Cycle 5 refueling outage as an preventive measure for PWSCC in the WEXTEX expansion-transition region. The quantities of circumferential indications identified were greatly reduced during the subsequent Unit 1 Cycle 6 outage inspections. Two tubes (three TSP intersections and two TTS expansion transitions) were pulled from SQN Unit 1 during the Cycle 6 refueling outage to characterize axial indications at TSPs. No circumferential cracking was observed by metallurgy analysis at TTS or TSP locations.

Unit 1 experienced a major chemistry excursion in February 1992. EPRI PWR Secondary Water Chemistry Guidelines, Level II values were exceeded for approximately five days. The excursion resulted in a unit power reduction to 30 percent.

Circumferential Crack Growth Rate

During the Cycle 5 inspection, 52 circumferential cracks were identified. A review of the previous eddy current examination data for all tubes with circumferential cracking was performed to determine a circumferential crack arc length growth rate. This comparison was made between the Cycle 5 eddy current data (knowing that a defect was present) and the Cycle 4 eddy current data to determine if the defects may have been present in the Cycle 4 exams. Eleven tubes with circumferential cracks found in Cycle 5 were examined with RPC in the previous Cycle 4 inspection. The average circumferential crack arc length growth from Cycle 4 to Cycle 5 was 63.9 degrees with a minimum of 5 degrees and a maximum of 128 degrees. NRC RG-1.121 analysis was performed and all tubes with circumferential cracks met the structural integrity requirements. This information is contained within a report, which was previously docketed by a letter to the NRC from J. L. Wilson dated December 9, 1991.

Unit 1 Past Inspection Scope

Number of Examinations

Eddy Current Exams	Unit 1 Cycle 4	Unit 1 Cycle 5	Unit 1 Cycle 6
TTS RPC	1343	13484	8785
U-Bend RPC	107	83	376
Dented TSP RPC	636(1)	410(1)	6388

(1)Tube support plate exams included dented and non-dented intersections

Unit 1 Past Inspection Results

Number of Tubes with Circ. Cracks

Circumferential Indications	Unit 1 Cycle 4	Unit 1 Cycle 5	Unit 1 Cycle 6
TTS	1	52	16
U-Bend	-	-	1(2)
Dented TSP	-	-	-

(2) Not an active damage mechanism. Indication conservatively plugged.

ENCLOSURE 3

SEQUOYAH NUCLEAR PLANT (SQN) UNIT 2

DETAILED HISTORY OF STEAM GENERATOR (S/G)

TUBE CIRCUMFERENTIAL CRACKING

Plant Specific Operating Parameters

SQN Unit 2 has Westinghouse Electric Corporation Model 51 S/Gs with 7/8-inch outside diameter and 0.050-inch wall Inconel Alloy 600 low temperature mill annealed tubing. The tubing was expanded full depth within the tubesheet by the Westinghouse explosive tube expansion (WEXTEX) method. Unit 2 will have approximately 7.7 effective full power years of operation at the next refueling outage (Unit 2 Cycle 7 scheduled for May 1996). SQN Unit 2 has a design reactor coolant system (RCS) T-hot of 610 degrees Fahrenheit (F), but operates at an average T-hot of approximately 607 degrees F.

SQN Unit 2 operates with all volatile treatment chemistry. During the first five operating cycles, SQN utilized ammonia for secondary chemistry pH control. Morpholine was utilized for pH control for one operating cycle. Ethanolamine is now utilized for pH control. Boric acid addition was started in 1994 after the Cycle 6 refueling outage. Molar ratio control has also been implemented as of February 1995.

SQN Areas Susceptible to Circumferential Cracking

SQN Unit 2 is susceptible to circumferential cracking in the following areas:

1. Top-of-tubesheet (TTS) expansion-transition region.
2. Dented tube support plate (TSP) intersections.
3. Low row U-bend region.

SQN Unit 2 tubes are not sleeved and therefore are not susceptible to sleeve related circumferential cracking.

SQN Unit 2 is susceptible to TTS expansion-transition circumferential cracking. This is based on SQN Unit 2 inspections and on industry WEXTEX experience.

Industry experience with circumferential cracking at dented TSPs is currently limited to one nuclear unit (North Anna 1 Nuclear Plant). TVA, in conjunction with Westinghouse, performed a comparison study with North Anna Unit 1 and found that SQN circumstances and tube conditions are similar. Only a small number of TSP intersections on SQN Unit 2 S/Gs are dented greater than or equal to 5 volts (from bobbin coil examinations), therefore, susceptibility to circumferential cracking is limited to a small number of tubes. A sample of the dented intersections have had RPC examinations performed for outside diameter stress corrosion cracking detection with no circumferential cracking at TSPs detected to date.

SQN Unit 2 has detected low row U-bend region circumferential cracks. These regions have been stress relieved during the Cycle 6 refueling outage. Industry experience has shown stress relief to be effective in precluding cracking in the low row U-bend regions.

SQN Unit 2 has been analyzed by Westinghouse for the rapidly propagating fatigue cracking at the seventh TSP due to unsupported U-bend regions (NRC Bulletin 88-02). All tubes identified as susceptible have been plugged on Unit 2. Therefore, Unit 2 is not susceptible to rapidly propagating fatigue cracking at the seventh TSP.

SQN Unit 2 Past Inspection Scope and Results

Attachment 2 contains the inspection scope and results pertaining to circumferential cracking for SQN Unit 2 Cycles 4, 5, and 6 refueling outages.

During the Unit 2 restart in April 1988, a circumferential indication was detected in a Row 1 U-bend region. Due to helium leak indications that were not confirmed with eddy current, all Row 1 tubes were subsequently plugged preventively. TVA initiated an effort which greatly improved the industry standard U-bend RPC probes detection of primary water stress corrosion cracking (PWSCC). During the Cycle 6 refueling outage, Row 1 tubes were deplugged, Rows 1 and 2 were stress relieved, and RPC examined. These examinations, performed prior to returning the Row 1 tubes to service, detected circumferential cracking. The subject tubes were plugged.

SQN Unit 2 first detected circumferential cracking at TTS during the Cycle 5 inspection utilizing an RPC probe. SQN, in accordance with the WOG WEXTEX Subgroup Rotating Pancake Coil Inspection and Leakage Monitoring Guidelines, examined tubes determined to be the most susceptible to TTS PWSCC with RPC during both the Cycle 5 and 6 refueling outages.

During the Unit 2 Cycle 6 refueling outage, all TSP intersections dented greater than or equal to 5 volts at the first three hot leg locations were examined with RPC and no circumferential cracks were detected.

Other Relevant Factors

No tube pulls have been performed on Unit 2. The tubesheet and expansion transition regions were shotpeened during the Cycle 5 refueling outage.

There have been no recent (over the last three operating cycles) chemistry excursions on Unit 2.

Circumferential Crack Growth Rate

Circumferential crack growth rates have not been determined for Unit 2. The previously identified Unit 1 and/or industry obtained circumferential crack growth rate would be assumed.

Unit 2 Past Inspection Scope

Number of Examinations

Eddy Current Exams	Unit 2 Cycle 4	Unit 2 Cycle 5	Unit 2 Cycle 6
TTS RPC	5428	9851	8535
U-Bend RPC	375	375	746
Dented TSP RPC	2252(1)	1041(1)	114

(1)Tube support plate exams included dented and non-dented intersections

Unit 2 Past Inspection Results

Number of Tubes with Circ. Cracks

Circumferential Indications	Unit 2 Cycle 4	Unit 2 Cycle 5	Unit 2 Cycle 6
TTS	-	2	-
U-Bend	-	-	10(2)
Dented TSP	-	-	-

(2)Tubes examined after U-bend stress relief and prior to being returned to service and therefore are not an active damage mechanism.

ENCLOSURE 4

SEQUOYAH NUCLEAR PLANT (SQN)

SAFETY ASSESSMENT JUSTIFYING CONTINUED OPERATION

1.0 INTRODUCTION

Recent nondestructive examination of the steam generator (S/G) tubing at the Maine Yankee Nuclear Plant has identified a large number of circumferential indications at the top of the tubesheet region. These most recent inspection findings, coupled with previously documented inspection results regarding circumferential cracking have led to the issuance of NRC Generic Letter (GL) 95-03, "Circumferential Cracking of Steam Generator Tubes," on April 28, 1995. The information detailed herein, will address the requested actions of the GL 95-03 as they pertain to Westinghouse designed and manufactured S/Gs in general and specifically to Sequoyah Units 1 and 2.

The most recent inspection findings concerning S/G tube expansion regions (Maine Yankee and Arkansas Nuclear One Unit 2) appear to have impacted those S/Gs utilizing the Combustion-Engineering EXPLANSION more than others. While there are similarities between the C-E EXPLANSION process and the Westinghouse WEXTEX process, the degree to which the Westinghouse units, regardless of tube expansion process, have been affected by circumferential cracking is significantly less than the most recent experience of the C-E units. Furthermore, the reported sludge pile height at Maine Yankee may have influenced indication detectability. Such sludge pile thicknesses are not representative of currently operating Westinghouse units.

Successive inspection results using RPC probes for Westinghouse plants with hardrolled or explosively expanded tubes have indicated steadily declining numbers of new indications, declining angular extent and to the degree achievable, very low growth rates. The only occurrences of significant levels of circumferential cracking have been found when plants perform the first large scale RPC inspection.

1.1 Historical Circumferential Degradation Locations

Available historical information shows that for some Westinghouse plants, circumferential corrosion has been detected in the tubesheet region tube expansion transitions from expanded to unexpanded tube, at Rows 1 and 2 U-bend tangent points, and at one plant (two twin units), at dented tube support plate intersections. The main focus of this response will be to address tubesheet region expansion transition cracking, since this was the reason for the issuance of the GL. Other circumferential crack initiation sites will be addressed in the following section due to their limited numbers of field indications detected and limited number of tubes which can be affected (specifically small radius U-bends and dented tube support plate intersections).

1.2 Circumferential Degradation Evaluation of Small Radius U-bends and TSPs

The incidence of circumferential indications at Rows 1 and 2 U-bend tangent points has not been significant, both in numbers of indications at indicated RPC angles. Some plants have administratively decided to preventively plug Row 1, and in some plants Rows 1 and 2 tubes. Additional plants have applied U-bend heat treatment in this region and have effectively recovered tubes previously preventively plugged. Westinghouse has applied UBHT at Sequoyah Unit 1 in 1987 and at Sequoyah Unit 2 in 1994. Field experience has shown the UBHT process to reduce new indication incidence rates at the tangent points. The incidence of circumferential cracking at dented TSP intersections has been limited to one plant which has since replaced S/Gs.

A leakage event occurred in 1987 which resulted in a S/G tube rupture due to high cycle fatigue at a dented top tube support plate. Pursuant to NRC Bulletin 88-02, all domestic Westinghouse S/Gs with carbon steel tube support plates have been analyzed for the potential to experience high cycle fatigue at this location using a methodology accepted by the NRC. In cases where the analysis indicated that fatigue usage could exceed 1.0, the tube was either plugged and stabilized or plugged using a leak limiting sentinel plug. Three conditions must be present for high cycle fatigue at the top tube support plate; denting, lack of AVB support, and locally elevated steam velocities due to nonuniform AVB insertion depths.

In many Westinghouse plants, an augmented top of tubesheet region inspection program is conducted on a cycle to cycle basis. Many Westinghouse plants have had all hot leg tubes inspected at the top of tubesheet region using the RPC probe and continue to do so on a cycle to cycle basis. Currently available probes, coupled with properly implemented calling criteria and techniques have been demonstrated to be and are sufficient to identify circumferential indications in the tubesheet region. Recognizing the potential susceptibility to cracking in the expansion transition regions, many Westinghouse units have implemented shotpeening or rotopeening of the expansion transitions to enhance the resistance of this region to the tube bundle to primary water stress corrosion cracking (PWSCC). This remedial measure, especially when implemented prior to commercial operation, can be effective in mitigating the effects of PWSCC.

Collectively, the items discussed above and further detailed on the following pages provide justification for the continued operation of Sequoyah Units 1 and 2.

2.0 OPERATING EXPERIENCE WITH CIRCUMFERENTIAL CRACKING FOR THE U.S. POPULATION OF WESTINGHOUSE STEAM GENERATORS

This section serves to classify and categorize all Westinghouse S/Gs according to tube material and expansion process. Other influencing factors, such as the application of shotpeening or rotopeening will be addressed in Section 3.0.

Sequoyah Units 1 and Unit 2 use Westinghouse Series 51 S/Gs with WEXTEX tube expansion. Both units use Alloy 600 MA tubing. The tubing dimensions for the Sequoyah Units are 0.875" OD x 0.050" nominal wall thickness. The plants using this type of tube expansion technique are listed in the table below.

WEXTEX Explosive Expansion Plants Alloy 600 Mill Annealed (MA) Tubing				
Plant/ Steam Generator Model	Start up	First Time Circ. Cracking	Location	Tube Pull and Results
Beaver Valley Unit 1/ 51	1976	1/95	Exp. Transition	No
Diablo Canyon Unit 1/ 51	1984	10/92	Row 1 U-Bend	No
		3/94	Exp. Transition	No
Diablo Canyon Unit 2/ 51	1985	3/93	Exp. Transition	No
Farley Unit 1/ 51	1977	3/91	Exp. Transition	No
		3/91	Row 1 U-Bend	No
Salem Unit 1/ 51	1976	3/91	Exp. Transition	No
Salem Unit 2/ 51	1980	4/93	Exp. Transition	No
Sequoyah Unit 1/ 51	1980	3/90	Exp. Transition	No
Sequoyah Unit 2/ 51	1981	4/88	Row 1 U-Bend	No
		8/90	Exp. Transition	No
Comanche Peak 1[a]/ D4	1990	None	N/A	N/A
North Anna Unit 1[b]/ 51	1978	1987	Exp. Transition	Yes, segmented Circ. PWSCC
		1991	Dented TSPs	Yes, circ. axial ODSCC
North Anna Unit 2[b]/ 51	1980	1988	Exp. Transition	No
		1991	Dented TSPs	No

(a): A total of 3839 tubes were removed in the shop to facilitate a stayrod modification. When the tubing was replaced, WEXTEX expansion was used.
(b): Original S/Gs

3.0 Safety Assessment Support

3.1 WEXTEX Tube Expansions

The WEXTEX tube expansion process uses an explosive charge to produce tube to tubesheet contact throughout the tubesheet region. WEXTEX tube expansion generally produces lower residual stresses within the expanded to unexpanded tube transition region than mechanical rolling processes. The WEXTEX process has been implemented only in Alloy 600 MA tubing.

3.1.1 Pulled Tube Summary and Evaluation Results

Circumferential degradation was first evidenced at North Anna Unit 1 in 1987. During the shutdown outage a leaking tube was found during a pressurized secondary side leak test. As a result of this finding, an extensive NDE program was performed. Two tubes with circumferential crack indications in the WEXTEX transition region were subsequently removed from the North Anna Unit 1 plant in 1987; R17 C31 and R18 C36. A discussion of the pulled tube examination results is included below. Two additional tubes, R3 C41 and R9 C58 were removed in 1985 due to distorted eddy current signals at the support plate elevations and clear dent signals at those locations. Neither tube (pulled in 1985) contained significant cracking at the WEXTEX transition region.

WEXTEX Pulled Tube Summary							
Plant and Tube	Burst Press (psi)	Macro-crack length	Max Depth	Avg Depth	Through wall length	PWSCC or ODSCC	Segmen -ted
North Anna 1 R17 C31	10,70 0	176°	90%	65%	N/A	PWSCC	Yes
North Anna 1 R18 C36	9,250	128°	100%	90%	53°(1)	PWSCC	Yes

(1): This tube was subjected to an accelerated corrosion test after removal from the S/G. It is believed that some ligament connection and possibly some further crack depth progression occurred during the accelerated corrosion testing. This was concluded based on an increase in primary to secondary leakage during the accelerated corrosion tests.

Several other WEXTEX pulled tubes from 1990 and 1993 provided useful data regarding the top of tubesheet elevation. In these tubes, no detectable degradation was evidenced by NDE but degradation was found during destructive examination, the largest circumferential extent being 80° and deepest penetration of 21 percent throughwall. These tubes were pulled due to significant axial degradation at the TSP intersections. Based on the shallow levels of cracking, burst pressures would be expected to be equal to that of undegraded tubing. Field and laboratory bobbin and RPC inspection results for these three tubes were NDD for the top of tubesheet region.

3.1.2 EOC Structural Limit Crack Angle for Throughwall Indications

To permit a rapid scoping assessment for tube burst capability of circumferential indications, a burst correlation was developed for throughwall circumferential indications. The burst correlation was then applied to define the structural limit on throughwall crack circumferential extent that satisfy the RG 1.121 burst margin for 3 times normal operating pressure differential. If measured RPC crack angles, after reduction for coil lead-in and lead-out affects (about 30°) for throughwall indications are less than the structural limit, it can be readily concluded that the indications satisfy burst margin guidelines. If the measured RPC angles exceed the assumed throughwall structural limit, additional inspection (such as UT) or structural analysis are needed to assess structural integrity. This section describes the development of the throughwall crack angle structural limit.

A development program was conducted by the WOG during the time period (1987-1992) when circumferentially oriented degradation began to appear in WEXTEX expanded tubes. In this program, the crack simulation was performed by throughwall slitting of tube samples using an EDM process. A sealing bladder with thin reinforcing foil was used to prevent premature bladder extrusion through the EDM slit. EDM crack simulations and subsequent burst testing were performed for single throughwall cracks, segmented crack networks, and complex crack networks (50 percent deep OD degradation in nonthroughwall areas). The single EDM slit test results would be considered to be a conservative representation of the actual PWSCC morphology of WEXTEX expansion transition cracks since the available tube pull results indicate limited throughwall crack extent (typically much less than the total measured RPC angle) and a more segmented crack network with multiple initiation sites around the circumference. The nondegraded ligament sections between corroded areas would add significantly to the burst pressure capability of an actual tube.

In the S/G, lateral support provided by the first tube support plate restrains bending of the tube during pressurization and significantly adds to the burst pressure capability. Additional burst pressure capability would be provided if the tube is axially constrained by the TSP due to corrosion product buildup for plants with drilled hole carbon steel TSPs. The TSP intersections at SQN are dented or considered packed by TSP corrosion product, and as such the listed EOC values would be conservative for SQN, based on added burst strength component due to axial constraint at the TSPs. The burst pressure correlations were developed based on burst tests with lateral but not axial restraint.

Based on comparisons of burst tests for segmented cracks, an analytical determination of the effect of nondegraded ligaments on the burst pressure capability of circumferential cracks was performed to develop a burst correlation for segmented cracks (with ligaments).

Utilizing the burst correlations developed from EDM data and analytical models, the structural limits for throughwall circumferential indications were developed as given for the crack models in the following table. The burst pressure data were adjusted to account for lower tolerance limit material properties.

7/8 Inch Tubing
EOC Structural Limits for Circumferentially Oriented Degradation

	Single Throughwall Crack Model	Single TW Crack with 50% Degraded Ligament	Segmented Throughwall Crack Model
3ΔP = 4500 psi	210°	210°	264°
3ΔP = 4300 psi	226°	226°	269°
SLBΔP = 2560 psi	321°	283°	318°

The single throughwall crack model is applicable to both ID or OD degradation. The segmented model is more typical of PWSCC. The throughwall plus 50 percent deep model was developed to represent 360° indications found for ODSCC.

It is informative to reexamine the burst data of North Anna Unit 1 R18 C36. Measured burst pressure was 9250 psi and macrocrack length was 128° with 53° of throughwall corrosion and an average macrocrack depth of 90 percent throughwall. Examining individual data points of the EDM burst data it is seen that a single throughwall EDM slit of 116° burst at 7500 psi while a segmented crack of 155° total crack length (including ligaments) burst at 9500 psi. Thus, the segmented EDM burst data is more representive of actual PWSCC networks in WEXTEX transitions than the single, uniform throughwall crack model, and that use of the single, uniform throughwall crack model is very conservative.

3.1.3 Inspection Methodologies and Adequateness

As part of the WOG subgroup efforts, WEXTEX owners developed a top of tubesheet region inspection plan. This inspection plan divides the tubesheet into 4 distinct inspection zones. Zone 4 represents the central region of the tubesheet and is coincident with the low cross flow velocity region where most sludge accumulation has occurred. Additionally, about 95 percent of all WEXTEX region cracking has been identified in Zone 4.

The WOG WEXTEX inspection plan utilizes an initial sample size of 50 percent of the Zone 4 active tubes (700 tubes minimum, ~ 22 percent of the total S/G tubes) utilizing the RPC probe for detection of circumferential indications at the top of the tubesheet. All S/Gs are be inspected with this minimum sample size at each outage. This inspection plan focuses on the region with the largest potential for finding indications and thus results in the highest likelihood for requiring an expansion of the sample size.

Depending upon the numbers of indications found and their extent in circumferential angle, the initial sample size may be increased. Some of the sample expansion criteria are;

- An increase in the sample size by 10 percent of the S/G tubes for each circumferential indication found.
- If more than seven indications are found in the initial sample, the inspection is increased to 100 percent of the hot leg transitions in that S/G.
- If any indication exceeds the circumferential throughwall structural limit (approximately 226°) or an axial length of 0.45" (above TTS), inspect 100 percent of the tubes in that S/G.

Since the development of the WEXTEX WOG inspection guidelines, all 7/8-inch OD tubing plants have either followed these guidelines or performed an initial sample size of 100 percent of the tubes.

The effectiveness of the WEXTEX inspection guidelines are clearly evidenced in the numbers and crack angles detected since this program has been implemented. At Sequoyah Unit 1, 100 percent of the hot leg transitions were RPC inspected in October 1991. A total of 52 circumferential indications ranging from 58° to 256° were detected. In March 1993, 100 percent of the S/G 4 and >50 percent of all other S/G hot leg transitions were again RPC inspected. A total of 16 indications ranging from 52° to 98° were detected. While TVA chose to inspect 100 percent of the hot leg transitions, the 1991 inspection distribution of indications was clearly biased to Zone 4. Of the 52 total circumferential indications detected, 48 were located in Zone 4. Since the expansion guidelines call for a 10 percent sample size increase for each detected indication, there is a favorable probability that at least 1 Zone 4 indication would have been detected, initiating an additional 10 percent sample expansion.

A point of interest regarding the Sequoyah Unit 1 data is that for the 1991 and 1993 inspections, the smallest detected RPC angles were 58° and 52°, respectively, while the maximum angle extent dropped dramatically. This suggests that WEXTEX region PWSCC does not grow at a rapid rate, and that the inspection practices sufficiently identify partial depth cracking in its early stages. No primary to secondary leakage attributed to WEXTEX indications was evidenced at any WEXTEX unit during at least the last two operating cycles.

Additional Inspection Information - SQN Nuclear Plant Units 1 and 2

TVA was among the first utilities to perform extensive examinations of the expanded region of the tubes in the Sequoyah Units 1 and 2 S/Gs. While rotating pancake probes were evolving during the late 1980's into practical inspection devices, application on a limited basis was made to characterize tubesheet signals obtained from bobbin data at similar plants. RPC inspection at Sequoyah Unit 1 was first used in 1988. A total of 1343 tubes in Unit 1 were inspected using RPC at the top of tubesheet elevation in 1990 (EOC 4); one circumferentially oriented and one axially oriented WEXTEX indication were detected. When it became practical to use RPC probes for large inspection programs, 100 percent of the Sequoyah Unit 1 tubesheet transitions were committed to inspection during the 1991 (EOC 5) outage. A total of 52 circumferentially oriented indications were identified along with 16 axially oriented indications. The largest arc length observed was 256°; this tube was examined by ultrasonic testing (UT) to determine whether the observed indication was continuous or had sufficient ligaments to meet tube structural integrity requirements. The UT result indicated a total circumferential arc length of 230°. The macrocrack (as determined by UT results) was determined to be comprised of two distinct cracks of 123 and 82° on the ID surface separated by a nondegraded ligament of 25°. On the OD surface, crack involvement was estimated to be 100° (two areas of 70 and 30°), separated by a ligament of 150°. Tube integrity assessments performed at the time indicate that the expected burst pressure would satisfy the RG 1.121 structural integrity recommendations. During the inspection of the Unit 1 S/Gs in 1993, examination of the WEXTEX transitions with RPC probes resulted in detection of 16 circumferential PWSCC indications, with the largest circumferential angle measured at the top of tubesheet of 98°.

A summary of the inspection programs performed at Sequoyah Units 1 and 2 over the last two outages are provided in the following tables.

Sequoyah Unit 1 1991 Inspection Program				
Area Inspected	S/G 1	S/G 2	S/G 3	S/G 4
TTS RPC	100%	100%	100%	100%
TSP RPC	102	107	100	101
U-bend RPC	0	0	42	41
Circ. Indications	52 TTS			

Sequoyah Unit 1 1993 Inspection Program				
Area Inspected	S/G 1	S/G 2	S/G 3	S/G 4
TTS RPC	50%	50%	61%	100%
TSP RPC	321	89	2099	3879
U-bend RPC	94	94	94	94
Circ. Indications	16 TTS, 1 U-bend			

Sequoyah Unit 2 1992 Inspection Program				
Area Inspected	S/G 1	S/G 2	S/G 3	S/G 4
TTS RPC	54%	100%	100%	42%
TSP RPC	311	300	214	216
U-bend RPC (1)	94	94	93	94
Circ. Indications	2 TTS			

Sequoyah Unit 2 1994 Inspection Program				
Area Inspected	S/G 1	S/G 2	S/G 3	S/G 4
TTS RPC	45%	100%	63%	45%
TSP RPC	33	27	27	27
U-bend RPC (2)	187	188	183	188
Circ. Indications	10 U-bend			

Note (1): All U-bend inspections were Row 2. Row 1 previously preventively plugged.

Note (2): Row 1 put back into service after UBHT this outage. Large number of U-bend indications due to first inspection of Row 1 since preventive plugging.

As evidenced by the above tables, WEXTEX region circumferential cracking has been much less pronounced in Unit 2 as opposed to Unit 1. Two WEXTEX circumferential indications of 74 and 69° were detected in Unit 2 in 1992, none in 1994. In 1994, 10 circumferential indications in the small radius U-bends were identified. The largest angle of these indications was 113°. The Row 1 tubes had previously been preventively plugged. In the 1994 outage these tubes were deplugged, U-bend heat treatment was applied to Rows 1 and 2 tubes, and Rows 1 and 2 U-bends without indications were returned to service.

While additional indications in lower numbers were observed in each inspection respectively, comparison of the later RPC data with earlier inspections' data demonstrated that very few new indications were being observed each year. Moreover, a low rate of PWSCC progression was evidenced by the small arc lengths observed for most of the indications.

The maximum arc lengths of the circumferential indications observed in recent outages were 256° in Unit 1 (EOC 5, October 1991) and 98° in 1993 (EOC 6). By comparison with the 1990 and 1991 RPC data for tubes inspected during both outage, these indications have shown approximately 64° growth per cycle.

Westinghouse has been the prime eddy current vendor at SQN for the past two outages. Efficacy of the probes and analyst evaluation criteria utilized can be judged against pulled tube data from another plant dating to 1991. Here the RPC probe performance was judged against tube pull destructive examination results. Based on this comparison, it was judged that circumferential degradation of 23° for 100 percent TW cracks and 50° (minimum) for 50 percent TW cracks were identified using similar analyst evaluation criteria and similar RPC probes as have been used at SQN.

Examination of Dented TSP Intersections

The RPC inspection of nearly 6000 dented intersections in S/Gs 3 and 4 of Unit 1 was performed in 1993. A large number of dented intersections are present in these two S/Gs and are attributed to a chemistry excursion early in the first operating cycle. Of the nearly 6,400 dented intersections RPC inspected in all S/Gs, no circumferentially oriented degradation was detected. Additional evaluation of these intersections has shown that the dents are not growing in physical dimension or relative dent voltage.

Inspection Programs for Next Outages

The existing program for inspection of regions potentially susceptible to circumferential cracking, i.e., Row 1 and 2 U-bends, dented tube support plate (TSP) intersections, and expansion transitions, already meets the EPRI recommendaticns as embodied in the PWR S/G Examination Guidelines (NP-6201 Rev.3).

Inspection Region	Sequoyah Unit 1	Sequoyah Unit 2
Row 1 and 2 U-bends	20% all S/Gs using U-bend RPC	20% all S/Gs using U-bend RPC
Dented TSPs	100% of >5 volt dents for TSPs 1 and 2, 20% for TSP 3 using qualified probe	100% of >5 volt dents for TSPs 1 and 2, 20% for TSP 3 using qualified probe
Expansion Transition	100% of WEXTEX Zone 4 (44% of tube bundle) using qualified probe	100% of WEXTEX Zone 4 (44% of tube bundle) using qualified probe

To assure the optimal application of the qualified techniques for detection and sizing of circumferential cracking, TVA will emphasize the recommendations issued by EPRI in response to GL 95-03. Analysts' qualification and training will be updated to include the most recent lessons learned from tube pulls at Byron 1, Maine Yankee, South Texas 1, and Kewaunee. The conservative guidelines for interpretation of RPC signals already in use at TVA will be reenforced by correlation of the past TVA experience with the cumulative industry experience with detection and sizing of circumferential cracks.

3.1.4 Tube Integrity Assessments Performed by Westinghouse

<u>Tube Burst Considerations</u>

As noted, the WEXTEX inspection guidelines were implemented in 1991. The largest circumferential indications were found in the first inspection implementing the WEXTEX guidelines. For currently operating units, 5 indications have been found with RPC crack angles (adjusted for coil size effects) exceeding the structural limit for assumed throughwall cracks. These indications were 322°, 271°, 255° and 245° at Farley Unit 1 in March 1991 and 256°, at Sequoyah Unit 1 in October 1991. These indications were UT inspected to obtain additional crack characterization to support structural integrity assessments. For the 322° indication, UT identified large ligaments of about 30° and 18° with intermittent cracking (segmented crack, small ligaments) of 50 to 60 percent depth over about 110°. Based on the large ligaments separating the larger indication into two distinct macrocracks and the large, about

50 percent deep wall thickness ligament, at the time, it was concluded that this indication would be expected to provide a burst capability exceeding the structural integrity requirements. The other large indications UT inspected were also found to satisfy burst requirements based on the presence of large structural ligaments and intermittent cracking suggestive of segmented cracks. For the last WEXTEX RPC inspection at each of these plants, the RPC crack angles have not exceeded 100°.

Overall, it is concluded that all circumferential indications found in WEXTEX expansions have burst capability exceeding RG 1.121 burst recommendations. The largest indications were found in the initial RPC inspections in 1991 and the number and size of indications since 1991 has steadily decreased. This is consistent with the modest growth rates in crack angles found for WEXTEX indications. The small crack angles found since 1991, the decreasing trend in maximum crack angles since 1991, and operating experience showing no WEXTEX region primary to secondary leakage, strongly supports adequate detectability with the RPC inspections. If large indications had been missed in the inspections, large crack angles would have been found since 1991.

Since no indications with experimental or calculated burst pressures less than the RG 1.121 recommendations have been detected to date at WEXTEX expansions, the growth rates are modest, and the WEXTEX plants have not significantly increased the operating cycle lengths or operating temperatures over the prior cycle, the WEXTEX plants can continue to operate to the next scheduled inspection with no discernable risk of exceeding RG 1.121 burst capability recommendations at the end of the current operating cycles. Although data will be reviewed against structural limits at each inspection per the WEXTEX guidelines of Section 3.1.3, it is expected that future operating cycles will also result in acceptable crack indications.

Growth Rate Discussion

As indications of circumferential degradation are plugged upon discovery, a quantified cycle to cycle growth is difficult to establish with a high degree of accuracy. A growth rate for WEXTEX indications has been established by examining indications having RPC inspections at the cycle detected and the prior cycle. Data for all plants have been obtained although the largest database is from the original North Anna Units 1 and 2 S/Gs between 1991 and 1993. Over 85 percent of the growth indications had RPC crack angle growth less than 30° per effective full power year (EFPY) with the largest growth <100° per EFPY. These relatively low growth rates would not result in challenges to structural integrity between inspections and are consistent with the modest RPC crack sizes found following the initial RPC inspections as discussed in Section 3.1.3.

As calling criteria are continually tightened, the chances of detecting a low level indication from a previous inspection becomes more remote. For the few numbers of indications at SQN traceable to a previous inspection, circumferential crack growth rates have been estimated to be on the order of 64°. This growth allowance was determined by comparing the 1991 RPC data with previous cycle data.

3.1.5 Sequoyah Units 1 and 2 Tube Integrity Assessments

The structural integrity discussion provided in Section 3.1.2 (WEXTEX 7/8-inch OD) is directly applicable to both Sequoyah Unit 1 and Unit 2. Nearly all WEXTEX circumferential indications found at SQN have been in Unit 1 and the plant specific assessment applicable to both units are given in this section.

As discussed above, no circumferential indications exceeding RG 1.121 tube burst recommendations have been found at either Sequoyah Unit 1 or Unit 2. This applies to the WEXTEX and expansion transitions, dented TSP intersections, and small radius U-bends. Since the initial 100 percent RPC inspections in 1991 (Unit 1), no field calls for WEXTEX circumferential indications exceeding RPC angles of 98° have been found. The current operating cycle lengths and primary temperatures are very similar to the past operating cycles for each unit.

Small crack angles found since 1991 demonstrate that the Sequoyah S/G RPC inspections have adequate detectability and no structurally challenging indications have been left in service. Sequoyah growth rates have been found to be on the order of 64° per cycle which is consistent with the lower range found for WEXTEX indications as discussed in Section 3.1.4.

Based on the extensive RPC inspection programs performed in Sequoyah Units 1 and 2 tubes at the top of the tubesheet elevation, resulting in either plugging of all detected circumferential indications, a decreasing incidence rate of new indications, low apparent growth rate and strict secondary side chemistry control, no SQN tubes are projected to challenge the structural integrity limits in the current operating cycle nor are circumferential indications expected to challenge tube integrity in future cycles. Thus, the Sequoyah Nuclear Plant S/Gs can safely operate to the next scheduled inspection.

4.0 Defense in Depth Positions

The following assessment points further strengthen the SQN S/G tube integrity conclusions, not only for the remainder of the current operating cycle but also for all future inspection periods.

1. An administrative primary to secondary leak rate of 128 gpd for Sequoyah Units 1 and 2 has been implemented into plant operating procedures. Previous evaluation by Westinghouse has established that these leak rates provide for leak before break protection for leakage assumed from a single throughwall cracks.

2. The S/G tube expansion transitions at Sequoyah Unit 1 were shotpeened in 1991, Unit 2 expansion transitions in 1992. This practice may have contributed to the low incidence rate of new indications.

3. Row 1 tubes preventively plugged have been recovered due to application of UBHT. Field data has shown that this process has effectively halted corrosion of small radius U-bends. When coupled with reduced primary to secondary leakage limits and the TVA commitment for RPC inspection of the historical elevations where circumferential degradation has been detected, it is unlikely that rapid, unanticipated corrosion would occur at this elevation. In the 1993 inspection, one small radius U-bend circumferential indication of 116° was detected in Unit 1. In fact, review of the data from the two previous inspections for this indication using enhanced analyst evaluation criteria show that the indication was apparent for both previous inspections, and that the growth was negligible. UBHT was applied in Unit 1 in 1987; this was the first circumferentially oriented U-bend indication since UBHT application.

4. The extensive tube examination programs at Sequoyah Units 1 and 2 have not shown a potential for rapid, unpredicted growth on a cycle to cycle basis at any tube locations which historically have experienced SCC. Operating conditions have not changed and therefore there are no outside contributing factors which may suggest unanticipated crack growth.

ENCLOSURE 5

SEQUOYAH NUCLEAR PLANT (SQN) UNITS 1 AND 2

FUTURE STEAM GENERATOR (S/G) INSPECTION PLANS

A. SQN UNIT 1 FUTURE S/G INSPECTION PLANS

Date of Next S/G Inspection

SQN Unit 1 Cycle 7 refueling outage is scheduled to start September 9, 1995.

Inspection Scope

The scope of the Unit 1 Cycle 7 S/G inspections include the requirements of technical specifications (TSs), the latest revision of Electric Power Research Institute (EPRI) PWR Steam Generator Examination Guidelines, and the Westinghouse Electric Corporation Owners Group (WOG), Westinghouse Explosive Tube Expansion (WEXTEX) Subgroup Rotating Pancake Coil Inspection and Leakage Monitoring Guidelines.

The following minimum tube examinations pertaining to circumferential cracking are planned:

1. 100 percent of top-of-tubesheet (TTS) Zone 4 (approximately 1,484 tubes) with rotating pancake coil (RPC) or equivalent.
2. 100 percent of hot leg dented tube support plates (TSPs) 1 and 2 dented intersections (greater than or equal to 5 volts) and 20 percent of hot leg TSP 3 dented intersections (greater than or equal to 5 volts) with RPC or equivalent.
3. 20 percent of Rows 1 and 2 U-bend regions with an RPC (or equivalent) qualified for U-bend primary water stress corrosion cracking (PWSCC) detection.

Expansion Criteria

At the TTS, SQN Unit 1 follows the expansion criteria defined in the WOG WEXTEX Subgroup Rotating Pancake Coil Inspection and Leakage Monitoring Guidelines.

At dented TSPs, the expansion criteria requires examining with RPC (or equivalent) 100 percent of the dented TSPs up to the highest TSP elevation known with outside diameter stress corrosion cracking (ODSCC) and/or PWSCC, plus a random 20 percent sample of dented TSP intersections at the next higher hot leg TSP elevation. A TSP intersection is defined as dented if bobbin coil examination has a dent signal greater than or equal to 5 volts.

An initial 20 percent low row U-bend sample will be expanded to 100 percent of Rows 1 and 2 if cracks are detected.

As a minimum, at each of the above areas, the examination expansion requirements of TSs will be fulfilled.

Inspection Methods

Eddy current techniques have been qualified (to ensure their capabilities and limitations are known and quantified) to EPRI PWR Steam Generator Inspection Guidelines, Appendix H, "Performance Demonstration For Eddy Current Examination."

TVA inspects with RPC (or equivalent) at the TTS, dented TSPs, and U-bend regions for circumferential cracking at SQN. If large circumferential arc lengths are detected with eddy current, supplemental methods (such as ultrasonic testing [UT]) may be utilized for determining if ligaments are present and ensuring tube structural integrity.

SQN reviews nondestructive examination (NDE) techniques to:

1. Optimize examination methods, to minimize noise and/or interference, and maximize flaw detection.
2. Evaluate interfering signals (e.g., lift-off) influence on detection.
3. Evaluate examination and analysis procedures to maximize flaw discrimination from unavoidable noise and/or interference.
4. Evaluate examinations for unique unit specific circumstances, which necessitate special examination techniques or analysis procedures.

The RPC examination "qualification" requires that a technique demonstrate, at a minimum, a probability of detection (POD) of 80 percent at a 90 percent confidence level for flaws greater than or equal to 60 percent through-wall depth on a suitable specimen-set as defined by EPRI PWR Steam Generator Examination Guidelines, Appendix H, Table S2-2. The actual field performance for qualified techniques is expected to exceed the minimum criteria with the use of RPC for detection of circumferential cracks. This is based on the field data of industry pulled tube specimen-set where the POD is 83 percent at 90 percent confidence level. Only two cracks from the industry pulled tube specimen-set were not detected, but the maximum depth of those cracks were less than 30 percent through-wall.

EPRI PWR Steam Generator Examination Guidelines provide the protocol for developing and applying NDE technology appropriate to manage both existing and emerging damage mechanisms, including circumferential cracking. Within this protocol, conventional RPC technology has been formally qualified since 1992 for detection of stress corrosion cracks (irrespective of orientation - axial or circumferential); and field tube-pull data indicates that for circumferentially oriented stress corrosion cracks, the performance of RPC exceeds the minimum requirements of EPRI PWR Steam Generator Examination Guidelines, Appendix H. Industry experience indicates that RPC technology applied in adherence with the above protocol have adequately managed circumferential cracking. This is based on available tube-pull and in-situ burst testing data, which indicates structural limits have not been violated.

Inspection Equipment

SQN plans to utilize the following equipment during the Cycle 7 inspection:

MIZ-18 (or equivalent)	-	RPC
TC-6700 (or MIZ-30)	-	RPC (Plus Point) and/or CECCO-5

All equipment will be qualified to EPRI PWR Steam Generator Examination Guidelines, Appendix H.

Inspection Criteria

All eddy current data analysts will be certified to eddy current Level IIA or III in accordance with American Society of Nondestructive Testing SNT-TC-1A and also qualified to EPRI "Qualified Data Analyst" program. SQN requires data analysts to successfully complete a site specific performance demonstration and written test. This performance demonstration includes SQN Units 1 and 2 data and also data from similar industry units with damage mechanisms, which are expected at SQN in the future. Data analysts are trained in site-specific analysis guidelines, which include the EPRI "Points to Consider in Circumferential Crack Detection and Length Sizing" (dated February 21, 1995). SQN requires the analysis of all data collected and also implements independent two-party review of eddy current data.

B. SQN UNIT 2 FUTURE S/G INSPECTION PLANS

Date of Next S/G Inspection

SQN Unit 2 Cycle 7 refueling outage is scheduled to start May 1, 1996.

Inspection Scope

The scope of the Unit 2 Cycle 7 S/G inspections will include the requirements of TS, the latest revision of EPRI PWR Steam Generator Examination Guidelines and the WOG WEXTEX Subgroup Rotating Pancake Coil Inspection and Leakage Monitoring Guidelines.

The following minimum tube examinations pertaining to circumferential cracking are planned:

1. 100 percent of TTS Zone 4 (approximately 1,484 tubes) with RPC or equivalent.
2. 100 percent of hot leg TSPs 1 and 2 dented intersections (greater than or equal to 5 volts) and 20 percent of hot leg TSP 3 dented intersections (greater than or equal to 5 volts) with RPC or equivalent.
3. 20 percent of Row 1 and 2 U-bend regions with an RPC (or equivalent) qualified for U-bend PWSCC detection.

Expansion Criteria

At the TTS, SQN Unit 2 follows the expansion criteria defined in the WOG WEXTEX Subgroup Rotating Pancake Coil Inspection and Leakage Monitoring Guidelines.

At dented TSPs, the expansion criteria calls for examining with RPC (or equivalent) 100 percent of the dented TSPs up to the highest TSP elevation known with ODSCC and/or PWSCC, plus a random 20 percent sample of dented TSP intersections at the next higher hot leg TSP elevation. A TSP intersection is defined as dented if bobbin coil examination has a dent signal greater than or equal to 5 volts.

An initial 20 percent low row U-bend sample will be expanded to 100 percent of Rows 1 and 2 if cracks are detected.

As a minimum, at each of the above areas, the requirements of TSs will be fulfilled.

Inspection Methods

Eddy current techniques have been qualified (to ensure their capabilities and limitations are known and quantified) to EPRI PWR Steam Generator Inspection Guidelines, Appendix H, "Performance Demonstration For Eddy Current Examination."

TVA inspects with RPC (or equivalent) at the TTS, dented TSPs, and U-bend regions for circumferential cracking at SQN. If large circumferential arc lengths are detected with eddy current, supplemental methods (such as UT) may be utilized for determining if ligaments are present and ensuring tube structural integrity.

SQN reviews NDE techniques to:

1. Optimize examination methods, to minimize noise and/or interference, and maximize flaw detection.
2. Evaluate interfering signals (e.g., lift-off) influence on detection.
3. Evaluate examination and analysis procedures to maximize flaw discrimination from unavoidable noise and/or interference.
4. Evaluate examinations for unique unit specific circumstances, which necessitate special examination techniques or analysis procedures.

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EPRI PWR Steam Generator Examination Guidelines provide the protocol for developing and applying NDE technology appropriate to manage both existing and emerging damage mechanisms, including circumferential cracking. Within this protocol, RPC technology has been formally qualified since 1992 for detection of stress corrosion cracks (irrespective of orientation - axial or circumferential); and field tube-pull data indicates that for circumferentially oriented stress corrosion cracks, the performance of RPC exceeds the minimum requirements of EPRI PWR Steam Generator Examination Guidelines, Appendix H. Industry experience indicates that RPC technology applied in adherence with the above protocol have adequately managed circumferential cracking. This is based on available tube-pull and in-situ burst testing data, which indicates structural limits have not been violated.

Inspection Equipment

SQN plans to utilize the following equipment during the Cycle 7 inspection:

MIZ-18 (or equivalent)	-	RPC
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All equipment will be qualified to EPRI PWR Steam Generator Examination Guidelines, Appendix H.

Inspection Criteria

All eddy current data analysts will be certified to eddy current Level IIA or III in accordance with American Society of Nondestructive Testing SNT-TC-1A and also qualified to EPRI "Qualified Data Analyst" program. SQN requires data analysts to successfully complete a site specific performance demonstration and written test. This performance demonstration includes SQN Units 1 and 2 data and also data from similar industry units with damage mechanisms, which are expected at SQN in the near future. Data analysts are trained in site-specific analysis guidelines, which include the EPRI, "Points to Consider in Circumferential Crack Detection and Length Sizing" (dated February 21, 1995). SQN requires the analysis of all data collected and also implements independent two-party review of eddy current data.