March 25, 2002

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

Gentlemen:

In the Matter of) Docket No. 50-327
Tennessee Valley Authority)

SEQUOYAH NUCLEAR PLANT (SQN) - STEAM GENERATOR (SG) 120-DAY REPORT FOR UNIT 1 CYCLE 11 (U1C11) REFUELING OUTAGE SG INSPECTIONS

In accordance with SQN Technical Specification (TS) 4.4.5.5.e, TVA is providing the 120-Day SG Report following the SG inspections performed during the Unit 1 Cycle 11 refueling outage.

The enclosed report provides a tabulation of primary water stress corrosion cracking indications found during the SG inspection, a tabulation of tubes repaired and left in service under the ARC, and growth rate distributions for indications found in the inspection as well as growth rate distributions used to establish the tube repair limits. The operational assessment found that all single indications met operational assessment limits with the lowest calculated predicted burst pressure equal to 4,525 pounds per square inch. Accordingly, the condition monitoring burst pressure requirements are satisfied and no further analyses are required.

Included with the enclosed report is information regarding mixed mode cracking and cracks at dented intersections. This information is provided in response to NRC staff questions that were asked during the U1C11 SG mid-inspection telephone call.

This letter is being sent in accordance with NRC RIS 2001-05. Please direct questions concerning this issue to me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

Sincerely,

Original signed by

Pedro Salas
Licensing and Industry Affairs Manager

Enclosures

ENCLOSURE

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 1

UNIT 1 CYCLE 11
STEAM GENERATOR (SG)
120-DAY REPORT
DENTED TUBE SUPPORT PLATE
AXIAL PRIMARY WATER STRESS CORROSION CRACKING
ALTERNATE REPAIR CRITERIA (ARC)

PWSCC Condition Monitoring
And Operational Assessment Report

Background

In accordance with the provisions of SQN TS 3/4.4.5.5.e, TVA continued implementation of an alternate repair criteria for axial primary water stress corrosion cracking (PWSCC) at dented tube support plate (TSP) intersections during the SQN Unit 1 Cycle 11 Refueling Outage (i.e., EOC-11). The following report documents the condition monitoring and operational assessment results required 120 days after restart of the unit.

Inspection Scope and Methodology

The plus-point coil was used to inspect 15,774 TSP intersections. A 100-percent full length inspection was performed using the bobbin coil probe. Analysts were trained in detecting indications in less than 1 volt dented intersections using Sequoyah-specific data. When a potential crack-like indication is identified in the bobbin coil data, the analyst calls the indication “DSI”, which indicates that this indication needs further evaluation using a plus-point coil. A total of 726 intersections with DSI bobbin coil calls were inspected using plus-point and a total of 85 axial PWSCC indications were confirmed. This represents a 11.7% confirmation rate. During the Unit 1 Cycle 11 outage, because of the extensive plus-point examination scope, the analysts evaluating the bobbin coil data were instructed not to make a “DSI” call if the intersection was already scheduled for plus-point examination. A total of 375 axial PWSCC indications were identified. The indications are in tabular form and are provided in Attachment 1 to this enclosure.

An operational assessment was performed on a single indication basis using the methodology documented in WCAP 15128, Revision 2. Each indication was sized using the plus-point probe. Analysts specifically trained in sizing cracks developed a line-by-line profile of each indication. These profiles were adjusted per WCAP 15128, Revision 2 criteria and further adjusted for uncertainties and growth. The growth rates used in calculating Operational Assessment were the Sequoyah-specific growth rates from WCAP 15128, Revision 2 plus the Sequoyah data from EOC-10. During the

inspection, growth was evaluated to ensure that EOC-11 growth rates were bounded by the WCAP plus EOC-10 data growth rates. The cumulative distribution curves for the Sequoyah EOC-11 growth rates, and the combined WCAP and Sequoyah Cycle 11 growth rates are depicted graphically in Attachment 2 to this enclosure.

Attachment 1 includes:

- Tabulation of axial PWSCC indications
- The support plate where the indication is located
- The adjusted length, adjusted maximum depth, adjusted average depth, and voltage
- The from and to position of the crack relative to the centerline of the support plate
- The flow stress used in the evaluation (Sequoyah-specific data where available)
- The Condition Monitoring / Operational Assessment results (calculated burst pressures and leakage)
- Tabulation of tube repair status

All single indications met operational assessment limits and the lowest calculated Operational Assessment predicted burst pressure was 4525 psi. TVA preventively plugged this tube.

Mixed Mode Cracking

At the EOC-11 inspection there were a total of 11 tube support plate intersections with both PWSCC axial and circumferential indications at the same locations. All of these locations were removed from service by plugging. WCAP-15579, “Burst Pressure Data for Steam Generator Tubes with Combined Axial & Circumferential Cracks” summarizes burst pressure testing data on combined axial and circumferential cracks in steam generator tubing and shows that crack tip to crack tip separation distance of 0.25 inches is sufficient to negate interaction effects at 3ΔP pressure levels even for 100% through wall cracks. There were six cases where the PWSCC axial cracks were close enough to a circumferential crack to consider them as possibly interacting.

Table 2

Interacting Mixed Mode Indication Data

SG	Row	Col	Location	Ax/Circ	Length (in.)	Max Depth (%)	Circ PDA or Axial Avg Depth (%)	Volts (*,**)
3	9	64	H01+0.18	Circ	0.48	67	7.0	1.05
			H01-0.05	Axial	0.17	46	26.3	0.69
			H01+0.33	Axial	0.09	58	33.5	0.37
3	16	86	H01+0.11	Circ	0.45	48	4.2	0.78
			H01-0.07	Axial	0.18	31	21.5	0.60
3	22	46	H01+0.18	Circ	0.31	57	4.6	0.70
			H01+0.04	Axial	0.12	65	39.0	0.29
			H01+0.04	Axial	0.09	27	18.0	0.55
3	25	72	H01+0.05	Circ	0.31	51	3.9	0.76
			H01-0.02	Axial	0.18	43	20.8	0.62
3	26	78	H01+0.05	Circ	0.42	74	6.4	0.65
			H01+0.32	Axial	0.14	46	29.6	0.61
3	32	78	H02+0.18	Circ	0.44	67	5.8	0.58
			H02+0.06	Axial	0.14	42	25.9	0.76

None of the interacting mixed mode cracks were close to being 100% through-wall and no individual axial or circumferential cracks presented a near challenge to the 1.43 times MSLB minimum burst pressure requirement for a tube support plate. As discussed in WCAP-15579, this fact alone is sufficient to rule out any interaction as significant to structural integrity requirements. The six possibly interacting locations had shapes best described as "L's," and "T's." The maximum length of any of the interacting circumferential indications was 0.48 inches and the maximum length of an interacting PWSCC axial component was 0.18 inches. Burst pressures for the axial PWSCC indications are greater than 3ΔP (refer to Attachment 1 for Operational Assessment burst pressures). Even reducing the calculated burst pressure by 25% (the maximum reduction observed in testing documented in WCAP-15579) maintained the calculated burst pressure above 3ΔP. Therefore, condition

monitoring indicates mixed mode indications were not a structural integrity issue EOC-11.

From an operational assessment perspective, a similar low frequency of PWSCC axial cracks interacting with circumferential cracks can be expected at EOC-12. Also, similar 95th percentile crack lengths, maximum depths, and average depths are expected EOC-12. Table 2 below identifies the 95th percentile crack characteristics from the EOC-11 inspection.

Table 2

EOC-11 95th Percentile Values

Degradation Mechanism	Upper 95th Percentile Length	Upper 95th Percentile Average Depth	Upper 95th Percentile Maximum Depth
Axial PWSCC at TSP	0.413″	41.76%	55.77%
Circ. PWSCC at TSPs	0.490″	28.15%	58.46%
Circ. ODSCC at TSP	0.664″	22.25%	37.152%

Test results in WCAP-15579 show that the axial crack length is the dominant consideration for determining the burst pressure for interacting axial and circumferential cracks. WCAP-15579 showed that axial and circumferential interaction is considerably strengthened when the axial EDM slots were not completely through wall. Also, WCAP-15579 shows that interaction of 100% through wall circumferential and/or 100% through wall axial slots produced burst pressure reductions for “L” and “T” shapes in the range of 10% to 25% compared to the burst pressure of only through wall axial slots of the same length. TVA has determined that a PWSCC axial crack 0.413 inches in length and 41.76% average depth (the 95th percentile values for EOC-11 PWSCC axial cracks) has a calculated burst pressure of 5348 psi (95% lower limit). This burst pressure is validated by a comparison to tube SG-4, R-22, Col-36 (listed in Attachment 1) which has length, maximum depth, and average depth values similar or greater than the 95th percentile axial PWSCC values and a freespan burst pressure of 5227 psi. A 10% reduction of 5348 equals 4813 psi which is greater than 1.43 times the MSLB (3661 psi) required for tube support plate intersections and also greater than 3ΔP (4176 psi). The preceding argument assumed a freespan condition. Mixed mode interactions leading to significant strength reductions require radial outward displacements of the tube wall. This is not a likely circumstance with dented TSP intersections even under

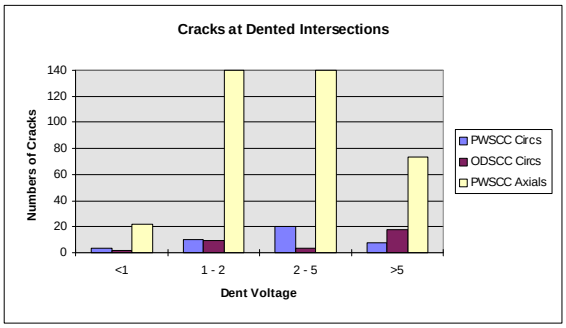
accident conditions. All of the EOC-11 circumferential cracks were within the tube support plate. WCAP-15579 test result shows that significant increases in burst pressure from a freespan interaction of axial and circumferential slots occurs when the circumferential slot was covered by a support structure. A 10% reduction is justified by the fact that the EOC-11 95th percentile average depth for axial PWSCC is far from through wall and the circumferential cracks are covered by the tube support plate. Therefore, mixed mode interaction of a PWSCC axial crack at the EOC-12 with EOC-11 95th percentile length and depth values passes Operational Assessment structural integrity requirements.

In summary, all locations with mixed mode cracking meet structural integrity performance criteria for condition monitoring and operational assessment.

Cracks at Dented Intersection

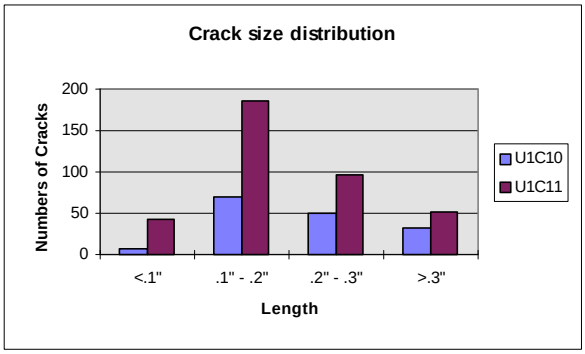
It was identified during the Unit 1 Cycle 10 inspection that the circumferential cracking at dented tube support plates behaved very similar to the ID axial cracking at these support plates. It was projected in the operational assessment that if a 10,007 inspection scope was performed Unit 1 Cycle 11 (no expansion from Unit 1 Cycle 10), that 200 axial cracks would be identified and 68% would be in dents greater than 2 volts. The plus point inspection scope for Unit 1 Cycle 11 was expanded to 15,774 intersections including all dented intersections >= 1 volt. With this expansion, 375 ID axial cracks were identified and 57% were in greater than 2 volt dented intersections.

Figure 1



Although the number of indications was larger than predicted, the size distribution identified U1C11 was very similar to the size distribution U1C10. More small indications were identified with the higher number of plus point exams. We continue to identify very small indications with very low growth.

Figure 2



Most Limiting PWSCC Indications

The most limiting indications at EOC-11, defined as those indications greater than 0.37 inches in length, are listed in Table 3 below. Also listed is growth information (if available). Some of the indications were identified for the first time during the EOC-11 inspection. The voltage from the dent in the intersection where the crack is located is also listed.

There are eight new indications out of the longest 27 indications that were new indications this inspection . However, none of the indications exceeded condition monitoring limits.

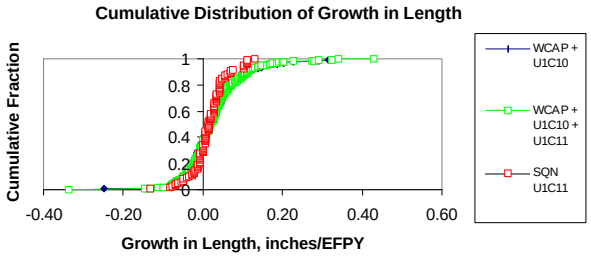
Interacting Mixed Mode Crack Information
Table 3

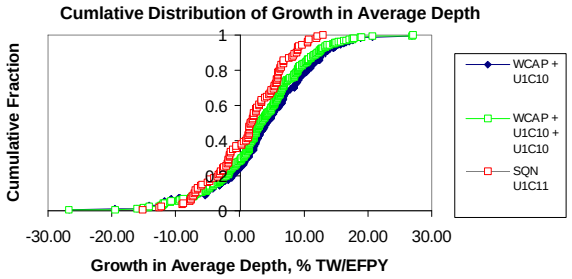
									Growth			
SG	Row	Col	Location	Length	Max Depth	Avg Depth	Volts	Dent Voltage	Length	Max Depth	Avg Depth	Volts
3	42	47	02H	0.63	44	34.38	0.79	<1	0.16	0	4.28	0.24
4	20	40	01H	0.57	44	23.89	0.95	1.00	No Previous Data			
3	36	72	01H	0.56	58	38.58	1.02	1.54	No Previous Data			
3	3	64	02H	0.54	34	23.10	0.93	7.32	0.06	2	1.30	0.01
3	11	65	01H	0.53	52	40.00	1.49	1.56	0.01	5	12.00	0.78
4	3	35	01H	0.49	44	30.72	1.08	6.68	0.05	11	9.22	0.37
4	22	36	02H	0.49	55	42.30	1.38	<1	No Previous Data			
3	11	85	01H	0.48	65	53.29	1.45	1.06	No Previous Data			
3	13	75	01H	0.48	31	21.09	0.69	3.34	0.06	4	5.49	0.08
4	25	17	03H	0.48	57	38.02	1.08	1.68	No Previous Data			
3	18	88	01H	0.47	34	23.10	0.84	3.18	0.06	-7	-11.10	-0.12
4	17	17	02H	0.46	42	30.46	1.17	3.39	0.05	3	-1.64	0.05
1	26	58	01H	0.45	48	36.79	0.70	<1	0.01	7	8.69	0.01
3	3	66	01H	0.45	56	43.73	0.15	1.99	No Previous Data			
3	34	56	04H	0.45	47	34.26	1.03	4.84	0.03	12	9.16	0.29
4	36	22	02H	0.45	36	28.97	0.95	<1	-0.12	-2	3.17	0.24
3	31	68	01H	0.44	30	15.27	0.67	2.68	0.02	8	3.57	0.13
3	36	68	02H	0.43	37	20.23	1.00	1.40	No Previous Data			
3	3	89	02H	0.42	52	41.26	1.05	<1	0.00	3	4.46	0.03
3	5	65	03H	0.41	46	33.94	1.14	<1	0.02	-1	-2.56	0.02
3	7	42	03H	0.41	47	32.26	1.12	1.04	0.16	1	2.96	0.09
4	17	61	03H	0.41	21	11.94	0.79	2.05	0.00	-5	-2.06	0.13
3	13	92	02H	0.39	45	32.54	0.58	2.12	0.05	17	16.74	0.25
3	33	78	03H	0.39	56	45.72	1.56	1.58	0.05	6	8.22	0.22
4	5	43	01H	0.39	30	18.48	0.71	3.93	0.15	9	5.18	-0.03
4	11	55	01H	0.38	35	22.30	0.77	2.23	0.16	10	7.80	0.18
4	6	55	01H	0.37	49	37.56	0.89	1.62	No Previous Data			

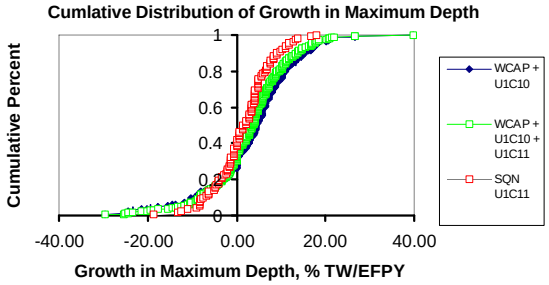
In conclusion, all PWSCC axial indications met condition monitoring and operational assessment structural and leakage limits. Indications were taken out of service by plugging because of the conservative requirement to plug all indications outside the support plate greater than 40% maximum depth. Some indications were plugged due to other degradation in the tube. One indication was preventively plugged to eliminate calculated operational assessment leakage. Mixed mode indications were not large enough to cause structural or leakage concerns.

ATTACHMENT 1

(Attachment 1 is a separate file entitled "U1C11 120-Day ARC Summary-NRC.pdf"


Cumulative Distribution of Growth in Length
Cumulative Fraction
1
0.8
0.6
0.4
0.2
0
-0.40
-0.20
0.00
0.20
0.40
0.60
Growth in Length, inches/EFPY
WCAP + U1C10
WCAP + U1C10 + U1C11
SQN U1C11


Cumlative Distribution of Growth in Average Depth
Cumulative Fraction
1
0.8
0.6
0.4
0
-30.00
-20.00
-10.00
0.00
10.00
20.00
30.00
Growth in Average Depth, % TW/EFPY
WCAP + U1C10
WCAP + U1C10 + U1C10
SQN U1C11


Cumlative Distribution of Growth in Maximum Depth
Cumulative Percent
1
0.8
0.6
0.4
0
-40.00
-20.00
0.00
20.00
40.00
Growth in Maximum Depth, % TW/EFPY
WCAP + U1C10
WCAP + U1C10 + U1C11
SQN U1C11