April 27, 2004

Mr. Roy A. Anderson
President & Chief Nuclear Officer
PSEG Nuclear, LLC - X04
Post Office Box 236
Hancocks Bridge, NJ 08038

SUBJECT: SALEM NUCLEAR GENERATING STATION, UNIT NO. 2, SUMMARY OF CONFERENCE CALLS TO DISCUSS STEAM GENERATOR TUBE INSPECTIONS CONDUCTED DURING THE 2003 REFUELING OUTAGE (TAC NO. MC0773)

Dear Mr. Anderson:

On October 24 and October 29, 2003, the U.S. Nuclear Regulatory Commission (NRC) staff participated in conference calls with PSEG Nuclear, LLC to discuss the steam generator (SG) inspection activities taking place at Salem, Unit No. 2. The conference calls were strictly voluntary on your part and occurred after the majority of the tubes had been inspected, but before the SG inspection activities were completed. A summary of the conference calls is enclosed.

This completes the NRC staff's efforts under TAC No. MC0773.

If you have any questions regarding this matter, please contact me at (301) 415-1427.

Sincerely,

/RA/

Daniel S. Collins, Project Manager, Section 1
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-311

Enclosure: As stated

cc w/encl: See next page

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Salem Nuclear Generating Station, Unit No. 2

cc:

Mr. A. Christopher Bakken, III
Senior Vice President - Nuclear Operations
PSEG Nuclear - X15
P.O. Box 236
Hancocks Bridge, NJ 08038

Mr. Michael H. Brothers
Vice President - Site Operations
PSEG Nuclear - X15
P.O. Box 236
Hancocks Bridge, NJ 08038

Mr. John T. Carlin
Vice President - Nuclear Assessments
PSEG Nuclear - N10
P.O. Box 236
Hancocks Bridge, NJ 08038

Mr. David F. Garchow
Vice President - Eng/Tech Support
PSEG Nuclear - N28
P.O. Box 236
Hancocks Bridge, NJ 08038

Mr. Steven Mannon
Acting Manager - Licensing
PSEG Nuclear - N21
P.O. Box 236
Hancocks Bridge, NJ 08038

Jeffrie J. Keenan, Esquire
PSEG Nuclear - N21
P.O. Box 236
Hancocks Bridge, NJ 08038

Ms. R. A. Kankus
Joint Owner Affairs
PECO Energy Company
Nuclear Group Headquarters KSA1-E
200 Exelon Way
Kennett Square, PA 19348

Lower Alloways Creek Township
c/o Mary O. Henderson, Clerk
Municipal Building, P.O. Box 157
Hancocks Bridge, NJ 08038

Dr. Jill Lipoti, Asst. Director
Radiation Protection Programs
NJ Department of Environmental
Protection and Energy
CN 415
Trenton, NJ 08625-0415

Brian Beam
Board of Public Utilities
2 Gateway Center, Tenth Floor
Newark, NJ 07102

Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Senior Resident Inspector
Salem Nuclear Generating Station
U.S. Nuclear Regulatory Commission
Drawer 0509
Hancocks Bridge, NJ 08038

CONFERENCE CALL SUMMARY

2003 STEAM GENERATOR INSPECTIONS

SALEM GENERATING STATION, UNIT NO. 2

PSEG NUCLEAR, LLC

On October 24 and October 29, 2003, the U.S. Nuclear Regulatory Commission (NRC) staff participated in conference calls with PSEG Nuclear, LLC (licensee) to discuss the steam generator (SG) inspection activities taking place at Salem Generating Station (Salem) , Unit No. 2. The discussion topics included the SG tube inspection scope, results, and other related SG activities. The initial call was conducted in response to an NRC letter to the licensee dated October 2, 2003 (electronic copy can be obtained through the NRC's Agencywide Document Access Management System (ADAMS) using accession number ML032750083). The purpose of the second call was to update the NRC staff on further inspection results and analysis. The plant has four Westinghouse Model 51 SGs with mill-annealed Alloy 600 tubing.

OCTOBER 24, 2003 CONFERENCE CALL

1. Primary to Secondary Leakage

   The licensee detected no leakage in any of the four SGs prior to shutdown.

2. Secondary-Side Pressure Testing

   No secondary-side pressure testing was conducted.

3. Inspection Scope and Status

   The scope of the inspection is listed below. At the time of the call, the bobbin probe eddy current testing was 100% complete, rotating probe eddy current testing at the top of the tubesheet (TTS) and tube support plates (TSP) was about 50% complete, rotating probe testing in row 2-10 U-bends was 100% complete, and rotating probe testing of row 11-20 U-bends in SG 23 was about 66% complete.

   - Bobbin probe inspection of 100% of the tubes from tube end to tube end
   - Rotating probe inspection (+Point™, 300 KHz) of the U-bend region of 100% of the tubes in rows 2-10 in all four SGs (row 1 tubes were previously plugged)
   - Rotating probe inspection of the U-bend region of 20% of the tubes in rows 13-17 in SGs 21, 22, and 24
   - Rotating probe inspection of the U-bend region of 100% of the tubes in rows 11-20 in SG 23 (an expansion of the initial test scope due to circumferential indications)
   - Rotating probe inspection of the tubesheet region on the hot side (TSH) from 3" above to 8" below the expansion transition in 100% of the tubes in each SG

- Rotating probe inspection of tubes with cold-leg tubesheet (TSC) expansion anomalies
- Rotating probe inspection of 100% of tube dents with bobbin-probe voltages of 1 volt or greater at hot-leg TSPs 01H, 02H, and 03H in each SG
- Rotating probe inspection of 20% of tube dents with bobbin-probe voltages of 1 volt or greater at hot-leg TSP 04H in each SG
- Rotating probe inspection of 25% of tube dents with bobbin-probe voltage of 5 volts or greater at hot-leg TSPs 05H, 06H, 07H in each SG
- Rotating probe inspection of 100% of tube dings caused by anti-vibration bars in each SG
- Rotating probe inspection of 25% of tube dings with bobbin-probe voltage of 2 volts or greater between the TSH and TSP 07H in each SG
- Visual inspection of 100% of the tube plugs in each SG

4. Exceptions to Industry Guidelines

The licensee reported that the following seven exceptions to the industry standard guideline were peer reviewed and approved in the management program. The applicable guideline is "Pressurized Water Reactor Steam Generator Examination Guidelines: Revision 6, Electric Power Research Institute, 2002."

- The contractor and licensee Level III eddy current analysts developed the site-specific performance test and were exempted from the performance demonstration.
- Analyst performance tracking emphasized missed indications rather than overcalls.
- Voltage normalization was done on four 20% flat-bottom holes. Dent/ding voltage normalization was based on a master standard at Westinghouse.
- Auto analysis performance demonstration database was not credited because protocol documents were not approved in time. Automated analysis qualification was based on the site-specific performance demonstration.
- The rotating probe was calibrated on the 20% inside diameter (ID) axial notch at a 10° phase angle rather than on the 40% ID notch since the calibration standard does not have a 40% notch. Calibration data from Sequoyah and Diablo Canyon were used to ensure an appropriate calibration since the standards used at those plants had both a 20% and 40% notch.
- Some of the licensee's three-letter inspection codes differ from those of industry standard guidelines.
- A new data quality verification software product was being implemented on a best effort basis. Due to limited verification of the software, the analysis of data quality was predominantly manual.

5. Inspection Findings

U-bend Circumferential Indications in SG 23: The most significant inspection finding was the discovery of 47 circumferential indications on the inside surface of the U-bend portion of 33 tubes between rows 5 and 9 in SG 23. The indications were attributed to

primary water stress corrosion cracking (PWSCC). Most of the indications (43-44) were in the "tangent" area, the transition from the bent part to the straight part of the tube. Indications were found both on the TSH and TSC of the bend. There were no indications of these flaws in the filtered bobbin probe data.

The voltage from the rotating probe for these indications was 0.35 to 1.99 volts, with amplitude and phase characteristic of PWSCC. The maximum depth (based on phase) was about 40%, and the circumferential extent typically 20-25°. Some small axial character was present in some of the signals. The degradation was associated with a ridge signal related to tube ovality, although the ovality was thought to be equivalent in all four SGs. Circumferential signals as small as 0.3 volt were not masked by the ridge signal. Eight of the flawed tubes were in row 9. The flaw with the greatest voltage (1.99 volts) was in row 5.

This degradation was similar to that found at Diablo Canyon, Unit 2 in Spring 2003, which is discussed in NRC Information Notice 2003-13, "Steam Generator Tube Degradation at Diablo Canyon" (ML032410215). At Diablo Canyon, the maximum flaw voltage was 2.5 volts and the location was the 8:00 - 8:30 position. At Salem, the degradation was more toward the tube intrados, with a magnetic indexing probe indicating 35° from the intrados toward the flank in all four tubes tested.

Rotating probe testing in the U-bend region was being expanded to include 100% of tubes through row 20 in SG 23. This testing was about 2/3 complete at the time of the phone call. This expansion in the scope of examinations was based on recommendations from Westinghouse, which believes that rows 9 and below constitute the critical area for circumferential cracking. A combination of lower stresses and a change in bending method makes rows 10 and higher less susceptible. The differences between tubes in the SGs were discussed. SG 23 was originally planned for installation at Salem Unit 1. It was the first of the four Unit 2 SGs to be fabricated and has tubing entirely from Huntington. SG 24 has tubes entirely from Blairsville (same as the Diablo Canyon unit with similar cracking), while SG 21 and SG 22 have a mixture of Huntington and Blairsville tubes.

The NRC staff requested that the licensee provide the results of the completed U-bend inspection, sample data from the circumferential flaws in C-scan presentation, and an assessment of the relationship between bending processes and testing recommendations.

Tubesheet Inspection Results: In the Wextex expansion transition area at the TTS, a total of nine axial ID indications were found in the four SGs. Eight of these flaw indications were located within 1" below the TTS. The remaining indication was 6" below the TTS. The staff reminded the licensee of the pending generic communication which addresses, in part, the examination of tubing within the tubesheet region.

Other indications: One axial indication of outside diameter stress corrosion cracking was found in SG 24 at the TTS. One volumetric indication was found in the expansion transition region of one of the SGs. The licensee believes this is not service-induced because the signal has been present since at least 1995.

Two indications of axial PWSCC had been found in dents at hot leg TSP intersections. They were found only with the rotating probe and neither extended beyond the TSP. One of these indications, at TSP 02H in SG 21, was about 55% through wall and about 3/8" long, with a flaw voltage of about 0.5 volts. The second, at TSP 01H in SG 22, was found in a 2.4 volt dent. Data from these indications was still being evaluated.

An axial anomaly was found in the apex of a Row 14 U-Bend in SG 21. This signal was found in bobbin probe data and could be traced back to the first inservice inspection (ISI) and was to be tested with the rotating probe. Data from this indication was still being evaluated.

6. Tube Repair/Plugging Plans

The licensee was planning to repair (plug) tubes with crack-like indications and indications greater than 40% through wall. All circumferential indications were to be evaluated to determine if the tube needed to be stabilized. All tubes with circumferential indications in the U-bend section were to be stabilized.

7. Comparison to Previous Results

Comparisons of present and historical data were based on the initial ISI in 1983, with the change criteria being a 10° phase change or 0.5 volt amplitude change in the bobbin coil signal. The staff expressed a concern that a change criterion of 0.5 volt could hide significant flaws. The licensee explained that signals not meeting the change criterion in the previous inspection (i.e., not required to be inspected with a rotating coil in the previous inspection) were automatically included in the rotating probe test program for the current inspection.

8. New Inspection Findings

The circumferential PWSCC found in the U-bends of rows 5-9 of SG 23 represent a new location for this degradation mode in Salem 2. This is the second reported case of circumferential PWSCC in Alloy 600 U-bends beyond row 2.

9. Reliance on Inspection Probes other than Bobbin and Typical Rotating Probes

There were no plans to use inspection probes other than the bobbin and rotating pancake coil probes.

10. In-Situ Pressure Test Plans

The licensee was anticipating that full-length pressure testing would be conducted with the tubes pressurized to three times the normal operating pressure differential on about six of the tubes with circumferential flaws in the U-bend area. These tubes would be re-examined with eddy current testing after the pressure tests.

11. Tube Removal Plans

No tube pulls were planned.

12. Condition Monitoring

The licensee reported that the inspection results did not appear to challenge the performance criteria. This was to be confirmed for the U-bend indications using in-situ pressure testing.

13. Schedule for Remaining Inspection Activities

The licensee expected to complete eddy current and in-situ pressure tests in all four SGs by October 27, 2003.

14. Loose Parts

Loose parts inspections were conducted by visual examination. Sludge was removed from the TTS by sludge lancing. No tubes had been plugged due to loose parts at the time of the call. There were button-shaped parts removed. Two pieces believed to be gasket material were wedged in place and not removed. The data were being analyzed to determine if these tubes could be left in service. No tube wear was apparent on any of the tubes associated with the loose parts.

The staff and the licensee agreed to have a second call after the inspections were complete. This was tentatively scheduled for October 29, 2003.

OCTOBER 29, 2003 CONFERENCE CALL

Inspection Status and Summary

By the time of the call, the following items had been completed: eddy current testing, pressure testing, plug installation, and plug repairs. Indications of wear on three tubes from possible loose parts in SG 24 were being examined. A total of 107 tubes was repaired in the four SGs. No leaks or bursts occurred in tubes that were pressure tested, and there was no significant change in the eddy current voltage or apparent flaw length for these indications following the pressure test. All free span indications had been checked with the rotating probe, something which had not been discussed in the previous call. Following the October 29, 2003, call the licensee provided a draft tube degradation summary, which is included on the last page of this attachment.

U-Bend Circumferential Indications in SG 23

A total of 59 indications were recorded in 46 tubes (30 in row 5, 8 in row 6, 2 in row 8, and 6 in row 9). The additional testing following the October 24, 2003, phone call did not detect any flaw signals exceeding the maximum voltage (1.99 volt) or calculated depth (40%) reported at that time. All of these tubes were plugged. Six of the circumferential indications met the screening criteria ($\geq$1.2 volt) for in-situ pressure testing. A seventh tube - row 9, column 23 - was tested because it had 9 indications (max. 0.84 volt). The tubes did not leak or burst during the pressure tests, and no change in the flaw characteristics were measured in the subsequent eddy current test. No indications were found in rows 10-20. All of the tubes with circumferential indications were to be plugged and stabilized with cables.

Tubesheet Inspection Results

A total of 15 tubes in the four SGs (10 in SG 24) were plugged due to axial PWSCC indications near the TTS. Most of these flaws were located 3" or less below the TTS, but the maximum depth was 9.7" below the TTS (SG 21). One tube in SG 21 was plugged due to a volumetric hot-leg tubesheet indication.

Other Tube Indications and Repairs

Additional details were provided on the axial PWSCC indication in SG 22 at TSP 01H at a 2.4 volt dent. The data indicated the flaw was 0.24" long and about 38% through wall, with a voltage of 0.58 volts.

Two axial anomalies were discussed. One was discussed in the October 24, 2003 phone call. This indication, in the apex of a row 14 U-bend in SG 21, was about 1.5" long and $\leq$40% through wall according to the analysis. No leak or burst occurred during a pressure test, and there was no measurable change in the subsequent eddy current test signal. The second axial anomaly discussed was on the cold leg between TSPs 04 and 05 in SG 22. This indication, examined as part of the free span history program, was 0.8" long and 30-40% through wall. Both of these tubes were plugged.

Six tubes were preventively plugged due to permeability signals (5 in SG 21, 1 in SG 22).

Mixed-Mode Indication

An indication at a 4.7 volt dent in SG 21 had both circumferential and axial characteristics located about 180° apart. This was located at the 2nd hot leg TSP in SG 21. The circumferential component indicated 66% maximum through wall depth and 26° extent. The axial component indicated 61% maximum through wall depth and 0.2" length.

Plug Repairs

Remote welded Alloy 690 plugs were installed in Row 1 of SG 23 to replace two leaking Framatome Alloy 600 plugs. All Row 1 tubes had been preventively plugged during the fifth refueling outage in 1990. In response to a question from the NRC staff, the licensee said that a Technical Specification change was not needed because remote welding is an American Society of Mechanical Engineers repair.

Closing Remarks

At the end of the call the staff requested that the licensee provide a preliminary summary of tube degradation and repairs, representative eddy current data (C-scan) for the circumferential cracking found in the SG 23 U-bends, a preliminary root cause analysis of the U-bend cracking, and the assessment of how tube bending methods relate to the critical rows for inspection. Subsequent to the call, the licensee provided a tabular summary of the tube degradation and repairs and informed the staff that they planned to complete an assessment of the U-bend indications by mid-January 2004. The licensee also informed the staff that the assessment of tube bending and inspection includes proprietary information and offered to facilitate any discussions the staff may wish to have with the owner of the proprietary information (Westinghouse).

PRELIMINARY SUMMARY
SALEM, UNIT NO. 2 TUBE DEGRADATION
2R13 REFUELING OUTAGE, FALL 2003

SALEM 2R13 Summary of Tube Degradation								
Degradation	**SG 21**		**SG 22**		**SG 23**		**SG 24**	
Axial PWSCC@TSH	3		1		1		10	
Volumetric OD Indication @TSC (Historical Loose Part Wear)	0		3		0		0	
Loose Part w/Tube Wear	0		0		0		3	
Volumetric PWSCC@TSH	1		0		0		0	
Circumferential PWSCC @TSH	0		0		0		0	
Axial ODSCC @TSH	0		0		0		1	
Volumetric OD in H/L TSP/Freespan	0		0		0		6	
Axial ODSCC @TSP	0		0		0		0	
Axial PWSCC @TSP	0		1		0		0	
Axial and Circ PWSCC @TSP (Mixed Mode)	1		0		0		0	
Axial PWSCC (Low Rad Bend)	0		0		0		0	
Circ PWSCC (Low Rad Bend)	0		0		0		0	
Axial PWSCC (High Rad Bend)	0		0		0		0	
Circ PWSCC (High Rad Bend)	0		0		59		0	
Preventive Plug (Ubend Stall or Ubend Signal)	0		2		9		0	
Tube Permeability Signals	5		1		0		0	
Freespan Axial Anomaly	1		1		0		0	
	Total	Repair	Total	Repair	Total	Repair	Total	Repair
AVB Wear	174	1	70	0	183	0	137	2
Cold Leg Thinning	6	1	51	2	19	6	38	3
TOTAL REPAIRABLE INDICATIONS	**13**		**11**		**75**		**25**	
TOTAL REPAIRABLE TUBES	**13**		**11**		**62**		**21**	
TOTAL REPAIRABLE TUBES	**107**							

KEY:

AVB	anti-vibration bar
H/L	hot leg
OD	outside diameter
ODSCC	outside diameter stress corrosion cracking
PWSCC	primary water stress corrosion cracking
TSC	tubesheet cold
TSH	tubesheet hot
TSP	tube support plate