July 27, 2001

Mr. L. W. Myers
Senior Vice President
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Post Office Box 4
Shippingport, PA 15077

SUBJECT: BEAVER VALLEY POWER STATION, UNIT NO. 1, NUCLEAR REGULATORY COMMISSION (NRC) STAFF REVIEW OF CYCLE 14 STEAM GENERATOR TUBE INSPECTION REPORT (TAC NO. MA9590)

Dear Mr. Myers:

By letter dated July 13, 2000, FirstEnergy Nuclear Operating Company (the licensee) submitted its steam generator (SG) tube inspection 90-day report, "Beaver Valley Unit 1, Cycle 14 Voltage-Based Repair Criteria 90 Day Report." The report was submitted in accordance with voltage-based alternate repair criteria in the Beaver Valley Power Station, Unit No. 1 (BVPS-1) Technical Specifications (TSs). The repair criteria were implemented in the TSs in accordance with Generic Letter (GL) 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking." The report summarized the licensee's condition monitoring and operational assessments for SG tubes for cycles 13 and 14, respectively. The licensee inspected the BVPS-1 SG tubes at the end of cycle 13 in spring 2000.

The licensee performed these assessments using an NRC-approved methodology. The NRC staff reviewed the report for consistency with the criteria of GL 95-05 and related correspondence, such as the probe wear protocol. The NRC staff concludes, as discussed in the enclosure, that the results of the licensee's condition monitoring and operational assessments were acceptable and did not identify any deviations from the approved criteria.

Sincerely,

/RA/

Lawrence J. Burkhart, Project Manager, Section 1
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-334

Enclosure: Documentation of NRC Staff Review

cc w/encl: See next page

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NRC STAFF REVIEW

OF THE STEAM GENERATOR 90-DAY REPORT

FIRSTENERGY NUCLEAR OPERATING COMPANY, ET AL.

BEAVER VALLEY POWER STATION, UNIT NO. 1 (BVPS-1)

DOCKET NO. 50-334

1.0 INTRODUCTION

In a letter dated July 13, 2000 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML003732416), FirstEnergy Nuclear Operating Company (the licensee) submitted its steam generator (SG) tube inspection 90-day report, "Beaver Valley Unit 1, Cycle 14 Voltage-Based Repair Criteria 90 Day Report." The report was submitted in accordance with voltage-based alternate repair criteria in the BVPS-1 Technical Specifications (TSs). The repair criteria were implemented in the TSs in accordance with Generic Letter (GL) 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," which was issued on August 3, 1995. The report summarized the licensee's condition monitoring and operational assessments for SG tubes for cycles 13 and 14, respectively. The licensee inspected the BVPS-1 SGs at the end of cycle (EOC) 13 in the spring of 2000.

The alternate repair criteria in the BVPS-1 TSs allow SG tubes having outside diameter stress corrosion cracking (ODSCC) that is predominately axially oriented and confined within the tube support plates (TSPs) to remain in service on the basis of, in part, the bobbin coil voltage response. The GL 95-05 guidelines for implementing the voltage-based repair criteria state that inspection results and associated tube integrity analyses should be submitted within 90 days of each plant restart after an SG tube inspection. The report should include, at a minimum, the projected EOC voltage distribution, the postulated tube leakage, and the tube burst probability under main steamline break (MSLB) conditions.

2.0 GENERAL PLANT DESCRIPTION

BVPS-1 has three Westinghouse Model 51 SGs, A, B, and C. The tubes are 7/8 inch in diameter and were fabricated from mill-annealed Alloy 600. The SGs have carbon steel TSPs with drilled holes.

In License Amendment 198, dated April 1, 1996 (ADAMS Accession No. ML003768291), the NRC staff approved the licensee's implementation of the 2-volt voltage-based alternate repair criteria for SG tubes in accordance with GL 95-05. The voltage-based tube repair criteria (1) allows tubes having indications confined within the thickness of the tube support plates and

having bobbin voltages less than or equal to 2 volts to remain in service; (2) allows tubes having indications confined within the thickness of the TSPs and having bobbin voltages greater than 2 volts but less than or equal to the upper voltage repair limit to remain in service if a motorized rotating pancake coil (RPC) probe or an acceptable inspection alternative does not detect degradation; and (3) requires tubes having indications confined within the thickness of the TSPs and having bobbin voltages greater than the upper voltage limit to be plugged or repaired. The licensee calculated the upper voltage limit to be 5.18 volts.

In a related matter, in License Amendment 263, dated March 12, 2001 (ADAMS Accession No. ML010460384), the NRC staff approved increasing the allowable accident-induced primary-to-secondary leak rate from 3.0 gallons per minute (gpm) to 5.5 gpm.

3.0 STAFF ASSESSMENT

3.1 Inspection Scope and Results

At EOC-13 the licensee inspected the full length of all tubes in all three SGs. The licensee used 0.720-inch-diameter bobbin probes to inspect all hot and cold leg TSP intersections. The licensee detected 3024 indications, of which 506 were over 1 volt and 12 over 2 volts. In addition, the licensee used the RPC probes to inspect all 12 hot leg bobbin indications above 2 volts and 440 indications below 2 volts. All 12 indications above 2 volts were confirmed by RPC as flaws and were repaired. Of the 440 indications below 2 volts, 423 indications were confirmed as flaws but were not repaired because they were within the 2-volt repair limit. The licensee did not identify any circumferential indications at the TSPs, indications extending outside the TSPs, primary water stress corrosion cracking, or volumetric signals. The licensee also did not find any circumferential indications or primary water stress corrosion cracking in the dented TSP intersections.

During the EOC-13 inspection, the licensee deplugged and inspected many deplugged tubes in SGs A and B. Deplugged tubes having above 1-volt ODSCC indications at 1H TSP (number 1 TSP on the hot leg side) intersections and above 1.2 volts ODSCC indications at 2H TSP intersections were repaired with sleeves. The remaining deplugged tubes with ODSCC indications greater than or equal to 1 volt were replugged. A total of 103 indications in SG A and 78 indications in SG B in the deplugged tubes were returned to service. The licensee included these indications in the operational assessment for cycle 14.

The licensee returned 1361 indications to service in SG A, which is the limiting SG for cycle 14 operation. Most indications occurred in the first three low-elevation TSPs (2848 out of 3024 indications) on the hot leg side. The low-elevation TSPs experienced higher operating temperature and were more susceptible to corrosion than the TSPs at the higher elevations.

3.2 Evaluation of Probabilistic Calculations

To demonstrate acceptable tube integrity in accordance with GL 95-05, the licensee has calculated that the conditional probability of a tube burst and the tube leak rate during an MSLB are below the TS reporting threshold for cycles 13 and 14. The licensee's calculations are summarized below:

3.2.1 Projected EOC Voltage Distribution

At EOC-12, the licensee projected 4681 indications for EOC-13 using voltage distributions at the beginning of cycle 13 and a constant probability of detection of 0.6. The total number of actual indications detected during the EOC-13 inspection was 3024. The number of maximum-volt indications projected was higher than the number of maximum-volt indications found in the field in all SGs. The staff noted that above 0.5 volts, the licensee overpredicted for all SGs; however, the licensee underpredicted indications in the ranges of 0.2 to 0.4 volts in SG B. In general, the licensee was conservative in predicting the EOC-13 indications.

For the operational assessment, the licensee projected EOC-14 voltage distributions using the voltage distributions at the beginning of cycle 14. For projections, GL 95-05 recommends that the more conservative growth distribution from the last two cycles be used to project EOC voltage distributions. The licensee compared the growth rate distributions for cycles 12 and 13. In cycle 13, SG B had a slightly higher average growth rate than the other SGs. The average growth rates observed for all voltages varied between 16.9% (0.097 volt/Effective Full-Power Year (EFPY)) and 20.5% (0.108 volt/EFPY). The overall average was 18.1% (0.101volt/EFPY).

The licensee stated that the average composite voltage growth rate of 18.1%/EFPY from SGs during cycle 13 was significantly higher than during cycle 12 (-3.8%/EFPY). The licensee attributed negative growth during cycle 12 to the calibration technique used during the EOC-11 inspection. The licensee stated that the higher voltage increase in cycle 13 was likely due to the length of the cycle (there was a mid-cycle plant shutdown). The larger voltage increases may be caused by the changes in the oxide layer on the crack faces rather than by growth in the length or depth of indications.

The licensee stated that according to the methodology in the Westinghouse Report, WCAP-14277, Revision 1, the larger of the composite growth rates for all SGs and the SG-specific growth rate should be used in projecting leak rate and tube burst probability for individual SGs. As mentioned above, the cycle 13 composite growth rates were higher than the cycle 12 composite growth rates. The cycle 13 composite growth rates were also higher than the cycle 13 SG A and SG C growth rates. However, the SG B cycle 13 growth rates were higher than the cycle 13 composite growth rates. For EOC-14 projections, the licensee applied the cycle 13 composite growth rates to SGs A and C and applied SG B cycle 13 growth rates to SG B.

The licensee's use of different growth rates for different SGs in projection calculations is acceptable as long as the projected tube leak rates and burst probabilities are conservative when compared to the leak rates and burst probabilities calculated from indications taken from the field during the EOC inspection. If the leak rates and burst probabilities were underpredicted, the licensee needs to resolve the non-conservatism in its projection calculations and report its resolutions in the subsequent 90-day report.

3.2.2 Conditional Probability of Tube Burst During an MSLB

At EOC-12 the licensee projected the tube burst probabilities for EOC-13 to be 1.6×10^{-4}, 1.1×10^{-4}, and 9.9×10^{-5}, for SGs A, B, and C, respectively. Using the actual EOC-13 voltage distributions, the licensee determined the as-found conditional burst probabilities to be 5.3×10^{-5}, 4.7×10^{-5}, and 5.3×10^{-5} for SGs A, B, and C, respectively. The projected EOC-13 burst probabilities were higher than the probabilities calculated based on actual indications

because the licensee overpredicted EOC-13 indications. This confirms that the licensee's prediction method is conservative. The actual burst probabilities are well within the threshold of 1×10^{-2} and, therefore, are acceptable.

For the operational assessment, the licensee projected the EOC-14 conditional tube burst probabilities to be 1.7×10^{-4}, 1.4×10^{-4}, and 1.4×10^{-4} for SGs A, B, and C, respectively. The projected EOC-14 burst probabilities are within the threshold of 1×10^{-2}; therefore, the NRC staff concludes that the structural integrity of ODSCC indications at TSPs will be maintained during the cycle 14 operation.

3.2.3 MSLB Leak Rate Projection

At EOC-12, the licensee projected the EOC-13 MSLB leak rates to be 1.0, 0.7, and 0.6 gpm for SGs A, B, and C, respectively. The prediction was calculated using the leak rate database in Addendum 2 to Electric Power Research Institute (EPRI) Report NP-7480-L which was the database available at the time. At EOC-13 the licensee calculated the potential leak rates to be 1.7, 1.1, and 1.0 gpm for SGs A, B, and C, respectively, using the actual EOC-13 inspection results and the database in Addendum 3 to EPRI report NP-7480-L, which was the updated database.

The database in Addendum 2 differs from the database in Addendum 3 in that the Addendum 3 database includes a number of data points from foreign nuclear plants for indications with high voltages (> 15 volts) that did not leak. The foreign plant data increase probability of leak for indications below 1 volt by a factor of 3 to 10 (or more). The differences in the databases resulted in the leakage under-projection. As a comparison, the licensee repeated the projection calculation using the Addendum 3 database and calculated a projected EOC-13 leak rate of 2.9 gpm for the limiting SG (SG A). The projected leak rate of 2.9 gpm is higher than the leak rate of 1.7 gpm calculated using the actual inspection data. This confirmed that had the Addendum 3 database been available at the time of EOC-12, the licensee's EOC-13 projection would have been conservative.

For the operational assessment, the licensee projected the EOC-14 MSLB leak rates to be 4.5, 3.1, and 2.8 gpm for SGs A, B, and C, respectively. These projected leak rates are much higher than EOC-13 leak rates (the database in Addendum 3 was used). The projected MSLB leak rates are below the accident-induced primary-to-secondary allowable leakage of 5.5 gpm. The predicted leakage shows that the leakage integrity of ODSCC indications will be maintained during the cycle 14 operation.

3.3 Tube Pull Results

GL 95-05 recommends periodic removal of degraded tube specimens to monitor the morphology of ODSCC degradation at TSP intersections and to obtain additional data for the correlations of bobbin coil voltage amplitude to tube burst pressure, probability of leakage, and leak rate. By letter dated February 28, 2000 (ADAMS Accession No. ML003686842), the NRC staff approved the licensee's request for deferral of tube removal during EOC-13, provided that SG inspection did not reveal TSP indications greater than 3.0 volts. The EOC-13 inspection showed that the highest voltage from an ODSCC indication was 2.2 volts. However, the licensee needs to remove tube specimens at EOC-14 in accordance with GL 95-05 and the NRC staff position in the February 28, 2000, letter.

3.4 Probe Wear Criteria

To evaluate probe wear, the licensee used an alternative method rather than the method outlined in GL 95-05. The alternative method was developed by the Nuclear Energy Institute (NEI) and was found acceptable by the NRC staff, as discussed in a February 9, 1996 (Nuclear Document System Accession No. 9602150031), letter from Brian Sheron of the NRC to Alex Marion of the NEI. The alternative method specifies that when a probe does not pass the 15% wear limit, the licensee needs to reinspect the full length of all tubes inspected since the last successful probe wear check that had indications above 75% of the voltage limit. Since the repair limit is 2 volts, all tubes measured with a worn probe that contained indications above 1.5 volts were reinspected with a new probe.

The licensee plotted worn probe voltages versus the new probe voltages that were measured at the same tube locations. From the data, the licensee calculated tolerance limits that bound 90% of the population at 95% confidence and ±25% limits of the new probe voltages. There were no occurrences for which a worn probe voltage was less than 1.5 volts and the new probe voltage exceeded the plugging limit (i.e., no pluggable tubes were missed due to probe wear considerations). Only one indication fell outside the 90%/95% tolerance limit and the ±25% limits of the new probe voltage. Both the worn probe volts and the new probe volts for that indication were below the 2-volt repair limit; therefore, the voltage data from this indication are acceptable. The NRC staff concludes that the licensee addressed probe wear satisfactorily.

4.0 SUMMARY

The NRC staff has reviewed the licensee's SG tube inspection 90-day report for cycle 14. Using an NRC-approved methodology, the licensee estimated the conditional tube burst probability at the EOC 14 to be below the reporting threshold of 1×10^{-2} for BVPS-1. In addition, the estimates of the primary-to-secondary tube leak rate during a postulated MSLB were below the allowable leak rate. The NRC staff reviewed the report for consistency with the criteria of GL 95-05 and related correspondence, such as the probe wear protocol. The NRC staff concludes that the results of the licensee's condition monitoring and operational assessments were acceptable and did not identify any deviations from the approved criteria.

Principal Contributor: J. Tsao

Date: July 27, 2001