

August 8, 2001

Mr. D. N. Morey  
Vice President - Farley Project  
Southern Nuclear Operating  
Company, Inc.  
Post Office Box 1295  
Birmingham, Alabama 35201-1295

SUBJECT: JOSEPH M. FARLEY NUCLEAR PLANT, UNITS 1 AND 2 RE: UNIT 2  
REFUELING OUTAGE 13 STEAM GENERATOR INSPECTION 90-DAY  
REPORT AND REQUEST FOR ADDITIONAL INFORMATION ON UNIT 1  
(TAC NO. MA8637)

Dear Mr. Morey:

In a letter dated March 2, 2000, you submitted the steam generator 90-Day report, "Farley Unit-2 Cycle 14 Voltage-Based Repair Criteria 90-Day Report." The report was submitted in accordance with Generic Letter 95-05, as a result of implementing the voltage-based alternate repair criteria in the Joseph M. Farley Nuclear Plant, Unit 2 (Farley-2) Technical Specifications.

The amendment approving the use of voltage-based repair criteria for this unit included a reporting threshold of  $1 \times 10^{-2}$  for the conditional probability of tube burst. Southern Nuclear Operating Company (SNC) estimated a conditional burst probability below this threshold using a NRC staff-approved methodology. The estimates of the primary-to-secondary leak rate during a postulated main steam line break for the Farley-2, were below the 11.8 gpm value from the licensing basis accident analyses and were determined using an NRC staff-approved methodology. Therefore, the staff concludes that SNC implemented the voltage-based repair criteria in accordance with its licensing basis. The staff's evaluation is enclosed.

However, during the review, the staff identified a discrepancy in the Joseph M. Farley Nuclear Plant, Unit 1 (Farley-1) report, which was submitted by a letter dated March 16, 1999. The reported signal growth statistics reported in your submittal of May 13, 1997, for Cycle 14 are significantly different than the signal growth statistics reported for the same cycle (Cycle 14) in the letter dated March 16, 1999. Therefore, it appears that you may have not used the appropriate growth rates when projecting the end of Cycle 16 conditions for Farley-1. This

D. N. Morey

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issue was discussed with your licensing staff on July 30, 2001. Please provide within 90 days an explanation for this noted difference and its effect on the integrity and leakage assessments. The staff did not find this discrepancy for Farley-2.

The steam generators have been replaced at both Farley units since these reports were generated. Voltage-based repair criteria are no longer being used at Farley. However, this information is needed by the staff to help ensure that the voltage-based methodology will continue to be properly implemented throughout the industry, as intended by GL 95-05.

Sincerely,

*/RA/*

Frank Rinaldi, Project Manager, Section 1  
Project Directorate II  
Division of Licensing Project Management  
Office of Nuclear Reactor Regulation

Docket Nos. 50-364 and 50-348

Enclosure: As stated

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Joseph M. Farley Nuclear Plant

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REVIEW BY THE OFFICE OF NUCLEAR REACTOR REGULATION  
OF THE STEAM GENERATOR 90-DAY REPORT  
SUBMITTED BY  
SOUTHERN NUCLEAR OPERATING COMPANY  
JOSEPH M. FARLEY NUCLEAR PLANT UNITS 1 AND 2  
DOCKET NOS. 50-348 AND 50-364

## 1.0 INTRODUCTION

By letter dated March 2, 2000, Southern Nuclear Operating Company submitted for staff review the report for Joseph M. Farley Nuclear Plant, Unit 2 (Farley-2), "Farley Unit-2 Cycle 14 Voltage-Based Repair Criteria 90-Day Report." The report was submitted in accordance with Generic Letter (GL) 95-05 as a result of implementing the voltage-based alternate repair criteria in the Farley-2 technical specifications (TS).

GL 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," allows steam generator (SG) tubes having outside diameter stress corrosion cracking (ODSCC) that is predominately axially oriented and confined within the tube support plates to remain in service on the basis of, in part, bobbin coil voltage response. GL 95-05 specifies that inspection results and associated tube integrity analyses should be submitted within 90 days of each plant restart following a steam generator tube inspection. The report should include, at a minimum, projected end of cycle (EOC) calculations on voltage distribution, postulated tube leakage, and tube burst probability under main steam line break (MSLB) conditions.

## 2.0 GENERAL PLANT DESCRIPTION

Farley-2 has been in operation since July 1981. Farley-2 has three Westinghouse Model 51 SGs. The tubes are 7/8-inch diameter and were fabricated from mill-annealed alloy 600 material. The SGs have drilled-hole carbon steel tube support plates.

On October 11, 1996, the staff approved a change to the licensee's TSs that implemented a SG voltage-based alternate repair criteria in accordance with GL 95-05.

## 3.0 STAFF ASSESSMENT

### 3.1 Inspection Scope and Results

In accordance with the alternate repair criteria guidance provided in GL 95-05, the EOC-13 inspection of the Farley-2 SGs consisted of a complete 100% bobbin probe full length examination using a 0.720-inch bobbin coil probe at all tube support plate (TSP) intersections in all three SGs. The licensee used a rotating pancake coil (RPC) probe to inspect 100% of the indications with bobbin coil voltages greater than 2.0 volts in all three of the SGs. The RPC examinations included all dents greater than 5 volts in all three SGs.

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The licensee inspected all large mixed residual signals. Large mixed residuals are defined in GL 95-05 as mixed residual signals that could mask a 1.0 volt bobbin signal causing it to be missed or misread.

The licensee detected a total of 48 indications above 2 volts in the three SGs during the bobbin probe examinations. All 48 indications were RPC-examined. Twelve of the greater than 2 volt bobbin indications were confirmed as flaws and removed from service following the RPC inspection.

All dented intersections with bobbin voltage greater than 5 volts were inspected with a RPC probe. The licensee stated that no RPC inside diameter or outside diameter indications were detected at these intersections.

The RPC inspections of large residual artifact signals found four axial TSP ODSCC indications. These four indications were found in SG "C." The licensee expanded the RPC examinations to include 192 more intersections in SG "C." No additional indications were found in the expanded RPC examinations. The four indications were repaired. It is not clear to the staff what criteria the licensee used to determine and bound the expansion. Also, it is not clear to the staff why the licensee only expanded inspections in SG "C" and what the initial sample size was in each SG. The staff noted in its previous review dated January 6, 1999, that the licensee found an indication in SG "B" through its RPC inspection of bobbin high residual signal locations during the EOC-12 inspection. The licensee expanded inspections to an additional 66 intersections in SG "B" during the EOC-12 inspection.

The licensee detected a total of 652 bobbin signals at tube support plate intersections during the EOC-13 inspection. These were called potential indications (PIs). Of the 652 PIs, 287 were above 1 volt and 48 exceeded 2 volts. Of the 34 indications that were removed from service prior to beginning of cycle (BOC)-14, twelve were repaired due to ODSCC at TSPs. The other 22 bobbin indications were plugged due to degradation mechanisms other than ODSCC at TSPs.

No tubes were deplugged during the EOC-13 outage with the intention of returning them to service after inspection.

As per the GL 95-05, the licensee calculated the upper repair limit using the more conservative of the plant-specific average growth rate per effective full power year (EFPY) or 30 percent per EFPY. The licensee documented in its report the average growth rates from cycle 12 and cycle 13 to determine the more limiting growth rate to be used to predict EOC-14 conditions for Farley-2. The licensee calculated the upper repair limit to be 5.32 volts. No indications identified during the EOC-13 inspection exceeded the upper repair limit.

Of the 618 bobbin indications returned to service for Cycle 14 operation, 304 bobbin indications are in SG "C." SG "C" had almost twice the number of indications over 2 volts returned to service as the other two SGs combined. Based on the number of tubes returned to service with bobbin coil indications and the voltages associated with the indications, SG "C" is considered to be the limiting steam generator for Cycle 14 operation. As discussed in Sections 3.2.2 and 3.2.3 of this safety evaluation, this conclusion is supported by the calculated estimate of the burst probability and accident tube leakage.

### 3.2 Evaluation of Probabilistic Methodologies for Estimating Conditional Probability of Burst and Total Leak Rate Under Postulated Steam Line Break Conditions

Acceptable tube integrity at the conclusion of Cycle 13 operation is demonstrated, in part, by a calculated conditional probability of tube burst for the limiting SG less than the reporting threshold indicated in GL 95-05 and an estimated accident-induced SG tube leak rate from ODSCC at tube support plate intersections less than the leakage limit from the licensing basis accident analysis. Three distinct probabilistic calculations are necessary to determine these results. The following summarizes the staff's evaluation of the results reported on these calculations.

#### 3.2.1 Projected End-of-Cycle Voltage Distribution

The licensee's 90-day report compared the as-found distribution of voltages from the EOC-13 refueling outage inspection to those estimated from the predictions made following the prior outage (EOC-12). The EOC-13 projections are based on a constant probability of detection of 0.6. SG "C" was predicted to be the limiting SG for EOC-13 which is consistent with the inspection results for EOC-13. SG "C" had the highest number of indications as well as the largest indication at EOC-13. The licensee's prediction for the EOC-13 bobbin voltage distribution was found to be a conservative representation of the actual EOC-13 bobbin voltage distribution.

During inspections in some plants with 7/8-inch SG tubes, relatively high growth rates were observed for indications in tubes unplugged and returned to service at the beginning of their last operating cycle. No tubes were unplugged during the EOC-12 (the last) refueling outage with the intent of returning them to service after inspection. Therefore, there is no growth data that fit this category from the EOC-13 inspections. Some licensees also noted an increase in growth rate with an increase in BOC voltage. This trend was not observed during the Farley-2 EOC 13 inspection.

In order to obtain the most conservative results with respect to the growth rate distribution used in Monte Carlo simulation, the licensee considered SG specific growth rate distributions obtained from EOC-12 and EOC-13 inspections. GL 95-05 recommends that the more conservative growth distribution from the last two cycles be used for projecting EOC distributions for the next operating cycle (EOC-14 for Farley-2). The data from the last two cycles (Cycles 12 and 13) are very similar. However, the top growth value for Cycle 13 is nearly twice as large as the largest Cycle 12 growth. Since the Cycle 13 growth rate is slightly higher (more limiting) than the Cycle 12 growth rates, the licensee used the Cycle 13 growth rates to perform the EOC-14 projections. The Cycle 13 growth rates for SGs "A" and "B" are below the composite growth rate. Therefore, the licensee used the composite Cycle 13 growth rate for SG "A" and "B" calculations. The Cycle 13 growth rate for SG "C" is higher than the composite growth rate distribution, and per the recommended methodology, the SG specific growth rate is used for SG "C" projections.

Using the inspection findings of the EOC-13 inspection and the appropriate probability distribution function of growth rates, the licensee calculated the projected EOC-14 voltage distribution for bobbin coil probe TSP indications.

### 3.2.2 Conditional Probability of Tube Burst

Following the EOC-12 refueling outage, the licensee estimated the EOC-13 burst probabilities for the three SGs. The burst probabilities were projected to be  $5.3 \times 10^{-5}$ ,  $2.1 \times 10^{-4}$ , and  $5.6 \times 10^{-4}$  for SGs A, B, and C, respectively. Using the actual inspection results as the input into the calculations for tube burst, the licensee determined the as-found conditional burst probabilities to be  $5.3 \times 10^{-5}$ ,  $6.8 \times 10^{-5}$ , and  $2.9 \times 10^{-4}$ . Therefore, the predictive methodology used by the licensee provided conservative results.

GL 95-05 specifies a reporting threshold of  $1 \times 10^{-2}$ . The licensee's calculated and as found burst probabilities for all three SGs are below the reporting threshold.

Following the guidance in GL 95-05, the licensee reported the projected EOC-14 conditional tube burst probabilities. The calculated probability of tube burst for SGs "A", "B", and "C" were determined to be  $7.3 \times 10^{-5}$ ,  $1.7 \times 10^{-4}$ , and  $4.4 \times 10^{-4}$ , respectively. The licensee's projected values are below the GL reporting threshold of  $10^{-2}$ . Therefore, the estimated tube burst probability due to ODSCC at tube support plates is projected to be within acceptable limits for Cycle 14 operation.

### 3.2.3 Steam Line Break Leak Rate Projection

The licensee determined the EOC-13 projected MSLB leak rate values for SGs "A", "B", and "C" to be 0.3, 0.8 and 2.0 gallons per minute (gpm), respectively. These values are the volumetric leak rate adjusted for room temperature. The licensee then recalculated these values using the inspection results obtained from the EOC-13 inspection. The MSLB leak values using the EOC-13 inspection data for SGs "A", "B", and "C" are 0.2, 0.4, and 1.1 gpm, respectively. The projected and as-found calculations for EOC-13 conditions are much smaller than the Farley-2 MSLB leak rate limit of 11.8 gpm (equivalent volumetric rate at room temperature). The licensee projects the EOC-14 MSLB leak rates for SGs "A", "B", and "C" to be 0.4, 0.9, and 2.2 gpm (equivalent volumetric rate at room temperature), respectively. These projected values are smaller than the current licensed limit for Farley-2.

### 3.3 Tube Pull Results

GL 95-05 requires periodic tube specimen removals to monitor the morphology of ODSCC degradation at tube support plate intersections and to obtain additional data for inclusion in the correlations relating bobbin coil voltage amplitude to tube burst pressure, probability of leakage, and leak rate. NEI submitted an "Industry Recommended Steam Generator Tube Pull Program," in a letter dated September 22, 1999. The NRC staff reviewed the industry tube pull program and documented its positions in a letter dated January 31, 2000. No tubes were pulled at Farley-2 during the EOC-13 refueling outage in regards to the continued use of the voltage based alternate repair criteria. The staff finds that a tube pull was not necessary during the EOC-13 refueling outage.



### 3.4 Probe Wear Criteria

The licensee used an alternative method of probe wear criteria as opposed to the method outlined in GL 95-05. The method was developed by Nuclear Energy Institute (NEI) and was found acceptable by the NRC staff as discussed in a letter from Brian Sheron of the NRC to Alex Marion of NEI dated March 18, 1996.

The guidelines used by the licensee for bobbin probe wear where when a probe does not pass the 15% wear limit, the criteria required that tubes with indications above 75% of the wear limit inspected since the last successful probe wear check be re-inspected with an acceptable probe. Accordingly, for Farley-2, all tubes containing indication above 1.5 volts that were originally inspected with a worn probe were to be re-inspected with a new probe. In accordance with the approved guidance, voltages measured with a worn probe and a new probe at the same location were analyzed to ensure that the voltages measured with worn probes are within 75% of the new probe voltages. The licensee stated no new large indications were detected with new probes. Two indications in SG "C" had a worn probe voltage about three times the new probe voltage. SG "C" also had two indications that measured significantly smaller than the new probe voltages (the worn probes failed in a non-conservative direction). The new probe voltages were approximately 1.2 and 1.3 volts. The worn probe voltages for these two indications were approximately 0.75 volts each. Neither indication would have triggered the tube(s) to be reinspected. The licensee's comparison of tubes with worn probe indications shows that no pluggable indications were missed by a worn probe in the selected tubes.

### 4.0 IMPLEMENTATION CONCERNS

During the review of Farley-2, the staff reviewed some submittals of Farley-1 and discovered that the reported cumulative probability distribution function (CPDF) reported for Unit 1 Cycle 14 in a submittal dated March 16, 1999, was significantly different than the Cycle 14 CPDF reported in a submittal dated May 13, 1997. GL 95-05 guidelines require that the more conservative growth distribution for the last two operating periods be applied for projecting the following cycle distributions. The licensee should provide an explanation of this difference and its effect on the integrity and leakage assessments. The staff did not find a similar discrepancy for the recent Farley-2 projections.

### 5.0 SUMMARY

The projected EOC-14 conditional probability of burst and projected MSLB leak rate were less than the GL 95-05 criteria. The staff has reviewed the licensee's methodology and results and has found them acceptable for Farley-2.

Principal Contributor: Andrea Keim, EMCB/DE

Date: August 8, 2001