

October 5, 1998

Mr. Roger O. Anderson, Director
Nuclear Energy Engineering
Northern States Power Company
414 Nicollet Mall
Minneapolis, Minnesota 55401

SUBJECT: REVIEW OF STEAM GENERATOR 90-DAY REPORT FOR PRAIRIE ISLAND
NUCLEAR GENERATING PLANT, UNIT 1 (TAC NO. MA1582)

Dear Mr. Anderson:

In a letter dated March 13, 1998, Northern States Power Company (NSP) submitted its steam generator 90-day report, "Prairie Island Unit 1, Cycle 19 Steam Generator Tube Support Plate Voltage Based Repair Criteria 90-Day Report." The report summarized the results of NSP's assessment of the eddy current inspection results with respect to the guidance established for voltage-based tube repair criteria applied to indications located at the tube support plate intersections and attributed to outside diameter stress corrosion cracking.

The license amendment approving the use of voltage-based repair criteria for Prairie Island Unit 1 included a reporting threshold of 1×10^{-2} for the conditional probability of tube burst. NSP's prediction for the end-of-cycle 19 (EOC-19) estimated a conditional burst probability below this threshold. NSP's prediction of 0.064 gallon per minute (gpm) for the EOC-19 primary-to-secondary leakage during a postulated main steam line break for Prairie Island Unit 1 is below the maximum allowable accident leak rate of 1.0 gpm.

We conclude NSP implemented the voltage-based repair criteria in accordance with its licensing basis. The staff's review of the subject 90-day report is enclosed.

Sincerely,

ORIGINAL SIGNED BY

Tae Kim, Senior Project Manager
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REVIEW OF PRAIRIE ISLAND UNIT 1 STEAM GENERATOR 90-DAY REPORT

1.0 INTRODUCTION

In a letter dated March 13, 1998, Northern States Power Company (NSP or the licensee) submitted its steam generator 90-day report, "Prairie Island Unit 1, Cycle 19 Steam Generator Tube Support Plate Voltage Based Repair Criteria 90-Day Report" [Reference 1]. The report was submitted in accordance with Generic Letter (GL) 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," as a result of implementing the voltage-based alternate repair criteria in the Prairie Island Nuclear Generating Plant, Unit 1 (Prairie Island Unit 1) technical specifications.

GL 95-05 allows steam generator tubes having outside diameter stress corrosion cracking (ODSCC) that is predominantly 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, calculations on voltage distribution, postulated tube leakage, and tube burst probability under normal and accident conditions.

2.0 GENERAL PLANT DESCRIPTION

Prairie Island Unit 1 has two Westinghouse Model 51 steam generators. The tubes are 7/8-inch in diameter and were fabricated from mill annealed alloy 600 material. The steam generators have drilled hole carbon tube support plates.

On November 18, 1997, the staff approved the licensee's request to implement the 2.0-volt alternate repair criteria. The licensee performed the end-of-cycle 18 (EOC-18) tube inspection during the October 1997 refueling outage. The licensee used a lower repair limit of 2.0 volts and established an upper voltage repair limit of 4.91 volts to disposition ODSCC at tube support plate intersections. References 2 and 3 describe the 2.0-volt alternate repair criteria methodology in more detail.

3.0 STEAM GENERATOR TUBE EDDY CURRENT INSPECTION SCOPE AND RESULTS

The licensee inspected 100% of the Prairie Island Unit 1 steam generator tubes full length using a 0.720-inch diameter bobbin probe at all intersections at which the 2.0-volt alternate repair criteria were applied. In addition, all except two of the tube support plate intersections with bobbin probe distorted support plate intersection (DSI) calls were inspected using the +point rotating pancake coil (RPC) probe. The two intersections not inspected with the RPC probe were removed from service.

ENCLOSURE

GL 95-05 only requires that potential ODSCC indications greater than 2.0 volts be inspected with an RPC probe. During the EOC-18 outage the licensee did not identify any indications over 2.0 volts. But at the time the tube inspections were being performed, the licensee's GL 95-05 license amendment request had not yet been approved. Therefore, the licensee conservatively chose to perform RPC inspections on 100% of the indications identified by the bobbin probe.

During this outage the licensee concluded that some of the indications at tube support plates (TSPs) contained a combination of ODSCC and thinning. Because there is no qualified sizing technique for combined ODSCC and thinning, the licensee removed these tubes from service, regardless of the bobbin voltage. During future inspections, unless the licensee develops a basis for applying the voltage-based repair criteria to these indications, NSP will inspect all bobbin indications with an RPC probe to determine whether the indication has a volumetric component.

The licensee reported a total of 485 bobbin indications (278 in SG-11 and 207 in SG-12) as potential ODSCC indications and returned 419 of these indications to service following an RPC inspection. Of the 66 indications confirmed by RPC and removed from service, 64 indications were interpreted as volumetric indications (i.e., thinning). The two remaining RPC confirmed indications were interpreted as a single axial indication and a multiple axial indication. These indications fell below the 2.0-volt repair limit but were removed from service for reasons unrelated to the requirements of GL 95-05.

The staff concludes the licensee's bobbin and RPC probe inspection were consistent with the guidance in References 2 and 3 and thus are acceptable.

4.0 EVALUATION OF PROBABILISTIC METHODOLOGIES FOR ESTIMATING CONDITIONAL PROBABILITY OF BURST AND TOTAL LEAK RATE UNDER POSTULATED STEAM LINE BREAK CONDITIONS

Acceptable tube integrity at EOC-19 operation is demonstrated, in part, by a calculated conditional probability of tube burst for the limiting steam generator less than the reporting threshold indicated in GL 95-05 and an estimated accident-induced steam generator tube leak rate from ODSCC at TSP intersections below plant-specific limits. Three distinct probabilistic calculations are necessary to determine these results. The following summarizes the staff's evaluation of the results reported on these calculations.

4.1 Projected End-of-Cycle Voltage Distribution

The licensee's 90-day report calculated the predicted EOC-19 voltage distributions based on the as-found EOC-18 voltage distribution. No comparisons were made between the as-found EOC-18 voltage distribution and projected EOC-18 voltage distribution because this was the first outage during which the voltage-based repair criteria was implemented and, therefore, there was no projected EOC-18 data. Projections of the voltage distributions for EOC-19 estimated that the Prairie Island Unit 1 steam generators will contain approximately 808 TSP indications.

In order to obtain the most conservative results with respect to the growth rate distribution used in the Monte Carlo simulation, the licensee compared steam generator growth rate distributions obtained from EOC-18 and from an EOC-17 look-back analysis. 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. Accordingly, the licensee conservatively used the composite EOC-18 bobbin voltage growth rates for predicting EOC-19 conditions because it was the most significant.

During recent inspections in some plants with 7/8-inch steam generator tubes, relatively high growth rates were observed for indications in tubes unplugged and returned to service at the beginning of their last operating cycle. NSP did not deplug and return to service any tubes during this outage.

The staff independently verified the licensee's calculations by completing Monte Carlo simulations to estimate the predicted EOC-19 voltage distribution. The results of these calculations correlated closely with the licensee's results and, therefore, confirm that the predictive methodology used by the licensee to estimate the EOC voltage distributions is consistent with the guidance provided in GL 95-05.

4.2 Conditional Probability of Tube Burst

Due to the relatively low number of higher voltage indications identified during the EOC-18 inspection at Prairie Island Unit 1 and projected for EOC-19, the calculated conditional probability of tube burst is expected to be below the reporting threshold of 1×10^{-2} specified in GL 95-05. Using the voltage distribution discussed above, the licensee reported the projected EOC-19 conditional tube burst probabilities. The calculated probability of tube burst for steam generators "11" and "12" were determined to be $< 1.9 \times 10^{-5}$ and 2.52×10^{-5} , respectively. The projected values are well below the GL reporting threshold, and therefore, the estimated tube burst probability due to ODSCC at TSPs is well within acceptable limits for Cycle 19 operation. The staff independently verified the licensee's calculations by completing Monte Carlo simulations to estimate the EOC-19 conditional probability of tube burst. The results of these calculations confirm that the predictive methodology used by the licensee to estimate the conditional probability of tube burst is consistent with the guidance provided in GL 95-05.

4.3 Steam Line Break Leak Rate Projection

The staff evaluated the steam line break leak rate reported by the licensee similar to the assessment of the conditional tube burst probabilities. The licensee estimated the steam line break leak rate for steam generators "11" and "12" to be 0.064 gpm and 0.055 gpm (at room temperature), respectively. This value is significantly smaller than the Prairie Island Unit 1 steam line break leak rate limit of 1.0 gpm (at room temperature). Therefore, the projected tube leakage integrity for ODSCC indications is well within the allowable limit established for Prairie Island Unit 1. The staff independently verified the licensee's calculations by completing Monte Carlo simulations to estimate the EOC-19 steam line break leak rate projections. The results of these calculations confirm that the predictive methodology used by the licensee to estimate the EOC steam line break leak rate projections is consistent with the guidance provided in GL 95-05.

5.0 DATABASE FOR TUBE INTEGRITY CALCULATIONS

In order to calculate the conditional tube burst probabilities and postulated steam line break primary-to-secondary leak rate the methodology approved for GL 95-05 requires the use of burst and leak rate data obtained from model boiler tubes and tubes removed from actual steam generators. The industry has developed correlations relating bobbin coil voltage to the measured leak rate, probability of burst, and burst pressure through testing of these tubes. The database used for the ARC correlations that were applied in the licensee's analysis were consistent with Reference 2 and industry- and NRC-approved methodology for the inclusion of new data.

6.0 TUBE PULL RESULTS

NSP removed three tubes, four TSP intersections, from the Prairie Island Unit 1 steam generators during the EOC-18 refueling outage to examine eddy current indications located at the TSP intersections. Of the four, the intersection with the largest voltage indication, 0.85 volt, contained both ODSCC and thinning. No other pulled tube intersection contained thinning. All four intersections contained bobbin voltage indications.

The licensee completed burst testing on all four intersections and leak testing on three intersections. All intersections burst at pressures similar to undegraded tubing. The intersections that were leak tested did not leak at accident conditions. Tube R27C21 (TSP 1) was both leak and burst tested, but will be excluded from the correlations due to exclusion criterion 2a which requires exclusion if the cracks contain less than or equal to 2 uncorroded ligaments and are shallow (<60% throughwall). Tube R27C21 (TSP 1) meets this criterion. Tube R32C41 (TSP 1) was burst and leak tested and was excluded due to criterion 1a. Criterion 1a excludes intersections whose eddy current signal is corrupted due to extraneous bobbin voltage effects other than ODSCC. The licensee stated that the bobbin voltage indication was dominated by the thinning degradation. Although tube R32C41 (TSP 3) was only burst tested, it will be included in both the burst correlation and probability of leakage (POL) correlation. The licensee stated it was included in the POL correlation because it was clear that the 8% depth flaw, determined from destructive examination, would not leak under accident conditions. Tube R19C11 (TSP 1) was both burst and leak tested and will be included in both the burst and POL correlations.

The licensee evaluated the leak and burst test results discussed above and found the inclusion of the additional data in the steam generator database would not impart significant changes into the leak rate, POL, and burst rate correlations. The results of the Prairie Island Unit 1 tube pulls are consistent with the guidance in Reference 3, and in addition, the metallurgical evaluation of the TSPs support implementation of the voltage-based repair criteria at Prairie Island Unit 1.

REFERENCES

1. Westinghouse Electric Corporation, "Prairie Island Unit 1, Cycle-19 Voltage Based TSP Alternate Repair Criteria 90-Day Report," SG-98-03-002, March 1998.
2. Letter from B.A. Wetzel (NRC) to R.O. Anderson (NSP), "Prairie Island Nuclear Generating Plant, Unit Nos. 1 and 2 - Issuance of Amendments Re: Incorporation of Voltage-Based Steam Generator Tube Repair Criteria (TAC Nos. M98944 and M98945)," dated November 18, 1997.
3. Generic Letter 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," August 3, 1995.