UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

APPROVAL OF PLANT RESTART

VIRGINIA ELECTRIC AND POWER COMPANY

NORTH ANNA UNIT 1

DOCKET NO. 50-338

1.0 INTRODUCTION

North Anna Unit 1 shut down on December 23, 1991 for a mid-cycle steam generator (SG) tube inspection outage. During this outage an inservice inspection of the SG tubes was performed in accordance with Technical Specification 4.4.5. The results of the SG tube inspection were found to be in Category C-3 (as defined in Technical Specification 4.4.5.2) for each of the three SGs. Prompt notifications of these Category C-3 findings were provided to the NRC staff on January 10, 1992 for SG C, on January 20, 1992 for SG A and on January 24, 1992 for SG B pursuant to Technical Specification 4.4.5.5.c and 10 CFR 50.73.

By letter dated March 2, 1992, the licensee requested NRC approval to return to power operation following this mid-cycle SG tube inspection outage. NRC approval is required pursuant to Technical Specification Table 4.4-2 whenever the inspection results for at least two of the three SGs are Category C-3. To support this request, the licensee met with the staff on March 2, 1992 to discuss the inspection results and the licensee's evaluation of these results.

2.0 DISCUSSION

Primary-to-secondary leakage during the last operating cycle was relatively low, with typical leakage less than 10 gallons-per-day (gpd) per SG prior to the mid-cycle SG tube inspection outage which commenced on December 23, 1991.

The mid-cycle SG tube inspection program was extremely comprehensive, consisting of the following elements:

- A 100%-full length inspection was performed with a bobbin coil probe in all three SGs except for row 2 U-bends.

- A 100% inspection of the tube-to-tube support plate intersections was performed with an 8x1 probe on the hot leg side up to the 7th tube support plate. The purpose of these 8x1 probe inspections was to provide improved sensitivity to stress corrosion cracking (SCC) activity at the tube support plate (TSP) locations. The 8x1 data were not analyzed, however, due to problems correlating 8x1 probe possible indications with the rotating pancake coil (RPC) probe data analysis. The 8x1 probe was generating approximately seven times the number of calls that could be confirmed by the RPC. The licensee instituted a 100% RPC program to ensure detection of SCC at the TSPs.

- A 100% inspection of hot leg TSP locations was performed with an RPC probe.

- A 100% inspection of WEXTEX expansion-transition locations (at the top of the tubesheet) was performed with an RPC probe on the hot leg side of each of the three SGs. These inspections were intended to provide sensitivity to circumferential cracks at this location.

- An RPC probe inspection of all row 2 U-bends was performed to ensure optimal sensitivity to SCC at these locations.

- RPC probe inspections were performed for all tubes at locations exhibiting bobbin indications to more fully characterize these indications. An RPC probe inspection of special interest tubes identified in the December 1991 reanalysis of the eddy current data from the previous outage was performed.

The number and attribution of pluggable indications found are as follows:

Attribution	No. of Tubes with Pluggable Indication
Cracks at WEXTEX transition axial or circumferential	36
Free span	3
Axial indications at support plates	257
Circumferential indications at support plates	212
Other	19
TOTAL	527

The SG tube bundle integrity was reestablished by plugging each of the above 527 tubes and by installing stabilizers in these tubes as necessary. Tube stabilization criteria were developed based on analyses of the maximum crack arc-lengths which could be allowed, such that circumferential cracks would not propagate by fatigue to the point of complete severance of the tube subsequent to plugging. These analyses considered axial loadings on the plugged tubes due to heatup/cooldown cycles (assuming the tubes are dented at the tube support plates) and flow-induced vibration loadings.

The licensee and Westinghouse presented arguments on March 2, 1992 to the NRC staff projecting the next end-of-cycle (January 1993) indications based on current inspection results. They claimed that since the duration of the next operating cycle in effective full power days (EFPD) will be less than in the previous cycle (252 EFPD vs 254 EFPD) and that the hot leg temperature will be lower in the upcoming cycle than in the previous cycle, the expected crack sizes at the end of the next cycle will be less than those observed this cycle. However these two benefits (shorter cycle duration and lower hot leg temperature) were not quantified. The licensee's approach to justify operation through January 1993 was to demonstrate that since all indications found during the mid-cycle SG tube inspection (December 1991) were within structural performance criteria contained in Regulatory Guide 1.121, then all indications in January 1993 will be within the structural performance criteria in Regulatory Guide 1.121 due to the benefits cited earlier. Arguments were presented for all modes of SG tube degradation observed at North Anna Unit 1. These arguments are detailed below.

Compliance with Regulatory Guide 1.121 with respect to single circumferential cracks at both the WEXTEX transition and the TSPs was presented. No single circumferential indications at the WEXTEX transitions that exceeded the limiting crack size with respect to meeting the structural performance criteria in Regulatory Guide 1.121 were found during this inspection (December 1991). With the exception of two single circumferential crack indications at the TSP area, the "as-found" crack indications at the TSPs were determined by the licensee and Westinghouse to be less than the limiting crack sizes for meeting the structural performance criteria in Regulatory Guide 1.121. The licensee and Westinghouse believe that the two exceptions at the TSP elevation will not recur in January 1993, since tubes inspected this outage (December 1991) were inspected with a more sensitive probe (RPC) with a lower threshold of detection than the probe used during the previous inspection (8x1 probe). Reexamination of the previous 8x1 and RPC probe data indicates that many of the circumferential cracks now being detected at the TSPs with the RPC were present during the previous refueling outage but were below detection thresholds, although they can be detected with hindsight. Furthermore, the licensee and Westinghouse claimed that the tubes meet the structural margins required in Regulatory Guide 1.121 since the cracks are not entirely through-wall and that the deepest part of the cracks are only a fraction (40%-60%) of the total crack angle measured. The staff does not

consider this argument to be convincing. However, the staff concurs that maximum end-of-cycle (EOC) crack sizes at the TSP are expected to be within the Regulatory Guide 1.121 criteria in view of the RPC inspections conducted during this inspection and the planned reduction in hot leg operating temperature during the upcoming cycle. The licensee should confirm this expectation by appropriate analysis in its forthcoming April submittal.

Several axial indications extending beyond the TSP area were observed and plugged during this inspection outage. All of the observed axial crack indications were less than the limiting crack size for meeting the structural performance criteria contained in Regulatory Guide 1.121. Since the size of these axial indications were less than the limiting crack size required to meet Regulatory Guide 1.121 structural performance criteria, the licensee and Westinghouse expect that the axial cracks at the end of next cycle will be within the structural performance criteria of Regulatory Guide 1.121.

Multiple circumferential indications were observed at both the WEXTEX transition area and the TSP areas during this outage (December 1991). These indications are typically composed of two circumferential cracks separated by a ligament (non-cracked portion of the tube wall). The licensee and Westinghouse presented arguments that all of the multiple circumferential indications at both the WEXTEX transition and the TSPs met the structural performance criteria contained in Regulatory Guide 1.121 since each had a ligament that exceeded the minimum ligament size required to meet the three-times-normal operating pressure differential burst capability limit.

Fourteen occurrences of mixed-mode cracking (axial and circumferential cracks at the same TSP) were observed during this inspection. Of these 14 mixed-mode cracks, only 7 had both circumferential and axial cracks at the same edge of the TSP. The licensee and Westinghouse claimed that a ligament of approximately 3-wall thicknesses (aproximately 20 degrees) is sufficient to ensure that the burst pressure of mixed-mode cracked tubes is due only to the axial component of the crack network. Since the axial lengths of the tubes with mixed-mode cracking were within structural limits and the minimum ligament was greater than or equal to 20 degrees, the licensee and Westinghouse claimed that these tubes met the structural limits of Regulatory Guide 1.121.

The licensee divided the WEXTEX transition and TSP cracks found during this inspection outage into four zones for determining their susceptibility to tube vibration. The licensee claims that only two tubes in zone 1 (the peripheral zone) contained indications that exceeded the minimum through-wall crack angle required for crack propagation due to tube vibration. All other tubes with indications, regardless of zone, had crack angles less than that required for crack propagation due to tube vibration. Of the two tubes in zone 1 whose crack angles were in excess of the through-wall crack angle required for crack propagation due to tube vibration, one was located at the TSP while the other

was located in the WEXTEX transition area. The licensee and Westinghouse claimed that the deepest part of both of these cracks was less than that required for crack propagation due to tube vibration, and therefore, no WEXTEX or TSP crack indications are subject to crack propagation due to tube vibration.

The Technical Specifications for North Anna Unit 1 incorporate a very tight limit (i.e. 100 gpd) on allowable primary-to-secondary leakage. In addition, the licensee plans to continue to adhere to an administrative limit of 50 gpd. As has been noted by the staff in previous safety evaluations, the staff considers the licensee's program for monitoring primary-to-secondary leakage to be very effective in terms of its ability to alert the operators in a timely manner to an increasing trend in primary-to-secondary leakage. The licensee's program includes the use of N-16 monitors, which allows for continuous monitoring in the control room of primary-to-secondary leakage. The program also includes use of all primary-to-secondary leak detection instrumentation in determining whether or not the Technical Specification limits on leakage have been exceeded.

The licensee concluded that the SGs have been restored to an operable condition and that operation through January 1993 is warranted.

3.0 CONCLUSION

The staff concurs with the licensee's conclusion that the SGs have been restored to an operable condition and that restart from the current outage poses no undue risk to the public health and safety. This conclusion is based on the preliminary review of the technical data presented to the NRC staff by the licensee and Westinghouse on March 2, 1992 at NRC headquarters. The extensive SG inspection activities and the stringent primary-to-secondary leakage monitoring program (and the associated leakage limits) provide reasonable assurance that the unit can be safely operated through January 1993.

The staff will conduct a detailed review of the formal submittal of the technical data presented on March 2, 1992. The formal report is to be submitted no later than April 30, 1992 and should contain a quantitative analysis demonstrating that the maximum end-of-cycle crack sizes at the TSP will not exceed Regulatory Guide 1.121 criteria.

Date: March 23, 1992

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