

UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
OFFICE OF NUCLEAR REACTOR REGULATION  
WASHINGTON, D.C. 20555-0001

June 25, 2002

NRC INFORMATION NOTICE 2002-21: AXIAL OUTSIDE-DIAMETER CRACKING  
AFFECTING THERMALLY TREATED ALLOY 600  
STEAM GENERATOR TUBING

Addressees

All holders of operating licenses for pressurized-water reactors (PWRs), except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to inform addressees of preliminary indications of axial outside-diameter (OD) cracking of thermally treated Alloy 600 steam generator (SG) tubing at Seabrook. The NRC anticipates that recipients will review the information for applicability to their facilities. No specific action or written response is required.

Description of Circumstances

Seabrook is a four-loop Westinghouse 1198 MWe PWR unit. Commercial operation started in August of 1990. The unit has operated for approximately 9.67 effective full-power years (EFPY).

Seabrook has four Westinghouse Model-F recirculating steam generators (A, B, C, D). Each steam generator contains 5626 thermally treated Inconel 600 tubes, which are nominally 0.688 inch in diameter with a wall thickness of 0.040 inch. Prior to installation, the tubes in rows 1 through 10 were stress relieved to relieve the stresses from bending the tubes. Each steam generator contains eight stainless steel tube support plates and six anti-vibration bars in the U-bend region. The first tube support plate is a partial plate, consisting of only a plate ring with drilled tube holes. The remaining seven plates contain quatrefoil broached tube holes. Plates 1 through 4 are 0.75 inches thick and plates 5 through 8 are 1.12 inches thick.

Seabrook started its eighth refueling outage in May 2002. During the outage, the licensee performed steam generator tube inspections as required by the plant technical specifications. The initial scope of the inspections included two of the four steam generators, SGs A and D. While performing bobbin probe inspections of tubes in steam generator D, the licensee

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detected indications at a number of tube to tube support plate intersections. Subsequent plus-point probe inspection confirmed the indications as axially oriented linear indications, initiating on the OD tube surface. The licensee also performed ultrasonic testing (UT), which further confirmed the findings. At that stage, the licensee classified these indications as potential axial OD cracking.

It was noted that all indications were confined to the intersections of tube and tube support plate, at the location within the thickness of the tube support plates, opposite the broached tube hole lands. As of May 23, 2002, the licensee found that 42 of these intersections in 15 tubes between Row 2 and Row 9 of SG D contain axial OD indications. The indications are located at tube support plates 2 through 6 on the hot-leg side and 3 through 5 on the cold-leg side. The maximum depth of the indications was estimated to be 62 percent through-wall using available techniques. The lengths ranged from 0.3 to 0.75 inch.

The licensee completed inspections of SG A and analyzed all the data collected. No similar degradation was noted in SG A. The inspection scope was expanded to steam generators B and C. Results of these inspections indicated no similar degradation. Based on the data analysis, the licensee has concluded that there was no similar degradation detectable in the other steam generators.

The licensee has pulled two tubes for metallurgical analysis to characterize the apparent degradation and identify the root cause. These activities are ongoing. The pulled tubes have four locations with indications, including the one with the maximum measured depth. All affected tubes were plugged.

### Discussion

Most steam generators placed into service before the early 1980's used tubing fabricated from mill-annealed Alloy 600. This tubing was found to be susceptible to degradation, including stress corrosion cracking. This degradation became extensive and has led to steam generator replacement at more than 30 units to date in the United States. The safety significance is that if tube degradation is not monitored, repaired, and managed appropriately, it may lead to primary-to-secondary leakage and/or a tube rupture.

To reduce susceptibility to stress corrosion cracking, many steam generators placed into service during the 1980s were made of thermally treated Alloy 600 tubing. Operating experience has confirmed the superior corrosion resistance of thermally treated Alloy 600 tubing. Until the recent findings at Seabrook, no known or likely instances of stress corrosion cracking affecting thermally treated Alloy 600 tubing had been reported in the United States.<sup>1 2</sup>

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1. Stress corrosion cracking in thermally treated Alloy 600 tubing has been reported at foreign units.
  2. In a few prior cases indications found in thermally treated Alloy 600 tubing at U.S. plants could not be ruled out as stress corrosion cracks; however, the general industry consensus is that these indications do not represent stress corrosion cracking (i.e., they were inconclusive, fabrication anomalies, or false calls).

Currently, 17 U.S. plants have steam generators with thermally treated Alloy 600 tubing. Another plant has thermally treated Alloy 600 tubes in the first 10 rows of tubes (the remaining tubes are mill-annealed Alloy 600). Steam generators with thermally treated Alloy 600 tubes have had as much as 20 calendar years and over 15 EFPYs of total service time. Seabrook has operated for only about 10 EFPYs. The Seabrook findings underscore the importance of being alert during inspections to evidence of possible stress corrosion cracking, regardless of how long the steam generators have been operating.

If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate project manager in the NRC's Office of Nuclear Reactor Regulation (NRR).

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