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

August 25, 2004

NRC INFORMATION NOTICE 2004-17: LOOSE PART DETECTION AND COMPUTERIZED EDDY CURRENT DATA ANALYSIS IN STEAM GENERATORS

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 is issuing this information notice to inform addressees about recent operating experience with (1) challenges associated with detection of loose parts and related tube damage in steam generators and (2) computerized data screening algorithms used in the evaluation of steam generator tube eddy current data. The NRC anticipates that recipients will review the information for applicability to their facilities and consider taking actions, as appropriate, to avoid similar issues. However, no specific action or written response is required.

Description of Circumstances:

In 2001, at the Shearon Harris nuclear power plant, the licensee, Progress Energy, installed replacement recirculating steam generators containing thermally treated Alloy 690 tubing. The licensee conducted a pre-service eddy current inspection before the steam generators were placed in service and, in 2003, conducted the first inservice eddy current inspection of all active tubes. No tube degradation was detected. In late April 2004, however, the licensee detected minor primary-to-secondary leakage in the C steam generator. In May 2004, following a unit trip for an unrelated reason, the licensee investigated the source of the primary-to-secondary leak. In the days preceding the unit trip, leak rates varied between approximately 20 to 40 liters per day (5 to 10 gallons per day). A secondary side pressure test, an eddy current inspection and a visual foreign object search were performed to identify the source of the leakage. This investigation identified the leaking tube and damage in two adjacent tubes above the cold leg tubesheet. A foreign object search and retrieval (FOSAR) examination identified a loose part in the C steam generator at the damage location. This part was removed during the FOSAR examination. The metallic object was magnetic and approximately 57 mm (2.25 inches) long and had an irregular shape with some sharp edges.

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Bobbin coil eddy current inspection performed during the May 2004 outage resulted in the identification of loose part wear in two of the three affected tubes, neither of which was the leaky tube. Even with the information from the secondary side pressure test, standard bobbin coil analysis techniques did not readily detect the damage in the tube with the primary-to-secondary leak. This indication, however, was apparent when a 3-frequency ("turbo") mix bobbin coil channel was used. Damage was also readily detected with the +Point™ coil. This damage was located about 4 mm (0.16 inch) above the tubesheet and was masked, when using standard bobbin coil analysis techniques, by signals from the nearby expansion transition located at the top of the cold leg tubesheet. The loose part wear that was detected in the other two tubes was located at about 12 mm (0.48 inch) and 20 mm (0.77 inch) above the cold leg tubesheet. A +Point™ coil measurement indicated the depth of loose part wear damage in the three tubes at 77 percent through-wall (the leaking tube), 80 percent through-wall, and 45 percent through-wall. This examination did not detect a loose part since the part had been removed prior to the +Point™ examination. Subsequent in situ pressure testing of the leaking tube and the tube with 80 percent through-wall wear (as measured by +Point™) demonstrated adequate structural integrity and indicated adequate leakage integrity.

After evaluating the 2004 inspection test results, the licensee reviewed the 2003 steam generator bobbin coil eddy current inspection results in the vicinity of the loose part location. Two of the three tubes with loose part wear, including the tube that leaked, had no detectable degradation and no signals indicative of a loose part in the 2003 data. However, a bobbin coil indication, estimated at 37 percent through-wall, was present in the third tube but was missed by both primary (manual) and secondary (computer) analysis. Since this tube was not inspected with a rotating probe in 2003, this depth estimate was obtained using bobbin coil phase angle analysis. This indication was estimated as 66 percent through-wall in 2004, using the same bobbin coil technique analysis.

Investigation into why the computerized data screening (CDS) algorithm used for secondary analysis did not detect this indication in 2003 revealed that some improper values were used in the CDS settings. Automated data analysis was facilitated by dividing the tube lengths into five regions. When the inspection parameters were entered into the CDS system for these regions, a 13-mm (0.5-inch) gap in the tube analysis (from 13 mm [0.5 inch] above the tubesheet to 25 mm [1 inch] above the tubesheet) was inadvertently created above the tubesheet. These input values caused the computerized tube analysis process to skip the portion of the tube containing the 37-percent through-wall bobbin indication in the 2003 analysis. The licensee properly adjusted the CDS settings and re-analyzed the portion skipped during the 2003 analysis. Other than the one wear indication discussed above, the licensee detected no other indications during the reanalysis of the 2003 data.

In addition to the eddy current data review from the 2003 outage, the licensee also reviewed secondary side steam generator FOSAR tapes from that outage. Though evident on the tape, the loose part was not identified in 2003. Comparison of the tapes from the 2003 and 2004 outages at the loose part location indicates that the loose part moved further into the tube bundle after the 2003 outage.

Discussion:

The staff recently issued Information Notice (IN) 2004-10, "Loose Parts In Steam Generators," to discuss the potential for loose part degradation to affect steam generator tube integrity. IN 2004-10 discussed the importance of supplementing the steam generator tube eddy current examinations with secondary side visual inspections. A secondary side visual inspection was performed at Shearon Harris during the 2003 refueling but the presence of the loose part was not detected. If the part had been detected and removed, it would have prevented continued tube wear and the subsequent leak. In addition, the visual detection of the part would have given the licensee an opportunity to detect the associated tube degradation and possibly notice the inappropriate settings for the CDS software.

IN 2004-10 also discussed the possibility that tube damage from loose parts may not always be identified due to the presence of interfering signals. The recent operating experience at Shearon Harris confirms this statement. Interfering signals from the nearby tube expansion transition posed an inspection challenge for the bobbin coil (i.e., the interfering signals masked the flaw signal associated with the leaking tube). Although this particular indication was detected in hindsight analysis by the application of a 3-frequency bobbin coil mix, it is not known if this analysis technique would detect loose part damage in different circumstances. Inspection with the +Point™ coil clearly identified damage in all three affected tubes.

In addition to reinforcing some of the information communicated in IN 2004-10, the recent experience at Shearon Harris shows the importance of properly setting automated data screening parameters. Improper settings caused a small portion of tubing not to receive the secondary analysis of eddy current data. This analysis would have detected loose part wear in one tube during the previous outage inspection before the primary-to-secondary leak occurred. This shows the importance of verifying proper automated data screening parameters used for either primary or secondary analysis. Improper setting of these parameters may not be readily apparent during data analysis. In this particular instance, the eddy current computer screening system completed the site-specific performance demonstration, but the demonstration data did not contain indications in the 0.5-inch length of tube that was not analyzed by the computer. Also, proper setting of the computerized screening system parameters is necessary to ensure the analysis of eddy current data by two independent analysis teams.

Recent steam generator tube leaks at a number of plants with thermally treated Alloy 600 or Alloy 690 tubing (i.e., H.B. Robinson, Palo Verde, Shearon Harris) illustrate the need for thorough inspections and robust inservice inspection programs alert to the potential for tube degradation regardless of tube material, location, or steam generator history. Overall, experience with corrosion-related degradation mechanisms in these plants has been favorable. Nevertheless, this experience indicates that damage by loose parts or damage incurred during manufacture of steam generator tubes can result in primary-to-secondary system leakage. These experiences also show the importance of being alert to all potential tube degradation mechanisms and to aggressively interrogate eddy current inspection signals that may be associated with tube degradation.

This information notice does not require any specific action or written response. 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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2004-14	Use of less than Optimal Bounding Assumptions in Criticality Safety Analysis at Fuel Cycle Facilities	07/19/2004	All licensees authorized to possess a critical mass of special nuclear material.
2004-13	Registration, Use, and Quality Assurance Requirements for NRC-Certified Transportation Packages	06/30/2004	All materials and decommissioning reactor licensees.
2004-12	Spent Fuel Rod Accountability	06/25/2004	All holders of operating licenses for nuclear power reactors, research and test reactors, decommissioned sites storing spent fuel in a pool, and wet spent fuel storage sites.

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