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

January 26, 1990

Information Notice No. 90-04: CRACKING OF THE UPPER SHELL-TO-TRANSITION CONE GIRTH WELDS IN STEAM GENERATORS

Addressees:

All holders of operating licenses or construction permits for Westinghouse-designed and Combustion Engineering-designed nuclear power reactors.

Purpose:

This information notice is intended to alert addressees to continuing problems related to cracking of the upper shell-to-transition cone girth welds in the steam generators (SGs) originally described in Information Notices 82-37, "Cracking in the Upper Shell to Transition Cone Girth Weld of a Steam Generator at an Operating Pressurized Water Reactor" and 85-65, "Crack Growth in Steam Generator Girth Welds." It is expected that recipients will review the in-formation for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

During the 1989 refueling outage at Zion Unit 1, a scheduled inservice inspection (ISI) was performed on the SG "D" upper shell-to-transition cone girth weld. The ultrasonic testing (UT) detected flaw indications that exceeded the allowable standard of Section XI of the ASME Code, Article IWC-3000 (Table IWB-3511-1). Based upon these results, the extent of UT was initially expanded to include the girth weld in SG "C" and further expanded to include SGs "A" and "B." All surface indications were removed by grinding, contoured to established profiles, and accepted by magnetic particle testing (MT) methods. The deepest repair excavation was approximately 0.50 inch in depth by 6.45 inches in length. Boat samples were removed for metallography. The results of the metallography are still under investigation by the licensee.

During the 1987 refueling outage at Indian Point Unit 2, flaw indications were detected during a scheduled ISI of the same upper shell-to-transition cone girth weld. Visual examination of the inside circumference revealed essentially horizontal intermittent linear indications around the entire weld length of SG #22. Subsequently, UT and MT were extended to essentially 100 percent of this girth weld in all SGs. A total of 291 surface indications were reported in the four SGs, with the most severe cracking occurring in SG #22. The linear indications were predominantly in the vicinity of the weld heat-affected zones.

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A repair program was completed that included progressive grinding to established profiles and nondestructive examination. All observed cracks detected by MT were removed; however, the corrosion pits outside the repair areas were not removed before the plant started up after the refueling outage. The repair resulted in a series of grooves that extended around essentially the entire circumference of SG #22 with the maximum depth of excavation approximately 1.07 inch, whereas the wall thickness is typically 3.5 inches. Eight boat samples were removed for metallurgical analysis. On the basis of this analysis, the licensee concluded that the cracking was most likely caused by corrosion fatigue.

During the 1989 refueling outage at Indian Point Unit 2, an MT was initially conducted on one third of the inside circumference of the SG #22 girth weld. Linear indications were detected during this examination. Subsequently, 100 percent of the inside circumferences of the girth welds in all SGs were inspected. Linear indications were also detected in these additional examinations. All observed cracks were ground out again; the maximum depth of grinding to remove the new flaw indications was 0.95 inch. A weld repair of localized areas and a post-weld heat treatment (PWHT) were accomplished on SG #22. An MT performed after the PWHT detected additional surface indications, which were later removed. The licensee concluded that the probable cause of the cracking was corrosion fatigue resulting from the combined action of thermal cycling, oxygen in the auxiliary feedwater, and copper alloys from the feedwater system. The licensee removed the downcomer flow resistance plate to minimize the thermal cycling mechanism. The licensee also committed to shutdown for an MT inspection during a mid-cycle outage to evaluate the effectiveness of corrective actions.

Discussion:

Cracks and linear indications on the inner circumference have been detected in the upper shell-to-transition cone girth weld in 18 SGs in the United States. In addition, linear indications have been found at one foreign plant. The degree of cracking ranges from severe in the case of Indian Point Unit 2 to isolated and dispersed at Zion Unit 1. At the domestic plants flaws have been observed only in Westinghouse Model 44 and Model 51 vertical recirculating U-tube SGs with the feedwater ring design.

The manufacturer, the affected licensees, and the NRC staff are still evaluating the available information to establish the root cause of the cracking problem and its generic implication. A common factor was the general corrosion pitting on the inside surface of the SGs. Metallography found that the surface pits served as crack initiation sites. The current information indicates that the degradation probably results from corrosion-assisted thermal fatigue. Thermal cycling results from relatively cold water that impinges upon the weld region during reactor trips from full power and certain transient operations. At Indian Point Unit 2, copper alloys from the feedwater system and the downcomer flow resistance plate probably were contributing factors.

The flaw indications can be detected with enhanced UT procedures that are performed by experienced nondestructive examination personnel. The upper shell-to-transition cone weld is located at a gross structural discontinuity. The weld is relatively wide and typically has an irregular crown. These inherent geometric features commonly result in innocuous reflectors. In addition, subsurface flaw indications are known to exist near the inside diameter surface of SGs at several plant sites. In order to distinguish innocuous reflectors from cracks, the following processes may be necessary: scanning at a high gain, the use of multiple transducers with optimum angles, careful plotting of reflector locations, and examination by experienced personnel.

The rules of Section XI of the ASME Code require a volumetric examination of one upper shell-to-transition cone weld during each 10-year inspection interval. The required examinations may be limited to one SG or may be distributed among all the SGs. However, if general corrosion pitting of the

SG shell is known to exist, the requirements of Section XI of the ASME Code may not be sufficient to differentiate isolated cracks from inherent geometric conditions. In lieu of volumetric examinations, visual and MT examinations of the interior circumference of the girth weld were used by the licensee of Indian Point Unit 2 to detect the surface-connected flaws.

This information notice requires no 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 NRR project manager.

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