UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

CORE SHROUD INSPECTION AND FLAW EVALUATION

NEBRASKA PUBLIC POWER DISTRICT

COOPER NUCLEAR STATION (CNS)

DOCKET NO. 50-298

1.0 INTRODUCTION

In response to NRC Generic Letter 94-03, the Nebraska Public Power District (the licensee, NPPD) performed an inspection of the core shroud at Cooper Nuclear Station during the 1995 refueling outage. All eight circumferential welds (H1, H2, H3, H4, H5, H6a, H6b, and H7) of the core shroud were ultrasonically examined. Crack-like indications were found at welds H2, H3, H5, and H6a. General Electric Company (GE) performed the inspection and flaw evaluation for the licensee. The inspection results and the flaw evaluation were documented in NPPD's submittal dated December 8, 1995, which was submitted to NRC for review. The results of NPPD's flaw evaluation showed that all eight (8) welds met the screening criteria and that no further detailed flaw evaluations or nondestructive examinations (NDE) were necessary for the current cycle. The staff's evaluation of NPPD's core shroud inspection and flaw evaluations is summarized below.

2.0 EVALUATION

Scope and Results of Inspection

The ultrasonic examination of the core shroud was performed by using GE's OD Tracker Scanner and the Smart 2000 data acquisition system. All accessible areas of the eight (8) circumferential welds were examined. The search units on the scanner consisted of three transducers, 45° shear wave, 60° refracted longitudinal wave and OD creeping wave. The ultrasonic examination was performed in accordance with the guidelines in UT-CNS-503V4, "Procedure for Automated Ultrasonic Examination of Shroud Assembly Welds," Revision 0. Due to the presence of guide rods, core spray downcomers, jet pump sensing lines and lifting lugs, some areas of the welds could not be inspected, and the coverage of some welds was limited due to the unfavorable weld geometry which restricted scanning. Because of these limitations, the reported weld coverage for the eight circumferential welds varied from 66.9% (H1 and H2 welds) to 79.9% (H3 weld) of the weld. Even with these limitations, the staff has determined that the licensee's inspection scope of the core shroud at CNS is acceptable because it meets the staff position and Boiling Water Reactor Vessel and Internals Project (BWRVIP) guidelines for the baseline inspection of the core shroud inspections.

ENCLOSURE

The licensee reported that IGSCC cracking was found at welds H1, H3, H5, and H6a. Eight circumferential flaws were detected at welds H3 and H1 and the combined flaw length was reported to be about 14.9% and 4.4% of the examined weld length, respectively. These flaws were initiated from the inside diameter (ID) surface of the core shroud. The deepest flaw was reported at H3 weld with a through-wall depth about 48.7%. The nominal shroud wall thickness was reported to be about 1.5 inches. Minor cracking (one short circumferential flaw) was found at the outside diameter (OD) surface of welds H5 and H6a.

Flaw Evaluations

In the flaw evaluation, GE performed both the limit load and linear elastic fracture mechanics (LEFM) analysis. All flaws and the uninspected areas were conservatively assumed to be cracked through-wall. The limit load analysis was performed for each of the eight circumferential core shroud welds in accordance with IWB-3640 and Appendix C of ASME Code, Section XI. Due to the concern of potential embrittlement resulting from cumulated radiation effects, a LEFM evaluation was performed for welds H4, H5, and H6a. Because welds H1, H2, H3, H6b, and H7 are located outside the vessel beltline region, the fluence levels at these locations are expected to be an order of magnitude lower, and, therefore, the potential embrittlement due to radiation effect will not be significant. The LEFM evaluation was performed by using a K_{Ic} of approximately 150 ksi $(in)^{1/2}$. This value was developed from J-R curves of irradiated stainless steel samples taken from a core shroud of an oversea plant with a fluence level of $8x10^{20}$ n/cm^2 which is higher than that of Cooper plant. In the limit load and LEFM analyses, appropriate Code safety factors were applied to the stresses and K_{Ic}. The faulted condition was determined to be the limiting condition for both limit load and LEFM evaluations.

In the limit load analysis, the allowable through-wall circumferential flaw length was calculated for each of the eight core shroud welds which varied from 323 inches (H7) to 423 inches (H1). The allowable through-wall circumferential flaw length for welds H4, H5, and H6a based on LEFM analysis was determined to be 235 inches, 168 inches, and 145 inches, respectively.

GE calculated the limit load effective flaw length for each flaw and the uninspected areas. The effective flaw length was calculated by considering the proximity rules and including the crack growth for a period of 18 months (12000 hours). The crack growth was evaluated by using a bounding crack growth rate of $5x10^{-5}$ inch/hour. In the LEFM analysis, the equivalent flaw length was similarly calculated with the proximity rules considering the potential interaction of crack tips.

The screening criteria were established for both the limit load and LEFM analysis. The limit load screening criteria require that the cumulated effective flaw length in any 90-degree sector of a weld should not exceed one-fourth of the allowable flaw length of the evaluated weld. When considering LEFM evaluation for welds H4, H5 and H6a, the screening criteria

require that each equivalent flaw length in a weld should not exceed the allowable flaw length. The results of GE's flaw evaluations showed that all the core shroud circumferential welds met the respective limit load and/or LEFM screening criteria. Therefore, the licensee concluded that no further flaw evaluation and NDE examination were necessary for the current cycle.

The staff has reviewed GE's flaw evaluations, and has determined that the methodologies and screening criteria used by GE are acceptable because they meet the BWRVIP guidelines and are consistent with those used in the evaluation of the Brunswick Unit 1 core shroud where we have accepted the screening criteria.

3.0 CONCLUSION

Based on the staff's review of the licensee's submittal, the staff concludes that the licensee's core shroud inspection and flaw evaluations are acceptable. The staff also concludes that the Cooper Nuclear station can be safely operated for at least one 18-month (12000 hours) fuel cycle without implementing a repair of the core shroud because the licensee's flaw evaluations have shown that the structural integrity of the core shroud will be maintained during the operation of the current fuel cycle.

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Date: June 27, 1996