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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
NINE MILE POINT NUCLEAR STATION, UNIT 2
FEEDWATER NOZZLE-TO-SAFE END WELD BUTTER INDICATION
NIAGARA MOHAWK POWER CORPORATION
OPERATING LICENSE NO. NPF-69
DOCKET NO. 50-410

1.0 INTRODUCTION

By letters dated June 17 and 23, 1998, Niagara Mohawk Power Corporation (NMPC or licensee) submitted, for NRC review, its evaluation of a flaw indication on feedwater (inlet nozzle N4D) safe end-to-nozzle weld at Nine Mile Point Nuclear Station, Unit 2 (NMP2). The indication, which exceeded the allowable flaw size specified in paragraph IWB-3514.3 of Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), was found during the current refueling outage (RFO-6) during the performance of ultrasonic (UT) examinations for category D welds, as required by Generic Letter (GL) 88-01, "NRC Position on Intergranular Stress Corrosion Cracking (IGSCC) in BWR Austenitic Stainless Steel Piping." The indication was located in the Alloy 182 (Inconel) weld butter on the safe end side of the weld and was reported to have a maximum depth of 0.29 inch and a circumferential length of 5.3 inches.

2.0 EVALUATION

2.1 Licensee

NMPC performed the flaw evaluation according to the procedures and acceptance criteria for austenitic piping in paragraph IWB-3640 of the ASME Code. NMPC evaluated and determined that the faulted condition was limiting, and used this loading condition to determine the allowable flaw sizes. Since the flaw indication is in the vicinity of the fusion line between the nozzle safe end and the weld, NMPC performed two separate analyses--one for the flaw located in the carbon steel nozzle safe end, and the other for the flaw located in the Alloy 182 weld butter. For the flaw in the nozzle safe end, the methodology used is Appendix H of Section XI of the ASME Code, which based on the analysis, gives an allowable flaw size of 75%T (where T is the pipe wall thickness). For the flaw in Alloy 182 weld butter, the methodology used is Appendix C of the ASME Code, for which the analysis gives an allowable flaw size of 60%T. Further, based on the characterized flaw dimensions (0.29 inch deep and 5.3 inches long) and the crack growth rate (CGR) of 2.2×10^{-5} inch/hour for a cycle of 16,000 hours, the licensee reported that the predicted end-of-cycle flaw size is 53.3%T, which is less than the limiting allowable flaw size of 60%T. Hence, the licensee concluded that the flaw meets the ASME criteria for continued operation without repairs for the next operating cycle.

2.2 NRC Staff

2.2.1 Allowable Flaw Sizes Determination

The NRC staff reviewed the licensee's allowable flaw sizes determination, and concludes that the licensee has adequately considered all technical issues in its evaluation. The NRC staff agrees with the licensee that: (1) the submittal covered all possible cases by evaluating a flaw in the nozzle safe end and a flaw in the Alloy 182 weld butter and (2) the evaluation methodologies--Appendix H for the flaw in the nozzle safe end and Appendix C for the flaw in the Alloy 182 weld--are in accordance with Section XI of the ASME Code. The NRC staff performed an independent verification of the licensee's calculations and agrees with the licensee that (3) the faulted condition was limiting and (4) the allowable flaw size of 60%T for the flaw in the Alloy 182 weld is limiting.

2.2.2 Crack Growth Rate

The licensee used a CGR of 2.2 x 10^{-5} inch/hour to calculate the final flaw size at the end of the operating cycle (16000 hours). It appears that the licensee's CGR can be supported by the relevant test data for application to the NMP-2 conditions. Based on a review of the licensee's submittal, the NRC staff has determined that the licensee's use of a crack growth rate of 2.2 x 10^{-5} inch/hour for crack growth calculation is acceptable because the crack growth at the flaw location is expected to be slow. The NRC staff's determination is based on the following considerations:

(1) The oxygen content in the feedwater system at the flaw location is reported to be normally kept in the range of 20 to 50 ppb, and based on the submitted water chemistry data sheets typical of the last fuel cycle (see Enclosure 2 of licensee's letter dated June 23, 1998), the average conductivity was maintained at less than 0.06 umho/cm. The crack growth in this environment of low oxygen content and low conductivity is expected to be small.

(2) In the licensee's crack growth calculation, the maximum through-wall stress intensity factor (K) shown in Figure 3-2 (see Enclosure 1 of licensee's letter dated June 23, 1998) as calculated from the sustained loading and residual stresses is less than 17 ksi.in$^{1/2}$. The NRC staff finds that most of the crack growth data presented in the licensee's submittal were tested at a stress intensity factor ranging from 25 to 39 ksi.in$^{1/2}$. These data tend to support the use of the bounding crack growth rate of 2.2 x 10^{-5} inch/hour for crack growth calculation. Since the crack growth rate decreases with decreasing stress intensity factor, the crack growth rate at a stress intensity factor of 17 ksi.in$^{1/2}$ is expected to be much lower than that at 25 ksi.in$^{1/2}$ and above. Therefore, based on the consideration of low stress intensity factor and good water chemistry at the flawed location, the use of the bounding crack growth rate of 2.2 x 10^{-5} inch/hour for crack growth calculation is determined to be adequate and conservative.

(3) The indication in the feedwater nozzle to safe end weld may be a fabrication related defect because the subject indication was reported to be present in the same general location in the previous two examinations performed in 1990 and 1995. Furthermore, the size of the recorded indication in all three examinations appears to be similar, indicating there is no significant growth. However, for the purpose of flaw evaluation, the subject indication is conservatively assumed to be an active IGSCC flaw.

The NRC staff notes that the application of a bounding crack growth rate of 2.2 x 10^{-5} inch/hour for IGSCC in Alloy 182 requires NRC review and approval on a case-by-case basis because various parameters such as the residual stress profile, water chemistry, weld joint geometry, and sustained loading will affect its acceptability.

2.2.3 Potential Effects of Water Hammer

The licensee considered the transients related to water hammer analytically, and included their effect in the applied forces and moments for various loads listed in the submittal. In response to NRC staff's comment on the potential effects of a water hammer, the licensee reviewed a database documenting all unusual configurations or unexpected system responses in the past, and found no indication of water hammer transients in the plant's history. Operationally, the licensee has taken, and will continue to take, actions and procedural steps to reduce the risk of water hammer occurrences as documented in Enclosure 6 of the licensee's letter dated June 23, 1998.

3.0 CONCLUSIONS

The NRC staff has reviewed the licensee's submittals. The NRC staff has determined that the flaw evaluation is performed in accordance with the procedures and criteria in the ASME Code and the assumed crack growth rate is adequate for this application. Since the predicted flaw size (53.3%T) at the end of the next cycle is less than the ASME Code allowable flaw size (60%T), the NRC staff accepts the licensee's flaw evaluation. Accordingly, the NRC staff concludes that the feedwater nozzle weld with the flaw is acceptable for continued operation without repairs for the next operating cycle of 16000 hours.

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