GE Nuclear Energy

DRF A00-03681

SAFETY EVALUATION

QUAD CITIES NUCLEAR POWER STATION

UNIT 2

REACTOR PRESSURE VESSEL

CLADDING INDICATIONS

April 1990

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JEL-SA01(QC2CRK-1)

I. INTRODUCTION

The Quad Cities Unit 2 (QC2) reactor pressure vessel (RPV) is designed to serve as a high integrity structure to house the reactor core. The RPV is designed in accordance with the rules of ASME Section III Class A with a design pressure of 1250 psig. The RPV shell and closure head plate material is SA-302 Grade B low alloy steel and the interior surfaces are clad with weld deposited type ER308 electrode. The reactor vessel head is flanged and bolted to the vessel and sealed with two concentric silver-plated, stainless steel, self-energizing O-rings. During operation, the head/dome is subject to a dry steam environment. During routine handling of the head during refueling following cycle 10, linear indications were discovered in the RPV head interior cladding material. The change being addressed in this safety evaluation is operation of Quad Cities Unit 2 with linear indications in the RPV head cladding and associated base metal heat affected zone (HAZ).

II. DISCUSSION OF LINEAR INDICATIONS

Ultrasonic testing (UT) and liquid penetrant (LP) examination of the RPV head cladding has revealed linear indications located primarily in a "belt" around the inside surface of the head. In general, these indications coincide with the "backclad" region.

The RPV head construction sequence was to first manufacture a machine clad hemisphere and a machine clad flange and to then join the hemisphere to the flange with a full penetration butt weld. Before the butt weld was made, the cladding was stripped back from the weld prep. After completion of the butt weld, "back cladding" was then applied to complete the cladding of the inside surface of the head. As indicated both by Non Conformance Reports (NCRs) included in the original records packages and the visual appearance of the backclad region, considerable repair welding was required in this area due to plate misalignment. Some regions of the clad, for example in the backclad "belt", were found to be low in ferrite, thereby making this repair susceptible to stress corrosion cracking. Based on metallurgical samples removed from the Quad Cities 2 RPV head, the cracking is concluded to be interdendritic stress corrosion initiating in the stainless steel cladding and propagating into the underlying alloy steel heat affected zone.

Generally, Type 308 weld cladding is resistant to stress corrosion cracking in the BWR environment provided sufficient ferrite is present in the weld deposit. Ferrite content of austenitic weld deposits is set primarily by the chemical composition. However, fabrication steps, particularly post weld heat treatment, can tend to reduce ferrite content. If the ferrite content falls below approximately 3%, Type 308 can potentially become susceptible to stress corrosion cracking. This can be particularly significant in weld regions and especially weld repair regions because of the induced weld residual stresses. Given the combination of relatively high carbon content, post weld heat treatment, and low ferrite such cladding may possess a potential for stress corrosion crack initiation and growth.

As required by the ASME Code Section III, the cladding was not used to reduce the stresses in the RPV head. In addition, the thickness of the base metal in the RPV head is considerably larger than required by the ASME Code. The depth of the cracking is well known from physical examination (LP and grinding out defects) and UT, so ASME Section XI fracture mechanics calculations have been used to predict crack growth over time. This analysis has shown that the cracks will be substantially less than critical size during the next operating cycle and, as a result, the RPV Code structural margin will not be compromised. Examination of the RPV head at the next refueling outage will allow confirmation of suitability for subsequent cycles.

III. SAFETY EVALUATION

For this safety evaluation, the criteria of 10CFR50.59 are applied to the change being considered (i.e., operation with linear indications in the RPV head). Conclusions are summarized as appropriate to the following safety considerations in accordance with 10CFR50.59.

1) Will the change increase the probability of occurrence of an accident previously evaluated in the SAR?

The probability of occurrence of an accident previously evaluated in the SAR is not increased. The probability of occurrence of an accident is based on the confidence established through the ASME design rules for reactor pressure vessels. Using those rules, the minimum wall thickness is calculated in accordance with accepted design rules. The ASME Code Section XI provides accepted alternative design rules to deal with known flaws (Sections IWB-3500 and IWB-3600). Using these accepted design rules and the demonstrated sensitivity of ultrasonic testing (UT) on known indications which were sampled and ground/polished away, the ASME fracture mechanics calculations predict, with considerable margin, that the worst case defects discovered to date will not grow to unacceptable size within the next operating cycle. That is, the calculations justify, with considerable margin, operation until the next refueling outage with no increase in the probability of occurrence of an accident on the basis of limiting ASME Section XI calculations.

2) Will the change increase the consequences of an accident previously evaluated in the SAR?

This change will not increase the consequences of an accident previously evaluated in the SAR. With acceptance of the indications based on use of accepted ASME Section XI rules (see item 1 above), the RPV head is shown to be in compliance with all applicable criteria for at least one additional operating cycle. This change does not affect the hypothetical limiting recirculation or steam line breaks evaluated in the SAR.

3) Will the change increase the probability of occurrence of a malfunction of equipment evaluated in the SAR?

This change will not increase the probability of occurrence of a malfunction of equipment evaluated in the SAR. There is no change in either the additional single failures or operator errors considered in conjunction with the accidents presented in the SAR.

4) Will the change increase the consequences of a malfunction of equipment previously evaluated in the SAR?

This change will not increase the consequences of a malfunction of equipment previously evaluated in the SAR. This change does not affect any equipment used to mitigate an accident evaluated in the SAR.

5) Will the change create the possibility of an accident or malfunction of a different type than previously evaluated in the SAR?

With RPV head integrity still judged adequate by ASME Section XI acceptance criteria, the change does not create the possibility of an accident or malfunction of a different type than previously evaluated in the SAR.

6) Will the change reduce the margin of safety as defined in the basis for any Technical Specification?

With RPV head integrity judged adequate by ASME Section XI, the change does not reduce the margin of safety as defined in the basis for any Technical Specification.

IV. CONCLUSION

The change has been investigated by metallurgical and non-destructive examination of the RPV head. Structural integrity has been judged acceptable on the basis of ASME Section XI acceptance criteria which have shown the head to be acceptable for at least one additional operating cycle. This change does not increase either the probability or consequences of an accident evaluated in the SAR. No unreviewed safety question has been identified and no Technical Specification changes are required.