

January 21, 2003

MEMORANDUM TO: Anthony J. Mendiola, Chief
Project Directorate Section III-2
Division of Licensing Project Management

FROM: Terence L. Chan, Chief **/RA/**
Piping Integrity and NDE Section
Materials and Chemical Engineering Branch
Division of Engineering

SUBJECT: SAFETY EVALUATION OF A PARTIALLY COMPLETED WELD
OVERLAY REPAIR OF THE 02BS-F4 WELD IN THE REACTOR
RECIRCULATION SYSTEM PIPING AT QUAD CITIES NUCLEAR
POWER STATION, UNIT 1 (TAC NO.: MB6698)

By letters dated November 13 and November 25, 2002, the Exelon Generation Company (the licensee) submitted for NRC review its evaluation of a partially completed weld overlay repair of a circumferential crack discovered in the 02BS-F4 weld in the reactor recirculation system piping at Quad Cities Nuclear Power Station, Unit 1. The licensee's analytical flaw evaluation used a reduced crack growth rate corresponding to operation with hydrogen water chemistry and a noble metal chemical application. The results of this evaluation indicated that the unit can operate for one additional fuel cycle without further repair of the subject weld.

The Materials and Chemical Engineering Branch has completed its review of the licensee's flaw evaluation and finds that it meets the rules in Section XI of the American Society of Mechanical Engineers (ASME) Code. Since the calculated safety factors associated with the detected cracks under normal, upset, emergency, and faulted conditions are greater than those specified in the ASME Code, the staff concludes that Quad Cities Nuclear Power Station, Unit 1, can operate for one additional fuel cycle (Cycle 18) with the partially completed weld overlay repair of the subject weld. This completes our effort for TAC No. MB6698.

Docket No.: 50-254

Attachment: As stated

CONTACT: S. Sheng, EMCB/DE
415-2708

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
QUAD CITIES NUCLEAR POWER STATION, UNIT 1
A PARTIALLY COMPLETED WELD OVERLAY REPAIR OF A CIRCUMFERENTIAL CRACK
IN THE 02BS-F4 WELD IN THE RECIRCULATION SYSTEM PIPING
EXELON GENERATION COMPANY
DOCKET NO. 50-254

1.0 INTRODUCTION

By letters dated November 13 and November 25, 2002, the Exelon Generation Company (the licensee) submitted for NRC review its evaluation of a partially completed weld overlay repair of a circumferential flaw discovered in the 02BS-F4 weld in the reactor recirculation system piping at Quad Cities Nuclear Power Station, Unit 1 (Quad Cities 1). The pipe is 28 inches in diameter with a nominal wall thickness of 1.24 inches, and the pipe material is austenitic stainless steel. The weld was fabricated using the shielded metal arc weld (SMAW) process.

During the fall 2000 Unit 1 refueling outage (Q1R16), the weld overlay repair of the flaw in the 02BS-F4 weld had only been partially repaired due to high dose rates. As a result, the licensee requested approval for continued operation of the unit with the partially completed repair based on a flaw evaluation. A safety evaluation (SE) dated November 7, 2000, approved this application for one fuel cycle until Fall 2002. However, instead of completing the weld overlay repair in the 2002 outage, the licensee, again due to anticipated high dose rates and concerns with performing a chemical decontamination of the reactor recirculation system, proposed to perform another flaw evaluation using improved Ultrasonic Test (UT) techniques in detecting flaws in the weld overlay and outer 50% of the original base metal. The licensee intended to demonstrate through this flaw evaluation, using a revised initial flaw size and a crack growth rate for plants operating with hydrogen water chemistry (HWC) and noble metal chemical addition (NMCA), that the unit can operate for one additional fuel cycle after the 2002 outage without completing the repair of the subject weld.

2.0 REGULATORY EVALUATION

Generic Letter 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping (Generic Letter 88-01)," specified that, for cracked weldments with inadequate or no repair, NRC approval of flaw evaluations and/or repairs in accordance with IWB-3640, "Evaluation Procedures and Acceptance Criteria for Austenitic Piping," and IWA-4130, "Repair Program," is required before resumption of operation. In this evaluation, only IWB-3640 applies. IWB-3640 further requires that the flaw shall be evaluated by analytical procedures such as those described in Appendix C. Complete information on IWB-3640, IWA-4130, and Appendix C can be found in Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code). Appendix C, which also contains the acceptance criteria, is the underlying basis for the licensee's limit load analysis methodology for this flaw evaluation.

3.0 TECHNICAL EVALUATION

3.1 Licensee

The licensee's flaw evaluation consists of two parts: the calculation of the allowable flaw depth and the calculation of the operation time corresponding to this allowable flaw depth. In the first part, the licensee employed the methodology of IWB-3640 and Appendix C. The loading that was considered included the pipe pressure of 1000 psi, weight, three types of thermal loading, and seismic loading (OBE and DBE). The upset condition was determined to be limiting, therefore, only loading pertinent to the upset condition (pressure, weight, the bounding thermal, and OBE) and a safety factor of 2.77 were used. In addition, the Z factor for SMAW welds was used because, except for the root pass, the remaining weld was completed using the SMAW. The licensee calculated the allowable flaw depths according to (1) the limit of 75% of the pipe wall thickness, to which the ASME Section XI allows the flaw to grow, and (2) the Appendix C limit from the limit load analysis. The latter calculation is limiting and gives an allowable flaw depth of 1.035 inches considering a 0.22 inch thickness for the weld overlay.

In the second part of the flaw evaluation regarding the calculation of the predicted flaw depth at the end of the requested period, the licensee assumed a postulated initial crack depth of 50% of the pipe wall, based on Electric Power Research Institute Performance Demonstration Initiative (EPRI/PDI) determination that the PDI procedure could effectively examine the 02BS-F4 weld overlay and the outer 50% of the original piping material. In addition, the plant has been operated with HWC since 1990 and NMCA since 1999, therefore, the licensee used a crack growth rate of 1.1×10^{-5} in/hour. This results in 37,740 hours of operation for the flaw to grow from the initial flaw depth based on the improved UT techniques to the allowable flaw depth of 1.035 inches. Since the calculated hours of operation to reach the allowable flaw depth (37,740 hours) are greater than the hours of operation for one fuel cycle (17,532 hours), the licensee concluded that the weld meets the Code requirements regarding flaw evaluation and the plant can operate with the partially completed weld overlay until the next outage.

3.2 NRC Staff

The licensee's allowable flaw calculation for the flaw in weld 02BS-F4 in the recirculation piping is in accordance with IWB-3640 and Appendix C of Section XI of the ASME Code. The pipe loading remains the same as that in the October 25, 2000 submittal, therefore, the applied membrane stress (P_m) of 5.58 ksi, bending stress (P_b) of 0.368 ksi, and thermal expansion stress of 3.065 ksi, which had been verified by the staff in the November 7, 2000 SE, still apply to the current evaluation. Likewise, the stress intensity (S_m) of 16.9 ksi for the 304 stainless steel at 550°F also applies to the current evaluation. However, two areas in the licensee's present methodology are different from the 2000 approach. First, the assumed flaw configuration now is complete circumferential instead of partially circumferential. Second, the initial flaw depth is assumed to be 50% of the pipe depth instead of 75%. The first change is conservative and is therefore, acceptable. The second change is based on the UT capability that the PDI procedure effectively examined the 02BS-F4 weld overlay and the outer 50% of the original piping material.

The licensee's UT inspection results confirmed that the weld overlay and outer 50% of the pipe base metal is free from IGSCC defects. The staff has reviewed the technical justification for this finding and determined that the UT inspection performed on weld 02BS-F4 is capable of

detecting flaws in the outer 50% of the original base metal of the piping based on the following considerations:

- (1) The UT examination performed on weld 02BS-F4 used a PDI qualified technique/procedure (UT-8). The PDI UT-8 procedure is designed for examination of IGSCC on weld overlay repaired welds. The subject examination was performed by PDI qualified personnel.
- (2) The UT-8 procedure has a demonstrated capability of detecting flaws located in a maximum depth of 1.42 inches from the outer diameter (OD) surface of the weld overlay. The weld overlay (0.22 inch) and 50% of the pipe wall thickness (0.62 inch) at weld 02BS-F4 has a total thickness of 0.84 inch which is well within the UT-8 demonstrated inspection capability in depth. Therefore, there is reasonable assurance that any flaw inside the outer 50% of the pipe wall thickness at weld 02BS-F4 will be detected using the PDI UT-8 procedure.
- (3) Weld 02BS-F4 is a 28-inch pipe to pipe weld in the reactor recirculation piping system. This weld has no geometrical limitation for the performance of a complete UT examination. Furthermore, the partially completed weld overlay has a sufficient width to allow the examination of the entire required volume using a 60 degree angle beam probe.

By comparing the allowable flaw size from the Appendix C limit load analysis to the additional Section XI limit of 75% of the wall thickness, the staff concludes that the allowable flaw size based on Appendix C is limiting and the predicted flaw depth at the next outage should not exceed this limit. For the IGSCC growth, the HWC since 1990 and the NMCA since 1999 provide the basis for using a growth rate of that approved in the SE for BWRVIP-14, which was the growth rate used in the licensee's flaw evaluation.

In summary, the calculated hours of operation to reach the allowable flaw depth (37,740 hours) are greater than the hours of operation for one fuel cycle (17,532 hours). Not accounted for in this calculation is the additional conservatism provided by the postulation of a complete circumferential flaw and the use of IWB-3640 and Appendix C for verified flaws to postulated flaws, which normally are associated with Code safety factors less than 2.77. Based on the above, the staff agrees with the licensee's conclusion that the weld meets the Code requirements on flaw evaluation and the plant can operate with the partially completed weld overlay until the next outage.

4.0 CONCLUSIONS

The NRC staff concludes that the licensee's flaw evaluation meets the rules in Section XI of the ASME Code. Since the calculated hours of operation to reach the allowable flaw depth (37,740 hours) are greater than the hours of operation for one fuel cycle (17,532 hours), the staff agrees with the licensee's conclusion that Quad Cities, Unit 1 can operate with the partially completed weld overlay until the next outage.