

January 24, 2003

Mr. John L. Skolds, President
Exelon Nuclear
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: QUAD CITIES NUCLEAR POWER STATION, UNIT 1 - APPROVAL OF PIPE
FLAW EVALUATION (TAC NO. MB6698)

Dear Mr. Skolds:

By letter dated November 13, 2002, as supplemented November 25, 2002, Exelon Generation Company, LLC (EGC), the licensee, submitted a request for NRC review and approval of a pipe flaw evaluation for a partially completed weld overlay repair of a circumferential crack in weld No. 02BS-F4 in the reactor recirculation system piping at Quad Cities Nuclear Power Station, Unit 1. The partial weld overlay repair was done during the Fall 2001 refueling outage (Q1R16) and subsequently reinspected during the Fall 2002 refueling outage (Q1R17). The flaw did not meet the acceptance standards of American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (Code) Section XI, 1989 Edition, for continued operation without evaluation. In accordance with NRC Generic Letter 88-01, "NRC Position on IGSCC [intergranular stress corrosion cracking] in BWR [boiling water reactor] Austenitic Stainless Steel Piping," identified cracks that do not meet the criteria given in ASME Code Section XI for continued operation without evaluation require NRC approval of the flaw evaluation and/or repairs in accordance with subarticles IWB 3640 and IWA 4130 before resumption of operation.

Your evaluation was submitted to the NRC for approval prior to resuming operation in accordance with GL 88-01. Your 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.

Following its review of your flaw evaluation, the staff finds that it meets the rules in Section XI of the 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.

Based on your letter dated November 13, 2002, and additional information provided in a conference call on November 22, 2002, the staff provided verbal approval on November 22, 2002, of your pipe flaw evaluation in accordance with GL 88-01. Subsequently, you provided

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supplemental and clarifying information supporting your request for approval of pipe flaw evaluation by letter dated November 25, 2002. The enclosed safety evaluation provides the details of the staff's conclusions on this issue.

If you have any questions regarding this matter, please call me at (301) 415-2296.

Sincerely,

/RA/

Carl F. Lyon, Project Manager, Section 2
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No.: 50-254

Enclosure: Safety Evaluation

cc w/encl: See next page

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*SE dated 01/21/03

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

1.0 INTRODUCTION

By letters dated November 13 and November 25, 2002, Exelon Generation Company, LLC (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. In a safety evaluation (SE) dated November 7, 2000, the NRC 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 percent 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 could operate for one additional fuel cycle after the 2002 outage without completing the repair of the subject weld.

2.0 REGULATORY EVALUATION

NRC Generic Letter 88-01, "NRC Position on IGSCC [intergranular stress corrosion cracking] in BWR [boiling water reactor] Austenitic Stainless Steel Piping," 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: (1) the calculation of the allowable flaw depth, and (2) 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 [operating basis earthquake] and DBE [design basis earthquake]). 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 percent 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 percent 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 percent 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 licensee's 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 its 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 flaw configuration is now assumed to be complete circumferential instead of partial circumferential. Second, the initial flaw depth is assumed to be 50 percent of the pipe depth instead of 75 percent. The first change is conservative and is 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 percent of the original piping material.

The licensee's UT inspection results confirmed that the weld overlay and outer 50 percent of the pipe base metal are 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 percent 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 percent 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 percent 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 percent 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). This calculation does not account for 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 CONCLUSION

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.

Principal Contributor: S. Sheng

Date: January 24, 2003