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

February 28, 2014

Mr. Michael J. Pacilio
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer (CNO)
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: QUAD CITIES NUCLEAR POWER STATION, UNIT 2 - SAFETY EVALUATION REGARDING RELIEF REQUEST I5R-11 FOR RELIEF FOR PENETRATION N-11B REPAIR (TAC NO. MF1462)

Dear Mr. Pacilio:

By letter dated February 13, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13044A662), as supplemented by letters dated October 28, 2013 (ADAMS Accession No. ML13302A597), and December 20, 2013 (ADAMS Accession No. ML13358A401), pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(a)(3)(i), Exelon Generation Company, LLC (EGC, the licensee), submitted to the U.S. Nuclear Regulatory Commission (NRC or Commission) Relief Request (RR) I5R-11 (ADAMS Accession No. ML13044A663), requesting permanent relief for an alternative repair of the N-11B reactor pressure vessel (RPV) instrument nozzle penetration. A revision to RR 15R-11 was submitted in the licensee's letter dated December 20, 2013. The alternative repair was implemented during the fourth 10-year inservice inspection interval at the Quad Cities Nuclear Power Station (QCNPS), Unit 2, and approved until the next refueling outage under RR I4R-19 (ADAMS Accession No. ML13016A454).

On the basis of a review and evaluation of the licensee's submittals, the NRC staff concludes that the proposed alternatives related to the repair of QCNPS, Unit 2, RPV penetration N-11B provides an acceptable level of quality and safety for two additional operating cycles beyond the spring 2014 refueling outage (i.e., through QCNPS, Unit 2, Cycle 24), scheduled to end during March 2018. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternative described in RR 15R-11 until the end of QCNPS, Unit 2, Cycle 24, or March 31, 2018, whichever comes first.

All other American Society of Mechanical Engineers and Boiler and Pressure Vessel Code, Section XI, requirements for which relief was not specifically requested and authorized herein by the NRC staff remain applicable, including the third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions on this action, please contact the NRC Project Manager, Brenda Mozafari, at (301) 415-2020.

Sincerely,

Travis L. Tate, Chief
Plant Licensing III-2 and
Planning and Analysis Branch
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-254

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST I5R-11 FOR RELIEF FOR PENETRATION N-11B REPAIR

EXELON GENERATION COMPANY, LLC

QUAD CITIES NUCLEAR POWER STATION, UNIT 2

DOCKET NO. 50-265

1.0 INTRODUCTION

By letter dated February 13, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13044A662), as supplemented by letters dated October 28, 2013 (ADAMS Accession No. ML13302A597), and December 20, 2013 (ADAMS Accession No. ML13358A401) pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(a)(3)(i), Exelon Generation Company, LLC (EGC, the licensee), submitted to the U.S. Nuclear Regulatory Commission (NRC or Commission) Relief Request (RR) I5R-11 (ADAMS Accession No. ML13044A663), requesting permanent relief for an alternative repair of the N-11B reactor pressure vessel (RPV) instrument nozzle penetration. A revision to RR 15R-11 was submitted in the licensee's letter dated December 20, 2013. The alternative repair was implemented during the fourth 10-year Inservice Inspection (ISI) Interval at the Quad Cities Nuclear Power Station (QCNPS), Unit 2, and approved until the next refueling outage scheduled to begin in April 2014, under RR I4R-19 approved by NRC safety evaluation (SE) dated January 30, 2013 (ADAMS Accession No. ML13016A454).

During the QCNPS, Unit 2, spring 2012 refueling outage (Q2R21), the licensee discovered signs of leakage through visual examinations consisting of water exiting the RPV from the N-11B RPV penetration. This penetration is part of the reference leg of the RPV water level instrument system. This observation necessitated the repair of this penetration during refueling outage Q2R21. The licensee submitted RR I4R-19 to implement an alternative repair that created a new pressure boundary on the outer diameter of the RPV. Under RR I4R-19, the licensee repaired the leaking penetration without removing, sizing, or repairing the postulated flawed volume of the penetration. The NRC verbally approved RR I4R-19 on April 15, 2012 (ADAMS Accession No. ML12107A472), and provided a formal SE by letter dated January 30, 2013. In support of RR I4R-19, the licensee provided a fracture mechanics analysis of a postulated flaw in the original attachment weld of the penetration demonstrating that the flaw would not grow to unacceptable size for one operating cycle. To support the current relief request, the licensee provided a revised fracture mechanics analysis demonstrating that a flaw in the original attachment weld would not grow to unacceptable size for 9 years.

Approval of this request would allow the previously implemented repair of the RPV penetration to remain in service until March 2018, or the end of QCNPS, Unit 2, Cycle 24, without performing a nondestructive examination (NDE) to determine the size, orientation, or exact location of the flaw in the penetration. Approval of this request also exempts the licensee from the requirement to remove or reduce the size of the flaw.

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(g)(4), the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Class 1, 2, and 3, components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements set forth in the ASME Code, Section XI, to the extent practical within the limitations of design, geometry, and materials of construction, of the components. The regulations require that ISI components and system pressure tests conducted during the 10-year intervals be in compliance with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b), 12 months prior to the start of the 120-month interval. The regulations in 10 CFR 50.55a(g)(6)(i) state that the Commission may grant such relief and may impose such alternative requirements as it determines applicable is authorized by law and will not endanger life or property or the common defense and security and is otherwise in the public interest, given due consideration of the burden upon the licensee.

The regulations in 10 CFR 50.55a(a)(3) state that alternatives to the requirements of paragraph (g) of 10 CFR 50.55a may be used when authorized by the NRC, if (i) the proposed alternatives would provide an acceptable level of quality and safety or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The regulations in 10 CFR 50.55a(g)(5)(iii) state that if the licensee has determined that conformance with certain code requirements is impractical for its facility, the licensee shall notify the Commission and submit, as specified in 10 CFR 50.4, information to support the determinations.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Relief Request

3.1.1 ASME Code Components Affected

Code Class:	1
Component Number:	RPV Penetration N-11B
Examination Category:	B-P
Item Number:	B15.10
Description:	RPV Water Level Instrument Penetration – 2" Nominal Pipe Size

3.1.2 Applicable Code Edition and Addenda

The Code of Record for the fifth 10-year ISI program interval at QCNPS, Unit 2, is the ASME Code, Section XI, 2007 Edition through 2008 Addenda. The fifth 10-year ISI interval began on April 2, 2013. The code of construction for the RPV is the ASME Code, Section III, 1965 Edition through summer, 1965 Addenda. The code of construction for the instrument penetration is the ASME Code, Section III, 1965 Edition through summer 1969 Addenda.

3.1.3 Applicable Code Requirements

The licensee listed the following ASME Code requirements for which use of the proposed alternative is being requested. The licensee noted these requirements are in the current Code of Record (ASME Code, Section XI, 2007 Edition through 2008 Addenda), but the repair and initial supporting flaw analysis were completed during the fourth 10-year ISI program interval in accordance with the ASME Code, Section XI, 1995 Edition through 1996 Addenda. By letter dated December 20, 2013, the licensee stated, in part, that

Flaw Removal

- IWA-5250(a)(3) states "Components requiring correction shall have repair/replacement activities performed in accordance with IWA-4000 or corrective measures performed where the relevant condition can be corrected without a repair/replacement activity."

- IWA-4412 states "Defect removal shall be accomplished in accordance with the requirements of IWA-4420."

- IWA-4421(d) states ""Defect removal or mitigation by modification shall be accomplished in accordance with the requirements of IWA-4340."

- IWA-4340 states:

  Modification of items may be performed to contain or isolate a defective area without removal of a defect, provided the following requirements are met.

  a) The defect shall be characterized using nondestructive examination and evaluated to determine its cause and projected growth.

  b) The modification shall provide for the structural integrity of the item such that it no longer relies on the defective area, including projected growth. The modification shall meet the Construction Code and Owner's Requirements for the item in accordance with IWA-4220.

  c) In lieu of reexamination of the defective area in accordance with IWA-4530(a), the Owner shall prepare a plan for additional examinations to detect propagation of the flaw beyond the limits of the modification, and when practicable, to validate the projected growth. The frequency and method of examination shall be determined by the Owner.

- IWA-4611.1(a) states "Defects shall be removed in accordance with IWA-4422.1. A defect is considered removed when it has been reduced to acceptable size."

- N-528 of Section III, 1965 Edition through Summer 1965, requires repair of weld defects including removal of defects detected by leakage tests.

Flaw Evaluation

- IWB-3522.1 states "... relevant conditions that may be detected during the conduct of system pressure tests shall require correction to meet the requirements of IWB-3142 and IWA-5250 prior to continued service... "

  1. IWB-3142.1(b) states "A component whose visual examination detects the relevant conditions described in the standards of Table IWB-3410-1 shall be unacceptable for continued service, unless such components meet the requirements of IWB-3142.2, IWB-3142.3, or IWB-3142.4."

  2. IWB-3142.4 states "A component containing relevant conditions is acceptable for continued service if an analytical evaluation demonstrates the component's acceptability. The evaluation analysis and evaluation acceptance criteria shall be specified by the Owner. A component accepted for continued service based on analytical evaluation shall be subsequently examined in accordance with IWB-2420(b) and (c)."

- IWB-2420(b) and (c) requires reexamination of the flaw during the next three inspection periods and IWB-2420(c) allows the examination schedule to revert to the original schedule provided the flaws remain essentially unchanged.

- IWA-3300(a) states in part "Flaws detected by the preservice and inservice examinations shall be sized..."

- IWA-3300(b) states in part "Flaws shall be characterized in accordance with IWA-3310 through IWA-3390, as applicable..."

- IWB-3610(b) states "For purposes of evaluation by analysis, the depth of flaws in clad components shall be defined in accordance with Fig. IWB-3610-1..."

- IWB-3420 states "Each detected flaw or group of flaws shall be characterized by the rules of IWA-3300 to establish the dimensions of the flaws. These dimensions shall be used in conjunction with the acceptance standards of IWB-3500."

3.1.4 ASME Code Requirement for Which Relief is Requested

The licensee requested relief from:

1) The requirements for removal and/or reduction in size of the flaws of IWA-4412 and IWA-4611.

2) The requirements to characterize the flaw of IWA-3300, IWB-3420, and IWB-3600.

3) The requirement for subsequent reexamination of flaws in accordance with IWB-2420(b) and (c) for components that have been accepted by an analytical evaluation as allowed by IWB-3132.3 (for flaws detected by volumetric examinations) or IWB-3142.4 (for flaws detected by a visual examination).

3.1.5 Licensee's Proposed Alternative

In its letter dated December 20, 2013, the licensee stated, in part, that

> In accordance with 10 CFR 50.55a(a)(3)(i), EGC proposes the following alternatives to the ASME Code Section XI requirements specified in Section 3 [of RR I5R-11].
>
> A. As an alternative to flaw removal or reduction in size to meet the applicable acceptance standards, EGC [proposes to implement] an OD [outside diameter] repair of the RPV instrument nozzle N-11B utilizing an OD weld pad as described below in the discussion of the repair of nozzle penetrations.
>
> B. As an alternative to performing the nondestructive examination required to characterize the flaw under IWB-3420 and IWB-3610(b) in RPV instrument nozzle N-11B, EGC proposes analyzing a maximum postulated flaw that bounds the range of flaw sizes that could exist in the J-groove weld and nozzle.
>
> C. As an alternative to performing the subsequent nondestructive examination required by IWB-3142.4 in accordance with IWB-2420(b) and (c) to assess potential growth of the flaw in RPV instrument nozzle N-11B, EGC proposes analyzing a maximum postulated flaw that bounds the potential growth of the existing flaw.

3.1.6 Licensee's Basis for Requesting Relief

With respect to the requirements for flaw characterization of IWB-3400 and IWB-3600, the licensee stated there is not currently a qualified or demonstrated technique to perform volumetric NDE of the partial penetration weld in this configuration that can be used to accurately characterize the location, orientation, or size, of a flaw in the weld. With respect to the requirements for reexamination of a component accepted for continued service in accordance with IWB-3142.4, the licensee stated that these subsequent examinations are intended to identify growth of the actual flaw over time, and that there is not a qualified or demonstrated technique to perform volumetric NDE of the partial penetration weld in this configuration that can be used to accurately determine flaw growth.

The licensee also described the repair method, which replaces the existing nozzle assembly with a nozzle penetration that is resistant to intergranular stress-corrosion cracking (IGSCC), meeting ASME Code, Section XI, and Code Case N-638-4, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [Gas Tungsten Arc Welding] Temper Bead Technique, Section XI, Division 1," as conditionally approved by the NRC in Regulatory Guide 1.147, Revision 16, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1." A welded pad was applied to the OD of the RPV using IGSCC-resistant nickel Alloy 52M (ERNiCrFe-7 or -7A) filler metals and was welded using the machine GTAW welding ambient temperature temper bead welding technique. The original partial penetration attachment weld and a remnant of the original nozzle remain in place. The licensee performed a weld flaw evaluation using linear elastic fracture mechanics (LEFM) of postulated axial and circumferential flaws that demonstrated that it was acceptable for the repaired penetration to remain in service for 9 years, which the licensee stated conservatively supports operation for two additional cycles of operation beyond the upcoming spring 2014 refueling outage. The flaw evaluation was based on Boiling Water Reactor Vessel Internals Project (BWRVIP)-60-A crack growth rates. The licensee provided a detailed summary of the weld flaw evaluation in its basis.

The licensee concluded that the proposed alternative provides an acceptable level of quality and safety because the repair used qualified welding procedures and IGSCC-resistant materials, and because the supporting flaw evaluation demonstrates that the RPV is acceptable without removal of the original nozzle remnant and partial penetration weld for 9 years, which conservatively supports the 8-year duration requested. The licensee also concluded that use of a maximum postulated flaw in the flaw evaluation is an acceptable alternative to NDE characterization of the actual flaw at this time, and in place of future NDEs. The licensee, therefore, requested the NRC to authorize the proposed alternative in accordance with 10 CFR 50.55a(a)(3)(i).

3.1.7 Duration of Proposed Alternative

The licensee requested relief for two additional cycles following the upcoming QCNPS, Unit 2, spring 2014 refueling outage (i.e., through the Unit 2, Cycle 24, currently scheduled to end March 2018).

3.2 NRC Staff Evaluation

The acceptability of the licensee's repair techniques was evaluated in the SE for the original RR I4-R19. Other than the ASME Code requirements related to removal and characterization of flaws, a relief request was not required for the repair technique since the welding and NDE were performed in accordance with the ASME Code, Section XI, or NRC-approved Code Cases.

The focus of the NRC staff review of the current relief request was on the revised flaw evaluation as detailed in Section 3.2.2 of this SE. The staff also evaluated the corrosion resistance of the licensee's repair, as detailed in Section 3.2.3 of this SE.

3.2.1 Inspections of the N-11B and Similar Nozzles at QCNPS

In a request for additional information (RAI) 2, the NRC staff asked the licensee about its plans for additional inspections to determine if the flaw in the N-11B instrument nozzle original weld was growing, and inspections of other similar nozzles to determine if these nozzles had cracking. By letter dated October 28, 2013, the licensee indicated no volumetric examinations of the N-11B nozzle were planned because there is no qualified ultrasonic testing (UT) technique to inspect this type of weld geometry. However, the licensee performed VT-2 visual inspections with the insulation removed on the similar nozzles at QCNPS, Units 1 and 2. Each unit has four similar nozzles. These inspections showed no indication of leakage in either unit.

The ASME Code, Section XI, does not require insulation removal for VT-2 visual examination, which are conducted to find evidence of leakage. Therefore, the VT-2 inspections conducted by the licensee are expected to be capable of identifying very small leaks in the nozzles. To verify no surface cracking exists in other similar nozzles, the licensee performed an external visual examination (EVT)-1 of the similar nozzles at QCNPS, Unit 1, in 2013, finding no issues, and plans to perform the same type of inspection in 2014 on the QCNPS, Unit 2, nozzles.

Given that there is no available UT technique to examine the J-groove weld, the EVT-1 examination (a high-resolution visual examination technique performed to detect surface-breaking cracking), the NRC staff concludes that this is an acceptable qualified technique to determine if cracking is present in the J-groove welds or adjacent RPV clad surfaces. Therefore, the staff finds the licensee's actions to determine if other similar nozzles as well as N-11B are affected by the same type of degradation to be acceptable.

3.2.2 Flaw Evaluation

The licensee provided a revised flaw evaluation by letter dated December 20, 2013, in response to RAI 3, which concerned the use of stress-corrosion cracking (SCC) growth rates in low-Alloy steel from a topical report not approved by the NRC staff. In the revised flaw evaluation, the licensee used NRC-approved SCC growth rates from topical report BWRVIP-60-A, "BWR Vessel and Internals and Internals Project, Evaluation of Stress Corrosion Crack Growth in Low Alloy Steel Materials in BWR Environment," June 2003 (ADAMS Accession No. ML031710331). The licensee's flaw evaluation is detailed in proprietary AREVA NP Inc., Document No. 32-9215236-002, "Quad Cities Unit 2 Instrument Nozzle J-Groove Weld LEFM Flaw Evaluation" (the non-proprietary version is included as Attachment 4 to the licensee's letter dated December 20, 2013). The current flaw analysis uses similar techniques to the flaw analysis supporting the previous (one-cycle) relief request, except that the previous flaw analysis did not use finite element analysis (FEA) to determine the stress intensity factors (SIFs).

Assumptions

The methodology postulates a radial flaw extending through the entire cross section of the J-groove weld. Flaws were postulated to be oriented in both the horizontal and vertical planes, such that the vertically oriented flaws would be acted on by hoop stresses in the RPV, leading to axial cracking in the RPV shell, while the horizontally oriented flaws would be acted on by axial stresses in the RPV, leading to circumferential cracking in the RPV shell.

The NRC staff finds the postulation of the flaw in the J-groove weld filler reasonable. Although flaws could also be present in the Alloy 600 penetration tube, such flaws could only grow into the RPV shell by first growing through the J-groove weld, since the penetration tube is only metallurgically bonded to the RPV at the J-groove weld. The staff also notes that the postulated flaws include the portion of the tube cross-section adjacent to the J-groove weld.

Transients Considered and Stresses

The transients evaluated for both fatigue crack growth and stability of the final flaw are heatup and cooldown, SCRAM, and safety/relief valve blowdown. These are the same transients evaluated in the one-cycle analysis. The analysis report lists the pressure and temperature for each time point of each transient. Both operating and residual stresses were considered both for crack growth and evaluation of the stability of the final crack.

For these transients and the steady-state condition, the stresses considered in determining the SIFs are pressure, thermal, residual stresses, and crack-face pressure. For each transient, SIFs were determined at multiple locations along the crack front by FEA for three different crack depths. For the crack sizes in between the three crack sizes analyzed, the SIF was determined by interpolation between the predetermined SIF. The NRC staff compared the K_I (applied SIF) determined via FEA to those determined in the prior analysis by hand solutions, and found that the maximum K_I determined by both methods were similar.

Crack Growth

Crack growth due to fatigue and SCC was added to the initial flaw size to arrive at the final flaw size. The fatigue crack growth calculation considered cyclic loads due the transients listed above and used the fatigue crack growth rate model from the ASME Code, Section XI, A-4300. The licensee referenced BWRVIP-60-A for the SCC crack growth rate in low-alloy steel. Crack growth was calculated in 1-year increments for each of the analyzed transients, considering the expected number of each applicable transient on a per-year basis. The detailed crack growth calculations in Appendix A of the analysis show that SCC crack growth is the largest contributor to crack growth. The NRC staff performed confirmatory checks of the licensee's fatigue crack growth rates using the ASME Code, Section XI, A-4300, methodology, finding crack growth rates consistent with the licensee. For the SCC crack growth rate, the staff verified the licensee used the appropriate rate for the stress intensity range. Therefore, the staff finds the crack growth rates used in the licensee's flaw evaluation to be appropriate.

<u>Linear Elastic Fracture Mechanics (LEFM) Analysis – Methodology and Acceptance Criteria</u>

For acceptance of the final flaws under the design basis loadings, the analysis applied the LEFM acceptance criteria from the ASME Code, Section XI, IWB-3612 and IWB-3613. These criteria require:

$K_I < K_{Ic}/\sqrt{10}$ (normal and upset conditions)
$K_I < K_{Ic}/\sqrt{2}$ (emergency/ faulted conditions)

Where K_I is the applied SIF, and K_{Ic} is the crack initiation fracture toughness.

Section XI, Article IWB-3613, provides alternate fracture toughness requirements for shell regions near structural discontinuities, such as vessel flange and nozzle-to-shell regions, when the pressure does not exceed 20 percent of the design pressure and the temperature is not less than the reference nil-ductility temperature (RT_{NDT}). The alternate criterion may only be applied to normal and upset conditions. Within these operational limits a lower safety factor may be used to evaluate fracture toughness margin:

$$K_I < K_{Ic}/\sqrt{2}$$

Article IWB-3612 provides the acceptance criteria based on applied stress intensity, except for those areas near structural discontinuities, which are covered by the alternate criteria of IWB-3613. Since the nozzle penetration is a discontinuity in the RPV shell, the NRC staff finds the use of the IWB-3613 criteria is appropriate within the prescribed limitation (normal or upset conditions, pressure less than 20 percent of design pressure, temperature greater than or equal to RT_{NDT}).

The Irwin plasticity correction was applied to the final flaw size as follows:

$$a_e = a_f + (1/6\pi)(K_f/\sigma_y)^2$$

where:

a_e is the effective flaw size
a_f is the final uncorrected flaw depth
K_f is the SIF corresponding to a flaw with depth a_f
σ_y is the material yield strength

The Irwin correction adjusts the final flaw size to account for the plastic zone ahead of the crack tip resulting in a slightly larger effective flaw size which generally results in a slightly larger applied SIF.

The method used in the licensee's flaw evaluation to correct for local plasticity is different from that in the ASME Code, Section XI, Appendix A, but is identical to the method used in the ASME Code, Section XI, Nonmandatory Appendix K. The licensee calculated the margins with and without the plastic zone correction. The licensee's results showed the margins are acceptable (greater than 1.0) for all flaw and transient combinations, both with and without the plasticity correction. The plastic zone correction increases the effective flaw size and thus tends to increase K_I for the more limiting axial flaws, resulting in conservative results. Therefore, the

NRC staff finds the licensee's method of plasticity correction acceptable because it is consistent with methods allowed by the ASME Code, Section XI, and because it results in conservative K_I values.

For flaw stability of the final flaw size, the licensee's analysis evaluated the K_I for each temperature/pressure point of each transient and calculated the margin. The K_Is determined from the FEA analyses are from both the operating and residual stresses. For the margin assessment, the total K_Is were broken down into the operating and residual stress components since different safety factors were applied to each. The plasticity correction was applied to both the operating and residual stress components. Therefore, the final margin is determined as follows:

$$\text{Margin} = K_{IC}/(SF^{*}K'_{OP} + K'_{R})$$

Where SF is the safety factor ($\sqrt{2}$ or $\sqrt{10}$ as applicable)
K'_{OP} is the plasticity-corrected stress intensity factor due to operating stresses
K'_{R} is the plasticity-corrected stress intensity factor due to residual stresses

The licensee stated that if the margin determined by the above equation is greater than 1.0, the required fracture mechanics safety margins are met. The safety factors (SFs) described above were applied to the stress intensity resulting from operating stresses (K'_{OP}), but an SF of 1.0 was applied to the stress intensity due to residual stresses (K'_{R}). The licensee stated that residual stresses are self-limiting secondary stresses that do not cause failure in flawed components and indicated that the use of a structural factor of 1.0 on the residual stress is consistent with Article C-7300 of Section XI of the ASME Code.

The ASME Code, Section XI, IWB-3600, provides methods for analytical evaluations of flaws. Article IWB-3610 provides acceptance criteria for ferritic steel components greater than or equal to 4 inches in thickness, such as the QCNPS, Unit 2, RPV shell, and states that a flaw that exceeds the size of allowable flaws defined in IWB-3500 may be evaluated by analytical procedures such as described in Appendix A to calculate its growth until the next inspection or the end-of-service lifetime of the component. Although IWB-3610 does not specifically refer to the procedures of the ASME Code, Section XI, Appendix C, the NRC staff finds the use of an SF of 1.0 on residual stresses to be acceptable because residual stresses are secondary, self-limiting stresses that do not cause failure without the addition of stresses due to operational loads such as pressure. Further, IWB-3600 does not prohibit the use of procedures other than those of Appendix A to evaluate the acceptability of flaws.

In summary, the NRC staff finds the licensee's flaw evaluation methodology acceptable because:

- The evaluation uses methods that are consistent with those allowed by the ASME Code, Section XI, 2007 Edition through 2008 Addenda, the Code of Record for the fifth 10-year ISI intervals for QCNPS, Unit 2.

- Conservative assumptions were made with regard to the initial flaw size, and acceptable SCC crack growth rates were used.

Flaw Evaluation Results

The flaw evaluation tabulated the most limiting margins for each transient for the axial and circumferential flaw, taking into account the stress intensity, temperature, and yield strength of the material, which varies with temperature. The licensee's evaluation found these margins were all acceptable, based on projected crack growth for 9 years. The licensee stated a 9-year period would allow QCNPS, Unit 2, to be operated until the second refueling outage after the spring 2014 refueling outage. Assuming the crack reached the interface with the RPV shell just after the VT-2 visual inspection in 2010, a 9-year period would allow operation until 2019, which conservatively supports operation until March 2018. With 2-year refueling cycles, the second refueling outage after 2014 would occur in March 2018. The NRC staff therefore finds that, based on the flaw evaluation results, the postulated flaw would not grow to unacceptable size during the period of relief requested; therefore, QCNPS, Unit 2, can be safely operated until two refueling outages after the 2014 refueling outage.

3.2.3 Corrosion Evaluation

Attachment 2 to the April 12, 2012, follow-up response to an RAI related to RR I4R-19 (ADAMS Accession No. ML12104A067) contained a proprietary corrosion evaluation of the exposed low-Alloy steel. This evaluation provided a general corrosion rate on a per-year basis for low-Alloy steel based on laboratory testing. In its October 28, 2013, response to RAI 1, the licensee confirmed the corrosion evaluation supporting RR I4-R19 remains applicable to RR 15R-11. The corrosion evaluation also qualitatively evaluated the susceptibility of the low-Alloy steel to crevice corrosion, galvanic corrosion, and SCC, and evaluated the susceptibility of the repair materials (Alloys 690, 52, and 152) to IGSCC. The NRC staff found the evaluation of these mechanisms to be acceptable. Based on the very low per-year corrosion rate of the low-Alloy steel, the NRC staff finds that corrosion of the repaired nozzle and the exposed low-Alloy steel will not adversely affect the integrity of the RPV and RAI 1 is thus resolved.

4.0 CONCLUSION

On the basis of review and evaluation of the licensee's submittals as discussed above, the NRC staff concludes that the proposed alternatives related to the repair of QCNPS, Unit 2, RPV penetration N-11B provides an acceptable level of quality and safety for two additional operating cycles beyond the spring 2014 refueling outage (i.e., through QCNPS, Unit 2, Cycle 24), scheduled to end during March 2018. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff authorizes the proposed alternative described in RR 15R-11 until the end of QCNPS, Unit 2, Cycle 24, or March 31, 2018, whichever comes first.

All other ASME Code, Section XI, requirements for which relief was not specifically requested and authorized herein by the NRC staff remain applicable, including the third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: J. Poehler

Date of issuance: February 28, 2014

If you have any questions on this action, please contact the NRC Project Manager, Brenda Mozafari, at (301) 415-2020.

Sincerely,

/ RA /

Travis L. Tate, Chief
Plant Licensing III-2 and
Planning and Analysis Branch
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-254

Enclosure:
Safety Evaluation

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