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

January 24, 2018

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer (CNO)
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: QUAD CITIES NUCLEAR POWER STATION, UNIT 2 – APPROVAL OF ALTERNATIVES TO THE ASME CODE REGARDING REACTOR VESSEL PENETRATION N-11B – RELIEF REQUEST I5R-11, REVISION 3 (CAC NO. MF9286; EPID L-2017-LLR-0004) (RS-17-014)

Dear Mr. Hanson:

By letter dated February 14, 2017, as supplemented by letter dated January 4, 2018, Exelon Generation Company, LLC (EGC) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) for the use of alternatives to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, requirements at Quad Cities Nuclear Power Station (QCNPS), Unit 2.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), EGC requested to use the proposed alternatives on the basis that the alternatives provide an acceptable level of quality and safety.

The NRC staff has reviewed the subject request and concludes, as set forth in the enclosed safety evaluation, that the proposed alternatives related to the flaw analysis and examinations of the QCNPS, Unit 2, reactor pressure vessel instrument nozzle penetration N-11B provide an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1).

The NRC authorizes the use of the proposed alternatives for QCNPS, Unit 2, through Cycle 27, currently scheduled to end in spring 2024, not to exceed 9 years from the spring 2016 outage when the demonstrated nondestructive examination was last performed.

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

If you have any questions, please contact Kimberly Green at (301) 415-1627.

Sincerely,

David J. Wrona, Branch Chief
Plant Licensing Branch III
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-265

Enclosure:
Safety Evaluation

cc w/enclosure: Listserv

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUEST NO. I5R-11, REVISION 3

REGARDING REACTOR VESSEL PENETRATION N11-B

EXELON GENERATION COMPANY, LLC

AND

MIDAMERICAN ENERGY COMPANY

QUAD CITIES NUCLEAR POWER STATION, UNIT 2

DOCKET NO. 50-265

1.0 INTRODUCTION

By letter dated February 14, 2017, as supplemented by letter dated January 4, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17045A681 and ML18004B515, respectively), Exelon Generation Company, LLC (EGC or the licensee) submitted relief request (RR) I5R-11, Revision 3, to the U.S. Nuclear Regulatory Commission (NRC) for the use of alternatives to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, requirements. Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), EGC proposed alternatives for the repair, evaluation, and subsequent examination of reactor pressure vessel (RPV) penetration N-11B for Quad Cities Nuclear Power Station (QCNPS), Unit 2.

During the spring 2012 refueling outage for QCNPS, Unit 2 (Q2R21), the RPV instrument penetration N-11B was found to have approximately 60 drops per minute leakage. By letter dated April 6, 2012 (ADAMS Accession No. ML12100A012), the licensee submitted RR I4R-19 proposing 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 authorized RR I4R-19 on April 15, 2012 (ADAMS Accession No. ML12107A472), and provided a formal safety evaluation (SE) by letter dated January 30, 2013 (ADAMS Accession No. ML13016A454). 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. The alternative repair was implemented during the fourth 10-year inservice inspection (ISI) interval at the QCNPS, Unit 2, and was authorized until the next refueling outage scheduled to begin in April 2014.

By letter dated February 13, 2013 (ADAMS Accession No. ML13044A662), as supplemented by letters dated October 28 and December 20, 2013 (ADAMS Accession Nos. ML13302A597 and ML13358A401, respectively), pursuant to 10 CFR 50.55a(a)(3)(i), EGC submitted RR I5R-11 (ADAMS Accession No. ML13044A663), requesting a permanent alternative repair of the N-11B RPV instrument nozzle penetration. A revision to RR I5R-11 was submitted in EGC's letter dated December 20, 2013, providing a revised flaw evaluation demonstrating that a flaw in the weld would not grow to an unacceptable size for 9 years. In the NRC's SE dated February 28, 2014 (ADAMS Accession No. ML14055A227), the staff found the licensee's flaw evaluation acceptable and authorized the proposed alternative described in I5R-11, Revision 1, until the end of QCNPS, Unit 2, Cycle 24, or March 31, 2018, whichever comes first.

2.0 REGULATORY EVALUATION

Adherence to Section XI of the ASME Code is mandated by 10 CFR 50.55a(g)(4), which states, in part, that ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the pre-service examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components." The regulation also requires that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code, which was incorporated by reference in 10 CFR 50.55a(a) 12 months prior to the start of the 120-month interval, subject to the conditions listed in 10 CFR 50.55a(b)(2).

The regulation in 10 CFR 50.55a(z)(1) states that alternatives to the requirements of 10 CFR 50.55a(b) through (h) or portions thereof may be used when authorized by the Director of the Nuclear Reactor Regulation. A proposed alternative must be submitted and authorized prior to implementation. The applicant must demonstrate that the proposed alternative would provide an acceptable level of quality and safety.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the licensee to request the use of an alternative and the NRC to authorize the proposed alternative.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Request for Alternative

3.1.1 ASME Code Components Affected

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

3.1.2 Applicable Code Edition and Addenda

The applicable code of record (COR) for the fifth 10-year ISI interval at QCNPS, Unit 2, is the 2007 Edition through 2008 Addenda of the ASME Code, Section XI. The fifth 10-year interval is effective from April 2, 2013, through April 1, 2023. 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 alternatives are being requested. The licensee noted these requirements are in the current COR (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.

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 (NDE) 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) require 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, in part, "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 Requirements for Which Alternatives Are 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 Proposed Alternatives and Basis

The licensee has already developed a flaw evaluation that was approved by the NRC which determined the acceptability of a postulated flaw remaining in the J-groove weld and extending into the RPV. Due to recently developed NDE techniques, the licensee suggested that it was able to examine the J-groove weld and surrounding low-alloy RPV metal to identify and size any flaws found in the examination region. These examinations allow the licensee to determine if any flaws found exceed the postulated flaw in the approved flaw analysis; therefore, the licensee proposed the following three alternatives to the ASME Code, Section XI, pursuant to 10 CFR 50.55a(z)(1):

A. As an alternative to flaw removal or reduction in size to meet the applicable acceptance standards, Exelon proposed and implemented an outer diameter repair of the RPV instrument nozzle N-11B utilizing an outer diameter weld pad as described in the Q2R21 Repair of Nozzle Penetration section of the request.

B. As an alternative to performing the NDE required to characterize the flaw under IWB-3420 and IWB-3610(b) in RPV instrument nozzle N-11B, Exelon proposes analyzing a maximum postulated flaw that bounds the range of flaw sizes that could exist in the J-groove weld and nozzle. The maximum postulated flaw size assumed in the analysis will be verified using demonstrated NDE techniques.

C. As an alternative to performing the subsequent NDE 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 Duration of Proposed Alternative

The licensee's proposed alternative is requested for three additional cycles following the spring 2018 refueling outage, i.e., through Unit 2 Cycle 27 currently scheduled to end in spring 2024. This supports the 9 years beyond Unit 2 spring 2016 refueling outage when the demonstrated NDE technique was performed.

3.2 NRC Staff Evaluation

The acceptability of the licensee's repair techniques was evaluated in the SE for the original RR I4R-19 and was found acceptable for the duration of operating Cycle 22. Subsequently, in RR I5R-11, the NRC staff approved the alternative through operating Cycle 24. The NRC staff finds that there has been no reduction in safety related to the repair techniques implemented, and, therefore, finds the repair to be acceptable until the end of the current operating license. Other than the ASME Code requirements related to removal and characterization of flaws, an RR 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 acceptability of the flaw evaluation and corrosion resistance of the licensee's repair were evaluated in the SE

for RR I5R-11. The focus of the NRC staff's review of RR I5R-11, Revision 3, is the newly developed NDE technique, which is discussed below.

A Boiling Water Reactor Vessel and Internals Project (BWRVIP)-IP-1 mockup and BWRVIP H9 weld mockups were used to demonstrate the ability of the new NDE technique to examine the J-groove weld. The BWRVIP-IP-1 mockup included two BWR instrument penetrations, both of which consisted of Alloy 600 penetration tubes that are joined to the inside surface of the RPV using an Alloy 82/182 partial penetration J-groove weld; both penetrations contained three manufactured cracks in the Alloy 82/182 welds, some of which propagated into the low-alloy RPV material. The BWRVIP H9 shroud support plate weld mockups contain three flaws which propagate out of the welds and into the low-alloy RPV material to represent flaws which would propagate out of the instrument penetration J-groove welds. These flaws were chosen to increase the number of demonstration flaws that initiate within dendritic Allow 82/182 weld material and propagate into fine-grain low-alloy RPV material. Further information regarding these mockups is contained in BWRVIP-03, Revision 19, "Reactor Pressure Vessel and Internals Examination Guidelines," Sections 14.4.1 and 5.3.2.

The licensee's inspector vendor utilized these mockups to develop a manual phased array ultrasonic (UT) examination technique which uses longitudinal waves as the primary examination technique to locate flaws in the Alloy 82/182 J-groove weld. Additionally, shear waves are used as the secondary technique to determine whether flaws have propagated into the low-alloy RPV material as they are less effective at penetrating the Alloy 82/182 weld but more sensitive to locating flaws in the ferritic base metal. In the licensee's NDE demonstration, the shear wave technique was able to detect all five of the flaws that propagated into the low-alloy RPV material. Supplemental information is found in Section 14.5.2 of BWRVIP-03, Revision 19.

During Q2R23 (spring 2016), the licensee performed the manual phased array examination on the instrument penetration as described above in accordance with BWRVIP-03 requirements considering there are no qualification criteria in ASME Code, Section XI, 2007 Edition through 2008 Addenda, Mandatory Appendix VII for BWR instrument penetrations. The personnel performing the examinations on the ferritic RPV base metal surrounding the Alloy 82/182 J-groove weld completed a Performance Demonstration for ASME Code, Section XI, 2007 Edition through 2008 Addenda, Mandatory Appendix VII, Supplement 4, for detection and sizing of flaws located in the ferritic material at nozzle inner-radius locations.

Two flaws were identified within the Alloy 82/182 J-groove weld material. The first flaw, which was likely the source of the observed leakage, initiated at the inside surface of the J-groove weld and propagates along the interface of the Alloy 600 penetration tube and Alloy 82/182 J-groove weld, perpendicular to the RPV surface. The flaw was oriented circumferentially and was approximately 0.25 inches in length and extends from the inner surface of the J-groove weld to the penetration tube-to-RPV penetration bore hole annulus. The licensee stated that this flaw exhibited characteristics of intergranular stress corrosion cracking (IGSCC) and did not intersect the low-alloy RPV material. The second flaw was completely contained within the J-groove weld and also did not propagate into the low-alloy RPV base metal. It was circumferentially oriented and sized at approximately 0.25 inches in length, but exhibited no measurable axial depth. This flaw neither connected to the inner diameter of the RPV nor connected to the low-alloy steel RPV base metal. The supplemental shear wave examination technique was performed along the entire circumference of the J-groove weld and no flaws were identified which provides additional confidence that the planar flaw found during the longitudinal examination had not extended into the low-alloy RPV base metal.

The linear elastic fracture mechanics flaw evaluation analysis, performed by the licensee and approved by the NRC staff, determined that conservative crack growth rates for a postulated flaw extending into the low-alloy base metal allow for 9 years of safe continued operation starting after Q2R20 (spring 2010). The licensee utilized NRC-approved stress corrosion cracking 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). During Q2R23 (spring 2016), the licensee performed the new NDE on the J-groove weld, which showed no indication of flaws extending into the RPV base metal.

The NRC staff finds that the crack growth rates in BWRVIP-60-A are conservative for this application, particularly since the N-11B instrument nozzle lies in steam space where crack growth rates are generally lower. The NRC staff agrees that the new NDE should have been able to identify flaws that grow into the low-alloy RPV metal. Therefore, the UT results from 2016 provide reasonable assurance the flaw remains bounded by the initial flaw size assumed in the flaw evaluation. The existing flaws do not compromise the structural integrity of the vessel because the original nozzle remnant is no longer a part of the credited pressure boundary following the repairs performed in 2012, and because the 2016 NDE showed the flaws were not growing into the low-alloy steel RPV shell. Considering the conservatisms built into the flaw analysis, that there is no operational experience showing IGSCC in low-alloy steel, and there is no indication of the flaws extending into the low-alloy steel RPV material, the NRC staff finds it acceptable for the flaw to remain in place, as is, without any new repair or replacement activities, examinations to characterize flaw growth, or subsequent NDE to assess potential growth of the flaw for up to 9 years from when the demonstrated NDE technique was last performed.

4.0 CONCLUSION

Based on the review and evaluation of the licensee's submittal as discussed above, the NRC staff concludes that the proposed alternatives related to the flaw analysis and examinations of the QCNPS, Unit 2, RPV instrument nozzle penetration N-11B provide an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). The NRC authorizes the use of proposed alternatives for QCNPS, Unit 2, through Cycle 27 currently scheduled to end in spring 2024, not to exceed 9 years from the spring 2016 outage when the demonstrated NDE was last performed.

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: A. Young, NRR

Date of issuance: January 24, 2018

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