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

September 21, 2023

Mr. David P. Rhoades
Senior Vice President
Constellation Energy Generation, LLC
President and Chief Nuclear Officer
Constellation Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: QUAD CITIES NUCLEAR POWER STATION, UNIT 2 – PROPOSED ALTERNATIVE TO THE REQUIREMENTS OF THE ASME CODE (EPID L-2022-LLR-0087)

Dear Mr. Rhoades:

By letter dated December 14, 2022 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML22348A205), Constellation Energy Generation, LLC (the licensee), proposed an alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plants," for Quad Cities Nuclear Power Station (Quad Cities), Unit 2.

Specifically, pursuant to Title 10 of *the Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee proposed alternatives for the repair, evaluation, and subsequent examination of reactor pressure vessel penetration N-11B for Quad Cities, Unit 2, for three additional refueling outages following the spring 2022 refueling outage (i.e., through cycle 30 currently scheduled to end in spring 2030).

The U.S. Nuclear Regulatory Commission (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 Quad Cities, 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 Quad Cities, Unit 2, through cycle 30 currently scheduled to end in spring 2030, and not to exceed 9 years from date when the demonstrated non-destructive examination 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.

If you have any questions, please contact the Project Manager, Robert Kuntz at 301-415-3733 or via e-mail at Robert.Kuntz@nrc.gov.

Sincerely,

Jeffrey A. Whited

Digitally signed by Jeffrey A. Whited
Date: 2023.09.21 15:54:40 -04'00'

Jeffrey Whited, Chief
Plant Licensing Branch III
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-265

Enclosure:
Safety Evaluation

cc: Listserv

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO

ALTERNATIVE REQUEST I6R-10

CONSTELLATION ENERGY GENERATION, LLC

QUAD CITIES NUCLEAR POWER STATION, UNIT 2

DOCKET NO. 50-265

1.0 INTRODUCTION

By letter dated December 14, 2022 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML22348A205), Constellation Energy Generation, LLC (the licensee) submitted relief request (RR) I6R-10, Revision 0, 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), the licensee proposed alternatives for the repair, evaluation, and subsequent examination of reactor pressure vessel (RPV) penetration N-11B for Quad Cities Nuclear Power Station, Unit 2 (Quad Cities, Unit 2), for three additional refueling outages (ROs) following the spring 2022 RO (i.e., through cycle 30 currently scheduled to end in spring 2030).

During the spring 2012 outage (RO21) for Quad Cities, Unit 2, the RPV instrument penetration N-11B was found to have approximately 60 drops per minute leakage. By letter dated April 6, 2012 (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's repair replaced the pressure boundary for the leaking penetration without removing, sizing, or repairing the flawed volume of penetration N-11B. The NRC verbally authorized RR I4R-19 on April 15, 2012 (ML12107A472), and later provided a formal safety evaluation (SE) by letter dated January 30, 2013 (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 an unacceptable size for one operating cycle. The alternative repair was implemented during the fourth 10-year inservice inspection (ISI) interval at the Quad Cities, Unit 2, and was authorized until the next outage (RO22), which was scheduled to begin in April of 2014.

By letter dated December 20, 2013 (ML13358A401), the licensee provided a revised flaw evaluation to demonstrate the acceptability of leaving the original partial penetration weld, with a maximum postulated flaw, in place for two additional cycles. The NRC staff found licensee's flaw evaluation acceptable and authorized the proposed alternative described in RR I5R-11,

Revision 1, until the end of Quad Cities, Unit 2, cycle 24, or March 31, 2018, whichever came first (ML14055A227).

By letter dated January 4, 2018 (ML18004B515), the licensee submitted RR I5R-11, Revision 3, which was based on a qualified nondestructive examination (NDE) performed on the N-11B penetration during RO23 (spring 2016), and requested the alternative be approved for three additional cycles, through cycle 27 (spring 2024). The NRC staff's SE dated January 24, 2018 (ML18022A616), approved the request. To support the current proposed alternative, the request provided the results of the NDEs performed on the nozzle during RO26 (spring 2022) to support operation for an additional 9 years.

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 for the sixth 10-year ISI interval at Quad Cities, Unit 2, is the 2017 Edition of the ASME Code, Section XI. The sixth 10-year interval is effective from April 2, 2023, through April 1, 2033. The code of construction for the RPV and the instrument nozzle penetration is the ASME Code, Section III, 1965 Edition through summer, 1965, Addenda.

3.1.3 Applicable Code Requirements

The alternative listed the following ASME Code requirements that are applicable to the request:

Flaw Removal

- Subarticle IWA-5250(a)(3) of ASME Code, Section XI, which states, “Components requiring correction shall have repair/replacement activities performed in accordance with Article IWA-4000 or corrective measures performed where the relevant condition can be corrected without a repair/replacement activity.”

- Paragraph IWA-4412 of ASME Code, Section, XI, which states, “Defect removal shall be accomplished in accordance with the requirements of IWA-4420.”

- Subparagraph IWA-4611.1(a) of ASME Code, Section XI, which states, “Defects shall be removed in accordance with IWA-4422.1. A defect is considered removed when it has been reduced to an acceptable size.”

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

Flaw Evaluation

- Subparagraph IWB-3522.1 of ASME Code, Section XI, which states, in part, that “A component whose visual examination (IWA-5240) detects any of the following relevant conditions shall meet the requirements of IWB-3142 and IWA-5250 prior to continued service...”

- Subparagraph IWB-3142.1(b) of ASME Code, Section XI, which 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.”

- Subarticle IWA-3300(a) of ASME Code, Section XI, which states, in part, that “Flaws detected by the preservice and inservice examinations shall be sized...”

- Subarticle IWA-3300(b) of ASME Code, Section XI, which states, in part, that “Flaws shall be characterized in accordance with IWA-3310 through IWA-3390, as applicable.”

- Subarticle IWB-3610(b) of ASME Code, Section XI, which states, that “For purposes of analytical evaluation, the depth of flaws in clad components shall be defined in accordance with Fig. IWB-3610-1 as follows...”

- Subarticle IWB-3420 of ASME Code, Section Xi, which 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

In its submittal, the licensee requested alternatives to the following:

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(a), IWA-3300(b), IWB-3420, and IWB-3610(b), and

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

Due to NDE examinations performed during Quad Cities, Unit 2, RO26 (spring 2022), the licensee determined that the repair performed in 2012 for RPV instrument penetration N-11B can remain in service for an additional 9 years (until 2030). Consequently, the licensee proposed the following 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, the licensee implemented an outer diameter repair of the RPV instrument nozzle N-11B utilizing an outer diameter weld pad as described in the RO21 repair and

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, the licensee 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.

3.1.6 Duration of Proposed Alternative

The proposed alternative requested three additional cycles following the NDEs performed during RO26 (spring 2022), i.e., through Quad Cities, Unit 2, cycle 30, currently scheduled to end in spring of 2030. The duration is bounded by 9 years of operation beyond the spring 2022 RO, when the demonstrated NDE technique was last performed.

3.2 NRC Staff Evaluation

The focus of the NRC staff’s review of RR I6R-10, Revision 0, is the NDE performed during the spring 2022 outage, and comparison of the results in relation to the NDE performed during the 2016 outage as discussed below.

A Boiling Water Reactor Vessel and Internals Project (BWRVIP)-IP-1 mockup and BWRVIP H9 weld mockup were used to demonstrate the ability of the NDE technique to examine the J-groove weld. The BWRVIP-IP-1 mockup included two boiling-water reactor (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 J-grove welds, with some cracks propagating into the low-alloy RPV material. Additionally, BWRVIP H9 shroud support plate weld mockups containing three flaws which propagate out of the welds and into the low-alloy RPV material were also used 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. A more detailed description of these mockups is contained in sections 14.5.1 and 5.3.2 of BWRVIP-03, Revision 19, “Reactor Pressure Vessel and Internals Examination Guidelines” (ML17054C674).

The licensee used these mockups to develop a manual phased array ultrasonic examination technique which used longitudinal waves as the primary examination technique to locate flaws in the Alloy 82/182 J-groove weld. Additionally, shear waves were 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.

During the RO23 (spring 2016), the licensee performed the manual phased array examination on the instrument penetration as described above in accordance with BWRVIP-03 requirements since there are no qualification criteria in ASME Code, Section XI, 2007 Edition through 2008 Addenda, mandatory appendix VIII 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 VIII, Supplement 4, for detection and sizing of flaws located in the ferritic material at nozzle inner-radius locations.

During the RO23, 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 propagated 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 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. This provided additional assurance that the planar flaw found during the longitudinal examination had not extended into the low-alloy RPV base metal.

During the NDEs of the instrument penetration in RO26, the same examination techniques were used, these examination results did not show any changes from the examinations performed during RO23.

The licensee previously submitted a linear elastic fracture mechanics flaw evaluation, which used a conservative initial flaw size, acceptable crack growth rates, and postulated the flaw extending into the low-alloy base metal of the RPV. The submittal concluded that the evaluations allowed for 9 years of continued operation. The NRC staff's safety evaluation dated February 24, 2014, approved the licensee's submittal (ML14055A227).

The NRC staff finds that the examination results performed in 2022 provide reasonable assurance that the flaw remains bounded by the flaw size assumed by licensee's flaw evaluation. Moreover, the existing flaws have not changed since NDEs were last performed in 2016. Additionally, the existing flaws do not compromise the structural integrity of the vessel because the 2016 and 2022 examinations confirmed that the flaws have not grown or extended into the low-alloy steel base metal of the RPV. Therefore, the NRC staff finds it acceptable to grant the proposed alternatives for an addition period of 9 years from the date when the demonstrated NDE technique was last performed (spring 2022).

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 Quad Cities, 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 Quad Cities, Unit 2, through cycle 30 currently scheduled to end in spring 2030, and not to exceed 9 years from date 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: V. Kalikian

Date of issuance: September 21, 2023

SUBJECT: QUAD CITIES NUCLEAR POWER STATION, UNIT 2 – PROPOSED ALTERNATIVE TO THE REQUIREMENTS OF THE ASME CODE (EPID L-2022-LLR-0087) DATED SEPTEMBER 21, 2023

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