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

April 23, 2021

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

SUBJECT: PEACH BOTTOM ATOMIC POWER STATION UNIT NO. 2 – APPROVAL OF ONE-TIME ALTERNATIVE TO FLAW CHARACTERIZATION AND REMOVAL REQUIREMENTS FOR N-16A NOZZLE (EPID L-2020-LLR-0144)

Dear Mr. Rhoades:

By letter dated November 4, 2020, as supplemented by letter dated November 24, 2020 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML20309B020 and ML20329A345, respectively), Exelon Generation Company, LLC (Exelon, the licensee) submitted a proposed one-time alternative to certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI in Articles IWB-3000 and IWA-4000 Peach Bottom Atomic Power Station, Unit No. 2 (Peach Bottom 2).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(2), the licensee requested to use proposed alternative I5R-14 on the basis that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

On November 6, 2020 (ADAMS Accession No. ML20314A028), the U.S. Nuclear Regulatory Commission (NRC) staff verbally authorized the use of alternative request I5R-14. In its verbal authorization, the NRC staff determined that the proposed alterative to repair the degraded reactor vessel instrument penetration nozzle N-16A by a half-nozzle method is technically justified and provides reasonable assurance of structural integrity and leak tightness for the duration of operating cycle 24, which is scheduled to end in the fall of 2022.

The NRC staff has reviewed the subject request and concludes, as set forth in the enclosed safety evaluation, that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(2).

The NRC authorizes the use of the proposed alternative in I5R-14 for Peach Bottom 2, for the duration of one operating cycle. The alternative provides reasonable assurance of structural integrity and leak tightness of the reactor vessel instrument penetration nozzle N-16A. All other ASME Code, Section XI, requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions concerning this matter, please contact the Peach Bottom Project Manager, Jennifer Tobin, at (301) 415-2328 or Jennifer.Tobin@nrc.gov.

Sincerely,

/RA/

James G. Danna, Chief
Plant Licensing Branch I
Division of Operator Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-277

Enclosure:
Safety Evaluation

cc: Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST I5R-14

ALTERNATIVE TO FLAW CHARACTERIZATION AND REMOVAL

REQUIREMENTS FOR N-16 NOZZLE

EXELON GENERATION COMPANY, LLC

PEACH BOTTOM ATOMIC POWER STATION UNIT NO. 2

DOCKET NO. 50-277

1.0 INTRODUCTION

By letter dated November 4, 2020 as supplemented by letter dated November 24, 2020 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML20309B020 and ML20329A345, respectively), Exelon Generation Company, LLC (Exelon, the licensee) submitted a proposed one-time alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI in Articles IWB-3000 and IWA-4000 Peach Bottom Atomic Power Station, Unit No. 2 (Peach Bottom 2).

Specifically, the licensee requested a one-time relaxation of certain flaw characterization and removal requirements in Articles IWB-3000 and IWA-4000 of ASME Code, Section XI. Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(2), the licensee requested to use the proposed alternative in Relief Request I5R-14 on the basis that performing the repair in accordance with the ASME Code, Section XI would result in an increased radiological exposure, and there exists a potential risk of loose parts or foreign materials accidentally getting into the reactor vessel (RV) during the ASME Code repair.

On November 6, 2020 (ADAMS Accession No. ML20314A028), the NRC staff verbally authorized the use of alternative request I5R-14. In its verbal authorization, the NRC staff determined that the proposed alternative to repair the degraded RV instrument penetration nozzle N-16A by a half-nozzle method is technically justified and provides reasonable assurance of structural integrity and leak tightness for the duration of operating cycle 24, which is scheduled to end in the fall of 2022. The verbal authorization documentation provides a summary of the NRC staff evaluation for this proposed alternative. This safety evaluation provides the details of the NRC staff review of proposed alternative I5R-14.

2.0 REGULATORY EVALUATION

The regulation at 10 CFR 50.55a(z) states, in part, that alternatives to the requirements of paragraphs (b) through (h) of 10 CFR 50.55a or portions thereof may be used when authorized by the Director, Office of Nuclear Reactor Regulation. A proposed alternative must be submitted and authorized prior to implementation. The applicant or licensee must demonstrate that:

(1) *Acceptable level of quality and safety*. The proposed alternative would provide an acceptable level of quality and safety; or

(2) *Hardship without a compensating increase in quality and safety*. Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the 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 use of the proposed alternative.

3.0 TECHNICAL EVALUATION

3.1 ASME Code Component(s) Affected

The affected component is the RV instrument penetration nozzle N-16A. Specifically, the applicable ASME Code, Section XI, flaw characterization requirements of ASME Code, Section XI, IWB-3420 and IWB-3620(b) and flaw removal requirements of ASME Code, Section XI, IWA-4412 and IWA-4611.

3.2 Applicable Code Edition and Addenda

The ASME Code, Section XI, 2013 Edition with no Addenda is the Code of Record for the fifth 10-year inservice inspection (ISI) interval. The code of construction for RV is the 1965 Edition through Winter 1965 Addenda of ASME Code, Section III.

3.3 Applicable Code Requirement

The ASME Code requirements applicable to this request originate in Articles IWB-3000 and IWA-4000 of Section XI, which include:

- Flaw characterization requirements of IWB-3420 and IWB-3620
- Flaw removal requirements of IWA-4412 and IWA-4611
- Analytical flaw evaluation requirements of IWB-3600
- ASME Code Case N-749, “Alternative Acceptance Criteria for Flaws in Ferritic Steel Components Operating in the Upper Shelf Temperature Range Section XI, Division 1.” ASME Code Case N-749 has been incorporated by reference into 10 CFR 50.55a via inclusion in Regulatory Guide (RG) 1.147, Revision 19, “Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1,” dated October 2019 (ADAMS Accession

No. ML19128A244), with a condition (i.e., In lieu of the code case defined upper shelf transition temperature T_c, the NRC-defined $T_c = 154.8\ ^oF + 0.82\ RT_{NDT}$ shall be used. In addition, the NRC defines temperature $T_{c1} = 95.36\ ^oF + 0.703\ RT_{NDT}$ which the linear elastic fracture mechanics (LEFM) must be applied. Between the NRC-defined T_{c1} and T_c, although the fracture mode is in transition from LEFM to elastic plastic fracture mechanics (EPFM), users should consider whether it is appropriate to apply the EPFM. Alternatively, a different T_c value may be used if it can be justified by the plant-specific Charpy curves).

- ASME Code Case N-638-7, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [Gas Tungsten Arc Welding] Temper Bead Technique, Section XI," has been incorporated by reference into 10 CFR 50.55a via inclusion in RG 1.147, Revision 19, with a condition (i.e., Demonstration of ultrasonic examination of the repaired volume is required using representative samples that contain construction-type flaws).

3.4 Proposed Alternative

During performance of a routine system leakage test in the refueling outage P2R23, the licensee discovered a leak at the RV instrument penetration nozzle N-16A. The results of combined and spatially-correlated internal and external visual and ultrasonic examinations suggested that the most probable cause of the external leakage identified in nozzle N-16A is a radial-axial-oriented intergranular stress-corrosion cracking (IGSCC) flaw which initiated in the Alloy 182 J-groove weld and propagated through the J-groove weld until it reached a depth where a leak path in the annulus between the nozzle and RV penetration existed. The licensee proposed to repair the degraded 2-inch nozzle N-16A using a half-nozzle method to restore the pressure boundary.

3.5 Basis for Use

To support its repair option, the licensee proposed an alternative to flaw characterization requirements of ASME Code, Section XI, IWB-3420 and IWB-3620(b) and flaw removal requirements of ASME Code, Section XI, IWA-4412 and IWA-4611. In addition, the licensee provided for the NRC review the following information to demonstrate that the structural integrity and leak tightness of repaired nozzle N-16A will be maintained for the duration of one operating cycle.

- An evaluation of the repair design, welding, and nondestructive examination (NDE) to be performed.

- An evaluation of the worst-case flaws left in service in the original J-groove weld that could propagate into the RV shell.

- An evaluation of general corrosion, crevice corrosion, and galvanic corrosion of the RV low-alloy steel that could be exposed to the reactor coolant as a result of the proposed repair method.

3.6 Duration of Proposed Alternative

The licensee's request is applicable to Peach Bottom 2 for the duration of one operating cycle.

4.0 NRC STAFF EVALUATION

The NRC staff evaluated alternative request I5R-14 pursuant to 10 CFR 50.55a(z)(2). The NRC staff focused on whether compliance with the specified requirements of 10 CFR 50.55a(g), or portions thereof, would result in hardship or unusual difficulty, without a compensating increase in the level of quality and safety.

Structural Integrity

In its evaluation, the NRC staff focused on two aspects of the licensee's technical basis which include the half-nozzle repair and examination process to restore the pressure boundary, and the plant-specific analysis (i.e., evaluation of the flaws left in service in the original J-groove weld and corrosion assessment of RV low-alloy steel (LAS)) to demonstrate that the structural integrity of repaired RV instrument penetration nozzle N-16A will be maintained for the duration of one operating cycle. Details of the licensee's plant-specific analyses are documented in non-proprietary Attachments 5, 6, and 7 of I5R-14 dated November 24, 2020 (ADAMS Accession No. ML20329A345).

Half-Nozzle Repair and Examination Process

To restore the pressure boundary, the licensee utilized a "half-nozzle" repair method where a portion of the existing degraded Alloy 600 nozzle N-16A assembly at or near the outside diameter (OD) surface of the RV was replaced with an Alloy 690 nozzle. The repair entailed a temper bead weld buildup (i.e., weld pad) on the OD of the RV using Alloy 52M filler metal in accordance with ASME Code Case N-638-7, and a final partial penetration manual welding between Alloy 690 nozzle and Alloy 52M weld pad using Alloy 52M filler metal. Alloy 690/52M materials are known to be resistant to IGSCC. The remnant of the original Alloy 600 nozzle and Alloy 182 partial penetration attachment weld that contained the flaw were left in place. The sketch of weld pad and other details of repair are documented in the figure in Enclosure 2 of I5R-14. The NRC staff finds that the licensee's half-nozzle repair method is acceptable because it relocates the pressure boundary from inside diameter to OD surface of the RV shell which includes Alloy 52M partial penetration J-groove weld joining Alloy 690 nozzle to Alloy 52M weld pad and the welding and design analysis comply with the ASME Code requirements. In addition, the NRC staff verified that the licensee performed the NDE required as a part of the half-nozzle repair to ensure compliance with the ASME Code, Sections III and XI, and ASME Code Case N-638-7 with the condition in RG 1.147, Revision 19. A brief summary of the repair and NDE performed is as follows:

- Install foreign material exclusion sealing plug, detach piping near reducing coupling, cut the existing Alloy 600 nozzle outboard of the RV, grind the nozzle flush with the RV shell OD surface, and attach the capacitor discharge studs (welding and boring tools) to RV. Then, perform surface and volumetric examinations of the RV shell OD surface in preparation for installing Alloy 52M weld pad.

- Install a weld dam to accommodate for depositing weld pad, deposit the Alloy 52M weld pad in accordance with ASME Code Case N-638-7, perform post weld grinding of the weld pad, and conduct dimensional inspection of weld pad. Then, perform surface and ultrasonic examinations of the weld pad upon completion of 48-hour hold time.

- Remove weld dam, perform final machining of the weld pad bore, perform a dimensional measurement of the final bore. Then, perform surface examination of the final bore.

- Machine replacement Alloy 690 nozzle. Then, perform visual and surface examinations of the replacement Alloy 690 nozzle.

- Weld new reducing coupling to nozzle. Then, perform visual and surface examinations of the reducing coupling-to-nozzle weld.

- Machine J-groove bevel in the weld pad. Then, perform visual and surface examinations of the J-groove bevel.

- Perform installation and welding of the replacement Alloy 690 nozzle. Then, perform a progressive surface examination of J-groove weld joining the replacement Alloy 690 nozzle to the weld pad.

- Remove capacitor discharge studs attached to RV. Then, perform surface examination of RV at the capacitor discharge stud attachment locations.

- Attach piping to new reducing coupling and remove foreign material exclusion sealing plug.

Based on the above, the NRC staff finds that the licensee met the NDE requirements of ASME Code, Sections XI and III, and ASME Code Case N-638-7 with the condition in RG 1.147, Revision 19, as applicable.

Plant Specific Analysis

To demonstrate reasonable assurance of RV structural integrity for one operating cycle following the nozzle repair, the licensee used a plant-specific analytical evaluation based on combination of LEFM and EPFM in accordance with the ASME Code, Section XI requirements, with the assumption that the entire as-left Alloy 182 J-groove attachment weld of Alloy 600 nozzle N-16A is completely cracked and the crack will potentially propagate into the RV LAS base material. The NRC staff finds that the licensee's assumption is conservative on the basis that any "as-left" flaws in the Alloy 182 J-groove weld cannot be characterized with reasonable confidence by the currently available NDE techniques, and this postulated initial flaw bounds any actual indications that have existed in the attachment weld of nozzle N-16A. The licensee further postulated that the preferential direction for crack propagation is radial-axial relative to the nozzle and RV because the hoop stress is determined to be dominant at the J-groove weld location. The stress intensity factors along the postulated crack front were calculated for pressure, residual stress, steady stress thermal and transient conditions. In its evaluation of the licensee's plant-specific analyses, the NRC staff verified that:

- The licensee used a bounding crack growth rate data in BWRVIP-60-A, "BWR Vessel and Internals Project, Evaluation of Stress Corrosion Crack Growth in Low Alloy Steel Vessel Materials in the BWR Environment," to determine cracking into the Peach Bottom's LAS RV material from the service-related degradation. The NRC staff finds that BWRVIP-60-A is an NRC acceptable methodology to use for determination of stress-corrosion cracking (SCC) in RV LAS in BWR environment, thus is adequate for this analysis.

- The licensee utilized a finite element model to obtain the applied stresses in the RV shell at the nozzle J-groove weld location based on bounding design basis transient conditions of normal/upset condition (heat-up/cool-down, loss-of-pump, and single relief)

and emergency/faulted condition (overpressure), and to perform fracture mechanics analysis. The licensee's modeling included the RV LAS base material, remnant of original Alloy 600/182 nozzle and attachment weld, stainless steel cladding, Alloy 52M weld pad, Alloy 690/52M replacement nozzle and attachment weld. Therefore, the NRC staff finds the licensee's finite element model acceptable because appropriate materials, plant-specific configurations, and loading conditions were used.

- In addition to the thermal and pressure stresses, the licensee's analysis included the welding residual stress (WRS) that contributes to the crack driving force. For this analysis, the licensee assumed the magnitude of WRS based on room temperature yield strength of the Alloy 182 J-groove weld material which is reduced by the compressive stress in the RV LAS shell. The reduction of WRS would minimize the potential for the crack, if it exists at the interface between weld and RV, to grow into the RV shell. The NRC staff finds that the licensee's WRS is adequate for this analysis because: (a) the RV was post weld heat treated following welding during fabrication which reduces the WRS, (b) the licensee's calculation has shown that magnitude of WRS is reduced by the compressive stress in the RV shell, and (c) similar WRS estimation was previously accepted by the NRC in Quad Cities Nuclear Power Station's request dated April 6, 2012 (ADAMS Accession No. ML12100A012), and Limerick Generating Station's request dated May 15, 2017 (ADAMS Accession No. ML17135A423).

- In its fracture mechanics analysis, the licensee utilized the screening criteria in ASME Code Case N-749 with the condition in RG 1.147, Revision 19, to determine acceptability of flaw in the RV LAS when the metal temperature is in the upper shelf range. The screening criteria is: (a) use EPFM method of analysis if the metal temperature exceeds the NRC-defined temperature T_c, (b) use LEFM method of analysis if the metal temperature drops below the NRC-defined temperature T_{c1}, and (c) for metal temperature between T_c and T_{c1}, assess suitability of using EPFM since the fracture mode is in transition from LEFM to EPFM. The NRC staff verified that the ASME Code required acceptance criteria for LEFM and EPFM are satisfied; therefore, the repaired instrumentation nozzle N-16A is acceptable for one operating cycle.

Corrosion Evaluation of RV LAS Base Material

In its review, the NRC staff assessed the licensee's corrosion analysis of the portion of the Peach Bottom 2's RV LAS base metal exposed to the boiler-water reactor (BWR) water environment as a result of the half-nozzle repair of nozzle N-16A. The possible corrosion mechanisms for LAS in BWR environment are known to be general corrosion, galvanic corrosion, crevice corrosion, and SCC. The licensee calculated the general corrosion rate on a per year basis for LAS based on bounding laboratory testing data and showed that the total surface corrosion of LAS at the exposed location for one operating cycle following nozzle repair would be very low. The licensee also addressed the crevice corrosion, galvanic corrosion, and SCC susceptibly of LAS, and determined that their rates are not significant for one operating cycle following the nozzle repair. The NRC staff finds the licensee's assertion that the SCC is not a concern for one operating cycle acceptable because of low corrosion rate of the LAS as well as the implementation of industry standard corrosion mitigate program at Peach Bottom 2 (e.g., on-line noble metal chemical addition with hydrogen water chemistry).

Hardship Justification

The NRC staff finds the licensee's hardship justification is acceptable because performing the repair in accordance with the ASME Code, Section XI would result in an increased radiological exposure, and there exists a potential risk of loose parts or foreign materials accidentally getting into the RV during the ASME Code repair. Therefore, the NRC staff determines that concerns from the foreign material falling into the RV and an as low as is reasonably achievable criteria for radiological exposure support the licensee's hardship justification.

In summary, the NRC staff finds the licensee's plant-specific analysis acceptable because a conservative initial flaw is assumed, and the flaw evaluation has demonstrated that the initial flaw will not grow to an unacceptable depth into the RV LAS base material over one operating cycle. Furthermore, the impact on RV LAS from exposure to BWR water environment is determined to be low. As a result, the staff finds that the licensee's proposed alternative provides reasonable assurance of the RV structural integrity for the duration of one operating cycle.

5.0 CONCLUSION

As set forth above, the NRC staff has determined that complying with the specified requirements described in the licensee's relief request I5R-14 would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The proposed alternative provides reasonable assurance of structural integrity and leak tightness of the RV instrument penetration nozzle N-16A. The NRC staff concludes that the licensee has adequately addressed the regulatory requirements set forth in 10 CFR 50.55a(z)(2). Therefore, the NRC staff authorizes use of proposed alternative I5R-14 at Peach Bottom 2, for the duration of one operating cycle.

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

Principal Contributor: A. Rezai, NRR

Date: April 23, 2021

SUBJECT: PEACH BOTTOM ATOMIC POWER STATION UNIT NO. 2 – APPROVAL OF ONE-TIME ALTERNATIVE TO FLAW CHARACTERIZATION AND REMOVAL REQUIREMENTS FOR N-16A NOZZLE (EPID L-2020-LLR-0144) DATED APRIL 23, 2021

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