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

September 9, 2020

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: BYRON STATION, UNIT NO. 2, RELIEF FROM THE REQUIREMENTS OF THE ASME CODE [COVID-19] (EPID L-2020-LLR-0098)

Dear Mr. Hanson:

By letter dated July 17, 2020 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML20199M304), Exelon Generating Company, LLC (the licensee) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) for the use of an alternative to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, requirements at Byron Station (Byron), Unit No. 2.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(2), the licensee requested to use the proposed alternative on the basis that the specified requirements would result in hardship or unusual difficulty without a compensating increase in the 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 alternative provides reasonable assurance that the integrity of the subject components is maintained and that complying with the requirement would result in hardship or unusual difficulty without a compensating increase in the 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)(2). Therefore, the NRC staff authorizes the use of the proposed alternative I4R-17 at Byron, Unit No. 2, for the duration of the next Byron, Unit No. 2, operating cycle until the spring 2022 refueling outage.

All other requirements of 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 In-service Inspector.

If you have any questions, please contact the Project Manager, Joel S. Wiebe at 301-415-6606 or via e-mail at Joel.Wiebe@nrc.gov.

Sincerely,

Nancy L. Salgado

Digitally signed by Nancy L. Salgado
Date: 2020.09.09 08:49:52 -04'00'

Nancy L. Salgado, Chief
Plant Licensing Branch III
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. STN 50-455

Enclosure:
Safety Evaluation

cc: Listserv

UNITED STATES
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SAFETY EVALUATION BY THE OFFICE NUCLEAR REGULATION

RELIEF REQUEST I4R-17 REGARDING

ALTERNATIVE FOLLOW-UP INSPECTIONS FOR

REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES

EXELON GENERATION COMPANY, LLC

BYRON STATION, UNIT NO. 2

DOCKET NO. 50-455

1.0 INTRODUCTION

By letter dated July 17, 2020 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML20199M304), Exelon Generating Company, LLC (the licensee) requested to use alternative I4R-17 for follow-up inspections of peening-applied reactor vessel head (RPV) penetration nozzles at Byron Station (Byron), Unit No. 2.

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

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(g)(6)(ii), the Nuclear Regulatory Commission (NRC or Commission) may require the licensee to follow an augmented inservice inspection (ISI) program for systems and components for which the NRC deems that added assurance of structural reliability is necessary.

Regulation 10 CFR 50.55a(g)(6)(ii)(D), "Reactor Vessel Head Inspections," requires licensees of pressurized water reactors (PWRs) to augment their ISI of the reactor vessel head with ASME Code Case N-729-6, "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads With Nozzles Having Pressure-Retaining Partial-Penetration Welds, Section XI, Division 1," with conditions.

Paragraph (z)(2) of 10 CFR 50.55a, states, in part, that alternatives to the requirements of 10 CFR 50.55a(g) may be used when authorized by the NRC if the licensee demonstrates compliance with the specified requirements 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 proposed alternative.

3.0 TECHNICAL EVALUATION

3.1 ASME Code Components Affected

The subject components are ASME Code Class 1, reactor pressure vessel head penetration nozzles (RPVHPN) that have pressure-retaining, partial-penetration J-groove welds. These nozzles are ASME Code Case N-729-6, Item B4.20, components fabricated with Alloy 600/82/182 materials. Peening was applied on the nozzles for mitigation against potential primary stress corrosion cracking (PWSCC) in accordance with the guidance in Electric Power Research Institute (EPRI) Report, MRP-335, Revision 3-A, "Materials Reliability Program: Topical Report for Primary Water Stress Corrosion Cracking Mitigation by Surface Stress Improvement."

3.2 Applicable ASME Code Edition and Addenda

The current code of record for the fourth ISI interval of Byron, Unit No. 2, is the 2007 Edition, including the 2008 Addenda, of ASME Code, Section XI. Examinations of the subject nozzles are performed in accordance with 10 CFR 50.55a(g)(6)(ii)(D), which specifies the use of ASME Code Case N-729-6 with conditions.

3.3 Applicable Code Requirements

By NRC safety evaluation, dated February 25, 2019 (ADAMS Accession No. ML19035A294), the NRC authorized the licensee's alternative volumetric examination of the Byron, Unit No. 2, RPVHPNs during the fall 2020 refueling outage (RFO) (B2R22). In addition, the licensee is required to perform ISI on the subject nozzles every 10 years, thereafter.

3.4 Licensee's Proposed Alternative

The licensee is proposing an alternative to defer the volumetric examination of the Byron, Unit No. 2, RPVHPNs to the next RFO (B2R23), which is scheduled in spring 2022. After this deferral, the approved volumetric examination frequency of once per inspection interval (nominally 10 calendar years) per MRP-335, Revision 3-A, Table 4-3, Item No. B4.60, will be followed.

3.5 Licensee's Basis

Due to the hardship presented by the Coronavirus-2019 (COVID-19) pandemic and resulting Public Health Emergency (PHE), the licensee requested approval for a one-time deferral of the next required volumetric examination of the subject RPVHPNs from the fall 2020 RFO to the following RFO in spring 2022. The licensee explained that performance of a volumetric examination during the fall 2020 RFO would result in a hardship without a compensating increase in the level of quality and safety in accordance with 10 CFR 50.55a(z)(2).

The licensee explained that the hardship is due to expected challenges with obtaining and maintaining staffing levels sufficient for the examination during the fall 2020 RFO. It reasoned that deferral of this examination would also reduce the risk of exposure (reduced personnel on

site and personnel physical distancing) for critical contract and direct hire personnel to COVID-19. The licensee supported their safety assessment based on crack growth analyses, assessments of the implications of previous indications of cracking that were repaired, direct visual examinations (VE) for evidence of leakage, and online leak detection capability.

3.6 Duration of the Proposed Alternative

The proposed alternative is requested for the duration of the next Byron, Unit No. 2, operating cycle, until the spring 2022 RFO (B2R23). After performing the volumetric examination in B2R23, the approved frequency of in-service inspections per 10 CFR 50.55a(g)(6)(ii)(D) and MRP-335, Revision 3-A, would resume.

3.7 NRC Staff Evaluation

The NRC staff has reviewed and evaluated the licensee's request on the basis that compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The licensee provided the following basis for hardship associated with performing the follow-up examinations during the PHE.

- The licensee does not have the internal capability and equipment to perform the volumetric examinations of the subject RPVHPNs. Therefore, twenty-four individuals from across the U.S. are required to mobilize on-site to support the volumetric examination of the subject RPVHPNs.

- The licensee also noted that the nature of the work prevents meeting the United States Center for Disease Control recommendations for social distancing by maintaining at least six feet from other personnel to limit the spread of COVID-19.

The NRC staff reviewed the licensee's hardship basis and has found the PHE to be a hardship for the additional workers, the plant staff personnel, and the public around the plant who could be exposed to additional risk of infection. The NRC staff reviewed the licensee's documented options to address these issues, including remote tooling, optional technology, and the lack of qualified personnel. The NRC staff finds that the licensee took all reasonable steps to evaluate possible alternatives and finds the licensee's evaluation of alternative options adequate to identify the hardship. Therefore, the NRC staff finds the licensee meets the hardship requirement of 10 CFR 50.55a(z)(2).

The NRC staff reviewed the level of quality and safety of the licensee's proposed alternative that the examinations of the subject RPVHPNs be delayed for one cycle of operation. The licensee provided supporting basis though a flaw analysis, prior volumetric and bare metal visual examination results and defense-in-depth actions including non-destructive examinations during the fall 2020 RFO and subsequent cycle of operation. The NRC staff reviewed each of these factors in evaluating the level of quality and safety in the licensee's proposed alternative.

The NRC staff notes that the degradation mechanism of concern is leakage of primary coolant containing boric acid from the RPVHPN and/or associated J-groove weld. This leakage can cause two issues to challenge the structural integrity of the reactor coolant pressure boundary of the RPV head or nozzles. The first challenge is circumferential cracking, and thereby ejection, of a penetration nozzle from the RPV head. This could cause a small break loss of coolant accident or control rod misalignment. The second challenge is that the leakage could cause boric acid corrosion of the low alloy steel material that comprises the bulk thickness of the RPV

head. Boric acid corrosion rates of low alloy steel could be up to 6 inches/year under very severe conditions as discussed in NRC report, NUREG/CR-6875, “Boric Acid Corrosion of Light Water Reactor Pressure Vessel Materials,” J.-H. Park, O. K. Chopra, K. Natesan, and W. J. Shack; July 2005 (ADAMS Accession No. ML052360563). After sufficient corrosion, a small or medium break loss of coolant accident could occur. To prevent significant degradation in RPV heads and penetration nozzles, 10 CFR 50.55a(g)(6)(ii)(D) requires an inspection program for these components, including volumetric examinations and bare metal visual examinations. The NRC staff further notes that the licensee applied peening on the subject nozzles and associated J-groove weld surfaces, in accordance with MRP-335, Revision 3-A, to mitigate against PWSCC initiation in the components.

The licensee provided technical information regarding crack growth calculations for hypothetical flaws and evaluations of previously-detected flaws in their submittal. The NRC staff reviewed the information and determined that the crack growth analyses were based on conservative assumptions and industry-wide crack size measurement data applicable for Byron, Unit No. 2. The licensee’s analysis includes a matrix of deterministic PWSCC crack growth calculations. The matrix considers various crack growth cases that involve different initial crack sizes, crack aspect ratios, operating temperatures and severity levels of stress profiles. The crack growth analysis discusses the effectiveness of follow-up volumetric examination to monitor pressure boundary leakage of the nozzles. The licensee’s analysis further estimates the growth of hypothetical, shallow PWSCC cracks. The licensee’s evaluation indicated that extending the currently approved examination schedule by one cycle of operation would result in a very low fraction of cases that would cause nozzle leakage.

The NRC staff reviewed the licensee’s assessment and determined that it is reasonable. The NRC staff notes that leakage is required to establish the necessary environmental conditions for circumferential cracking of the nozzle above the J-groove weld or boric acid corrosion of the low alloy steel RPV head. Therefore, additional time would be required to initiate and grow a circumferential crack in the nozzle material above the J-groove weld or produce sufficient boric acid corrosion of the upper head material to challenge the structural integrity of the RPV head. The NRC staff notes that while the possibility of leakage from a nozzle or J-groove weld cannot be completely discounted, the time necessary for any such hypothetical leakage can be evaluated to determine the potential to challenge structural integrity of the RPV head or nozzle.

The NRC staff performed a series of independent evaluations to verify the licensee’s assessment. Based on MRP-335, Revision 3-A , the NRC staff determined that there is reasonable assurance that the prior peening prevents new crack initiation. The NRC staff also determined that the bare metal visual examination of the RPV head to be performed during the fall 2020 outage ensures no active indication of nozzle leakage, at that time. The NRC staff’s independent evaluations found some cases of crack growth and specific weld residual stress profiles where leakage could result if the examination frequency was increased by one cycle of operation. However, the NRC staff evaluations showed insufficient time, after hypothetical leakage could occur either in the nozzle or J-groove weld, for these cases to allow leakage to challenge the structural integrity of the RPV head. The NRC staff bases this conclusion on the need for additional circumferential crack growth for nozzle ejection or the leaking flaw to grow to allow leakage rates to cause boric acid corrosion rates identified in NUREG/CR-6875. Therefore, the NRC staff determined that the conclusions of the licensee’s assessment are reasonable.

The NRC staff also noted that the licensee had performed the volumetric examination of the Braidwood Station (Braidwood), Unit 1, RPVHPNs during the plant’s spring 2020 RFO. During

this examination of RPVHPNs of similar manufacture and operating temperature conditions, no new indications of PWSCC were identified in the nozzles. Further, no indications of leakage were found through the J-groove weld by the volumetric leak path examination. The NRC staff determined that these examination results provide statistical results that indicate the margin of the postulated flaw analyses performed by the licensee and NRC are conservative.

The NRC staff further assessed the adequacy of the defense-in-depth of the licensee's examination and monitoring requirements to evaluate the structural integrity of the upper head and nozzles. The NRC staff notes the licensee confirmed that a bare metal visual examination has been and will be performed on each nozzle for evidence of pressure boundary leakage every refueling outage in accordance with MRP-335, Revision 3-A. The NRC staff finds that the visual examination is an effective defense-in-depth inspection. The NRC staff also notes that technical specifications of Byron, Unit No. 2, requires operational leakage monitoring, which includes containment sump monitoring and atmosphere radioactivity monitoring. The NRC staff finds that the history of no indication of cracking or leakage at either Braidwood, Unit 1, or Byron, Unit No. 2, the bare metal visual examination of the nozzles at Byron, Unit No. 2, during the fall 2020 RFO, and the ongoing leakage monitoring program at Byron, Unit No. 2, during the additional cycle of operation, provide effective defense-in-depth basis to ensure the structural integrity of the RPV head and nozzles at Byron, Unit No. 2, for the period of the licensee's proposed alternative. The NRC staff also notes that if any leakage from a nozzle is identified, it would be required to be repaired and the examination requirements of 10 CFR 50.55a(g)(6)(ii)(D) would be implemented.

Given the licensee's identified hardship, the NRC staff finds that the licensee has provided an adequate technical basis to extend the follow-up volumetric examination of the subject RPVHPNs for one operating cycle. The NRC staff also finds that the defense-in-depth bare metal visual examination, along with operational leakage monitoring, provides reasonable assurance that the structural integrity of the RPV head and nozzles are maintained, and that complying with the current volumetric examination requirement in the fall of 2020 would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

4.0 CONCLUSION

The NRC staff determines that the proposed alternative provides reasonable assurance of the integrity of the subject components and that complying with the requirement would result in hardship or unusual difficulty without a compensating increase in the 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)(2). Therefore, the NRC staff authorizes the use of the proposed alternative I4R-17 at Byron, Unit No. 2, for the duration of the next operating cycle until the spring 2022 refueling outage.

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. Collins, NRR/DNLR/NPHP

Date of Issuance: September 9, 2020

SUBJECT: BYRON STATION, UNIT NO. 2, RELIEF FROM THE REQUIREMENTS OF THE ASME CODE [COVID-19] (EPID L-2020-LLR-0098) DATED SEPTEMBER 9, 2020

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