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

March 8, 2021

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

SUBJECT: BRAIDWOOD STATION, UNIT 1 – RELIEF FROM THE REQUIREMENTS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS CODE [COVID-19] (EPID L-2021-LLR-0006)

Dear Mr. Rhoades:

By letter dated January 25, 2021 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21025A417), Exelon Generation Company, LLC (Exelon, the licensee), 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 Braidwood Station (Braidwood), Unit 1.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(2), the licensee requested to use an alternative on the basis that complying with the specified requirement would result in hardship or unusual difficulty due to the hardship presented by the Coronavirus-2019 (COVID-19) pandemic and resulting public health emergency.

The NRC staff has reviewed the subject request and concludes, as set forth in the enclosed safety evaluation, that complying with the specified requirements described in the licensee's request referenced above would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety and the proposed alternative provides reasonable assurance of structural integrity of the subject components. The NRC staff therefore concludes that the licensee has adequately addressed the regulatory requirements set forth in 10 CFR 50.55a(z)(2).

Therefore, the NRC staff authorizes the use of relief request I4R-13 for the fourth inservice inspection interval at Braidwood, Unit 1, currently scheduled to start on August 29, 2018, and end on July 28, 2028.

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 Inservice Inspector.

If you have any questions, please contact the Project Manager, Joel 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: 2021.03.08 11:55:50 -05'00'

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

Docket No. 50-456

Enclosure:
Safety Evaluation

cc: ListServ

SUBJECT: BRAIDWOOD STATION, UNIT 1 – RELIEF FROM THE REQUIREMENTS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS CODE (EPID L-2021-LLR-0006) DATED MARCH 8, 2021

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BRAIDWOOD, UNIT 1 – AUTHORIZATION AND SAFETY EVALUATION FOR ALTERNATIVE REQUEST NO. I4R-13 (EPID L-2021-LLR-0006)

LICENSEE INFORMATION

Licensee:	Exelon Generation Company, LLC
Plant Name(s) and Unit(s):	Braidwood Station, Unit 1
Docket No(s).:	50-456

APPLICATION INFORMATION

Submittal Date: January 25, 2021

Submittal Agencywide Documents Access and Management System (ADAMS) Accession No.: ML21025A417

Applicable Inservice Inspection (ISI) or Inservice Testing (IST) Program Interval and Interval Start/End Dates: The fourth 10-year ISI Interval, starting August 29, 2018, and ending July 28, 2028.

Alternative Provision: The applicant requested an alternative under Title 10 of the *Code of Federal Regulations* (10 CFR), paragraph 50.55a(z)(2).

ISI or IST Requirement: 10 CFR 50.55a(g)(6)(ii)(D), which specifies the use of American Society of Mechanical Engineers Boiler and Pressure Vessel (ASME Code) Case N-729-6, "Alternative Examination Requirements for [pressurized water reactor] PWR Reactor Vessel Upper Heads With Nozzles Having Pressure-Retaining Partial-Penetration Welds, Section XI, Division 1," with conditions.

Applicable Code Edition and Addenda: 2013 Edition of ASME Code, Section XI

Brief Description of the Proposed Alternative: The licensee is proposing an alternative to defer the volumetric examination of the Braidwood Station (Braidwood), Unit 1, reactor pressure vessel head penetration nozzles (RPVHPNs) to the next scheduled refueling outage (RFO), which is A1R23, scheduled in fall 2022. After this deferral, the approved volumetric examination frequency of once per inspection interval (nominally ten calendar years) per 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," Table 4-3, Item No. B4.60, will be followed.

The licensee explained the request was due to the hardship presented by the Coronavirus-2019 (COVID-19) pandemic and resulting public health emergency (PHE). The licensee explained

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that performance of a volumetric examination during the spring 2021 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).

For additional details on the licensee's request, please refer to the documents located at the ADAMS Accession No. identified above.

STAFF EVALUATION

The U.S. Nuclear Regulatory Commission (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, 24 individuals from across the U.S. [United States] 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 from spread of COVID-19. 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 spring 2021 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 RPVHPNs 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 primary water stress corrosion cracking (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 letter dated January 25, 2021. 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 Braidwood, Unit 1. 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 prior peening of the Braidwood, Unit 1, nozzles will mitigate new crack initiation. The NRC staff also determined that the bare metal visual examination of the RPV head to be performed during the spring 2021 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 Byron Station (Byron), Unit No. 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 additional assurance that indicates 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 Braidwood, Unit 1, require 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 of the peened RPVHPNs at Byron, Unit No. 1, the bare metal visual examination of the nozzles at Braidwood, Unit 1, during the spring 2021 RFO, and the ongoing leakage monitoring program at Braidwood, Unit 1, during the additional cycle of operation provide effective defense-in-depth basis to ensure the structural integrity of the RPV head and nozzles at Braidwood, Unit 1, 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 spring of 2021, under the COVID-19 pandemic, would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

CONCLUSION

The NRC staff has determined that complying with the specified requirements described in the licensee's request referenced above would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety, and the proposed alternative provides reasonable assurance of structural integrity of the subject components.

The NRC staff therefore concludes that the licensee has adequately addressed the regulatory requirements set forth in 10 CFR 50.55a(z)(2).

The NRC staff authorizes the use of proposed alternative I4R-13 at Braidwood, Unit 1, to extend the follow-up volumetric examination of the subject RPVHPNs for one operating cycle from the spring 2021 scheduled refueling outage, A1R22 until the next scheduled refueling outage in fall 2022, A1R23.

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: Jay Collins

Date: March 8, 2021