



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

April 20, 2020

Mr. Eric Carr
President and Chief Nuclear Officer
PSEG Nuclear LLC - N09
P.O. Box 236
Hancocks Bridge, NJ 08038

SUBJECT: SALEM NUCLEAR GENERATING STATION, UNIT NO. 1 – ISSUANCE OF
ALTERNATIVE REQUEST S1-I4R-191 FOR THE FOURTH 10-YEAR
INSERVICE INSPECTION INTERVAL (EPID L-2019-LLR-0091)

Dear Mr. Carr:

By letter dated September 10, 2019 (Agencywide Documents Access and Management System Accession ML19253B670), PSEG Nuclear LLC (the licensee) requested an alternative to certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI. In Relief Request S1-I4R-191, the licensee proposed to delay the volumetric and/or surface inservice inspection (ISI) of the reactor vessel closure head (RVCH) nozzles and dissimilar metal (DM) J-groove welds at the Salem Nuclear Generating Station (Salem), Unit No. 1.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee proposed an alternative volumetric and/or surface examination frequency for the subject RVCH nozzles and DM J-groove welds on the basis that the alternative provides an acceptable level of quality and safety.

The U.S Nuclear Regulatory Commission (NRC) staff has reviewed the subject request and determines that the proposed alternative provides an acceptable level of quality and safety for the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds by providing reasonable assurance that the structural integrity of the subject RVCH will be maintained. 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). Therefore, the NRC staff authorizes the use of Relief Request S1-I4R-191 at Salem, Unit No. 1, for the remainder of the fourth 10-year ISI interval up to, and including, the November 2025 refueling outage in the fifth 10-year ISI interval.

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

E. Carr

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If you have any questions, please contact the Salem Project Manager, James Kim, at 301-415-4125 or by e-mail to James.Kim@nrc.gov.

Sincerely,

/RA/

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

Docket No. 50-272

Enclosure:
Safety Evaluation

cc: Listserv



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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATIVE REQUEST S1-I4R-191 FOR

FOURTH 10-YEAR INTERVAL INSERVICE INSPECTION

SALEM NUCLEAR GENERATING STATION, UNIT NO. 1

PSEG NUCLEAR LLC

EXELON GENERATION COMPANY, LLC

DOCKET NO. 50-272

1.0 INTRODUCTION

By letter dated September 10, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession ML19253B670), PSEG Nuclear LLC (the licensee) requested an alternative to certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI. In Relief Request S1-I4R-191, the licensee proposed to delay the volumetric and/or surface inservice inspection (ISI) of the reactor vessel closure head (RVCH) nozzles and dissimilar metal (DM) J-groove welds at the Salem Generating Station (Salem), Unit No. 1.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee proposed an alternative volumetric and/or surface examination frequency for the subject RVCH nozzles and DM J-groove welds on the basis that the alternative provides an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(g)(6)(ii)(D), holders of operating licenses or combined licenses for pressurized-water-reactors (PWRs), as of August 17, 2017, shall implement the requirements of ASME Code Case N-729-4, "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads with Nozzles Having Pressure-Retaining Partial-Penetration Welds Section XI," instead of ASME Code Case N-729-1, subject to the conditions specified in paragraphs (g)(6)(ii)(D)(2) through (4) of Section 50.55a, by the first refueling outage after August 17, 2017.

Pursuant to 10 CFR 50.55a(z), alternatives to the requirements of paragraph (b) through (h) of Section 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 licensee must demonstrate that (1) the proposed alternative would provide an acceptable level of quality and safety or (2) compliance with the specified requirements of

10 CFR 50.55a 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 U.S. Nuclear Regulatory Commission (NRC) staff finds that regulatory authority exists for the licensee to request, and the NRC to authorize, the alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 Background

By letter dated December 24, 2015 (ADAMS Accession ML15349A956), the NRC approved Relief Request S1-I4R-150 (ADAMS Accession ML15098A426) for Salem, Unit No. 1, authorizing the licensee to perform the volumetric and/or surface examination of the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds in nominally 15 calendar years in the fall 2020 refueling outage (1R27) instead of the spring 2016 refueling outage (1R24), as required by 10 CFR 50.55a(g)(6)(ii)(D).

3.2 Components Affected

ASME Code Class 1 RVCH nozzles and DM J-groove welds are affected. In accordance with Table 1 of ASME Code Case N-729-4, the licensee classified the RVCH nozzles and the DM J-groove welds in this relief request as Item B4.40.

The licensee stated that the current RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds entered service in the unit's November 2005 refueling outage. The current RVCH was manufactured as a single forging, which eliminated several welds, including the flange-to-head weld. The materials of construction of current RVCH base material are SA-508, Grade 3, Class 1 low alloy steel clad with an initial layer of 309L stainless steel and subsequent layers of 308L stainless steel. The nozzles are Inconel SB-167 (UNS N06690) attached to the RVCH with J-groove welds made of ERNiCrFe-7 (UNS N06052) and ENiCrFe-7 (UNS W86152) weld metals. Alloy 690/52/152 materials are known to be less susceptible to the primary water stress corrosion cracking (PWSCC) than Alloy 600/82/182.

The licensee stated that the RVCH is exposed to the normal operating temperature of 597.2 degrees Fahrenheit (°F).

3.3 Applicable Code Edition and Addenda

The code of record for the fourth 10-year ISI interval is the 2004 Edition and no addenda of the ASME Code.

3.4 Duration of Relief Request

The licensee submitted S1-I4R-191 for the remainder of the fourth 10-year ISI interval up to, and including, the November 2025 refueling outage in the fifth 10-year ISI interval. The fourth 10-year ISI interval began on May 20, 2011, and is scheduled to end on December 31, 2020. The fifth 10-year ISI interval is scheduled to begin on January 1, 2021, and end on December 31, 2031.

3.5 ASME Code Requirement

In accordance with 10 CFR 50.55a(g)(6)(ii)(D), the NRC has mandated an augmented inspection for the RVCH nozzles and the DM J-groove welds to implement the requirements of ASME Code Case N-729-4 with conditions specified in paragraphs (g)(6)(ii)(D)(2) through (4) of Section 50.55a.

In accordance with Table 1 in Code Case N-729-4, the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds classified as Item B4.40 shall be subjected to volumetric and/or surface examination every inspection interval (i.e., nominally 10 calendar years).

3.6 Proposed Alternative

The licensee proposed to delay the volumetric and/or surface examination of the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds. The proposed alternative is to perform the volumetric and/or surface examination of the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds in the November 2025 refueling outage, which is nominally 20 calendar years from the November 2005 refueling outage.

3.7 Basis for Use of Alternative

As discussed below, the licensee's basis for the proposed alternative relies on (1) acceptable results from prior inspections of the subject RVCH, (2) the Code Case N-729-4 required frequency of inspection for the subject RVCH is based on the PWSCC growth rates for Alloy 600/82/182 materials, and (3) the plant-specific factor of improvement (FOI) analysis for Alloy 690/52/152 materials.

3.7.1 Prior Inspections of Subject RVCH

The licensee stated that the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds has been in service at Salem, Unit No. 1, since November 2005. A history of the licensee's inspection activities on the subject RVCH is summarized below:

- Preservice or baseline volumetric examination of the subject RVCH, as mandated by 10 CFR 50.55a(g)(6)(ii)(D) with conditions.
- Bare-metal visual examination (VE) of the subject RVCH in 2010, 2013, and 2017, as mandated by 10 CFR 50.55a(g)(6)(ii)(D) with conditions.
- VE (VT-2) of the subject RVCH, as mandated by 10 CFR 50.55a(g)(6)(ii)(D) with conditions.
- The subject RVCH will continue to receive the required bare-metal VE and VT-2 in the remainder of the fourth 10-year ISI interval and the fifth 10-year ISI interval.

The licensee stated that the examinations performed did not identify any unacceptable indications or any evidence of streaking and precipitation of white crystals of boric acid on the outer surface of the RVCH, including the annulus area of the nozzles that would be indicative of nozzle leakage.

3.7.2 Code Case N-729-4 Required Frequency of Inspection for Subject RVCH

The licensee asserted that the Code Case N-729-4 required frequency of inspection for RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds was conservatively assigned based, in part, on reinspection years equal to 2.25, which is derived from the crack growth rate

curve for PWSCC of Alloy 600/82/182 materials contained in Electric Power Research Institute Materials Reliability Program (MRP)-55, "Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick-Wall Alloy 600 Material," and MRP-115, "Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Alloy 82, 182, and 132 Welds."

To date, the PWSCC growth rates for Alloy 690/52/152 materials are significantly lower than Alloy 600/82/182, and therefore, the augmented inspection of the subject RVCH merits a longer inspection interval. The licensee's assertion is based on (a) no cracking has been observed in other Alloy 690/52/152 components such as steam generators and pressurizers in more than 20 years of service; (b) no cracking has been identified by the examinations performed on the existing RVCHs with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds, including the ones that operate at higher temperatures than the RVCH at Salem, Unit No.1; (c) the similarity of configuration, manufacturing, design, and operating conditions of the existing RVCHs with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds to the RVCH at Salem, Unit No. 1; and (d) laboratory test data for Alloy 690/52/152. as contained in MRP-375, "Technical Basis for Reexamination Interval Extension for Alloy 690 PWR Reactor Vessel Top Head Penetration Nozzles," and MRP-386, "Recommended Factors of Improvement for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) Growth Rates of Thick-Wall Alloy 690 Materials and Alloy 52, 152, and Variants Welds," showed substantially improved resistance to the PWSCC initiation and growth.

The licensee stated that the evaluations performed in MRP-375 and MRP-386 considered an FOI approach to assess the increased resistance of Alloy 690/52/152 compared to Alloy 600/82/182 at equivalent temperatures and stress conditions. Results from both crack initiation and crack growth rates data concluded that Alloy 690/52/152 materials have a higher resistance to PWSCC than Alloy 600/82/182 materials; thus, use of significantly higher FOI is recommended. Therefore, the licensee based its proposed inspection interval extension on the plant service experience and FOI studies using laboratory data.

3.7.3 Plant-Specific FOI Analysis for Subject RVCH

Additional support for the acceptability of extending the inspection interval for the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds is contained in the plant-specific FOI analysis, as documented in Relief Request S1-I4R-191. The licensee calculated a plant-specific FOI by using the actual temperature of the RVCH at Salem, Unit No. 1, and conservatively assuming calendar years to be equal to effective full power years. Based on this calculation, the licensee showed that a minimum FOI of 8.28 in the crack growth rate was acceptable to justify the proposed inspection interval by comparing the available crack growth rate curves of Alloy 600/82/182 materials to the available crack growth rate data for Alloy 690/52/152 materials. The licensee concluded that the use of an FOI of 8.28 would not result in a reduction in safety, and therefore, was justified.

3.8 NRC Staff Evaluation

The NRC staff has evaluated Relief Request S1-I4R-191 pursuant to 10 CFR 50.55a(z)(1). The NRC staff focused on whether the proposed alternative (i.e., accepting deferral of the volumetric and/or surface examinations for the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds from fall 2020 until November 2025) provides an acceptable level of quality and safety. To reach a conclusion, the NRC staff performed an independent confirmatory evaluation of the proposed FOI between Alloy 690/52/152 and Alloy 600/82/182 materials that justifies the

extension of volumetric and/or surface inspection interval for the subject RVCH nozzles and DM J-groove welds.

3.8.1 Staff's Independent Assessment

The licensee determined that an extension of inspection interval to nominally 20 calendar years was justified by an FOI of 8.28, which bounds the available Alloy 690/52/152 crack growth rate data in MRP-375 and MRP-386. Alternatively, the NRC staff relies upon available Alloy 690/52/152 crack growth rate data from two NRC contractors, Pacific Northwest National Laboratory (PNNL) and Argonne National Laboratory (ANL). The NRC data (documented in ADAMS Accession No. ML14322A587), generally supports the contention that the crack growth rate of Alloy 690/52/152 is lower than Alloy 600/82/182 but differs from MRP-375 and MRP-386 in some respects.

The NRC staff independently verified that the proposed inspection interval is reasonably bounded by the application of the FOI of 8.28. The NRC staff also determined that the application of FOI of 8.28 bounds essentially all of the NRC data included in the PNNL and ANL data summary report. Therefore, the NRC staff finds the licensee's proposed alternative acceptable and that the structural integrity of the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds would be maintained through the period of the proposed volumetric and/or surface inspection extension. The NRC staff also finds that the proposed inspection interval does not pose a higher risk than the inspection interval for an RVCH with Alloy 600/82/182 nozzles and DM J-groove welds.

3.8.2 Bare Metal Visual Examination (VE)

In addition, the NRC staff finds that performance of bare-metal VE in accordance with ASME Code Case N-729-4 every third refueling outage, or 5 calendar years, whichever is less, will monitor the nozzle leaktightness, thereby providing added confidence that the structural integrity of the RVCH nozzles and DM J-groove welds will be maintained through the period of the proposed volumetric and/or surface inspection extension.

Based on the above assessments, the NRC staff concludes that there is reasonable assurance that the licensee's proposed alternative has a minimal, if any, impact on safety. The proposed alternative provides an acceptable level of quality and safety.

4.0 CONCLUSION

As set forth above, the NRC staff determines that the proposed alternative provides an acceptable level of quality and safety for the RVCH with Alloy 690 nozzles and Alloy 52/152 DM J-groove welds by providing reasonable assurance that the structural integrity of the subject RVCH will be maintained. 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). Therefore, the NRC staff authorizes the use of Relief Request S1-I4R-191 at Salem, Unit No. 1, for the remainder of the fourth 10-year ISI interval up to, and including, the November 2025 refueling outage in the fifth 10-year ISI interval.

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

Principal Contributor: A. Rezai

Date: April 20, 2020

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