



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

April 13, 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 NOS. 1 AND 2 –  
ALTERNATIVE REQUEST SC-I4R-190 FOR THE FOURTH 10-YEAR  
INSERVICE INSPECTION INTERVAL (EPID L-2019-LLR-0089)

Dear Mr. Carr:

By letter dated September 11, 2019 (Agencywide Documents Access and Management System Accession No. ML19254A590), PSEG Nuclear LLC (the licensee) requested relief from the requirements of the American Society of the Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (B&PV Code) for Salem Generating Station, Unit Nos. 1 and 2 (Salem). The licensee's proposed alternative, SC-I4R-190, requests to eliminate the volumetric examination of the reactor pressure vessel threads in flange during the fourth inservice inspection (ISI) interval at Salem.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee requested to use the proposed alternative in request SC-I4R-190 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 concludes that for alternative request SC-I4R-190 for Salem, the proposed alternative provides an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all the regulatory requirements set forth in 10 CFR 50.55a(z)(1) for alternative request. Therefore, the NRC staff authorizes the use of alternative request SC-I4R-190 to eliminate the volumetric examination of the reactor pressure vessel threads in flange for the duration of the fourth 10-year ISI interval at Salem.

The fourth ISI interval for Salem, Unit No. 1, began on May 20, 2011, and is scheduled to end on December 31, 2020. The fourth ISI interval for Salem, Unit No. 2, began on November 27, 2013, and is scheduled to end on December 31, 2021.

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

E. Carr

- 2 -

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](mailto: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 Nos. 50-272 and 50-311

Enclosure:  
Safety Evaluation

cc: Listserv



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

ALTERNATIVE REQUEST SC-I4R-190 FOR

FOURTH 10-YEAR INTERVAL INSERVICE INSPECTION

SALEM NUCLEAR GENERATING STATION, UNIT NOS. 1 AND 2

PSEG NUCLEAR LLC

EXELON GENERATION COMPANY, LLC

DOCKET NOS. 50-272 AND 50-311

1.0 INTRODUCTION

By letter dated September 11, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19254A590), PSEG Nuclear LLC, (the licensee) requested relief from the requirements of the American Society of the Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (B&PV Code) for Salem Generating Station, Unit Nos. 1 and 2 (Salem). The licensee proposed alternative SC-I4R-190 to eliminate the volumetric examination of the reactor pressure vessel (RPV) threads in flange during the fourth inservice inspection (ISI) interval at Salem.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee requested to use the proposed alternative in request SC-I4R-190 on the basis that the alternative provides an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

The regulations in 10 CFR 50.55a(g)(4) state, in part, that ASME B&PV Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in Section XI of the applicable editions and addenda of the ASME B&PV Code to the extent practical within the limitations of design, geometry, and materials of construction of the components. The threads in the RPV flange are categorized as ASME B&PV Code Class 1 components. Therefore, per 10 CFR 50.55a(g)(4), ISI of these threads must be performed in accordance with Section XI of the applicable edition and addenda of the ASME B&PV Code.

The regulations in 10 CFR 50.55a(z), "Alternatives to codes and standards requirements," state:

Alternatives to the requirements of paragraphs (b) through (h) of this 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

Enclosure

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 [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 the licensee may propose an alternative to ASME B&PV Code, Section XI, and the NRC staff has the regulatory authority to authorize the licensee's proposed alternative.

### 3.0 TECHNICAL EVALUATION

#### 3.1 Licensee's Request for Alternative

##### 3.1.1 ASME B&PV Code Components Affected

Proposed alternative SC-I4R-190 applies to the RPV threads in flange Examination Category B-G-1, Item No. B6.40, in Section XI of the ASME B&PV Code.

<b>Examination Category</b>	<b>Item No.</b>	<b>Examination Method</b>	<b>Description</b>	<b>Code Class</b>
B-G-1	B6.40	Volumetric	RPV Threads in Flange	1

##### 3.1.2 Applicable ASME B&PV Code Edition and Addenda

For the fourth 10-year ISI interval at Salem, the Code of Record for the inspection of ASME B&PV Code Class 1, 2, and 3 components is the 2004 Edition of the ASME B&PV Code, Section XI.

##### 3.1.3 Applicable ASME B&PV Code Requirements and Proposed Alternative

The applicable inspection requirement for this component is contained in Examination Category B-G-1, Item No. B6.40, which is listed in Table IWB-2500-1, "Examination Categories," of the ASME B&PV Code, Section XI. This item requires volumetric examination, every ISI interval, of all the threads in RPV flange stud holes, as indicated in Figure IWB-2500-12, "Closure Stud and Threads in Flange Stud Hole," of the ASME B&PV Code, Section XI.

The licensee proposes to eliminate the ASME B&PV Code requirement to volumetrically examine the threads in the RPV flange stud holes during the fourth ISI interval. Proposed alternative SC-I4R-190 is requested for the fourth ISI interval for Salem. The fourth ISI interval for Salem, Unit No. 1, began on May 20, 2011, and is scheduled to end on December 31, 2020. The fourth ISI interval for Salem, Unit No. 2, began on November 27, 2013, and is scheduled to end on December 31, 2021.

### 3.1.4 Licensee's Technical Basis for Proposed Alternative

The licensee states that the technical basis for eliminating the RPV threads in flange volumetric examinations is provided in Electric Power Research Institute (EPRI) Report No. 3002007626, "Nondestructive Evaluation: Reactor Pressure Vessel Threads in Flange Examination Requirements" (the "EPRI report") (ADAMS Accession No. ML16221A068). The licensee discussed the potential degradation mechanisms, bounding stress analysis, flaw tolerance evaluation, and operating experience that were included in the EPRI report and concludes that they justify the elimination of volumetric examination of RPV threads. The licensee also states that the requirements in the relief request are based on ASME B&PV Code Case N-864, which has been approved by the ASME Board on Nuclear Codes and Standards. ASME B&PV Code Case N-864 states that the examination requirements of Examination Category B-G-1, Item Number B6.40, are not required.

#### Preload Stress Analysis

The licensee performed a stress analysis specific to Salem and compared the plant-specific preload stress to the bounding preload stress provided in the EPRI report. The licensee found that the preload stress for Salem, Unit Nos. 1 and 2 (calculated as 31,105 pounds per square inch (psi)) was bounded by the preload stress in the EPRI report (calculated as 42,338 psi).

#### Flaw Tolerance Evaluation

The licensee stated that it used the acceptance criteria found in the ASME B&PV Code, Section XI, Article IWB-3610 and Appendix A, to compare the stress intensity factor ( $K_I$ ) for both preload and operating conditions with the fracture toughness based on crack initiation ( $K_{IC}$ ) using a structural factor of  $\sqrt{10}$ . The licensee assumed a preload temperature of 62 degrees Fahrenheit ( $^{\circ}\text{F}$ ) for the evaluations of preload only. For the evaluations of operating conditions, the licensee adopted the EPRI analysis, which assumed an operating temperature of 600  $^{\circ}\text{F}$ . For the preload only condition for Unit No. 1, the licensee used a maximum  $K_I$  of 17.4 kilopound per square inch (ksi) $\sqrt{\text{inch}}$ , and a calculated  $K_{IC}$  of 54.8 ksi $\sqrt{\text{inch}}$ . For the preload only condition for Unit No. 2, the licensee used a maximum  $K_I$  of 17.4 ksi $\sqrt{\text{inch}}$ , and a calculated  $K_{IC}$  of 89.6 ksi $\sqrt{\text{inch}}$ . For the operating condition for both units, the licensee used a maximum  $K_I$  of 19.8 ksi $\sqrt{\text{inch}}$  and assumed a  $K_{IC}$  of 220 ksi $\sqrt{\text{inch}}$ . The licensee stated that, with the exception of the Unit 1 preload only evaluation,  $K_I < K_{IC}/\sqrt{10}$ , the allowable stress intensity factor is not exceeded for all crack depths up to the deepest analyzed flaw.

For the Unit No. 1 preload only evaluation, the licensee stated that  $K_{IC}/\sqrt{10}$  is slightly smaller than  $K_I$ , but that the minor difference can be considered negligible in light of the existing conservatism contained in the  $RT_{\text{NDT}}$  value, which was an input in the calculation of  $K_{IC}$ .

#### Maintenance and Inspection

The licensee describes the maintenance activities and inspections that will be performed on the RPV threads in flange and studs each time the RPV head is removed. The licensee states that these controlled maintenance activities provide assurance that any degradation would be detected and mitigated prior to returning the reactor to service.

Finally, the licensee notes that the conclusion from the EPRI evaluation is that the safety benefit of the current examination requirements is not commensurate with the associated impact on

worker exposure, personnel safety, generation of radwaste, critical path time, and additional time at reduced water inventory.

### 3.2 NRC Staff Evaluation

The basis for proposed alternative SC-I4R-190 is provided in the EPRI report. By letter dated January 26, 2017 (ADAMS Accession No. ML17006A109), the NRC staff authorized Southern Nuclear Operating Company, Inc. (Southern Nuclear) to use a similar alternative that was based on the generic stress analysis and flaw tolerance evaluation in the EPRI report. The NRC staff's evaluation of the EPRI report is documented in Section 3.2.1, "The EPRI's Generic Stress Analysis and Flaw Evaluation," of the Southern Nuclear safety evaluation. Section 3.2.1 of the Southern Nuclear safety evaluation concludes that the generic stress analysis and flaw tolerance evaluation in the EPRI report are acceptable, and the results can be used to support eliminating the RPV threads in flange examination. It should be noted that this conclusion was drawn in the context of authorizing the elimination of the volumetric inspection for a single 10-year ISI interval.

The NRC staff confirmed that the licensee performed the stress analysis consistent with the EPRI report. The NRC staff also verified the licensee's calculation of preload stress at Salem (31,105 psi) and verified that it was bounded by the preload stress in the EPRI report (42,338 psi).

The NRC staff confirmed that the licensee performed a linear elastic fracture mechanics evaluation consistent with the ASME B&PV Code, Section XI, IWB-3600, and the EPRI report. The licensee assumed a maximum  $K_I$  of 19.8 ksi $\sqrt{\text{inch}}$  for the operating condition (combined pressure, preload, and thermal stress), and a maximum  $K_I$  of 17.4 ksi $\sqrt{\text{inch}}$  for the preload only condition, consistent with the EPRI report. For its evaluation of the operating condition, the licensee assumed a  $K_{IC}$  of 220 ksi $\sqrt{\text{inch}}$ , consistent with the assumptions of the EPRI report. For its evaluation of the preload only condition, the licensee calculated  $K_{IC}$  based on the following equation in ASME B&PV Code, Section XI, Appendix A, Article A-4200:

$$K_{IC} = 33.2 + 20.734 \exp [0.2(T-RT_{NDT})]$$

$$\text{Unit No. 1: } K_{IC} = 54.8 \text{ ksi}\sqrt{\text{inch}} \text{ given that } T=62 \text{ }^\circ\text{F} \text{ and } RT_{NDT}=60 \text{ }^\circ\text{F}$$

$$\text{Unit No. 2: } K_{IC} = 89.6 \text{ ksi}\sqrt{\text{inch}} \text{ given that } T=62 \text{ }^\circ\text{F} \text{ and } RT_{NDT}=12 \text{ }^\circ\text{F}$$

For Unit No. 2, the licensee has demonstrated that  $K_I < K_{IC}/\sqrt{10}$  for both preload and operating conditions and the threads in the RPV flange are reasonably flaw tolerant. For Unit No. 1, although  $K_{IC}/\sqrt{10}$  is slightly smaller than  $K_I$  for the preload condition, the NRC staff does not consider the difference of 0.1 ksi $\sqrt{\text{inch}}$  to be significant from a safety perspective when considering the conservatism inherent in performing evaluations of preload only at  $T=62 \text{ }^\circ\text{F}$  rather than at an operating temperature of  $600 \text{ }^\circ\text{F}$ , as assumed by the EPRI report evaluations for full power operations.

The NRC staff reviewed the licensee's description of the maintenance activities and inspections that will be performed on the RPV threads in flange and studs each time the RPV head is removed. The licensee stated that the RPV threads would be inspected when the studs are removed, cleaned, and lubricated. The NRC staff finds that the licensee's maintenance activities provide an opportunity, at frequent intervals, for the licensee to detect and mitigate degradation of the threads in flange during the fourth ISI interval. These maintenance activities, combined with the linear elastic fracture mechanics evaluation discussed in the prior paragraph

of this safety evaluation, provide a defense in depth to the possibility of component failure resulting from undetected and unmitigated cracking.

The NRC staff notes that the basis for the acceptability of the proposal is ASME Code Case N-864, which the licensee correctly identified as being approved by the ASME B&PV Code and supported by a generic fatigue crack growth analysis contained in the EPRI report. The NRC staff also notes that some measure of defense in depth must be provided in the event of an alternate mode of failure. Therefore, in its review, the NRC staff focused on the adequacy of the generic fatigue crack growth analysis, the applicability of the generic analysis to the licensee, and the adequacy of the defense-in-depth measures proposed by the licensee.

In summary, the NRC staff has concluded that the stress analysis and flaw tolerance evaluation in the generic EPRI evaluation are bounding for Salem.

#### 4.0 CONCLUSION

As set forth above, the NRC staff determines that the licensee has demonstrated that the proposed alternative provides an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all the regulatory requirements set forth in 10 CFR 50.55a(z)(1) for the alternative request. Therefore, the NRC staff authorizes the use of alternative request SC-I4R-190 to eliminate the volumetric examination of the RPV threads in flange for the duration of the fourth 10-year ISI interval at Salem. The fourth ISI interval for Salem Unit No. 1, began on May 20, 2011, and is scheduled to end on December 31, 2020. The fourth ISI interval for Salem, Unit No. 2, began on November 27, 2013, and is scheduled to end on December 31, 2021.

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

Principal Contributor: J. Jenkins

Date: April 13, 2020

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