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

May 25, 2017

Mr. Daniel G. Stoddard
Senior Vice President and
Chief Nuclear Officer
Dominion Nuclear Connecticut, Inc.
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, VA 23060-6711

SUBJECT: MILLSTONE POWER STATION, UNIT NOS. 2 AND 3 – ALTERNATIVE REQUESTS RR-04-24 AND IR-3-30 FOR ELIMINATION OF THE REACTOR PRESSURE VESSEL THREADS IN FLANGE EXAMINATION (CAC NOS. MF8468 AND MF8469)

Dear Mr. Stoddard:

By letter dated October 6, 2016, as supplemented by letter dated February 16, 2017 (Agencywide Documents Access and Management System Accession Nos. ML16287A724 and ML17053A106, respectively), Dominion Nuclear Connecticut, Inc. (the licensee) submitted Alternative Requests RR-04-24 and IR-3-30 to request relief from the volumetric examination requirement for the threads in the reactor pressure vessel (RPV) flange as defined in Figure IWB-2500-12, "Closure Stud and Threads in Flange Stud Hole," and as specified in Table IWB-2500-1 for Examination Category B-G-1, Item No. B6.40, of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI. The licensee proposed to eliminate the requirements for volumetric examination of the threads in the RPV flange for Millstone Power Station (Millstone), Unit Nos. 2 and 3, for the remainder of the fourth and third 10-year inservice inspection intervals, respectively.

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 on the basis that the alternative would provide an acceptable level of quality and safety.

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the subject request and concludes, as set forth in the enclosed safety evaluation, that the licensee's proposed alternative to eliminate the volumetric ultrasonic examination requirements for the RPV threads in flange for Millstone, Unit Nos. 2 and 3, provides an adequate 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)(1). Therefore, the NRC staff authorizes Alternative Request RR-04-24 for Millstone, Unit No. 2, for the remainder of the fourth 10-year inservice inspection interval that is scheduled to end on March 31, 2020, and Alternative Request IR-3-30 for Millstone, Unit No. 3, for the remainder of the third 10-year inservice inspection interval that is scheduled to end on April 22, 2019.

If you have any questions, please contact the Project Manager, Richard Guzman, at 301-415-1030 or by e-mail to Richard.Guzman@nrc.gov.

Sincerely,

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

Docket Nos. 50-336 and 50-423

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATIVE REQUESTS RR-04-24 AND IR-3-30

FOR ELIMINATION OF THE REACTOR PRESSURE VESSEL THREADS IN FLANGE

EXAMINATION FOR THE FOURTH AND THIRD 10-YEAR INSPECTION INTERVALS

MILLSTONE POWER STATION, UNIT NOS. 2 AND 3

DOMINION NUCLEAR CONNECTICUT, INC.

DOCKET NOS. 50-336 AND 50-423

1.0 INTRODUCTION

By letter dated October 6, 2016, as supplemented by letter dated February 16, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML16287A724 and ML17053A106, respectively), Dominion Nuclear Connecticut, Inc. (the licensee) submitted Alternative Requests RR-04-24 and IR-3-30 to request relief from the volumetric examination requirement for the threads in the reactor pressure vessel (RPV) flange (or "RPV threads in flange") as defined in Figure IWB-2500-12, "Closure Stud and Threads in Flange Stud Hole," and as specified in Table IWB-2500-1 for Examination Category B-G-1, Item No. B6.40 of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI. The licensee proposed to eliminate the requirements for volumetric examination of the threads in the RPV flange for Millstone Power Station (Millstone), Unit Nos. 2 and 3, for the remainder of the fourth and third 10-year inservice inspection (ISI) intervals, respectively.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(1), the licensee requested to use the proposed alternative on the basis that the alternative would provide an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

2.1 Requirements of Title 10 of the *Code of Federal Regulations*

The threads in the RPV flange at Millstone, Unit Nos. 2 and 3, are categorized as an ASME Code, Class 1 component, of which ISI is performed in accordance with Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," of the ASME Code and applicable edition and addenda, as required by 10 CFR 50.55a(g). Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) shall meet the requirements,

Enclosure

except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(a)(1)(ii) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications in 10 CFR 50.55a(b)(2).

Alternatives to the requirements above must be submitted and authorized by the U.S. Nuclear Regulatory Commission (NRC) prior to implementation. Specifically, 10 CFR 50.55a(z)(1) requires licensees to demonstrate that the proposed alternative would provide an acceptable level of quality and safety.

Paragraph 50.55a(z) of 10 CFR 50 states, in part, that alternatives to the requirements of 10 CFR 50.55a(b)-(h) may be used, when authorized by the NRC, if: (1) the proposed alternatives would provide an acceptable level of quality and safety or (2) 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, and the Commission to authorize, the alternative requested by the licensee.

2.2 ASME Code Requirements

The examination requirement for the threads in the RPV flange is specified in Table IWB-2500-1, "Examination Categories," of the ASME Code, Section XI, for Examination Category B-G-1, Item No. B6.40, and as shown in Figure IWB-2500-12, "Closure Stud and Threads in Flange Stud Hole." Specifically, the RPV threads in flange are required to be examined using a volumetric examination technique with 100 percent of the flange ligament areas examined every ISI. The examination area is the 1-inch area around each RPV stud hole.

The applicable ASME Code of record for the fourth 10-year ISI interval ISI at Millstone, Unit No. 2, and the third 10-year ISI interval at Millstone, Unit No. 3, is the 2004 Edition with no addenda. The fourth 10-year ISI interval at Millstone, Unit No. 2, began on April 1, 2010, and is scheduled to end on March 31, 2020, and the third 10-year ISI interval at Millstone, Unit No. 3, began on April 23, 2009, and is scheduled to end on April 22, 2019.

3.0 TECHNICAL EVALUATION

3.1 Alternative Requests RR-04-24 and IR-3-30

3.1.1 Component Identification

Alternative Requests RR-04-24 and IR-3-30 apply to ASME Code, Section XI, Examination Category B-G-1, Item No. B6.40, "Threads in Flange."

3.1.2 Licensee's Proposed Alternative

Pursuant to 10 CFR 50.55a(z)(1), the licensee proposes eliminating the requirements for volumetric examination of the threads in the RPV flange for Millstone, Unit No. 2, for the remainder of the fourth 10-year ISI interval (scheduled to end March 31, 2020), and for Millstone, Unit No. 3, for the remainder of the third 10-year ISI interval (scheduled to end April 22, 2019).

3.1.3 Licensee's Basis

The licensee cited three major sections from the Electric Power Research Institute (EPRI) Report No. 3002007626, "Nondestructive Evaluation: Reactor Pressure Vessel Threads in Flange Examination Requirements" (ADAMS Accession No. ML16221A068, hereafter referred as the "EPRI report") and included them as four topics in Section 4 of its October 6, 2016, submittal to support the proposed alternative. The EPRI report presents bases for eliminating the requirements for volumetric examination of threads in RPV flanges. The four topics from the EPRI report included in the submittal are operating experience, stress analysis, flaw tolerance analysis, and potential degradation mechanisms, as discussed in the following paragraphs.

Additionally, the licensee stated in its submittal that during the removal of the RPV studs, the threads in the RPV flange are inspected for damage, cleaned, and lubricated. These maintenance activities, performed during each refueling outage, provide assurance that general degradation is detected and mitigated prior to returning the reactor to service.

Operating Experience

The licensee included in its October 6, 2016, submittal, "Table 3: Summary of Survey Results – US Fleet," in Attachments 1 and 2, which is a survey of the examination results for the threads in the RPV flange obtained for 94 units of the nuclear power plant fleet in the United States. These 94 units include 33 boiling-water reactor units and 61 pressurized-water reactor units. The total number of examinations for all 94 units is 10,662, with no reportable indications.

Stress Analysis

The licensee referred to Section 6.1, "Stress Analysis," of the EPRI report, which determined the stresses at the critical thread locations in the RPV flange. These stresses were used as input into the flaw tolerance analysis. As documented in the EPRI report, a stress analysis was performed using a three-dimensional, symmetric finite element model (FEM) of a portion of the threads in the RPV flange, RPV shell immediately below the flange, and a symmetric half of an RPV stud. Geometric parameters were used that bound those of Millstone, Unit Nos. 2 and 3, such as number of RPV studs, RPV stud diameter, RPV inside diameter, and flange thickness at the threads to create the FEM. The loads that were applied to the FEM were the preload on the RPV studs, internal pressure, and thermal loads due to heatup and cooldown.

Flaw Tolerance Analysis

The licensee referred to Section 6.2, "Flaw Tolerance Evaluation," of the EPRI report, which determined the crack driving force or stress intensity factor (K_I) due to the applied loads. In the

EPRI report, FEM stresses in the region of the root of the threads were evaluated to determine the critical location based on the largest tensile axial stress. The evaluation simulated a flaw with crack tip elements in the FEM that originated at this critical location to determine K_I. The evaluation also modeled the flaw that was all the way around the critical thread and oriented such that axial stresses act normal to the face of the flaw. Four depths were modeled to determine the variation of K_I with flaw depth. The EPRI report provided a comparison of the maximum applied K_I to the allowable value permitted by IWB-3600 of the ASME Code. Finally, a flaw growth evaluation was performed with a postulated initial flaw size at the root of the critical thread to show that the structural integrity of the threads in the RPV flange was not compromised for 80 years of plant life.

Potential Degradation Mechanisms

The EPRI report presented an evaluation of the susceptibility of the threads in the RPV flange to the following degradation mechanisms: pitting, intergranular attack, corrosion fatigue, stress corrosion cracking, crevice corrosion, velocity phenomena, dealloying corrosion and general corrosion, stress relaxation, creep, mechanical wear, and mechanical/thermal fatigue. The EPRI report concluded that the threads in the RPV flange were not susceptible to these degradation mechanisms, except potentially to mechanical/thermal fatigue. To address this potential for mechanical/thermal fatigue, the licensee referred to the generic stress analysis and flaw tolerance analysis in the EPRI report, which are discussed above and evaluated by the NRC staff in Sections 3.2.3 and 3.2.4 of this safety evaluation (SE).

3.2 NRC Staff Evaluation

3.2.1 Scope of Evaluation

The licensee referred to the EPRI report for the technical basis for the proposed alternative in Alternative Requests RR-04-24 and IR-3-30. The major sections of the EPRI report that were included in the licensee's October 6, 2016, submittal are Section 4, "Operating Experience"; Section 5, "Evaluation of Potential Degradation Mechanisms"; and Section 6, "Stress Analysis and Flaw Tolerance Evaluation."

The NRC staff focused its evaluation on the technical adequacy of the analyses contained in Section 6 of the EPRI report, which presented a deterministic basis for the proposed alternative. While the NRC staff considers the technical adequacy of the deterministic analysis in Section 6 of the EPRI report as the primary criterion for acceptance of the proposed alternative, it also considered in its evaluation Sections 4 and 5 of the EPRI report regarding operating experience and potential degradation mechanisms, since it was included by the licensee in its submittal.

3.2.2 Operating Experience

The licensee referenced from the EPRI report the results of an industry survey of over 10,000 RPV threads in flange examinations for both boiling-water reactor and pressurized-water reactor plants in the United States. The examinations resulted in no reportable indications. While the examination results do not necessarily provide reasonable assurance of structural integrity, they offer ample supporting evidence that the threads in the RPV flange are performing

without a credible threat to the structural integrity of the RPV flange. As mentioned in Section 3.2.1 of this SE, the NRC staff's determination of reasonable assurance of structural integrity of the threads in the RPV flange relies primarily on the deterministic stress analysis and flaw tolerance analysis, which are discussed in Sections 3.2.3 and 3.2.4 of this SE.

3.2.3 Stress Analysis

As mentioned in Section 3.2.1 of this SE, the licensee referenced the stress analysis in the EPRI report as part of its deterministic basis to support the proposed alternative. The EPRI report determined stresses from the FEM and used these stresses as input into the flaw tolerance analysis (evaluated in Section 3.2.4 of this SE). The sections that follow discuss the three major parts of the NRC staff's evaluation with respect to the stress analysis performed and documented in the EPRI report.

Finite Element Model

The stress analysis included an FEM developed with the ANSYS finite element software. The FEM was a symmetric portion of the threads in the RPV flange and RPV shell immediately below the flange and a symmetric half of an RPV stud. The FEM applied appropriate boundary conditions, such as symmetric boundary conditions on the symmetry faces, a boundary condition to prevent rigid body motion, and contact surfaces on the threaded interface of the modeled bolt and RPV flange. These are FEM modeling techniques consistent with standard industry practice. Therefore, the NRC staff determined that the FEM was appropriate for stress analysis.

Applied Loads

The loads applied to the FEM included the preload on the RPV studs, internal pressure, and thermal loads due to heatup and cooldown transient. These are normal operating loads. Section XI of the ASME Code provides evaluation procedures and acceptance criteria for detected flaws and postulated flaws in various components. In addition to normal operating loads, Section XI of the ASME Code considers emergency and faulted loads for evaluating detected flaws such as in Appendix A, "Analysis of Flaws," and Appendix C, "Evaluation of Flaws in Piping." However, Section XI of the ASME Code considers only normal operating loads for evaluating postulated flaws, such as in Appendix G, "Fracture Toughness Criteria for Protection against Failure." Considering only normal operating loads for the current submittal is acceptable because it is consistent with Section XI of the ASME Code evaluation principle for postulated flaws. Although there are exceptions such as Appendix K, "Assessment of Reactor Vessels with Low Upper Shelf Charpy Impact Energy Levels," and Appendix L, "Operating Plant Fatigue Assessment," for postulated flaws, they are created for special applications with specific considerations as indicated in the titles of the appendices.

The licensee included in Table 1 of Attachments 1 and 2 of its October 6, 2016, submittal a comparison of the Millstone-specific geometric parameters used in the calculation of the preload on the RPV studs with those used in the bounding preload calculation. The NRC staff verified the Millstone-specific geometric parameters from the Millstone, Unit Nos. 2 and 3, Updated Final Safety Analysis Report. The NRC staff verified that the value of preload the licensee calculated

and used in the stress analysis is bounding for the Millstone, Unit Nos. 2 and 3, RPV flange. Finally, the NRC staff verified in the Millstone, Unit No. 2, Updated Final Safety Analysis Report that the tensile stress for each stud is 40,000 pounds per square inch (psi) when elongated for operational conditions. This 40,000 psi tensile stress is less than the preload stress of 42,338 psi used in the bounding analysis. Therefore, the 42,338 psi preload stress used in the bounding analysis is reasonable for the Millstone, Unit No. 2, RPV flange. The NRC staff also determined that for the Millstone, Unit No. 3, RPV flange, there is significant margin between the maximum applied K_I of 17.4 ksi√in due to the 42,338 psi preload stress reported in Table 2 of Attachment 2 of the October 6, 2016, submittal and the fracture toughness (K_{IC}) of the Millstone, Unit No. 3, RPV flange, as discussed below.

In its supplemental letter dated February 16, 2017, in response to a request for additional information (RAI) by the NRC staff dated February 2, 2017 (ADAMS Accession No. ML17033B614), the licensee stated that the nil-ductility transition reference temperature (RT_{NDT}) for the Millstone, Unit No. 3, RPV flange is -40 degrees Fahrenheit (°F) and that head tensioning (preloading of the RPV studs) occurs at 70 °F or above (less a measurement uncertainty of 13 °F). The NRC staff thus assessed a temperature 57 °F (i.e., 70 °F – 13 °F) during head tensioning. Therefore, the margin from the RT_{NDT} of the Millstone, Unit No. 3, RPV flange is 97 °F (i.e., 57 °F – (-40 °F)). Using this value, the NRC staff determined an allowable K_I of 56.1 ksi√in from the K_{IC} curve in Appendix A to Section XI of the ASME Code, divided by a safety factor of √10. Thus, for the Millstone, Unit No. 3, RPV flange, the margin of the allowable K_I of 56.1 ksi√in to the maximum applied K_I of 17.4 ksi√in is at least 3 times. Therefore, the 42,338 psi preload stress used in the bounding analysis is reasonable for the Millstone, Unit No. 3, RPV flange.

The evaluation in the EPRI report applied an internal pressure of 2,500 psia (typical design pressure for pressurized-water reactors) to the internal surfaces of the FEM considered exposed to the reactor coolant. The NRC staff determined that the use of design pressure versus operating pressure (2,250 psia) is conservative for the analysis. The EPRI report appropriately applied an end-cap pressure to the bottom of the FEM to simulate the effect of the internal pressure acting in the direction parallel to the RPV axis (axial direction).

For the heatup and cooldown transient, the EPRI report presented a thermal transient analysis due to a 100 °F/hour ramp up (heatup) to operating temperature. The NRC staff verified that the heatup rate of 100 °F/hour is equivalent to, or bounds, the maximum heatup rate specified in the Millstone, Unit Nos. 2 and 3, Technical Specifications. The transient in the FEM is simulated by applying convective heat transfer coefficients to the internal surfaces of the FEM considered exposed to the reactor coolant. The NRC staff determined that the licensee's consideration of only a heatup transient was reasonable for the purpose of the analysis, since the heatup transient would generate tensile stresses toward the outside surface of the RPV flange, and the threads in the RPV flange are closer to the outside surface. Regarding the crack growth analysis performed as part of the flaw tolerance analysis, the NRC staff determined that running only a heatup transient was acceptable because the cooldown down transient at the same rate (100 °F/hour) would generate the same stress range used in the crack growth analysis. The NRC staff determined that the reasoning above is consistent with the response to an RAI for a similar submittal dated August 4, 2016 (ADAMS Package Accession No. ML16221A072). Discussion of this RAI is documented in the NRC staff's SE (ADAMS Accession

No. ML17006A109) under the section titled, "Heatup Versus Cooldown (RAI-5, Question 3 and follow-up)." The August 4, 2016, submittal, referred to the same EPRI report for the technical basis of the alternative, and the RAI was directed to the generic stress analysis in the EPRI report.

Based on the above, the NRC staff determined that the loads were properly applied to the FEM and reasonably bounded the loads for the Millstone, Unit Nos. 2 and 3, RPV flange.

Stress Results

The EPRI report presented stress contour plots due to preload, internal pressure, and heatup transient. The plots show the stress in the axial direction, which is the stress normal to the face of the modeled flaw, and therefore, the major driver of growth of the flaw. The NRC staff reviewed the stress contour plots and determined that the magnitude and distribution of the stresses are reasonable. Therefore, the NRC staff determined that the stress results are appropriate for informing the selection of the critical thread location, which is described in Section 3.2.4 under "Finite Element Model with Crack Tip Elements" of this SE.

3.2.4 Flaw Tolerance Analysis

As mentioned in Section 3.2.1 of this SE, the licensee referenced the flaw tolerance analysis in the EPRI technical report as part of its deterministic basis to support the proposed alternative. The flaw tolerance analysis in the EPRI report, including the crack growth analysis, is based on the principles of linear elastic fracture mechanics. The sections that follow discuss the two major parts of the NRC staff's evaluation of the flaw tolerance analysis.

Finite Element Model with Crack Tip Elements

The flaw tolerance analysis included simulations of a postulated flaw of four sizes inserted into the FEM to determine K_I due to preload, internal pressure, and heatup transient. The analysis simulated the postulated flaws with crack tip elements, which have the capability of internally computing K_I at the sharp edge (tip) of the flaw. The postulated flaws were oriented such that the stress in the axial direction is normal to the face of the flaw; and the stress is inserted at the thread location where the largest tensile axial stress occurs. The postulated flaws originate from the root of the thread and span 180 degrees (equivalent to 360 degrees because of symmetry) around the same thread. The NRC staff determined that this approach of computing values of K_I due to the applied loads is acceptable because the postulated flaws are relatively large (360 degrees around the thread) and take into account the effect of the geometric configuration of threads in the RPV flange that would otherwise not be accounted for in generic handbook values of K_I.

Allowable K_I and Crack Growth Analysis

The analysis in the EPRI report applied the same loads (reload, internal pressure, and heatup transient) to the FEM with crack tip elements. The maximum applied K_I value around the postulated flaw for each of the modeled flaw depth was extracted for two load cases: (1) preload-only and (2) preload + heatup + pressure. The licensee reported, in Table 2 of

Attachments 1 and 2 of the October 6, 2016, submittal, a maximum applied K_I value of 17.4 ksi√in for the preload-only case and 19.8 ksi√in for the preload + heatup + pressure case. The NRC staff notes that these maximum applied K_I values are for a flaw depth-to-thickness ratio (a/t) of 0.29. The licensee reported K_I values for a flaw size as large as a/t = 0.77, for which the K_I values are lower. The licensee compared the maximum applied K_I value of 19.8 ksi√in to the allowable K_I value of 69.6 ksi√in, which is based on the RPV flange K_{IC} value at operating temperature. Since 19.8 ksi√in is less than 69.8 ksi√in, the NRC staff determined that the Millstone, Unit Nos. 2 and 3, threads in the RPV flange are reasonably flaw-tolerant at operating temperatures. The K_{IC} value was from the lower bound K_{IC} curve applicable to ferritic steels in Appendix A to Section XI of the ASME Code.

The licensee did not include a comparison of the maximum applied K_I value of 17.4 ksi√in for the preload case to the allowable K_I value at the temperature appropriate during head tensioning. Therefore, on February 2, 2017, the NRC staff issued its RAI requesting a comparison. In its February 16, 2017, RAI response, the licensee stated that the limiting RT_{NDT} is 10 °F for the Millstone, Unit No. 2, RPV flange, which bounds the Millstone, Unit No. 3, RPV flange. The licensee stated that the limiting head tensioning temperature, with measurement uncertainty included, is 57 °F. The licensee used the difference of these two values (47 °F) to calculate a K_{IC} value from the K_{IC} curve in Appendix A to Section XI of the ASME Code. The resulting K_{IC} value is 86.3 ksi√in, and dividing it by a safety factor of √10, yields an allowable K_I value of 27.3 ksi√in. The NRC staff verified from the Millstone, Unit Nos. 2 and 3, Updated Final Safety Analysis Report that RT_{NDT} = 10 °F for the Millstone, Unit No. 2, RPV flange, and that this RT_{NDT} value bounds the Millstone, Unit No. 3, RPV flange. The NRC staff also independently calculated K_{IC} using the equation for the K_{IC} curve in Appendix A to Section XI of the ASME Code, and determined an allowable value of K_I = 27.3 ksi√in, which is less than the maximum applied K_I value of 17.4 ksi√in for the preload case. The NRC staff's calculation matches the licensee's calculation. Therefore, the NRC staff's RAI is resolved. Since the maximum applied K_I value of 17.4 ksi√in is less than the allowable K_I value of 27.3 ksi√in, the NRC staff determined that the Millstone, Unit Nos. 2 and 3, threads in the RPV flange are reasonably flaw-tolerant at head tensioning temperatures.

In addition to comparing the maximum applied K_I to the allowable value, the licensee included the crack growth analysis in the EPRI report to support the proposed alternative. The EPRI report performed the crack growth analysis for an 80-year period with the following inputs: (1) an initial flaw depth of 0.2 inch, (2) the applied K_I for preload (assumption of 5 occurrences per year), and (3) the applied K_I for heatup/cooldown (assumption of 50 occurrences per year). The NRC staff's SE of the August 4, 2016, submittal, which referenced the same crack growth analysis in the EPRI report, indicates that the resulting crack growth for 80 years is 0.005 inch. The NRC staff performed a confirmatory calculation of this crack growth value based on the fatigue crack growth curves in Figure A-4300-1 in Appendix A to Section XI of the ASME Code and determined that 0.005 inch is reasonable. The NRC staff used the maximum K_I values in Table 2 of Attachments 1 and 2 of the October 6, 2016, submittal in the confirmatory calculation. Additionally, the NRC staff considers the crack growth analysis acceptable because it postulated a reasonable initial flaw size (the largest allowable size in IWB-3500 of Section XI of the ASME Code) and a conservative number of occurrences over an 80-year period for the two cases considered (a total of 400 occurrences for the preload and 4,000 occurrences for

heatup/cooldown). Even with these conservative number of occurrences, the total crack growth for 80 years is negligible.

3.2.5 Potential Degradation Mechanisms

The NRC staff agrees that mechanical/thermal fatigue is the only potential degradation mechanism for the Millstone, Unit Nos. 2 and 3, threads in the RPV flange. The other degradation mechanisms listed in the licensee's October 6, 2016, submittal are not credible degradation mechanisms for the threads in the RPV flange because the threads are not in contact with the reactor coolant, do not receive significant neutron fluence as they are well above the active core, and are not in the operating temperature range where metal creep can occur. The licensee referred to the generic stress analysis and flaw tolerance analysis provided in the EPRI report to address the potential susceptibility to mechanical/thermal fatigue.

3.2.6 NRC Staff Conclusion on the Stress Analysis and Flaw Tolerance Analysis

Based on the evaluation in Sections 3.2.3 and 3.2.4 of this SE, the NRC staff determined that the licensee has adequately shown that the deterministic stress analysis and flaw tolerance analysis in the EPRI report are reasonably bounding for Millstone, Unit Nos. 2 and 3, threads in the RPV flange. Therefore, the NRC staff determined that the licensee has: 1) demonstrated technical adequacy of the proposed alternative to the examination requirements of the Millstone, Unit Nos. 2 and 3, threads in the RPV flange, and 2) provided reasonable assurance of structural integrity of the Millstone, Unit Nos. 2 and 3, threads in the RPV flange, without required examinations for the remainder of their current ISI intervals.

4.0 CONCLUSION

As set forth above, the NRC staff determined that the licensee's proposed alternative to the examination requirements for the Millstone, Unit Nos. 2 and 3, threads in the RPV flange provides an acceptable 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)(1). Therefore, the NRC staff authorizes Alternative Request RR-04-24 for Millstone, Unit No. 2, for the remainder of the fourth 10-year ISI interval that is scheduled to end on March 31, 2020 and IR-3-30 for Millstone, Unit No. 3, for the remainder of the third 10-year ISI interval that is scheduled to end on April 22, 2019.

All other requirements of Section XI of the ASME Code for which relief has not been specifically requested and approved in the subject relief requests remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: D. Dijamco

Date: May 25, 2017

SUBJECT: MILLSTONE POWER STATION, UNIT NOS. 2 AND 3 – ALTERNATIVE REQUESTS RR-04-24 AND IR-3-30 FOR ELIMINATION OF THE REACTOR PRESSURE VESSEL THREADS IN FLANGE EXAMINATION (CAC NOS. MF8468 AND MF8469) DATED MAY 25, 2017

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