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

October 18, 2016

Mr. David A. Heacock
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 NO. 2 – REQUEST FOR ALTERNATIVE RR-04-22 TO IMPLEMENT EXTENDED REACTOR VESSEL INSERVICE INSPECTION INTERVAL (CAC NO. MF7369)

Dear Mr. Heacock:

By letter dated February 18, 2016, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16057A179), Dominion Nuclear Connecticut, Inc. (the licensee), submitted a request for alternative to the inservice inspection (ISI) interval requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Paragraph IWB-2412, "Inspection Program B," for Millstone Power Station, Unit No. 2 (MPS2). Inspection Program B requires volumetric examination of essentially 100% of reactor vessel pressure-retaining welds identified in Table IWB-2500-1 once each 10-year interval.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50.55a(z)(1), the licensee requested the use of a proposed alternative to extend the MPS2 reactor vessel fourth inspection interval from 10 years to 20 years on the basis that the alternative provides an acceptable level of quality and safety.

The Nuclear Regulatory Commission (NRC) staff has reviewed the subject request and has concluded, as set forth in the enclosed safety evaluation, that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff concludes that the licensee's alternative ISI schedule for the specified welds is acceptable for extension to March 31, 2030. The examination of the Category B-A and B-D components for MPS2 shall be conducted prior to the end of the extended fourth 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.

If you have any questions, please contact the project manager, Richard Guzman, at (301) 415-1030 or Richard.Guzman@nrc.gov.

Sincerely,

Douglas V Pickett

Douglas Pickett, Acting Chief
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-336

Enclosure:
Safety Evaluation

cc w/enclosure: Distribution via Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR ALTERNATIVE TO IMPLEMENT EXTENDED REACTOR VESSEL

ALTERNATIVE REQUEST RR-04-22

FOURTH INSERVICE INSPECTION INTERVAL

DOMINION NUCLEAR CONNECTICUT, INC.

MILLSTONE POWER STATION, UNIT NO. 2

DOCKET NO. 50-336 (CAC NO. MF7369)

1.0 INTRODUCTION

By letter dated February 18, 2016, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16057A179), Dominion Nuclear Connecticut, Inc. (the licensee), submitted a request which proposed an alternative to the inservice inspection (ISI) interval requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Paragraph IWB-2412, "Inspection Program B," for Millstone Power Station, Unit 2 (MPS2). Inspection Program B requires volumetric examination of essentially 100% of reactor vessel pressure-retaining welds identified in Table IWB-2500-1 once each 10-year interval. Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50.55a(z)(1), the licensee requested the use of a proposed alternative to extend the MPS2 reactor vessel fourth inspection interval from 10 years to 20 years on the basis that the alternative provides an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

ISI of the ASME Code Class 1, 2, and 3 components is performed in accordance with Section XI of the ASME Code and applicable addenda as a way to detect anomaly and degradation indications so that structural integrity of these components can be maintained. This is required by 10 CFR 50.55a(g), except where specific relief has been granted by the U.S. Nuclear Regulatory Commission (NRC) pursuant to 10 CFR 50.55a(g)(6)(i). Paragraph 10 CFR 50.55a(z) states that alternatives to the requirements of paragraphs (b) through (h) of 10 CFR 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 applicant or 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 this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Enclosure

Pursuant to 10 CFR 50.55a(g)(4), components (including supports) that are classified as ASME Code Class 1, 2, and 3 must meet the requirements, except design and access provisions and preservice examination requirements, as set forth in Section XI of editions and addenda of the ASME Code, which become effective subsequent to editions specified in paragraphs (g)(2) and (3) of this section, 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 successive 120-month inspection intervals (following the initial 120-month inspection interval) must comply with the requirements in the latest edition and addenda of the ASME Code, which was incorporated by reference in 10 CFR 50.55a(a), 12 months before the start of the 120-month interval (or the optional ASME Code Cases listed in NRC Regulatory Guide (RG) 1.147, Revision 17, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1,") subject to the conditions listed in 10 CFR 50.55a(b).

RG 1.99, Rev. 2, "Radiation Embrittlement of Reactor Vessel Materials," (ADAMS Accession No. ML003740284) describes general procedures acceptable to the staff for calculating the effects of neutron radiation embrittlement of the low-alloy steels currently used for light-water-cooled reactor pressure vessels (RPVs).

RG 1.174, Rev. 1, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," (ADAMS Accession No. ML023240437) describes a risk-informed approach, acceptable to the NRC, for assessing the nature and impact of proposed licensing basis changes by considering engineering issues and applying risk insights.

The licensee has requested an alternative to the ASME Code requirements pursuant to 10 CFR 50.55a(z)(1). The MPS2 fourth 10-year ISI interval is based on the ASME Code, Section XI, 2004 Edition. 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 proposed by the licensee. The end date for the current MPS2 fourth 10-year interval ISI program is March 31, 2020.

3.0 TECHNICAL EVALUATION

3.1 Background

The ISI of Categories B-A and B-D components consists of visual and ultrasonic examinations intended to discover whether new flaws have initiated, whether pre-existing flaws have extended, and whether pre-existing flaws may have been missed in prior examinations. These examinations are required to be performed at regular intervals, as defined in Section XI of the ASME Code.

3.2 Summary of Westinghouse Commercial Atomic Power (WCAP) Topical Report 16168-NP, Revision 2

By letter dated May 8, 2008 (ADAMS Accession No. ML081060051), the NRC staff issued a final safety evaluation (SE) (ADAMS Accession No. ML081060045), which found that Topical Report WCAP-16168-NP, Revision 2, "Risk-Informed Extension of the Reactor Vessel In-

Service Inspection Interval" (the WCAP), was acceptable for referencing in licensing applications for pressurized-water reactors (PWRs) designed by Westinghouse Electric Company (Westinghouse); Combustion Engineering, Inc.; and Babcock & Wilcox, Inc. (B&W). The WCAP was developed to support a risk-informed assessment of extensions to the ISI intervals for ASME Code, Section XI, Categories B-A and B-D components from 10 years to 20 years, using data from three different PWR plants (referred to as the pilot plants) representing each of the vendors.

The analyses in the WCAP used probabilistic fracture mechanics tools and input from the work described in NUREG-1806, "Technical Basis for Revision of the Pressurized Thermal Shock (PTS) Screening Limit in the PTS Rule (10 CFR 50.61): Summary Report" (ADAMS Accession No. ML061580318), and NUREG-1874, "Recommended Screening Limits for Pressurized Thermal Shock (PTS)" (ADAMS Accession No. ML070860156). The PWR Owners Group (PWROG) analyses incorporated the effects of fatigue crack growth and ISI data. Design-basis transient data was used as an input for the fatigue crack growth evaluation. The effects of ISI data were modeled consistently with the previously approved probabilistic fracture mechanics codes WCAP-14572, Revision 1-NP-A, "Westinghouse Owners Group Application of Risk-Informed Methods to Piping Inservice Inspection Topical Report" (ADAMS Accession Nos. ML012630349 and ML012630327), and Supplement 1 to WCAP-14572, Revision 1-NP-A, "Westinghouse Structural Reliability and Risk Assessment (SRRA) Model for Piping Risk Informed Inservice Inspection" (ADAMS Accession No. ML012630313). These effects were inputs into the evaluations performed with the "Fracture Analysis of Vessels - Oak Ridge" computer code. All other inputs were identical to those used in the PTS risk reevaluation underlying 10 CFR 50.61a, "Alternative fracture toughness requirements for protection against pressurized thermal shock events."

The PWROG concluded, as a result of these studies, that the ASME Code, Section XI, 10-year ISI interval for Categories B-A and B-D components in PWR RPVs can be safely extended from 10 years to 20 years. This conclusion, based on the results from the pilot plant analyses, was considered to apply to any plant designed by the three PWR vendors represented in the pilot plant study, as long as certain critical plant-specific criteria (defined in Appendix A of the WCAP) are bounded by the analysis for the applicable pilot plant.

3.3 Summary of NRC Staff Evaluation for WCAP-16168-NP, Revision 2

The NRC staff issued a revised SE dated July 26, 2011 (ADAMS Accession No. ML111600303), superseding the initial May 8, 2008, SE in the WCAP and addressing the PWROG's request for clarification of the information needed in applications utilizing the WCAP. In this SE, the staff concluded that the methodology presented in the WCAP is consistent with the guidance provided in RG 1.174, Revision 1, and is acceptable for referencing in requests to implement alternatives to ASME Code inspection requirements for PWR plants in accordance with the limitations and conditions specified in the SE. In addition to showing that the subject plant is bounded by the pilot plants/parameters identified in Appendix A in the WCAP, licensees that submit a request for an alternative based on the WCAP should submit the following plant-specific information:

1. Licensees must demonstrate that the embrittlement of their RPV is within the envelope used in the supporting analyses. Licensees must provide the

95th percentile total through-wall cracking frequency ($TWCF_{TOTAL}$) and its supporting material properties at the end of the period in which the relief is requested to extend the ISI from 10 years to 20 years. The 95th percentile total TWCF ($TWCF_{95\text{-}TOTAL}$) must be calculated using the methodology in NUREG-1874. The Radiographic Testing temperature-maximum ($RT_{MAX\text{-}X}$) and the shift in the Charpy transition temperature produced by irradiation defined at the 30 foot-pound (ft-lb) energy level, ΔT_{30}, must be calculated using the methodology documented in the latest revision of RG 1.99 or other NRC-approved methodology. $RT_{MAX\text{-}X}$ is the material property that characterizes the reactor vessel's resistance to fracture, initiating from flaws in plates ($RT_{MAX\text{-}PL}$), forgings ($RT_{MAX\text{-}FO}$), axial welds, and circumferential welds ($RT_{MAX\text{-}AW/CW}$).

2. Licensees must report whether the frequency of the limiting design-basis transients during prior plant operation are less than the frequency of the design-basis transients identified in the PWROG fatigue analysis that are considered to significantly contribute to fatigue crack growth.

3. Licensees must report the results of prior ISI of RPV welds and the proposed schedule for the next 20-year ISI interval. The 20-year inspection interval is a maximum interval. In its request for an alternative, each licensee shall identify the years in which future inspections will be performed. The dates provided must be within plus or minus one refueling cycle of the dates identified in the implementation plan provided to the NRC in PWROG letter OG-10-238, dated July 12, 2010 (ADAMS Accession No. ML11153A033).

4. Licensees with B&W plants must (a) verify that the fatigue crack growth of 12 heat-up/cool-down transients per year, which was used in the PWROG fatigue analysis, bounds the fatigue crack growth for all of its design-basis transients; and (b) identify the design-basis transients that contribute to significant fatigue crack growth.

5. Licensees with RPVs having forgings that are susceptible to underclad cracking and with $RT_{MAX\text{-}FO}$ values exceeding 240 degrees Fahrenheit must submit a plant-specific evaluation to extend the inspection interval for ASME Code, Section XI, Categories B-A and B-D RPV welds from 10 years to a maximum of 20 years because the analyses performed in the WCAP are not applicable.

6. Licensees seeking second or additional interval extensions shall provide the information and analyses requested in Section (e) of 10 CFR 50.61a.

WCAP-16168-NP-A, Revision 3, which contains a copy of the NRC staff's January 26, 2011, SE of the WCAP was issued in October 2011 (ADAMS Accession No. ML11306A084) and is hereafter referred to as the WCAP-A.

3.4 Description of Proposed Alternatives

The licensee proposes to defer the ASME Code required Categories B-A and B-D weld ISI for MPS2 until 2027. The proposed ISI date is consistent with OG-10-238 which is the latest updated implementation plan for the PWROG plants (ADAMS Accession No. ML11153A033).

3.5 Components for Which Relief is Requested

The affected component is the MPS2 RPV. The following examination categories and item numbers from IWB-2500 and Table IWB-2500-1 of the ASME Code, Section XI, are addressed in this request:

Examination Category	Item Number	Description
B-A	B1.11	Circumferential Shell Welds
B-A	B1.12	Longitudinal Shell Welds
B-A	B1.21	Circumferential Head Welds
B-A	B1.22	Meridional Head Welds
B-A	B1.30	Shell-to-Flange Weld
B-A	B1.40	Head-to-Flange Weld
B-D	B3.90	Nozzle-to-Vessel Welds
B-D	B3.100	Nozzle Inside Radius Section

3.6 Basis for Proposed Alternative

The basis for the proposed alternative is WCAP-A. Plant-specific parameters for MPS2 are summarized in the attachment to the licensee's letter dated February 18, 2016. The format of the information is patterned after that found in Appendix A of the WCAP-A. Tables 1, 2, and 3 of the attachment to the licensee's submittal lists the critical parameters identified in the WCAP-A and compares the results of the Combustion Engineering pilot plant to those at MPS2.

3.7 NRC Staff Evaluation

The NRC reviewed the licensee's proposal to extend the MPS2 ISI interval in order to determine whether the licensee met the risk-informed criteria set forth in the WCAP-A for a Combustion Engineering plant. By showing that MPS2 is bounded by the Combustion Engineering pilot plant analysis with respect to the six criteria discussed in section 3.2 of this SE, the licensee would have a sufficient technical basis for extending the ISI in accordance with the provisions of the WCAP-A. The MPS2 RPV has a single layer cladding and is bounded by the Combustion Engineering pilot plant basis.

The licensee stated that three complete 10-year ISIs have been performed on MPS2. Fourteen indications were identified in the beltline region during the most recently completed ISI and were found in the upper to intermediate shell circumferential weld seam, the intermediate to lower shell circumferential weld seam, and a lower shell longitudinal weld seam. All fourteen indications were found to be acceptable per Table IWB-3510-1 of the ASME Code, Section XI. Table 3 of 10 CFR 50.61a defines the maximum allowable number

of flaws per 1000 square-inches of inside surface area in the inspection volume that lie within given through-wall extent (TWE [in.]) minimums and maximums. Based on the volumetric examination area, the licensee provided a scaled table containing applicable flaw limitations along with the number of axial and circumferential plate flaws identified and their respective TWEs. One axial and one circumferential plate flaw were found to lie within 0.075 and 0.375 inches; the axial flaw also lied within the TWE range of 0.125 and 0.375 inches. For MPS2, the allowable number of flaws to be identified in these length ranges are 102 and 40 respectively. Therefore the licensee has verified that the indications found are acceptable per the requirements of 10 CFR 50.61a.

The MPS2 fourth ISI of the reactor vessel full penetration pressure-retaining Examination Category B-A and B-D welds is scheduled for spring 2016 (refueling outage 24), preceding the end of the fourth 10-year ISI interval, scheduled for March 31, 2020. The licensee has requested to extend the end of the interval to 2030 and proposed to perform the fourth examination of the welds in 2028 plus or minus one refueling outage. The proposed date is consistent with the PWROG letter OG-10-238, and the staff finds the date acceptable so long as the examination is completed prior to March 31, 2030.

Table 3 of the licensee's submittal provided the TWCF of the limiting axial weld, plate and circumferential weld, along with the parameters necessary to perform the calculations. The licensee utilized the methodology provided in RG 1.99, Rev. 2 to calculate the shift in the Charpy transition temperature produced by irradiation defined at the 30 ft-lb energy level, ΔT_{30}. The licensee reported that the $TWCF_{95\text{-}TOTAL}$ for MPS2 was 1.49×10^{-11} per year, which is well below the Combustion Engineering pilot plant bounding value of 3.16×10^{-7} per year. The NRC staff performed independent calculations which verified the results reported by the licensee; therefore, the staff finds the $TWCF_{95\text{-}TOTAL}$ for MPS2 acceptable.

With regard to the frequency and severity of design basis transients, the licensee was required to show that MPS2 has a number of heatup/cooldown transients bounded by that of the Combustion Engineering pilot plant basis (13 heatup/cooldown cycles per year). Table 4.3-2 of MPS2's License Renewal Application shows that there had been 61 heatups and cooldowns between September 26, 1975 and December 31, 2002, correlating to approximately two cycles per year. Exceeding the 13 cycle per year limit would require an average of about two cycles each month since the beginning of 2003, which is not consistent with the plant's operating history. Therefore, the staff agrees that the frequency of the limiting design basis transients during prior plant operation are less than the frequency of the Combustion Engineering design basis transients identified in the PWROG fatigue analysis.

Since MPS2 is a Combustion Engineering plant, the 4th criterion stated in section 3.3 related to B&W plants is not applicable. Furthermore, the licensee did not report any forgings that are susceptible to underclad cracking so the 5th criterion also is not applicable to this plant. Lastly, the licensee is not currently seeking additional interval extensions, so the 6th and final criterion is not applicable.

In summary, the licensee's submittal demonstrated that the RPV for MPS2 is bounded by the Combustion Engineering limitations set forth in the WCAP-A and the associated SE from the NRC staff. The licensee adequately confirmed that the MPS2 RPV meets all of the applicable criterion set forth in the WCAP-A.

4.0 CONCLUSION

As set forth above, the NRC staff finds that extending the fourth ISI interval for Categories B-A and B-D components from 10 to 20 years will not result in any considerable increase in risk in failure of these components. This is based on the determination that the MPS2 RPV is bounded by the WCAP-A and the request met all of the provisions set forth in the WCAP-A as described in the NRC staff's January 26, 2011, SE of the WCAP-A. 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) and the proposed alternative will provide an acceptable level of quality and safety. Therefore, the licensee's alternative ISI schedule for the specified welds is acceptable for extension to March 31, 2030. The examination of the Category B-A and B-D components for MPS2 shall be conducted prior to the end of the extended fourth interval.

All other requirements of the ASME Code, Section XI and Alternate Request RR-04-22 for which relief has not been specifically requested and authorized by NRC staff remain applicable, including a third party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: Austin Young

Date: October 18, 2016

If you have any questions, please contact the project manager, Richard Guzman, at (301) 415-1030 or Richard.Guzman@nrc.gov.

Sincerely,

/RA/

Douglas Pickett, Acting Chief
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-336

Enclosure:
Safety Evaluation

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ADAMS Accession No.: ML16277A678 * Concurrence via e-mail dated April 22, 2016)

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