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

March 24, 2020

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

SUBJECT: MILLSTONE POWER STATION, UNIT NO. 2 – ALTERNATIVE REQUEST RR-05-03 FOR THE FIFTH 10-YEAR INSERVICE INSPECTION INTERVAL (EPID L-2019-LLR-0095)

Dear Mr. Stoddard:

By letter dated September 24, 2019 (Agencywide Documents Access and Management System Accession No. ML19275D252), Dominion Energy Nuclear Connecticut, Inc. (the licensee) requested relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Case N-770-2, "Alternative Examination Requirements and Acceptance Standards for Class 1 PWR [Pressurized Water Reactor] Piping and Vessel Nozzle Butt Welds Fabricated With UNS N06082 or UNS W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities, Section XI, Division 1," for the Millstone Power Station, Unit No. 2 (Millstone 2).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee proposed an alternative, RR-05-03, for the fifth 10-year inservice inspection interval, regarding a one-time extension of the volumetric examination frequency of the N-770-2, Table 1, Inspection Item B, reactor coolant pump inlet and outlet nozzle dissimilar metal butt welds of Millstone 2, 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, as set forth in the enclosed safety evaluation, that the licensee has adequately addressed all the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes RR-05-03 for the fifth 10-year inservice inspection interval at Millstone 2 until the fall 2021 refueling outage.

All other ASME 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.

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

Sincerely,

/RA/

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

Docket No. 50-336

Enclosure:
Safety Evaluation

cc: Listserv

UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATIVE REQUEST RELATED TO THE FIFTH 10-YEAR

INSERVICE INSPECTION INTERVAL

DOMINION ENERGY NUCLEAR CONNECTICUT, INC.

MILLSTONE POWER STATION, UNIT NO. 2

DOCKET NO. 50-336

1.0 INTRODUCTION

By letter dated September 24, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19106A049), Dominion Energy Nuclear Connecticut, Inc. (the licensee) requested relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Case N-770-2, "Alternative Examination Requirements and Acceptance Standards for Class 1 PWR [Pressurized Water Reactor] Piping and Vessel Nozzle Butt Welds Fabricated With UNS N06082 or UNS W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities, Section XI, Division 1," for Millstone Power Station, Unit No. 2 (Millstone 2).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee proposed an alternative, RR-05-03, for the fifth 10-year inservice inspection (ISI) interval, regarding a one-time extension of the volumetric examination frequency of the N-770-2, Table 1, Inspection Item B, reactor coolant pump inlet and outlet nozzle dissimilar metal butt welds of Millstone 2, 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)(F), all licensees of PWRs must augment their ISI program by implementing ASME Code Case N-770-2 subject to the conditions specified in paragraphs (g)(6)(ii)(F)(2) through (13) of 10 CFR 50.55a. ASME Code Case N-770-2, Table 1, Inspection Item B (unmitigated butt welds at cold leg operating temperature), requires that the licensee perform a volumetric examination of subject Millstone 2 welds every second inspection period not to exceed 7 years.

The regulations in 10 CFR 50.55a(z) state 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. Section 50.55a(z)(1) of 10 CFR states that alternatives to the requirements of paragraphs (b) through (h) may be used when authorized by

the U.S. Nuclear Regulatory Commission (NRC) if the licensee demonstrates that "the proposed alternative would provide an acceptable 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 NRC to authorize, the proposed alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 Applicable ASME Code Requirement and Components Affected

Millstone 2 has adopted ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 2013 Edition, as the code of record for the fifth 10-year ISI interval, as required by 10 CFR 50.55a.

The regulation in 10 CFR 50.55a(g)(6)(ii)(F) requires, in part, that licensees of PWRs augment their ISI program by implementing the requirements of ASME Code Case N-770-2. The eight Millstone 2 reactor coolant pump (RCP) inlet and outlet nozzle dissimilar metal (DM) butt welds listed in the table below are categorized as Inspection Item B (Table 1 of Code Case N-770-2), which requires that these welds undergo bare-metal visual examinations once per inspection interval and volumetric examinations every second inspection period, not to exceed 7 years.

ASME Code Class 1 Welds Affected

RCP Inlet Nozzle Safe-End-to Elbow Welds	RCP Outlet Nozzle Safe-End-to-Pipe Welds
Weld No. P-4-C-1	Weld No. P-5-C-3
Weld No. P-8-C-1	Weld No. P-9-C-3
Weld No. P-13-C-1	Weld No. P-14-C-3
Weld No. P-17-C-1	Weld No. P-18-C-3

3.2 Reason for Request

Dominion Energy Nuclear Connecticut, Inc. requests a one-time extension of the frequency of the next RCP inlet and outlet nozzle DM butt weld volumetric examination to approximately 7.5 years. If approved, this extension would allow the welds to be examined during the fall 2021 outage (2R27) versus the spring 2020 outage (2R26), which would be required to meet the not-to-exceed 7 years requirement. Examination during the 2R26 outage would only allow 6 years between examinations, as the welds were last examined during the spring 2014 outage. The licensee states that analyses demonstrate that the proposed alternative reexamination frequency of a nominal 7.5 years will maintain an acceptable level of safety and quality.

3.3 Licensee's Proposed Alternative and Basis for Use

The licensee's proposed alternative, RR-05-03, is to allow a one-time extension of the requirement to volumetrically examine the eight ASME Code Case N-770-2, Table 1, Inspection Item B RCP, inlet and outlet nozzle DM butt welds to approximately 7.5 years. This will allow examination of these eight welds during the fall 2021 refueling outage (2R27) instead of during the spring 2020 refueling outage (2R26).

The licensee's technical basis for the relief request is based on cold leg Alloy 82/182 DM butt weld operating experience and deterministic crack growth calculations demonstrating structural

integrity of the subject welds, along with other required examinations and existing monitoring practices providing defense in depth. The licensee provided this technical basis to demonstrate that the reexamination interval can be extended, while maintaining an acceptable level of quality and safety.

The licensee states that the eight Alloy 82/182 RCP inlet and outlet nozzle DM butt welds are located in the cold leg temperature region of the reactor coolant system (RCS), which has a large benefit compared to Alloy 82/182 welds operating at hot leg or pressurizer temperatures. However, the subject welds are still considered susceptible to primary water stress corrosion cracking (PWSCC).

The licensee mentioned that plant experience shows that detectable PWSCC is unlikely to affect the subject welds over the time period of the alternative examination frequency ending in fall 2021. The licensee cited MRP-349, "Materials Reliability Program: PWR Reactor Coolant System Cold-Loop Dissimilar Metal Butt Weld Reexamination Interval Extension: A Basis for Revision to the Requirements of MRP-139 and American Society of Mechanical Engineers Code Case N-770 for Large-Diameter Welds at Cold Leg Temperatures," dated August 2012 (see ADAMS Accession No. ML12276A110), as a reference. The licensee stated that as of spring 2012, PWSCC indications have not been reported for nominal pipe size 14 and greater Alloy 82/182 piping butt welds operating at reactor cold leg temperature, including RCP inlet and outlet nozzle Alloy 82/182 welds. The licensee further stated that there remains no service experience involving cracking in these types of welds to date.

The licensee states that the flaw growth and flaw tolerance calculations in WCAP-17128-NP, "Flaw Evaluation of CE [Combustion Engineering] Design RCP Suction and Discharge Nozzle Dissimilar Metal Welds, Phase III Study, Revision 1," dated May 2010 (ADAMS Accession No. ML12306A291), bound the weld geometry and loads specific to the subject RCP inlet and outlet nozzle Alloy 82/182 welds at Millstone 2. The licensee also states that WCAP-17128-NP and Section 5.3.1 of MRP-349 present the results of advanced finite-element analysis crack growth studies that model flaw shape development based on the stress intensity factor calculated at each point along the crack front. The licensee concludes that the results of these calculations demonstrate that structural integrity of the subject weld joints will be maintained under the proposed alternative reexamination frequency of a nominal 7.5 years.

Additionally, the licensee states that the frequent visual examination performed from the exterior of the welds and the RCS leak rate monitoring provide defense in depth to address the possibility of through-wall cracking and consequent boric acid corrosion.

3.4 Duration of Proposed Alternative

This request is applicable to the Millstone 2 ISI program for the fifth 10-year ISI interval. The proposed alternative is applicable until the fall 2021 refueling outage (2R27). This is a one-time extension inspection frequency request.

3.5 NRC Staff Evaluation

The NRC staff notes that the generic requirements for the frequency of volumetric examination of DM butt welds was established to provide reasonable assurance of the leaktightness and structural integrity of the reactor coolant pressure boundary. However, the NRC staff finds that a plant-specific analysis could be used to provide a basis for inspection relief if the inspection frequency can be shown to maintain reasonable assurance of the leaktightness and structural

integrity of the weld. The NRC staff reviewed the licensee's proposed alternative under the requirements of 10 CFR 50.55a(z)(1) such that "The proposed alternatives would provide an acceptable level of quality and safety."

The NRC staff reviewed each of the following licensee's bases: (1) there has been no service experience with cracking found in any large diameter cold leg DM welds; (2) crack growth calculations demonstrate structural integrity of the subject welds will be maintained; and (3) other required examinations and existing RCS leak rate monitoring practices provide defense in depth.

The NRC staff's review of industry PWSCC operating experience found no indications of PWSCC in large diameter cold leg temperature Alloy 82/182 DM butt welds. The NRC staff notes that cracking has been identified in cold leg temperature DM welds of smaller pipe size than the RCP inlet and outlet nozzle welds. Further, cracking has been found in other locations at cold leg temperatures in the reactor coolant pressure boundary. Therefore, the NRC staff notes that the Millstone 2 RCP inlet and outlet nozzle DM welds are made with weld materials susceptible to PWSCC.

The NRC staff reviewed the information submitted for the 2014 examination of the Millstone 2 RCP inlet and outlet nozzle DM butt weld volumetric examinations alternative request RR-04-15 (ADAMS Accession Nos. ML13108A008 and ML14051A109) to ensure the flaw growth and tolerance calculations in WCAP-17128-NP were bounding for the subject welds. The NRC staff found that the volumetric examination coverage estimated for the 2014 ultrasonic examinations was sufficient to detect the assumed flaws in the WCAP-17128-NP and MRP-349 evaluations.

The NRC staff determined that the flaw evaluations of WCAP-17128-NP and MRP-349 are bounding for the subject welds. The results for circumferential flaws show that very large flaws can be tolerated in the cold leg region because the residual stress effects were found to retard flaw growth in the circumferential direction. WCAP-17128-NP and MRP-349 documented flaw tolerance calculations to determine the required time for a postulated flaw to reach the ASME Code, Section XI allowable flaw size. Both fatigue crack growth and stress corrosion cracking were considered. These results showed that a flaw with an aspect ratio (crack depth/length) as large as 0.10 and a through-wall depth of 20 percent would remain acceptable for 10 years. The flaw tolerance evaluations were supplemented with advanced finite-element analysis where the postulated flaw was allowed to grow due to PWSCC in a natural shape, dictated by the stresses present. Results of the flaw tolerance analysis showed the postulated flaw would remain within the ASME Code acceptable depth for 7.5 to over 11 years. This analysis did not consider the beneficial effects of the adjacent stainless-steel field weld, which induces a region of compressive stress in the mid-wall region of the pipe, which would further slow the crack growth.

The WCAP-17128-NP and MRP-349 analyses find that axial cracks affecting the subject welds are not a credible concern for producing a pipe rupture and loss-of-coolant-accident because the crack size is limited to the width of the PWSCC susceptible material (i.e., of the Alloy 82/182 weld metal). For the subject Millstone 2 RCP nozzle Alloy 82/182 welds, the width (i.e., axial extent) of Alloy 82/182 weld metal is nominally 2.20 inches for the inlet nozzles and 1.88 inches for the outlet nozzles. These widths are much smaller than the critical through-wall axial flaw length of 38.2 inches documented in MRP-349 for the limiting RCP nozzle case of the Millstone 2 RCP inlet and outlet nozzle dissimilar metal butt welds. Therefore, the NRC staff finds that the extension of the inspections to 7.5 years is not a structural integrity issue for axial flaws. However, the reports do find that results for some axially-oriented flaws show shorter

through-wall crack growth times than either the current ASME Code Case N-770-2 and the proposed alternative reexamination frequencies.

WCAP-17128-NP and MRP-349 performed evaluations to quantify the margin between leakage detection and the time it would take for a flaw to reach a critical length. Initial flaws were postulated that resulted in leakage rates within typical nuclear power plant leak detection capabilities. The growth of the flaws by PWSCC and fatigue crack growth was then calculated to determine the length of time it would take for the flaws to reach critical size. The critical size based on limit load methodology is the circumferential flaw length required to cause pipe failure due to plastic collapse. Plant technical specifications require that plants be able to detect a 1 gallon/minute RCS leak rate; therefore, the time for a circumferential through-wall flaw to grow to critical length is approximately 10 years. As stated above, axial flaws are limited in length to the width of the weld and, therefore, not a credible concern for producing a pipe rupture. Therefore, the NRC staff believes that the visual examinations required by ASME Code, Section XI; 10 CFR 50.55a(g)(ii)(E); and 10 CFR 50.55a(g)(ii)(F) would ensure that if through-wall cracking did occur, it would be detected prior to impacting structural integrity of the piping systems.

In summary, the NRC staff reviewed the licensee's previous examinations and verified the evaluations performed in WCAP-17128-NP and MRP-349 are bounding for the eight Millstone 2 RCP inlet and outlet nozzle DM butt welds. Review of operating experience showed that PWSCC in these large diameter cold leg temperature RCS piping welds is unlikely. However, if present, the licensee's evaluations demonstrated that significant undetected flaws would likely still meet the ASME acceptance criteria at the 7.5-year reexamination frequency. Also, the visual examinations required by the ASME Code, Section XI, and 10 CFR 50.55a provide defense in depth for the detection of PWSCC degradation of these welds. Therefore, the NRC staff finds that the licensee has provided an adequate technical basis to provide reasonable assurance of leaktightness and structural integrity for the extended inspection frequency, which increases the maximum inspection frequency for these welds from 7 to 7.5 calendar years. Accordingly, the NRC staff finds that the licensee's proposed alternative RR-05-03 would provide an acceptable level of quality and safety.

4.0 CONCLUSION

As set forth above, the NRC staff has determined that proposed alternative RR-05-03 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). Therefore, the NRC staff authorizes the use of the licensee's proposed alternative RR-05-03 at Millstone 2 for the fifth 10-year ISI Interval until the fall 2021 refueling outage (2R27).

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

Principal Contributor: K. Hoffman

Date: March 24, 2020

SUBJECT: MILLSTONE POWER STATION, UNIT NO. 2 – ALTERNATIVE REQUEST RR-05-03 FOR THE FIFTH 10-YEAR INSERVICE INSPECTION INTERVAL (EPID L-2019-LLR-0095) DATED MARCH 24, 2020

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