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

April 4, 2014

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 - ISSUANCE OF RELIEF REQUEST RR-04-16 REGARDING USE OF ENCODED PHASED ARRAY ULTRASONIC EXAMINATION IN LIEU OF RADIOGRAPHY (TAC NO. MF2520)

Dear Mr. Heacock:

By letter dated August 1 2013, as supplemented by letters dated November 22, 2013, February 27, and March 14, 2014, Dominion Nuclear Connecticut, Inc. the licensee, submitted relief request (RR) RR-04-16, requesting relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Section XI, Paragraph IWA-4221 for Millstone Power Station Unit 2 (Millstone Unit 2). The 2004 Edition of ASME Section XI, paragraph IWA-4221 requires the owner to use the requirements of the construction code for repair and replacement activities. Section III, paragraph NC-5200, of the construction code specifies the use of radiographic examinations. The licensee is proposing to use phased array ultrasonic testing (UT) as an alternative to the required radiographic testing (RT).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3)(ii), the licensee requested to use the proposed alternative on the basis that complying with the requirement to use RT for repair and replacement activities would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. However, the Nuclear Regulatory Commission (NRC) staff has determined that the relief request is more appropriately evaluated under 10 CFR 50.55a(a)(3)(i) on the basis that the proposed alternative would provide an acceptable level of quality and safety.

The NRC staff concludes that the licensee's proposed alternative to use UT in lieu of RT using encoded phased array examinations provides reasonable assurance of structural integrity and leak tightness of the nineteen subject Class 2 ferritic piping welds. Thus, UT using the procedure described in the submittal of the nineteen subject welds provides an acceptable level of quality and safety. Accordingly, the staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(a)(3)(i). Therefore, the staff authorizes RR-04-16 for Millstone Unit 2 for the remainder of the fourth 10-year Inspection interval that began on April 1, 2010, and is scheduled to end on March 31, 2020.

All other requirements of the ASME Code for which relief has not been specifically requested remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact the Millstone Power Station Project Manager, Mohan Thadani, at (301) 415-1476.

Sincerely,

Douglas V Pickett for

Benjamin G. Beasley, Chief
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-336

Enclosure:
As stated

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

RELIEF REQUEST RR-04-16

DOMINION NUCLEAR CONNECTICUT, INC.

MILLSTONE POWER STATION, UNIT NO. 2

DOCKET NUMBER 50-336

1.0 INTRODUCTION

By letter dated August 1, 2013,[1] as supplemented by letters dated November 23, 2013,[2] February 27, 2014,[3] and March 14, 2014,[4] Dominion Nuclear Connecticut, Inc., the licensee, submitted relief request (RR) RR-04-16, requesting relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Section XI, Paragraph IWA-4221 for Millstone Power Station Unit 2 (Millstone Unit 2). The 2004 Edition of ASME Section XI, paragraph IWA-4221 requires the owner to use the requirements of the construction code for repair and replacement activities. Section III, paragraph NC-5200, of the construction code specifies the use of radiographic examinations. The licensee is proposing to use phased array ultrasonic testing (UT) as an alternative to the required radiographic testing (RT).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3)(ii), the licensee requested use of the proposed alternative on the basis that complying with the requirement to use RT for repair and replacement activities would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. However, the Nuclear Regulatory Commission (NRC) staff has determined that the relief request is more appropriately evaluated under 10 CFR 50.55a(a)(3)(i) on the basis that the proposed alternative would provide an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

The licensee has requested relief from the requirements of ASME Code Section XI paragraph IWA-4221. Section XI section IWA-4200 covers repair and replacement activities, and paragraph IWA-4221 requires the use of Section III paragraph NC-5200, which requires the use of radiographic examinations on Class 2 piping butt welds.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) shall meet the requirements, except the design and access provisions and the

---

[1] Agencywide Document Access and Management System (ADAMS) Accession No. ML13220A019
[2] ADAMS Accession No. ML13338A284
[3] ADAMS Accession No. ML14063A206
[4] ADAMS Accession No. ML14084A383

pre-service examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that repair and replacement activities 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(b) 12 months prior to the start of the 120-month inspection interval, subject to the conditions listed therein.

Paragraph 55a(a)(3) of 10 CFR 50 states, in part, that alternatives to the requirements of 10 CFR 50.55a(g) may be used, when authorized by the NRC, if (i) the proposed alternatives would provide an acceptable level of quality and safety or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The staff evaluated RR-04-16 under 10 CFR 50.55a(a)(3)(i).

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.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Relief Request

Applicable Code Requirement

The ASME Code for Inservice Inspection of Nuclear Power Plant Components, Section XI, 2004 Edition, no Addenda as amended by 10 CFR 50.55a, is the code of record for the Millstone Unit 2 fourth 10-year inspection interval.

The 2004 Edition of ASME Section XI, paragraph IWA-4221 (Construction Code and Owner's Requirements) requires the owner to use the requirements of the construction code for repair and replacement activities. The examination requirements for ASME Section III, Class 2 circumferential butt welds are contained in the ASME Code, Section III, paragraph NC-5200. The requirement is to perform radiographic examinations of these welds using the acceptance standards specified in paragraph NC-5300.

The RT must be conducted according to ASME Code Section V "Nondestructive Examination" Subsection A, Article 2 "Radiographic Examination" (Section V Article 2).

Components Covered

All welds are in the feedwater and auxiliary feedwater system associated with two containment penetrations that provide feedwater supply to two steam generators and are constructed using ASTM A335, Grade P22 ferritic steel. The initial RR dated August 1, 2013, described 23 welds, but the request for additional information (RAI) response dated November 22, 2013, reduced the scope of the RR to nineteen welds. The nineteen welds are a mix of butt welds and pipe to flue welds. Eleven of the welds allow for dual-sided access and eight of the welds allow only single sided access. The welds are described in Tables 1 and 2.

Table 1: Steam Generator 1 A-Train

ID/Weld No.	Configuration	Size	Access
1A/AC-G-13-A	90° long radius (LR) elbow to 90° LR elbow	18" SCH 60 (0.750" nominal wall)	Dual
1B/AC-G-12-A	90° LR elbow to pipe at containment (CTMT) penetration	18" SCH 60 (0.750" nominal wall)	Dual
1C/N/A	CTMT Pipe to Flue	18" SCH 60 (0.750" nominal wall)	Single
1D/N/A	Flue to pipe inside CTMT	18" SCH 60 (0.750" nominal wall)	Single
1E/AC-G-11-A	Pipe to 90° Long Radius elbow	18" SCH 60 (0.750" nominal wall)	Dual
1F/AC-G-10A	90° LR elbow to 90° LR elbow	18" SCH 60 (0.750" nominal wall)	Dual
1G/AC-G-09-A	90° LR elbow to pipe	18" SCH 60 (0.750" nominal wall)	Dual
1H/AC-G-08-A	Pipe to pipe	18" SCH 60 (0.750" nominal wall)	Dual
1L/AC-G-16	6" auxiliary feedwater (AFW) nozzle to pipe	6" (0.280" nominal Wall)	Single
1M/AC-G-17	6" AFW pipe to LR elbow	6" (0.280" nominal Wall)	Dual

Table 2: Steam Generator 2 B-Train

ID/Weld No.	Configuration	Size	Access
2A/BC-G-14	Check valve to 90° LR elbow	18" SCH 60 (0.750" nominal wall)	Single
2B/BC-G-13	90° LR elbow to pipe at CTMT penetration	18" SCH 60 (0.750" nominal wall)	Dual
2C/NA	Pipe to pipe	18" SCH 60 (0.750" nominal wall)	Dual
2D/NA	CTMT pipe to flue	18" SCH 60 (0.750" nominal wall)	Single
2E/N/A	Flue to pipe inside CTMT	18" SCH 60 (0.750" nominal wall)	Single
2F/BC-G-12	Pipe to 90° LR elbow	18" SCH 60 (0.750" nominal wall)	Dual
2G/BC-G-11	90° LR elbow to vertical pipe	18" SCH 60 (0.750" nominal wall)	Dual
2K/BC-G-16	6" AFW nozzle to pipe	6" (0.280" nominal Wall)	Single
2L/BC-G-17	6" AFW pipe to valve	6" (0.280" nominal Wall)	Single

Proposed Alternative

The licensee is proposing the use of encoded phased array ultrasonic examination technique in lieu of the code required radiographic examination for the feedwater piping replacement in containment during the upcoming Refueling Outage 22.

Elements of the licensee's proposed alternative examination include:

> The surface shall be conditioned such that transducers may properly couple with the scanning surface with no more than a 1/32-inch gap between the search unit and the scanning surface.
>
> The ultrasonic examination shall be performed with equipment, procedures, and personnel qualified by performance demonstration.
>
> The ultrasonic examination shall include 100 percent of the weld volume, which includes the weld-to-base material interface on each side of the weld.
>
> The acceptance standards for volumetric ultrasonic examination shall be in accordance with ASME Section III, NC-5330 "Ultrasonic Acceptance Standards" with evaluation of flaw indications in accordance with the procedure rather than using a 20 percent amplitude reference level threshold.
>
> The ultrasonic examination shall be performed using encoded (position and amplitude) examination methods.
>
> A written ultrasonic examination procedure qualified by performance demonstration for flaw detection, characterization, and sizing shall be used.
>
> Ultrasonic examination personnel shall be qualified in accordance with ASME Section XI, IWA-2300. In addition, examination personnel shall demonstrate their capability to detect, characterize and size flaws by performance demonstration.

Several examples of successful detection of planar flaws and volumetric flaws for both thickness ranges were provided to NRC staff for review.

The licensee described the results of the ultrasonic tests in context with the results of an ASME Code Section V Article 2 radiographic test used to characterize the test blocks used to qualify the ultrasonic technique.

Basis for Use

The overall basis for this relief is that encoded phased array UT is equivalent to or superior for detecting and sizing critical (planar) flaws as compared to the required radiographic examination.

Duration of Proposed Alternative

The licensee requests approval of this relief for the remainder of the fourth 10-year Inspection interval that began on April 1, 2010 and is scheduled to end on March 31, 2020.

3.2 NRC Staff Evaluation

The licensee is proposing to use encoded phased array UT in lieu of RT in RR-04-16. UT, like RT, is a volumetric inspection technique that is commonly used to inspect welds in nuclear power plants and in other industries. Ultrasonic examinations are not equivalent to radiographic examinations as they use different physical mechanisms to detect and characterize discontinuities. These differences in physical mechanisms result in several key differences in sensitivity and discrimination capability. The NRC has examined the differences between UT and requiring RT in a technical letter report "Replacement of Radiography with Ultrasonics for the Nondestructive Inspection of Welds – Evaluation of Technical Gaps – An Interim Report" (ADAMS Accession No. ML101031254). More recent information, including work performed at the Pacific Northwest National Laboratory on the application of UT in lieu of RT was presented at the public meeting on August 30, 2012 (ADAMS Accession No. ML12243A447).

The RR was initially submitted under 10 CFR 50.5a(a)(3)(ii), to use the proposed alternative on the basis that complying with the requirement to use radiographic testing for repair and replacement activities would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The licensee has stated that performing RT examinations would involve increased radiation doses to a larger crew of workers than with UT examinations. The projected increase in dose was estimated to be between 50-100 millirem (mrem). The NRC staff has determined that 50-100 mrem of dose does not constitute a hardship. Furthermore, RT is a commonly-used NDE technique, and the general use of RT is not considered a hardship and is not unusual. Based on this determination the staff evaluated RR-04-16 under 10 CFR 50.55a(a)(3)(i), if the proposed alternative would provide an acceptable level of quality and safety.

The initial RR proposed the use of a generic qualification program for qualifying ultrasonic procedures to be used in lieu of RT. The initial RR did not provide a sufficient technical basis to allow the use of the generic qualification procedure, and the NRC staff has ongoing concerns with the developments of a generic qualification procedure for such ultrasonic tests. To address this issue the NRC issued an RAI, dated October 1, 2013, on the specific procedure that would be used to inspect the welds covered in this RR and the experimental data showing that the procedure was capable of performing the inspections effectively. The licensee provided responses on February 27 and March 14, 2014, showing the effectiveness of the procedure to be used in the inspections.

The proposed inspections would include, as a minimum, scans using encoded phased array search units with the weld crowns removed. Eleven of the welds will be examined from both sides of the welds in four directions, using two circumferential scans for axial flaws and two axial scans for circumferential flaws. Eight of the welds will be scanned from one side of the weld due to limitations in the geometry of the component. These welds will be scanned from two circumferential directions for axial flaws and one axial direction for circumferential flaws.

These examinations would not count as the pre-service ultrasonic examinations, which would be conducted in accordance with ASME Section XI. RR-04-16 is applicable only to the ferritic steel welds described in Tables 1 and 2 of this Safety Evaluation.

The licensee developed a set of test blocks for use in qualifying the procedure and personnel. This set of test blocks consists of five 18 inch diameter and 0.75 inch thick blocks and three 6 inch diameter 0.28 inch thick blocks. These test blocks were then scanned using the proposed ultrasonic procedure and examined by using a radiographic test following the requirements of ASME Code Section V Article 2 utilizing an Iridium 192 source.

Single Sided Ultrasonic Examinations

One area of concern for the NRC staff is the proposed use of single-sided ultrasonic examinations for eight components in RR-04-16. The technical basis for the reliable detection and characterization of fabrication flaws has thus far assumed that the inspections will be conducted from both sides of the weld. The few published experimental evaluations that have explored the reliability of single-sided ultrasonic examinations suggest that detecting fabrication flaws, especially lack of fusion defects, using single sided UT misses flaws found by inspections conducted from both sides (see EPRI Report 1021181 page A-5 and the paper "An Empirical Study on Ultrasonic Testing in Lieu of Radiography for Nuclear Power Plants" in the Proceedings of the 9th international conference on NDE [nondestructive examination] in relation to structural integrity for nuclear and pressurized components). One of the characteristics of lack of fusion defects is that they produce a reduced or no indication when examined from one side of the weld.

The licensee addressed this concern in their letter dated February 27, 2014, by showing successful detections of lack of fusion defects from either side of the welds. The proposed procedure addresses the difficulties in detecting lack of fusion defects on the near side of the weld by using the "second leg" of the ultrasonic beam. As shown in the letter dated February 27, 2014, the use of the second leg enables the procedure to detect lack of fusion defects from either side of the weld. The amplitudes of the responses from the defects are lower from the near side of the weld, but the lack-of-fusion defects are still clearly detectable.

Additionally, the licensee compared the results of the proposed ultrasonic procedure to the results of the ASME Code required RT examination of the welds. The licensee provided examples of cracks and lack of fusion flaws that were detected by UT from either side of the weld but were not detected by RT.

Permanent Records

As stated in the letter dated November 22, 2013, the electronic data files for the UT examinations will be stored as part of the archival quality record. In addition to the electronic data, hard copy prints of the data will also be included as part of the record that allows viewing without the use of hardware or software.

Acceptance Criteria

The licensee is planning to use the acceptance criteria in ASME Code, Section III NC-5330 acceptance criteria for the weld inspections. The NC-5330 acceptance criteria describe two

classes of flaws. Planar-type flaws that are defined as cracks, lack of fusion, and incomplete penetration are not acceptable at any length. Other volumetric-type flaws, such as slag and porosity, are acceptable if their length is below certain thresholds defined in NC-5330. The two classes of flaws require that the inspector be able to discriminate between the flaw types. While it makes little difference if the inspector cannot distinguish between slag and porosity, as they have the same acceptance criteria, it is critical that the inspector be able to properly characterize cracks, lack of fusion, and incomplete penetration, as these types of flaws are unacceptable in ASME Code Section III NC-5330. The licensee will not use the 20 percent amplitude threshold in ASME Code Section III NC-5330.

The NRC staff finds that the use of ASME Code Section III NC-5330 acceptance criteria without the 20 percent amplitude threshold is acceptable for the UT techniques described in RR-04-16.

Procedure Demonstration

The procedure demonstration described in RR-04-16 is an open demonstration using a minimum of 30 flaws. The inspection procedures would be qualified by examining a set of open test specimens to determine if the procedure can detect and characterize the flaws in the specimens. The specimens will contain a variety of fabrication-style flaws, including incomplete fusion, incomplete penetration, slag inclusions, porosity, and cracking.

Additionally, as described in the letter dated August 1 2013, the personnel performing the examination must pass a blind demonstration prior to analyzing data from the welds. An analyst reviewing data from a poorly-performing procedure would have a very challenging time passing a performance demonstration.

The combination of the limitation of RR-04-16 to Class 2 ferritic welds, the flaws scanned, detected, and identified in the information provided in the letters dated February 27, 2014, and March 14, 2014, and the use of the blind personnel performance demonstration qualification (described below) addresses the NRC staff concerns with the development of a generic qualification procedure for such ultrasonic tests.

Personnel Demonstration

As stated in RR-04-16, personnel conducting the examinations would need to pass a blind performance demonstration examination. The analyst would have to examine a minimum of ten flaws. To pass the demonstration, the personnel would need to detect 80 percent or greater of the intended flaws, and no more than 20 percent of the grading units shall contain a false call.

ASME Code Section III NC-5330 describes two sets of acceptance standards for different types of flaws, i.e. no acceptable flaw lengths for cracks, lack of fusion, and incomplete penetration and acceptable flaw lengths for other flaws. To be qualified for flaw characterization, 80 percent or greater of the intended flaws within the demonstration set shall be correctly characterized as planar (which includes cracks, lack of fusion and incomplete penetration) or volumetric (which includes slag and porosity). Any non-flaw condition (geometry, etc.) reported as a flaw shall be considered a false call.

Procedure Optimization

When comparing the proposed encoded phased-array ultrasonic procedure as an alternative to the Section V Article 2 RT it is important to consider that the UT procedure was optimized to inspect these specific welds while Section V Article 2 is a generic RT standard. The licensee built a series of test blocks of the same thicknesses and geometries as the piping to be examined containing implanted flaws. The licensee then developed and optimized an inspection method capable of finding the flaws. While the NRC staff finds this specific encoded phased array UT procedure to be effective for detecting fabrication flaws in the 19 specified welds, there is currently no technical basis to apply the proposed inspection procedure on other configurations.

Summary

The qualification program described in the letter dated August 1 2013, while important, does not provide sufficient justification for the use of UT in lieu of RT. The procedure description, the UT results given in the letters dated November 22, 2013, February 27, 2014, and March 14, 2014, provided the needed assurance that the procedure will be able to adequately perform the inspections. The results of the inspection procedure were required to determine that the proposed alternative provides an adequate level of quality and safety. Also, the procedure was developed using mockups matching the components to be inspected and was optimized to find flaws in components with these specific geometries.

While the NRC staff has concerns with the generic use of UT in lieu of RT, the use of the procedure provided by the licensee on the Class 2 ferritic welds included in Tables 1 and 2 of this Safety Evaluation sufficiently address these concerns. This Safety Evaluation is not a generic endorsement of the concept of using a procedure and personnel qualification program for the use of UT in lieu of RT. This evaluation is limited to the application of the procedure and the qualification program described in RR-04-16 on the 19 welds described in the letter dated November 22, 2013.

4.0 CONCLUSION

As set forth above, the NRC staff concludes that the licensee's proposed alternative to use UT in lieu of RT using encoded phased array examinations provides reasonable assurance of structural integrity and leak tightness of the nineteen subject Class 2 ferritic piping welds. Thus, UT using the procedure described in the submittal of the nineteen subject welds will provide an adequate level of quality and safety. Accordingly, the staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(a)(3)(i). Therefore, the staff authorizes RR-04-16 for Millstone Unit 2 for the remainder of the fourth 10-year Inspection interval that began on April 1, 2010, and is scheduled to end on March 31, 2020.

All other requirements of the ASME Code for which relief has not been specifically requested remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: Stephen Cumblidge

Date: April 4, 2014

If you have any questions, please contact the Millstone Power Station Project Manager, Mohan Thadani, at (301) 415-1476.

Sincerely,

/ra/ (DPickett for)

Benjamin G. Beasley, Chief
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-336

Enclosure:
As stated

cc w/encl: Distribution via Listserv

Distribution:
PUBLIC
RidsNrrDorlLpl1-1 Resource
RidsNrrPMMillstone Resource
SCumblidge, NRR
LPL I-1 Reading
RidsNrrDeEpnb Resource
RidsNrrDorlDpr
RidsAcrsAcnw_MailCTR Resource
RidsNrrLAKGoldstein Resource
RidsRgn1MailCenter Resource

ADAMS ACCESSION NO.: ML14091A973 *See memo dated April 2, 2014

OFFICE	LPL4-2/PM	LPL1-1/PM	LPL1-1/LA	EPNB/BC	LPL1-1/BC
NAME	JKim	MThadani	KGoldstein	TLupold*	BBeasey (DPickett for)
DATE	04 / 03 /2014	04/04/2014	04/03/2014	04/02/14	04 /04/ 2014

OFFICIAL RECORD COPY