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

May 2, 2013

Mr. David A. Heacock
President and Chief Nuclear Officer
Virginia Electric and Power Company
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, VA 23060-6711

SUBJECT: NORTH ANNA POWER STATION, UNIT 2 (NAPS2), FOURTH 10-YEAR INTERVAL INSERVICE INSPECTION (ISI) PROGRAM, STEAM GENERATOR NOZZLE-TO-VESSEL WELD EXAMINATION REQUIREMENTS ALTERNATIVE REQUEST N2-I4-LMT-001-R1 (TAC NO. MF1401)

Dear Mr. Heacock:

By letter dated April 4, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession Number ML13102A034) as amended by letter dated April 22, 2013 (ADAMS Accession No. ML13114A253), the Virginia Electric and Power Company (Dominion, the licensee) submitted alternative N2-I4-LMT-001-R1. N2-I4-LMT-001-R1 requests an alternative to the essentially 100 percent volumetric nondestructive examination (NDE) coverage requirements for axial welds required by the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Case N-770-1 baseline NDE conditioned by Title 10 of the *Code of Federal Regulations* Part 50 (10 CFR 50) Paragraph 55a(g)(6)(ii)(F)(3) for two steam generator inlet and outlet dissimilar metal welds at the North Anna Power Station, Unit 2 (NAPS2) for one operating cycle.

The U.S. Nuclear Regulatory Commission staff has concluded based on the information provided by the licensee, pursuant to 10 CFR 50.55a(a)(3)(ii), that Relief Request N2-I4-LMT-001-R1 is authorized on the basis that compliance with the specified requirements of the ASME Code would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

If you have any questions concerning this matter, please contact Dr. Sreenivas at (301) 415-2597.

Sincerely,

Robert L. Pascarelli, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-339

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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

FOURTH 10-YEAR INTERVAL INSERVICE INSPECTION (ISI)

RELIEF REQUEST N2-I4-LMT-001-R1

NORTH ANNA POWER STATION, UNIT NO. 2

VIRGINA ELECTRIC AND POWER COMPANY

DOCKET NO. 50-339

1.0 INTRODUCTION

By letter dated April 4, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession Number ML13102A034) as amended by letter dated April 22, 2013 (ADAMS Accession No. ML13114A253), the Virginia Electric and Power Company (Dominion, the licensee) submitted alternative N2-I4-LMT-001-R1. N2-I4-LMT-001-R1 requests an alternative to the essentially 100 percent volumetric nondestructive examination (NDE) coverage requirements for axial welds required by the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Case N-770-1 baseline NDE conditioned by Title 10 of the *Code of Federal Regulations* Part 50 (10 CFR 50) Paragraph 55a(g)(6)(ii)(F)(3) for two steam generator inlet and outlet dissimilar metal welds at the North Anna Power Station, Unit 2 (NAPS2) for one operating cycle.

Specifically, pursuant to 10 CFR 50.55a(a)(3)(ii) the licensee requested to use an alternative on the basis that complying with the specified requirements would result in hardship or unusual difficulty. The licensee provided information on the hardship associated with obtaining the essentially 100 percent coverage for the inspection procedure used to inspect the steam generator welds during the Spring 2013 refueling outage.

2.0 REGULATORY REVIEW

By letter dated April 4, 2013, the licensee proposed the use of an alternative inservice inspection of two welds pursuant to 10 CFR 50.55a(a)(3)(ii) on the basis that complying with the specified requirement would result in hardship or unusual difficulty.

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 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, which was incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein.

Pursuant to 10 CFR 50.55a(g)(6)(ii)(F) licensees must follow the rules for dissimilar metal weld inspections described in ASME Code Case N-770-1 "Alterative Examination Requirements and Acceptance Standards for Class 1 PWR 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" subject to the conditions specified in 10 CFR 50.55a(g)(6)(ii)(F)(2) through 10 CFR 50.55a(g)(6)(ii)(F)(10).

Pursuant to 10 CFR 50.55a(g)(6)(ii)(F)(3) baseline examinations for welds in ASME Code Case N-770-1 Table 1, inspection Items A–1, A–2, and B, shall be completed by the end of the next refueling outage after January 20, 2012. These baseline examinations require essentially 100 percent examination coverage.

Paragraph 50.55a(a)(3) to 10 CFR states, in part, that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if the applicant demonstrates that: (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.

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 Component Descriptions

Welds N-SE29 IN and N-SE31 IN are nozzle-to-safe end dissimilar metal welds on the inlet and outlet of the "C" loop steam generator at NAPS2. The welds are made of 82/182 weld metal with a 0.13 inch thick alloy 52/152 inlay on the inner diameter (ID) surface. As dissimilar metal welds both are covered by ASME Code Case N-770-1. Weld N-SE29 IN is an ASME Code Case N-770-1, Inspection Item "A-2", Unmitigated Butt Weld at Hot Leg Operating Temperature ≤ 625°F (329°C). Weld N-SE31 IN is an ASME Code Case N-770-1, Inspection Item "B", Unmitigated Butt Weld at Cold Leg Operating Temperature ≥ 525° (274°C) and < 580°F (304°C). The welds are further described in Table 1.

Table 1: Welds Covered by Relief Request N2-14-LMT -001-R1

Weld #	Outer Diameter	Weld Thickness	N-770-1 Item Number	Axial Flaw Coverage (%)	Circumferential Flaw Coverage (%)	Total Coverage (%)
N-SE29 IN	41 in.	4.84 in.	A-2	53.0	97.9	75.5
N-SE31 IN	41 in.	4.84 in.	B	20.3	93.9	57.1

Both welds have 50 percent through-wall repairs that left a 2.75 inch wide convex area on the outer diameter (OD) surface.

3.2 Code Requirements

Examination requirements for Class 1 piping and nozzle dissimilar-metal butt welds are described in ASME Code Case N-770-1. The use of ASME Code Case N-770-1 is required by 10 CFR 50.55a(g)(6)(ii)(F). Additionally, 10 CFR 50.55a(g)(6)(ii)(F)(3) states that baseline examinations "shall be completed by the end of the next refueling outage after January 20, 2012."

Weld N-SE29 IN is an ASME Code Case N-770-1, Inspection Item A-2 weld and requires visual examination each refueling outage and volumetric examination with essentially 100 percent coverage every 5 years.

Weld N-SE31 IN is an ASME Code Case N-770-1, Inspection Item B weld and requires visual examination once per interval and volumetric examination with essentially 100 percent coverage every second inspection period not to exceed 7 years.

The baseline and subsequent volumetric examinations are to be conducted in accordance with ASME Section XI, Appendix VIII, Supplement 10, "Qualification Requirements for Dissimilar Metal Piping Welds" which is applicable to dissimilar metal welds. These baseline examinations require essentially 100 percent inspection coverage. 10 CFR 50.55a(g)(6)(ii)(F)(4) states that "The axial examination coverage requirements of [ASME Code Case N-770-1 paragraph]–2500(c) may not be considered to be satisfied unless essentially 100 percent coverage is achieved."

3.3 Requested Relief

Relief is requested to the Code-required examination volume of essentially 100 percent for the axial examination coverage of Code Case N-770-1 as conditioned in 10 CFR 50.55a(g)(6)(ii)(F)(3) for volumetric examination of the NAPS 2 Steam Generator "C" hot leg and cold leg nozzle-to-safe-end welds.

3.4 Basis for Relief (As Stated)

> [North Anna Power station] NAPS utilized volumetric examination techniques that are qualified to the requirements of ASME Section XI, Appendix VIII, as required in 10 CFR 50.55a(g)(6), that achieved the maximum practical amount of coverage obtainable within the limitations imposed by the final fabrication condition of the Steam Generator "C" nozzles. Additionally, [bare metal visual] BMV examinations for leakage (VE examinations in accordance with ASME Code Case N-722-1) were performed on the Steam Generator nozzle [dissimilar metal welds] DMWs during the fall 2011 refueling outage (during the current interval) and will continue to be performed as required by [ASME] Code Case N-722-1 and the station's Boric Acid Corrosion Control Program. To date, those examinations have not identified any evidence of leakage at the Steam Generator nozzle-to-safe-end DMWs. The volumetric examination limitations only result in less than required coverage in the circumferential beam direction for detection of axially oriented flaws. The combination of required volumetric coverage for detection of safety significant circumferential flaws, the presence of PWSCC resistant materials at the wetted surface of the welds and BMV examinations provides confidence that an acceptable level of quality

and safety is maintained until the fall 2014 refueling outage. It is noted that a flaw analysis of the time for the smallest detectable axial flaw to reach a 75% thru-wall extent in the "C" Loop welds was considered, however, based on the current examination volumes, it would only be feasible to perform a sensitivity study to predict a bounding flaw length in the weld region, which would provide little to no additional information in support the current request, and is therefore not available.

The examinations were performed to the extent possible. The applicable procedure utilizes encoded phased array technology to provide data imaging, which allows off-line analysis by multiple qualified examiners. The examinations were performed with a series of beam angles to interrogate the examination volume. For the axial beam direction examination for circumferential flaws, low inside impingement angles, i.e., 30 degrees, were qualified to ASME Section XI, Appendix VIII, Supplement 10 requirements, as modified by the [Performance Demonstration Initiative] PDI, and were applied to maximize coverage of the examination volume where restricted scan areas exist. For the circumferential beam direction examination for axial flaws, qualified electronic beam skewing into the weld was utilized to maximize coverage of the examination volume where the surface contour prevented scanning from the weld surface. Focal laws and beam simulations were created to validate the ability of the phased array probe to effectively produce the required beam skews.

Although qualified [ultrasonic testing] UT techniques and procedures exist for performing the UT examinations from the ID surface, the required tooling for the delivery of the UT probes for the North Anna 3-loop Westinghouse design has not been validated. Mockups would be necessary to ensure the capabilities of the delivery system to properly install the equipment and perform the examinations. In addition, the high radiation levels inside the steam generator channel head will require remote installation capabilities, which would also require mockup training and practice with the installation team. These factors do not allow this technology to be implemented during the current refueling outage.

Based on existing fabrication records, the DMWs final ID welding would have been completed using the Automated [gas tungsten arc welding] GTAW process with weld filler materials having a minimum chromium content of 28% (i.e., Alloy 52). The fabrication records also show that the Alloy 52 material would have filled the last 0.27" of the safe-end DMW groove. Documentation from Westinghouse engineering has confirmed that it is conservative to assume a minimum of two weld layers were used in the application of the weld inlays, while maintaining the >24% chromium content of the weld surfaces that contact the primary water (Reference 8.5). After final machining, the Alloy 52 inlays have a nominal thickness of 0.13", and the Alloy 52 cladding tie-ins to the nozzles have a nominal thickness of 0.22". Figure 7 illustrates the final configuration and filler materials used during the construction of the nozzle-to-safe-end DMWs. The completed DMWs received final visual, [penetrant testing] PT, [radiographic testing] RT, and UT [nondestructive examination] NDE for ASME Section III and Section XI acceptance.

Baseline UT examinations were also performed on the Steam Generator "A" hot leg (99.8% total coverage) and cold leg (99.8% total coverage), as well as the Steam Generator "B" hot leg (100% total coverage) and cold leg (99.8% total coverage), nozzle to safe-end DMWs, as described in Table 1 [Table 1 is in the letter dated April 22, 2013].

3.5 Proposed Alternative

In lieu of the required essentially 100 percent volumetric ultrasonic baseline examination, the licensee proposes to use the ultrasonic examination achieved for the two welds.

3.6 Duration of Proposed Relief

The duration of the proposed alternative in this request is one operating cycle, until the next refueling outage at NAPS2, which is currently scheduled for the fall of 2014.

3.7 Staff Evaluation

The staff reviewed the licensee's proposed alternative under the requirements of 10 CFR 50.55a(a)(3)(ii). Welds N-SE29 IN and N-SE31 IN are dissimilar metal welds made with the nickel alloy 82/182 which is known to be susceptible to primary water stress corrosion cracking. These dissimilar metal welds are covered by ASME Code Case N-770-1 which was developed in response to the rapid propagation of PWSCC in 82 and 182 weld metals. The use of ASME Code Case N-770-1 is required by 10 CFR 50.55a(g)(6)(ii)(F). Additionally, 10 CFR 50.55a(g)(6)(ii)(F)(3) states that baseline examinations meeting Appendix VIII Supplement 10 requirements shall be completed by the end of the next refueling outage after January 20, 2012. The baseline examinations at NAPS2 would therefore need to be completed prior to reactor startup in the spring 2013 refueling outage.

Both welds have an approximately 2.75 inch wide convex region over the weld that limits inspection coverage by preventing adequate ultrasonic coupling between the ultrasonic search unit and the weld. This convex region is the result of 50 percent through-wall repairs that extend 360 degrees around both welds.

Both steam generator dissimilar metal welds have a thin (≈0.13 inch thick) inlay of the nickel Alloy 52. Alloy 52 is known to have a longer initiation time and slower crack growth rate than alloys 82 and 182, and provides a degree of protection to the welds. The licensee has not requested re-categorization of the welds to include the inlays and the welds are still categorized as ASME Code N-770-1 Inspection Items A-2 and B.

The licensee has stated that an ASME Code Appendix VIII qualified examination that would achieve essentially 100 percent coverage can be performed on the welds, but this procedure cannot be implemented during the current refueling outage. The licensee has stated that the equipment and tooling required for conducting the inspection on the steam generator welds has not been validated. Site-specific mockups would be necessary to ensure the capabilities of the delivery system to properly install the equipment and perform the examinations. These factors would prevent this technology from being implemented without significantly extending the current refueling outage. Prolonging the current outage by weeks or months to obtain and validate the tooling and manipulators to apply the inspections would pose a hardship on the licensee.

The examinations were performed using encoded phased array ultrasound. No service-induced indications were found in the examinations. The licensee provided modeling information showing that the phased array probes were able to adequately insonify the weld to the angles used to calculate coverage. Independent ultrasonic modeling by NRC staff confirmed the modeling results provided by the licensee.

In addition to the "C" loop, the licensee performed baseline examinations on the "A" and "B" loop steam generator inlet and outlet dissimilar metal welds and achieved essentially 100 percent coverage. No service-induced indications were found.

The inspection of weld N-SE29 IN was able to obtain 97.3 percent coverage for circumferential flaws and 53 percent coverage for axial flaws. The coverage for circumferential flaws is sufficient to provide reasonable assurance of the structural integrity of the weld. The 53 percent coverage for axial flaws does not inspect the weld buttering and also misses part of the weld itself. An axial flaw that is confined to the buttering material would not be detected by this inspection. The NRC staff estimated the largest flaw that would be hidden by the missed coverage as 0.75 inches in depth. This estimate was made by placing a semi-circular flaw at the interface between the buttering and the ferritic steel and growing the flaw (keeping the semi-circular shape) until the crack reached a depth of approximately 10 percent through-wall (0.5 inches) in the inspected region.

The inspection of weld N-SE31 IN was able to obtain 93.9 percent coverage for circumferential flaws and 20.3 percent coverage for axial flaws. The coverage for circumferential flaws is sufficient to provide reasonable assurance of the structural integrity of the weld. The 20.3 percent coverage for axial flaws does not inspect any of the buttering and misses a significant part of the weld. An axial flaw that is confined to the buttering material would not be detected by this inspection. The NRC staff estimated the largest flaw that would be hidden by the missed coverage as one inch in depth. This estimate was made by placing a semi-circular flaw at the interface between the buttering and the ferritic steel and growing the flaw (keeping the semi-circular shape) until the crack reached a depth of approximately 10 percent through-wall (0.5 inches) in the inspected region.

The NRC staff performed an independent and conservative crack growth analysis using finite element crack growth analysis software. For weld N-SE29 IN a 0.75 inch deep semi-elliptical flaw, a coolant temperature of 625 degrees F, and a conservative residual stress profile were used. For weld N-SE31 IN a 1 inch deep semi elliptical flaw, a coolant temperature of 580 degrees F, for both crack growth calculation, a conservative residual stress profile was used. In both cases the postulated flaws did not grow to beyond 75 percent through wall before the fall 2014 refueling outage.

While the flaw growth analysis did not take the alloy 52 inlay into account, the staff does recognize that the inlays would almost certainly slow the propagation of any possible cracks. The alloy 52 inlays can be assumed to add an additional assurance to the flaw growth calculations.

As stated above, the examination coverage for circumferential flaws provides reasonable assurance of structural integrity for the welds for one cycle. Based on the inspections performed for axial flaws and the flaw growth analysis, there is also reasonable assurance of leak tightness of the welds for one cycle.

4.0 CONCLUSIONS

As set forth above, the NRC staff determines that complying with the essentially 100 percent coverage for the baseline examination requirements prior to startup in the spring 2013 refueling outage at the North Anna Power Station, Unit 2, would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The ultrasonic examinations

performed to the extent possible provide reasonable assurance of structural integrity and leak tightness of the subject components until the next refueling outage scheduled for the fall of 2014. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(a)(3)(ii).

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.

Therefore, the NRC staff authorizes alternative N2-14-LMT-001-R1 at the North Anna Power Station, Unit 2, until the end of the next refueling outage currently scheduled for the fall of 2014.

Principal Contributor: Stephen Cumblidge, NRR

Date: May 2, 2013

If you have any questions concerning this matter, please contact Dr. Sreenivas at (301) 415-2597.

Sincerely,

/RA/

Robert L. Pascarelli, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-339

Enclosure:
Safety Evaluation

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