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

October 10, 2017

Mr. William R. Gideon
Site Vice President
Brunswick Steam Electric Plant
8470 River Rd., SE
M/C BNP001
Southport, NC 28461

SUBJECT: BRUNSWICK STEAM ELECTRIC PLANT, UNIT 2 – RELIEF FROM THE REQUIREMENTS OF THE ASME CODE, SECTION XI, IWA-4000 (INSERVICE INSPECTION PROGRAM ALTERNATIVE ISI-07) (CAC NO. MF9561)

Dear Mr. Gideon:

By letter dated April 6, 2017 (Agencywide Documents Access and Management (ADAMS) Accession No. ML17096A619), Duke Energy Progress, LLC (the licensee) submitted a request entitled, "Inservice Inspection (ISI) Program Alternative ISI-07, Weld Overlay of Control Rod Drive Return Line Nozzle N9 Dissimilar Metal Weld," to the U.S. Nuclear Regulatory Commission (NRC) for the use of alternatives to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, IWA-4000 requirements at the Brunswick Steam Electric Plant (Brunswick), Unit 2.

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee submitted Inservice Inspection (ISI) Program Alternative ISI-07 for the alternate repair of the degraded dissimilar metal butt weld B211N9-RPV-FW2CRD52 of the control rod drive return line nozzle N9 on the basis that the alternate repair provides an acceptable level of quality and safety.

On April 6, 2017 (ADAMS Accession No. ML17096A333), the NRC verbally authorized the use of the Alternative ISI-07 at Brunswick, Unit 2, for the fourth 10-year ISI interval, which began on May 11, 2008, and ends on May 10, 2018. As set forth in the enclosed safety evaluation, the NRC staff concludes that the weld overlay provides acceptable structural integrity and may remain in place for the remaining life of the plant. The NRC staff also determined that the proposed alternative is technically justified and provides reasonable assurance of the structural integrity of the affected weld. As such, the NRC staff finds that the alternate repair provides an acceptable level of quality and safety and concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC authorizes the use of ISI Program Alternative ISI-07 at Brunswick, Unit 2, for the fourth 10-year ISI interval, which began on May 11, 2008, and ends on May 10, 2018.

All other ASME Code requirements for which relief was not specifically requested and approved in this proposed alternative remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact the Project Manager, Andrew Hon, at 301-415-8480 or Andrew.Hon@nrc.gov.

Sincerely,

Undine Shoop, Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-324

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

UNITED STATES
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SAFETY EVALUATION BY THE OFFICE NUCLEAR REGULATION

FOR INSERVICE INSPECTION PROGRAM ALTERNATIVE ISI-07

ALTERNATE REPAIR OF CONTROL ROD DRIVE RETURN LINE NOZZLE N9

DUKE ENERGY PROGRESS, INC.

BRUNSWICK STEAM ELECTRIC PLANT, UNIT 2

DOCKET NO. 50-324

1.0 INTRODUCTION

By letter dated April 6, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17096A619), Duke Energy Progress, LLC (the licensee) requested the use of an alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, IWA-4000, at the Brunswick Steam Electric Plant, Unit 2.

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee submitted Inservice Inspection (ISI) Program Alternative ISI-07 for the alternate repair of the degraded dissimilar metal butt weld (DMW) B211N9-RPV-FW2CRD52 of the control rod drive (CRD) return line nozzle N9 on the basis that the alternate repair provides an acceptable level of quality and safety.

On April 6, 2017 (ADAMS Accession No. ML17096A333), the U.S. Nuclear Regulatory Commission (NRC) verbally authorized the use of ISI Program Alternative ISI-07 at the Brunswick Steam Electric Plant, Unit 2, for the fourth 10-year ISI interval, which began on May 11, 2008, and ends on May 10, 2018. The NRC staff concluded that the weld overlay provides acceptable structural integrity and may remain in place for the remaining life of the plant. The NRC staff determined that the proposed alternative is technically justified and provides reasonable assurance of the structural integrity of the affected weld. This safety evaluation documents the technical basis for the NRC's verbal authorization.

2.0 REGULATORY EVALUATION

Adherence to Section XI of the ASME Code is mandated by 10 CFR 50.55a(g)(4), which states, in part, that ASME Code Class 1, 2, and 3 components will meet the requirements, except the design and access provisions and the pre-service examination requirements, set forth in the ASME Code, Section XI.

Section 50.55a(z) *Alternatives to codes and standards requirements* of 10 CFR 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, as appropriate. A proposed alternative must be

submitted and authorized prior to implementation. The licensee must demonstrate that:

(1) *Acceptance level of quality and safety.* The proposed alternative would provide an acceptable level of quality and safety; or

(2) *Hardship without a compensating increase in quality and safety.* 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.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the licensee to request the use of an alternative and the NRC to authorize the proposed alternative.

3.0 TECHNICAL EVALUATION

3.1 ASME Code Affected Component

The ASME Code component affected is the ASME Class 1, DMW B211N9-RPV-FW2CRD52, which joins reactor vessel CRD line nozzle N9 and an end cap. The weld is classified as Examination Category B-J, Item Number B9.11, in accordance with Table IWB-2500-1 of the ASME Code, Section XI. The weld is also covered under the risk-informed ISI program and is classified as Examination Category R-A and Item Number R1.20-4.

The weld material is nickel-based Alloy 82/182 (ER NiCr-3, SFA 5.14). The reactor vessel CRD return line nozzle is made of low alloy steel, SA-508, Class 2. The end cap is fabricated with nickel-based Alloy 600, SB-166 (N06600).

The reactor vessel CRD return line nozzle is 5-inch nominal size. The nozzle is buttered with Alloy 82/182 weld material and is internally clad with stainless steel.

3.2 Applicable ASME Code Edition and Addenda

The code of record for the current fourth ISI interval is ASME Code, Section XI, 2001 Edition through 2003 Addenda.

The licensee compared the proposed alternative to the ASME Code, Section XI, Non-Mandatory Appendix Q, 2007 Edition through 2008 Addenda.

The NRC staff notes that Appendix Q does not appear in the 2001 Edition through 2003 Addenda. Appendix Q was initially incorporated in the 2004 Edition of the ASME Code, Section XI. The NRC staff has approved the 2007 Edition through 2008 Addenda of the ASME Code, Section XI, in 10 CFR 50.55a. Therefore, the licensee is permitted to use Appendix Q of the 2007 Edition through 2008 Addenda for comparison purposes.

3.3 Applicable ASME Code Requirement

IWA-4411 of the ASME Code, Section XI, states: "Welding, brazing and installation shall be performed in accordance with the Owner's Requirements and, except as modified below, in accordance with the original Construction Code of the item."

IWA-4411(a) of the ASME Code, Section XI, states, in part: "Later Editions and Addenda of the Construction Code, or a later different Construction Code, either in its entirety or portions thereof, and Code Cases may be used, provided the substitution is as listed in IWA-4221(c)."

IWA-4411(b) of the ASME Code, Section XI, states: "Revised Owner's Requirements may be used, provided they are reconciled in accordance with IWA-4222."

IWA-4411(e) of the ASME Code, Section XI, states: "The requirements of IWA-4600(b) may be used when welding is to be performed without the post-weld heat treatment required by the Construction Code."

ASME Code, Section XI, Appendix VIII, Supplement 11, provides requirements for the qualification requirements for the ultrasonic testing (UT) examination of full structural overlaid wrought austenitic piping welds.

3.4 Licensee's Basis for Proposed Alternative

The licensee stated that welds containing nickel-based Alloys 82 and 182 material have experienced stress corrosion cracking (SCC) in components operating at pressurized water and boiling water reactor (BWR) temperatures. The licensee proposed to mitigate the SCC susceptibility of the subject DMW by installing a full structural weld overlay (FSWOL) on the DMW. This approach provides an alternative to replacement of the component as a means of restoring full component integrity and assuring the structural integrity of this location.

The licensee noted that currently there are no NRC-approved criteria for a licensee to apply an FSWOL to an Alloy 82/182 DMW. Also, the edition and addenda of the ASME Code, Section XI, applicable to the plant does not contain requirements for weld overlays. However, DMW overlays have been applied to RPV nozzle DMWs in the BWRs using alternative requirements. The licensee proposed to use ASME Code Case N-740-2, "Dissimilar Metal Weld Overlay for Repair or Mitigation of Class 1, 2, and 3 Items," for application of an FSWOL to the subject DMW. Because the NRC has not approved Code Case N-740-2 in the latest revision of Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," an alternative is required.

3.5 Licensee's Proposed Alternative to the ASME Code

In lieu of repairing or replacing the subject weld in accordance with the ASME Code, Section XI, IWA-4000, the licensee proposed to install an FSWOL using Alloy 52M weld metal that structurally replaces the existing weld based on ASME Code Case N-740-2 as discussed in Enclosure 1 of the submittal dated April 6, 2017.

In lieu of performing UT examinations on the overlaid weld in accordance with Appendix VIII, Supplement 11 of the 2001 Edition through 2003 Addenda of ASME Code, Section XI, the licensee requested to use the Performance Demonstration Initiative (PDI) program to ultrasonically examine the FSWOL as discussed in Attachment 3 to Enclosure 1 of the submittal dated April 6, 2017.

3.6 Licensee's Basis for Use

Flaw Sizing and Characterization

The licensee stated that the indication in the nozzle N9 weld is circumferentially oriented and located within the weld and butter. In accordance with proximity rules of the ASME Code, Section XI, IWA-3000, the circumferentially oriented indication has been combined with two embedded axially oriented indications for a combined indication with an estimated length of 6.36 inches and a through-wall dimension of 0.48 inches. The remaining ligament from the outside weld surface is 0.386 inches. The minimum as-left thickness of the weld is 0.829 inches. The indication is located 5.50 inches clockwise from top dead center (i.e., looking at the nozzle). The licensee reported that the circumferential indication is connected to the inside surface of the weld.

Material Specification

The licensee will use nickel-based Alloy 52M weld material for the FSWOL installation.

Design

The licensee stated that the ASME Code Committee has approved Code Case N-740-2 to allow the application of FSWOLs on nickel-based alloy DMWs. Code Case N-740-2 provides the basis and requirements for the weld overlay techniques as discussed in Attachments 1 and 2 to Enclosure 1 of the submittal dated April 6, 2017. Code Case N-740-2 incorporates the approved version of ASME Code Case N-638-4 for application of a temper bead surface area over the ferritic low alloy steel RPV nozzle that is as large as 500 square inches.

The licensee demonstrated the applicability of Code Case N-740-2 to the FSWOL installation by comparing it with Code Case N-504-4, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Section XI, Division 1," and the ASME Code, Section XI, Appendix Q, "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments," as shown in Attachment 4 to Enclosure 1 of the submittal dated April 6, 2017.

The licensee stated that the proposed alternative provides an acceptable methodology for mitigating SCC and for mitigating the defect in the subject weld to the acceptable size in accordance with the ASME Code, Section XI. The weld overlay filler metals that are resistant to SCC (e.g., Alloy 52/52M), create compressive residual stresses within the original weld, and post-overlay preservice and ISI examinations provide assurance that structural integrity will be maintained for the remaining service life of the weld. The FSWOL will also meet the applicable stress limits of the ASME Code, Section III. The licensee further stated that crack growth evaluations for SCC and fatigue of the as-found flaw demonstrate that structural integrity of the overlaid weld will be maintained for the remaining service life of the component.

Installation

The licensee proposed to install the FSWOL using the machine gas tungsten arc welding (GTAW) process in combination with the ambient temperature temper bead welding technique. The technical basis of this welding process is documented in Electric Power Research Institute (EPRI) Topical Report GC-111050, "Ambient Temperature Preheat for Machine GTAW Temper

Bead Applications," November 1998. According to the EPRI report, repair welds performed with an ambient temperature temper bead procedure using the machine GTAW process exhibit mechanical properties equivalent to or better than those of the surrounding base material. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this welding process.

The use of the ambient temperature temper bead welding technique with the GTAW eliminates the pre-weld and post-weld heat treatments as required by the ASME Code or Construction Code. The reason to preheat a component prior to welding is to minimize the potential for cold cracking. The two cold cracking mechanisms are hydrogen cracking and restraint cracking. Both mechanisms occur at ambient temperature. Preheating slows down the cooling rate resulting in a ductile, less brittle microstructure, thereby lowering susceptibility to cold cracking. Preheat also increases the diffusion rate of monatomic hydrogen that may have been trapped in the weld during solidification. As an alternative to preheat, the ambient temperature temper bead welding process uses the tempering action of the welding procedure to produce tough and ductile microstructures. Because precision bead placement and heat input control are used in the machine GTAW process, effective tempering of the weld heat affected zone is possible without the application of preheat.

The proposed machine GTAW process is not likely to result in hydrogen cracking or cold restraint cracking. The GTAW process uses dry inert shielding gases that cover the molten weld pool from oxidizing atmospheres. Any moisture on the surface of the component being welded is vaporized ahead of the welding torch. The vapor is prevented from mixing with the molten weld pool by the inert shielding gas that blows the vapor away before it can be mixed. Furthermore, modern filler metal manufacturers produce weld wires having very low residual hydrogen. The potential for hydrogen-induced cracking is greatly reduced by using the machine GTAW process.

The ASME Code, Section XI, IWA-4600 temper bead process requires a post-weld soak requirement that is performed at 300 degrees Fahrenheit (°F) for 4 hours for P-No. 3 base materials. This post-weld soak assists diffusion of any remaining hydrogen from the repair weld. As such, the post-weld soak is a hydrogen bake-out and not a post-weld heat treatment as defined by the ASME Code. At 300 °F, the post-weld soak does not stress relieve, temper, or alter the mechanical properties of the weldment in any manner. Because the potential for hydrogen absorption is greatly diminished using the GTAW temper bead process, no post-weld soak is needed for the proposed FSWOL application.

Examinations

The licensee stated that the FSWOL length, surface finish, and flatness are designed to allow for post-installation examinations. The licensee will perform surface and UT examinations of the overlaid weld as discussed below. The licensee's UT examination is qualified through the industry's PDI program that is managed by the EPRI. The industry has implemented the PDI program to satisfy the UT examination requirement of the ASME Code, Section XI, Appendix VIII.

Acceptance Examination

Section A1.4(a) of Attachment 1 to the proposed alternative (Enclosure 1 to the licensee's letter dated April 6, 2017) provides provisions for the acceptance examination. The proposed alternative requires that the FSWOL have a surface finish of 250 micro-inches (µ-in) roughness

measurement system (root-mean-square) or better and a contour that permits ultrasonic examinations.

The FSWOL and adjacent base material for at least 1/2 inch from each side of the overlay will be examined using the liquid penetrant method. The FSWOL will satisfy the surface examination acceptance criteria for welds of the Construction Code or the ASME Code, Section III, NB-5300. The adjacent base material will satisfy the surface examination acceptance criteria for base material of the Construction Code or the ASME Code, Section III, NB-2500. The liquid penetrant examination of the completed FSWOL will be conducted no sooner than 48 hours following completion of the three tempering layers over the ferritic steel.

In addition to a surface examination, Section A1.4(a) of Attachment 1 to the proposed alternative also requires a UT examination. Figure A1-1(a) in Attachment 1 of the proposed alternative specifies the FSWOL volume that will be ultrasonically examined to assure adequate fusion (i.e., adequate bond) with the base material to detect welding flaws such as interbead lack of fusion, inclusions, or cracks. The ultrasonic examination will be conducted no sooner than 48 hours following completion of the three tempering layers over the ferritic steel.

Planar flaws detected in the FSWOL will meet the preservice examination standards of the ASME Code, Section XI, IWB-3514. In applying the planar flaw standards, the thickness of the component must be defined as the thickness of the FSWOL, and the issue of any flaws masked from examination must also be addressed.

Laminar flaws detected in the FSWOL will meet the following requirements:

1. The total laminar flaw area will not exceed 10 percent of the weld surface area and no linear dimension of the laminar flaw area shall exceed the greater of 3 inches or 10 percent of the pipe circumference.

2. For the required examination volume, the reduction in coverage due to laminar flaws will be less than 10 percent.

3. Any uninspectable volume in the weld overlay will be assumed to contain the largest radial planar flaw that could exist within that volume. This assumed flaw will meet the preservice examination acceptance standards of Table IWB-3514-3 of the ASME Code, Section XI, with nominal wall thickness as defined above the planar flaws. Alternatively, the assumed flaw will be evaluated and meet the requirements of IWB-3640. Both axial and circumferential planar flaws will be assumed.

Preservice Examination

Section A1.4(b) of Attachment 1 to the proposed alternative request provides provisions for the preservice examination. Figure A1-2 in Attachment 1 of the proposed alternative specifies the overlaid weld volume that will be ultrasonically examined for the preservice examination. The angle beam will be directed perpendicular and parallel to the piping axis with scanning performed in four directions to locate and size any planar flaw that has propagated into the outer 25 percent of the base metal thickness or into the weld overlay.

The preservice examination acceptance standards of the ASME Code, Section XI, IWB-3514, will be met for the weld overlay. Section A1.4(b) of Attachment 1 to the proposed alternative provides

additional requirements on how the thickness of the weld overlay and base metal are used to satisfy the acceptance standards.

The flaw evaluation requirements of IWB-3640 of the ASME Code, Section XI, will not be applied to planar flaws identified during preservice examination that exceed the preservice examination acceptance standards of IWB-3514.

Inservice Examinations

Section A1.4(c) of Attachment 1 to the proposed alternative provides for the inservice examination. Figure A1-2 of Attachment 1 to the proposed alternative specifies the overlaid weld volume that will be ultrasonically examined for the inservice examination to determine if any new or existing planar flaws have propagated into the outer 25 percent of the base material thickness or into the overlay. The angle beam will be directed perpendicular and parallel to the piping axis with scanning performed in four directions.

The weld overlay will meet the inservice examination acceptance standards of the ASME Code, Section XI, IWB-3514. If the acceptance standards of IWB-3514 cannot be met, the weld overlay will meet the acceptance standards of IWB-3600. If a planar flaw is detected in the outer 25 percent of the base material, thickness will meet the design analysis requirements of Section A1.3 of Attachment 1 to the proposed alternative. Any indication characterized as SCC in the weld overlay material will be deemed unacceptable.

If inservice examinations reveal planar flaw growth or new planar flaws meeting the acceptance standards of IWB-3514, the weld overlay examination volume will be reexamined during the first or second refueling outage following discovery of the growth or new flaws.

The licensee stated that if an unacceptable indication is detected in accordance with Section A1.4(c)(5) of Attachment 1 to the proposed alternative, the weld overlay and original defective weld will be removed. In this scenario, the licensee will perform a repair/replacement activity in accordance with the ASME Code, Section XI, IWA-4000.

The licensee stated that Category E welds (i.e., cracked welds reinforced by weld overlay) are required by BWRVIP-75-A, "BWR Vessel and Internals Project, Technical Basis for Revisions to Generic Letter 88-01 Inspection Schedules," to be examined on the frequency of 25 percent of the population every 10 years. As such, the FSWOL applied to the N9 nozzle-to-end cap weld will be added to the ISI program's Category E population and be eligible for inspection at this frequency. All weld overlays, including those not in the 25 percent sample, will be examined prior to the end of their design life.

Additional Examinations

Section A1.4(d) of Attachment 1 to the proposed alternative provides provisions for the additional examinations, which state that if inservice examinations reveal a defect in accordance with Section A1.4(c)(5) of Attachment 1 to the proposed alternative, planar flaw growth into the weld overlay design thickness or axial flaw growth beyond the specified examination volume, additional weld overlay examination volumes equal to the number scheduled for the current inspection period will be examined prior to return to service. If additional defects are found in the second sample, 50 percent of the total population of weld overlay examination volumes shall be examined prior to return to service. If additional defects are found, the entire remaining population of weld overlay examination volumes shall be examined prior to return to service.

The licensee further stated that regarding the sample expansion, BWRVIP-75-A, Category D, Section 3.4.1, states that if cracking is detected, the sample size will be expanded to a sample equal in number to the size of the initial sample. If cracking is detected in the additional sample, all remaining Category D welds will be examined. The licensee stated that the characteristics of the observed indication in the subject weld are not typical of intergranular stress corrosion cracking (IGSCC), and no SCC flaws were detected during the examination. As the intent of BWRVIP-75-A is to provide guidance on IGSCC-related inspections, the sample expansion requirements of Category D should not apply to the observed indication in the subject weld.

The licensee noted that the subject weld is unique in that it is a cap-to-nozzle nickel-based dissimilar metal weld, which experiences no flow and is located above the top of the active fuel and is not protected by hydrogen water chemistry. This set of conditions is similar to other capped BWR CRD return nozzles, which have previous industry experience with weld indications. In addition, NRC Information Notice 2004-08, "Reactor Coolant Pressure Boundary Leakage Attributable to Propagation of Cracking in Reactor Vessel Nozzle Welds," dated April 22, 2004, concerning cracking on a nuclear plant's CRD return cap-to-nozzle weld concluded no scope expansion was required based on a comparable set of attributes (i.e., Category D nozzle weld, low hydrogen water chemistry protection, and dissimilar metal weld).

The licensee explained that the inspection scope for the current refueling outage includes eight additional scheduled BWRVIP-75-A Category D welds, the remaining four welds in Category D have recent satisfactory inspection results, and weld 2B11N9-RPV-FW2CRD52 is unique in its component type (i.e., a cap-to-nozzle weld). Therefore, the licensee concluded that sample expansion is not considered to provide any additional benefit. The licensee stated that the Brunswick, Unit 1, N9 nozzle is scheduled for inspection in the Spring 2018 refueling outage.

Analyses and Verifications

The licensee stated that it will perform the following analyses and verifications subject to the specific design, analysis, and inspection requirements that are defined in the proposed alternative.

1. The as-built dimensions of the FSWOL will be measured and evaluated to demonstrate that they equal or exceed the minimum design dimensions of the overlay design.

2. Overall component shrinkage will be measured after the weld overlay application.

3. Nozzle specific stress analyses will be performed within 90 days after application of the FSWOL to establish a residual stress profile in the N9 nozzle. Inside diameter weld repairs will be assumed in these analyses to effectively bound any actual weld repairs that may have occurred in the nozzles. The analysis will then simulate application of the FSWOL to determine the final residual stress profile. Post-weld overlay residual stresses at normal operating conditions will be shown to result in an improved stress state at the inside diameter of the N9 nozzle weld region that reduces the probability for further crack propagation due to SCC.

4. The analyses will demonstrate that the application of the FSWOL satisfies all ASME Code, Section III stress and fatigue criteria that will be met for the regions of the overlay remote from observed or assumed cracks.

5. Fracture mechanics analyses will be performed to predict crack growth. Crack growth due to SCC and fatigue in the original DMW will be evaluated. These crack growth analyses will consider all design loads and transients plus the post-weld overlay through-wall residual stress distributions, and will demonstrate that the assumed cracks will not grow beyond the design bases for the weld overlay (i.e., through the original DMW thickness and any additional allowance for crack growth within the weld overlay) for the time period until the next scheduled ISI. The crack growth analyses will determine the amount of growth for assumed cracks to grow over the entire intended service life of the weld overlay.

6. The total added weight on the piping system due to the overlay will be evaluated for potential impact on RPV nozzle stresses and dynamic characteristics.

Post-Installation Submittals

The licensee stated that it will submit summaries of the analysis results listed in Items 1 and 2 above to the NRC prior to entry into Mode 2 following completion of the weld overlay. Items 3 through 6 above will be submitted to the NRC within 90 days of completing the B223R1 refueling outage.

In addition, the licensee stated that the following information will be submitted to the NRC within 14 days of completion of the final UT examination of the overlaid weld.

1. A listing of indications detected in the overlaid weld.

2. The disposition of all indications using the acceptance criteria of ASME Code, Section XI, IWB-3514-2 and/or IWB-3514-3, and, if possible, the type and nature of the indications.

3. A discussion of any repairs to the overlay material and/or base metal and the reason for the repair.

3.7 Duration of Proposed Alternative

The licensee's proposed alternative is applicable to the fourth 10-year ISI interval, which began on May 11, 2008, and will end on May 10, 2018. The licensee stated that the FSWOL installed in accordance with the proposed alternative will remain in place for the design life of the repair.

3.8 NRC Staff Evaluation

The licensee proposed to install the FSWOL on the subject weld based on the provisions of ASME Code Case N-740-2, which the NRC has not approved. However, the NRC has conditionally approved ASME Code Cases 504-4 and N-638-4 in Regulatory Guide 1.147, Revision 17. The NRC staff has also approved Appendix Q of the 2007 Edition through 2008 Addenda of the ASME Code, Section XI, in 10 CFR 50.55a. The NRC staff uses Code Cases N-504-4 and N-638-4 and Appendix Q to review the proposed alternative because they are applicable to FSWOL.

The NRC staff notes that most provisions of Code Case N-740-2 are consistent with provisions of Code Cases N-504-4 and N-638-4 and Appendix Q of the ASME Code, Section XI.

The NRC staff evaluated the proposed alternative in terms of the following categories: flaw sizing and characterization, material specification, design, pre-installation evaluation, installation, examinations, pressure testing, and post-installation submittals.

Flaw Sizing and Characterization

As the licensee stated above, the indication in the subject weld is circumferentially oriented and located within the weld and butter. The NRC finds that the licensee has appropriately combined several flaws into a single flaw in accordance with the proximity rules of the ASME Code, Section XI, IWA-3000. The circumferentially oriented indication has an estimated length of 6.36 inches, which is approximately 36 percent of the pipe circumference. The indication has a depth of 0.48 inches. The remaining ligament from the outside weld surface is 0.386 inches. The indication depth is approximately 55 percent through wall. The NRC staff notes that the circumferential indication is considered as unacceptable in accordance with the ASME Code, Section XI, IWB-3514, and requires repair or replacement.

The NRC staff notes that flaw sizing and characterization are a necessary part of the pre-repair evaluation such that the information is used to design the FSWOL and to perform the necessary crack growth calculation. The NRC staff finds that the licensee has adequately characterized the indication and provided sufficient information on flaw depth and length for its FSWOL design and crack growth calculation.

Material Specification

As stated above, the licensee will use Alloy 52M weld metal to install the FSWOL. The NRC staff recognizes that Alloy 52M weld metal is less susceptible to SCC than Alloy 82/182 weld metal based on laboratory data and operating experience. The NRC staff notes that Alloy 52M has been used in weld overlay installations in many nuclear plants. Thus far, the NRC staff is not aware of service-induced cracking in Alloy 52M weldments. Therefore, the NRC staff finds acceptable that the licensee will use Alloy 52M weld metal to install the FSWOL.

Design

The design basis of the FSWOLs is to maintain the original design margins with no credit taken for the underlying SCC-susceptible weldment. The NRC staff finds acceptable that the licensee's design basis flaw for the purpose of structural sizing of the FSWOL is a 360 degree circumferential flaw that is 100 percent through the original wall thickness of the subject weld because this is the worst case scenario flaw. The NRC staff finds that the FSWOL is designed such that (1) it will support the applied loadings and stresses at the location of the subject weld without taking credit for the underlying existing weld, (2) the detected flaw will not grow to challenge structural integrity of the repaired weld, (3) it provides sufficient compressive stresses in the existing weld wall thickness to minimize further growth of the detected flaw, and (4) it covers the axial length of the existing subject weld with sufficient length on either side of the subject weld to maximize UT examination coverage. The NRC staff finds the proposed design is consistent with Code Case N-504-4 and Appendix Q to the ASME Code, Section XI.

As part of the FSWOL design, the NRC staff finds that the licensee will perform (1) a stress analysis to establish the residual stress profile of the overlaid weld, (2) a fracture mechanics analysis to determine crack growth of the detected flaw to ensure that the detected flaw will not affect the structural integrity of the pipe and that the ASME Code, Section III allowable stresses will be maintained, and (3) an evaluation of added weight on the piping systems due to the

FSWOL for potential impact on stresses and dynamic characteristics of the N9 nozzle-and-end cap. The NRC staff finds these analyses are consistent with Code Case N-504-4 and Appendix O to the ASME Code, Section XI.

Pre-Installation Evaluation

Prior to FSWOL installation, in accordance with Section A1.2.2(d) of Attachment 1 and Section A2.2(e) of Attachment 2 to the proposed alternative, the licensee will perform a surface examination on the area to be welded. The NRC staff finds that the licensee will perform a surface examination and repair any small indications greater than 1/16 inch before installation of the FSWOL. In addition to the required surface examination, the licensee characterized the flaw and its location based on UT. The NRC staff finds that the licensee's pre-installation evaluation is acceptable because it is consistent with Code Case N-504-4, paragraphs (c) and (d), and the ASME Code, Section XI, Appendix Q, paragraphs Q-2000(b) and Q-2000(c).

Installation

The NRC staff recognizes that based on the operating experience in nuclear plants, the machine GTAW in combination with the ambient temperature temper bead welding technique have provided satisfactory results for weld overlay installations. This welding technique combination was developed based on industry research and field applications. The capability of the welding process is demonstrated by laboratory testing, analysis, procedure qualifications, and repairs in the nuclear plants. Therefore, the NRC staff finds acceptable that the licensee will use this welding process to deposits of weld on the ferritic base metal of the reactor vessel nozzle N9.

The proposed alternative provides detailed welding procedure qualification requirements for base materials, filler metals, restraint, impact properties, and other procedure variables. The qualification requirements provide assurance that the mechanical properties of repair welds are equivalent to or superior to those of the surrounding base material. Therefore, the NRC staff finds that the proposed installation satisfies Code Cases N-504-4 and N-648-4 and the ASME Code, Section XI, Appendix Q, and is acceptable.

The NRC staff notes that after the FSWOL installation, the licensee stated that it will (1) measure weld shrinkage, (2) demonstrate that shrinkage stresses at other locations in the piping systems arising from the FSWOL will not have an adverse effect on the systems, (3) check clearances of affected supports and restraints after the overlay repair, and (4) reset within the design ranges if required. The NRC staff notes that the subject weld is located between reactor vessel nozzle N9 and an end cap. There is no piping or pipe support involved. Therefore, items (2) and (3) do not apply. Notwithstanding, NRC staff finds that the proposed post-installation verifications satisfy Code Case N-504-4(g)(3) and, therefore, are acceptable.

Examination

Performance Demonstration Initiative

The NRC staff notes that the U.S. nuclear utilities created the PDI program to implement performance demonstration requirements of the ASME Code, Section XI, Appendix VIII. The industry's PDI program qualifies equipment, procedures, and personnel in accordance with the UT criteria of Appendix VIII, Supplement 11, which provides specific criteria for FSWOLs. Prior to Supplement 11, EPRI maintained a performance demonstration program (the precursor to the

PDI program) for weld overlay qualification under the Tri-party Agreement with the NRC, Boiling Water Reactor Owner's Group, and EPRI, as discussed in the NRC letter dated July 3, 1984 (ADAMS Legacy Library Accession No. 8407090122). Later, the NRC staff recognized the EPRI-managed PDI program for weld overlay qualifications as an acceptable alternative to the Tri-party Agreement in its letter dated January 15, 2002, to the PDI Chairman (ADAMS Accession No. ML020160532).

The PDI program does not fully comport with the requirements of Supplement 11. However, through various public meetings between the industry and NRC in 2001 and 20002 (ADAMS Accession Nos. ML010940402 and ML013330156), the NRC staff determined that the PDI program provides an acceptable level of quality and safety. The NRC staff routinely assesses the PDI program for consistency with the current ASME Code and proposed changes. The NRC staff and industry hold periodic meetings to discuss the adequacy of the PDI program because the PDI program is continuously evolving and improving based on the operating experience in the nuclear plants.

The NRC staff evaluated the differences identified in the licensee's proposed PDI program with respect to the requirements in Supplement 11 of Appendix VIII to the ASME Code, Section XI, and associated justifications as shown in Attachment 3 of the proposed alternative. The NRC staff concludes that the justifications for the differences are reasonable and the proposed PDI program provides an acceptable level of quality and safety. Therefore, the NRC staff finds that the proposed PDI program that will be used to examine the FSWOL is acceptable.

Acceptance Examination

The NRC staff finds that the proposed acceptance examination in the areas of the FSWOL surface condition, examination methods, examination coverage, and disposition of potential planar and laminar indications are consistent with Section Q-4100 of Appendix Q to the ASME Code, Section XI. Therefore, the NRC staff finds that the licensee's proposed acceptance examination is acceptable.

Preservice Examination

The NRC staff finds that the proposed preservice examination in the areas of the examination coverage, examination method, and disposition of the potential flaws are consistent with Section Q-4200 of Appendix Q to the ASME Code, Section XI. The NRC staff notes that in addition, the licensee proposed that if a flaw exceeds the acceptance standards of IWB-3514, the flaw cannot be accepted by IWB-3640 of the ASME Code, Section XI. This provision is more stringent than Section Q-4200 and is acceptable. Therefore, the NRC staff finds that the licensee's proposed preservice examination is acceptable.

Inservice Examination

The NRC staff finds that the proposed inservice examination in the areas of the examination coverage, examination method, and disposition of potential flaws are consistent with Section Q-4300 of Appendix Q to the ASME Code, Section XI. Therefore, the NRC staff finds that the licensee's proposed inservice examinations are acceptable.

Additional Examinations

The NRC staff finds that the subject weld has a unique configuration and operating conditions. There is no coolant flow through the subject weld. The weld is located above the reactor core beltline region such that irradiation embrittlement would not be a concern. There is no pipe connected to the N9 nozzle, only an end cap. Therefore, the NRC staff finds that it is acceptable that additional examination and sample inspection requirements of Section Q-4310 of Appendix Q to the ASME Code, Section XI, and BWRVIP-75-A are not applicable to the overlaid weld.

Pressure Testing

Code Case N-504-4, paragraph (h), requires that a system hydrostatic test be performed in accordance with the ASME Code, Section XI, IWA-5000, if a flaw penetrates the pressure boundary during welding. The licensee proposed to perform a system leakage test in accordance with IWA-5000. The NRC staff notes that regardless of whether a flaw penetrates the pressure boundary, the licensee is required to perform a system leakage test in accordance with IWA-5000 whenever a plant starts up from a refueling outage. The NRC staff finds acceptable that the licensee will perform a system leakage test in accordance with IWA-5000.

Post-Installation Submittals

The NRC notes that prior to the plant entry into Mode 2, the licensee will submit (1) the as-built dimensions of the FSWOL and the evaluation to demonstrate that the FSWOL dimensions equal or exceed the minimum design dimensions of the overlay design, and (2) the overall component shrinkage after the weld overlay installation.

Within 14 days of the final UT examination of the overlaid weld, the licensee will submit a listing of indications detected in the overlaid weld, how the indications are dispositioned, and the post-installation repair, if any.

Within 90 days of completing the B223R1 refueling outage, the licensee will submit the following analyses and evaluations: (1) residual stress analysis of the overlaid weld, (2) stress analysis per the ASME Code, Section III, (3) fracture mechanics analysis on crack growth, and (4) impact of the weight of the weld overlay on the existing piping.

The NRC staff requires licensees who submit a proposed alternative to install FSWOLs on Alloy 82/182 DMWs to submit information regarding FSWOL examinations after completion of installation to demonstrate the acceptability of the as-built FSWOL. In addition, Code Case N-504-4 and Appendix Q to the ASME Code, Section XI, requires analyses be performed as part of the FSWOL design. However, the exigent nature of the proposed alternative precludes the licensee's ability to complete the necessary analyses at the time of the alternative submission. The NRC staff finds that the analyses, evaluations, and examination results that the licensee proposed to submit, and the proposed submittal time line, are consistent with the NRC staff's previously approved exigent FSWOL alternatives for other licensees. Therefore, the NRC staff finds the post-installation submittal and the associated submittal schedule are acceptable.

Summary

The NRC staff finds that installing the proposed FSWOL on the subject weld will maintain the structural integrity of the subject weld because the proposed alternative satisfies the

requirements of Code Cases N-504-3 and N-638-4 and the ASME Code, Section XI, Appendix Q. For those ASME Code requirements to which the licensee takes exception, the licensee has provided acceptable justification.

4.0 CONCLUSION

The NRC staff concludes that the proposed alternative provides reasonable assurance of structural integrity of the subject weld B211N9-RPV-FW2CRD52 of the CRD return line nozzle N9. As such, the NRC staff finds that the alternate repair 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 authorizes the use of ISI Program Alternative ISI-07 at Brunswick, Unit 2, for the fourth 10-year ISI interval, which began on May 11, 2008, and ends on May 10, 2018. The NRC staff concludes that the weld overlay provides acceptable structural integrity and may remain in place for the remaining life of the plant.

All other requirements in ASME Code, Section XI, for which relief was not specifically requested and approved in this proposed alternative remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: John Tsao

Date: October 10, 2017

SUBJECT: BRUNSWICK STEAM ELECTRIC PLANT, UNIT 2 – RELIEF FROM THE REQUIREMENTS OF THE ASME CODE, SECTION XI, IWA-4000 (INSERVICE INSPECTION PROGRAM ALTERNATIVE ISI-07) (CAC NO. MF9561) DATED OCTOBER 10, 2017

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