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

August 9, 2018

Mr. William R. Gideon, Vice President
Brunswick Steam Electric Plant
Duke Energy Progress, LLC
8470 River Rd., SE (M/C BNP001)
Southport, NC 28461

SUBJECT: BRUNSWICK STEAM ELECTRIC PLANT, UNIT 1 – RELIEF REQUEST ISI-10 REGARDING ALTERNATE REPAIR OF FEEDWATER NOZZLE DISSIMILAR METAL WELDS (EPID L-2018-LLR-0030)

Dear Mr. Gideon:

By letter dated March 19, 2018, Duke Energy Progress, LLC (the licensee) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) for the use of an alternative to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements at Brunswick Steam Electric Plant (Brunswick), Unit No. 1.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(z)(1), the licensee submitted Relief Request Inservice Inspection (ISI)-10 in which it proposed to perform an alternative full structural weld overlay (FSWOL) repair of the degraded Alloy 82/182 dissimilar metal butt welds of the reactor vessel feedwater inlet nozzles, on the basis that the alternative provides an acceptable level of quality and safety.

On March 23, 2018, the NRC verbally authorized the use of Relief Request ISI-10 at Brunswick, Unit 1. The NRC staff reviewed the subject request and concluded, as set forth in the enclosed safety evaluation, that the licensee adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorized the use of the licensee's proposed alternative at Brunswick, Unit 1, for remainder of the fourth 10-year ISI interval that began on May 11, 2008, and ended on May 10, 2018. Furthermore, the NRC staff authorized the FSWOL that is installed in accordance with provisions of Relief Request ISI-10 to remain in place for the remaining life of the plant or their design life, whichever is shorter. All other ASME Code, Section XI, requirements for which relief was not specifically requested and approved remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact the Project Manager, Dennis Galvin, at 301-415-6256 or Dennis.Galvin@nrc.gov.

Sincerely,

V. Booma

Booma Venkataraman, Acting Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-324

Enclosure:
Safety Evaluation

cc: Listserv

UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST ISI-10 REGARDING ALTERNATE REPAIR OF

FEEDWATER NOZZLE DISSIMILAR METAL WELDS

DUKE ENERGY PROGRESS, LLC

BRUNSWICK STEAM ELECTRIC PLANT, UNIT 1

DOCKET NO. 50-325

1.0 INTRODUCTION

By letter dated March 19, 2018 (Agencywide Documents and Access Management System (ADAMS) Accession No. ML18078A804), Duke Energy Progress (the licensee) requested relief from requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, specifically related to the repair of the degraded Alloy 82/182 dissimilar metal (DM) butt welds of the reactor vessel (RV) feedwater inlet nozzles at the Brunswick Steam Electric Plant (Brunswick), Unit 1.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(z)(1), the licensee submitted Relief Request Inservice Inspection (ISI)-10 in which it proposed to perform an alternative full structural weld overlay (FSWOL) repair on the basis that the alternative provides an acceptable level of quality and safety.

In the March 2018 refueling outage during routine ISI, the licensee detected unacceptable flaws in two of four RV feedwater inlet nozzle DM welds by ultrasonic testing (UT). The licensee analytically evaluated the flaws in accordance with IWB-3600 of Section XI, and found that the depth of flaws meet the ASME Code allowable limit. The licensee decided to repair the degraded DM welds by installing a FSWOL in the March 2018 refueling outage, and requested the U.S. Nuclear Regulatory Commission (NRC) authorization of Relief Request ISI-10.

On March 23, 2018 (ADAMS Accession No. ML18124A308), the NRC verbally authorized the use of Relief Request ISI-10 at Brunswick, Unit 1, on the basis that the proposed alternative provides an acceptable level of quality and safety, and the structural integrity of the subject overlaid welds is maintained for the remaining life of the plant or their design life, whichever is shorter. This safety evaluation documents the technical basis for the NRC's verbal authorization.

2.0 REGULATORY EVALUATION

Components (including supports) that are classified as ASME Code Class 1, Class 2, and Class 3 must meet the requirements in 10 CFR 50.55a(g)(4), *Inservice Inspection Standards Requirement for Operating Plants,* throughout the service life of a boiling or pressurized water-reactor, except design and access provisions and preservice examination requirements, set forth in Section XI of editions and addenda of the ASME Code that become effective subsequent to editions specified in paragraphs (g)(2) and (3) of 50.55a and that are incorporated by reference in paragraph (a)(1)(ii) of 50.55a, to the extent practical within the limitations of design, geometry, and materials of construction of the components.

Pursuant to 10 CFR 50.55a(g)(4)(ii), *Applicable ISI Code: Successive 120-month Intervals,* inservice examination of components and system pressure tests conducted during successive 120-month inspection intervals must comply with the requirements of the latest edition and addenda of the ASME Code incorporated by reference in paragraph (a) of 50.55a 12 months before the start of the 120-month inspection interval (or the optional ASME Code Cases listed in NRC Regulatory Guide (RG) 1.147, when using ASME Code, Section XI, as incorporated by reference in paragraph (a)(3)(ii) of 50.55a), subject to the conditions listed in paragraph (b) of 50.55a. However, a licensee whose ISI interval commences during the 12-month through 18-month period after August 17, 2017, may delay the update of their Appendix VIII program by up to 18 months after August 17, 2017. Alternatively, licensees may, at any time in their 120-month ISI interval, elect to use Appendix VIII in the latest edition and addenda of the ASME Code incorporated by reference in paragraph (a) of 50.55a, subject to any applicable conditions listed in paragraph (b) of 50.55a. Licensees using this option must also use the same Edition and Addenda of Appendix I as Appendix VIII, including any applicable conditions listed in paragraph (b) of 50.55a.

Pursuant to 10 CFR 50.55a(z), *Alternatives to Codes and Standards Requirements,* alternatives to the requirements of paragraphs (b) through (h) of 50.55a or portions thereof may be used when authorized by the Director, Office of Nuclear Reactor Regulation, or Director, Office of New Reactors, as appropriate. A proposed alternative must be submitted and authorized prior to implementation. The applicant or licensee must demonstrate that: (1) *Acceptable 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 50.55a 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 NRC to authorize the alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 ASME Code Components Affected

The ASME Code component affected are the ASME Code Class 1 DM butt welds of the RV feedwater inlet nozzles N4A and N4D. The licensee stated that the RV inlet nozzles are low alloy steel joined through a series of welds to carbon steel feedwater piping. Within the series of weldments (shown in schematic diagram in Figure 5-1 of Relief Request ISI-10), the carbon steel safe end extension is buttered and welded with Alloy 82/182 weld material to Alloy 600 safe end. The safe end extension is then welded to an intermediate safe end extension (i.e., old

safe end stub), which is subsequently welded to the nozzle of the vessel. Detailed descriptions of the welds and associated components are documented in Section 1 of Enclosure 1 to Relief Request ISI-10. The outer diameter (OD) and material specification of the nozzles (N4A and N4D) and associated components are as follows:

Nozzles OD – 13.75 inches
Safe End Extension – SA-508 Class 1 (P-No. 1)
Alloy 600 Safe End – SB-166 UNS N06600 (P-No. 43)
Alloy 82/182 Weld – ERNiCr-3, Spec. SFA 5.14 / ENiCrFe-3, Spec. SFA 5.11 (Both F-No. 43)

3.2 Applicable Code Edition and Addenda

The code of record for the fourth 10-year ISI interval is the 2001 Edition through 2003 Addenda of the ASME Code.

3.3 Duration of Relief Request

The licensee submitted this relief request for remainder of the fourth 10-year ISI interval that began on May 11, 2008, and ended on May 10, 2018. The licensee stated that the FSWOL installed on nozzles N4A and N4D in accordance with the provisions of Relief Request ISI-10 will remain in place for the design life of the repair.

3.4 Applicable ASME Code Requirement

The ASME Code requirements applicable for repair/replacement and mitigation of the degraded DM welds in this relief request originate in Article IWA-4000 of Section XI. According to IWA-4411, 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) states that 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) states that revised owner's requirements may be used, provided they are reconciled in accordance with IWA-4222.

The ASME Code requirements applicable for performance demonstration of the UT procedures, equipment, and personnel utilized for the volumetric examinations of the FSWOL originate in Appendix VIII, Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds."

3.5 Licensee's Proposed Alternative

The licensee proposed to install FSWOL (i.e., nickel-based Alloy 52M filler weld) over the existing degraded DM weld (i.e., Alloy 82/182) in accordance with the methodology and provisions contained in ASME Code Case N-740-2 "Dissimilar Metal Weld Overlay for Repair or Mitigation of Class 1, 2, and 3 Items." ASME Code Case N-740-2 has not been incorporated by reference into 10 CFR 50.55a by inclusion in NRC RG 1.147, Revision 18, therefore, the NRC approval of an alternative is required. Attachments 1 and 3 of Relief Request ISI-10 document the provisions of Code Case N-740-2 applicable for this proposed alternative.

The licensee proposed to utilize the Performance Demonstration Initiative (PDI) program for the UT procedures demonstration, equipment and personnel qualification in lieu of Supplement 11

of Appendix VIII. Attachment 2 of Relief Request ISI-10 documents the proposed PDI program as compared to Supplement 11 requirements.

As part of this proposed alternative, the licensee will submit to the NRC the following information about the N4A and N4D nozzles after the FSWOL application:

- Prior to the plant entry into Mode 2, the licensee will submit:
    - As-built dimensions of the FSWOL and the evaluation to demonstrate that the FSWOL dimensions are equal or exceed the minimum design dimensions of the overlay design;
    - Overall component shrinkage after the weld overlay installation.
- Within 14 days of the final UT of the overlaid weld, the licensee will submit:
    - A listing of indications detected in the overlaid weld;
    - The disposition of all indications;
    - The post-installation repair, if any.
- Within 90 days of completion of the Brunswick, Unit 1, Refueling Outage B1R22, the licensee will submit:
    - Residual stress analysis of the overlaid weld;
    - Stress analysis in accordance with the Section III of the ASME Code;
    - Fracture mechanics analysis on crack growth;
    - Impact of the weight of the weld overlay on the existing piping.

3.6 Licensee's Basis for Use of Alternative

The licensee stated that the Alloy 52M weld overlay adds full structural reinforcement on the OD of degraded Alloy 82/182 DM weld, and that replaces the existing pressure boundary with the stress-corrosion cracking (SCC) resistant material. The schematic diagram in Figure 5-1 of Relief Request ISI-10 shows the proposed FSWOL.

The licensee stated that the FSWOL has been used for several years on piping of both boiling water reactor (BWR) and pressurized water reactor to arrest the growth of existing flaws while establishing a new structural pressure boundary. The 2001 Edition through 2003 Addenda of the ASME Code, Section XI, applicable to Brunswick, Unit 1, does not contain provisions for weld overlays. The criteria that is currently available for overlay are as follows:

- ASME Code Case N-504-4 "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI" provides requirements for the stainless steel pipe to pipe weld overlay repair.
- ASME Code Case N-638-6 "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temperbead Technique, Section XI" provides requirements for the ambient-temperature temper bead welding technique without a need for preheat or postweld heat treatment of the Construction Code.
- Nonmandatory Appendix Q "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments" provides guidance for the design and examinations of

austenitic stainless steel pipe to pipe weld overlay repair. Appendix Q was initially added to the ASME Code, Section XI, in the 2005 addenda.

ASME Code Case N-504-4 has been incorporated by reference into 10 CFR 50.55a by inclusion in NRC RG 1.147, Revision 18, with condition that the provisions of Nonmandatory Appendix Q must be met. The licensee stated that it utilizes Nonmandatory Appendix Q of the 2007 Edition with the 2008 Addenda of Section XI. ASME Code Case N-638-6 has also been incorporated by reference into 10 CFR 50.55a by inclusion in NRC RG 1.147, Revision 18, with conditions.

The licensee stated that ASME Code Committee approved Case N-740-2 in 2008, which contains provisions for repair and mitigation of the DM welds by FSWOL. Utilizing a FSWOL repair process in accordance with Case N-740-2 provides an alternative to the replacement of the degraded Alloy 82/182 DM welds of the feedwater nozzles (i.e., N4A and N4D), restores the structural integrity of the component, and establishes a new reactor coolant pressure boundary. This overlay process consists of applying SCC resistant filler metals (e.g., Alloy 52/52M) over the degraded Alloy 82/182 DM weld. The overlay process creates compressive residual stress profiles within the original weld to mitigate future SCC. In addition, the post-overlay pre-service inspection (PSI) and the ISI requirements provide assurance that the structural integrity is maintained for the life of the plant. The crack growth evaluations for SCC and fatigue of a bounding postulated flaw will demonstrate that the structural integrity of the component, with the FSWOL in place, will be maintained for the remaining service life of the component.

The licensee presented its technical basis for the proposed alternative in the following attachments to Relief Request ISI-10. Attachment 1 of Relief Request ISI-10 documents the requirements for the design, analysis, fabrication, examination, and pressure testing of the proposed FSWOL. The licensee derived these requirements from ASME Code Case N-740-2. In Attachment 3 of Relief Request ISI-10, the licensee compared Code Case N-740-2 to Code Case N-504-4 and Appendix Q of Section XI to demonstrate similarity of the requirements. Attachment 2 of Relief Request ISI-10 documents the proposed PDI program as compared to Supplement 11 of Appendix VIII. The licensee's technical basis is briefly discussed below.

- Flaw characterization

  The licensee stated that the flaws detected in the original DM welds of the N4A and N4D feedwater nozzles were determined to be surface connected, circumferentially oriented, located within the Alloy 82/182 weld zone on the Alloy 600 safe end side of the joint. The measured length, depth, and remaining ligament of each flaw are tabulated in Section 4 of Relief Request ISI-10. The licensee performed analytical flaw evaluations in accordance with IWB-3600, and found the flaws meet the ASME Code allowable flaw size, and therefore, acceptable in the as-found condition. The postulated worst-case flaw will be used to define the life of installed FSWOL.

- Design, installation, and examinations of FSWOL

  The licensee stated that applicable methodology of Code Case N-740-2 as documented in Attachment 1 of Relief Request ISI-10 will be used for the design, installation, and examinations of the proposed FSWOL for the nozzles N4A and N4D. The licensee's proposed methodology is briefly discussed below.

  - The licensee stated that as an alternative to flaw removal, it will deposit weld reinforcement (i.e., FSWOL) using Alloy 52M filler metal on the OD surface

around full circumference of the pipe using a Welding Procedure Specification qualified in accordance with the Construction Code and Owner's Requirements.

- The licensee stated that the proposed FSWOL will not require ambient temperature temper bead welding because the overlay thickness is less than 0.75 inches.
- The licensee stated that it may elect to apply a layer of Alloy 82 weld deposit over the existing DM weld and adjacent base material. It has been observed that when depositing Alloy 52M over Alloy 182 weld metal, hot cracking can occur. The deposition of Alloy 82 filler weld can mitigate the occurrence of hot cracking in the Alloy 52M deposit. If added, the thickness of the Alloy 82 deposit will not be credited toward the structural thickness of the FSWOL.
- The licensee stated that the microstructure of Alloy 52M is fully austenitic; therefore, the ferrite number requirements are not applicable.
- The licensee stated that the thermal neutron fluence at the N4A and N4D nozzles FSWOL location is less than the threshold, as it is external to the vessel.
- The licensee stated that the examination requirements of this proposed method will be met for the life of the overlay. Specifically, future ISI required by 10 CFR 50.55a, if more stringent than those specified herein, will be met in lieu of the proposed ISI included in this relief request.
- The licensee stated that the UT procedures and personnel will be qualified in accordance with the proposed modifications to Supplement 11 of Appendix VIII as described in Attachment 2 of Relief Request ISI-10. The UT will be performed in the axial and circumferential directions with coverage of essentially 100 percent of the required examination volume. If 100 percent coverage of the required volume for axial flaws cannot be achieved, but essentially 100 percent coverage for circumferential flaws can be achieved, the examination for axial flaws will be performed to the maximum extent practicable with limitations noted in the examination report.
- The licensee stated that the system leakage test will be performed in accordance with IWA-5000 of Section XI.

In addition, the licensee stated that the proposed FSWOL will temporarily limit future examination of the carbon steel similar metal welds closest to the RV (i.e., Item 5 welds in Figure 5-1 of Relief Request ISI-10). The FSWOL will limit the examination of the adjacent carbon steel similar metal weld and may limit the examination of the carbon steel similar metal weld that is inboard of this weld (i.e., a single-sided examination of the inboard weld may be possible). The similar metal welds closest to the RV on each nozzle leg are subject to augmented examination and/or risk-informed-ISI program requirements. Should the carbon steel welds in question be selected for examination in a future ISI interval, the licensee will extend the installed FSWOL to restore accessibility to these welds for the purposes of ISI. The licensee, prior to installation of the FSWOL, has preemptively inspected both similar metal welds, and found no unacceptable flaws in the volume examined. Both similar metal welds were also preemptively inspected by the UT in March 2018 refueling outage, and no unacceptable indications were identified.

3.7 NRC Staff Evaluation

The NRC staff has evaluated Relief Request ISI-10 pursuant to 10 CFR 50.55a(z)(1). The NRC staff focused on whether the proposed alternative provides an acceptable level of quality and safety. In evaluating the technical sufficiency of the licensee's proposed alternative, the NRC staff considered the following aspects of the licensee's basis: (1) Evaluation of general criteria

for DM FSWOL repair process; (2) Evaluation of DM FSWOL design and analysis; and (3) Evaluation of inspections. For its review, the NRC staff utilized Appendix Q of the 2007 Edition with the 2008 Addenda of the ASME Code, Section XI, Code Cases N-504-4 and N-638-6, the conditions mandated in NRC RG 1.147, Revision 18, for use of these code cases, and the NRC-approved Electric Power Research Institute (EPRI) Materials Reliability Program (MRP)-169, Revision 1-A "Technical Basis for Preemptive Weld Overlay for Alloy 82/182 Butt Welds in Pressurized Water Reactors (PWRs)" as guidance.

Evaluation of General Criteria for DM FSWOL Repair Process

The NRC staff notes that general criteria for the DM FSWOL include provisions for chromium (Cr) content of weld overlay filler metal (i.e., 28 to 30 percent by weight Cr) and hot cracking. From review of Enclosure 1 and Attachments 1 and 3 of Relief Request ISI-10, the NRC staff verified that:

- The weld overlay filler metal utilized for the proposed FSWOL repair consists of austenitic nickel Alloy 52M with chromium content of at least 28 percent, applied 360 degrees around the circumference of the original DM welds and the associated safe-end welds. Alloy 52M has been known to be resistant to SCC due to its significantly high chromium content. Installing overlay over full circumference of the existing welds creates compressive residual stress in the inner region of the welds, thereby minimizing the likelihood of initiation or growth of SCC in susceptible materials. Thus far, no known service-induced cracking has been reported in Alloy 52M weldments by nuclear industries. Therefore, the NRC staff finds that use of Alloy 52M filler metal is acceptable.
- The licensee has taken measures to mitigate for potential hot cracking when depositing Alloy 52M overlay directly over existing Alloy 182 portion of the DM weld configuration. The licensee will deposit Alloy 82 as a buffer layer on the existing Alloy 182 weld metal, and then deposit Alloy 52M on top of the Alloy 82 buffer layer. Alloy 82 weld metal can mitigate the hot cracking concern in Alloy 52M weld metal. The licensee acknowledged that the thickness of the buffer layer will not be credited toward the structural thickness of FSWOL. The NRC staff finds that adding the buffer layer mitigates potential occurrence of hot cracking.
- For installing the proposed FSWOL, the ambient temperature temper bead welding is not required because the proposed overlay thickness is less than 0.75 inch. The NRC staff finds that this is consistent with the requirements of the ASME Code, Section III.

Evaluation of DM FSWOL Design and Analysis

The NRC staff notes that the design basis for FSWOL repair is to maintain the original design margins with no credit taken for the underlying SCC susceptible weldment. From review of Enclosure 1 and Attachments 1 and 3 of Relief Request ISI-10, the NRC staff verified that:

- For design basis flaw for the purpose of structural sizing of the proposed FSWOL repair, the licensee assumed a circumferential flaw of 100 percent through-wall thickness extending 360 degrees around the DM weld of the original nozzle cross section. In the axial direction, the licensee assumed an axial flaw of 100 percent through-wall thickness with length of 1.5 inches, or the combined width of the weld plus buttering plus any SCC susceptible material, whichever is greater.

- For purpose of defining design life of the proposed FSWOL repair, the licensee conservatively postulated a flaw of 75 percent through-wall thickness in both an axial and circumferential direction since the detected flaws in the original DM welds were characterized as less than 75 percent deep (table in Enclosure 1 of Relief Request ISI-10 shows the measured flaws' depth).
- The licensee has designed the proposed FSWOL with sufficient axial length and end slope to cover the weld, heat-affected zones (HAZs) on each side of the weld, and any SCC susceptible base material adjacent to the weld. This allows for adequate transfer of loads without violating applicable stress limits of NB-3200 of Section III. Furthermore, this facilitates the post-overlay inspection requirements that include volumetric examinations of weld overlay and the outer 25 percent of original pipe wall thickness (i.e., original DM weld, adjacent welds, and HAZs of base materials).

- As part of the FSWOL design and analysis, the licensee will perform:

    - A stress analysis to establish the residual stress profile of the overlaid weld;
    - A fracture mechanics analysis to determine growth of the detected flaw due to both fatigue and SCC. This ensures that the existing flaws in the DM weld do not affect the structural integrity of the piping, and that the Section III allowable stresses are maintained;
    - An evaluation of added weight on the piping systems due to FSWOL deposit for potential impact on stresses and dynamic characteristics;
    - An evaluation of effects of shrinkage stresses that may be developed in other locations in the piping as a result of the FSWOL.

Therefore, the NRC staff determined that the licensee's overlay design, stress analysis, and crack growth evaluation are acceptable because they are consistent with the provisions in Appendix Q of Section XI, ASME Code Case N-504-4, and EPRI MRP-169, Revision 1-A.

Evaluation of DM FSWOL Inspections

From review of Enclosure 1, Sections A1.4 and A1.5 of Attachment 1, Attachments 2 and 3 of Relief Request ISI-10, the NRC staff verified that the licensee's proposed nondestructive examinations for the FSWOL include:

Pre-weld overlay deposition examination

Prior to application of FSWOL, the licensee will inspect the surface to be weld overlaid by the liquid penetrant testing (PT). Any indications with major dimensions greater than 1/16 inch must be removed, reduced in size, or weld repaired. The NRC staff finds the licensee's pre-weld overlay examination acceptable because it is consistent with the provisions in ASME Code Case N-504-4, Appendix Q of Section XI, and EPRI MRP-169, Revision 1-A.

Overlay acceptance examination

After application of FSWOL, the licensee will inspect the installed weld overlay for acceptance. The provisions for the overlay acceptance examination include the overlay surface finish, surface examination of the overlay and base metal by PT, volumetric examination of the overlay by UT, and VT-3 visual examination.

- The licensee will inspect the weld overlay to verify that it has an acceptable configuration, surface finish (i.e., 250 micro-inches root mean square or better), and contour.
- The licensee will perform the PT of the weld overlay and adjacent base material surface (i.e., at least 1/2 inch from each side of the overlay). The surface examinations will meet the applicable acceptance criteria of the Construction Code, or NB-5300 or NB-2500 of the ASME Code, Section III.
- The licensee will inspect the weld overlay volume (i.e., A-B-C-D in Figure A1-1(a) of Attachment 1 to Relief Request ISI-10) by UT to assure adequate fusion or bond with the base material.

    - Planar flaws detected will meet the preservice examination standards of IWB-3514. In applying the acceptance standards to planar indications, the thickness, t_1 or t_2 (defined in Figure A1-1(b) of Attachment 1 to Relief Request ISI-10) will be used as the nominal wall thickness in IWB-3514, provided the base material beneath the flaw (i.e., safe end, nozzle, or piping material) is not susceptible to SCC. For susceptible material, t_1 will be used. If a flaw in the overlay crosses the boundary between the two regions, the more conservative of the two dimensions (t_1 or t_2) shall be used.
    - Laminar flaws detected will meet acceptance standards of IWB-3514, with the additional limitation that the total laminar flaw area will not exceed 10 percent of the weld surface area and that no linear dimension of the laminar flaw area will exceed the greater of 3 inches or 10 percent of the pipe circumference.
    - For examination volume A-B-C-D (Figure A1-1(a) of Attachment 1 to Relief Request ISI-10), the reduction in coverage due to laminar flaws will be less than 10 percent. The uninspectable volume is the volume in the weld overlay underneath the laminar flaws for which coverage cannot be achieved with the angle beam examination method.
    - 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 PSI acceptance standards of IWB-3514, 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.

- After completion of all welding activities, the licensee will perform the VT-3 visual examination on all affected restraints, supports, and snubbers, to verify that design tolerances are met.

The NRC staff finds the licensee's overlay acceptance examination acceptable because it is either consistent with or exceeds the provisions in ASME Code Case N-504-4, Appendix Q of Section XI, and EPRI MRP-169, Revision 1-A.

Preservice examination

Prior to placing the FSWOL in service and as part of PSI, the licensee will inspect by UT the volume A-B-C-D (Figure A1-2 of Attachment 1 to Relief Request ISI-10). For this examination, the licensee will utilize the angle beam directed perpendicular and parallel to the piping axis, and the scanning will be performed in four directions to locate and size any planar flaws that have propagated into the outer 25 percent of the base metal thickness or into the weld overlay.

The licensee will meet the PSI acceptance standards of IWB-3514 for the weld overlay. In applying the acceptance standards to planar indications, the thickness, t_1 or t_2, defined in Figure A1-1(b) of Attachment 1 will be used as the nominal wall thickness in IWB-3514, provided the base material beneath the flaw (i.e., safe end, nozzle, or piping material) is not susceptible to SCC. For susceptible material, t_1 will be used. Planar flaws in the outer 25 percent of the base metal thickness will meet the FSWOL design analysis requirements.

The NRC staff finds that the licensee's PSI acceptable because it is either consistent with or exceeds the provisions in ASME Code Case N-504-4, Appendix Q of Section XI, and EPRI MRP-169, Revision 1-A.

Inservice examination

The NRC staff notes that the ISI of FSWOL is governed by BWR Vessel and Internals Project (BWRVIP)-75-A "Technical Basis for Revisions to Generic Letter 88-01 Inspection Schedules."

- In accordance with BWRVIP-75-A, Category E welds (i.e., cracked welds reinforced by weld overlay) are required to be inspected on the frequency of 25 percent of the population every 10 years. As such, the licensee will add the FSWOL applied to the nozzles N4A and N4D to the ISI program's Category E population and inspect them at this frequency. All weld overlays, including those not in the 25 percent sample, will be examined prior to the end of the FSWOL design life.
- In the first or second refueling outage of Brunswick, Unit 1, following overlay installation, the licensee will ultrasonically inspect the FSWOL applied to the nozzles N4A and N4D. Examination volumes that show no indication of crack growth or new cracking will then be placed into a population of Category E welds to be examined on a sample basis. In accordance with BWRVIP-75-A, the 25 percent of this population will be added to the ISI program. The 25 percent sample will consist of the same welds in the same sequence during successive intervals to the extent practical provided the 25 percent sample contains welds that experience the hottest operating temperature in the population. All weld overlays, including those not in the 25 percent sample, will be examined prior to the end of FSWOL design life.
- The licensee will ultrasonically inspect the examination volume A-B-C-D (Figure A1-2 of Attachment 1) 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 licensee will scan the examination volume in four directions by the angle beam directed perpendicular and parallel to the piping axis.
- The licensee will meet the ISI acceptance standards of IWB-3514. In applying the acceptance standards to planar indications, the thickness, t_1 or t_2, defined in Figure A1-1(b) of Attachment 1 will be used as the nominal wall thickness in IWB-3514, provided the base material beneath the flaw (i.e., safe end, nozzle, or piping material) is not susceptible to SCC. For susceptible material, t_1 will be used. 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, the identified flaw will be demonstrated to satisfy all requirements, limits and assumptions defined in the FSWOL design evaluation. Any indication characterized as SCC in the weld overlay material will be deemed unacceptable.
- Weld overlay examination volumes (Figure A1-1(b) of Attachment 1) that show no indication of planar flaw growth or new planar flaws will be placed into a population to be

examined on a sample basis as defined in the inspection plan. Each inspection interval, 25 percent of this population will be examined.

- If the ISI reveals planar flaw growth, or new planar flaws, meeting the acceptance standards of IWB-3514 and IWB-3600, the licensee will reexamine the weld overlay examination volume in the first or second refueling outage following discovery of flaw growth or new flaws.
- For weld overlay examination volumes with unacceptable indications, the weld overlay and original defective weld will be removed. A repair/replacement activity will be performed in accordance with IWA-4000.

The NRC staff finds that the licensee's ISI is acceptable because it is either consistent with or exceeds the provisions in ASME Code Case N-504-4, Appendix Q of the ASME Code, Section XI, and EPRI MRP-169, Revision 1-A.

Additional examination

If future ISI reveals a defect (i.e., planar flaw growth into the weld overlay design thickness or axial flaw growth beyond the specified examination volume), the licensee will inspect additional weld overlay examination volumes equal to the number scheduled for the current inspection period prior to return to service. If additional defects are found in the second sample, the licensee will inspect 50 percent of the total population of weld overlay examination volumes prior to return to service. If additional defects are found, the entire remaining population of weld overlay examination volumes will be examined prior to return to service. The NRC staff finds the additional examination acceptable because it is either consistent with or exceeds the provisions in Appendix Q of the ASME Code, Section XI.

System leakage testing

The licensee will pressure test the completed FSWOL repair in accordance with IWA-5000 of Section XI regardless of whether a flaw penetrates the pressure boundary. The NRC staff finds the above pressure test is acceptable because it is either consistent with or exceeds the provisions in ASME Code Case N-504-4, Appendix Q of Section XI, and EPRI MRP-169, Revision 1-A.

Evaluation of UT Qualification

The NRC staff notes that the ASME Code, Section XI, Appendix VIII, Supplement 11, specifies procedure demonstration and personnel qualification for the UT utilized for the inspection of FSWOL. The licensee proposed to use the qualification requirements of the PDI program specific to FSWOL in lieu of Supplement 11. EPRI maintains the PDI program, and the NRC staff routinely assesses the PDI program for consistency with the current ASME Code and proposed changes incorporated by reference in 10 CFR 50.55a. From review of Attachment 2 of Relief Request ISI-10 that documents the differences between the PDI program and Supplement 11, the NRC staff verified that:

- Almost all of the differences between Supplement 11 requirements and the PDI program for FSWOL are largely administrative, rewording for clarification, or semantic in nature;
- The major technical difference is the use of 3-inch long minimum grading units in Supplement 11 and 1-inch long minimum grading units in the PDI program. This change was reviewed by the NRC staff to determine the effects on the qualification program and

the staff found the use of 1-inch grading units acceptable. This change is also included in the 2007 Edition through 2013 Edition of ASME Code, Section XI, which is incorporated by reference in 10 CFR 50.55a.

Therefore, the NRC staff finds that use of PDI program for the UT procedure demonstration and personnel qualification for FSWOL is acceptable because the PDI program satisfies the intent of Supplement 11.

Evaluation of Post-Installation Submittals

The NRC staff requires licensees who submit a proposed alternative to install FSWOL on Alloy 82/182 DM welds 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 Section XI require analyses be performed as part of the FSWOL design. As stated above, the licensee will submit the as-built dimensions of the FSWOL, overall component shrinkage, ultrasonic examination, and analysis package. Therefore, the NRC staff finds that the licensee's proposed post-installation submittals are acceptable.

Summary

In summary, the NRC staff finds that the requirements described in Relief Request ISI-10 for the design, analysis, installation, inspections of the FSWOL are either consistent with or exceed the intent of the provisions of ASME Code Case N-504-4, Appendix Q of the ASME Code, Section XI, and EPRI MRP-169, Revision 1-A. In addition, the licensee will follow the ISI requirements of the NRC-approved BWRVIP-75-A. Therefore, the NRC staff finds that the licensee has provided adequate technical basis to demonstrate that its proposed FSWOL repair will provide an acceptable level of quality and safety.

4.0 CONCLUSION

As set forth above, the NRC staff determines that the licensee's proposed alternative 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 staff authorizes the use of the licensee's proposed alternative at Brunswick, Unit 1, for the remainder of the fourth 10-year ISI interval that began on May 11, 2008, and ended on May 10, 2018. Furthermore, the NRC staff authorizes the FSWOL that is installed in accordance with provisions of Relief Request ISI-10 to remain in place for the remaining life of the plant or the design life, whichever is shorter

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

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SUBJECT: BRUNSWICK STEAM ELECTRIC PLANT, UNIT 1 – RELIEF REQUEST ISI-10 REGARDING ALTERNATE REPAIR OF FEEDWATER NOZZLE DISSIMILAR METAL WELDS (EPID L-2018-LLR-0030) DATED AUGUST 9, 2018

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