Brunswick Nuclear Plant
P.O. Box 10429
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March 19, 2018 10 CFR 50.55a(z)(1)

Serial: BSEP 18-0039

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: Brunswick Steam Electric Plant, Unit No. 1
Renewed Facility Operating License No. DPR-71
Docket No. 50-325
Proposed In-service Inspection Alternative for Application of Dissimilar Metal Weld Full Structural Overlay – Nozzles N4A and N4D

Ladies and Gentlemen:

In accordance with 10 CFR 50.55a(z)(1), Duke Energy Progress, LLC (Duke Energy), is proposing an In-service Inspection (ISI) alternative for the Brunswick Steam Electric Plant (BSEP), Unit No. 1.

During the BSEP Unit 1 refueling outage, which began on March 3, 2018, flaws were found by ultrasonic testing (UT) examination in the dissimilar metal welds of the reactor pressure vessel (RPV) nozzles N4A and N4D (i.e., feedwater nozzles). There are four feedwater inlet nozzles to the reactor vessel. The feedwater nozzles were modified prior to original plant startup to add an Alloy 600 thermal sleeve transition. The N4A and N4D nozzle welds containing the flaws are ASME Section III, Class 1 dissimilar metal welds located between the carbon steel RPV nozzle extension and an austenitic Inconel safe end. In order to maintain the pressure boundary and structural integrity of the welds, Duke Energy proposes to perform full structural weld overlays based on the American Society of Mechanical Engineers (ASME) Code Case N-740-2. As a condition of using Code Case N-740-2, the provisions of Appendix Q of ASME Section XI will be met.

The proposed alternative, as described in Enclosure 1, complies with 10 CFR 50.55a(z)(1) and provides an acceptable level of quality and safety. Duke Energy requests approval of the proposed alternative no later than March 30, 2018, in support of the current BSEP Unit 1 refueling outage.

Enclosure 2 summarizes the new regulatory commitments made in this submittal.

Please refer any questions regarding this submittal to Lee Grzeck, Manager - Regulatory Affairs, at (910) 832-2487.

Sincerely,

William R. Gideon

Enclosures:

1. In-service Inspection (ISI) Program Alternative ISI-10, Full Structural Weld Overlay of N4A and N4D Feedwater Nozzle Dissimilar Metal Welds
2. List of Regulatory Commitments

cc (with enclosures):

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In-service Inspection (ISI) Program Alternative ISI-10
Full Structural Weld Overlay of N4A and N4D Feedwater Nozzle Dissimilar Metal Welds

## 1. American Society of Mechanical Engineers (ASME) Code Component Affected

| **Component:** | Feedwater Dissimilar Metal Welds (DMWs) | | | |
|---|---|---|---|---|
| **Code Class:** | Class 1 | | | |
| **Weld Number:** | **Examination Category** | **Description** | **Size** | **Materials** |
| 1B21N4A-2-SW1-2 | BWRVIP 75-A, Category D | Nozzle N4A extension to safe end (DM) | 13.75" OD | Safe End Extension/ Alloy 82-182 Weld/ Alloy 600 Safe End |
| 1B21N4D-5-SW1-2 | BWRVIP 75-A, Category D; R-A, R1.14-2 | Nozzle N4D extension to safe end (DM) | 13.75" OD | Safe End Extension/ Alloy 82-182 Weld/ Alloy 600 Safe End |

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)

## 2. Applicable Code Edition and Addenda

American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section XI – 2001 Edition through 2003 Addenda (i.e., Reference 1).

## 3. Applicable 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.

ASME Code, Section XI, Appendix VIII, Supplement 11 (i.e., Reference 2) provides requirements for the qualification requirements for the ultrasonic testing (UT) examination of Full Structural Overlaid Wrought Austenitic Piping Welds.

## 4. Reason for Proposed Alternative

Dissimilar metal welds (DMWs) containing nickel welding alloys 82 and 182 have experienced stress corrosion cracking (SCC) in components operating at pressurized water and boiling water reactor temperatures (i.e., References 3, 5, 6, 7, 8, 9, and 12).

Duke Energy Progress, LLC (Duke Energy) proposes, as an emergent repair, to mitigate the SCC susceptibility of the Brunswick Steam Electric Plant (BSEP), Unit 1 Feedwater nozzles N4A and N4D dissimilar metal welds between the safe end and safe end extension by installing a full structural weld overlay (FSWOL) on the DMWs. 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.

Currently, there are no Nuclear Regulatory Commission (NRC) approved criteria for a licensee to apply a FSWOL to an Alloy 82/182 DMW. The edition and addenda of ASME Code, Section XI applicable to BSEP Unit 1 does not contain requirements for weld overlays. However, DMW overlays have been applied to other RPV nozzle DMWs in boiling water reactors (BWRs) using alternative requirements, including BSEP Unit 2 in 2017. This request proposes to use the guidance of ASME Code Case N-740-2 (i.e., Reference 4), for application of a full structural weld overlay to the N4A and N4D nozzle DMWs at BSEP Unit 1. Since Code Case N-740-2 has not been approved by the NRC in the latest revision of Regulatory Guide (RG) 1.147, an alternative is required. This request describes the requirements Duke Energy proposes to use to design and install a FSWOL on the N4A and N4D nozzle DMWs.

Indication Characterization

The indications in the N4A and N4D feedwater nozzle dissimilar metal welds are circumferentially oriented and located within the weld zone, on the Alloy 600 safe end side of the joint. The circumferential indications are inside surface connected and exposed to the reactor coolant. The indications to be mitigated by the FSWOL are reported as follows:

| Weld Number: | Indication # | Circumferential Location (0 at Top Center) | Flaw Length | Flaw Depth | Nominal Remaining Ligament |
|---|---|---|---|---|---|
| 1B21N4A-2-SW1-2 | 1 | 1.45" to 4.64" | 3.19" | 0.12" | 0.755” |
| | 2 | 25.90" to 26.37" | 0.47” | Not Measurable | Not Applicable |
| | 3 | 36.73" to 41.10" | 4.37" | 0.32” | 0.555” |
| 1B21N4D-5-SW1-2 | 1 | -0.08” to 5.58” | 5.66” | 0.25” | 0.625” |
| | 2 | 19.00” to 25.40” | 6.40” | 0.18” | 0.695” |
| | 3 | 31.80” to 34.30” | 2.50” | 0.04” | 0.835” |

These flaws have been evaluated in accordance with IWB-3600 and the reported depths are less than the allowable flaw size at the current time. Therefore, the indications are acceptable in the as-found condition

## 5. Proposed Alternative and Basis for Use

Pursuant to 10 CFR 50.55a(z)(1), Duke Energy proposes an alternative to the ASME Code requirements stated above. The alternative and its proposed use are described in Attachment 1 to this request and includes installation of a FSWOL that structurally replaces the existing weld and defects. This alternative is based on the methodology contained in ASME Code Case N-740-2.

Appendix VIII, Supplement 11 of the 2001 Edition with Addenda through 2003 of ASME Code, Section XI (i.e., Reference 2) specifies requirements for performance demonstration of UT examination procedures, equipment, and personnel used to detect and size flaws in full structural overlays of wrought austenitic piping welds. Relief is requested to allow use of the Performance Demonstration Initiative (PDI) program implementation of Appendix VIII for qualification of UT examinations used to detect and size flaws in the FSWOLs of this request. The proposed changes to Appendix VIII, Supplement 11 for use on FSWOLs are detailed in Attachment 2.

The use of this alternative is requested on the basis that the proposed requirements will provide an acceptable level of quality and safety.

Duke Energy plans to apply a full structural, Alloy 52M, overlay to the dissimilar metal Alloy 82/182 DMWs identified in Section 1 and extend it over the adjacent similar metal weld as presented schematically in Figure 5-1, below.

Duke Energy understands that the installation of the FSWOL will temporarily limit future examination of the carbon steel similar metal welds closest to the reactor vessel (i.e., Item 5 welds in Figure 5-1). 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 exam of the inboard weld may be possible). The similar metal welds closest to the vessel on each nozzle leg are subject to augmented examination and/or RI-ISI requirements. Code Case N-740-2 does not address the ability to examine welds obstructed by the overlay, except in 1.2(b) which is permissive and states,

> If a weld overlay on any of the material combinations in (a) obstructs a required examination of an adjacent P-8 to P-8 weld, the overlay may be extended to include overlaying the adjacent weld.

The welds in question are joining P-No. 3 to P-No. 1 and P-No. 1 to P-No 1 materials. The fifth interval ISI program update is currently in progress. Should the carbon steel welds in question be selected for examination in a future ISI interval, Duke Energy will extend the installed FSWOL to restore accessibility to these welds for the purposes of in-service examination. Duke Energy has preemptively volumetrically examined these welds in the current outage and identified no indications, prior to installation of the FSWOL.

Duke Energy proposes to use ASME Code Case N-740-2 as an alternative to the requirements specified in Section 3 of this request. Code Case N-740-2 has been approved by the ASME Code Committee to specifically allow FSWOLs on nickel alloy DMWs. However, ASME Code Case N-740-2 has not yet been accepted by the NRC in RG 1.147, Revision 18. Code Case N-740-2 provides the basis and requirements for the weld overlay techniques. The Code Case N-740-2 design requirements which are applicable to BSEP Unit 1 are detailed in Attachment 1, and the implementation requirements that are applicable are detailed in Attachments 1 and 2.

A comparison of the proposed alternative, Code Case N-740-2, and ASME Code Case N-504-4/Appendix Q (i.e., 2007 Edition with the 2008 Addenda) is provided in Attachment 3.

The proposed alternative provides an acceptable methodology for mitigating SCC and for mitigating the defects that were detected in the identified welds to acceptable Code requirements and margins. The use of weld overlay filler metals that are resistant to SCC (e.g., Alloy 52/52M), weld overlay procedures that create compressive residual stress profiles within the original weld, and post overlay preservice and inservice inspection requirements provide assurance that structural integrity will be maintained for the remaining service life of the welds. Crack growth evaluations for SCC and fatigue of a bounding postulated flaw will demonstrate that structural integrity of the component, with the FSWOLs in place, will be maintained for the remaining service life of the component.

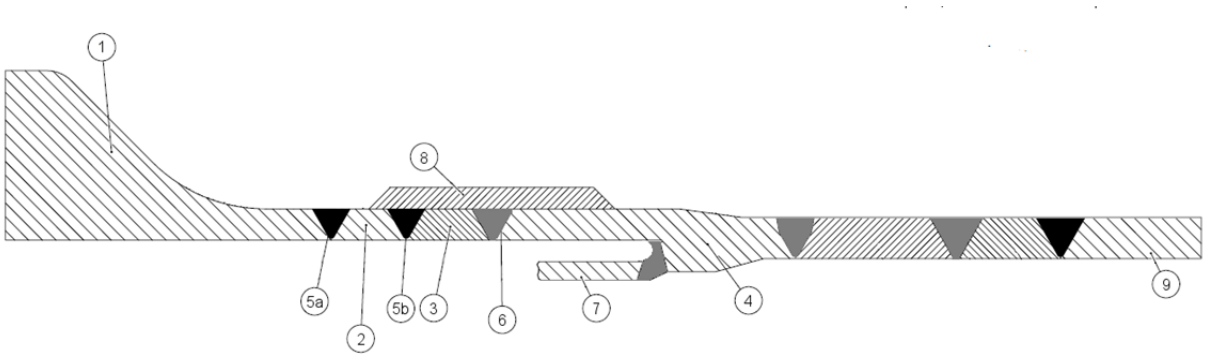
*Schematic Configuration for the FSWOL*

A representation of the FSWOLs for the N4A and N4D nozzles DMW configuration is presented schematically in Figure 5-1, below.

*RPV Feedwater Nozzle Dissimilar Metal Weld*

The RPV Feedwater N4 nozzles are low alloy steel nozzles that, through a series of welds, are joined to the feedwater piping system. Within the series of welds, an Alloy 600 safe end is joined to a carbon steel safe end extension. The safe end extension is buttered with Alloy 82/182 weld material and subsequently joined to the Alloy 600 safe end. The safe end extension is welded to an intermediate safe end extension (i.e., old safe end stub), which is welded to the nozzle of the vessel.

Figure 5-1 Schematic Configuration for the N4 Nozzle with FSWOL (Applicable for both N4A and N4D)




| | Parts List | Material | ASME IX P-No. |
|---|---|---|---|
| 1. | Nozzle | SA-508 Class 2 | 3 |
| 2. | “Old” Safe End Stub | SA-508 Class 1 | 1 |
| 3. | Safe End Extension | SA-508 Class 1 | 1 |
| 4. | Safe End | SB-166 UNS N06600 | 43 |
| 5a. | Low Alloy to Carbon Steel Weld | SFA-A5.1 E8018G | -- |
| 5b. | Carbon to Carbon Steel Weld | Carbon Steel | -- |
| 6 | DMW and Butter | SFA 5.14 ERNiCr-3 / SFA 5.11 ENiCrFe-3 (Alloy 82/182) | -- |
| 7. | Thermal Sleeve | SB-564 UNS N06600 | 43 |
| 8. | FSWOL | SFA-A5.14 ERNiCrFe-7a (Alloy 52M) | -- |
| 9. | Feedwater Piping | Carbon Steel | 1 |

*Suitability of Proposed Post Overlay Nondestructive Examination (NDE)*

As part of the design of the FSWOL, the FSWOL length, surface finish, and flatness are specified to allow for post-installation, qualified ASME Code Section XI, Appendix VIII UT examinations, as implemented through the Electric Power Research Institute (EPRI) PDI Program. These examinations include the FSWOL and the required volume of the base material and original weld underneath the FSWOL. The examinations specified in this proposed alternative provide adequate assurance of structural integrity for the following reasons:

- The UT examinations that will be performed with the proposed alternative are in accordance with ASME Code Section XI, Appendix VIII, Supplement 11 (i.e., Reference 2), as implemented through the PDI Program. These examinations are considered more sensitive for detection of defects, either from fabrication or service induced, than ASME Code, Section III radiography or UT methods. Further, construction flaws are included in the PDI qualification sample sets for evaluating procedures and personnel.

- ASME Code, Section XI has specific acceptance criteria and evaluation methodology to be utilized with the results from these more sensitive UT examinations. The criteria consider the materials in which the flaw indications are detected, the orientation and size of the indications, and ultimately their potential structural effects on the component. The acceptance criteria include allowable flaw indication tables for planar flaws (i.e., Table IWB-3514-2) and for laminar flaws (i.e., Table IWB-3514-3).

- A laminar flaw is defined in ASME Code, Section XI as a flaw oriented within 10 degrees of a plane parallel to the surface of the component. This definition is applicable to welds, weld overlays, and base materials. The standard imposed for evaluating laminar flaws in ASME Code, Section XI is more restrictive than the Section III standard for evaluating laminations. The ASME Code, Section XI laminar flaw standards are contained in Table IWB-3514-3 of the ASME Code, Section XI, and are supplemented in Attachment 1. These criteria require that the sum of laminar flaw lengths in any direction must be less than 10 percent of the overlay length, with a total reduction in area equal to or less than Table IWB-3514-3. For weld overlay areas where examination is precluded by the presence of the flaw, the areas must be postulated to be cracked.

- Any planar flaws found in the FSWOLs during either the weld overlay acceptance or preservice examinations are required to meet the preservice standards of ASME Code, Section XI, Table IWB-3514-2. 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 as a part of the proposed alternative.

- Weld overlays for repair of cracks in piping are not addressed by ASME Code, Section III. ASME Code, Section III utilizes NDE procedures and techniques with flaw detection capabilities that are within the practical limits of workmanship standards for welds. These standards are most applicable to volumetric examinations conducted by radiographic examination. Radiography (RT) of weld overlays is not practical because of the presence of radioactive material in the reactor coolant system and water in the pipes. The ASME Code, Section III acceptance standards are written for a range of fabrication flaws including lack of fusion, incomplete penetration, cracking, slag inclusions, porosity, and concavity. However, experience and fracture mechanics have demonstrated that many of the flaws that would be rejected using ASME Code, Section III acceptance standards do not have a significant effect on the structural integrity of the component. The proposed alternatives in Attachments 1 and 2 were written to specifically address weld overlays, and not only does this alternative adequately examine the weld overlay, but it provides appropriate examinations and acceptance criteria.

The ASME Code, Section XI acceptance standards are the logical choice for evaluation of potential flaw indications in post-overlay examinations, in which unnecessary repairs to the overlays would result in additional personnel radiation exposure, and could potentially degrade the effectiveness of the overlays by affecting the favorable residual stress field that they produce. The criteria are consistent with previous criteria approved by the NRC for weld overlay installations. Weld overlays have been used for repair and mitigation of cracking in BWRs for many years. In NRC Generic Letter 88-01, *NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping*, the NRC approved the use of ASME Code, Section XI inspection procedures for determining the acceptability of installed weld overlays in BWR reactor coolant pressure boundary piping. In addition, the NRC has conditionally accepted ASME Code Case N-504-4 in RG 1.147, Revision 18. ASME Code Case N-504-4 was developed to codify the BWR weld overlay experience, and NRC approval is consistent with the NRC acceptability of BWR weld overlays. Code Case N-740-2 has since been developed for use on DMWs; NRC review of this Code Case is still pending.

The NRC found the use of the ASME Code, Section XI, Appendix VIII, Supplement 11 acceptable for identifying both construction and service induced flaws in the Safety Evaluation Report (SER) for Brunswick Steam Electric Plant Unit 2 dated October 10, 2017; James A. Fitzpatrick Nuclear Power Plant dated February 8, 2017; Millstone Power Station Unit 2 dated April 24, 2015; Edwin I. Hatch Nuclear Plant, Unit 1, dated December 18, 2015; and D.C. Cook Plant dated February 19, 2006; and tacitly approved the associated ASME Code, Section XI acceptance criteria, Tables IWB-3514-2 and IWB-3514-3. The NRC also accepted the use of ASME Code, Section XI acceptance standards in an SER dated July 21, 2004, for the Three Mile Island Plant, for disposition of flaws identified in a weld overlay by PDI qualified ultrasonic examinations, with additional restrictions similar to those proposed herein for regions in which inspection is precluded by the flaws. The Brunswick Unit 2 submittal is the most recent example of NRC-approved use of Code Case N-740-2 for application to a BWR nozzle DMW.

*Need for Ambient Temperature Temper Bead Techniques*

The N4A and N4D nozzle FSWOLs addressed by this alternative will not require Ambient Temperature Temper Bead Welding as described in Mandatory Appendix I of Code Case N-740-2 or Code Case N-638-6. Ambient Temperature Temper Bead Welding techniques are not required as the FSWOL thickness is less than 0.75 inches.

*Analyses and Verifications*

The following list of analyses and verifications will be performed subject to the specific design, analysis, and inspection requirements that have been defined in this relief request.

1. The as-built dimensions of the FSWOLs 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 for the N4A and N4D nozzles. The effects of any changes in applied loads, as a result of weld shrinkage from the entire overlay, on other items in the piping system (e.g., support loads and clearances, nozzle loads, and changes in system flexibility and

weight due to the weld overlay) shall be evaluated. Existing flaws previously accepted by analytical evaluation shall be evaluated in accordance with IWB-3640, IWC-3640, or IWD-3640, as applicable.

3. Nozzle specific stress analyses will be performed within 90 days after application of the FSWOLs to establish a residual stress profile in the N4A and N4D nozzles. Inside diameter (ID) 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 FSWOLs to determine the final residual stress profiles. Post weld overlay residual stresses at normal operating conditions will be shown to result in an improved stress state at the ID of the N4A and N4D nozzle weld region that reduces the probability for further crack propagation due to SCC.

4. The analyses will demonstrate that the application of the FSWOLs satisfies all ASME Code, Section III stress and fatigue criteria.

5. Fracture mechanics analyses will be performed to predict crack growth. Crack growth due to SCC and fatigue crack growth in the original DMWs 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 overlays.

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

Summaries of the results of the analyses listed in Items 1 and 2 above will be submitted to the NRC prior to entry into Mode 2 following completion of the weld overlay. Summaries of Items 3 through 6 will be submitted to the NRC within 90 days of completing the BSEP Unit 1 refueling outage B1R22.

The following information will be submitted to the NRC within 14 days of completion of the final UT examination of the overlaid welds. Also, included in the results will be a discussion of any repairs to the overlay material and/or base metal and the reason for the repair.

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 criteria and, if possible, the type and nature of the indications.

*Conclusions*

*Quality and Safety of Proposed Alternative*

Implementation of the FSWOL alternative described in Attachments 1 and 2 of this request produces effective repairs for future mitigation of SCC in the identified welds and maintains the nozzle geometry to permit future ASME Code, Appendix VIII UT examinations as implemented through the PDI Program. FSWOL repairs of DMWs have been installed and performed successfully for many years in both PWR and BWR applications. The alternative provides improved structural integrity and reduces the likelihood of leakage at the N4A and

N4D nozzle locations. Accordingly, the use of the alternative provides an acceptable level of quality and safety in accordance with 10 CFR 50.55a(z)(1).

## 6. Duration of Proposed Alternative

The provisions of this alternative are applicable to the fourth 10-year in-service inspection interval for BSEP which commenced on May 11, 2008 and will end on May 10, 2018.

The FSWOLs for the N4A and N4D nozzles, installed in accordance with the provisions of this alternative, will remain in place for the design life of the repair established as described in Attachments 1 and 2.

## 7. References

1. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, 2001 Edition through 2003 Addenda.

2. ASME Boiler and Pressure Vessel Code, Section XI, 2001 Edition through 2003 Addenda, Appendix VIII, Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds."

3. EPRI Materials Reliability Program Report: Crack Growth Rates for Evaluating PWSCC of Alloy 82, 182, and 132 Welds (MRP-115), EPRI, Palo Alto, CA, and Dominion Engineering, Inc., Reston, VA: November 2004. 1006696.

4. ASME Code Case N-740-2, "Dissimilar Metal Weld Overlay for Repair or Mitigation of Class 1, 2, and 3 Items."

5. W. Hübner, B. Johansson, and M. de Pourbaix, "Studies of the Tendency to Intergranular Stress Corrosion Cracking of Austenitic Fe-Cr-Ni Alloys in High Purity Water at 300°C," Studsvik Report AE-437, Nykoping, Sweden, 1971.

6. W. Debray and L. Stieding, Materials in the Primary Circuit of Water-Cooled Power Reactors, International Nickel Power Conference, Lausanne, Switzerland, May 1972, Paper No. 3.

7. C. Amzallag, et al., "Stress Corrosion Life Assessment of 182 and 82 Welds used in PWR Components," Proceedings of the 10th International Symposium on Environmental Degradation of Materials in Nuclear Power Systems - Water Reactors, NACE, 2001.

8. NUREG/CR-6907, "Crack Growth Rates of Nickel Alloy Welds in a PWR Environment," U.S. Nuclear Regulatory Commission (Argonne National Laboratory), May 2006

9. EPRI Material Reliability Program Report: "Primary System Piping Butt Weld Inspection and Evaluation Guidelines (MRP-139)," EPRI, Palo Alto, CA: August 2005. 1010087.

10. ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Power Plant Components, 1974 Edition with Addenda through Summer 1976

11. ASME Code Case N-504-4, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping."

12. D. Buisine, et al., "PWSCC Resistance of Nickel Based Weld Metals with Various Chromium Contents," Proceedings: 1994 EPRI Workshop on PWSCC of Alloy 600 in PWRs, EPRI, Palo Alto, CA: 1995. TR-105406, Paper D5.

13. ASME Boiler and Pressure Vessel Code, Section XI, Nonmandatory Appendix Q, 2007 Edition through 2008 Addenda.

14. Regulatory Guide (RG) 1.147, Revision 18, “Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1”

Attachment 1

Proposed Alternative for N4A and N4D Feedwater Dissimilar Metal Weld Overlays

## A1.1 INTRODUCTION

Duke Energy proposes the following detailed requirements for the design, analysis, fabrication, examination, and pressure testing of the BSEP Unit 1 Reactor Pressure Vessel (RPV) Feedwater nozzles N4A and N4D dissimilar metal weld overlays. These requirements, which are derived from applicable portions of ASME Code Case N-740-2, provide an acceptable methodology for reducing potential defects in these austenitic nickel alloy welds to an acceptable size and mitigating the potential for future stress corrosion cracking by increasing the wall thickness through deposition of weld overlays. The weld overlays will be applied by deposition of weld reinforcement (i.e., weld overlay) on the outside surface of the safe end, safe end extension, and associated dissimilar metal weld, in accordance with the following requirements:

## A1.2 GENERAL REQUIREMENTS (Correlated to N-740-2, paragraph 1)

### A1.2.1 Definitions

(a) **Full structural weld overlay** - deposition of weld reinforcement on the outside diameter of the piping, component, or associated weld, such that the weld reinforcement is capable of supporting the design loads, without consideration of the piping, component, or associated weld beneath the weld reinforcement. Full structural weld overlay can be either mitigative or repair weld overlay as defined in A1.2.1(b) and (c).

(b) **Mitigative weld overlay** - weld overlay that is applied over material with no inside-surface-connected flaws found during an examination performed in accordance with A1.3(a)(3), prior to the weld overlay being applied

(c) **Repair weld overlay** - weld overlay that is applied over material with an inside-surface-connected flaw or subsurface defect, or where a pre-weld overlay examination is not performed

(d) **SCC susceptible materials** - for this proposed alternative, the stress-corrosion-cracking (SCC) susceptible materials are Unified Numbering System (UNS) N06600, N06082, or W86182 in pressurized water reactor environments; or the associated welds in UNS N06600, W86182, or austenitic stainless steels in boiling water reactor environments.

### A1.2.2 General Overlay Requirements

(a) A full-structural weld overlay will be applied by deposition of weld reinforcement (i.e., weld overlay) on the outside surface of circumferential welds. This proposed method applies to austenitic nickel alloy and austenitic stainless steel welds between the following:

P-No. 8 or P-No. 43 and P-Nos. 1, 3, 12A, 12B, or 12C
P-No. 8 and P-No. 43
Between P-Nos. 1, 3, 12A, 12B, and 12C materials

(b) If a weld overlay on any of the material combinations in A1.2.2(a) obstructs a required examination of an adjacent P-No. 8 to P-No. 8 weld, the overlay will be extended to include overlaying the adjacent weld.

(c) Weld overlay filler metal will be austenitic nickel alloy (i.e., 28 percent chromium minimum, ERNiCrFe-7/7A) meeting the requirements of 1.2.2(e)(1) or (2), as applicable, applied 360 degrees around the circumference of the item and deposited using a Welding Procedure Specification (WPS) for groove welding, qualified in accordance with the Construction Code and Owner's Requirements identified in the Repair/Replacement Plan.

(d) Prior to deposition of the weld overlay, the surface to be weld overlaid will be examined using the liquid penetrant method. Indications with major dimensions greater than 1/16 inch (i.e., 1.5 millimeters) will be removed, reduced in size, or weld repaired in accordance with the following requirements:

(1) One or more layers of weld metal will be applied to seal unacceptable indications in the area to be repaired with or without excavation. The thickness of these layers will not be used in meeting weld reinforcement design thickness requirements. Peening the unacceptable indication prior to welding is permitted.

(2) If weld repair of indications identified in A1.2.2(d) is required, the area where the weld overlay is to be deposited, including any local weld repairs or initial weld overlay layer, will be examined by the liquid penetrant method. The area shall contain no indications with major dimensions greater than 1/16 inch (i.e., 1.5 millimeters) prior to application of the structural layers of the weld overlay.

(3) Per ASME Code Case N-740-2, to reduce the potential of hot cracking when applying an austenitic nickel alloy over P-No. 8 base metal, a layer or multiple layers of austenitic stainless steel filler material will be applied over the austenitic stainless steel base metal. The stainless steel filler metal shall have a delta ferrite content of 5 to 15 Ferrite Number (FN), as reported on the Certified Material Test Report. The thickness of these buffer layers will not be used in meeting weld reinforcement design thickness requirements.

Since a stainless steel buffer layer will not be applied for the BSEP Unit 1 N4A and N4D nozzle overlays, this stipulation of ASME Code Case N-702-2 will not apply.

Duke Energy may elect to apply a layer of Alloy 82 weld deposit over the existing DMW and adjacent material. It has been observed that when depositing Alloy 52M over Alloy 182 deposits, hot cracking can occur. The deposition of Alloy 82 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 towards the structural thickness of the FSWOL. The microstructure of Alloy 52M is fully austenitic, therefore the ferrite number requirements of Code Case N-740-2 are not applicable.

(e) Weld overlay deposits will meet the following requirements:

(1) Per ASME Code Case N-740-2, the austenitic stainless steel weld overlay shall consist of at least two weld layers having as-deposited delta ferrite content of at least 7.5 FN. The first layer of weld metal with delta ferrite content of at least 7.5 FN shall constitute

the first layer of the weld reinforcement that may be credited toward the required thickness. Alternatively, layers of at least 5 FN are acceptable, provided the carbon content of the deposited weld metal is determined by chemical analysis to be less than 0.02 percent.

Since an Alloy 52M weld overlay will be used, this stipulation of ASME Code Case N-740-2 will not apply.

(2) The Alloy 52M weld overlay will consist of at least two weld layers deposited using a filler material with a chromium (Cr) content of at least 28 percent. The first layer of weld metal deposited may not be credited toward the required thickness except that a first diluted layer may be credited toward the required thickness, provided the portion of the layer over the austenitic base material, austenitic filler material weld, and the associated dilution zone from an adjacent ferritic base material contain at least 20 percent Cr, and the Cr content of the deposited weld metal is determined by chemical analysis of the production weld or of a representative coupon taken from a mockup prepared in accordance with the weld procedure for the production weld.

(f) With reference to N-740-2 paragraph 1.2(f): This case is only for welding in applications predicted not to have exceeded thermal neutron (E < 0.5 eV) fluence of $1 \times 10^{17}$ neutrons per $cm^2$ prior to welding. Duke Energy confirms the thermal neutron fluence at the N4A and N4D nozzles FSWOL location is less than the threshold specified as it is external to the vessel.

(g) With reference to N-740-2 paragraph 1.2(g): A new weld overlay is not being installed over the top of an existing weld overlay that has been in service.

**A1.3 CRACK GROWTH AND DESIGN (Correlated to N-740-2, paragraph 2)**

(a) Crack Growth Calculation of Flaws in the Original Weld or Base Metal. The size of the flaw detected in the base metal will be used to define the life of each overlay. The inspection interval will not be longer than the shorter of the life of the overlay or the period specified in A1.4(c). Crack growth due to both stress corrosion and fatigue, will be evaluated. Flaw characterization and evaluation will be based on the examination results or postulated flaw, as described below. The flaw is at or near the boundary of two different materials. As such, an evaluation of flaw growth in both materials will be performed.

(1) For the repair overlay, a pre-overlay examination has been performed and the initial flaw size for crack growth in the base metal will be based on the as-found flaw.

(2) Per ASME Code Case N-740-2, for postulated flaws, the axial flaw length will be 1.5 inches (i.e., 38 millimeters) or the combined width of the weld plus buttering plus any adjacent SCC susceptible material, whichever is greater. The circumferential flaw length will be assumed to be 360 degrees. The depths associated with these lengths are specified in A1.3(a)(3) and A1.3(a)(4).

(3) Per ASME Code Case N-740-2, if an ASME Section XI, Appendix VIII, Supplement 10, or Supplement 2, as applicable, ultrasonic examination is performed prior to application of the overlay, and no inside-surface-connected planar flaws are discovered, initial flaws originated from the inside surface of the weldment equal to 10 percent of the original wall

thickness will be assumed in both the axial and circumferential directions, and the overlay shall be considered mitigative.

This stipulation of ASME Code Case N-740-2 is not applicable because ultrasonic examinations have determined the identified indication to be ID connected.

(4) Per ASME Code Case N-740-2, if an ASME Section XI, Appendix VIII, Supplement 10, or Supplement 2, as applicable, ultrasonic examination is not performed prior to application of the overlay, initial inside-surface-connected planar flaws equal to at least 75 percent through the original wall thickness shall be assumed, in both the axial and circumferential directions, and the overlay shall be considered a repair. For cast austenitic stainless steel (CASS) items, a 100 percent through-wall flaw shall be assumed unless the subsequent inservice inspection schedule is modified as discussed in A1.4(c)(4).

This stipulation of ASME Code Case N-740-2 is not applicable because ultrasonic examinations have been performed prior to application of an overlay. In addition, this application does not involve a cast austenitic stainless steel item.

(5) Per ASME Code Case N-740-2, there may be circumstances in which an overlay examination is performed using an ultrasonic examination procedure qualified in accordance with Appendix VIII, Supplement 11 for depths greater than the outer 25 percent of the original wall thickness (i.e., see Figure A1-2 below). For such cases, the initial flaw depths are assumed to be the detected depth found by the Appendix VIII, Supplement 11 qualified examination, plus the postulated worst-case flaw in the region not covered by the Appendix VIII ultrasonic examination.

This stipulation of ASME Code Case N-740-2 is not applicable because ultrasonic examinations have been performed; however, for the proposed crack growth evaluation, the flaw will be assumed to have 75 percent through-wall depth, for both an axial and circumferential flaw.

(6) In determining the life of each overlay, any inside-surface-connected planar flaw found by the overlay preservice inspection of A1.4(b) that exceeds the depth of (3), (4), or (5) above has been used as part of the initial flaw depth. The initial flaw depth assumed is the detected flaw depth plus the postulated worst-case flaw depth in the region of the pipe wall thickness that was not examined using an ultrasonic examination procedure meeting Appendix VIII for that region. Since the overlays will meet this condition, it is considered a repair, rather than mitigation.

(b) Structural Design and Sizing of the Overlay. The design of the weld overlays will satisfy the following, using the assumptions and flaw characterization requirements in A1.3(a). The following design analysis will be completed in accordance with IWA-4311:

(1) The axial length and end slope of the weld overlay will cover the weld and heat-affected zones on each side of the weld, as well as any stress corrosion cracking susceptible base material adjacent to the weld and provide for load redistribution from the item into the weld overlay and back into the item without violating applicable stress limits of NB-3200. Any laminar flaws in the weld overlay will be evaluated in the analysis to

ensure that load redistribution complies with the above. These requirements are usually satisfied if the weld overlay full thickness length extends axially beyond the SCC-susceptible material or projected flaw by at least $0.75\sqrt{Rt}$, where R is the outer radius of the item and t is the nominal wall thickness of the item at the applicable side of the overlay (i.e., R and t of the nozzle on the nozzle side and R and t of the safe-end on the safe-end side).

(2) In accordance with A1.3(b)(1), the end transition slope of the overlay will be analyzed for the design configuration.

(3) The assumed flaw in the underlying base material or weld will be based on the limiting case of A1.3(b) (3)(a) or (b)which results in the larger required overlay thickness.

(a) 100 percent through-wall circumferential flaw for the entire circumference.

(b) 100 percent through-wall flaw with length of 1.5 inches (i.e., 38 millimeters), or the combined width of the weld plus buttering plus any SCC-susceptible material, whichever is greater, in the axial direction.

(4) The overlay design thickness will be verified, using only the weld overlay thickness conforming to the deposit analysis requirements of A1.2.2(e). The combined wall thickness at the weld overlay, any postulated worst-case planar flaws under the laminar flaws in the weld overlay, and the effects of any discontinuity within a distance of $2.5\sqrt{Rt}$, from the toes of the weld overlay, including the flaw size assumptions defined in A1.3(b)(3) above, will be evaluated and shall meet the requirements of IWB-3640, IWC-3640, or IWD-3640, as applicable.

(5) The effects of any changes in applied loads, as a result of weld shrinkage from the entire overlay, on other items in the piping system (e.g., support loads and clearances, nozzle loads, and changes in system flexibility and weight due to the weld overlay) will be evaluated.

### A1.4 EXAMINATION (Correlated to N-740-2, paragraph 3)

In lieu of all other examination requirements, the examination requirements of this proposed method will be met for the life of the overlay. Specifically, future inservice examinations required by 10 CFR 50.55a, if more stringent than those specified herein, shall be met in lieu of the proposed inservice examinations included in this relief request. Nondestructive examination methods will be in accordance with IWA-2200, except as specified herein. Nondestructive examination personnel shall be qualified in accordance with IWA-2300. Ultrasonic examination procedures and personnel will be qualified in accordance with the modified requirements to ASME Code, Section XI, Appendix VIII, Supplement 11 as described in Attachment 2. The examination will be performed, to the maximum extent practicable, for axial and circumferential flaws. If 100 percent coverage of the required volume for axial flaws cannot be achieved, but essentially 100 percent coverage for circumferential flaws (i.e., 100 percent of the susceptible volume) can be achieved, the examination for axial flaws will be performed to achieve the maximum coverage practicable, with limitations noted in the examination report. The examination coverage requirements will be considered to be met.

(a) Acceptance Examination

(1) The weld overlay will have a surface finish of 250 micro-inches (µ-in), 6.3 micrometer (µm) RMS or better and contour that permits ultrasonic examination in accordance with procedures qualified in accordance with ASME Code, Section XI, Appendix VIII. The weld overlay will be inspected to verify acceptable configuration.

(2) The weld overlay and the adjacent base material for at least 1/2 inch (i.e., 13 millimeters) from each side of the overlay will be examined using the liquid penetrant method. The weld overlay will satisfy the surface examination acceptance criteria for welds of the Construction Code or NB-5300. The adjacent base material will satisfy the surface examination acceptance criteria for base material of the Construction Code or NB-2500. If ambient temperature temper bead welding is performed, the liquid penetrant examination of the completed weld overlay will be conducted no sooner than 48 hours following completion of the three tempering layers over the ferritic steel.

(3) The examination volume A-B-C-D in Figure A1-1(a), shown below, will be ultrasonically examined to assure adequate fusion (i.e., adequate bond) with the base material and to detect welding flaws, such as interbead lack of fusion, inclusions, or cracks. The interface C-D shown between the overlay and weld includes the bond and heat-affected zone from the overlay. If ambient temperature temper bead welding is performed, 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 weld overlay acceptance examination 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) 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 stress corrosion cracking. 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 $t_2$) will be used. Laminar flaws in the weld overlay will meet the following requirements:

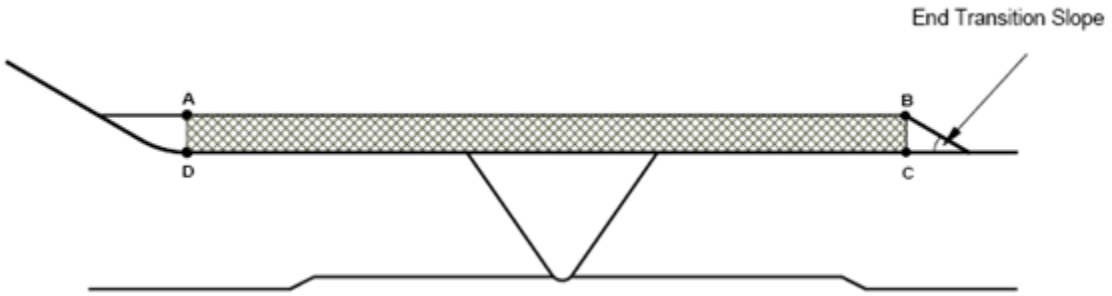
(a) The acceptance standards of IWB-3514 will be met, with the additional limitation that the total laminar flaw area will not exceed 10 percent of the weld surface area and that no linear dimension of the laminar flaw area shall exceed the greater of 3 inches (i.e., 76 millimeters) or 10 percent of the pipe circumference.

(b) For examination volume A-B-C-D in Figure A1-1(a), shown below, 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.

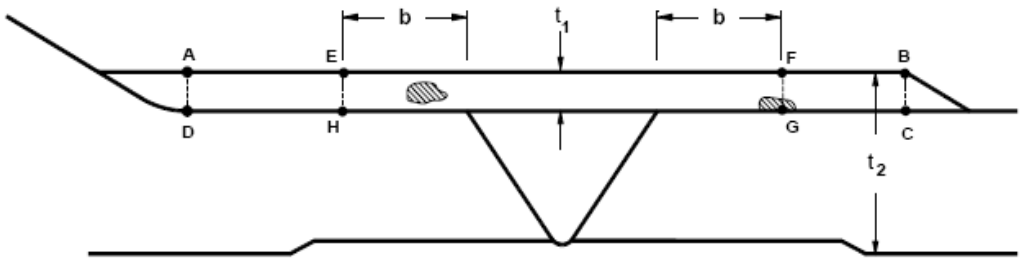
(c) Any uninspectable volume in the weld overlay will be assumed to contain the largest radial planar flaw that could exist within that volume. This assumed flaw will meet the preservice examination acceptance standards of IWB-3514, with nominal wall thickness as defined above the planar flaws. Alternatively,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

(4) After completion of all welding activities, VT-3 visual examination shall be performed on all affected restraints, supports, and snubbers, to verify that design tolerances are met.

Figure A1-1 Examination Volume and Thickness Definitions




(a) Examination Volume A–B–C–D




(b) Thickness ($t_1$ and $t_2$) for Table IWB-3514-2

Notes:
1 Dimension *b* is equivalent to the nominal thickness of the nozzle or pipe being overlaid, as appropriate.
2 The nominal wall thickness is $t_1$ for flaws in E-F-G-H, and $t_2$ for flaws in A-E-H-D or F-B-C-G.
3 For flaws that span two examination volumes (e.g., illustrated at F-G), the $t_1$ thickness shall be used.
4 The weld includes the nozzle or safe end butter, where applied, plus any stress corrosion cracking susceptible base material in the nozzle.

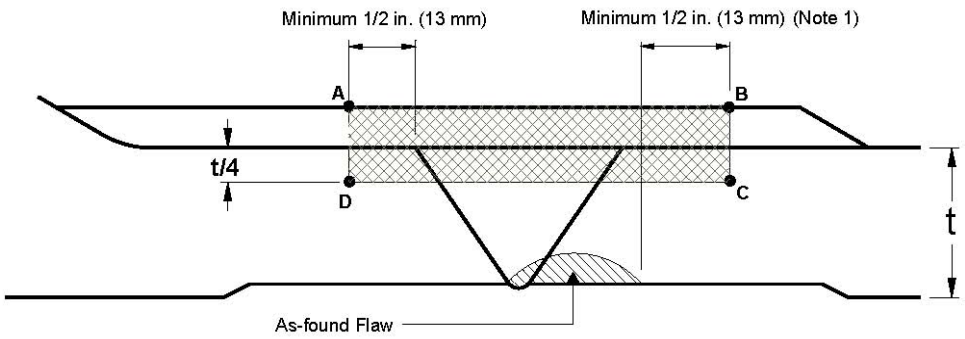
(b) Preservice Inspection

(1) The examination volume in Figure A1-2 will be ultrasonically examined. 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 have propagated into the outer 25 percent of the base metal thickness or into the weld overlay.

(2) The preservice examination acceptance standards of IWB-3514 will be met 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) 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 design analysis requirements of A1.3(b).

(3) The flaw evaluation requirements of IWB-3640, IWC-3640, or IWD-3640 will not be applied to planar flaws, identified during preservice examination, that exceed the preservice examination acceptance standards of IWB-3514.

Figure A1-2 Preservice and Inservice Examination Volume




Examination Volume A–B–C–D

Notes:
1 The weld includes the nozzle or safe end butter, where applied.
2 For axial or circumferential flaws, the axial extent of the examination volume shall extend at least 1/2 inch (i.e., 13 millimeters) beyond the as-found flaw and at least 1/2 inch (i.e., 13 millimeters) beyond the toes of the original weld, including weld end butter, where applied.

(c) Inservice Inspection

(1) Category E welds (i.e., cracked welds reinforced by weld overlay) are required by BWRVIP-75-A to be examined on the frequency of 25 percent of the population every 10 years. As such, the FSWOL applied to the N4 nozzle dissimilar metal welds 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 as determined in A1.3(a).

(2) The weld overlay will be ultrasonically examined during the first or second refueling outage following application. Examination volumes that show no indication of crack growth or new cracking will then be placed into a population of Category E welds (i.e., cracked welds reinforced by weld overlay) to be examined on a sample basis. Twenty-five (25) percent of this population will be added to the ISI Program in accordance with BWRVIP-75-A. 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. If hot leg and cold leg welds are included in the population, the 25 percent sample does not need to include the cold leg welds. All weld overlays, including those not in the 25 percent sample, will be examined prior to the end of their design life as determined in A1.3(a).

(3) The weld overlay examination volume in Figure A1-2 above will be ultrasonically examined 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.

(4) The weld overlay will meet the inservice examination 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) above 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, IWC-3600, or IWD-3600, as applicable. If a planar flaw is detected in the outer 25 percent of the base material thickness the identified flaw shall be demonstrated to satisfy all requirements, limits and assumptions defined in the design evaluation of A1.3. Any indication characterized as stress corrosion cracking in the weld overlay material will be deemed unacceptable.

(5) Weld overlay examination volumes in Figure A1-1(b) above that show no indication of planar flaw growth or new planar flaws shall be placed into a population to be examined on a sample basis as defined in the inspection plan. Twenty-five percent of this population shall be examined once during each inspection interval.

(6) If inservice examinations reveal planar flaw growth, or new planar flaws, meeting the acceptance standards of IWB-3514, IWB-3600, IWC-3600, or IWD-3600, the weld overlay examination volume will be reexamined during the first or second refueling outage following discovery of flaw growth or new flaws.

(7) For weld overlay examination volumes with unacceptable indications in accordance with A1.4(c)(5), the weld overlay and original defective weld will be removed. A repair/replacement activity will be performed in accordance with IWA-4000.

(8) No cast austenitic stainless steel components will be overlaid.

(d) Additional Examinations. If future inservice examinations reveal a defect, in accordance with A1.4(c)(5), 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.

Regarding the initial sample expansion, requirements for both BWRVIP-75-A and CC N-578-1 were evaluated and implemented as applicable. Results of these evaluations are captured in the Duke Energy corrective action program.

**A1.5 PRESSURE TESTING**

A system leakage test will be performed in accordance with IWA-5000.

**A1.6 DOCUMENTATION**

Use of this proposed method will be documented on Form NIS-2A.

Attachment 2

Proposed Changes to ASME Code, Section XI, Appendix VIII
for Compatibility With the
Performance Demonstration Initiative Program

| **Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds** | **PDI Program: The Proposed Alternative to Supplement 11 Requirements** |
|---|---|
| | **Title Alternative:** "Qualification Requirements for Overlaid Wrought Austenitic Piping Welds"<br>**Basis:** *The title was clarified to be applicable for all overlays on wrought austenitic piping welds. The specific qualification shall detail the range of qualification.* |
| **1 0 SPECIMEN REQUIREMENTS** | |
| **1.1 General.** The specimen set shall conform to the following requirements. | |
| (b) The specimen set shall consist of at least three specimens having different nominal pipe diameters and overlay thicknesses. They shall include the minimum and maximum nominal pipe diameters for which the examination procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diameter shall be considered equivalent. If the procedure is applicable to pipe diameters of 24-inch or larger, the specimen set must include at least one specimen 24-inch or larger but need not include the maximum diameter. The specimen set must include at least one specimen with overlay thickness within minus 0.1 inch to plus 0.25 inch of the maximum nominal overlay thickness for which the procedure is applicable. | **Alternative:** (b) The specimen set shall include specimens with overlays not thicker than 0.1 inch more than the minimum thickness, nor thinner than 0.25 inch of the maximum nominal overlay thickness for which the examination procedure is applicable.<br>**Basis:** *To avoid confusion, the overlay thickness tolerance contained in the last sentence was reworded and the phrase "and the remainder shall be alternative flaws" was added to the next to last sentence in paragraph 1.1(d)(1).* |
| (d) Flaw Conditions | |
| (1) Base metal flaws. All flaws must be cracks in or near the approximate butt weld heat-affected zone, open to the inside surface, and extending at least 75 percent through the base metal wall. Flaws may extend 100 percent through the base metal and into the overlay material; in this case, | **Alternative:** (1) ... must be in or… extending at least 50 percent through…intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws. Specimens containing intergranular stress corrosion cracking shall be used when available. At least 70 percent of the |

| Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds | PDI Program: The Proposed Alternative to Supplement 11 Requirements |
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| intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the cracking. Specimens containing IGSCC shall be used when available. | flaws in the detection and sizing tests shall be cracks and the remainder shall be alternative flaws. Alternative flaw mechanisms, if used, shall provide crack-like reflective characteristics and shall be limited by the following:<br>(a) The use of alternative flaws shall be limited to when the implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws.<br>(b) Flaws shall be semi elliptical with a tip width of less than or equal to 0.002 inches.<br>**Basis:** *This paragraph requires that all base metal flaws be cracks and to extend at least 75 percent through the base metal wall. Implanting a crack requires excavation of the base material on at least one side of the flaw. While this may be satisfactory for ferritic materials, it does not produce a useable axial flaw in austenitic materials because the sound beam, which normally passes only through base material, must now travel through weld material on at least one side, producing an unrealistic flaw response. To resolve this issue, the PDI program revised this paragraph to allow use of alternative flaw mechanisms under controlled conditions. For example, alternative flaws shall be limited to when implantation of cracks precludes obtaining an effective ultrasonic response, flaws shall be semi elliptical with a tip width of less than or equal to 0.002 inches, and at least 70 percent of the flaws in the detection and sizing test shall be cracks and the remainder shall be alternative flaws. To avoid confusion, the overlay thickness tolerance contained in paragraph 1.1(b) last sentence, was reworded and the phrase “and the remainder shall be alternative flaws” was added to the next to last sentence. Paragraph 1.1(d)(1) includes the statement that intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws. Additionally, 1.1(d)(1) was revised to state that flaws must extend at least 50 percent through the base metal wall. This allows qualification to take advantage of additional test specimens to demonstrate* |

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| | *increased examination depth.* |
| (e) Detection Specimens | |
| (1) At least 20 percent but less than 40 percent of the flaws shall be oriented within +/-20° of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access. The rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws. | **Alternative:** (1) At least 20 percent but less than 40 percent of the base metal flaws shall be oriented within +/-20 degrees of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access.<br>**Basis:** *The requirement for axially oriented overlay fabrication flaws was excluded from the PDI Program as an improbable scenario. Weld overlays are typically applied using automated gas tungsten arc welding techniques with the filler metal applied in a circumferential direction. Because resultant fabrication induced discontinuities would also be expected to have major dimensions oriented in the circumferential direction axial overlay fabrication flaws are unrealistic. The requirement for using IWA-3300 for proximity flaw evaluation was excluded; instead indications shall be sized based on their individual merits.* |
| (2) Specimens shall be divided into base and overlay grading units. Each specimen shall contain one or both types of grading units. | **Alternative:** (2) Specimens shall be divided into base metal and overlay fabrication grading units. Each specimen shall contain one or both types of grading units. Flaws shall not interfere with ultrasonic detection or characterization of other flaws.<br>**Basis:** *Inclusion of "metal" and "fabrication" provides clarification. Flaw identification is improved by ensuring flaws are not masked by other flaws.* |
| (a)(1) A base grading unit shall include at least 3 inch of the length of the overlaid weld. The base grading unit includes the outer 25 percent of the overlaid weld and base metal on both sides. The base grading unit shall not include the inner 75 percent of the | **Alternative:** (a)(1) A base metal grading unit includes the overlay material and the outer 50 percent of the original overlaid weld. The base metal grading unit shall extend circumferentially for at least 1 inch and shall start at the weld centerline and be wide enough |

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| overlaid weld and base metal overlay material, or base metal-to-overlay interface. | in the axial direction to encompass one half of the original weld crown and a minimum of 0.50 inch of the adjacent base material.<br>**Basis:** *The phrase "and base metal on both sides," was inadvertently included in the description of a base metal grading unit. The PDI program intentionally excludes this requirement because some of the qualification samples include flaws on both sides of the weld. To avoid confusion several instances of the term "cracks" or "cracking" were changed to the term "flaws" because of the use of alternative Flaw mechanisms. Modified to require that a base metal grading unit include at least 1 inch of the length of the overlaid weld, rather than 3 inches.* |
| (a)(2) When base metal cracking penetrates into the overlay material, the base grading unit shall include the overlay metal within 1 inch of the crack location. This portion of the overlay material shall not be used as part of any overlay grading unit. | **Alternative:** (a)(2) When base metal flaws penetrate into the overlay material, the base metal grading unit shall not be used as part of any overlay fabrication grading unit.<br>**Basis:** *Substituted terms provide clarification and are consistent with 1d(1) above. The PDI program adjusts for this conservative change for excluding this type grading unit.* |
| (a)(3) When a base grading unit is designed to be unflawed, at least 1 inch of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. The segment of weld length used in one base grading unit shall not be used in another base grading unit. Base grading units need not be uniformly spaced around the specimen. | **Alternative:** (a)(3) Sufficient unflawed overlaid weld and base metal shall exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws.<br>**Basis:** *Modified to require sufficient unflawed overlaid weld and base metal to exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws, rather than the 1 inch requirement.* |
| (b)(1) An overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 $in^2$. The overlay grading unit shall be rectangular, with minimum dimensions of 2 inches. | **Alternative:** (b)(1) An overlay fabrication grading unit shall include the overlay material and the base metal-to-overlay interface for a length of at least 1 inch.<br>**Basis:** *The PDI program reduces the base metal-to-overlay interface to at least 1 inch (in lieu of a minimum of 2 inches) and eliminates the minimum rectangular dimension. This criterion is necessary to allow use of existing examination specimens that were fabricated in* |

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| | *order to meet NRC Generic Letter 88-01. This criterion may be more challenging than the ASME Code because of the variability associated with the shape of the grading unit.* |
| (b)(2) An overlay grading unit designed to be unflawed shall be surrounded by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch around its entire perimeter. The specific area used in one overlay grading unit shall not be used in another overlay grading unit. Overlay grading units need not be spaced uniformly about the specimen. | **Alternative:** (b)(2) Overlay fabrication grading units designed to be unflawed shall be separated by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch at both ends. Sufficient unflawed overlaid weld and base metal shall exist on both sides of the overlay fabrication grading unit to preclude interfering reflections from adjacent flaws. The specific area used in one overlay fabrication grading unit shall not be used in another overlay fabrication grading unit. Overlay fabrication grading units need not be spaced uniformly about the specimen.<br>**Basis:** *Paragraph 1.1 (e)(2)(b)(2) states that overlay fabrication grading units designed to be unflawed shall be separated by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch at both ends, rather than around its entire perimeter.* |
| (b)(3) Detection sets shall be selected from Table VIII-S2-1. The minimum detection sample set is five flawed base grading units, ten unflawed base grading units, five flawed overlay grading units, and ten unflawed overlay grading units. For each type of grading unit, the set shall contain at least twice as many unflawed as flawed grading units. | **Alternative:** Base metal grading units, ten unflawed base metal grading units, five flawed overlay fabrication grading units, and ten unflawed overlay fabrication grading units. For each type of grading unit, the set shall contain at least twice as many unflawed as flawed grading units. For initial procedure qualification, detection sets shall include the equivalent of three personnel qualification sets. To qualify new values of essential variables, at least one personnel qualification set is required.<br>**Basis:** *Clarified the guidance for initial procedure qualifications versus qualifying new values of essential variables.* |
| (f) Sizing Specimen | |
| (1) The minimum number of flaws shall be ten. At least 30 percent of the flaws shall be overlay fabrication flaws. At least 40 percent of the flaws shall be cracks open to the inside surface. | **Alternative:** (1) The...least 40 percent of the flaws shall be open to the inside surface. Sizing sets shall contain a distribution of flaw dimensions to assess sizing capabilities. For initial procedure qualification, sizing sets shall include the equivalent of three personnel |

| Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds | PDI Program: The Proposed Alternative to Supplement 11 Requirements |
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| | qualification sets. To qualify new values of essential variables, at least one personnel qualification set is required.<br>**Basis:** *Clarified the guidance for initial procedure qualifications versus qualifying new values of essential variables and is consistent with 1.1(d)(1) above.* |
| (3) Base metal cracking used for length sizing demonstrations shall be oriented circumferentially. | **Alternative:** (3) Base metal flaws used…circumferentially.<br>**Basis:** *Clarified wording to be consistent with 1.1(d)(1) above.* |
| (4) Depth sizing specimen sets shall include at least two distinct locations where cracking in the base metal extends into the overlay material by at least 0.1 inch in the through-wall direction. | **Alternative:** (4) Depth sizing specimen sets shall include at least two distinct locations where a base metal flaw extends into the overlay material by at least 0.1 inch in the through-wall direction.<br>**Basis:** *Clarified wording to be consistent with 1.1(d)(1) above.* |
| **2.0 Conduct of Performance Demonstration** | |
| The specimen inside surface and identification shall be concealed from the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited. | **Alternative:** The specimen ...prohibited. The overlay fabrication flaw test and the base metal flaw test may be performed separately.<br>**Basis:** *Clarified wording to describe process.* |
| **2.1 Detection Test.** | |
| Flawed and unflawed grading units shall be randomly mixed. Although the boundaries of specific grading units shall not be revealed to the candidate, the candidate shall be made aware of the type or types of grading units (base or overlay) that are present for each specimen. | **Alternative:** Flawed…(i.e., base metal or overlay fabrication)…each specimen.<br>**Basis:** *Clarified wording similar to 1.1(e)(2) above.* |
| **2.2 Length Sizing Test** | |
| (d) For flaws in base grading units, the candidate shall estimate the length of that part of the flaw that is in the outer 25 percent of the base wall thickness. | **Alternative:** (d) For . . . base metal grading . . . 50 percent of the base metal wall thickness.<br>**Basis:** *Clarified wording for consistency and to be consistent with 1.1(d)(1) above.* |
| **2.3 Depth Sizing Test.** | |
| For the depth sizing test, 80 percent of the | **Alternative:** (a) The depth sizing test may be |

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| flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region. | conducted separately or in conjunction with the detection test.<br>(b) When the depth sizing test is conducted in conjunction with the detection test and the detected flaws do not satisfy the requirements of 1.1(f), additional specimens shall be provided to the candidate. The regions containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.<br>(c) For a separate depth sizing test, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.<br><br>**Basis:** *Clarified wording to better describe process.* |
| **3.0 ACCEPTANCE CRITERIA** | |
| **3.1 Detection Acceptance Criteria** | |
| Examination procedures, equipment, and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls. The criteria shall be satisfied separately by the demonstration results for base grading units and for overlay grading units. | **Alternative:** Examination procedures are qualified for detection when:<br>a. All flaws within the scope of the procedure are detected and the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for false calls.<br>b. At least one successful personnel demonstration has been performed meeting the acceptance criteria defined in (c).<br>c. Examination equipment and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls.<br>d. The criteria in (b) and (c) shall be satisfied separately by the demonstration results for base metal grading units and for overlay fabrication grading units.<br>**Basis:** *Clarified wording to better describe the difference between procedure qualification and equipment and personnel qualifications.* |
| **3.2 Sizing Acceptance Criteria** | |
| (a) The RMS error of the flaw length measurements, as compared to the true flaw lengths, is less than or equal to 0.75 inch. | **Alternative:** (a) The...base metal flaws is…50 percent through-base-metal position.<br>**Basis:** *Clarified wording to be consistent with* |

| **Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds** | **PDI Program: The Proposed Alternative to Supplement 11 Requirements** |
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| The length of base metal cracking is measured at the 75 percent through-base-metal position. | *1.1(d)(1) above.* |
| (b) All extensions of base metal cracking into the overlay material by at least 0.1 inch are reported as being intrusions into the overlay material. | **Alternative:** This requirement is omitted.<br>***Basis:*** *The requirement for reporting all extensions of cracking into the overlay is omitted from the PDI Program because it is redundant to the RMS calculations performed in paragraph 3.2(c) and its presence adds confusion and ambiguity to depth sizing as required by paragraph 3.2(c). This also makes the weld overlay program consistent with the Supplement 2 depth sizing criteria.* |

Attachment 4

Comparison of ASME Code Case N-504-4 and Appendix Q
of ASME Code, Section XI With the
Proposed Alternative of Attachment 1 for Weld Overlay, Code Case N-740-2

| **ASME Code Case N-504-4 and Appendix Q of ASME Code Section XI** | **Proposed Alternative of Attachment 1-Code Case N-740-2** |
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| ASME Code Case N-504-4 provides requirements for reducing a defect to a flaw of acceptable size by deposition of weld reinforcement (weld overlay) on the outside surface of the pipe using austenitic stainless steel filler metal as an alternative to defect removal. ASME Code Case N-504-4 is applicable to austenitic stainless steel piping only. According to Regulatory Guide 1.147, Revision 17, the provisions of Nonmandatory Appendix Q of ASME Code Section XI must also be met when using this Case. Therefore, the Code Case N-504-4 requirements presented below have been supplemented by Appendix Q of ASME Code Section XI. | The proposed alternative of Attachment 1 provides requirements for installing a repair or preemptive full structural weld overlay by deposition of weld reinforcement (i.e., weld overlay) on the outside surface of the item using Nickel Alloy 52M filler metal. Attachment 1 is applicable to dissimilar metal welds associated with nickel alloy materials. The proposed alternative of Attachment 1 is based on ASME Code Case N-740-2. |
| *General Requirements* | *General Requirements* |
| ASME Code Case N-504-4 and Appendix Q are only applicable to P-No. 8 austenitic stainless steels. | As specified in paragraph 1.1(a), the proposed alternative is applicable to dissimilar metal 82/182 welds joining P-No. 1 to P-No. 8 or 43 materials and P-No. 8 to P-No. 43 materials. It is also applicable to austenitic stainless steel welds joining P-No. 8 materials.<br><br>*Basis: ASME Code Case N-504-4 and Appendix Q are applicable to austenitic weld overlays of P-No. 8 austenitic stainless steel materials. Based on ASME Code Case N-740-2, the proposed alternative of Attachment 1 was specifically written to address the application of weld overlays over dissimilar metal welds and austenitic stainless steel welds.* |
| According to paragraph (b) of ASME Code Case N-504-4 as supplemented by Appendix Q, weld overlay filler metal shall be | The weld filler metal and procedure requirements of paragraph 1.1(b) are equivalent to ASME Code Case N-504-4 and |

| ASME Code Case N-504-4 and Appendix Q of ASME Code Section XI | Proposed Alternative of Attachment 1-Code Case N-740-2 |
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| low carbon (0.035 percent max.) austenitic stainless steel applied 360 degrees around the circumference of the pipe, and shall be deposited using a Welding Procedure Specification for groove welding, qualified in accordance with the Construction Code and Owner's Requirements and identified in the Repair/Replacement Plan. | Appendix Q except as noted below:<br><br>• Weld overlay filler metal shall be austenitic Nickel Alloy 52M (ERNiCrFe-7A) filler metal which has a chromium content of at least 28 percent. If a stainless steel buffer layer is used as permitted by N-740-2, the ferrite content of the filler material shall be 5 – 15 FN as required by the Construction Code.<br><br>As an alternative to post-weld heat treatment, the provisions for "Ambient Temperature Temper Bead Welding" may be used on the ferritic nozzle , but are not required for this application.<br><br>*Basis: The weld overlay shall be deposited with ERNiCrFe-7A (Alloy 52M) filler metal. It has been included into ASME Code Section IX as F-No. 43 filler metals. Containing 28.0 - 31.5 percent chromium (i.e., roughly twice the chromium content of 82/182 filler metal), this filler metal has excellent resistance to stress corrosion cracking. This point has been clearly documented in EPRI Technical Report MRP-115, Section 2.2[5]. Regarding the welding procedure specification (WPS), the requirements of Attachments 1 and 2 provide clarification that the WPS used for depositing weld overlays must be qualified as a groove welding procedure to ensure that mechanical properties of the WPS are appropriately established. Where welding is performed on ferritic nozzles, an ambient temperature temper bead WPS shall be used. Suitability of an ambient temperature temper bead WPS is addressed in Section 5 of this Request.* |
| According to paragraph (e) of ASME Code Case N-504-4 as supplemented by Appendix Q, the weld reinforcement shall consist of at least two weld layers having as-deposited delta ferrite content of at least 7.5 FN. The first layer of weld metal with delta ferrite content of at least 7.5 FN shall constitute the first | The weld overlay described in Attachment 1 is deposited using nickel Alloy 52M filler metal instead of austenitic stainless steel filler metals. Therefore, the basis for crediting the first layer towards the required design thickness is based on the chromium content of the nickel alloy filler metal. According to paragraph |

| ASME Code Case N-504-4 and Appendix Q of ASME Code Section XI | Proposed Alternative of Attachment 1-Code Case N-740-2 |
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| layer of the weld reinforcement that may be credited toward the required thickness. Alternatively, first layers of at least 5 FN provided the carbon content is determined by chemical analysis to be less than 0.02 percent. | A1.1(e), the first layer of nickel Alloy 52M deposited weld metal may be credited toward the required thickness provided the portion of the layer over the austenitic base material, austenitic weld, and the associated dilution zone from an adjacent ferritic base material contains at least 20 percent chromium. The chromium content of the deposited weld metal may be determined by chemical analysis of the production weld or from a representative coupon taken from a mockup prepared in accordance with the WPS for the production weld.<br><br>*Basis: The weld overlay shall be deposited with ERNiCrFe-7A (Alloy 52M) filler metal. Credit for the first weld layer may not be taken toward the required thickness unless it has been shown to contain at least 24 percent chromium. This is a sufficient amount of chromium to prevent stress corrosion cracking. Section 2.2 of EPRI Technical Report MRP-115 states the following: "The only well explored effect of the compositional differences among the weld alloys on primary water stress corrosion cracking is the influence of chromium. Buisine, et al. (Reference 12) evaluated the primary water stress corrosion cracking resistance of nickel-based weld metals with various chromium contents ranging from about 15 percent to 30 percent chromium. Testing was performed in doped steam and primary water. Alloy 182, with about 14.5 percent chromium, was the most susceptible. Alloy 82 with 18-20 percent chromium took three or four times longer to crack. For chromium contents between 21 and 22 percent, no stress corrosion crack initiation was observed ... "* |
| Design and Crack Growth Considerations | Design and Crack Growth Considerations |
| The design and flaw characterization provisions of ASME Code Case N-504-4, paragraphs (f) and (g) as supplemented by Appendix Q are summarized below:<br><br>(i) Flaw characterization and evaluation are based on the as- | The design and flaw evaluation provisions in the proposed alternative are the same as ASME Code Case N-504-4 as supplemented in Appendix Q with the exceptions below. The proposed design and flaw evaluation provisions are based on postulated flaws or as-found flaws. |

| ASME Code Case N-504-4 and Appendix Q of ASME Code Section XI | Proposed Alternative of Attachment 1-Code Case N-740-2 |
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| found flaw. Flaw evaluation of the existing flaws is based on IWB-3640 for the design life.<br><br>• Multiple circumferential flaws shall be treated as one flaw of length equal to the sum of the lengths of the individual flaws.<br><br>• Circumferential flaws are postulated as 100 percent through-wall for the entire circumference with one exception. When the combined length of circumferential flaws does not exceed 10 percent of the circumference, the flaws are only assumed to be 100 percent through-wall for the combined length of the flaws.<br><br>• For axial flaws 1.5 inches or longer, or for five or more axial flaws of any length, the flaws shall be assumed to be 100 percent through-wall for the axial length of the flaw and entire circumference of the pipe.<br><br>(ii) For four or fewer axial flaws less than 1.5 inches in length, the weld overlay thickness need only consist of two or more layers of weld metal meeting the deposit analysis requirements.<br><br>(iii) The axial length and end slope of the weld overlay shall cover the weld and HAZs on each side of the weld, and shall provide for load redistribution from the item into the weld overlay and back into the item without violating applicable stress limits of the Construction Code. Any laminar flaws in the weld overlay shall be evaluated in the analysis to ensure that load redistribution complies with the above. These requirements are usually met if the weld overlay extends beyond the projected flaw by at least $0.75(Rt)^{1/2}$.<br><br>(iv) Unless specifically analyzed, the end transition slope of the overlay shall not exceed 45 degrees, and a slope of not more | • For weld overlay crack growth evaluations, a flaw with a depth of 10 percent and a circumference of 360 degrees shall be assumed or the as-found flaw size shall be used. The size of the flaws shall be projected to the end of the design life of the overlay. Crack growth, including both stress corrosion and fatigue crack growth, shall be evaluated in the materials in accordance with IWB-3640. If the flaw is at or near the boundary of two different materials, evaluation of flaw growth in both materials is required.<br><br>*Basis: A preservice volumetric examination shall be performed after application of the weld overlay using an ASME Code Section XI, Appendix VIII (i.e., as implemented through PDI) examination procedure. This examination shall verify that there is no cracking in the upper 25 percent of the original weld and base material for a full structural weld overlay. The preservice examination shall also demonstrate that the assumed through-wall crack depths are conservative. However, if any crack-like flaws are identified in the upper 25 percent of the original weld or base material by the preservice examination, then the as-found flaw (i.e., postulated 75 percent through-wall flaw plus the portion of the flaw in the upper 25 percent) shall be used for the crack growth analysis. With regard to design, flaws are considered to be either 75 percent through-wall for assumed crack depth or 100 percent through the original weld when a flaw is identified by inspection and no structural credit is taken for the weld. All other requirements are equivalent to ASME Code Case N-504-4 as supplemented by Appendix Q.* |

| ASME Code Case N-504-4 and Appendix Q of ASME Code Section XI | Proposed Alternative of Attachment 1-Code Case N-740-2 |
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| than 1:3 is recommended.<br><br>(v) The overlay design thickness of items shall be based on the measured diameter, using only the weld overlay thickness conforming to the deposit analysis requirements. The combined wall thickness at the weld overlay, any planar flaws in the weld overlay, and the effects of any discontinuity (for example, another weld overlay or reinforcement for a branch connection) within a distance of $0.75(Rt)^{1/2}$ from the toes of the weld overlay, shall be evaluated and meet the requirements of IWB-, IWC-or IWD-3640.<br><br>(vi) The effects of any changes in applied loads, as a result of weld shrinkage or existing flaws previously accepted by analytical evaluation shall be evaluated in accordance with IWB-3640, IWC-3640, or IWD-3640, as applicable. | |
| Examination and Inspection | Examination and Inspection |
| Acceptance Examination<br>Q-4100(c) states that the examination volume in Figure Q-4100-1 shall be ultrasonically examined to assure adequate fusion (that is, adequate bond) with the base metal and to detect welding flaws, such as inter-bead lack of fusion, inclusions, or cracks. Planar flaws shall meet the preservice examination standards of Table IWB-3514-2. Laminar flaws shall meet the following: | The acceptance standards in Attachment 1 are identical to those of paragraph Q-4100(c) except that the proposed method includes requirements and clarifications that are not included in Appendix Q. First, it specifies that the ultrasonic examination shall be conducted at least 48 hours after completing the third layer of the weld overlay when ambient temperature temper bead welding is used. Secondly, it provides the following clarifications:<br><br>• The interface C-D between the weld overlay and the weld includes the bond and the HAZ from the weld overlay.<br><br>• In applying the acceptance standards, wall thickness "$t_w$" shall be the thickness of the weld overlay.<br><br>*Basis: Appendix Q is applicable to austenitic stainless steel materials only; therefore, ambient temperature temper bead* |

| ASME Code Case N-504-4 and Appendix Q of ASME Code Section XI | Proposed Alternative of Attachment 1-Code Case N-740-2 |
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| | *welding would not be applicable. It is applicable to welding performed in the proposed alternative. When ambient temperature temper bead welding is performed, nondestructive examinations must be performed at least 48 hours after completing the third layer of the weld overlay to allow sufficient time for hydrogen cracking to occur, if it is to occur. Technical justification for starting the 48 hours after completion of the third layer of the weld overlay is provided in Section 5 of the Request. The other two changes are simply clarifications that were added to ensure that the examination requirements were appropriately performed.* |
| Q-4100(c)(1) states that laminar flaws shall meet the acceptance standards of Table IWB-3514-3. | The acceptance standards of the proposed method are identical to paragraph Q-4100(c)(1) except that the proposal includes the additional limitation that the total laminar flaw shall not exceed 10 percent of the weld surface area and that no linear dimension of the laminar flaw area exceeds 3.0 inches<br><br>*Basis: These changes were made to provide additional conservatism to the weld overlay examination and to reduce the size of the un-inspectable volume beneath a laminar flaw. See Section 5 of this Request for additional information.* |
| Q-4100(c)(4) allows the performance of radiography in accordance with the Construction Code as an alternative to Q-4100(c)(3). | The acceptance standards of the proposed alternative do not include the radiographic alternative of paragraph Q-4100(c)(4).<br><br>*Basis: The ultrasonic examinations performed in accordance with the proposed alternative are in accordance with ASME Code, Section XI, Appendix VIII, Supplement 11 as implemented through the PDI. These examinations are considered more sensitive for detection of defects, either from fabrication or service-induced, than either ASME Code Section III radiographic or ultrasonic methods. Furthermore, construction type flaws have been included in the PDI qualification sample sets for evaluating* |

| ASME Code Case N-504-4 and Appendix Q of ASME Code Section XI | Proposed Alternative of Attachment 1-Code Case N-740-2 |
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| | *procedures and personnel. See Section 5 of this Request for additional justification.* |
| Preservice Inspection | Preservice Inspection |
| Q-4200(b) states that the preservice examination acceptance standards of Table IWB-3514-2 shall be met for the weld overlay. Cracks in the outer 25 percent of the base metal shall meet the design analysis requirements of Q-3000. | The acceptance standards of the proposed alternative are identical to paragraph Q-4200(b) except proposed alternative includes the following statement: "In applying the acceptance standards, wall thickness, shall be the thickness of the weld overlay."<br><br>*Basis: This provision is actually a clarification that the nominal wall thickness of Table IWB-3514-2 shall be considered the thickness of the weld overlay. It must be remembered that the acceptance standards were originally written for the welds identified in IWB-2500. Because IWB-2500 does not address weld overlays, this clarification was provided to avoid any potential confusion. However, defining the weld overlay thickness as the nominal wall thickness of Table IWB-3514-2 has always been the practice since it literally becomes the new design wall of the piping or component nozzle.* |
| Pressure Testing | Pressure Testing |
| (h) The completed repair shall be pressure tested in accordance with IWA-5000. A system hydrostatic test is required if the flaw penetrated the pressure boundary. A system leakage test may be performed if pressure boundary is not penetrated. | The pressure testing requirements included in the alternative are similar to paragraph (h) of ASME Code Case N-504-4 except that only a system leakage test per IWA-5000 is required. |

**List of Regulatory Commitments**

The following table identifies the actions in this document to which the Brunswick Steam Electric Plant (BSEP) has committed. Statements in this submittal, with the exception of those in the table below, are provided for information purposes and are not considered commitments.

Please direct questions regarding these commitments to Mr. Lee Grzeck, Manager – Regulatory Affairs, at (910) 832-2487.

| COMMITMENT DESCRIPTION | ONE-TIME ACTION | CONTINUING COMPLIANCE | SCHEDULED COMPLETION DATE |
|---|---|---|---|
| For the N4A and N4D nozzles, summaries of the results of the analyses of the following will be submitted to the NRC:<br>1. The as-built dimension of the full structural weld overlay (FSWOL) shall be measured and evaluated to demonstrate that they equal or exceed the minimum design dimensions of the overlay design.<br>2. Overall component shrinkage will be measured after the weld overlay application. | ☒ | | Prior to entry into Mode 2 following completion of the FSWOLs. |
| The following information regarding the N4A and N4D nozzles will be submitted to the NRC:<br>1. A listing of indications detected in the overlaid weld.<br>2. The disposition of all indications using the acceptance criteria of ASME Code, Section XI, IWB-3514-2 and/or IWB-3514-3 criteria and, if possible, the type and nature of the indications. | ☒ | | Within 14 days of completion of the final ultrasonic testing examination of the overlaid welds. |

| COMMITMENT DESCRIPTION | ONE-TIME ACTION | CONTINUING COMPLIANCE | SCHEDULED COMPLETION DATE |
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| | | | |
| For the N4A and N4D nozzles, the following items will be performed and submitted to the NRC:<br>1. Nozzle specific stress analyses will be performed to establish a residual stress profile in the N4 nozzle. Inside diameter (ID) weld repairs will be assumed in these analyses to effectively bound any actual weld repairs that may have occurred in the nozzle. The analysis shall 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 ID of the N4 nozzle weld region that reduces the probability for further crack propagation due to stress corrosion cracking (SCC).<br>2. The analyses will demonstrate that the application of the FSWOL satisfies all ASME Code, Section III stress and fatigue criteria.<br>3. Fracture mechanics analyses will be performed to predict crack growth. Crack growth due to SCC and fatigue crack growth in the original dissimilar metal weld (DMW) shall be evaluated. These crack growth analyses will consider all design loads and transients, plus the post weld overlay through-wall residual stress | ☒ | | Submit this analysis within 90 days of completing the BSEP Unit 1 refueling outage B1R22 |

| COMMITMENT DESCRIPTION | ONE-TIME ACTION | CONTINUING COMPLIANCE | SCHEDULED COMPLETION DATE |
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| distributions and will demonstrate that the assumed cracks will not grow beyond the design bases for the weld overlay.<br><br>4. The total added weight on the piping system due to the overlay will be evaluated for the potential impact on reactor pressure vessel nozzle stresses and dynamic characteristics. | | | |