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10 CFR 50.55a

W3F1-2019-0009

January 28, 2019

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

Subject: Proposed Inservice Inspection Program Alternative WF3-RR-19-1 for Application of Dissimilar Metal Weld Full Structural Weld Overlay – Reactor Coolant System Cold Leg Drain Nozzles

Waterford Steam Electric Station, Unit 3
NRC Docket No. 50-382
Renewed Facility Operating License No. NPF-38

In accordance with 10 CFR 50.55a, "Codes and Standards," paragraph (z)(1), Entergy Operations, Inc. (Entergy) hereby requests U.S. Nuclear Regulatory Commission (NRC) approval of the attached proposed alternative for the Fourth Inservice Inspection (ISI) interval of the Waterford Steam Electric Station, Unit 3 (Waterford 3) ISI program.

During the current Waterford 3 Refueling Outage (RF22), flaws were found by ultrasonic testing (UT) examination in the dissimilar metal welds of two of the cold leg drains of the reactor coolant system piping. The cold leg drain nozzle welds containing the flaws are American Society of Mechanical Engineers (ASME) Code, Section III, Class 1 dissimilar metal welds located between the carbon steel reactor coolant system piping nozzle and an austenitic stainless steel safe end. In order to maintain the pressure boundary and structural integrity of the welds, Entergy proposes to perform full structural weld overlays based on ASME Code Case N-740-2.

The proposed alternative, as described in the Enclosure, complies with 10 CFR 50.55a(z)(1) and provides an acceptable level of quality and safety. Entergy requests approval of the proposed alternative no later than January 31, 2019, with the plan to complete the repair prior to entering Mode 5. Entergy will keep the NRC apprised of the RF22 schedule.

Enclosure Attachment 4 summarizes the new regulatory commitments made in this submittal.

If you have any questions or require additional information, please contact the Acting Regulatory Assurance Manager, John V. Signorelli, at (504) 739-6032.

Respectfully,

Mandy K. Halter

MKH/mmz

Enclosure:	10 CFR 50.55a Inservice Inspection (ISI) Program Alternative WF3-RR-19-1, Full Structural Weld Overlay of Cold Leg Drain Nozzle Dissimilar Metal Welds
Attachment 1:	Proposed Alternative for Full Structural Weld Overlay of Reactor Coolant System Drain Nozzle Dissimilar Metal Welds
Attachment 2:	Comparison of ASME Code Case N-504-4 and Appendix Q of ASME Code, Section XI with the Proposed Alternative of Attachment 1 for Full Structural Weld Overlays
Attachment 3:	Reactor Coolant System Cold Leg Drain Nozzle Dissimilar Metal Weld Indication Details
Attachment 4:	List of Regulatory Commitments

cc: NRC Region IV Regional Administrator
NRC Senior Resident Inspector – Waterford Steam Electric Station, Unit 3
NRR Project Manager

ENCLOSURE

W3F1-2019-0009

Entergy Operations, Inc.

10 CFR 50.55a Inservice Inspection (ISI) Program Alternative WF3-RR-19-1

Full Structural Weld Overlay of Cold Leg Drain Nozzle Dissimilar Metal Welds

Attachment 1: Proposed Alternative for Full Structural Weld Overlay of RCS Drain Nozzle Dissimilar Metal Welds

Attachment 2: Comparison of ASME Code Case N-504-4 and Appendix Q of ASME Code, Section XI with the Proposed Alternative of Attachment 1 for Full Structural Weld Overlays

Attachment 3: Reactor Coolant System Cold Leg Drain Nozzle Dissimilar Metal Weld Indication Details

Attachment 4: List of Regulatory Commitments

Entergy Operations, Inc.

10 CFR 50.55a Inservice Inspection (ISI) Program Alternative WF3-RR-19-1

Full Structural Weld Overlay of Cold Leg Drain Nozzle Dissimilar Metal Welds

1. PLANT/UNIT

Waterford Steam Electric Station, Unit 3 (Waterford 3).

2. INTERVAL

Fourth Interval beginning December 1, 2017 and ending November 30, 2027.

3. AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) CODE COMPONENTS AFFECTED

Component	Reactor Coolant System Piping, Cold Leg Drain Nozzle Dissimilar Metal Welds (DMWs)		
Code Class	Class 1		
Examination Category	ASME Code Case N-770-2, Item B		
Weld Number	Description	Size	Materials of Construction
07-009	Loop 1A nozzle to safe end (DMW)	3.875" OD	Carbon Steel Nozzle / Alloy 82-182 Weld / Stainless Steel Safe End
11-007	Loop 2A nozzle to safe end (DMW)	3.875" OD	Carbon Steel Nozzle / Alloy 82-182 Weld / Stainless Steel Safe End

Carbon Steel Nozzle – SA-105 Gr. 2 (P-No. 1)
Stainless Steel Safe End – SA-182 F 316 (P-No. 8)
Alloy 82-182 Weld – ERNiCr 3, Spec. SFA 5.14 / ENiCrFe-3, Spec. SFA 5.11 (F-No. 43)

4. APPLICABLE CODE EDITION AND ADDENDA

American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section XI – 2007 Edition with 2008 Addenda

American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section III, 1971 Edition through Winter 1971 Addenda

American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section III, 1992 Edition

American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section III, 2007 Edition with 2008 Addenda

5. APPLICABLE CODE REQUIREMENTS

IWA-4410 of the ASME Code, Section XI states:
Welding, brazing, defect removal, metal removal by thermal methods, fabrication, and installation performed by a Repair/Replacement Organization shall be performed in accordance with the requirements of this Subarticle. Mechanical metal removal not associated with defect removal is not within the scope of this Subarticle.

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

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

IWA-4520(a) of the ASME Code, Section XI states in part:
Welding or brazing areas and welded joints made for fabrication or installation of items by a Repair/Replacement Organization shall be examined in accordance with Construction Code identified in the Repair/Replacement Plan.

IWA-4611.1(a) of the ASME Code, Section XI states:
Defects shall be removed in accordance with IWA-4422.1. A defect is considered removed when it has been reduced to an acceptable size.

6. REASON FOR PROPOSED ALTERNATIVE

DMWs containing nickel based welding Alloys 82 and 182 have experienced stress corrosion cracking (SCC) in components operating at pressurized water reactor (PWR) and boiling water reactor (BWR) temperatures (References 4, 5, 6, 7, 8, and 9).

Entergy Operations, Inc. (Entergy) proposes, as an emergent repair, to mitigate the SCC susceptibility of the Waterford Steam Electric Station, Unit 3 (Waterford 3) reactor coolant system (RCS) cold leg drain nozzle DMWs between the nozzle and safe end by installing a full structural weld overlay (FSWOL) on the DMWs. This approach provides an alternative to replacement of the weld, 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 Waterford 3 does not contain requirements for weld overlays for DMWs. However, DMW overlays have been applied to other RCS nozzle DMWs in PWRs using alternative requirements. This request proposes to use the methodology of ASME Code Case N-740-2 for application of a FSWOL to the RCS cold leg drain nozzle DMWs at Waterford 3. 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 Entergy proposes to use to design and install a FSWOL on the RCS cold leg drain nozzle DMWs.

Indication Characterization

During the current refueling outage, RF22, the four RCS cold leg drain line nozzle to safe end DMWs were ultrasonically examined in accordance with Code Case N-770-2. Two of the four DMWs were identified as having unacceptable ultrasonic testing (UT) indications. The indications are axially oriented and located within the butt weld and weld butter. The axial indications are inside surface connected and exposed to the reactor coolant. The indications are reported as shown below. See Attachment 3 for additional details.

Weld Number	Indication #	Axial Flaw Depth	Nominal Remaining Ligament	Axial Flaw Length
07-009	1	0.59"	0.49"	0.60"
11-007	2	0.58"	0.59"	0.40"

The Waterford 3 RCS cold leg drain lines operate at 543°F. As such, the DMW butt welds are categorized as Inspection Item B in accordance with Code Case N-770-2. A review of original construction records for DMWs 07-009 and 11-007 indicated that weld repairs were not performed on these welds during original installation. Prior to the current refueling outage, the last UT examination of DMWs 07-009 and 11-007 was performed in November 2012 with manual Phased Array utilizing PDI personnel and procedure qualified to Supplement 10. The demonstration included these tapered configurations.

The characteristics of the flaws identified in DMWs 07-009 and 11-007 are indicative of Primary Water Stress Corrosion Cracking (PWSCC). The following is noted:

- Both indications break the inner surface and are thus exposed to the reactor coolant environment during initiation and propagation;
- Both indications are oriented along the axis of the nozzle (axial);
- Indications are exclusively located within deposited weld material(s) known to be susceptible to PWSCC:
    - Indication #1 in DMW 07-009 is located in the butt weld deposit near the root of the weld and extends into the adjoining edge of the Alloy 182 nozzle butter;
    - Indication #2 in DMW 11-007 is located within the Alloy 182 nozzle butter and partially extends into the adjoining weld;
- Indication geometries are narrow and remain within known susceptible materials ("l/a" ratio for indications #1 and #2 are 1.02 and 0.69, respectively, based on ultrasonic inspection characterization using the flaw characterization definitions given in Nonmandatory Appendix C, Figure C-2200-02 of Reference 1).

The operating experience of PWRs has broadly demonstrated that the nickel based Alloy 82 and Alloy 182 welding filler metals are susceptible to SCC when exposed to the reactor coolant. This susceptibility has been confirmed by laboratory studies; however, the adjacent materials (austenitic stainless steel and carbon steel) exhibit high resistance to SCC in the same environment. Similar laboratory studies indicate a strong susceptibility to PWSCC for Alloy 182

due to its lower chromium content, and to a lesser extent Alloy 82 due to its increased chromium content (Reference 13).

PWSCC flaws propagate in a plane perpendicular to the primary stress, thus axial flaws are driven by the hoop stress. The hoop stresses in a pipe configuration primarily are the result of internal pressure and are superimposed on any short range residual stresses that may be present due to a variety of sources, including welding and thermal. Any stress fluctuation enhances PWSCC crack initiation. Welding residual stresses do not fluctuate during operation, and fluctuations of internal pressure are small during operation; therefore, fatigue from these sources is of low probability. Vibration loads are often associated with fatigue mechanisms; however, in a piping system, vibration loads are primarily axial loads which favor circumferential flaws.

Thermal fatigue of branch lines has been reported in the industry and the Electric Power Research Institute (EPRI) has developed screening tools (References 14 and 15). The subject drain lines are not flagged using the EPRI guidance; however, the downstream elbows on these lines are susceptible to thermal fatigue based on the screening evaluations. The reported instances of thermal fatigue cracking have been circumferential in nature and are characterized with a shallow depth relative to the surface connected length, (i.e., “l/a” ratio much greater than 2) (Reference 16). It is possible for thermal fatigue to result in lower “l/a” ratios, but it is required to have a significantly increased loading at the tip of the crack, and special conditions are necessary for this to happen. The reported indications at the drain line DMWs exhibit very low “l/a” ratios (≤ 1), which is typical of PWSCC and not fatigue. Based upon the characteristics of the reported indications and the operating experience in the industry, a PWSCC flaw mechanism is suggested by the evidence.

7. PROPOSED ALTERNATIVE

Pursuant to 10 CFR 50.55a(z)(1), Entergy proposes an alternative to the ASME Code requirements stated above. The alternative and its proposed use are described in Attachment 1 of this request and involves the installation of a FSWOL that structurally replaces the existing weld and defect. This alternative is based on the methodology contained in ASME Code Case N-740-2 and is implemented using an ambient temperature temper bead welding technique as specified below.

A. The design, fabrication, examination, pressure testing, and inservice inspection of FSWOLs will be performed in accordance with the alternative specified in Attachment 1.

  - When using IWB-3641 and Nonmandatory Appendix C to perform the flaw evaluations required by Attachment 1, the 2013 Edition of ASME Code, Section XI will be used in lieu of the 2007 Edition/2008 Addenda.

B. Ambient temperature temper bead welding will be performed in accordance with Code Case N-638-6, as conditionally approved in RG 1.147, with the following proposed alternatives:

  - Code Case N-638-6, paragraphs 3(c) states that the interpass temperature during welding shall be determined by temperature measurement (e.g., pyrometers, temperature indicating crayons, thermocouples). In monitoring preheat and interpass temperatures during FSWOL welding, Entergy proposes the following alternative:

> "Preheat and interpass temperatures will be measured using a contact pyrometer. In the first three layers, the interpass temperature will be measured every three to five passes. After the first three layers, interpass temperature measurements will be taken every six to ten passes for the subsequent layers. Contact pyrometers will be calibrated in accordance with approved calibration and control program documents."

- Code Case N-638-6, paragraphs 4(a) and 4(a)(4) state that all welds (including repair welds) shall be volumetrically examined in accordance with the requirements and acceptance criteria of the Construction Code or ASME Code, Section III. As a condition to Code Case N-638-6, RG 1.147 also states:

  > "Demonstration for ultrasonic examination of the repaired volume is required using representative sample which contain construction type flaws."

  As an alternative, Entergy proposes to volumetrically examine the FSWOL using the UT method in accordance with the requirements and acceptance criteria of Attachment 1, Section A1.4(a).

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

8. BASIS FOR PROPOSED ALTERNATIVE

Entergy plans to apply an Alloy 52M FSWOL to the Alloy 82/182 DMWs identified in Section 3. The FSWOL will be extended over the adjacent stainless steel similar metal weld as shown in Figure 1, below, to facilitate inservice inspection of the adjacent weld.

Entergy's proposed alternative is based on the methodology of ASME Code Case N-740-2 in lieu of the requirements specified in Section 5 of this request. Code Case N-740-2 has been approved by the ASME Code Committee to specifically allow FSWOLs on nickel-based 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 Waterford 3 are detailed in Attachment 1.

A tabular comparison of the Attachment 1 proposed alternative with Code Case N-504-4 and Appendix Q of ASME Code, Section XI has been performed and is provided in Attachment 2. Note that ASME Code Case N-504-4 has been conditionally approved by the NRC in RG 1.147 with the condition that the provisions of ASME Code, Section XI, Appendix Q be met when using the Code Case.

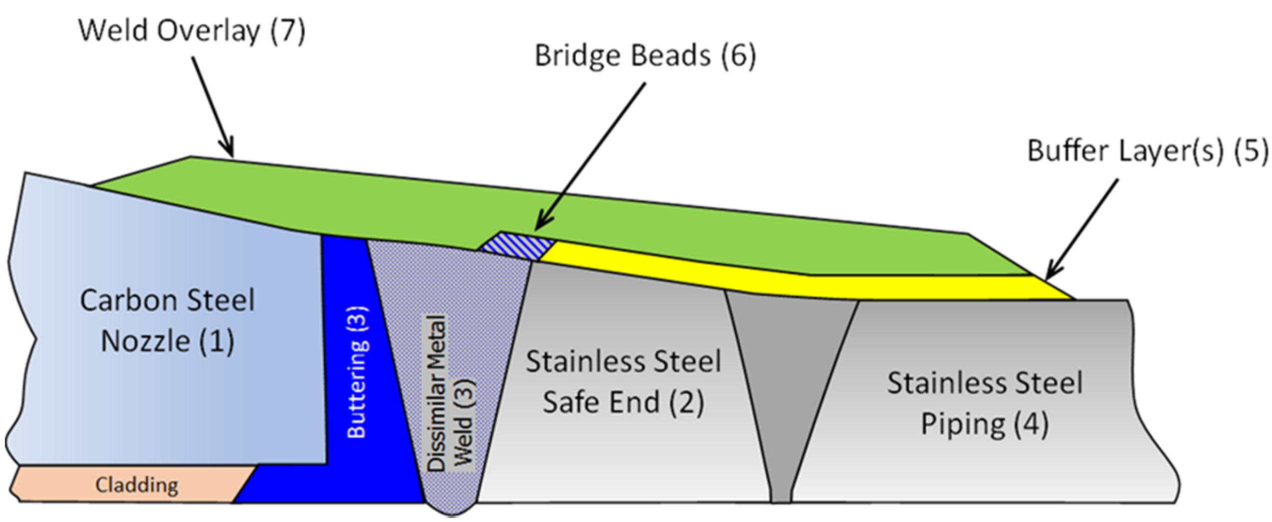
The proposed alternative provides an acceptable methodology for mitigating SCC and for mitigating the defect that was detected in the identified welds to acceptable ASME Code requirements and margins. The use of weld overlay filler metals that are resistant to PWSCC (e.g., Alloy 52/52M), weld overlay procedures that create compressive residual stress profiles within the original weld, and post weld 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 FSWOL in place, will be maintained for the remaining service life of the component.

Schematic Configuration for the FSWOL

A representation of the FSWOL for the cold leg drain nozzles DMW configuration is presented schematically in Figure1 below. Note that the figure is not a design drawing.

Figure 1 Schematic Configuration for the Drain Nozzle with FSWOL



Item	Parts List	Material	ASME IX P-No.
1	Nozzle	SA-105 Gr 2	1
2	Safe End	SA-182 F 316	8
3	DMW and Butter	SFA 5.14 ERNiCr-3 / SFA 5.11 ENiCrFe-3 (Alloy 82/182)	--
4	Drain Piping	SA-376 TP304	8
5	Buffer Layer(s)	SFA 5.9 ER308L or ER309L	--
6	Bridge Beads	SFA 5.14 ERNiCr-3 (Alloy 82)	--
7	Weld Overlay	SFA 5.14 ERNiCr-7a (Alloy 52M)	--

Note: Prior to installation of the FSWOL, minor surface preparation of the carbon steel nozzle, stainless steel safe end, stainless steel piping, and welds will be performed, as appropriate, to facilitate weld overlay welding. Surface preparation requirements of the proposed alternative of Attachment 1, paragraph A1.2.2 will also be met.

As shown in Figure 1, above, the FSWOL will be installed using Alloy 52M filler metal. However, Alloy 52M weld metal has a demonstrated sensitivity to certain impurities, such as sulfur, when deposited onto austenitic stainless steel base materials. To mitigate this condition, Entergy intends to deposit one or more buffer layers of ER308L or ER309L austenitic stainless steel filler metal across the austenitic stainless steel safe end, similar metal weld, and piping prior to installation of the FSWOL. While the balance of these initial layers will be deposited with Alloy 52M weld metal, one or more Alloy 82 bridge beads (or transitional beads) will also be deposited over the fusion line between the existing Alloy 82/182 DMW and stainless steel safe end. The Alloy 82 bridge beads will be deposited with ERNiCr-3 filler metal. The ER308L or ER309L filler metal will have a maximum carbon content of 0.03% and a delta ferrite content of 5 - 15 FN as reported on the CMTR. Buffer layers will be deposited with a welding procedure and welders that have been qualified in accordance with ASME Code, Section IX. Liquid penetrant (PT) examinations will be performed prior to and after deposition of the buffer layers and bridge beads. The second PT examination is performed to ensure that the completed buffer layers and bridge beads are free from cracks and other unacceptable indications prior to deposition of the Alloy 52M weld overlay. Finally, the thickness of the buffer layers and bridge beads will not be structurally credited towards the minimum design thickness of the FSWOL.

<u>Suitability of Proposed Post Overlay Nondestructive Examination (NDE)</u>

As a part of the design of the FSWOL, the FSWOL length, surface finish, and flatness are specified to provide for of the examination volumes specified in Attachment 1, Section A1.4 and allow for post-installation, qualified ASME Code, Section XI, Appendix VIII UT examinations, as implemented through the EPRI PDI Program. The examinations specified in this proposed alternative provide adequate assurance of structural integrity for the following reasons:

- Personnel, procedures, and equipment are qualified to Appendix VIII and Code Case N-653-1. Code Case N-653-1 will be used in lieu of Supplement 11 of Appendix VIII. Code Case N-653-1 specifies performance demonstration and procedure qualification requirements for FSWOLs of austenitic piping welds and complies with the EPRI Performance Demonstration Initiate (PDI) Program. Code Case N-653-1 has been unconditionally approved by the NRC in RG 1.147, Revision 18. 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. Construction flaws are also included in the PDI qualification sample sets utilized for evaluating procedures and personnel. Furthermore, the UT procedure qualified in accordance with these requirements is also demonstrated to ultrasonically examine the FSWOL configuration being designed in accordance with the requirements of Attachment 1.

- ASME Code, Section XI has specific acceptance criteria and evaluation methodology to be utilized with the results from the more sensitive UT examinations. These 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 (Table IWB-3514-2) and for laminar flaws (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, and are supplemented in Attachment 1. These criteria require that the total laminar flaw area shall not exceed 10% of the weld surface area and that no linear dimension of the laminar flaw area shall exceed the greater of 3 in. (76 mm) or 10% of the pipe circumference. For weld overlay areas where examination is precluded by the presence of the flaw, the areas must be postulated to be flawed.

- Any planar flaws found in the FSWOL 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.

- Weld overlays for repair of cracks in piping are not addressed by ASME Code, Section III. ASME Code, Section III utilizes nondestructive examination (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 alternative of Attachment 1 was written to specifically address FSWOLs and specifies examination requirements and acceptance standards appropriate for FSWOLs.

Suitability of Ambient Temperature Temper Bead Techniques

An ambient temperature temper bead welding technique will be used when welding on the ferritic base material of the carbon steel nozzle in lieu of the preheat and PWHT requirements of the Construction Code. Research by EPRI and other organizations on the use of an ambient temperature temper bead process using the machine gas tungsten arc welding (GTAW) process is documented in EPRI Report GC 111050 (Reference 17). According to the EPRI report, repair welds performed with an ambient temperature temper bead procedure utilizing the machine GTAW process exhibit mechanical properties equivalent to or better than those of the surrounding base material. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this process.

The ambient temperature temper bead technique of Code Case N-638-6 will be used. Code Case N-638-6 was conditionally approved by the NRC in Regulatory Guide 1.147, Revision 18. The suitability of the proposed alternatives to Code Case N-638-6 is provided below.

- Code Case N-638-6, paragraph 3(c) states that the interpass temperature during welding shall be determined by direct measurement (e.g., pyrometers, temperature indicating crayons, thermocouples). In monitoring preheat and interpass temperatures during FSWOL welding, Entergy has proposed the following:

  "Preheat and interpass temperatures will be measured using a contact pyrometer. In the first three layers, the interpass temperature will be measured every three to five passes. After the first three layers, interpass temperature measurements will be

taken every six to ten passes for the subsequent layers. Contact pyrometers will be calibrated in accordance with approved calibration and control program documents."

The proposed preheat and interpass temperature controls are based on field experience with depositing FSWOLs and have been successfully used throughout the industry. Interpass temperatures beyond the third layer have no impact on the metallurgical properties of the ferritic steel heat affected zone.

- Code Case N-638-6, paragraphs 4(a) and 4(a)(4) state that all welds (including repair welds) shall be volumetrically examined in accordance with the requirements and acceptance criteria of the Construction Code or ASME Code, Section III. As an alternative, Entergy proposes to volumetrically examine the FSWOL using the UT method in accordance with the requirements and acceptance criteria specified in the proposed alternative of Attachment 1, Section A1.4(a). Based on Code Case N-740-2, the UT examination requirements and acceptance standards in Attachment 1, Section A1.4(a) were developed specifically for FSWOLs unlike those in Code Case N-638-6. According to Attachment 1, UT examination procedures and personnel shall be qualified in accordance with Code Case N-653-1. Code Case N-653-1 specially addresses qualification requirements for FSWOLs. When UT examinations are performed in accordance with Code Case N-653-1 (as implemented through EPRI PDI Program), the examinations are considered more sensitive for detecting fabrication and service-induced flaws than traditional radiographic and ultrasonic examination methods. Furthermore, construction-type flaws have been included in the PDI qualification sample sets for evaluating procedures and personnel. Attachment 1, Section A1.4(a) also establishes UT acceptance standards for FSWOL examinations. Similar to NB-5330, the UT examination must assure adequate fusion with the base material and detect welding flaws such as interbead lack of fusion, inclusions, and cracks. Detected planar and laminar flaws are required to meet the acceptance standards of Tables IWB-3514-2 and 3, respectively. Section A1.4(a) of Attachment 1 also limits the reduction in coverage due to a laminar flaw to less than 10% while uninspectable volumes are assumed to contain the largest radial planar flaw that could exist within the volume.

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 each of the nozzles. In addition, the effects of any changes in applied loads, as a result of weld shrinkage from the weld 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.

3) Nozzle specific stress analyses will be performed of each FSWOL to establish a residual stress profile in the DMW. A 50% inside diameter (ID) weld repairs will be assumed in these analyses to effectively bound any actual weld repairs that may have occurred in the DMWs, although plant records indicate that no repairs were performed. 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 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 for the regions of the overlay remote from observed, or assumed, flaws.

5) Fracture mechanics analyses will be performed to predict crack growth. Crack growth due to SCC and fatigue 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 RCS nozzle stresses and dynamic characteristics.

Use of 2013 Edition of IWB-3641 and Nonmandatory Appendix C

The ASME Section XI Code of Record for Waterford 3 is the 2007 Edition/2008 Addenda. However, requirements in 2007 Edition/2008 Addenda of IWB-3641 and Nonmandatory Appendix C applicable to evaluation of flaws in piping only apply to piping "NPS 4 (DN100) or greater." Since the reactor coolant pump drain nozzle welds and piping are less than NPS 4, these ASME Code, Section XI requirements cannot be used. In the 2013 Edition of ASME Code, Section XI, IWB-3641 and Nonmandatory Appendix C were revised to make them applicable to piping "NPS 1 (DN 25) and greater." Furthermore, the NRC has approved the 2013 Edition of ASME Code, Section XI in 10 CFR 50.55a with no conditions on either IWB-3641 or Nonmandatory Appendix C. Therefore, Entergy requests approval to use IWB-3641 and Nonmandatory Appendix C in the 2013 Edition of ASME Code, Section XI when performing FSWOL design in accordance with Attachment 1, Section A1.3. When using these provisions from the 2013 Edition, Entergy will comply with all related requirements as stipulated in 10 CFR 50.55a(g)(4)(iv).

NRC Submittals

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 repairs.

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.

Nozzle specific stress analyses will be performed for each FSWOL to establish a residual stress profile in the DMW. This information will be submitted to the NRC within 120 days of the completion of the Waterford 3 refueling outage RF22.

9. CONCLUSIONS

Implementation of the FSWOL alternative described herein produces effective repair 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 ASME Code Case N-653-1. 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 drain 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).

10. DURATION OF PROPOSED ALTERNATIVE

The provisions of this alternative are applicable to the Fourth 10-year ISI interval for Waterford 3 which commenced on December 1, 2017 and will end on November 30, 2027.

The FSWOLs for the subject drain nozzles, installed in accordance with the provisions of this alternative, will remain in place for the design life of the repair.

11. PRECEDENTS

1. Brunswick Steam Electric Plant, Unit 1 - Relief Request ISI-10 Regarding Alternative Repair of Feedwater Nozzle Dissimilar Metal Welds (EPID L-2018-LLR-0030), Dated August 9, 2018 (ADAMS Accession No. ML18197A430).

2. Waterford Steam Electric Station, Unit 3 – Request for Alternative W3-R&R-006 – Proposed Alternative to ASME Code Requirements for Weld Overlay (TAC No. MD5388), dated April 21, 2008 (ADAMS Accession No. ML080950273).

3. James A. Fitzpatrick Nuclear Power Plant – Alternative to ASME Code Requirements for Weld Overlay Repair (CAC No. MF9128), dated April 12, 2017 (ADAMS Accession No. ML17090A168).

4. James A. Fitzpatrick Nuclear Power Plant – Request for Alternative JAF RR-7, Rev. 1 to Install a Weld Overlay on N2C Nozzle to Recirculation Inlet Piping Safe-End Dissimilar Metal Weld (TAC No. MD9780), dated April 1, 2009 (ADAMS Accession No. ML090710008).

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ENCLOSURE, ATTACHMENT 1

W3F1-2019-0009

Proposed Alternative for Full Structural Weld Overlay of Reactor Coolant System Drain Nozzle Dissimilar Metal Welds

Attachment 1
Proposed Alternative for Full Structural Weld Overlay of Reactor Coolant System Drain Nozzle Dissimilar Metal Welds

A1.1 INTRODUCTION

Entergy proposes the following detailed requirements for the design, analysis, fabrication, examination, and pressure testing of the Waterford 3 reactor coolant system cold leg drain nozzle dissimilar metal weld (DMW) 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-based 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 (weld overlay) on the outside surface of the nozzle, safe end, piping and associated similar and DMWs, 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 overlays can be either a 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 examinations 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 UNS N06600, W86182, or austenitic stainless steels and associated welds in boiling water reactor environments.

A1.2.2 General Overlay Requirements

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

(1) P-No. 8 or P-No. 43 and P Nos. 1
(2) P-No. 8 and P-No. 43

(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 may be extended to include overlaying the adjacent weld.

(c) Weld overlay filler metal will be an austenitic nickel-based alloy (28 percent chromium minimum, ERNiCrFe-7/7A) meeting the requirements of A1.2.2(e)(1), 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. As an alternative to the postweld heat treatment (PWHT) requirements of the Construction Code and Owner's Requirements, the provisions of Code Case N-638-6 or an approved alternative may be used for ambient temperature temper bead welding.

(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 (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 an 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 (1.5 millimeters) prior to application of the structural layers of the weld overlay.

(3) To reduce the potential of hot cracking when applying an austenitic nickel-based alloy over P-No. 8 base metal, a layer or multiple layers of austenitic stainless steel filler material (e.g., ER308L or ER309L) will be applied over the austenitic stainless steel base metal and similar metal weld. 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. In addition, Alloy 82 bridge beads (or transitional beads) will also be deposited over the fusion line between the existing Alloy 82/182 weld and the stainless steel safe end. The Alloy 82 bridge beads will be deposited with ERNiCr-3 filler metal. The thickness of these buffer layers will not be used in meeting weld reinforcement design thickness requirements.

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

(1) 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. Alternatively, 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 contains at least 24 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 Welding Procedure Specification (WPS) for the production weld.

(f) This case is only for welding in applications predicted not to have exceeded thermal neutron (E < 0.5 eV) fluence of 1×10^{17} neutrons per cm^2 prior to welding. (Entergy confirms that the thermal neutron fluence at RCS drain nozzle DMWs 07-009 and 11-007 is less than the threshold specified as it is remote from the vessel.)

(g) A new weld overlay shall not be 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 original weld or 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 a postulated flaw, as described below. If the flaw is at or near the boundary of two different materials, 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) For postulated flaws, the axial flaw length will be 1.5 inches (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).

(3) If an ASME Code, 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.

(4) 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 A1.3(a)(1) or (2), above, shall be 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 by the qualified ultrasonic examination procedure.

(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 or NB-3600. 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 axial flaw with length of 1.5 inches (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 (e.g., another weld overlay or reinforcement for a branch connection) 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 weld 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. Existing flaws previously accepted by analytical evaluation shall be evaluated in accordance with IWB-3640, IWC-3640, or IWD-3640, as applicable.

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. 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 ASME Code Case N-653-1. 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 (6.3 micrometer) RMS or better and contour that permits ultrasonic examination in accordance with procedures qualified in accordance with ASME Code Case N-653-1. The weld overlay will be examined to verify acceptable configuration.

(2) The weld overlay and the adjacent base material for at least 1/2 inch (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:

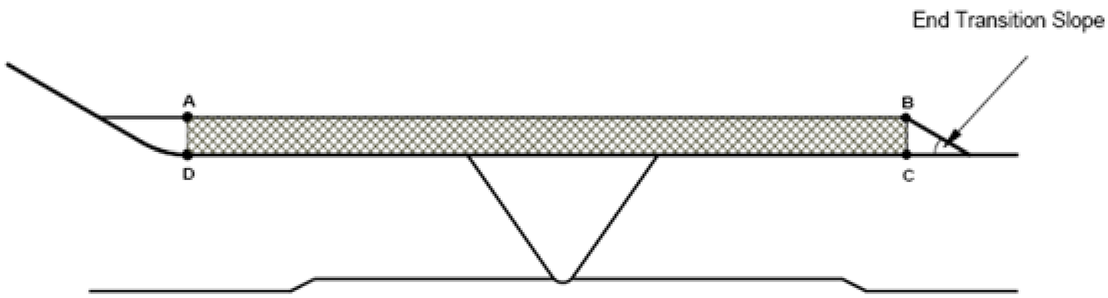
(a) The acceptance standards of IWB-3514 will be met, with the additional limitation that the total laminar flaw area will not exceed 10 percent of the weld surface area and that no linear dimension of the laminar flaw area shall exceed the greater of 3 inches (76 millimeters) or 10 percent of the pipe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

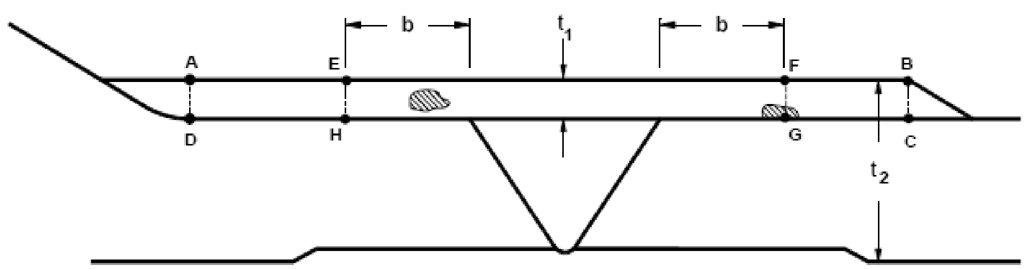
(c) Any uninspectable volume in the weld overlay will be assumed to contain the largest radial planar flaw that could exist within that volume. This assumed flaw will meet the preservice examination acceptance standards of IWB-3514, with nominal wall thickness as defined above for planar flaws. Alternatively,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

Preservice examination will be performed in accordance with Code Case N-770-2 as endorsed by the NRC in 10 CFR 50.55a.

(c) Inservice Inspection

Inservice examinations will be performed in accordance with Code Case N-770-2 as endorsed by the NRC in 10 CFR 50.55a. If a later revision of Code Case N-770 becomes mandatory in 10 CFR 50.55a, then the later revision along with any NRC conditions and limitations shall be used at the time of the examination. Flaws identified in the examination volume of the adjacent stainless steel weld (only) may be accepted in accordance with the acceptance standards of IWB-3500.

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.

ENCLOSURE, ATTACHMENT 2

W3F1-2019-0009

Comparison of ASME Code Case N-504-4 and Appendix Q of ASME Code, Section XI with the Proposed Alternative of Attachment 1 for Full Structural Weld Overlays

Attachment 2
Comparison of Code Case N-504-4 and Appendix Q of ASME Code, Section XI with the Proposed Alternative of Attachment 1 for Full Structural Weld Overlays

Code Case N-504-4 and Appendix Q of ASME Code Section XI	Proposed Alternative of Attachment 1 (Based on Methodology of Code Case N-740-2)
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 18, 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 A1.2,2(a) and (b), the proposed alternative is applicable to dissimilar metal Alloy 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. ***Basis***: *Code Case N-504-4 and Appendix Q are applicable to austenitic weld overlays of P-No. 8 austenitic stainless steel materials. Based on 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.*

Code Case N-504-4 and Appendix Q of ASME Code Section XI	**Proposed Alternative of Attachment 1 (Based on Methodology of Code Case N-740-2)**
According to paragraph (b) of ASME Code Case N-504-4 as supplemented by Appendix Q, weld overlay filler metal shall be 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.	The weld filler metal and procedure requirements of paragraph A1.2.2(c) are equivalent to Code Case N-504-4 and Appendix Q except as noted below: • Weld overlay filler metal shall be austenitic nickel based 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. As an alternative to post-weld heat treatment, the provisions for "Ambient Temperature Temper Bead Welding" technique may be used on the ferritic nozzle. ***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 Alloy 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.*

Code Case N-504-4 and Appendix Q of ASME Code Section XI	**Proposed Alternative of Attachment 1 (Based on Methodology of Code Case N-740-2)**
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 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.	The weld overlay described in Attachment 1 is deposited using nickel based 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 based alloy filler metal. According to paragraph A1.2.2(e), the first layer of nickel based 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 24 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. ***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 (Reference 4) 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. 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..."*

Code Case N-504-4 and Appendix Q of ASME Code Section XI	Proposed Alternative of Attachment 1 (Based on Methodology of Code Case N-740-2)
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: (i) Flaw characterization and evaluation are based on the as-found flaw. Flaw evaluation of the existing flaws is based on IWB-3640 for the design life. [Ref: Q-3000(a)] • Multiple circumferential flaws shall be treated as one flaw of length equal to the sum of the lengths of the individual flaws characterized in accordance with IWA-3000. • 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. • 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. (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. (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 design and flaw evaluation provisions in the proposed alternative are similar to those in 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. • 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. ***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*

Code Case N-504-4 and Appendix Q of ASME Code Section XI	Proposed Alternative of Attachment 1 (Based on Methodology of Code Case N-740-2)
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 $0.75(Rt)^{1/2}$. (iv) Unless specifically analyzed, the end transition slope of the overlay shall not exceed 45 degrees, and a slope of not more than 1:3 is recommended. (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 $2.5(Rt)^{1/2}$ from the toes of the weld overlay, shall be evaluated and meet the requirements of IWB-, IWC-, or IWD-3640. (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.	*requirements are equivalent to ASME Code Case N-504-4 as supplemented by Appendix Q.*

Code Case N-504-4 and Appendix Q of ASME Code Section XI	**Proposed Alternative of Attachment 1 (Based on Methodology of Code Case N-740-2)**
Examination and Inspection	**Examination and Inspection**
Acceptance Examination 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.	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: ***Basis:*** *Appendix Q is applicable to austenitic stainless steel materials only; therefore, ambient temperature temper bead 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.*
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. ***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.*

Code Case N-504-4 and Appendix Q of ASME Code Section XI	Proposed Alternative of Attachment 1 (Based on Methodology of Code Case N-740-2)
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). ***Basis**: The ultrasonic examinations performed in accordance with the proposed alternative are in accordance with Code Case N-653-1. 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 procedures and personnel.*
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.	Preservice inspections under the proposed alternative are performed in accordance with Code Case N-770-2. According to Table 1, Note 9 of Code Case N-770-2, the preservice examination acceptance standards of IWB-3514 shall be met for flaws in the weld overlay material. Planar flaws in the outer 25 percent of the original weld and base material shall meet the design analysis requirements of -3132.3(d) of N-770-2. ***Basis**: The preservice inspection criteria of Code Case N-770-2 (Table 1, Inspection Item F-1) was specifically developed for cracked butt welds reinforced by FSWOL of nickel based Alloy 52/52M material. The NRC has mandated use of Code Case N-770-2, including its preservice inspection requirements applicable to FSWOLs, in 10 CFR 50.55a These requirements are similar to those in Q-4200 of Appendix Q.*

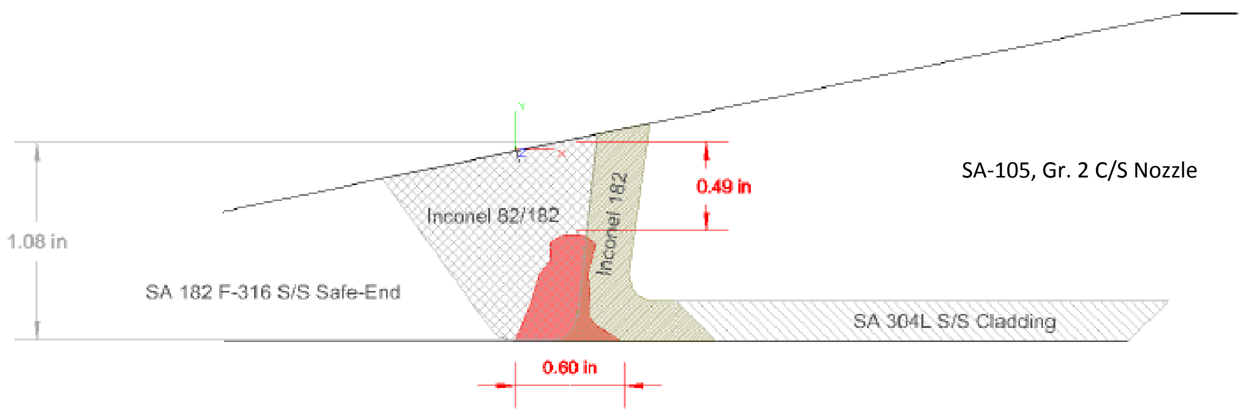
Code Case N-504-4 and Appendix Q of ASME Code Section XI	Proposed Alternative of Attachment 1 (Based on Methodology of Code Case N-740-2)
Pressure Testing	**Pressure Testing**
Q-4400 states that pressure testing is to be performed in accordance with IWA-4540. Weld overlay of a through-wall flaw shall be considered a welding activity that penetrates the pressure boundary. In other words, if a weld overlay is installed over a crack that does not penetrate the full thickness of the pressure boundary, then pressure testing is not required.	According to the proposed alternative, a system leakage test must be performed in accordance with IWA-5000. ***Basis***: Pressure testing requirements of the proposed alternative are more stringent than Q-4400. While a system leakage test under Q-4400 is only required when a weld overlay is installed over a through-weld (wall) flaw, a system leakage test is required for all weld overlays installed under the proposed alternative.

ENCLOSURE, ATTACHMENT 3

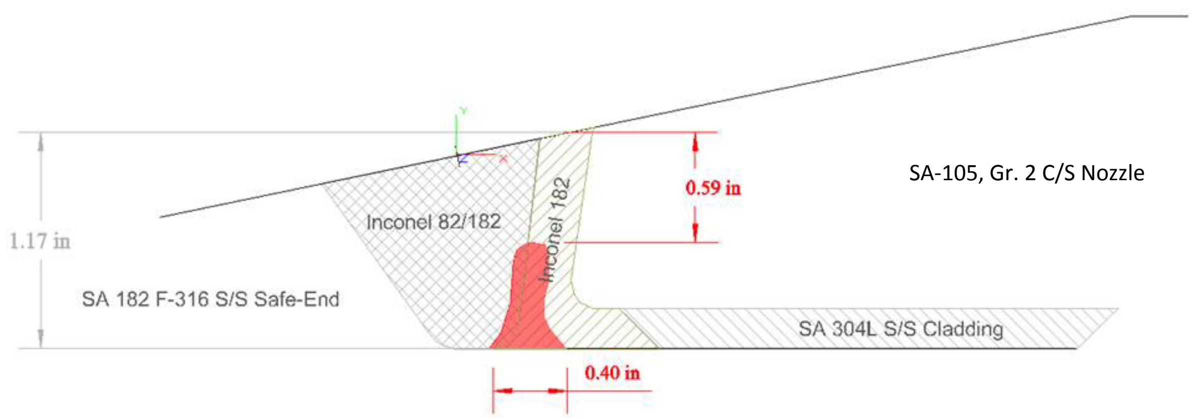
W3F1-2019-0009

Reactor Coolant System Cold Leg Drain Nozzle Dissimilar Metal Weld Indication Details

UT Indication in Drain Nozzle to Safe-End Butt Weld 07-009



UT Indication in Drain Nozzle to Safe-End Butt Weld 11-007



ENCLOSURE, ATTACHMENT 4

W3F1-2019-0009

List of Regulatory Commitments

Attachment 4
List of Regulatory Commitments

This table identifies actions discussed in this submittal for which Entergy commits to perform. Any other actions discussed in this submittal are described for the NRC's information and are not commitments.

<table>
<tr><th rowspan="2">COMMITMENT</th><th colspan="2">TYPE
(Check one)</th><th rowspan="2">SCHEDULED COMPLETION DATE
(If Required)</th></tr>
<tr><th>ONE-TIME ACTION</th><th>CONTINUING COMPLIANCE</th></tr>
<tr><td>The following information will be submitted to the NRC:

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

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.</td><td>X</td><td></td><td>Within 14 days of completion of the final ultrasonic testing examination of the overlaid welds.</td></tr>
<tr><td>For each nozzle with a Full Structural Weld Overlay (FSWOL) installed, the following items will be performed and submitted to the NRC:

1. Nozzle specific stress analyses will be performed to establish a residual stress profile in the Dissimilar Metal Weld (DMW). Inside diameter (ID) weld repairs will be assumed in these analyses to effectively bound any actual weld repairs that may have occurred in the DMW. 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 drain nozzle weld region that reduces the probability for further crack propagation due to stress corrosion cracking (SCC).</td><td>X</td><td></td><td>Submit a summary report within 120 days of completing the Waterford 3 refueling outage RF22, or outage in which the FSWOL is installed.</td></tr>
</table>

2. The analyses will demonstrate that the application of the FSWOL satisfies all ASME Code, Section III stress and fatigue criteria for the regions of the overlays remote from observed, or assumed, cracks. 3. Fracture mechanics analyses will be performed to predict crack growth. Crack growth due to SCC and fatigue in the original DMW shall be evaluated. These crack growth analyses will consider all design loads and transients, plus the post weld overlay through-wall residual stress distributions, and will demonstrate that the assumed cracks will not grow beyond the design bases for the weld overlay. 4. The total added weight on the piping system due to the overlay will be evaluated for the potential impact on nozzle stresses and dynamic characteristics.			