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

August 27, 2019

Site Vice President
Entergy Operations, Inc.
Waterford Steam Electric Station, Unit 3
17265 River Road
Killona, LA 70057-3093

SUBJECT: WATERFORD STEAM ELECTRIC STATION, UNIT 3 – AUTHORIZATION OF PROPOSED ALTERNATIVE TO ASME CODE, SECTION XI, IWA-4000, "REPAIR/REPLACEMENT ACTIVITIES" (EPID L-2019-LLR-0003)

Dear Sir or Madam:

By letter dated January 28, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19028A436), as supplemented by letter dated February 4, 2019 (ADAMS Accession No. ML19035A658), Entergy Operations, Inc. (Entergy, licensee) requested relief from certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, IWA-4000, "Repair/Replacement Activities," at Waterford Steam Electric Station Unit 3 (Waterford 3).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(1), Entergy submitted Alternative WF3-RR-19-1 proposing an alternate repair of two degraded welds in the cold leg drain lines of the reactor coolant system on the basis that the alternate repair provides an acceptable level of quality and safety.

On February 6, 2019 (ADAMS Accession No. ML19042A298), the U.S. Nuclear Regulatory Commission (NRC) verbally authorized the use of inservice inspection (ISI) program Alternative WF3-RR-19-1, for Waterford 3, for the fourth ISI interval. The NRC staff concluded that the alternate repair of using weld overlay provides acceptable structural integrity. The NRC staff further concluded that the weld overlay may remain in place for the design life of the repair. The NRC staff determined that the proposed alternative is technically justified and provides reasonable assurance of structural integrity of the affected welds. This safety evaluation documents the technical basis for the NRC's verbal authorization.

As set forth in the enclosed safety evaluation, the NRC staff concludes that the proposed alternative provides reasonable assurance of structural integrity of the subject dissimilar metal welds. As such, the NRC staff finds that the alternate repair provides an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC authorizes the use of Alternative WF3-RR-19-1, dated January 28, 2019, as supplemented by letter dated February 4, 2019, at Waterford 3 for fourth 10-year ISI interval, which commenced on December 1, 2017, and will end on November 30, 2027. The NRC staff further concludes that full structural weld overlays 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.

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

If you have any questions, please contact the project manager, April Pulvirenti at 301-415-1390 or via e-mail at April.Pulvirenti@nrc.gov.

Sincerely,

/RA/

Robert J. Pascarelli, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-382

Enclosure:
Safety Evaluation

cc: Listserv

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

SAFETY EVALUATION BY THE OFFICE NUCLEAR REACTOR REGULATION

REQUEST FOR ALTERNATIVE WF3-RR-19-1

WATERFORD STEAM ELECTRIC STATION, UNIT 3

ENTERGY OPERATIONS, INC.

DOCKET NO. 50-382

1.0 INTRODUCTION

By letter dated January 28, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19028A436), as supplemented by letter dated February 4, 2019 (ADAMS Accession No. ML19035A658), Entergy Operations, Inc. (Entergy, the licensee) requested relief from certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, IWA-4000, "Repair/Replacement Activities," at Waterford Steam Electric Station, Unit 3 (Waterford 3).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(1), "Acceptable level of quality and safety," the licensee submitted Alternative WF3-RR-19-1 proposing an alternate repair of two degraded welds in the cold leg drain lines of the reactor coolant system (RCS) on the basis that the alternate repair provides an acceptable level of quality and safety.

On February 6, 2019 (ADAMS Accession No. ML19042A298), the U.S. Nuclear Regulatory Commission (NRC) verbally authorized the use of inservice inspection (ISI) program Alternative WF3-RR-19-1, for Waterford 3, for the fourth ISI interval, which ends on November 30, 2027. The NRC staff concluded that the alternate repair of using weld overlay provides acceptable structural integrity. The NRC staff further concluded that the weld overlay may remain in place for the design life of the repair. The NRC staff determined that the proposed alternative is technically justified and provides reasonable assurance of structural integrity of the affected welds. This safety evaluation documents the technical basis for the NRC's verbal authorization.

2.0 REGULATORY EVALUATION

Adherence to Section XI of the ASME Code is mandated by 10 CFR 50.55a(g)(4), "Inservice inspection standards requirement for operating plants," which states, in part,

> Throughout the service life of a boiling or pressurized water-cooled nuclear power facility, components (including supports) that are classified as ASME Code Class 1, Class 2, and Class 3 must meet the requirements, except design and

> access provisions and preservice examination requirements, set forth in Section XI of editions and addenda of the ASME BPV Code….

Paragraph 50.55a(z), "Alternatives to codes and standards requirements," of 10 CFR states, in part:

> Alternatives to the requirements of paragraphs (b) through (h) of [10 CFR 50.55a] or portions thereof may be used when authorized by the Director, Office of Nuclear Reactor Regulation…. A proposed alternative must be submitted and authorized prior to implementation. The applicant or licensee must demonstrate that:
>
> (1) The proposed alternative would provide an acceptable level of quality and safety;

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

3.0 TECHNICAL EVALUATION

3.1 Licensee's Proposed Alternative

ASME Code Components Affected

The affected components are two ASME Code Class 1 dissimilar metal welds (DMWs) (i.e., Weld Nos. 07-009 and 11-007). The welds are in the drain line of cold leg Loop 1A and Loop 2A of the RCS piping. Each weld joins the nozzle at the cold leg pipe and the safe end. The outer diameter of the pipe is 3.875 inches.

The weld filler metal is nickel-based Alloy 82/182 with a specification of ERNiCr 3, Spec. SFA 5.14/ENiCrFe-3, Spec. SFA 5.11 (F-No. 43 material). The nozzle at cold leg piping is fabricated with carbon steel, SA-105 Grade 2 (P-No. 1 material). The safe end is fabricated with stainless steel, SA-182 F 316 (P-No. 8 material). The drain pipe is made of stainless steel, SA-376 TP 304.

The Alloy 82/182 weld is examined in accordance with Examination Category B of ASME Code Case N-770-2, "Alternative Examination Requirements and Acceptance Standards for Class 1 PWR [Pressurized-Water Reactor] Piping and Vessel Nozzle Butt Welds Fabricated With UNS N06082 or UNS W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities Section XI, Division 1."

Applicable Code Edition and Addenda

ASME Code, Section XI, 2007 Edition with 2008 Addenda
ASME Code, Section III, 1971 Edition through Winter 1971 Addenda
ASME Code, Section III, 1992 Edition
ASME Code, Section III, 2007 Edition with 2008 Addenda

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 the 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."

Reason for Request

In lieu of repairing or replacing the subject welds in accordance with the ASME Code, Section XI, the licensee proposed to install a full structural weld overlay (FSWOL) on the affected welds based on the methodology contained in ASME Code Case N-740-2, "Full Structural Dissimilar Metal Weld Overlay for Repair or Mitigation of Class 1, 2, and 3 Items Section XI, Division 1," and an ambient temperature temper bead welding technique. The proposed alternative will be performed, as stated in part, in the licensee's letter dated February 4, 2019:

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

   - When using the [ASME Code, Section XI] 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 ["Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique Section XI, Division 1"], as conditionally approved in RG [Regulatory Guide] 1.147 [Revision 18, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," (ADAMS Accession No. ML16321A336)], with the following proposed alternative:

- 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 samples which contain construction type flaws.

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

Proposed Alternative and Basis for Use

The licensee stated that it plans to apply an Alloy 52M FSWOL to the subject Alloy 82/182 DMWs. The FSWOL will be extended over the adjacent stainless steel similar metal weld to facilitate ISI of the adjacent weld.

The licensee stated that the proposed alternative is based on the methodology of ASME Code Case N-740-2, which 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 been endorsed 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 design requirements in Code Case N-740-2 that are applicable to Waterford 3, are detailed in Attachment 1 of the licensee's submittal.

The licensee compared the proposed alternative to ASME Code Case N-504-4, "Alternative Rules for Repair of Class 1, ,2 and 3 Austenitic Stainless Steel Piping, Section XI, Division 1," and the ASME Code, Section XI, Appendix Q, as shown in Attachment 2 of the relief request dated February 4, 2019. NRC has approved Code Case N-504-4 in RG 1.147 with the condition that the provisions of ASME Code, Section XI, Appendix Q, be met when using N-504-4.

In its letter dated February 4, 2019, the licensee stated, in part, that "The use of weld overlay filler metals that are resistant to PWSCC [pressurized water stress corrosion cracking] (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." The licensee further stated, in part, that it will perform crack growth evaluations for stress corrosion cracking (SCC) and fatigue of a bounding postulated flaw to demonstrate that structural integrity of the overlaid welds will be maintained for the remaining service life of the subject welds.

Schematic Configuration for the FSWOL

The licensee presented a representative drawing of the FSWOL for the cold leg drain nozzles DMW configuration in Figure 1, "Schematic Configuration for the Drain Nozzle with FSWOL," of its submittals. The FSWOL will be installed using Alloy 52M filler metal.

In its letter dated February 4, 2019, the licensee stated, in part, that:

> …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 [ferrite number] as reported on the CMTR [certified mill test report]. 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.

Suitability of Proposed Post Overlay Nondestructive Examination (NDE)

In its letter dated February 4, 2019, the licensee stated, in part, that:

> …the FSWOL length, surface finish, and flatness are specified to provide for 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 [Electric Power Research Institute] PDI [Performance Demonstration Initiative] 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 [“Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds Section XI, Division 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 [of the ASME Code, Section XI]) and for laminar flaws (Table IWB-3514-3 [of the ASME Code, Section XI]).

- 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 [ASME Code] 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. [inches] (76 mm [millimeter] or 10% of the pipe circumference. The proposed alternative requires that 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 the ASME Code, Section XI, Table IWB-3514-2.

- Weld overlays for repair of cracks in piping are not addressed by the 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 the 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

In its letter dated February 4, 2019, the licensee stated, in part, that:

> 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 [post weld heat treatment] 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 [(Ambient Temperature Preheat for Machine GTAW Temperbead Applications)]. 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, 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 the 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 [“Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds, Section XI, Division 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 [the ASME Code, Section III] 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.

Preservice/Inservice Inspection Requirements of Weld Overlay

In its letter dated February 4, 2019, the licensee stated, in part, that:

> Entergy intends to install [an] FSWOL in accordance with the design, fabrication, examination, and pressure testing requirements specified in the proposed alternative provided in Attachment 1; however, preservice/inservice examination of the completed FSWOL will comply with the following requirements:
>
> - Preservice/inservice inspection of the weld overlay volume associated with the Alloy 82/182 dissimilar metal weld will be performed in accordance with Code Case N-770-2 ["Alternative Examination Requirements and Acceptance Standards for Class 1 PWR Piping and Vessel Nozzle Butt Welds Fabricated With UNS N06082 or UNS W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities Section XI, Division 1"], as stipulated by the NRC in 10 CFR 50.55a(g)(6)(ii)(F).
>
> - Preservice/inservice inspection of the weld overlay volume associated with the adjacent austenitic stainless steel weld will be performed in accordance with Nonmandatory Appendix Q, Sections Q-4200 and Q-4300 of the ASME Code, Section XI. Nonmandatory Appendix Q applies specifically to weld overlays of austenitic stainless steel welds. The 2007 Edition/2008 Addenda of Nonmandatory Appendix Q has been approved by the NRC in 10 CFR 50.55a.

Analyses and Verifications

In its letter dated February 4, 2019, the licensee stated that:

> The following list of analyses and verifications will be performed subject to the specific design, analysis, and inspection requirements that are 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.

In its letter dated February 4, 2019, the licensee stated, in part, that 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 [nominal pipe size] 4 (DN100) or greater.'" The licensee indicated that because the subject DMWs are located on pipes that are less than NPS 4, the requirements in the 2007 Edition through 2008 Addenda of the ASME Code, Section XI, cannot be used. The licensee explained that IWB-3641 and Nonmandatory Appendix C in the 2013 Edition of ASME Code, Section XI, were revised to make them applicable to piping "NPS 1 (DN 25) and greater." The licensee further stated that "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, as part of the proposed alternative, Entergy requested NRC to approve the 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, of the relief request. The licensee also stated that 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)."

Post-Installation Submittals

The licensee stated that it will submit the following information to the NRC within 14 days of completion of the final UT examination of the overlaid DMWs: (1) A listing of indications detected in the overlaid DMWs; and (2) The disposition of all indications using the acceptance criteria of ASME Code, Section XI, IWB-3514-2 and/or IWB-3514-3 criteria. The licensee indicated that 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.

The licensee also stated that it will perform nozzle-specific stress analyses for each FSWOL to establish a residual stress profile in the DMWs. The licensee further stated that it will submit this information to the NRC within 120 days of the completion of Refueling Outage 22.

Duration of the Proposed Alternative

The licensee requested to apply the alternative to the fourth 10-year ISI interval, which commenced on December 1, 2017 and will end on November 30, 2027. The licensee proposed that 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.

3.2 NRC Staff Evaluation

As stated above, Entergy proposed to install the FSWOL on the subject DMWs based on the provisions of ASME Code Case N-740-2, which the NRC has not approved in RG 1.147. However, the NRC has conditionally approved ASME Code Cases N-504-4 and N-638-6 in Regulatory Guide 1.147, Revision 18. The NRC staff has also approved Appendix Q, "Weld Overlay Repair of Classes 1, 2, And 3 Austenitic Stainless Steel Piping Weldments," of the 2007 Edition through 2008 Addenda of the ASME Code, Section XI, in 10 CFR 50.55a. The NRC staff uses Code Cases N-504-4 and N-638-6, and Appendix Q to review the proposed alternative because they are applicable to the FSWOL. The NRC staff notes that most provisions of Code Case N-740-2 are consistent with the provisions of Code Cases N-504-4 and N-638-6, and Appendix Q of the ASME Code, Section XI.

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

Flaw Sizing and Characterization

Flaw sizing and characterization are a necessary part of the pre-repair evaluation, because the information is used to design the FSWOL and to perform the necessary crack growth calculation. As stated above, the licensee discovered an axial indication in each of the subject DMWs. As shown in Attachment 3 of the relief request dated February 4, 2019, Entergy provided dimensions and locations of the indication. The licensee also indicated that the axial indications are connected to the inside surface of the pipe and therefore, are exposed to the reactor coolant. The NRC staff finds that the licensee has adequately characterized the depth and length of the indications in both subject DMWs using UT (ultrasonic testing) following PDI procedures.

Material Specification

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

The NRC staff notes that Entergy will apply a stainless steel buffer layer on the safe end, similar metal weld, and piping prior to depositing Alloy 52M. These three components are made of stainless steel. Based on previous industry experience, it is known that if Alloy 52M is applied directly to these three components, cracks may occur. The licensee will also apply short Alloy 82 bridge beads on the DMWs to minimize potential cracking. The NRC staff finds that the buffer layer and bridge beads are applied to minimize fabrication defects and, therefore, are acceptable.

Design

The licensee's design basis of the FSWOLs is to maintain the original design margins with no credit taken for the underlying PWSCC-susceptible weldment. The design-basis flaw for structural sizing of the FSWOL is a 360-degree circumferential flaw that is 100 percent through the original wall thickness of the subject DMWs. The design-basis flaw also considered a 100-percent through-wall axial flaw with length of 1.5 inches or the combined width of the weld plus buttering plus any PWSCC-susceptible material, whichever is greater, in the axial direction. The NRC staff finds that the postulated design-basis flaws are acceptable because they are the worst flaws in the DMWs that the FSWOL is designed to repair. The NRC staff finds that the FSWOL is designed such that (1) it will support the applied loadings and stresses at the location of the subject welds without taken credit for the underlying existing welds, (2) the detected flaw will not grow to challenge structural integrity of the subject DMWs, (3) it provides sufficient compressive stresses in the subject DMWs wall thickness to minimize further growth of the detected flaw, and (4) it covers the axial length of the subject DMWs with sufficient length to maximize UT examination coverage. The NRC staff finds the proposed FSWOL design is consistent with Code Case N-504-4 and Appendix Q of the ASME Code, Section XI.

The licensee identified that the provisions of IWB-3641 and Nonmandatory Appendix C of the ASME Code, Section XI, 2007 Edition/2008 Addenda are not applicable to analyze flaws in the subject DMWs because the provisions are applicable to pipe size that is greater than 4 inches, whereas the diameter of the affected pipes is less than 4 inches. The licensee requested to use IWB-3641 and Nonmandatory Appendix C in the 2013 Edition of ASME Code, Section XI when performing FSWOL design. The NRC staff notes that Entergy will comply with all related requirements as stipulated in 10 CFR 50.55a(g)(4)(iv) when using the 2013 Edition of the ASME Code, Section XI. The NRC staff finds that it is acceptable for Entergy to use the provisions in IWB-3641 and Appendix C of the ASME Code, Section XI, 2013 Edition to perform design calculations, because the NRC staff has approved the 2013 Edition for generic use in 10 CFR 50.55a.

As part of the FSWOL design, the NRC staff confirms that Entergy will perform (1) a stress analysis to show a favorable residual stress profile on the inside diameter region of the overlaid DMWs, which will include a postulated 50 percent deep repaired flaw at the time of construction, (2) a fracture mechanics analysis to determine crack growth of the detected flaw to ensure that the detected flaw will not affect structural integrity of the pipe/weld and that the ASME Code, Section III allowable stresses will be maintained, and (3) an evaluation of added weight on the piping systems due to the FSWOL for potential impact on stresses and dynamic characteristics of the affected piping. The NRC staff finds these analyses are consistent with Code Case N-504-4 and Appendix Q of the ASME Code, Section XI.

Pre-Installation Evaluation

Section A1.2.2 of Attachment 1 of the relief request dated February 4, 2019, requires that prior to FSWOL installation, a surface examination be performed on the area to be welded and that any small indications greater than 1/16 inch be repaired. As stated, in part, in the footnote of Figure 1 in the relief request, "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." The NRC staff finds that Entergy's pre-installation evaluation is acceptable because it is consistent with Code Case N-504-4, paragraphs (c) and (d) and the ASME Code, Section XI, Appendix Q, paragraphs Q-2000(b) and Q-2000(c).

Installation

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

The proposed alternative provides detailed welding procedure qualification requirements for base materials, filler metals, restraint, impact properties, and other procedure variables. The qualification requirements provide assurance that the mechanical properties of repaired welds are equivalent to, or superior to, those of the surrounding base material. Therefore, the NRC staff finds that the proposed installation satisfies Code Cases N-504-4 and N-638-6, and the ASME Code, Section XI, Appendix Q, and is acceptable.

The NRC staff notes that after the FSWOL installation, Entergy will (1) measure weld shrinkage, (2) verify the as-built FSWOL dimensions meeting the minimum design dimension, (3) demonstrate that weld shrinkage will not adversely affect other locations in the piping systems, and (4) check clearances of affected supports and restraints after the overlay repair. The NRC staff finds that the proposed post-installation verifications satisfy Code Case N-504-4(g)(3), and therefore, are acceptable.

Examination

Attachment 1 of the relief request dated February 4, 2019, requires that UT examination procedures and personnel be qualified in accordance with Code Case N-653-1. The licensee stated that Code Case N-653-1 addresses qualification requirements for UT of 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. The licensee further stated that construction-type flaws have been included in the PDI qualification sample sets for evaluating procedures and personnel. The NRC staff has approved Code Case N-653-1 for generic use as documented in RG 1.147, Revision 18. Therefore, the NRC staff finds that the UT examinations of overlaid DMWs based on Code Case N-653-1 are acceptable.

Acceptance Examination

Code Case N-638-6, paragraphs 4(a) and 4(a)(4) requires that all welds (including repair welds) be volumetrically examined in accordance with the requirements and acceptance criteria of the Construction Code or ASME Code, Section III. As an alternative, the licensee proposed 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) of the relief request dated February 4, 2019.

The proposed alternative requires that the UT examination can detect adequate fusion between the overlay and the base material, and to detect welding flaws such as interbead lack of fusion, inclusions, and cracks. Attachment 1 of the relief request states that 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 of the relief request limits the reduction in coverage due to a laminar flaw to less than 10 percent while uninspectable volumes are assumed to contain the largest radial planar flaw that could exist within the uninspectable volume.

The proposed alternative requires that the total laminar flaw area shall 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 or 10 percent of the pipe circumference. The proposed alternative further requires that for weld overlay areas where examination is precluded by the presence of the flaw, the areas must be postulated to be flawed.

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

Preservice Examination

Section A1.4(b) in Attachment 1 of the relief request states that preservice examination will be performed in accordance with ASME Code Case N-770-2 as approved by the NRC in 10 CFR 50.55a. The NRC staff notes that the provisions of Code Case N-770-2 provide preservice examination requirements for FSWOLs in the areas of the acceptance criteria, examination coverage, and examination method. The NRC staff finds acceptable that the preservice examination of the proposed FSWOL will follow Code Case N-770-2 as conditioned in 10 CFR 50.55a(g)(6)(ii)(F).

Inservice Examination

Section A1.4(c) in Attachment 1 of the relief request states that inservice examinations will be performed in accordance with Code Case N-770-2, which has been approved by the NRC in 10 CFR 50.55a. The licensee further stated that 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.

The NRC staff notes that Code Case N-770-2, as conditioned in 10 CFR 50.55a(g)(6)(ii)(F), specifies the examination volume, inspection method and frequency for the overlaid welds. Therefore, the NRC staff finds that the licensee proposed inservice examination is acceptable because it follows Code Case N-770-2 as conditioned in 10 CFR 50.55a(g)(6)(ii)(F).

Pressure Testing

Section A1.5 in Attachment 1 of the relief request requires that a system leakage test be performed in accordance with the ASME Code, IWA-5000, "System Pressure Tests." The NRC staff finds acceptable that the licensee will perform a system leakage test in accordance with IWA-5000 because the system leakage test will demonstrate leakage tightness of repaired DMWs.

Post-Installation Submittals

The NRC staff requires licensees, who submit a proposed alternative to install FSWOLs on Alloy 82/182 DMWs, to submit UT results to NRC after completion of overlay installation to demonstrate the acceptability of the as-built FSWOL. The licensee stated that within 14 days of the final UT examination of the overlaid welds, it will submit a listing of indications, if any, detected in the overlaid welds, how the indications are dispositioned, and the post-installation repair.

The NRC staff notes that Code Case N-504-4 and Appendix Q of the ASME Code, Section XI require analyses be performed as part of the FSWOL design. However, the exigent nature of the proposed alternative precludes Entergy's ability to complete the necessary analyses at the time of the alternative submission. The licensee stated that within 120 days of completing the Refueling Outage 22, it will submit nozzle-specific stress analyses for each FSWOL to establish a residual stress profile in the subject welds.

The NRC staff finds that the design, flaw evaluations, examination results that Entergy proposed to submit, and the proposed submittal timeline provide reasonable assurance of adequate protection for the public health and safety. The NRC will review the weld overlay examination results to ensure that each FSWOL is appropriately installed without unacceptable fabrication defects. The NRC staff will also review the nozzle-specific stress analyses to verify that the weld overlay design will provide structural integrity of the subject welds. Therefore, the NRC staff finds that the post-installation submittal and the associated submittal schedule are acceptable.

Summary

The NRC staff finds that the proposed FSWOL will maintain structural integrity of the subject DMWs because the proposed alternative satisfies the requirements of Code Cases N-504-4, N-638-6, N-770-2, and the ASME Code, Section XI, Appendix Q.

4.0 CONCLUSION

As set forth above, the NRC staff concludes that the proposed alternative provides reasonable assurance of structural integrity of the subject DMWs. As such, the NRC staff finds that the alternate repair provides an acceptable level of quality and safety. Accordingly, the NRC staff concludes that Entergy has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC authorizes the use of Alternative WF3-RR-19-1

dated January 28, 2019, as supplemented by letter dated February 4, 2019, at Waterford Steam Electric Station Unit No. 3 for fourth 10-year ISI interval which commenced on December 1, 2017, and will end on November 30, 2027. The NRC staff further concludes that 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.

The NRC staff notes that authorization of Alternative WF3-RR-19-1 dated January 28, 2019 as supplemented by letter dated February 4, 2019, does not imply or infer the generic use of Code Case N-740-2.

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

Principal Contributor: J. Tsao

Date: August 27, 2019

SUBJECT: WATERFORD STEAM ELECTRIC STATION, UNIT 3 – AUTHORIZATION OF PROPOSED ALTERNATIVE TO ASME CODE, SECTION XI, IWA-4000, "REPAIR/REPLACEMENT ACTIVITIES" (EPID L-2019-LLR-0003) DATED AUGUST 27, 2019

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