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

April 12, 2017

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: JAMES A. FITZPATRICK NUCLEAR POWER PLANT – ALTERNATIVE TO ASME CODE REQUIREMENTS FOR WELD OVERLAY REPAIR (CAC NO. MF9128)

Dear Mr. Hanson:

By application dated January 27, 2017, Entergy Nuclear Operations, Inc. (Entergy) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) for relief from the use of alternatives to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI requirements at the James A. Fitzpatrick Nuclear Power Plant (Fitzpatrick).

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee requested to use the proposed alternative on the basis that the alternative provides an acceptable level of quality and safety.

On March 31, 2017, Exelon Generation Company, LLC (Exelon) purchased FitzPatrick from Entergy and requested that the NRC continue the review of all licensing actions under review. Exelon adopted and endorsed all docketed requests that were currently pending before the NRC for its review and approval. This relief request is one of the actions previously under review for Entergy but will be issued to Exelon.

Based on the discussion in the enclosed safety evaluation, the NRC staff concludes that the alternative proposed in Relief Request RR-21 will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(z)(1), the NRC staff authorizes the use of Relief Request RR-21 for the fourth 10-year inservice inspection interval, and this authorization is acceptable until the end of the period of extended operation, which expires on October 17, 2034.

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

If you have any questions, please contact the Project Manager, Diane L. Render, Ph.D., at 301-415-3629 or Diane.Render@nrc.gov.

Sincerely,

James G. Danna, Chief
Plant Licensing Branch I
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-333

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST RR-21

EXELON GENERATION COMPANY, LLC

DOCKET NO. 50-333

JAMES A. FITZPATRICK NUCLEAR POWER PLANT

1.0 INTRODUCTION

By application dated January 27, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17028A011), Entergy Nuclear Operations, Inc. (Entergy, the licensee) requested relief from the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, IWA-4000, at the James A. FitzPatrick Nuclear Power Plant (FitzPatrick). As of March 31, 2017 (ADAMS Accession No. ML17082A283), Exelon purchased FitzPatrick with plans of continued operation.

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), Entergy submitted Relief Request RR-21 for the alternate repair of the degraded dissimilar metal butt weld 24-10-130 of 'A' residual heat removal (RHR) low pressure coolant injection (LPCI) piping. This was requested on the basis that the alternate repair provides an acceptable level of quality and safety.

On January 30, 2017 (ADAMS Accession No. ML17031A280), the U.S. Nuclear Regulatory Commission (NRC) verbally authorized the use of Relief Request RR-21 (RR-21) at FitzPatrick for the fourth 10-year inservice inspection (ISI) interval. The NRC staff concluded that the repair is acceptable for the remaining life of the plant until the end of the period of extended operation, which expires on October 17, 2034. The NRC staff determined that the proposed alternative is technically justified and provides reasonable assurance of the structural integrity of the affected piping. Entergy completed the weld overlay (WOL), Refueling Outage No. 22 (RO-22), and submitted its final ultrasonic test (UT) results on March 9, 2017 (ADAMS Accession No. ML17068A370). The technical basis for the NRC staff's verbal authorization is documented in this safety evaluation and reflects work that has already been completed.

2.0 REGULATORY EVALUATION

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

Pursuant to 10 CFR 50.55a(z), the NRC may authorize alternatives to requirements if the licensee demonstrates that: (1) the proposed alternatives provide an acceptable level of quality and safety, or (2) compliance with the specified requirements would result in hardship or unusual difficulty, without a compensating increase in the level of quality and safety.

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

3.0 TECHNICAL EVALUATION

3.1 ASME Code Component Affected

The affected component is dissimilar metal weld 24-10-130. It is located in the 'A' train of RHR LPCI piping. This piping is ASME Code Class 1. The weld is part of risk-informed ISI Examination Category R-A, Item R1.16, and joins a tee to a gate valve.

3.2 Applicable Code Edition and Addenda

The following ASME Codes and Code cases are applicable to this relief request:

- ASME Code, Section XI, 2001 Edition through 2003 Addenda.
- ASME Code, Section XI, 2001 Edition, "Performance Demonstration for Ultrasonic Examination Systems," in accordance with 10 CFR 50.55a(b)(2)(xv).
- USA Standard Code B31.1.0, "Power Piping," 1967 Edition through 1969 Addenda.
- ASME Code, Section IX, B31.1, "Power Piping," 2007 Edition, no addenda.
- ASME Code, Section III, subsection NB, 1992 Edition, no addenda.
- ASME Code Case N-578-1, "Risk Informed Requirements for Class 1, 2 and 3 Piping, Method B, Section XI, Division 1."
- ASME Code Case N-504-4, "Alternative Rules for Repair of Class 1, 2 and 3 Austenitic Stainless Steel Piping, Section XI, Division 1."
- ASME Code, Section XI, Appendix Q, 2004 Edition through 2005 Addenda. This is required by Regulatory Guide (RG) 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," when using ASME Code Case N-504-4.
- ASME Code Case N-638-4, "Similar and Dissimilar Metal Welding using Ambient Temperature Machine GTAW [Gas Tungsten Arc Welding] Temper Bead Technique."

3.3 Applicable Code Requirement

The requirement that activities for repair and replacement be performed and examined in accordance with the Owner's Requirements and the original construction code of the component or system is listed in Subsections IWA-4411 and IWA-4520(a) in Section XI of the

ASME Code. Alternatively, Subsections IWA-4411(a) and (b) allow use of later editions and addenda of the construction code or a later different construction code, such as Section III of the ASME Code, either in its entirety or portions thereof, Code cases, and revised Owner's Requirements.

Specific requirements for performing defect removal and the associated nondestructive examinations (NDE) for repairs performed with and without welding is provided in IWA-4420.

Temper bead welding requirements as an alternative to the welding and post-weld heat treatment requirements of the construction code are provided in IWA-4600(b).

Preservice and inservice examination requirements for ISI weld 24-10-130 are provided in Code Case N-578-1, Table 1, Examination Category R-A, Item R1.16.

Alternative requirements to reduce a defect to a flaw of acceptable size in austenitic stainless steel materials are provided in Code Case N-504-4. The flaw is reduced by the deposition of a full structural WOL on the outside surface of the pipe or component, as conditioned in RG 1.147. One of the conditions requires that Appendix Q of the ASME Code, Section XI, 2004 Edition through 2005 Addenda, be used.

Requirements for performing ambient temperature temper bead welding as an alternative to the preheat and post-weld heat treatment requirements of the construction code are established in Code Case N-638-4. These requirements are conditioned in RG 1.147.

3.4 Reason for Alternative

In January 2017, Entergy UT examined ISI welds 24-10-130, 24-10-131, 24-10-132, 24-10-142, 24-10-143, and 24-10-144, to comply with the inspection requirements in BWRVIP-75-A, "BWR Vessel and Internals Project, Technical Basis for Revisions to Generic Letter 88-01 Inspection Schedules," during RO-22. This report was previously approved by the NRC and provides justification for the inspection criteria for Category "A" through Category "E" welds for their respective water chemistry. Entergy performed the UT examination of its Category "D" welds in accordance with the ASME Code, Section XI, Appendix VIII, Supplement 10, as implemented by the Electric Power Research Institute (EPRI) Performance Demonstration Initiative (PDI). Intergranular stress corrosion cracking (IGSCC) was detected in ISI weld 24-10-130. The indication is axially oriented and located within the weld and butter. The estimated length of the indication is 0.95 inches. The depth of the indication is 0.81 inches with a remaining ligament from the outside weld surface of 0.34 inches. The indication is located 62.25 inches clockwise from top dead center (looking at the tee in the direction of flow) or 13 inches counter-clockwise from top dead center.

Entergy used UT to inspect six additional Category "D" welds during the RO-22 to comply with the scope expansion criteria in paragraph 3.4.1 in BWRVIP-75-A.

ISI weld 24-10-130 is an Alloy 82/182 dissimilar metal weld that joins an austenitic stainless steel (A-403, WP304) reducing tee to a cast carbon steel (A-216, WCB) gate valve. The austenitic stainless steel tee material was solution annealed, water quenched (per the specification), and, as such, is resistant to IGSCC. However, the heat of welding creates a heat affected zone in this material that becomes sensitized due to carbide precipitation in the grain boundaries, rendering the heat affected zone potentially susceptible to IGSCC in a boiling-water reactor (BWR) environment.

Entergy stated that it is not feasible to perform an ASME Code repair of weld 24-10-130. The RHR LPCI piping is 24-inch nominal pipe size, while the reactor recirculation piping is 28-inch nominal pipe size. The reactor recirculation piping is open to the reactor vessel. To perform an ASME Code repair, the reactor recirculation and RHR LPCI piping have to be drained by installing jet pump nozzle plugs from the reactor pressure vessel inside diameter. According to Entergy, the plugs are currently not available.

As an alternative to an ASME Code repair, Entergy proposed the installation of a WOL to repair the subject weld. Structural WOLs have been used for years on piping in both BWRs and pressurized-water reactors to arrest the growth of flaws while establishing a new structural pressure boundary. In Generic Letter 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping," the NRC approved the use of the acceptance standards for determining the acceptability of installed WOLs in ASME Code, Section XI. In addition, BWRVIP-75-A also allows for the use of the acceptance standards for determining the acceptability of installed WOLs in ASME Code, Section XI.

However, the 2001 Edition through 2003 Addenda of ASME Code, Section XI, which is the code of record for performing the ASME Code repair, does not include requirements for installing full structural WOLs on dissimilar metal welds and non-austenitic stainless steels. Moreover, requirements for installing structural WOLs on dissimilar metal welds and non-austenitic stainless steels are not presently included in any edition or addenda of ASME Code, Section XI, or NRC-approved code cases.

Entergy used Code Cases N-504-4 and N-638-4 to install a structural WOL on ISI weld 24-10-130. The full structural WOL will be applied by deposition of ERNiCrFe-7A (Alloy 52M) filler metal on the outside surface of the dissimilar metal weld and adjacent base metal.

3.5 Alternative

In lieu of performing an ASME Code repair, Entergy followed Code Cases N-504-4 and N-638-4 and the ASME Code, Section XI, Appendix Q, to install a full structural WOL on weld 24-10-130 with the following alternatives.

Code Case N-504-4 and the ASME Code, Section XI, Appendix Q

1. Code Case N-504-4 and the ASME Code, Section XI, Appendix Q, strictly apply to austenitic stainless steel piping and weldments; however, the subject weld is fabricated with nickel-based Alloy 82/182 filler metal. As an alternative, Entergy used Code Cases N-504-4 and Appendix Q to install a WOL on the carbon steel gate valve, weld 24-10-130, and austenitic stainless steel tee using nickel-based Alloy 52M filler metal.

2. Paragraph (b) in Code Case N-504-4 and paragraph Q-2000(a) in Appendix Q require that weld metal used to fabricate WOLs be low carbon (maximum 0.035 percent) austenitic stainless steel to reduce the sensitization of the austenitic stainless steel WOL, thereby reducing its susceptibility to IGSCC. As an alternative, Entergy installed a WOL using Alloy 52M. While carbon content is not a critical factor in assessing resistance of nickel alloys to IGSCC, the chromium content is. A minimum chromium content of 20 percent is necessary to ensure resistance to IGSCC. Because Alloy 52M weld metal has a high chromium content (28 – 31.5 percent), it has excellent resistance

to IGSCC. However, WOL buffer layers were deposited using ER308L austenitic stainless steel filler metal, which has a maximum of 0.03 percent carbon content. Therefore, ER308L complies with the low carbon requirement of paragraph (b) in Code Case N-504-4 and paragraph Q-2000(a) in Appendix Q.

3. Paragraph (e) in Code Case N-504-4 and paragraph Q-2000(d) in Appendix Q require that the WOL consist of at least two austenitic stainless steel weld layers, each layer having an as-deposited delta ferrite content of at least 7.5 FN [ferrite number] or 5 FN under certain conditions. As an alternative, Entergy installed the WOL using Alloy 52M, which is purely austenitic microstructure. Therefore, this delta ferrite requirement does not apply to Alloy 52M filler metal.

4. The buffer layers were deposited with ER308L austenitic stainless steel filler metal and comply with the delta ferrite requirement of paragraph (e) in Code Case N-504-4 and paragraph Q-2000(d) in Appendix Q. The susceptibility of nickel alloys to IGSCC is dependent on its chromium content as explained above. Furthermore, the chromium content of the first layer of Alloy 52M weld metal could be reduced due to dilution with the underlying base and weld materials. 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 intended to deposit buffer layers across the austenitic stainless steel tee prior to the installation of the WOL. While the balance of these initial layers was deposited with Alloy 52M weld metal, an Alloy 82 bridge bead (or transitional bead) was deposited over the fusion line between the existing Alloy 82/182 weld and the stainless steel tee. The bridge bead was deposited with Alloy 82 filler metal. The ER308L filler metal will have a maximum carbon content of 0.03 percent and a delta ferrite content of 5 - 15 FN as reported on the Certified Material Test Report. Entergy deposited buffer layers with a welding procedure and welders that have been qualified in accordance with ASME Code, Section IX. Entergy performed liquid penetrant test (PT) examinations before and after deposition of the buffer layer. The second PT examination was performed to ensure that the completed buffer layer is free from cracks and other unacceptable indications prior to deposition of the Alloy 52M WOL. Finally, the thickness of the buffer layers was not structurally credited towards the minimum design thickness of the WOL. Because this is the case, Entergy imposed the following restriction on the first layer of the WOL, which is consistent with ASME Code Case N-740-2:

> The first layer of Alloy 52M weld metal deposited may not be credited toward the required thickness. Alternatively, a diluted layer may be credited toward the required thickness, provided the portion of the layer over the austenitic base material, austenitic weld, and the associated dilution zone from an adjacent ferritic base material contains at least 20% 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 [welding procedure specification] (or a representative WPS) for the production weld.

5. Paragraph (f)(1) in Code Case N-504-4 and paragraph Q-3000(b)(2) in Appendix Q require that the end transition slope of the WOL not exceed 45 degrees. However, it is not possible to meet this requirement at some azimuthal locations (e.g., 0 and 180 degrees) due to the configuration or geometry of the weldment. As an alternative,

Entergy blended the WOL into the associated components and demonstrated the acceptability of the end transition slope by analysis. To address this issue, Entergy analyzed the as-built configuration of the WOL using the finite element analysis to demonstrate compliance with the applicable stress limits of the construction code. According to paragraph Q-3000(b)(2) in Appendix Q, the performance of analysis is an acceptable method for demonstrating the suitability of this type of end transition slope.

6. Paragraph (h) in Code Case N-504-4 requires that a system hydrostatic test be performed in accordance with the ASME Code, Section XI, IWA-5000, if a flaw penetrates the pressure boundary during welding. If the pressure boundary has not been penetrated, Code Case N-504-4 allows performance of a system leakage test. Pressure testing is not addressed by Appendix Q. As an alternative, Entergy performed a system leakage test in accordance with IWA-5000. This action is consistent with the pressure testing requirements of IWA-4540, except that the NDE requirements of IWA-4540 would not apply to a WOL. However, the WOL acceptance examinations will include both PT and UT examinations. Entergy performed PT examinations in accordance with the construction code or the ASME Code, Section III, while the UT examination was performed in accordance with Appendix VIII, Supplement 11 of the ASME Code, Section XI, as implemented by the EPRI PDI program. The UT acceptance standards are specified by paragraph Q-4100(c) in Appendix Q, which defaults to Tables IWB-3514-2 and 3 of the ASME Code, Section XI.

7. Paragraph (j) in Code Case N-504-4 and Section Q-4100 in Appendix Q specify requirements for acceptance examination of WOLs. The UT examination volume is defined in Figure Q-4100-1 of Appendix Q. However, the configuration of the weldment and geometric limitations imposed by the adjoining tee may restrict Entergy's ability to examine 100 percent of this WOL examination volume. As an alternative, Entergy performed a manual phased array UT examination by conducting scans from the WOL surface and both base materials surfaces, as necessary, to obtain the maximum coverage possible. The overlay design allows for greater than 90 percent interrogation of the examination volume, as defined in Figure Q-4100-1. Therefore, these examinations would obtain "essentially 100 percent" coverage (i.e., greater than 90 percent) as defined in NRC Information Notice 98-42, "Implementation of 10 CFR 50.55a(g) Inservice Inspection Requirements," and ASME Code Case N-460, "Alternative Examination Coverage for Class 1 and Class 2 Welds, Section XI, Division 1," which has been approved, without conditions, by the NRC in RG 1.147. Entergy stated that the length, surface finish, and flatness of the WOL complies with Q-4100(a) to facilitate examination in accordance with the ASME Code, Section XI, Appendix Q.

8. Paragraph (i) in Code Case N-504-4 and Section Q-4200 in Appendix Q specify preservice inspection requirements for WOLs, while Section Q-4300 of Appendix Q specifies ISI requirements. Figure Q-4300-1 of Appendix Q defines the UT examination volume for both preservice and ISIs. However, the configuration of the weldment and geometric limitations imposed by the adjoining tee may restrict Entergy's ability to examine 100 percent of this examination volume. As an alternative, Entergy performed a manual phased array UT examination by conducting scans from the WOL surface and both base materials surfaces, as necessary, to obtain the maximum coverage possible. The WOL design allows for greater than 90 percent interrogation of the examination volume, as defined in Figure Q-4300-1. These preservice and inservice examinations

would constitute "essentially 100 percent" coverage (i.e., greater than 90 percent) based on NRC Information Notice 98-42 and Code Case N-460.

9. Paragraph Q-4000 in Appendix Q specifies that procedures and personnel for examining WOLs be qualified in accordance with Appendix VIII, Supplement 11 of the ASME Code, Section XI. As an alternative, Entergy used UT to examine the WOL in accordance with Appendix VIII, Supplement 11, except as modified by the EPRI PDI program. Previously, an NDE mock-up of the WOL configuration was fabricated. The mock-up contained manufactured flaws and was used for training, prior to performing the actual WOL examination, to ensure that the qualified examiners were familiarized with aspects of the plant-specific WOL examination.

Entergy stated that once the WOL is installed, it would reclassify this weld as a Category "E" weld. As defined in paragraph 3.5 in BWRVIP-75-A, Category "E" welds "are defined by Generic Letter 88-01 as cracked weldments that have been mitigated by either a [WOL] repair or a stress improvement process." Regarding future ISIs, the repaired weld 24-10-130 will be inspected in accordance with paragraph 3.5.1.1 in BWRVIP-75-A. In addition, the ASME Code, Section XI, ISIs will be performed in accordance with Appendix Q, Section Q-4300.

Code Case N-638-4

Entergy used an ambient temperature temper bead welding technique when welding on the ferritic base material of the carbon steel valve in lieu of the preheat and post-weld heat treatment requirements of the construction code. EPRI and other organizations have performed research on the use of the ambient temperature temper bead process using the machine gas tungsten arc welding (GTAW) process. Repair welds performed with an ambient temperature temper bead procedure using the machine GTAW process exhibit mechanical properties equivalent to or better than those of the surrounding base material. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this process.

Entergy completed the following alternative to Code Case N-638-4.

1. Paragraph 3 in Code Case N-638-4 specifies several methods for measuring or monitoring weld interpass temperatures (e.g., pyrometers, temperature indicating crayons, thermocouples). However, as a condition to Code Case N-638-4, RG 1.147 restricts use of the interpass temperature monitoring methods of paragraphs 3(e)(2) and 3(e)(3) to cases where it is impractical to use the methods of paragraph 3(e)(1) due to inaccessibility or radiological conditions. In monitoring preheat and interpass temperatures during WOL welding, Entergy proposed 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.

The proposed preheat and interpass temperature controls are based on field experience with depositing WOLs 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.

2. Paragraphs 4(a)(1) and 4(b) in Code Case N-638-4 state that prior to repair welding, a VT-1 visual examination may alternatively be performed on the area to be welded if it is impractical to perform a surface examination. Entergy did not use the alternative VT-1 visual examination method. Prior to welding, Entergy performed a surface examination of the area to be welded as required by paragraphs (c) and (d) in Code Case N-504-4 and paragraphs Q-2000(b) and Q-2000(c) in Appendix Q.

3. Paragraphs 4(a), 4(a)(2), and 4(a)(4) in Code Case N-638-4 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 a condition to Code Case N-638-4, RG 1.147 states: "Demonstration for ultrasonic examination of the repaired volume is required using representative samples which contain construction type flaws." As an alternative, Entergy volumetrically examined the WOL using the UT method in accordance with the requirements and acceptance criteria of paragraph Q-4100 of the ASME Code, Section XI, Appendix Q. According to Article Q-4000, UT examination procedures and personnel shall be qualified in accordance with Appendix VIII of the ASME Code, Section XI. Supplement 11 of Appendix VIII specially addresses qualification requirements for WOLs. The license will also comply with the performance demonstration requirements of ASME Code, Section XI, Appendix VIII, Supplement 11, as modified by the EPRI PDI program. When UT examinations are performed in accordance with Supplement 11 of Appendix VIII (as implemented through the EPRI PDI program), the examinations are considered more sensitive for detecting fabrication and service-induced flaws than traditional radiographic and ultrasonic examination methods. Furthermore, Entergy has included construction-type flaws in the PDI qualification sample sets (mock-up) for evaluating procedures and personnel. Article Q-4100 in Appendix Q also establishes UT acceptance standards for WOL examinations. Similar to NB-5330 of the ASME Code, Section III, 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 in Tables IWB-3514-2 and IWB-3514-3 of the ASME Code, Section XI. Paragraph Q-4100(c) of Appendix Q also 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 volume. The conditions in RG 1.147 applicable to Appendix Q will also be met.

Post-Installation Submittals

Entergy has submitted the following information to the NRC within 14 days of the completion of RO-22:

1. The examination results of the WOL, including a listing of any indications detected. Entergy explained that the recording criteria of the ultrasonic examination procedure to be used for the WOL examination requires that all indications, regardless of amplitude, be investigated to the extent necessary to provide accurate characterization, identity, and location. Additionally, the procedure requires that all indications, regardless of

amplitude that cannot be clearly attributed to the geometry of the overlay configuration, be considered flaw indications.

2. Disposition of indications using the standards of the ASME Code, Section XI, IWB-3514-2 and/or IWB-3514-3 criteria and, if possible, the type and nature of the indications. The ultrasonic examination procedure requires that all suspected flaw indications are to be plotted on a cross-sectional drawing of the weld and that the plots should accurately identify the specific origin of the reflector.

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

4. A description of the examination coverage achieved during the examination of the repaired weld.

In addition, Entergy will submit a stress analysis summary within 90 days of the completion of RO-22. The stress analysis is to demonstrate that the WOL on ISI weld 24-10-130 will perform its intended design function after installation. The stress analysis report will include results showing that the requirements of NB-3200 and/or NB-3600 of the ASME Code, Section III, and IWB-3000 of the ASME Code, Section XI, are satisfied. The results will show that the detected flaw, including its growth in the subject weld, will not adversely affect the integrity of the WOL repair.

3.6 Basis for Alternative

The alternative provided a methodology for preventing potential failures due to IGSCC based on the use of filler metals that are resistant to IGSCC (e.g., Alloy 52M), enhancing the residual stress profile along the inside diameter of the original weld, and imposing post-overlay preservice and ISI requirements that ensure structural integrity for the life of the plant.

The fundamental design basis for full structural WOLs is to maintain the original design margins with no credit taken for the underlying IGSCC-susceptible weldments. The assumed design-basis flaw for the purpose of structural sizing of the WOL is a flaw completely around the circumference (360 degrees) and 100 percent through the original wall thickness of the dissimilar metal weld. Entergy analyzed the crack growth of detected axial flaw at the subject weld to determine its acceptability. The specific analyses and verifications performed are summarized as follows:

- Entergy will perform a stress analysis to establish a residual stress profile in the WOL and the underlying weld and base materials. The analysis will simulate application of the WOL to determine the final residual stress profile. Post-WOL residual stresses at normal operating conditions are expected to result in an improved stress condition on the inside surface of the underlying weld and base materials, reducing or eliminating further crack initiation in susceptible materials due to IGSCC.

- Entergy will perform fracture mechanics analyses to predict crack growth of the detected flaw considering IGSCC and fatigue degradation mechanisms. The crack growth analyses will consider all design loads and transients, plus the post-WOL and through-wall residual stress distributions. The analyses will demonstrate that applying the WOL does not impact the conclusions of the existing stress reports. The primary stress criteria in the ASME Code, Section III, will continue to be met.

- Entergy measured weld shrinkage during the WOL application and demonstrated that shrinkage stresses at other locations in the piping systems arising from the WOL will not have an adverse effect on the systems. Entergy checked clearances of affected supports and restraints after the WOL repair and reset within the design ranges, if required.

- Entergy evaluated added weight on the piping systems due to the WOL for potential impact on piping system stresses and dynamic characteristics.

- Entergy measured and evaluated the as-built dimensions of the WOL to demonstrate that they meet or exceed the minimum design dimensions of the WOL.

3.7 Duration of Alternative

The alternative is applicable to the fourth 10-year ISI interval and the period of extended operation, which expires October 17, 2034. The ISI requirements of this alternative are applicable for the life of the WOL associated with ISI weld 24-10-130.

3.8 NRC Staff Evaluation

Entergy followed the requirements of Code Cases N-504-4 and N-638-4 and the ASME Code, Section XI, Appendix Q, to install the WOL and alternatives on weld 24-10-130. The NRC staff evaluated the requirements in these three documents to which Entergy proposed alternatives (modifications). The NRC staff also evaluated the requirements for which Entergy did not take exceptions but are significant to the WOL installation.

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

Flaw Sizing and Characterization

The indication detected in weld 24-10-130 was axially oriented and located within the weld and butter. The estimated length of the indication is 0.95 inches. The depth of the indication was 0.81 inches with a remaining ligament from the outside weld surface of 0.34 inches. The indication was located 62.25 inches clockwise from top dead center of the pipe. Entergy attributed the indication to IGSCC. The NRC staff notes that the flaw, based on the reported depth, was unacceptable in accordance with the standards of the ASME Code, Section XI, IWB-3500. Entergy could have accepted the flaw by analysis, repair, or replace weld 24-10-130, but it chose to repair the weld. The NRC staff notes that flaw sizing and characterization are a necessary part of the pre-repair evaluation such that the information is used to design the WOL. The NRC staff finds that Entergy adequately characterized the indication and provided sufficient information on flaw depth and length for its crack growth calculation.

Material Specification

The NRC staff recognizes that Alloy 52M weld metal is less susceptible to IGSCC than Alloy 82/182 weld metal based on laboratory data and operating experience. Therefore, the NRC staff finds acceptable that Entergy used Alloy 52M weld metal to install the WOL.

Based on operating experience, if stainless steel base metal has certain sulfur content, applying Alloy 52M weld metal directly on stainless steel base metal may result in fabrication defects. Using ER308L stainless steel weld metal to build a buffer layer, Alloy 52M weld metal will not be in direct contact with the stainless steel tee. This minimizes fabrication defects. Therefore, the NRC staff finds acceptable that Entergy used stainless steel ER308L weld metal for the buffer layer.

Entergy used Alloy 82 weld metal as a bridge bead deposited between the tee and the existing weld. The NRC staff notes that industry has used the bridge bead in many WOL repairs to minimize fabricate defects associated with the WOL installation. The NRC staff recognizes that the operating experience of the bridge bead has been favorable; therefore, use of Alloy 82 as a bridge bead is acceptable.

Therefore, the NRC staff finds that the alternative weld filler metal provides an acceptable alternative to the material requirements in paragraphs (b) and (e) of Code Case N-504 and the ASME Code, Section XI, Appendix Q, Q-2000.

Design

The technical basis for the WOLs was to maintain the original design margins with no credit taken for the underlying IGSCC-susceptible weldments. The NRC staff finds acceptable that Entergy's design-basis flaw for the purpose of structural sizing of the WOL was a 360-degree circumferential flaw that was 100 percent through the original wall thickness of the dissimilar metal weld, because this is the worst case scenario flaw. The NRC staff finds acceptable that the thickness of the WOL was designed such that (a) it will support the loadings and stresses of the existing weld and pipe/tee without considering the underlying existing weld, (b) the detected flaw will not grow to challenge structural integrity of the repaired weld, and (c) it provides sufficient compressive stresses in the existing weld wall thickness to minimize further growth of the detected flaw. The NRC staff notes the length of the WOL is designed such that it covers the axial length of the existing weld with sufficient length on either side of the subject weld to maximize UT examination coverage of 100 percent of the required volume.

As part of the design, Entergy needed to perform various analyses. The NRC staff finds acceptable that Entergy will perform a stress analysis to establish the residual stress profile in the WOL, weld 24-10-130, and the base meal of the tee and gate valve as part of the WOL design. The NRC staff finds acceptable that Entergy will perform fracture mechanics analysis to determine crack growth of the detected flaw in weld 24-10-130 to ensure that the detected flaw will not affect the structural integrity of the pipe and that the ASME Code, Section III, allowable stresses will be maintained. The NRC staff further finds acceptable that Entergy evaluated added weight on the piping systems due to the WOL for potential impact on piping system stresses and dynamic characteristics.

Pre-Installation Evaluation

Paragraphs (c) and (d) in Code Case N-504-4 and paragraphs Q-2000(b) and Q-2000(c) in Appendix Q require that before installing WOL, the surface to be repaired shall be examined by the liquid PT method. Any indication greater than 1/16 inch shall be repaired.
Paragraph 4(a)(1) in Code Case N-638-4 requires that surface examination be performed on the area to be welded; however, when surface examination is impractical, a VT-1 visual examination may be performed. Entergy stated that prior to WOL welding, it would perform a

surface examination of the area to be welded. The NRC staff finds acceptable that Entergy performed a surface examination and repaired any small indications greater than 1/16 inch before installation of the WOL in accordance with Code Cases N-504-4 and N-638-4 and Appendix Q.

Installation

The NRC staff has approved the use of ambient temperature temper bead welding technique method in Code Case N-638-4 with conditions. The NRC staff recognizes that based on the operating experience in the nuclear plants, the ambient temperature temper bead welding has provided satisfactory results. This welding technique was developed based on industry research and field applications. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this process. The NRC staff recognizes that repair welds performed with an ambient temperature temper bead procedure using the machine GTAW process do not significantly alter mechanical properties of those of the surrounding base material. Therefore, the NRC staff finds acceptable that Entergy will use the ambient temperature temper bead welding technique to deposit weld on the ferritic base metal of the gate valve in accordance with Code Case N-638-4.

Entergy proposed to use a contact pyrometer to measure preheat and interpass temperatures to meet Code Case N-638-4, paragraph 3(e)(1). In addition, in the first three layers, Entergy measured the interpass temperature every three to five passes. After the first three layers, Entergy measured the interpass temperature every six to ten passes for the subsequent layers. Entergy stated that the proposed preheat and interpass temperature controls are based on field experience with depositing WOLs and have been successfully used throughout the industry. The NRC staff finds that using a contact pyrometer and the proposed temperature measurements are acceptable because the interpass temperature of the WOL was monitored with sufficient frequency to ensure metallurgical properties of the heat affect zone to minimize fabrication defects.

Entergy stated that after the WOL installation, it would (a) measure weld shrinkage, (b) demonstrate that shrinkage stresses at other locations in the piping systems arising from the WOL will not have an adverse effect on the systems, (c) check clearances of affected supports and restraints after the overlay repair, and (d) reset within the design ranges if required. The NRC staff finds that these post-installation verifications satisfy Code Case N-504-4(g)(3) and are, therefore, acceptable.

Entergy stated that it is not possible to achieve the end transition slope of the WOL less than 45 degrees at some pipe azimuthal locations as required by paragraph (f)(1) in Code Case N-504-4 and paragraph Q-3000(b)(2) in Appendix Q. Entergy proposed to blend the WOL into the associated components to reduce stress concentration point and demonstrate the acceptability of the end transition slope by a finite element analysis. The NRC staff finds the proposed alternative acceptable because Entergy blended the end transition slope of the WOL into either the tee or gate valve to minimize stress concentrations and demonstrate the stresses are acceptable by analysis.

Entergy deposited buffer layers with a welding procedure and welders that have been qualified in accordance with the ASME Code, Section IX. Entergy performed liquid PT examinations before and after deposition of the buffer layer. The thickness of the buffer layers was not structurally credited towards the minimum design thickness of the WOL. The NRC staff finds that the proposed two PT examinations before and after deposition of the buffer layer are

appropriate because frequent examinations ensure integrity of the buffer layer. Also, the NRC staff finds it is conservative and acceptable that the thickness of the butter layer is not credited towards the design thickness of the WOL.

Examination – General Requirements

The NRC imposed the following conditions on Code Case N-504-4 in Revision 17 of RG 1.147: (a) the provisions of the ASME Code, Section XI, Appendix Q, must be met; (b) the sum of laminar flaw length in any direction shall be less than 10 percent of the overlay with a total reduction in area equal to or less than the ASME Code, Section XI, Table IWB-3514-3; (c) the finished overlay surface shall be 250 micro-inch (6.3 micrometers) root mean square or smoother; (d) the surface flatness shall be adequate for ultrasonic examination; and (e) radiography shall not be used to detect planar flaws under or masked by laminar flaws.

The NRC staff finds acceptable that the alternative does not take exceptions to the above conditions imposed on Code Case N-504-4.

The ASME Code, Section XI, Appendix Q, paragraph Q-4000, specifies that procedures and personnel for examining WOLs be qualified in accordance with the ASME Code, Section XI, Appendix VIII, Supplement 11. In addition, paragraphs 4(a), 4(a)(2), and 4(a)(4) in Code Case N-638-4 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 volumetrically examined the WOL using the UT method in accordance with the requirements and acceptance criteria of paragraph Q-4100 of the ASME Code, Section XI, Appendix Q. Entergy also complied with the performance demonstration requirements of the ASME Code, Section XI, Appendix VIII, Supplement 11, as modified by the EPRI PDI program.

The NRC staff notes that U.S. nuclear utilities created the PDI initiative to implement performance demonstration requirements contained in the ASME Code, Section XI, Appendix VIII. The industry's PDI initiative has developed a PDI program for qualifying equipment, procedures, and personnel in accordance with the UT criteria of Appendix VIII, Supplement 11. Prior to the Supplement 11 program, EPRI was maintaining a performance demonstration program (the precursor to the PDI program) for WOL qualification under the Tri-party Agreement with the NRC, BWR Owner's Group, and EPRI, as discussed in the NRC letter dated July 3, 1984 (ADAMS Legacy Accession No. 8407090122). Later, the NRC staff recognized the EPRI PDI program for WOL qualifications as an acceptable alternative to the Tri-party Agreement in its letter to the PDI Chairman, dated January 15, 2002 (ADAMS Accession No. ML020160532).

The PDI program is routinely assessed by the NRC staff for consistency with the current ASME Code and proposed changes. The PDI program does not fully comport with the existing requirements of Supplement 11. However, through various public meetings between the industry and NRC in 2001 and 2002 (ADAMS Accession Nos. ML010940402 and ML013330156), the NRC staff determined that the PDI program provides an acceptable level of quality and safety.

The NRC staff evaluated the differences identified in the proposed PDI program with respect to the requirements in Supplement 11 and the associated justifications as shown in Attachment 1 of this relief request. The NRC staff concludes that the justifications for the differences are reasonable, and the proposed PDI program provides an acceptable level of quality and safety.

Therefore, the proposed PDI program that will be used to examine the WOL as part of this relief request is acceptable.

Entergy stated that the length, surface finish, and flatness of the WOL complies with the general requirements of the ASME Code, Section XI, Appendix Q, Q-4100(a), to facilitate for the examinations. Figure Q-4100-1 in Appendix Q prescribes the examination volume for acceptance examinations, while Figure Q-4300-1 does the same for preservice and inservice examinations. Preservice and inservice examination requirements are specified in Q-4200 and Q-4300 of Appendix Q, respectively.

Entergy fabricated an NDE mock-up of the proposed WOL configuration. The NRC staff has imposed a condition on Code Case N-638-4 as shown in RG 1.147 that states: "Demonstration for ultrasonic examination of the repaired volume is required using representative samples which contain construction type flaws." Entergy has satisfied this condition by including manufactured flaws in the mock-up. The mock-up was used for training, prior to performing the actual WOL examination, to ensure that the qualified examiners are familiarized with aspects of the plant-specific WOL examination. The NRC staff finds acceptable that Entergy fabricated a mock-up for UT.

Acceptance Examination

Paragraph (j) in Code Case N-504-4 and Section Q-4100 of Appendix Q specify requirements for acceptance examination of WOLs. Figure Q-4100-1 of Appendix Q defines the UT examination volume for the acceptance examination. However, Entergy will not be able to achieve 100 percent coverage because of the configuration of the tee and gate valve. As an alternative, Entergy performed a manual phased array UT examination to obtain greater than 90 percent of the examination volume. The NRC staff has traditionally required 100 percent UT examination coverage of the Alloy 82/182 dissimilar metal butt weld for WOL relief requests. The NRC staff notes that the subject weld at FitzPatrick is located between a tee and a gate valve, which have a configuration that is not conducive for the UT of the weld. The NRC staff recognizes that it is difficult and impractical for Entergy to achieve 100 percent UT examination coverage. However, Entergy stated that it can achieve, at a minimum, greater than 90 percent UT examination coverage that is permitted under NRC-approved Code Case N-460. Therefore, the NRC staff finds that the greater than 90 percent UT examination coverage is acceptable in this plant-specific situation.

Preservice and Inservice Examination

Paragraph (i) in Code Case N-504-4 and Section Q-4200 in Appendix Q specify preservice inspection requirements for WOLs, while Section Q-4300 of Appendix Q specifies ISI requirements. Figure Q-4300-1 of Appendix Q defines the UT examination volume for both preservice and ISIs. Entergy will not be able to achieve 100 percent of examination coverage for the preservice and inservice examination. As an alternative, Entergy performed a manual phased array UT examination to achieve greater than 90 percent of the examination volume, as defined in Figure Q-4300-1. As discussed above, the NRC staff finds that the greater than 90 percent UT examination coverage is acceptable because the examination coverage satisfies Code Case N-460.

The NRC staff finds acceptable that once the WOL is installed, weld 24-10-130 will be classified as Category "E" weld, which is a cracked weld that has been mitigated by a WOL repair as defined by paragraph 3.5 in BWRVIP-75-A. As such, weld 24-10-130 will be inspected in

accordance with paragraph 3.5.1.1 in BWRVIP-75-A in the future. In addition, the weld will be inspected in accordance with the ASME Code, Section XI, Appendix Q, Section Q-4300. The NRC staff finds Entergy's inservice examination acceptable because it is consistent with the ASME Code, Section XI, Appendix Q, Section Q-4300, and paragraph 3.5.1.1 in BWRVIP-75-A.

Pressure Testing

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

Extent of Condition

The NRC staff notes that during RO-22, Entergy UT examined ISI welds 24-10-130, 24-10-131, 24-10-132, 24-10-142, 24-10-143, and 24-10-144, to comply with the inspection requirements of BWRVIP-75-A for Category "D" welds. Also, Entergy inspected six additional Category "D" welds by UT during the RO-22 to comply with the scope expansion criteria in paragraph 3.4.1 in BWRVIP-75-A. The NRC staff finds acceptable that Entergy has satisfied the extent of condition inspection of BWRVIP-75-A.

Post-Installation Submittals

The NRC staff has requested all licensees who submit a relief request to install WOLs on Alloy 82/182 dissimilar metal butt welds to submit information regarding WOL examinations after completion of installation. The NRC staff was concerned with potential fabrication defects because of the complexity involved in using Alloy 52M and the WOL design. In addition, the exigent nature of RR-21 precludes Entergy's ability to have completed the necessary analyses at the time of the relief request submission. Entergy submitted its examination results shortly after completion of RO-22. The NRC staff finds the examination results of the WOL and the stress analysis summary acceptable and submitted in a specified timeframe.

Based on the above evaluation, the NRC staff finds that the WOL of weld 24-10-130 is acceptable to maintain the structural integrity of the subject piping because Entergy followed the requirements of Code Cases N-504-3 and N-638-4 and the ASME Code, Section XI, Appendix Q, with certain alternatives. For those requirements to which Entergy takes exceptions, acceptable justification was provided.

4.0 CONCLUSION

Based on the discussion above, the NRC staff concludes that the alternative used in RR-21 will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(z)(1), the NRC staff authorizes the use of RR-21 for the fourth 10-year ISI interval and this authorization is acceptable until the end of the period of extended operation, which expires on October 17, 2034.

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

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