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

April 1, 2019

Mr. Fadi Diya
Senior Vice President and
Chief Nuclear Officer
Ameren Missouri
Callaway Energy Center
8315 County Road 459
Steedman, MO 65077

SUBJECT: CALLAWAY PLANT, UNIT NO. 1 – REQUEST FOR ALTERNATIVE I4R-05 TO REACTOR VESSEL NOZZLE WELD EXAMINATION FREQUENCY REQUIRMENTS (EPID L-2018-LLR-0051)

Dear Mr. Diya:

By letter dated April 9, 2018, as supplemented by letter dated January 25, 2019, Union Electric Company, dba Ameren Missouri (the licensee) submitted Relief Request I4R-05 to the U.S. Nuclear Regulatory Commission (NRC) for the Callaway Plant, Unit No. 1 (Callaway), for use of an alternative to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI requirements. The licensee has requested the NRC to authorize the use of an alternative to the examination frequency requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(g)(6)(ii)(F), with conditions, for reactor pressure vessel inlet and outlet dissimilar metal butt welds mitigated by peening at Callaway.

Specifically, pursuant to 10 CFR 50.55a(z)(1), the licensee requested to use a proposed alternative on the basis that the alternative would provide an acceptable level of quality and safety.

The NRC staff has reviewed the subject request and concludes, as set forth in the enclosed safety evaluation, that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(g)(6)(ii)(F). Therefore the NRC staff authorizes Relief Request I4R-05, at Callaway, for the fourth inservice inspection interval concerning this examination frequency.

All other ASME Code, Section XI and 10 CFR 50.55a(g)(6)(ii)(F) requirements for which relief was not specifically requested and approved in the subject requests for relief remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact the Project Manager, John Klos, at 301-415-5136 or via e-mail at John.Klos@nrc.gov.

Sincerely,

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

Docket No. 50-483

Enclosure:
Safety Evaluation

cc: Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR ALTERNATIVE I4R-05 TO REACTOR VESSEL NOZZLE WELD

EXAMINATION FREQUENCY REQUIREMENTS

UNION ELECTRIC COMPANY

CALLAWAY PLANT, UNIT NO. 1

DOCKET NO. 50-483

1.0 INTRODUCTION

By letter dated April 9, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18099A120), as supplemented by letter dated January 25, 2019 (ADAMS Accession No. ML19025A070), Union Electric Company, dba Ameren Missouri (the licensee), submitted Relief Request I4R-05 to the U.S. Nuclear Regulatory Commission (NRC) for the Callaway Plant, Unit No. 1 (Callaway), for use of an alternative to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI requirements. The licensee has requested the NRC to authorize the use of an alternative to the examination frequency requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(g)(6)(ii)(F), with conditions, for reactor pressure vessel inlet and outlet dissimilar metal butt welds (DMBWs) mitigated by peening at Callaway.

Specifically, pursuant to 10 CFR 50.55a(z)(1), the licensee requested to use a proposed alternative on the basis that the alternative would provide an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(g)(4), "Inservice inspection standards requirement for operating plants," ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components.

Pursuant to 10 CFR 50.55a(g)(6)(ii), "Augmented ISI program," the NRC may require licensees to follow an augmented inservice inspection (ISI) program for systems and components for which the Commission deems that added assurance of structural reliability is necessary.

Pursuant to 10 CFR 50.55a(g)(6)(ii)(F)(1), "Augmented ISI requirements: Examination requirements for Class 1 piping and nozzle dissimilar-metal butt welds—(1) Implementation," licensees shall implement the requirements of ASME Code Case N-770-2 instead of ASME Code Case N-770-1, subject to the conditions specified in paragraphs [50.55a(g)(6)(ii)(F)(2) through 50.55a(g)(6)(ii)(F)(13) of 10 CFR], by the first refueling outage starting after August 17, 2017."

The regulation in 10 CFR 50.55a(z), "Alternatives to codes and standards requirements," states, in part, that alternatives to the requirements of paragraph (g) of 10 CFR 50.55a may be used, when authorized by the NRC, if the licensee demonstrates that (1) the proposed alternative provides 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 the NRC to authorize the licensee's proposed alternative for Callaway. Accordingly, the NRC staff reviewed and evaluated the licensee's request pursuant to 10 CFR 50.55a(z)(1), "Acceptable level of quality and safety."

3.0 TECHNICAL EVALUATION

3.1 ASME Code Components Affected by the Proposed Alternative

The licensee's request is applicable to the following reactor pressure vessel inlet and outlet DMBWs:

Weld Designation	Weld Description
2-RV-301-121-A	Loop 1 outlet nozzle to safe-end
2-RV-301-121-B	Loop 2 outlet nozzle to safe-end
2-RV-301-121-C	Loop 3 outlet nozzle to safe-end
2-RV-301-121-D	Loop 4 outlet nozzle to safe-end
2-RV-302-121-A	Loop 1 inlet safe-end to nozzle
2-RV-302-121-B	Loop 2 inlet safe-end to nozzle
2-RV-302-121-C	Loop 3 inlet safe-end to nozzle
2-RV-302-121-D	Loop 4 inlet safe-end to nozzle

3.2 Applicable Code Edition, Addenda, and Requirement

Paragraph 50.55a(g)(6)(ii)(F)(1) of 10 CFR requires the use of ASME Code Case N-770-2. The licensee's request pertains to the examination frequency requirements of ASME Code Case N-770-2, Table 1, Items A-2 and B that requires volumetric examination of unmitigated butt welds at hot leg and cold leg operating temperatures every 5 years and every second inspection period not to exceed 7 years, respectively.

The NRC staff notes that the inspection requirement under 10 CFR 50.55a(g)(6)(ii)(F) is a requirement regardless of the inspection requirements of the ASME Code, Section XI for the 10-year ISI interval at Callaway. This is because the requirement for which the licensee is requesting relief is an augmented ISI program in 10 CFR 50.55a, and a direct regulation.

3.3 Licensee's Proposed Alternative

The licensee's proposed alternative is to extend the weld examination frequency required by 10 CFR 50.55a(g)(6)(ii)(F) for the Callaway DMBWs, listed above in Section 3.1 of this safety evaluation (SE). This would allow the inspections to be conducted in accordance with the inspection frequency requirements for Alloy 82/182 DMBWs mitigated by water jet peening (WJP), based on Item L of Table 4-1 in the Electric Power Research Institute report "Materials Reliability Program [MRP]: Topical Report for Primary Water Stress Corrosion Cracking Mitigation by Surface Stress Improvement (MRP-335, Revision 3-A)" (ADAMS Accession No. ML16319A282).

3.4 Licensee's Bases for Use

The licensee explained that the WJP process, implemented at Callaway during the fall 2017 refueling outage, was developed by vendor Mitsubishi Heavy Industries (MHI) for use in Japan and has been successfully implemented on the reactor vessel nozzles in the Japanese pressurized-water reactor (PWR) fleet. It was brought to the United States by MHI subsidiary Mitsubishi Nuclear Energy Systems (MNES) (MHI and MNES are referred to hereafter as Mitsubishi). Mitsubishi has classified WJP as a special process in accordance with 10 CFR Part 50, Appendix B, on such welds as those identified in Section 3.1 of this SE.

The licensee is seeking NRC authorization of the proposed alternative in accordance with 10 CFR 50.55a(z)(1) on the basis that the proposed alternative would provide an acceptable level of quality and safety. In its application of the WJP mitigation process, the licensee indicated that its proposed alternative does not adversely impact the level of safety or quality, and provides reasonable assurance that the structural integrity and the leak tightness of the welds will be maintained. The licensee states that WJP will prevent future primary water stress corrosion cracking, and arrest the growth of pre-existing shallow flaws not identified in the pre-peening volumetric examinations.

The licensee indicated that the WJP process would follow the inspection guidance and meet the performance criteria of MRP-335, Revision 3-A. The licensee explained that it performed pre-peening inspections and would perform followup and subsequent ISI examinations, as required by Table 4-1 of MRP-335, Revision 3-A. The licensee also provided a complete description of the application of the WJP as a special process at Callaway. The licensee summarized the performance demonstration to confirm all performance criteria requirements of MRP-335, Revision 3-A, were met by the application of the WJP process at Callaway. The performance criteria are listed below:

- Peening Coverage - The required coverage is the full area of the susceptible material along the entire wetted surface under steady-state operation. Susceptible material includes the weld, butter, and base material, as applicable. The coverage shall be extended at least 0.25 in [inches] (0.64 cm [centimeters]) beyond the susceptible material.

- Stress Magnitude - The residual stress plus normal operating stress is compressive on all peened surfaces.

- Depth of Effect - The compressive residual stress field extends to a minimum nominal depth of 0.04 in (1.0 mm [millimeters]) on the susceptible material along the wetted surface.

- Sustainability of Effect - The mitigation process is effective for at least the remaining service life of the component, i.e., the residual plus normal operating surface stress state after considering the effects of thermal relaxation and load cycling (i.e., shakedown) must remain compressive.

- Inspectability - The capability to perform ultrasonic examinations of the relevant volume of the component is not adversely affected, and the relevant volume is inspectable using a qualified process. The capability to perform eddy current examinations of the relevant surface of the component is not adversely affected.

- Lack of Adverse Effects - As verified by analysis and testing, the mitigation process is not to have degraded the component, caused detrimental surface conditions, or adversely affected other components in the system.

The licensee provided an additional specific basis to demonstrate compliance with these performance criteria items, and address the "Practical Considerations" of Section 5 of the NRC SE for the use of MRP-335, Revision 3-A, by letter dated August 24, 2016 (ADAMS Accession No. ML16208A485). These "Practical Considerations" included additional information on the peening application, peening coverage, residual stresses at the end of plant life, uncertainty of residual stress measurements, and use of x-ray diffraction to determine residual stresses.

The licensee also provided a summary of the application of the WJP process on the subject welds. The licensee concluded that the applicable peening performance criteria of MRP-335, Revision 3-A, Section 4.2.8, were satisfied, considering coverage area and post-peened residual plus operating stresses. The testing, analysis and implementation documentation showed that the surface stress improvement was achieved, and that the required operating stress effect and depth of compression will be sustained with sufficient margin for the remaining service life of the reactor vessel nozzles.

3.5 Duration of Proposed Alternative

The licensee has requested that the duration of the proposed alternative would be for the remainder of the fourth 10-year ISI interval at Callaway, which is currently scheduled to end on December 18, 2024.

3.6 NRC Staff's Technical Evaluation

The NRC staff has reviewed and evaluated the licensee's request on the basis that the proposed alternative would provide an acceptable level of quality and safety. The applicable requirement is the qualified volumetric inspection of the subject welds, which is currently based on an inspection category for the unmitigated weld associated with reactor coolant loop temperature, as specified in 10 CFR 50.55a(g)(6)(ii)(F). This requirement is based on a general assessment of the necessary qualified volumetric inspection frequency for all DMBWs, of any size, in the reactor coolant system to maintain reasonable assurance of structural integrity. The licensee's proposed alternative would, after application of the WJP process, extend the inspection frequency of the subject welds per MRP-335, Revision 3-A. The NRC SE of MRP-335, Revision 3, concluded that the peening application, in combination with the proposed inspection requirements of MRP-335, Revision 3, and conditions imposed by the safety evaluation, would provide reasonable assurance of the adequate protection of public health and safety.

The NRC staff reviewed the licensee's use of the WJP process at Callaway to support the licensee's proposed alternative. The purpose of the NRC staff review was to determine if the licensee met the performance criteria, practical considerations, and pre-peening inspection requirements of MRP-335, Revision 3-A as documented in the NRC SE. Once the NRC staff finds that the proposed WJP is acceptable, the licensee's proposed extension of the inspection frequency of the subject DMBWs would be acceptable per the NRC's SE for MRP-335, Revision 3-A.

Performance Criteria

Peening Coverage

As discussed in paragraph 4.2.8.1 of MRP-335, Revision 3-A, the stress effect performance criterion provides the required peening coverage area. It is the full area of the susceptible material along the entire wetted surface under steady-state operation. Susceptible material includes the weld, butter, and base material, as applicable. The coverage shall be extended at least 0.25 in (0.64 cm) beyond the susceptible material (see the red or dashed line in Figure 1 below).

The licensee used eddy current testing to verify the dissimilar metal weld boundaries on the inside diameter of the pipe. The NRC staff found this to be a reliable methodology to determine the size of the weld on the inside surface of the pipe. The licensee also used a predetermined coverage scheme that accounted for the spray width from the WJP nozzle, spray overlap between passes, and spray coverage relative to the edge of the DMBWs on the inside surface. The licensee used a value of 13.4 mm to extend the coverage beyond the edge of the susceptible weld material on the inside surface on either side of the weld (see the blue or dotted lines of the 1st to 3rd Steps in Figure 1 below). This value exceeds the required 6.4 mm of MRP-335, Revision 3-A. The licensee further provided additional information demonstrating the quality controls over the software program and data collection used to verify the remote control and coverage requirements that were obtained by the spray nozzles. Therefore, the NRC staff finds the licensee met the coverage requirements of paragraph 4.2.8.1 of MRP-335, Revision 3-A, for the subject welds.

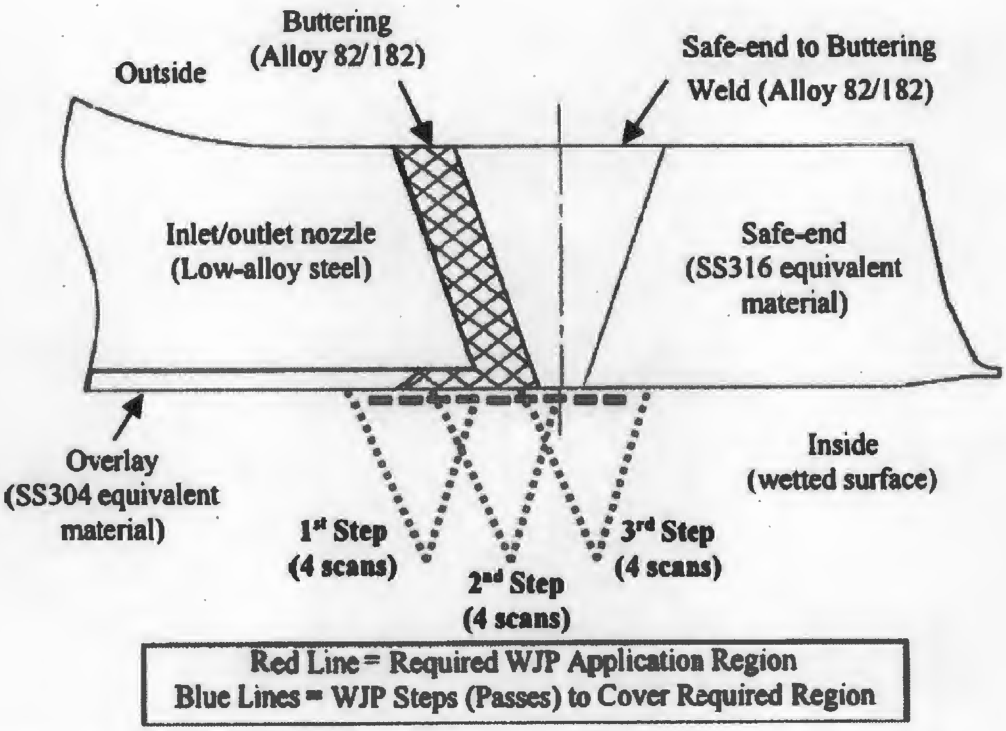

Figure 1 – B-HL Reactor Vessel Nozzle WJP Application

Stress Magnitude

As discussed in paragraph 4.2.8.1.1 of MRP-335, Revision 3-A, the stress magnitude performance criterion occurs when the residual stress plus normal operating stress is compressive on all peened surfaces.

The licensee measured residual stress of the peened base metal surface near the weld on representative test coupons. The NRC staff reviewed the effectiveness of this technique given the differences in microstructure between the plate base metal and weld materials. The licensee noted that the similarities in the elasto-plastic behavior, along with the consideration of the microstructure influence, showed that the residual stress profiles of both base metal and weld materials would be similar. Additionally, the licensee's supplement dated January 25, 2019, provided data to support these assessments. The NRC staff found the assessment adequate and consistent with the use of the x-ray diffraction weld residual stress measurement technique for welds in other industries. Therefore, the NRC staff finds that the licensee's methodology to measure the weld residual stresses of the weld on the base material was acceptable.

The licensee used these residual stress measurements to demonstrate the stress improvement effect of the peening methodology used on the subject welds. The NRC staff reviewed the results of the measurements on the test coupons. The NRC staff found the surface stresses were in significant compression typical of similar peening techniques on welded surfaces. The licensee used these measurements as an input into a finite element analysis to evaluate the effect of operating stresses, including potential shakedown stresses that might occur to reduce the magnitude of the peening effect over the lifetime of the current authorized period of operation. The NRC staff reviewed the use and application of the finite element analysis and found it adequately simulated the effect of expected operating stresses and their effect on the surface conditions of the peened welds. The NRC staff found that the resulting surface stresses were in compression through the analysis and would be for the remaining plant lifetime of Callaway. Therefore, the NRC staff finds that the licensee's demonstration and finite element analysis, and their results, were acceptable.

The licensee also noted that the WJP process had been demonstrated through testing to remain effective under plant operating conditions. These tests included the thermal aging, and the application of startup and shutdown cyclic stress to be expected over a plant's lifetime. The licensee noted that the results of the finite element analysis and testing concluded that the subject weld surfaces would remain in compression for the remaining plant lifetime for Callaway. The NRC staff considered the impact of these additional tests, and found it was effective and representative to address the effects of operating conditions expected at Callaway for the remaining authorized license. Therefore, the NRC staff finds that the testing provides additional defense-in-depth to demonstrate that the WJP application is acceptable.

The NRC staff's review of the licensee's basis to show the application of the WJP process at Callaway was effective to meet the surface stress magnitude performance criterion of MRP-335, Revision 3-A, included an assessment of the measurement technique, the results, use of finite element analysis, and additional testing. The NRC staff finds that each of these techniques were acceptable, and together provides reasonable assurance that the surface stress magnitude performance criterion of paragraph 4.2.8.1.1 of MRP-335, Revision 3-A was met at Callaway.

Nominal Depth of Compressive Residual Stress

As discussed in paragraph 4.2.8.1.2 of MRP-335, Revision 3-A, the nominal depth of compressive residual stress performance criterion requires a compressive residual stress field that extends to a minimum nominal depth of 0.04 inches (1.0 mm) on the susceptible material along the wetted surface.

Similar to the stress magnitude performance criterion, the licensee used residual stress measurements of the peened base metal surface near the weld on representative test coupons. As stated previously, the NRC staff finds the licensee's measurements and measuring techniques for the residual stresses of the weld base material to be acceptable.

The licensee explained that through this testing, critical parameters were developed that identified the minimum and maximum application ranges for effective WJP treatment. One critical parameter that the NRC staff verified was the number of passes or scans used for the mock-up test versus the application of the technique on the subject field welds. The licensee clarified in its supplement dated January 25, 2019, that four scans were used for both processes, as noted in Figure 1 above. In reviewing this and other critical parameters identified by the licensee, the NRC staff confirmed that the mockup testing results were representative of the stress effect caused by the application of the WJP process on the subject welds and was an acceptable demonstration technique.

The licensee stated that these tests demonstrated that under all test conditions applied, the WJP process created a layer of compressive residual stress to a minimum depth of 0.04-inch (1 mm). The NRC staff reviewed the licensee's results and confirmed the conclusion that using the applicable critical parameter ranges, the licensee was able to obtain compressive residual stresses to, at minimum, a depth of 0.04-inch (1.0 mm). Therefore, the NRC staff finds the licensee met the performance criterion of paragraph 4.2.8.1.2 of MRP-335, Revision 3-A, for the nominal depth of compressive residual stress.

Sustainability

As discussed in paragraph 4.2.8.2 of MRP-335, Revision 3-A, the sustainability performance criterion requires that the mitigation process is effective for at least the remaining service life of the component.

The licensee stated that;

1) In accordance with the performance criteria, testing and analysis performed, it demonstrates the required stress improvement effect meets the required stress magnitude and depth; and

2) That these also show that the effect will be sustained for at least the service life of the peened components.

The NRC staff notes that this performance criterion addresses the compressive surface stress condition only. The licensee stated that testing was performed, which included thermal aging and application of startup and shutdown cyclic stress expected over a plant's lifetime. The licensee also stated that the results of the finite element analysis and testing concluded that the subject weld surfaces would remain in compression for the remaining plant lifetime. The NRC staff reviewed the type of testing and analysis and found it was effective and representative of the effects of operating conditions expected at Callaway for the remaining authorized license. The NRC staff found the licensee demonstrated with reasonable assurance that the surface stresses would remain in compression for the remaining service life. Therefore, the NRC staff finds that the licensee met the sustainability performance criterion of paragraph 4.2.8.2 of MRP-335, Revision 3-A.

Inspectability

As discussed in paragraph 4.2.8.3 of MRP-335, Revision 3-A, the inspectability performance criterion requires that the capability to perform qualified ultrasonic examinations of the relevant volume and eddy current examinations of the relevant surfaces of the peened component is not adversely affected.

The licensee verified through testing that WJP will result in no adverse impact on the surface of the weld using both visual and liquid dye penetrant tests. Further, the licensee stated that no adverse surface profile changes occurred that could interfere with the inspectability from the wetted surface of the weld. The licensee also provided references of testing on successful reexamination of plants in Japan where the WJP process had been applied to components. In all cases, the licensee stated, there was no geometry change, no significant increase in surface roughness, and no measurable change in surface contour from the WJP process. The licensee also provided documentation of a third-party review by EPRI of the WJP process used at Callaway to show that the peened surface was not adversely affected, and the capability to perform eddy current and ultrasonic testing was retained. The NRC staff reviewed this information and found the analysis comprehensive, and provided defense-in-depth with third-party review, and operational experience from international application of the same WJP process used at Callaway. The NRC staff finds the licensee's conclusion acceptable and that the licensee met the inspectability performance criterion of paragraph 4.2.8.3 of MRP-335, Revision 3-A.

Lack of Adverse Effects

As discussed in paragraph 4.2.8.4 of MRP-335, Revision 3-A, the lack of adverse effects performance criterion requires that, as verified by analysis or testing, the mitigation process does not degrade the component, cause detrimental surface conditions, or adversely affect other components in the system.

The licensee used the qualification testing that identified critical parameters and their acceptable ranges of application to verify the lack of adverse effects. The primary purpose of the testing for critical parameters and their acceptable ranges was to establish the application conditions of the WJP process for the subject welds, and then monitor these parameters as the WJP process is applied. Through this process, the licensee was able to provide an effective and controlled process. To address the possibility that this monitoring system may not respond promptly to critical parameters and ranges, the licensee tested the process for the singular mechanism, which could cause harm to the subject welds—that being the longer application of the WJP to a particular spot or area. In order to accomplish this, the licensee tested the process with the application nozzle slowed to a rate of 480 minutes per meter and, also, in a case where it would not move for 2 minutes, thereby, simulating a stuck nozzle. The average recorded application time in the field was stated in the licensee's supplement dated January 25, 2019, which was significantly better than the licensee's tested speed. In all testing, the licensee stated that no adverse effects of the WJP application were identified, and the overall effect of increasing the application time in a spot or area did not cause adverse effects. The NRC staff reviewed the testing used by the licensee to verify these conditions and found the parameters were consistent with the application, and the cause of potential failure was correctly identified and analyzed through the qualification testing. The NRC staff reviewed the results and finds the licensee's conclusion acceptable for the qualification testing.

The licensee also reviewed the data collected from the application of the WJP process on each of the subject welds and confirmed that all critical parameter ranges during the process stayed within the values identified in the initial qualification testing. The licensee explained that if critical parameters exceed the specified range during the peening process in the field, the operators are notified via software alarms and the process is shutdown. The NRC staff found that the licensee did not identify any condition in the field application that would challenge the testing parameters used by the licensee to verify no adverse effects. Further, the licensee stated that no adverse effect of the WJP application occurred at Callaway. The NRC staff found that this review provides clear evidence that the process did not allow the nozzle to either slow to an unacceptable rate or become stuck. Therefore, the NRC staff finds with reasonable assurance that no adverse effects occurred during the WJP application process at Callaway, and the performance criterion of paragraph 4.2.8.4 of MRP-335, Revision 3-A, regarding lack of adverse effects, was met.

Ultrasonic Testing Qualification

As discussed in paragraph 4.2.8.5 of MRP-335, Revision 3-A, the ultrasonic testing qualifications performance criterion requires that the required examination volume of the mitigated configuration is within the scope of an ASME Code, Section XI, Mandatory

Appendix VIII, supplement or supplements, and that the examination procedures to be used have been qualified in accordance with Mandatory Appendix VIII.

The licensee confirmed that ultrasonic testing was performed in accordance with MRP-335, Table 4-1. This requires a volumetric inspection that meets the requirements of Mandatory Appendix VIII of the ASME Code, Section XI. The NRC staff finds that the licensee meets the ultrasonic testing qualification performance criterion of paragraph 4.2.8.5 of MRP-335, Revision 3-A.

Pre-peening Ultrasonic and Eddy Current Testing

As discussed in paragraph 4.2.8.6 of MRP-335, Revision 3-A, the pre-peening ultrasonic and eddy current testing performance criterion requires that both tests have been performed in accordance with Table 4-1 of MRP-335, Revision 3-A, to ensure the absence of planar surface flaws before the application of the peening mitigation.

The licensee stated that in accordance with MRP-335, Revision 3-A, Table 4-1, both ultrasonic and eddy current testing were performed for all of the subject welds. In addition, the licensee stated that 100 percent coverage of the required volume or area was obtained and no indications were identified in the welds or on their surfaces by the licensee. The NRC staff reviewed the information provided and finds that the licensee meets the performance criterion of paragraph 4.2.8.6 of MRP-335, Revision 3-A, pre-peening ultrasonic and eddy current testing.

Practical Considerations

Uncertainty of Residual Stress Measurements using X-ray Diffraction

In Section 5 of the NRC SE for MRP-335, Revision 3-A, the NRC staff stated that the precise residual stress measurement specified will be achieved in the peening qualification testing. However, the NRC staff is aware of a substantial body of data that indicates that there is considerable uncertainty in residual stress measurements.

The licensee addressed the residual stress measurement uncertainties in large part by performing the measurements on the plate material next to the weld on the mock-up test specimens. The licensee also stated that both plate and weld materials received the same WJP application and scans to accurately simulate the same stress effect in the plate versus the weld material. The licensee stated that there was no difference in the uncertainties of the x-ray residual stress measurements in the calibration method and the x-ray residual stress measurement in the mockup. The licensee explained that the American Society for Testing and Materials' standards were used to develop the parameters and determined a +/- 2 kilo pound per square inch uncertainty band. The licensee explained that while the materials were different between the plate and weld, both materials had a similar elasto-plastic behavior (mechanical strength). Therefore, the licensee contended that the residual stress measured in the plate material would be a valid representation of the weld. The licensee did not measure residual stresses in the peened weld in the test specimen. The licensee also provided summary tables of the material properties for review.

The NRC reviewed the licensee's assessment; however, several questions were raised by the NRC staff regarding the use of x-ray diffraction measurements on the plate material versus directly on the weld itself that included issues of stress profile, measurement error, oxide layers, mockup size, and thickness. In the licensee's supplemental response, dated January 25, 2019, the NRC staff found the use of an ASTM standard for determination of uncertainty on a plate material consistent with the use of x-ray diffraction as a measurement technique throughout all industry applications, and therefore acceptable. The NRC staff reviewed the provided materials' data and found the licensee's assessment of the effect of a similar elasto-plastic behavior effect allowing representative weld residual stress impact on materials with a similar peening process applied acceptable. The NRC staff finds that the licensee's analysis of the thinness of the oxide layer having minor impact on the effectiveness of the peening process, which is also stated in MRP-335, Revision 3-A, is acceptable. The NRC staff also found, given the overall dimension of the subject DMBWs being peened as so large that their curvature could be reasonably ignored in a test mockup, that the licensee's position that the flat plate was a reasonable representative sample. The NRC staff also found that the test piece itself was thick enough to support the relatively shallow compression effects imparted by the peening effect. Therefore, the NRC staff finds that the licensee adequately addressed the NRC's concern on the uncertainty in the residual stress measurements using x-ray diffraction for the application of WJP of the subject welds at Callaway.

Application of WJP

Confirmation of Meeting Qualification Process

The licensee stated that through the demonstration process, the critical parameters were identified and their effective ranges were defined for the qualification process. Any deviation from these ranges would cause an alarm in the software, and the peening process would be shutdown during field application. The NRC staff raised two concerns regarding this approach. The first was to verify that the residual stresses in the mockup were representative of the field condition; and the second was to understand any deviations from the critical parameters as implemented at Callaway, and the basis for how the licensee stayed within the qualified acceptance criteria.

The licensee stated that the original tensile stresses in the plate mockup were equivalent or higher than the weld in the field due to the fabrication process of the mockup. The original residual stresses were also provided in the licensee's supplement dated January 25, 2019. The NRC staff reviewed the information and agrees that the tensile stresses in the mockup would be representative of a field weld. Therefore, this along with the discussion of plate versus weld measurement in the uncertainty section above, provides the NRC staff with reasonable assurance that the demonstration mockup was representative of the field weld conditions.

The licensee stated that with the exception of one deviation, all aspects of the qualification testing critical parameters, as implemented at Callaway, were achieved and stayed within the qualified acceptance criteria. According to the licensee, the single deviation during field application occurred for only 3 seconds on the Bravo-Hot Leg reactor pressure vessel nozzle WJP application process. A low flow rate occurred from the WJP nozzle for 3 seconds during the second of four WJP scanning passes while in the third WJP step, as shown in Figure 1 above in this SE. The actual flowrate exiting the peening nozzle, at the time, was above the minimum qualified critical parameter, but the application of a -3.39 percent accuracy correction caused the calculated minimum possible flow rate to be 44.9 liter/minute, which is just below the qualified level of 45 liter/minute. The licensee considered this deviation to be insignificant because the other three scans were not similarly affected when this section was re-peened. The licensee also considered this deviation insignificant because it occurred for a limited time of 3 seconds with the potential for lower flow of only 0.1 liter/minute. The NRC staff reviewed this information and finds that it is reasonable considering the licensee's assessment of this deviation, specifically due to the limited time and impact. Additionally the NRC staff notes that the surface stress for this area of the mockup is in significant compression, greater than 400 mega pascal (MPa) compressive pressure, and 3 seconds of a minor potential flow distribution in one of four passes of the direct application of the water jet over this area is reasonably insignificant. Therefore, the NRC staff finds that the licensee's quality controls and the application of the WJP process, at Callaway provides reasonable assurance that an effective WJP application was performed over the entire required coverage area for each of the subject welds.

NRC Staff Technical Conclusion

The NRC staff finds the licensee's proposed alternative is acceptable on the basis that the licensee demonstrated that the application of the WJP process at Callaway for the subject welds met the performance criteria, practical consideration, and pre-peening inspection requirements of MRP-335, Revision 3-A. Therefore, in accordance with the conclusion of the NRC safety evaluation for the use of MRP-335, Revision 3-A, the NRC staff finds that the licensee's application of the WJP process provides reasonable assurance of structural integrity for the subject welds through the period of duration for the proposed alternative. Therefore, the NRC staff finds that the proposed alternative will provide an acceptable level of quality and safety.

4.0 CONCLUSION

As set forth above, the NRC staff determines that the licensee has demonstrated that alternative request I4R-05 provides reasonable assurance of structural integrity of the subject components and will provide an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes the use of the alternative to I4R-05 at Callaway, for the remainder of the fourth 10-year ISI interval at Callaway, which is currently scheduled to end on December 18, 2024.

All other ASME Code, Section XI and 10 CFR 50.55a(g)(6)(ii)(F) requirements for which relief was not specifically requested and approved in the subject requests for relief remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

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Date: April 1, 2019

SUBJECT: CALLAWAY PLANT, UNIT NO. 1 – REQUEST FOR ALTERNATIVE I4R-05 TO REACTOR VESSEL NOZZLE WELD EXAMINATION FREQUENCY REQUIRMENTS (EPID L-2018-LLR-0051) DATED APRIL 1, 2019

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