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

June 22, 2023

**NINE MILE POINT NUCLEAR STATION, UNIT NO. 1– AUTHORIZATION AND SAFETY EVALUATION FOR ALTERNATIVE RELIEF REQUEST I5R-11 CONCERNING THE INSTALLATION OF A WELD OVERLAY ON REACTOR PRESSURE VESSEL RECIRCULATION INLET NOZZLE N2E SAFE END-TO-NOZZLE DISSIMILAR METAL WELD (EPID: L-2023-LLR-0011)**

## LICENSEE INFORMATION

**Recipient's Name and Address**: Mr. David P. Rhoades
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**Licensee:** Constellation Energy Generation, LLC (CEG)

**Plant Name and Unit:** Nine Mile Point Nuclear Station, Unit No. 1

**Docket No.:** 50-220

## APPLICATION INFORMATION

**Application Date:** March 24, 2023

**Application Agencywide Documents Access and Management System (ADAMS) Accession No.:** ML23083B991

**Supplement Dates:** March 27, March 29, and March 30, 2023

**Supplement ADAMS Accession Nos.:** ML23086C088, ML23088A165, and ML23089A230, respectively.

**Licensee Proposed Alternative No. or Identifier:** I5R-11

**Applicable Inservice Inspection (ISI) Program Interval and Interval Start/End Dates:** The fifth 10-year ISI interval for Nine Mile Point Nuclear Station, Unit No. 1 (Nine Mile Point, Unit 1), began on April 23, 2019, and is scheduled to end August 22, 2029.

**Alternative Provision:** The applicant requested an alternative under Title 10 of the *Code of Federal Regulations* (10 CFR), paragraph 50.55a(z)(1).

**ISI Requirement:** American Society of Mechanical Engineer (ASME) Boiler & Pressure Vessels Code (Code), Section XI, “Rules for Inservice Inspection of Nuclear Power Plant Components,” IWA-4411, IWA-4411(a), IWA-4411(b), IWA-4412, IWA-4611and IWB-3640.

**Applicable Code Edition and Addenda:** The applicable code of record for the fifth 10-year ISI interval at Nine Mile Point, Unit 1, is ASME Code, Section XI, 2013 Edition.

**Verbal Authorization:**

On March 31, 2023 (ML23090A130), the U.S. Nuclear Regulatory Commission (NRC) verbally authorized the use of Relief Request I5R-11 at Nine Mile Point, Unit 1, on the basis that the proposed alternative provides an acceptable level of quality and safety, and the structural integrity and leak tightness of the subject overlaid weld will be maintained until the end of the next refueling outage (N1R28). This safety evaluation documents the technical basis for the NRC's verbal authorization.

**Brief Description of the Proposed Alternative:**

During automated encoded ultrasonic testing (UT) examination of N2E safe end-to-nozzle dissimilar metal (DM) weld 32-WD-208, an axial flaw was discovered in the Alloy 82/182 weld metal and adjacent 316 stainless steel safe end. The flaw has attributes that are indicative of intergranular stress corrosion cracking (IGSCC). In lieu of performing an ASME Code repair/replacement activity in accordance with IWA-4000 and IWB-3640, CEG plans to apply a “design” (leakage barrier) weld overlay (WOL) using Alloy 52M. The leakage barrier WOL will ensure continued leak tightness of the DM weld 32-WD-208 until a permanent repair can be performed during the next refueling outage (N1R28), at which time a full structural weld overlay (FSWOL) will be applied over the weld flaw.

The proposed repair, to install a WOL, uses guidance from 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 ASME Code, Section XI, 2013 Edition, Nonmandatory Appendix Q, *Weld Overlay Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping Weldments*. Temper bead welding on the ferritic steel nozzle will comply with ASME Code Case N-638-10 *Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique, Section XI, Division 1* except for the specified 48-hour hold time from the completion of the three tempering layers. After completion of the WOL, the flaw will be less than 75 percent through-wall. However, the flaw may be greater than 75 percent through-wall before the next refueling outage begins.

As stated by the licensee in the March 30, 2023, supplemental letter:

> At the time of mode change, the axial flaw will not exceed the 75% through wall dimension of IWB-3640. The final through wall dimension of the axial flaw will be determined during the pre-service inspection of the overlay. CEG intends to perform a residual stress and crack growth analysis to determine the projected flaw growth of the axial flaw indication over the next operating cycle. Until this analysis is completed, it must be conservatively assumed that the flaw will

> exceed the IWB-3640 through wall extent limit of 75% in the upcoming operating cycle...
>
> Although the leakage barrier overlay is not classified as a Full Structural Weld Overlay per N-740-2, there is reasonable assurance of structural integrity due to the geometry of the weld overlay and the flaw orientation. Axial flaws do not pose a structural concern in areas of high fracture toughness.

A summary of the residual stress and crack growth analysis will be submitted to the NRC within 60 days following the end of the current refueling outage (N1R27).

The proposed alternative has been requested in accordance with the provisions of 10 CFR 50.55a(z)(1). The proposed alternative would provide an acceptable level of quality and safety.

For additional details on the licensee's request, please refer to the documents located at the ADAMS Accession No(s). identified above.

## STAFF EVALUATION

The subject axial flaw is in a 28-inch recirculation discharge N2E nozzle-to-safe end DM weld. The nozzle is low alloy steel, the weld is Alloy 82/182, and the safe end is type-316 stainless steel. The length of the flaw is 1.65-inches with a flaw depth of 1.52-inches. The thickness of the weld is 1.83-inches, and the flaw is 83 percent through-wall. In accordance with ASME Code, Section XI, IWB-3640, flaws with depths greater than 75 percent of the wall thickness are unacceptable. This 75 percent acceptance criteria applies at startup as well as at any evaluated time period. The NRC staff's review of the proposed alternative focused on the structural integrity, leak tightness, design, installation, and examination of the design WOL.

WOLs have been used extensively to mitigate stress corrosion cracking flaws in boiling-water reactors (BWRs) and pressurized-water reactors for several years. The licensee's proposed alternative uses guidance from ASME Code, Section XI, Appendix Q, ASME Code Cases N-740-2 and N-638-10. ASME Code Section XI, Appendix Q, provides guidance for WOLs installed over austenitic stainless steel to austenitic stainless-steel welds using austenitic stainless steel weld filler material. Appendix Q does not address DM WOLs, temper bead welding or the use of Alloy 52M weld metal. Code Case N-740-2, which is not endorsed by the NRC for generic use, provides general requirements, design, installation, and examination criteria for WOLs using Alloy 52M weld filler materials and includes criteria for temper bead welding. Code Case N-740-2, Mandatory Appendix I provides requirements for ambient temperature temper bead welding; however, the licensee has indicated that it will use NRC-endorsed Code Case N-638-10 to apply temper bead welding to the first three layers of the WOL applied to the ferritic nozzle (N2E). Code Case 638-10 provides requirements when performing ambient temperature temper bead welding on ferritic materials using the machine gas tungsten arc welding (GTAW) temper bead welding technique. The licensee has requested an exception to the N-638-10 requirement that three tempering layers must be in place for at least 48 hours prior to examination.

Appendix Q provides design criteria for FSWOLs where the WOL is designed to replace the structural integrity and leak tightness function of the original weld. Appendix Q also provides design criteria, in limited cases for axial flaws only, where limited structural reinforcement is necessary. This is commonly known as a "Design Overlay" and is discussed in NUREG-0313, Revision 2, "Technical Report on Material Selection and Processing Guidelines for BWR

Coolant Pressure Boundary Piping," Section 4.4.2, *Design Overlays*. While Appendix Q, Article Q-3000(a)(5) limits design WOLs to welds having four or fewer axial flaws less, each less that 1.5-inches in length, NUREG-0313 suggests a limit of four axial flaws but does not discuss flaw length. As stated above, the flaw in the subject weld is 1.65-inches. In the March 27, 2023, letter, the licensee included Structural Integrity Associates Inc. (SI) Report 2300376.401, which provides an evaluation of the leakage barrier WOL to be installed over the subject weld flaw.

To justify the use of the design WOL on an axial flaw larger than 1.5-inches, the licensee calculated the allowable and critical end-of-period (maximum) flaw length to determine the stability of a through-wall flaw. The licensee used the limit load analysis equation in footnote Number 3 of Table C-5410-1 of the ASME Code, Section XI. The equation provides the "critical" flaw length, $\ell_{crit}$, for a through-wall axial flaw, if the structural (safety) factor is not applied to the hoop stress. If the structural factor is applied to the hoop stress, the calculated flaw length would be the allowable flaw size. The licensee used a structural factor of 2.7 which is specified for the service level "A" loading in accordance with the ASME Code, Section XI, Appendix C, C-2622. The staff noted that the structural factor of 2.7 is the highest of all four service levels in Subarticle C-2622 and is conservative. Therefore, it is acceptable for use to calculate the allowable flaw length.

The licensee used the material properties of the nozzle (SA-336), the weld (Alloy 82/182, N06600) and the safe end (SA-182, F316) based on the design temperature of 570°F along with the design pressure of 1200 pounds-per-square-inch gauge (psig). Of the three materials calculated, the licensee obtained the shortest (i.e., conservative) allowable and critical flaw length of 10.5-inches and 34-inches, respectively, based on the material properties of the SA-182 safe end. In comparison, the staff noted that safety margin exists between the measured indication length of 1.65-inches with the allowable and critical flaw lengths. As such, the staff finds that although the actual flaw length of 1.65-inches exceeds the allowable length of 1.5- inches of Article Q-3000(a)(5), the degraded weld maintains adequate safety margin for one operating cycle. The above-described evaluation does not consider the additional structural integrity that will be provided by the design WOL.

The staff noted that ASME Code, Section XI, Appendix Q, states that the length of the design WOL shall cover the weldment and the heat-affected zones and shall extend at least one-half inches beyond the ends of the observed flaws. The licensee reported that the actual flaw is 1.65-inches long, is centered on the DM weld, and the DM weld crown width is 1.88-inches. The licensee further stated that as WOL installations are measured from the toes of the weld, and in this case, the toes of the weld will extend beyond the flaw ends, the 0.5-inches additional length will be applied outside of the weld crown toes. Thus, the minimum WOL length is 1.88-inches + (0.5-inches x 2-inches) = 2.88-inches. The licensee stated that the WOL length will have to be increased beyond this value to facilitate UT examination of the overlay inspection box as shown in Figure 2 of ASME Code Case N-740-2. The staff finds that (1) the WOL minimum length of 2.88-inches is acceptable because it covers the actual flaw length of 1.65-inches, and (2) the safety margin exists between the actual flaw length and the allowable flaw length, thereby, the structural integrity and leak tightness of the degraded weld will be maintained for one operating cycle.

The design WOL consist of three different weld filler materials: ER309L, Alloy 82, and Alloy 52M. Certain elements such as sulfur can cause welding defects such as hot cracking when applying Alloy 52M on austenitic stainless steel base materials. The licensee intends to mitigate this potential issue by applying an ER309 buffer layer(s) on the safe end prior to applying Alloy 52. The staff noted that the thickness of these buffer layers will not be used in meeting weld reinforcement design thickness requirements. In addition, given that stainless steel weld filler metal such as ER309 cannot be welded directly over nickel-based alloys, Alloy 82 will be used to apply a layer to bridge the area where the nozzle interfaces the existing Alloy 82/182 weld and stainless-steel safe end. The configuration of the WOL, buffer layer and bridge beads can be seen in in Figure 5-1 of the licensee's March 30, 2023, letter referenced above.

As stated above, the licensee conservatively assumed that the flaw will exceed the IWB-3640 through-wall extent limit of 75 percent in the upcoming operating cycle and will extend through the original weld. To show that leak tightness will be maintained, the licensee calculated the time it would take for the flaw to grow through the WOL due IGSCC. The calculation conservatively did not take credit for the thickness of the buffer layer/s or the thickness of the bridge beads and only considered the Alloy 52M portion of the WOL. The licensee showed by calculation that it would take 20.1 years for the flaw to grow through the WOL. Therefore, the staff finds that the licensee has provide reasonable assurance, with respect to IGSCC, that the weld will maintain leak tightness until the end of the next refueling outage (N1R28). The licensee determined that crack growth due to fatigue is not a concern for one operating cycle because the recirculation does not see significant pressure cycling. The NRC staff finds this acceptable because any crack growth due to fatigue would be insignificant during one operating cycle.

The licensee will perform temper bead welding in accordance with ASME Code Case N-638-10 with the exception that surface and volumetric examinations may be performed on the completed weld prior to 48 hours after the completion of the three tempering weld layers. The WOL is being applied with the machine GTAW process which produces welds with very low diffusible hydrogen when compared to welding processes that use flux. Therefore, hydrogen-induced cracking is not likely to occur, making the 48-hour time requirement unnecessary. In addition, the NRC staff is unaware of any instances of hydrogen-induced cracking out of the numerous WOLs that have been completed by the nuclear industry using any of the revisions of Code Case N-638. Therefore, staff finds the licensee's exception to be acceptable.

The licensee's examination procedures will be qualified in accordance with ASME Code Case N-653-2, *Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds Section XI, Division 1* in lieu of ASME Code, Section XI, *Mandatory Appendix VIII, Performance Demonstration for Ultrasonic Examination Systems.* Code Case N-653-2 is endorsed by the NRC staff in Regulatory Guide 1.147 and is, therefore, acceptable to use.

The examination volume used by the licensee for the initial examination of the WOL is that shown in Appendix Q, Figure Q-4100-1 which is identical to Figure 1(a) in Code Case N-740-2. The preservice examination volume used is that shown in Appendix Q, Figure Q-4300-1 which is different that the examination volume show in Figure 1(b) in Code Case N-740-2. The staff finds this acceptable because the examination volumes shown in Appendix Q adequately covers the area of interest and provides reasonable assurance that any flaw that could affect the leak tightness of the WOL thought the end of the next refueling outage will be detected.

Based on the above, the NRC staff finds that the licensee's proposed alternative provides reasonable assurance of structural integrity and leak tightness of subject weld and is, therefore, acceptable.

## CONCLUSION

The NRC staff has determined that the licensee's proposed alternative provides an acceptable level of quality and safety, and that there is reasonable assurance that the structural integrity and leak tightness of the subject overlaid weld will be maintained until the end of the next refueling outage (N1R28). The NRC concludes that the licensee has adequately addressed the regulatory requirements set forth in 10 CFR 50.55a(z)(1).

The NRC staff authorizes the use of proposed alternative, Relief Request I5R-11, at Nine Mile Point, Unit 1, until the next refueling outage (N1R28).

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

Principal Contributor: Robert Davis

Date: June 22, 2023

Hipolito J. Gonzalez

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SUBJECT: NINE MILE POINT NUCLEAR STATION, UNIT NO. 1 - AUTHORIZATION AND SAFETY EVALUATION FOR ALTERNATIVE RELIEF REQUEST I5R-11 CONCERNING THE INSTALLATION OF A WELD OVERLAY ON REACTOR PRESSURE VESSEL RECIRCULATION INLET NOZZLE N2E SAFE END-TO-NOZZLE DISSIMILAR METAL WELD (EPID: L-2023-LLR-0011) DATED: JUNE 22, 2023

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