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

May 31, 2018

Vice President, Operations
Entergy Nuclear Operations, Inc.
Indian Point Energy Center
450 Broadway, GSB
P.O. Box 249
Buchanan, NY 10511-0249

SUBJECT: INDIAN POINT NUCLEAR GENERATING UNIT NO. 2 – SAFETY EVALUATION FOR RELIEF REQUEST IP2-ISI-RR-06 REGARDING APPROVAL OF ALTERNATIVE TO USE EMBEDDED WELD REPAIR (EPID L-2018-LLR-0050)

Dear Sir or Madam:

By letter dated April 4, 2018 (Agencywide Documents and Access Management System (ADAMS) Accession No. ML18101A032), as supplemented by letter dated April 6, 2018 (ADAMS Accession No. ML18098A088), Entergy Nuclear Operations, Inc. (the licensee) submitted Relief Request IP2-ISI-RR-06 for Indian Point Nuclear Generating Unit No. 2 (Indian Point Unit 2) to the U.S. Nuclear Regulatory Commission (NRC). Entergy Nuclear Operations, Inc., proposed an alternative to the requirements of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," Article IWA-4000. Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(z)(1), the licensee proposed to repair the J-groove weld of reactor vessel head (RVH) penetration nozzle No. 3 using the embedded flaw weld repair method described in the NRC-approved Westinghouse Topical Report, WCAP-15987-P-A, Revision 2, "Technical Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations," on the basis that the alternative provides an acceptable level of quality and safety.

During a teleconference[1] held on April 9, 2018, between the NRC staff and the licensee, the licensee was granted verbal authorization to use the proposed alternative. The enclosed safety evaluation provides the technical basis for the authorization of the embedded flaw weld repair for the RVH penetration nozzle No. 3 at Indian Point Unit 2 for Cycle 24 that is scheduled to end in the spring of 2020.

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

[1] Script of the verbal authorization for Indian Point Unit 2, Relief Request IP2-ISI-RR-06, dated April 9, 2018 (Accession No. ML18099A373).

If you have any questions concerning this matter, please contact the Indian Point Unit 2 Project Manager, Mr. Richard Guzman, at (301) 415-1030 or Richard.Guzman@nrc.gov.

Sincerely,

James G. Danna, Chief
Plant Licensing Branch 1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-247

Enclosure:
Safety Evaluation

cc: Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUEST IP2-ISI-RR-06 FOR AN EMBEDDED FLAW WELD REPAIR

ON REACTOR VESSEL HEAD PENETRATION NOZZLE NO. 3

ENTERGY NUCLEAR OPERATIONS, INC.

INDIAN POINT NUCLEAR GENERATING UNIT NO. 2

DOCKET NO. 50-247

1.0 INTRODUCTION

By letter dated April 4, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18101A032) as supplemented by letter dated April 6, 2018 (ADAMS Accession No. ML18098A088), Entergy Nuclear Operations, Inc. (Entergy or the licensee) submitted its Relief Request IP2-ISI-RR-06 for Indian Point Nuclear Generating Unit No. 2 (Indian Point Unit 2). In the relief request, the licensee proposed an alternative to the requirements of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," Article IWA-4000.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee proposed to repair the J-groove weld of reactor vessel head (RVH) penetration nozzle No. 3 using the embedded flaw weld repair method described in the NRC-approved Westinghouse Topical Report, WCAP-15987-P-A, Revision 2, "Technical Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations."

On April 9, 2018 (ADAMS Accession No. ML18099A373), the NRC verbally authorized the proposed alternative for Cycle 24 that ends in spring 2020, at Indian Point Unit 2. The NRC staff determined that the alternative is technically justified and provides an acceptable level of quality and safety. This safety evaluation documents the basis for the verbal authorization.

2.0 REGULATORY EVALUATION

The licensee proposed to repair the subject RVH penetration nozzle weld using an alternative to the requirements of ASME Code, Section XI, Article IWA-4000.

Paragraph (g)(4) of 10 CFR 50.55a requires, in part, that the components that are classified as ASME Code Class 1, Class 2 and Class 3 meet the requirements set forth in the editions and addenda of ASME Code, Section XI that are incorporated by reference in 10 CFR 50.55a, to the extent practical within the limitations of design, geometry, and materials of construction of the components.

The provision in 10 CFR 50.55a(z)(1) permits the use of alternatives to the requirements of paragraph (g) of 10 CFR 50.55a, when authorized by the NRC, if the licensee demonstrates that the proposed alternative provides an acceptable level of quality and safety.

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

3.0 TECHNICAL EVALUATION

3.1 ASME Code Component(s) Affected

The proposed alternative applies to RVH penetration nozzle No. 3 (ASME Code Class 1). While performing the visual examination of the RVH during Refueling Outage 23 as required by ASME Code Case N-729-4, the licensee detected boric acid in the nozzle-to-vessel-head annulus region. Additional surface examinations on the J-groove weld of the penetration nozzle indicated that an axial through-wall crack in the J-groove weld resulted in the observed leakage due to primary water stress corrosion cracking (PWSCC).

3.2 Applicable ASME Code Edition and Addenda

The current code of record for Indian Point Unit 2 is the 2007 Edition through the 2008 Addenda of ASME Code, Section XI, including Code Case N-729-4 as mandated and conditioned in 10 CFR 50.55a(g)(6)(ii)(D). The original code of construction is the 1965 Edition through summer 1965 Addenda of ASME Code, Section III (including Code Cases 1332, 1335, 1339 and 1359). Subsection NB of the 2001 Edition through the 2003 Addenda of ASME Code, Section III is also applicable for the RVH penetration nozzles.

3.3 Applicable ASME Code Requirements

Due to the through-weld indication described above, a repair activity was required for the J-groove weld in accordance with ASME Code, Section XI, Article IWA-4000 that contains the requirements for removing weld defects from ASME Code components. Paragraph IWA 4421 states in part that defects be removed or mitigated in accordance with the requirements in IWA-4461 (by thermal methods), IWA-4462 (by mechanical processing) or IWA-4411 (by welding or brazing). Specifically, Paragraph IWA-4411 requires that welding, brazing, fabrication, and installation shall be performed in accordance with the Owner's Requirements and the Construction Code of the item, with additional provisions allowing the use of later editions or addenda of the Construction Code.

ASME Code, Section III, Paragraph NB-4451 provides the general requirements for removal and repair of weld metal defects. In addition, ASME Code, Section III, Paragraph NB-4452 and Subparagraph NB-4453.1 specify the requirements for eliminating weld surface defects and the requirements for excavating weld defects for repair activities, respectively.

3.4 Licensee's Proposed Alternative

As an alternative to the defect removal and weld repair requirements in ASME Code, Section XI, IWA-4000 and Section III, NB-4450, the licensee proposed to repair the subject J-groove weld using the embedded flaw repair method described in the WCAP-15987-P-A, Revision 2.

In the proposed repair, the J-groove weld is sealed and isolated from the primary water environment by deposition of a 360-degree overlay that consists of at least 3 layers of Alloy 52 or 52M weld metal that is resistant to PWSCC. The PWSCC-resistant seal weld also extends onto the outside diameter of the Alloy 600 penetration nozzle by at least 0.5 inch. In the repair process, excavation of the J-groove weld is not required in accordance with the guidelines in WCAP-15987-P-A, Revision 2. In addition, the repair weld extends at least 0.5 inch beyond the interface of the RVH cladding and J-groove weld after deposition of the ER309L stainless steel buffer layer on the cladding. This proposed alternative is for one cycle of operation (Cycle 24) that ends in spring 2020.

3.5 Licensee's Basis of the Proposed Alternative

The licensee proposed that repairing the weld in accordance with WCAP-15987-P-A, Revision 2, provides an acceptable level of quality and safety, as described in the NRC safety evaluation for the topical report (ADAMS Accession No. ML031840237), dated July 3, 2003. The repair weld material (Alloy 52/52M) with a high chromium content retains high resistance to PWSCC and isolates the subject J-groove weld from the reactor coolant environment, thereby preventing the occurrence of PWSCC.

Volumetric and surface examinations were performed on the completed repair weld as specified in the NRC safety evaluation for the WCAP-15987-P report with modifications to implement the requirements described in 10 CFR 50.55a(g)(6)(ii)(D). The licensee proposed that these examinations will confirm the acceptability of the repair weld.

In addition, the fracture mechanics assessment for the subject penetration nozzle was performed to evaluate the potential fatigue crack growth of a conservatively postulated J-groove weld flaw into the RVH. The licensee proposed that the results of this evaluation confirmed that the growth of a postulated fatigue crack did not affect the structural integrity of the reactor vessel head, consistent with the conclusion of WCAP-15987-P-A, Revision 2. The licensee also proposes that the conservative fatigue crack growth evaluation also confirms that the repair weld is sufficient to maintain the seal weld integrity for the period of the relief request (until spring 2020).

3.6 NRC Staff Evaluation

The licensee performed visual examinations on the RVH and associated penetration nozzles as part of the periodic examinations in accordance with ASME Code Case N-729-4 as conditioned in 10 CFR 50.55a(g)(6)(ii)(D). The visual examinations detected the presence of boric acid indicating RVH leakage. The visual examinations and subsequent ultrasonic, eddy current and liquid penetrant examinations did not reveal any degradation in the RVH and penetration nozzles (e.g., wastage and cracking) other than the degradation in the J-groove weld of nozzle no. 3. The NRC staff finds that the examination results confirm that the degradation due to PWSCC is limited in the J-groove weld of penetration nozzle No. 3, and therefore, support the application of the proposed repair on the subject J-groove weld, consistent with the guidance in the WCAP-15987-P-A, Revision 2.

The repair weld material (Alloy 52/52M) contains a high chromium content of approximately 28 - 31 weight percent, which provides high resistance to PWSCC. The proposed repair process involves the deposition of a 360-degree overlay consisting of at least 3 layers of the weld material, consistent with WCAP-15987-P-A, Revision 2. Therefore, the NRC staff finds that the

repair weld is highly resistant to PWSCC and is reliable to prevent the exposure of the subject J groove weld to the reactor coolant environment that can cause PWSCC.

In addition, the licensee proposed to apply a buffer layer (ER309L stainless steel) between the RVH cladding and the repair weld, where the repair weld is deposited on the cladding. The purpose of the buffer layer is to isolate the repair weld from potential contaminants that may exist in the cladding. The NRC staff finds the application of the additional buffer layer acceptable because it can prevent potential contamination of the repair weld that could potentially occur over the stainless steel cladding material, thereby minimizing the potential for cracking due to contamination in the repair weld (e.g., sulfer induced hot cracking).

Preservice non-destructive examinations are performed on the repair weld as specified in the NRC safety evaluation for the WCAP-15987-P report with modifications that are consistent with the implementation requirements for ASME Code Case N-729-4 (specified in 10 CFR 50.55a(g)(6)(ii)(D)). The ultrasonic examination coverage plus surface examination coverage for the repair is 100 percent, consistent with the safety evaluation for the WCAP-15987-P report. The personnel and procedure qualification is also consistent with the implementation requirements for ASME Code Case N-729-4 in 10 CFR 50.55a. The licensee further clarified that future inservice inspections are not necessary for the repair weld because the proposed alternative is only for one cycle of operation. The NRC staff finds the proposed examinations for the repair weld are acceptable for one cycle of operation because they are consistent with the NRC safety evaluation for the WCAP-15987 P report with relevant modifications and consistent with the inspection requirements for RVH penetration nozzles specified in 10 CFR 50.55a(g)(6)(ii)(D).

With respect to the fracture mechanics assessment, the licensee indicated that, upon the completion of the weld repair, PWSCC is no longer a credible crack growth mechanism and fatigue is the only remaining credible crack growth mechanism for the repaired J-groove weld. The licensee also indicated that the fatigue usage factor at the J-groove weld at Indian Point Unit 2 is approximately 0.3 over 40 years of operation and that the conservative estimate of the fatigue usage factor remains essentially unchanged for the period of the proposed alternative (Cycle 24). The NRC staff finds that the licensee adequately identified that (a) fatigue is the only credible crack growth mechanism for the repaired J-groove weld based on the high resistance of the repair weld to PWSCC and the repair being limited to only one cycle of application; and (b) the susceptibility of the repaired J-groove weld to fatigue cracking is relatively low based on the low value of fatigue usage factor and low number of fatigue cycles for the component.

The licensee also indicated that extensive analytical work, including fracture mechanics analyses, was performed to support embedded flaw weld repair activities in the industry. The licensee further indicated that the results of the previous flaw evaluations performed in accordance with Appendix C of WCAP-15987-P-A, Revision 2, are applicable and bounding for the subject J-groove weld of Indian Point Unit 2. For example, the fatigue crack growth analyses for degraded J-groove welds assumed an initial, hypothetical flaw that extended axially over the entire weld cross-section, which is very conservative for the subject J-groove weld of Indian Point Unit 2.

In addition, the licensee indicated that the fatigue crack growth of the postulated J-groove weld flaw considered crack growth through the repair weld and also through the RVH. The conservative flaw evaluations confirmed that any assumed postulated flaw in the J-groove weld takes a period longer than 10 years to grow through the repair weld. The licensee also

confirmed that the postulated fatigue crack growth through the RVH is much slower and provides the structural integrity of the RVH for more than 40 years of operation. The licensee further indicated that the fracture mechanics assessment results are supported by the extensive operating experience that, since the weld repair method was first used in 2001, no fatigue crack initiation or growth has been observed in the J-groove welds repaired using the repair method.

In its review, the NRC staff finds the licensee's flaw evaluations for the J-groove weld including fatigue crack growth and fracture mechanics analyses acceptable because (a) the flaw evaluations used conservative assumptions (e.g., a postulated flaw across the whole axial cross-section of the J-groove weld assuming conservative loading conditions); (b) the flaw evaluations adequately used the linear elastic fracture mechanics approach including the use of stress intensity factor, consistent with the WCAP-15987-P-A, Revision 2; (c) the low fatigue usage factor (approximately 0.3) for the RVH of Indian Point Unit 2 indicates that the repaired J-groove weld will have resistance to fatigue cracking; (d) the conservative flaw evaluations estimate a design life longer than 10 years for the repair weld, which is significantly longer than the period of the proposed alternative (approximately 2 years); and (e) the conclusion of the flaw evaluations is supported by the operating experience indicating the absence of fatigue cracking issues associated with embedded flaw weld repairs.

4.0 CONCLUSION

As set forth above, the NRC staff has determined that the proposed alternative, Relief Request IP2-ISI-RR-06, provides an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes the embedded flaw weld repair for the RVH penetration nozzle No.3 at Indian Point Unit 2 for Cycle 24 that ends in spring 2020.

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

Principal Contributor: S. Min

Date: May 31, 2018

SUBJECT: INDIAN POINT NUCLEAR GENERATING UNIT NO. 2 – SAFETY EVALUATION FOR RELIEF REQUEST IP2-ISI-RR-06 REGARDING APPROVAL OF ALTERNATIVE TO USE EMBEDDED WELD REPAIR (EPID L-2018-LLR-0050) DATED MAY 31, 2018

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