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

August 27, 2018

Mr. Richard D. Bologna
Site Vice President
FirstEnergy Nuclear Operating Company
Beaver Valley Power Station
Mail Stop A-BV-SEB1
P.O. Box 4, Route 168
Shippingport, PA 15077

SUBJECT: BEAVER VALLEY, UNIT NO. 2 – REQUEST FOR RELIEF FROM THE REQUIREMENTS OF THE ASME CODE (EPID L-2018-LLR-0026)

Dear Mr. Bologna:

By letter dated March 12, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18072A288), FirstEnergy Nuclear Operating Company (FENOC, the licensee) proposed an alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) regarding alternative requirements for repair of reactor vessel head penetrations (VHPs) at Beaver Valley Power Station, Unit No. 2 (Beaver Valley).

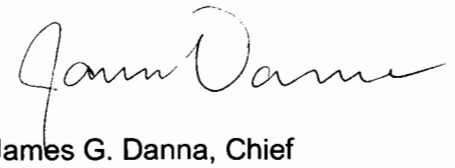
Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee requested to use the proposed alternative on the basis that its requirements for repair of VHPs provides an acceptable level of quality and safety.

The U.S. Nuclear Regulatory Commission (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(z)(1). The NRC staff finds that the proposed alternative provides an acceptable level of quality and safety. Therefore, the NRC staff authorizes the use of the proposed alternative in relief request (RR) 2-TYP-4-RV-04, for the fourth 10-year inservice inspection (ISI) interval of Beaver Valley, Unit 2, which is scheduled to begin on August 29, 2018 and end on August 28, 2028.

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

If you have any questions, please contact Jennifer Tobin, Project Manager, at 301-415-2328 or via e-mail at Jennifer.Tobin@nrc.gov.

Sincerely,



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

Docket No.: 50-412

Enclosure:
Safety Evaluation

cc: Listserv

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST NO.2-TYP-4-RV-04, REVISION 0,

REGARDING REACTOR VESSEL HEAD PENETRATION REPAIRS

FIRSTENERGY NUCLEAR OPERATING COMPANY

BEAVER VALLEY POWER STATION, UNIT NO. 2

DOCKET NO. 50-412

1.0 INTRODUCTION

By letter dated March 12, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18072A288), FirstEnergy Nuclear Operating Company (FENOC, the licensee) proposed an alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) regarding alternative requirements for repair of reactor vessel head penetrations (VHPs) at Beaver Valley Power Station, Unit No. 2 (Beaver Valley).

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 its alternative requirements for repair of VHP's provides an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

The licensee proposes to use alternatives to the requirements of ASME Code, Section XI, IWA-4000, regarding removal of defects from and welded repair of VHPs.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3, components (including supports) must meet the requirements, except the design and assess provisions and the pre-service examination requirements, set forth in the ASME Code, Section XI, "Rules for In-service Inspection (ISI) 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)(4)(ii), ISI examination of components during successive 120-month inspection intervals must comply with the requirements of the latest edition and addenda of the ASME Code incorporated by reference in paragraph (a) of 10 CFR 50.55a, 12 months before the start of the 120-month inspection interval (or the optional ASME Code Cases listed in NRC Regulatory Guide (RG) 1.147, Revision 18, when using Section XI) that are incorporated by reference in paragraphs (a)(3)(ii) of 10 CFR 50.55a), subject to the conditions listed in paragraph (b) of 10 CFR 50.55a.

Pursuant to 10 CFR 50.55a(g)(6)(ii)(D), "Augmented ISI requirements: Reactor vessel head inspections - *1*) Implementation." *h*olders of operating licenses or combined licenses for pressurized-water reactors (PWRs) as of or after August 17, 2017, shall implement the requirements of ASME Code Case N-729-4 "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads With Nozzles Having Pressure-Retaining Partial-Penetration Welds, Section XI, Division 1," instead of ASME Code Case N-729-1, subject to the conditions specified in paragraphs (g)(6)(ii) (D)(*2*) through (*4*) of 10 CFR 50.55a, by the first refueling outage starting after August 17, 2017.

Pursuant to 10 CFR 50.55a(z), alternatives to the requirements of paragraph (g) of 10 CFR 50.55a may be used when authorized by the Director, Office of Nuclear Reactor Regulation. A proposed alternative must be submitted and authorized prior to implementation. The licensee must demonstrate: (1) the proposed alternative would provide an acceptable level of quality and safety; or (2) compliance with the specified requirements of this section 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 U.S. Nuclear Regulatory Commission (NRC) staff finds that regulatory authority exists for the licensee to request and the NRC to authorize the alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 The Licensee's Proposed Alternative

ASME Code Components Affected

The ASME Code Class 1 VHP nozzles (1 through 65) and their associated partial penetration J-groove attachment welds are affected.

Applicable Code Edition and Addenda

The code of record for the fourth 10-year ISI interval for Beaver Valley Unit 2, is the 2013 Edition of the ASME Code, Section XI. Examinations of the VHPs are performed in accordance with 10 CFR 50.55a(g)(6)(ii)(D), which specifies the use of Code Case N-729-4, with conditions.

The licensee stated that the Construction Code for Beaver Valley, Unit 2, is the 1971 Edition through summer 1972 Addenda of the ASME Code, Section III.

Duration of Relief

The licensee submitted relief request (RR) 2-TYP-4-RV-04 for the fourth 10-year ISI interval at Beaver Valley, Unit 2, which is scheduled to begin on August 29, 2018, and end on August 28, 2028.

Applicable Code Requirements

ASME Code, Section XI, 2013 Edition, subparagraph IWA-4000 contains requirements for the removal of defects from and welded repairs performed on ASME Code components. For the removal or mitigation of defects by welding, ASME Code, Section XI, IWA-4411, requires that

repairs and installation of replacement items shall be performed in accordance with the owner's design specification and the original Construction Code of the component or system.

The original Construction Code of the reactor vessel is the ASME Code, Section III, 1971 Edition through summer 1972 Addenda. The licensee requests relief from the ASME Code, Section III, subparagraphs NB-4131, NB-2538, and NB-2539, which pertain to the removal of base material defects prior to repair by welding, and NB-4451, NB-4452, and NB-4453 which pertain to the removal of weld material defects prior to repair by welding.

Proposed Alternative and Basis for Use

As an alternative to the requirements of ASME Code, Sections III and XI, the licensee proposed to repair VHPs using the methodology described in Westinghouse Commercial Atomic Power (WCAP)-15987-P, Revision 2-P-A, "Technical Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations," December 2003 (WCAP-15987-2) (ADAMS Accession No. ML040290246), with modifications as described in Section 5 of the licensee's submittal. Design and implementation of the repairs will be consistent with WCAP-15987-2 and WCAP-16158-P, Revision 1, "Technical Basis for Repair Options for Reactor Vessel Head Penetration Nozzles and Attachment welds: Beaver Valley Unit 2," January 2018. The nonproprietary version of WCAP-16158 is also included in Appendix D of the licensee's March 12, 2018 letter.

Basis for Relief

The licensee stated that the embedded flaw repair (EFR) technique is considered a permanent repair. The licensee stated that as long as a primary water stress corrosion cracking (PWSCC) flaw remains isolated from the primary coolant environment, it cannot propagate. Further, the licensee stated that since Alloys 52/52M weldment is considered resistant to PWSCC, a new PWSCC flaw cannot initiate and grow through Alloys 52/52M overlay to reconnect the primary water environment with the embedded flaw.

The licensee stated that the residual stresses produced by the embedded flaw technique have been measured and found to be relatively low, indicating that no new flaws will initiate and grow in the area adjacent to the repair weld. Therefore, fatigue-driven crack growth is not a mechanism for further crack growth into Alloys 52/52M overlay after the EFR process is implemented.

According to the licensee, the small residual stresses produced by the embedded flaw will act constantly, and, therefore, will have no impact on the fatigue effects in this region. Since the residual stress would be additive to the maximum and minimum stress, the stress range will not change and the negligible fatigue usage factor for the region will not change. The licensee stated that WCAP-16158, Revision 1, provides the plant-specific analysis performed for Beaver Valley, Unit 2, using the same methodology as WCAP-15987-2. WCAP-16158, Revision 1, provides the means to evaluate a broad range of postulated repair scenarios to the VPH penetrations and J-groove welds relative to ASME Code requirements for allowable size and service life.

3.2 NRC Staff Evaluation

The licensee requested authorization of its alternative RR 2-TYP-4-RV-04 under 10 CFR 50.55a(z)(1). The licensee requested to use the proposed alternative on the basis that its requirements for repair of VHP's provides an acceptable level of quality and safety.

The purpose of the licensee's proposed repair is to address PWSCC, which typically initiates in susceptible materials, such as Alloy 600 material and Alloys 82/182 weld materials, in areas of tensile stress and certain environmental conditions, such as higher temperatures and corrosive environments. The reactor VHPs and their associated J-groove attachment welds at Beaver Valley meet these conditions to be susceptible to PWSCC. The proposed repair technique isolates the susceptible material using a seal weld of Alloy 52M weld material which is less susceptible to PWSCC.

The licensee's basis for the design, implementation, and inspection of the repairs for VHPs is Westinghouse WCAP-15987, Revision 2-A. In a letter dated July 3, 2003, from H. N. Berkow (NRC) to H. A. Sepp (Westinghouse Electric Company), (ADAMS Accession No. ML031840237), the NRC staff provided a safety evaluation (SE), in which the NRC staff found WCAP-15987-2 to be acceptable for referencing in licensing applications as an alternative to Section XI of the ASME Code, with the following conditions:

1. Licensees must follow the NRC flaw evaluation guidelines provided in the R. J. Barrett (NRC) letter to A. Marion (Nuclear Energy Institute), "Flaw Evaluation Guidelines," April 11, 2003. (ADAMS Accession No. ML030980322)

2. The crack growth rate referenced in WCAP-15987-P, Revision 2, is not applicable to Alloy 600 or Alloy 690 weld material, i.e., Alloys 52, 82, 152, and 182, filler material.

3. The nondestructive examination (NDE) requirements listed in the table below must be implemented for examinations of repairs made using the embedded flaw process.

Repair Location	Flaw Orientation	Repair Weld	Repair NDE	ISI NDE of the Repair Note 2
VHP Nozzle ID (inside diameter)	Axial	Seal	UT (ultrasonic testing) and Surface	UT or Surface
VHP Nozzle ID	Circumferential	Note 1	Note 1	Note 1
VHP Nozzle OD (outside diameter) above J-groove weld	Axial or Circumferential	Note 1	Note 1	Note 1
VHP Nozzle OD below J-groove weld	Axial or Circumferential	Seal	UT or Surface	UT or Surface
J-groove weld	Axial	Seal	UT and Surface, Note 3	UT and Surface, Note 3
J-groove weld	Circumferential	Seal	UT and Surface, Note 3	UT and Surface, Note 3

Notes:

1. Repairs must be reviewed and approved separately by the NRC.

2. Inspection consistent with the NRC Order EA-03-009 [Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors] dated February 11, 2003, and any subsequent changes (ADAMS Accession No. ML030380470).

3. Inspect with personnel and procedures qualified with UT performance-based criteria. Examine the accessible portion of the repaired region. The UT coverage plus surface coverage must equal 100 percent.

The licensee stated that their proposed alternative will use the methodology of the NRC approved WCAP-15987-2 as described by Section 5.1 of the submittal, with some modification. NRC staff reviewed Section 5.1 to ensure the licensee's proposed actions would meet the requirements of WCAP-15987-2, and any modifications would be acceptable under 10 CFR 50.55a(z)(1). As part of this review the NRC staff identified the following technical changes between the requirements of WCAP-15987-2, and Section 5.1, of the licensee's submittal:

A. The Alloy 600 tube material with a flaw will be repaired with two Alloy 52 isolation weld layers rather than the three layers required in WCAP-15987-2-A.

B. A circumferential flaw on the nozzle or tube inside diameter can be repaired using the seal weld technique without additional submission of the repair method for approval by the NRC.

C. Prior to the application of the Alloy 52 or 52M seal weld repair on the reactor pressure vessel clad surface, the stainless steel (SS) head cladding will have three beads of 309L SS installed 360 degrees around the interface of the clad and the J-groove weld metal as a buffer layer. The J-groove weld will be covered with three layers of Alloys 52/52M deposited 360 degrees around the nozzle over and extend to the SS buffer layer.

D. In lieu of Notes 2 and 3 of the NRC acceptance for WCAP-15987-P, Revision 2-A, the NDE of the repair will be performed in accordance with ASME Code Case N-729-4, as conditioned by 10 CFR 50.55a(g)(6)(ii)(D).

E. Surface examination of the embedded flaw repair (EFR), for repaired J-groove welds, shall be performed to ensure the repair satisfies ASME Section III, NB-5350 acceptance standards. The frequency of examination shall be as follows:

   a. Perform surface examination during the first and second refueling outage after installation or repair of the EFR.

   b. When the examination results in a. above verify acceptable results then reinspection of the EFR will be continued at a frequency of every other refueling outage. If these examinations identify unacceptable results that require flaw removal, flaw reduction to acceptable dimensions or welded repair the requirements of a.

above shall be applied during the next refueling outage.

The inspection frequency described in a. and b. above is in lieu of performing reinspections every refueling outage.

The NRC staff verified that the changes in methodology identified in RR 2-TYP-4-RV-04 from the previously approved WCAP-15987-2 would still meet the methodology approved by the NRC for effective EFR and provide an acceptable level of quality and safety.

The NRC staff reviewed the licensee's proposal in paragraph A (above) to allow a reduction in the maximum three layers of the seal weld over the Alloy 600 nozzle material to only two layers.

The licensee's basis is that the flaw would be isolated from the primary coolant environment necessary for continued PWSCC growth with less stress being introduced in the base metal with the proposed repair. The NRC staff finds that operational experience has shown that two layers of Alloy 52 material have been sufficient to address dilution layer effects of the high chromium content of the Alloy 52 material, which is the principle reason for the material's resistance to PWSCC. In addition, the concern of increased residual stresses in the Alloy 600 material that might still be exposed to primary coolant is a cause for concern for future flaw initiation. Therefore, since the repair can be effective using two weld layers, a smaller seal weld that generates less weld residual stresses in the base metal would be more preferable than using three weld layers. Therefore, the NRC staff finds this change to be acceptable.

The NRC staff reviewed the licensee's proposal in paragraph B (above) which alleviates the licensee from the need to submit a repair plan for each circumferential flaw identified that initiates from the inside diameter of the tube or nozzle surface. The licensee detailed a generic repair plan in accordance with Section 5.2 of the licensee's submittal. The licensee's proposed alternative repair would be to partially excavate the flaw to reduce it to an acceptable size, examine it by UT or surface examination, inlay with Alloys 52 or 52M, and examine by UT and surface examination. This is in compliance with embedded flaw technique. Further, operational experience has shown this repair technique is effective in arresting growth of PWSCC flaws. Hence, the NRC staff finds it is an effective generic repair plan to address circumferential flaws that initiate on the inside tube or nozzle surface. Therefore, the NRC staff finds this change to be acceptable.

The NRC staff reviewed the licensee's proposal in paragraph C (above) that the head cladding will have three beads of SS 309L buffer layer installed 360 degrees around the interface of the clad and the J-groove weld metal. The NRC staff notes that it is common practice to apply a buffer layer of SS weld metal over existing SS base material or existing SS weld metal before applying Alloy 52. Existing SS material may potentially contain sufficient levels of sulphur, phosphorous and silicon that can contribute to weld solidification cracking when diluted into Alloy 52 welds. Applying a buffer layer of SS weld metal that contains controlled levels of these elements, which can be detrimental to Alloy 52 welds, decreases the potential for weld cracking. The NRC staff finds the proposed alternative to be appropriate as the buffer layer of SS 309L weld metal will improve weld quality by decreasing the potential for welding defects at the SS cladding/Alloy 52 interface.

The NRC staff reviewed the licensee's proposal in paragraph D (above) for alternatives for NDE examination requirements of the seal weld and future ISI requirements. During the time period in which WCAP-15987-2 was approved by the NRC staff, the regulatory requirements for upper head inspection were dictated under NRC Order EA-03-009. In September 2008, by rule, the

NRC established 10 CFR 50.55a(g)(6)(ii)(D) which defined the regulatory requirements for upper head inspections as using ASME Code Case N-729-1, with conditions, and rescinded NRC Order EA-03-009. In July 2017, by rule, the NRC modified 10 CFR 50.55a(g)(6)(ii)(D) to replace ASME Code Case N-729-1 with ASME Code Case N-729-4.

The NRC staff finds that the licensee's proposed alternative inspections for the upper head penetration nozzles, under the current regulatory guidelines of ASME Code Case N-729-4, satisfy the previous NRC conditions on the NDE required for implementation of an EFR under WCAP-15987-2. Therefore, the NRC staff finds these changes to be acceptable.

The NRC staff reviewed the licensee's proposal in paragraph E (above) regarding alternatives for ISI of repaired J-groove welds. The licensee proposes to perform penetrant testing examinations of repaired J-groove welds for the first two outages after the repairs and then every other outage in lieu of every outage following J-groove weld repairs. The alternative in paragraph E and the licensee's supporting information are identical to the the previous NRC approved alternative for Beaver Valley, as described in the NRC staff SE of alternative RR 2-TYP-3-RV-04, Revision 1, dated March 2, 2017 (ADAMS Accession No. ML17041A185). The NRC staff is unaware of any plant operating conditions or industry operating experience that would invalidate the staff's previous conclusion. Therefore, the NRC staff finds the alternative described in paragraph E acceptable.

In order to support the use of WCAP-15987-2 with a plant-specific technical basis for the use of the EFR, the licensee submitted WCAP-16158 Revision 1, "Technical Basis for Repair Options for Reactor Vessel Head Penetration Nozzles and Attachment Welds: Beaver Valley Unit 2," January 2018, to support its current fourth 10-year ISI interval request.

WCAP-16158, Revision 0, Technical Basis for Repair Options for Reactor Vessel Head Penetration Nozzles and Attachment Welds: Beaver Valley Unit 2," November 2003, was referenced by the licensee in support of its VHP nozzle repair alternative request, 2-TYP-3-RV-01, for the third ISI interval which ends August 28, 2018. For the most limiting condition, WCAP-16158, Revision 0 supported any remaining ligaments of the flaws identified by the licensee in VHP nozzle J-groove weld material to be safely encapsulated for 5 years of operation.

WCAP-16158, Revision 1, provides a basis for any remaining ligaments of the flaws identified by the licensee in the VHP nozzle J-groove weld material to be safely encapsulated for 22 years of operation. The increase in repair life is based on the use of more realistic assumptions such as use of the design pressure of 2500 pounds per square inch (psi) in lieu of the primary hydro test condition of 3125 (psi) and a maximum embedded flaw aspect ratio of 2 instead of 6. The NRC staff notes that the vessel received a hydrostatic test at the completion of fabrication and will not have the primary hydro test condition again. An aspect ratio of 2 is more realistic than 6 because an aspect ratio of 2 bounds the weld dimensions of all of the VHP nozzle attachment welds. The NRC staff finds WCAP-16401, Revision 1, provides a basis for any remaining ligaments of the flaws identified by the licensee in VHP nozzle J-groove weld material to be safely encapsulated for 22 years of operation.

In accordance with the previous NRC conditions imposed on the use of WCAP-15987-2, and the plant-specific technical basis for the EFR, the NRC staff confirms that the licensee has followed the NRC flaw evaluation guidelines and will implement the appropriate NDE for the repairs to VHP nozzles and their associated J-groove welds at Beaver Valley, Unit 2. As previously shown in the July 3, 2003, NRC SE, the EFR process is considered to be an

alternative to ASME Code requirements that provides an acceptable level of quality and safety, as required by 10 CFR 50.55a(z)(1).

4.0 CONCLUSION

Based on the above evaluation, the NRC staff finds that the proposed alternative 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 use of the proposed alternative in RR 2-TYP-4-RV-04, Revision 0, for the fourth 10-year ISI interval of Beaver Valley, Unit 2, which is scheduled to begin on August 29, 2018 and end on August 28, 2028.

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

Principal Contributor: Robert Davis

Date of issuance: August 27, 2018

SUBJECT: BEAVER VALLEY, UNIT NO. 2 – REQUEST FOR RELIEF FROM THE REQUIREMENTS OF THE ASME CODE (EPID: L-2018-LLR-0026) DATED AUGUST 27, 2018

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