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

July 2, 2018

Mr. Richard D. Bologna
Site Vice President
FirstEnergy Nuclear Operating Company
Beaver Valley Power Station
Mail Stop A-BV-SSB
P.O. Box 4, Route 168
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SUBJECT: BEAVER VALLEY POWER STATION, UNIT NO. 2 - RELIEF REQUEST NO. 2-TYP-4-RV-02 REGARDING THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER AND PRESSURE VESSEL CODE CASE N-729-4 EXAMINATION REQUIREMENTS (EPID L-2017-LLR-0138)

Dear Mr. Bologna:

By letter dated November 13, 2017, FirstEnergy Nuclear Operating Company (FENOC or licensee) submitted a request for authorization of a proposed alternative to American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Case N-729-4 volumetric and surface examination coverage requirements for certain Beaver Valley Power Station, Unit No. 2 (BVPS-2) reactor vessel head penetrations for the fourth 10-year inservice inspection (ISI) interval, scheduled to begin August 29, 2018. Specifically, the licensee defined an alternate examination zone below the J-groove weld. FENOC submitted the proposed alternative in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.55a(z)(2).

The U.S. Nuclear Regulatory Commission (NRC) staff has concluded that compliance with 10 CFR 50.55a(g)(6)(ii)(D) would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety, and that the proposed alternative provides reasonable assurance of structural integrity is provided in the enclosed safety evaluation. Therefore, pursuant to 10 CFR 50.55a(z)(2), the NRC staff authorizes the proposed alternative for BVPS-2 for the fourth 10-year ISI interval.

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

If you have any questions, please contact the Project Manager, Jennifer Tobin, at (301) 415-2328.

Sincerely,

James G. Danna, Chief
Plant Licensing Branch 1
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

REGARDING THE 10-YEAR INSERVICE INSPECTION PLAN INTERVAL

FOR RELIEF REQUEST NO. 2-TYP-4-RV-02

FIRSTENERGY NUCLEAR OPERATING COMPANY

BEAVER VALLEY POWER STATION, UNIT NO. 2

DOCKET NO. 50-412

1.0 INTRODUCTION

By letter dated November 13, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17318A030), FirstEnergy Nuclear Operating Company (FENOC or licensee) submitted a request for authorization of a proposed alternative to American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Case N-729-4 volumetric and surface examination coverage requirements for certain Beaver Valley Power Station, Unit No. 2 (BVPS-2), reactor vessel head penetrations for the BVPS-2 fourth 10-year inservice inspection (ISI) interval, scheduled to begin in August 2018 and end in August 2028. Specifically, the licensee defined an alternate examination zone below the J-groove weld.

2.0 REGULATORY EVALUATION

The ISI of the ASME Code, Section XI, Class 1, 2 and 3 components shall be performed in accordance with the requirements of Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," of the ASME Code and applicable editions and addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.55a(g), except where specific written relief has been granted by the U.S. Nuclear Regulatory Commission (NRC or Commission).

Components which are classified as ASME Code Class 1, 2, and 3 must meet the requirements in 10 CFR 50.55a(g)(4) throughout the service life of a pressurized-water reactor (PWR), except design and access requirements and pre-service examination requirements, set forth in the ASME Code, Section XI, to the extent practical within the limitations of design, geometry and materials of construction of the components. Pursuant to10 CFR 50.55a(g)(4)(i), the ISI of components and system pressure tests conducted during the first 10-year ISI interval and subsequent intervals shall comply with the requirements in the latest edition and addenda ASME Code, Section XI, incorporated by reference in paragraph (b) of 10 CFR 50.55a 12 months prior to the start of the 120-month ISI interval subject to the limitations and modifications listed herein. The ASME Code of Record for the fourth 10-year ISI interval is the 2013 Edition with no Addenda.

Regulation 10 CFR 50.55a(g)(6)(ii) states that the Commission may require the licensee to follow an augmented ISI program for systems and components for which the Commission deems that added assurance of structural reliability is necessary. The regulations in 10 CFR 50.55a(g)(6)(ii)(D)(1) require augmented ISI of reactor vessel head penetration nozzles of PWRs in accordance with ASME Code Case N-729- 04, subject to the conditions specified in paragraphs (2) through (6) of 10 CFR 50.55a(g)(6)(ii)(D).

Pursuant to 10 CFR 50.55a(z), the proposed alternatives to the requirements of 10 CFR 50.55a(g) may be used when authorized by the Commission if: (1) the proposed alternatives would provide an acceptable level of quality and safety, or (2) hardship without a compensating increase in quality and safety. The licensee requests relief from the requirements of 10 CFR 50.55a(g)(6)(ii)(D) for the fourth 10-year ISI interval of BVPS-2 under 10 CFR 50.55a(z)(2).

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the licensee to request, and the NRC to authorize, the proposed alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 System/Components for Which Alternative is Requested

Control rod drive mechanism (CRDM) nozzle penetration numbers 1, 3, 5-34, 37, 38, 41-43, 45, 46, 48, 49, and 54-65, designated as Item No. B4.20, "UNS [unified numbering system] N06600 nozzles and UNS N06082 or UNS W86182 partial-penetration welds in head," in Table 1 of Code Case N-729-4.

3.2 ASME Code Edition and Addenda

The ASME Code of Record for the fourth 10-year ISI interval is the 2013 Edition with no Addenda.

3.3 Duration of Relief Request

The proposed alternative would extend for the duration of the fourth 10-year ISI interval of BVPS-2 which is scheduled to start on August 29, 2018, and end on August 28, 2028.

3.4 ASME Code Requirements

Regulation 10 CFR 50.55a(g)(6)(ii)(D)(1) requires examinations of the reactor vessel head be performed in accordance with ASME Code Case N-729-4, subject to the conditions specified in paragraphs 10 CFR 50.55a(g)(6)(ii)(D)(2) through (6).

Paragraph 2500 of Code Case N-729-4 states, in part:

> " . . . If obstructions or limitations prevent examination of the volume or surface required by Fig. 2 for one or more nozzles, the analysis procedure of Mandatory Appendix I shall be used to demonstrate the adequacy of the examination volume or surface for each such nozzle. If Appendix I is used, the evaluation shall be submitted to the regulatory authority having jurisdiction at the plant site."

3.5 Proposed Alternative and Basis for Use

The bottom end of all of the BVPS-2 reactor vessel head CRDM penetrations are externally (outside diameter or "OD") threaded, internally (inside diameter or "ID") tapered, and have an ultrasonic corner shadow zone produced by the thread relief, precluding ultrasonic or eddy current data acquisition in a zone extending up approximately 1.45 inches from the bottom of each nozzle. For the majority of the penetrations, these geometric limitations reduce the inspectable distance from the bottom of the J-groove weld fillet to the top of the thread relief to some value less than the required coverage dimension "a" shown in Figure 2 of Code Case N-729-4.

Therefore, due to this physical hardship, relief is required for some CRDM penetrations that do not meet the required inspection coverage dimension "a" shown in Figure 2 of Code Case N-729-4.

In Figure 1 and Table 1 of the November 13, 2017, submittal, the licensee provided information on the geometry of the BVPS-2 reactor vessel head penetrations and the attainable examination coverage (in inches) below the J-groove weld fillet on the downhill (limiting) side of each penetration.

The licensee supported the previous relief request for the third ISI interval (RR 2-TYP-3-RV-02, dated December 30, 2008; ADAMS Accession No. ML090020385), with a stress analysis and deterministic fracture mechanics analysis. The stress analysis is addressed in WCAP-16144-NP, Revision 1, "Structural Evaluation of Reactor Vessel Head Penetrations to Support Continued Operation: Beaver Valley, Unit 2," a nonproprietary document (ADAMS Accession No. ML090020386). The plant-specific stress analysis demonstrated that the hoop and axial stresses remain below 20 kilo-pounds per square inch (ksi) over the entire region outside the alternative examination zone defined by the licensee's proposed alternative. The stress analysis was provided for NRC staff review. The plant-specific fracture mechanics analysis demonstrated that a potential axial crack in the unexamined zone will not grow to the toe of the J-groove weld prior to the next scheduled examination. The licensee noted that because previous primary water stress-corrosion cracking (PWSCC) had been found in the BVPS-2 head penetrations, volumetric reinspection of the head was required each refueling outage. The licensee's analysis noted, for all cases, the crack growth predictions show greater than 4 years of full power operations required to grow the postulated flaw to the toe of the weld.

The licensee in its November 13, 2017, submittal, noted that thermal sleeves in the majority of the CRDM penetrations prohibit dye penetrant testing of the tapered inside diameter surface of the penetration tube. Dye penetrant testing of the outside diameter surface of the penetration tube is difficult due to the threads and the need to properly clean the surface to provide accurate test results. Furthermore, the licensee stated that performing dye penetrant testing on the bottom nozzle inside diameter area would require thermal sleeve removal and would result in significant radiation exposure to plant personnel. The radiation exposure is estimated to be in excess of 100-person-rem (roentgen equivalent man) without a compensating increase in the level of quality or safety.

As an alternative to the volumetric and surface examination coverage requirements shown as Dimension "a" in Figure 2 of ASME Code Case N-729-4, the licensee proposes the use of attainable ultrasonic examination distances shown as Dimension "B" in

Table 1 of the November 13, 2017, submittal. Specifically, in lieu of the required 1.5 inches for incidence angles less than or equal to 30 degrees (penetrations 1, 3, and 5 through 33), and the required 1.0 inch for incidence angles greater than 30 degrees (penetrations 34, 37, 38,41, 42, 43, 45, 46, 48, 49, and 54 through 65), the examination coverage recorded as Dimension "B" in Table 1 above will be obtained. For all other penetrations, the BVPS-2 coverage Dimension "a" reflected in Figure 2 of ASME Code Case N-729-4 will be met or exceeded. Table 2 provides the scope of this request as a summary of the applicable N-729-4 examination coverage distances "a" (based upon incidence angle) and alternative (achievable) examination coverage for each penetration.

The licensee stated that Section I-1000 in Mandatory Appendix I in ASME Code Case N-729-4 requires that for alternative examination zones that eliminate portions of the Figure 2 of ASME Code Case N-729-4 examination zone below the J-groove weld, the analyses shall be performed using at least the stress analysis method (I-2000) or the deterministic fracture mechanics analysis method (I-3000) to demonstrate that the applicable criteria are satisfied. In support of this request, the techniques of both I-2000 and Method 1 of I-3200 were performed and are included in WCAP-16144-P, Revision 1 (ADAMS Accession No. ML090020384, December 30, 2008), previously provided to the NRC with request 2-TYP-3-RV-02.

The analyses and evaluations presented in WCAP-16144-P, Revision 1, were developed in 2008 based on the requirements of ASME Code Case N-729-1 and remain applicable to BVPS-2 for the fourth 10-year ISI interval. The requirements of Appendix I of ASME Code Case N-729-1 are identical to the requirements of Appendix I of ASME Code Case N-729-4. The calculation inputs for the stress analysis and fracture mechanics analysis contained in WCAP-16144-P, Revision 1, are expected to remain the same throughout the fourth 10-year ISI interval. There have been no major modifications to the operating limits for BVPS-2 since 2008 that would affect these calculation inputs. Because the calculation inputs used in WCAP-16144-P, Revision 1, have not changed and are not expected to change throughout the fourth 10-year inservice inspection interval, the technical basis contained in WCAP-16144-P, Revision 1, remains applicable.

Table 1: BVPS-2 CRDM Nozzle Minimum Required Inspection Coverage

Penetration No.	Minimum Inspection Coverage Below the J-Groove Weld Toe on the Downhill Side (in)	Penetration No.	Minimum Inspection Coverage Below the J-Groove Weld Toe on the Downhill Side (in)
1	1.44	29	0.88
2	1.68	30	1.00
3	1.32	31	1.40
4	1.52	32	1.24
5	1.24	33	1.12
6	1.26	34	0.92
7	1.20	37	0.88
8	1.12	38	0.84
9	1.40	41	0.92
10	1.40	42	0.92
11	1.08	43	0.96
12	1.40	45	0.88

13	1.36	46	0.80
14	1.32	48	0.88
15	1.20	49	0.88
16	1.44	54	0.96
17	1.26	55	0.80
18	1.12	56	0.72
19	1.19	57	0.92
20	1.00	58	0.40
21	1.32	59	0.76
22	1.08	60	0.68
23	1.20	61	0.68
24	1.28	62	0.48
25	1.20	63	0.68
26	1.04	64	0.88
27	1.24	65	0.60
28	1.12		

3.6 NRC Staff Evaluation

The NRC staff's review was based on 10 CFR 50.55a(z)(2) which states: (1) compliance with the specified requirements of this section would result in hardship without a compensating increase in the level of quality and safety and (2) regulations in 10 CFR 50.55a(g)(6)(ii)(D)(1) requires that examinations of the reactor vessel head be performed in accordance with ASME Code Case N-729-4 subject to the conditions specified in paragraphs10 CFR 50.55a(g)(6)(ii)(D)(2) through (6).

The specific regulatory requirements for which relief is requested are defined in 10 CFR 50.55a(g)(6)(ii)(D)(3), "Bare metal visual frequency," which states: "Instead of Note 4 of ASME BPV Code Case N–729–4, the following shall be implemented. If effective degradation years < 8 and if no flaws are found that are attributed to primary water stress-corrosion cracking: (i) A bare metal visual examination is not required during refueling outages when a volumetric or surface examination is performed; and (ii) If a wetted surface examination has been performed of all of the partial penetration welds during the previous nonvisual examination, the reexamination frequency may be extended to every third refueling outage or 5 calendar years, whichever is less, provided an IWA–2212 VT–2 visual examination of the head is performed under the insulation through multiple access points in outages that the VE is not completed. This IWA–2212 VT–2 visual examination may be performed with the reactor vessel depressurized." The extent of the examination of the nozzle tube in question is determined by the incidence angle, Θ, and the distance "a" below the J-groove weld, as defined in Figure 2 of N-729-4 , "a = 1.5 in. (38 mm [millmeter]) for incidence angle, Θ, ≤ 30 degrees and for all nozzles ≥ 4.5 in. (115 mm) OD or 1 in. (25 mm) for incidence angle, Θ, ≥ 30 degrees; or to the end of the tube, whichever is less." The licensee has identified 53 CRDM penetration nozzles in Table 1 of November 13, 2017, submittal, for which this inspection coverage is not physically obtainable with ultrasonic inspection.

The licensee has shown a physical and radiological hardship which would be incurred in order to be within compliance with the specified requirements. The NRC staff finds that a physical hardship exists due to the inability of ultrasonic or eddy current inspection to effectively scan the bottom end of each CRDM penetration as each nozzle is threaded on the OD and internally tapered. While dye penetrant inspection would be an option for the licensee, the inspection

would require manual application in a high radiation area. Further, additional setup work would require additional accumulation of dose for each nozzle. Therefore, the NRC staff finds that the radiological dose required to perform the additional inspection would be a significant radiological hardship for the limited additional inspection coverage.

The NRC staff then compared the regulatory requirement to the proposed alternative to ensure that given this hardship, compliance with the regulation did not provide a compensating increase in the level of quality and safety. The NRC staff reviewed the licensee's basis for the proposed alternative through a stress and fracture mechanics analysis.

The NRC staff's review of the stress analysis was based on the degradation phenomenon of concern being PWSCC which typically initiates in the areas of the highest tensile stress in susceptible materials, such as UNS N06600 material, and propagates in a controlled fashion in response to time, environment (i.e., temperature) and stress intensity. The NRC staff reviewed the licensee's stress analysis and conclusions by comparison of the licensee's supporting data for various nozzle angles, the conservative analysis performed to support Materials Reliability Program Report, MRP-95R1, "Generic Evaluation of Examination Coverage Requirements for Reactor Pressure Vessel [RPV] Head Penetration Nozzles, Revision 1," dated September 2004 (ADAMS Accession No. ML043200602). The results of the NRC staff review supports the licensee's stress analysis. The NRC staff finds the missed inspection coverage is in a reduced stress area, (less than 20 ksi). The staff noted that the requirements of Appendix I of ASME Code Case N-729-1 are identical to those of Appendix I of ASME Code Case N-729-4.

The licensee's fracture mechanics analysis showed that a conservative through-wall axial flaw located in the uninspected region of the nozzle would not grow to the toe of the J-groove weld, to challenge the reactor coolant pressure boundary in less than 4 years of full-power operation. As the inspection frequency for each penetration nozzle at BVPS-2 is every refueling outage, the licensee's fracture mechanics analysis provides a basis for reasonable assurance of the structural integrity for each penetration nozzle with reduced inspection coverage as identified in Table 1 of November 13, 2017, submittal.

The NRC staff's assessment of the licensee's fracture mechanics analysis for the axial crack growth predictions for various nozzle angles is based on the data analysis of the supporting Figures B-1 through B-9 of WCAP-16144-P, Revision 1. In addition, the NRC staff reviewed methodology addressed in WCAP-16144-P, Revision 1, and concludes the following:

(1) Based on the applied hoop stress in the nozzle located below the J-groove weld, the licensee calculated axial crack growth of a postulated flaw originated from the ID surface of the nozzle in an uninspected region. The licensee conservatively assumed that any postulated crack is a through-wall crack. The licensee projected time shown in Figures B-1 through B-9 of WCAP-16144-P, Revision 1, for the crack to grow to the toe of the J-groove weld is more conservative (i.e., shorter than the actual time it would take to travel to the toe of the J-groove weld). This would give the licensee extra time (margin) by one outage cycle to identify any leakage at the toe of the J-groove weld, if any through-wall crack were to occur in the nozzle below the J-groove weld.

(2) During the third ISI inspections at BVPS-2, the licensee did not identify the presence of any boric acid deposits on the vessel head and in the annulus region of the nozzle. Therefore, the NRC staff finds the adequacy of the re-inspection frequency to provide reasonable assurance of structural integrity of each nozzle (due to the area of missed

inspection coverage as defined in Table 1 of November 13, 2017 submittal) is maintained during the fourth ISI interval.

(3) The licensee stated that the calculation inputs for the stress analysis and fracture mechanics analysis contained in WCAP-16144-P, Revision 1, are expected to remain the same throughout the fourth 10-year ISI interval. This is due to the fact that there have been no major modifications to the operating limits for BVPS-2 since 2008 that would affect stress calculation inputs. Because the calculation inputs used in WCAP-16144-P, Revision 1, have not changed and are not expected to change throughout the fourth 10-year ISI interval, the technical basis contained in WCAP-16144-P, Revision 1, remains applicable for the BVPS-2 fourth 10-year ISI interval.

The safety issues that are addressed by the 10 CFR 55a(g)(6)(ii)(D) are degradation of the low-alloy steel RPV upper head, reactor coolant pressure boundary integrity and ejection of the RPV upper head penetration nozzle due to circumferential cracking of the nozzle above the J-groove weld. The licensee's proposed alternative inspection provides reasonable assurance that these safety issues are addressed at BVPS-2. The licensee stated that while surface examination could be performed to increase the inspection coverage for the nozzle, these additional inspections would be of limited value and require extensive work in very high radiation fields. The NRC staff finds that performing these additional surface examinations would result in hardship without a compensating increase in the level of quality or safety.

4.0 CONCLUSION

Based on the above discussion, the NRC staff has concluded that compliance with 10 CFR 50.55a(g)(6)(ii)(D) would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety, and that the proposed alternative provides reasonable assurance of structural integrity. Therefore, pursuant to 10 CFR 50.55a(z)(2), the NRC staff authorizes the proposed alternative 2-TYP-4-RV-02 for BVPS-2 for the fourth 10-year ISI interval, or until the RPV head is replaced, whichever occurs first.

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

Principle Contributor: G. Cheruvenki

Date of issuance: July 2, 2018

SUBJECT: BEAVER VALLEY POWER STATION, UNIT NO. 2 - RELIEF REQUEST NO. 2-TYP-4-RV-02 REGARDING THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER AND PRESSURE VESSEL CODE CASE N-729-4 EXAMINATION REQUIREMENTS (EPID L-2017-LLR-0138) DATED JULY 2, 2018

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ADAMS ACCESSION No.: ML18178A112 ***Input received. No substantial changes made.**

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