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

March 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 POWER STATION, UNIT NO. 2 – SAFETY EVALUATION OF PROPOSED ALTERNATIVE TO USE ASME CODE CASES N-695-1 AND N-696-1 IN LIEU OF CERTAIN REQUIREMENTS OF THE ASME CODE (EPID L-2017-LLR-0130)

Dear Mr. Bologna:

By letter dated October 25, 2017, FirstEnergy Nuclear Operating Company (FENOC, the licensee) submitted proposed alternative, 2-TYP-4-RVSE-2, for Beaver Valley Power Station, Unit No. 2 (BVPS 2). The licensee proposed to use the inner diameter (ID) flaw depth sizing root mean square error (RMSE) criteria of American Society of Mechanical Engineers (ASME) Code Case N-695-1 "Qualification Requirements for Dissimilar Metal Piping Welds, Section XI" and ASME Code Case N-696-1 "Qualification Requirements for Mandatory Appendix VIII Piping Examinations Conducted from the Inside Surface, Section XI" at BVPS-2. The Code Cases represent voluntary alternatives to compliance with Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," of the ASME Boiler and Pressure Vessel (BPV) Code. The licensee submitted the proposed alternative in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(z)(2).

Specifically, pursuant to 10 CFR 50.55a(z)(2), the licensee proposed an alternative ID flaw depth sizing RMSE criteria for the ultrasonic testing performance demonstration on the basis that complying with the ASME BPV Code requirement would result in hardship or unusual difficulty without a compensating increase in the 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 FENOC has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(2), for BVPS-2. Our safety evaluation concludes that the proposed alternative provides reasonable assurance of the structural integrity and leak-tightness of the subject welds, and that complying with the ASME BPV Code requirements would result in hardship or unusual difficulty, without a compensating increase in the 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)(2). Therefore, the NRC staff authorizes the use of relief request 2-TYP-4-RVSE-2 for the fourth 10 year inservice inspection interval of BVPS-2, which will start on August 29, 2018, and end on August 28, 2028.

All other ASME Code requirements for which relief was not specifically requested and approved in the proposed alternatives remain in effect, 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 or 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
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# SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

# REQUEST FOR ALTERNATIVE 2-TYP-4-RVSE-2

# REGARDING USE OF ASME CODE CASES N-695-1 AND N-696-1

# FIRSTENERGY NUCLEAR OPERATING COMPANY

# BEAVER VALLEY POWER STATION, UNIT NO. 2

# DOCKET NO. 50-412

## 1.0 INTRODUCTION

By letter dated October 25, 2017 (Agencywide Documents Access and Management System Accession No. ML17299A030), FirstEnergy Nuclear Operating Company (FENOC, the licensee) submitted proposed alternative, 2-TYP-4-RVSE-2, for Beaver Valley Power Station, Unit No. 2 (BVPS-2). The licensee proposed to use the inner diameter (ID) flaw depth sizing root mean square error (RMSE) criteria of American Society of Mechanical Engineers (ASME) Code Case N-695-1 "Qualification Requirements for Dissimilar Metal Piping Welds, Section XI" and ASME Code Case N-696-1 "Qualification Requirements for Mandatory Appendix VIII Piping Examinations Conducted from the Inside Surface, Section XI" at BVPS-2. The Code Cases represent voluntary alternatives to compliance with Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," of the ASME Boiler and Pressure Vessel (BPV) Code. The licensee submitted the proposed alternative in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(z)(2).

Specifically, pursuant to 10 CFR 50.55a(z)(2), the licensee proposed an alternative ID flaw depth sizing RMSE criteria for the ultrasonic testing (UT) performance demonstration on the basis that complying with the ASME Code requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

## 2.0 REGULATORY EVALUATION

Section 50.55a(z) of 10 CFR states that alternatives to the requirements of paragraph (g) of 10 CFR 50.55a may be used when authorized by the U.S. Nuclear Regulatory Commission (NRC, the Commission) if the licensee demonstrates (1) the proposed alternatives would provide 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.

The regulations in 10 CFR 50.55a(g)(4), "Inservice inspection standards requirement for operating plants," require that the inservice inspection (ISI) of ASME Code Class 1, 2, and 3 components and system pressure tests occur during the first 10-year interval and subsequent

10-year intervals that comply with the requirements in the latest edition and addenda of Section XI of the ASME BPV Code incorporated by reference in 10 CFR 50.55a(a), subject to the limitations and modifications listed in 10 CFR 50.55a(b). For certain ASME Code Class 1, 2, and 3 components, licensees must meet the requirements of the ASME BPV Code and applicable addenda, except where alternatives have been authorized pursuant to 10 CFR 50.55a(z)(1) or 10 CFR 50.55a(z)(2).

The regulations in 10 CFR 50.55a(g)(4)(ii), "Applicable ISI Code: Successive 120-Month Intervals," require that inservice examination of components and system pressure tests conducted 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 voluntary ASME Code Cases listed in NRC Regulatory Guide (RG) 1.147, Revision 18, when using ASME Code, Section XI, as incorporated by reference in paragraphs (a)(3)(ii) of 50.55a, subject to the conditions listed in paragraph (b) of 50.55a. However, a licensee whose ISI interval commences during the 12 through 18-month period after August 17, 2017, may delay the update of their Appendix VIII program by up to 18 months after August 17, 2017. Alternatively, licensees may, at any time in their 120-month ISI interval, elect to use the Appendix VIII in the latest edition and addenda of the ASME Code incorporated by reference in paragraph (a) of 50.55a, subject to any applicable conditions listed in paragraph (b) of 50.55a. Licensees using this option must also use the same edition and addenda of Appendix I as Appendix VIII, including any applicable conditions listed in paragraph (b) of 50.55a.

The regulations in 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," require holders of operating licenses or combined licenses for pressurized-water reactors as of or after August 17, 2017, to 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 (g)(6)(ii)(F)(2) through (13) of 50.55a, by the first refueling outage starting after August 17, 2017.

## 3.0 TECHNICAL EVALUATION

### 3.1 Components for which Alternative is Requested

The affected components are the ASME Code Class 1 piping welds in the reactor coolant system. The licensee described the welds in this relief request as follows:

- Dissimilar metal (DM) butt welds
    - Three reactor pressure vessel (RPV) outlet (hot leg) nozzle to safe-end DM butt welds have nominal ID of 28.97 inches and wall thickness of 2.63 inches. The licensee classified all three welds as Inspection Item A-2 in accordance with Code Case N-770-2 (Table 1).

| | |
|---|---|
| 2RCS*REV21-N-24 | Inspection Item A-2 |
| 2RCS*REV21-N-26 | Inspection Item A-2 |
| 2RCS*REV21-N-28 | Inspection Item A-2 |

    - Three RPV inlet (cold leg) nozzle to safe-end DM butt welds with nominal ID of 27.47 inches and wall thickness of 2.50 inches. The licensee classified all three welds as Inspection Item B in accordance with Code Case N-770-2 (Table 1).

| | |
|---|---|
| 2RCS*REV21-N-23 | Inspection Item B |
| 2RCS*REV21-N-25 | Inspection Item B |
| 2RCS*REV21-N-27 | Inspection Item B |

The licensee stated that the materials of construction of the above welds and associated components are low alloy steel nozzles welded to austenitic stainless steel safe-ends by nickel based alloy (e.g., Alloy 82/182) weld metals. The nickel based alloy materials (e.g., Alloy 82/182) are known to be susceptible to the primary water stress-corrosion cracking.

- Similar metal butt welds

  The licensee stated that the six similar metal welds listed below have been part of the BVPS-2, risk-informed (RI)-ISI program. For the fourth 10-year ISI interval, the BVPS-2, RI-ISI program will be revised in accordance with ASME Code Case N-716-1, and the subject similar metal welds will be classified (i.e., inspection item) accordingly. Code Case N-716-1 has been incorporated by reference into 10 CFR 50.55a by inclusion in RG 1.147, Revision 18 (January 17, 2018, 82 FR 2331).

  - Three RPV outlet (hot leg) safe-end to pipe butt welds have nominal ID of 29.20 inches and wall thickness of 2.51 inches.

    2RCS*001-F01
    2RCS*004-F01
    2RCS*007-F01

  - Three RPV inlet (cold leg) safe-end to pipe butt welds have nominal ID of 27.70 inches and wall thickness of 2.39 inches.

    2RCS*003-F04
    2RCS*006-F04
    2RCS*009-F04

The licensee stated that the materials of construction of the above six similar metal welds and associated components are austenitic stainless steel safe-ends welded to austenitic stainless steel pipes by austenitic stainless steel weld metals. The austenitic stainless steel materials are known to be not susceptible to primary water stress-corrosion cracking.

The licensee stated that prior to utilizing the UT for the examinations of the above welds (i.e., RPV nozzle to safe end welds and safe end to pipe welds at BVPS-2), the UT procedures demonstration, equipment, and personnel qualification shall meet applicable Appendix VIII supplements of ASME BPV Code Section XI.

3.2 ASME Code Edition and Addenda

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

3.3 Duration of Relief Request

The proposed alternative would extend for the duration of the fourth 10-year ISI interval of BVPS-1 which is scheduled to start on August 29, 2018, and end on August 28, 2028.

3.4 ASME Code Requirements

The ASME Code ISI requirements applicable to the DM welds in this relief request originate in Table IWB-2500-1 of Section XI. However, the regulations under 10 CFR 50.55a(g)(6)(ii)(F) mandate augmented inspection in accordance with Code Case N-770-2 with conditions, for the DM welds that contain Alloy 82/182. Code Case N-770-2 (Table 1), requires the RPV hot and cold leg nozzle to safe-end DM butt welds to be volumetrically examined by UT. Footnote 4 of Code Case N-770-2 (Table 1) requires that the UT procedures demonstration and personnel qualification meet applicable supplements of Appendix VIII of Section XI.

The ASME Code ISI requirements applicable to the similar metal welds in this relief request originate in Table IWB-2500-1. The BVPS-2 RI-ISI program for the fourth 10-year ISI interval that will be in accordance with Code Case N-716-1, provides an alternative to the ASME Code requirements. In both the ASME Code and the RI-ISI program, it is required that the austenitic welds listed in this request be volumetrically examined by UT, and that the UT procedures and personnel be demonstrated and qualified in accordance with applicable supplements of Appendix VIII.

For the welds (i.e., DM and austenitic welds) in this relief request, applicable supplements of Appendix VIII are Supplement 10 "Qualification Requirements for Dissimilar Metal Piping Welds," Supplement 2 "Qualification Requirements for Wrought Austenitic Piping Welds," and Supplement 14 "Qualification Requirements for Coordinated Implementation of Supplements 2, 3, and 10 for Piping Examinations Performed from the Inside Surface." In accordance with these supplements, it is required that the UT procedures, equipment, and personnel be qualified for the ID flaw depth sizing, and that the flaw depths estimated by the UT as compared with the true flaw depths do not exceed 0.125 inch RMSE.

A voluntary alternative to Supplement 10 is Code Case N-695-1. A voluntary alternative to Supplement 14 (i.e., coordinate implementation of Supplements 2, 3, and 10) is Code Case N-696-1. Neither of these code cases have yet been incorporated by reference into 10 CFR 50.55a by inclusion in RG 1.147.

3.5 Proposed Alternative and Basis for Use

Performance demonstration of UT

For the UT procedures demonstration, equipment, and personnel qualification, the licensee proposed to use the ID flaw depth sizing RMSE criteria of Code Case N-695-1 and Code Case N-696-1 in lieu of the requirements contained in Supplement 10 and Supplement 14, respectively.

According to the examination procedures contained in Code Case N-695-1 and Code Case N-696-1, the flaw depths estimated by the UT as compared with the true flaw depths shall not exceed, 0.125 inch RMSE for piping less than 2.1 inches in thickness, and 0.250 inch RMSE for piping greater than or equal to 2.1 inches in thickness (i.e., large diameter piping welds).

Examination of RPV nozzle welds

In the event that a flaw is detected in the RPV nozzle to safe end DM welds and/or the safe end to pipe austenitic welds that requires depth sizing, the licensee's proposed alternative is as follows:

The licensee stated that:

> If a flaw or flaws are detected and are measured as less than 50 percent through-wall in depth, they will be sized in accordance with the personnel, procedures, and equipment qualified to meet the requirements of ASME Code Cases N-695-1 and N-696-1.
>
> If a flaw or flaws are detected and they are measured as greater than 50 percent through-wall depth, and the flaws will be left in service without mitigation or repair, flaw evaluations will be submitted to the NRC for review and approval prior to reactor startup. In addition to the information normally contained in flaw evaluations, this evaluation will include:
>
> 1. Information concerning the mechanism that caused the flaw.
> 2. Information concerning the inside surface roughness/profile in the region of the inspection.
> 3. Information concerning areas in which the UT probe may lift off from the surface of the pipe/weld.

The licensee also stated that, although utilities' contracted vendors have qualified for flaw detection and length sizing for inspections performed from ID surface of the weld, the UT qualification for ID flaw depth sizing has not yet been successful to meet the ASME Code required 0.125 inch RMSE. To date, no vendor has been capable of meeting the required 0.125 inch RMSE criterion for flaw depth sizing for inspections performed from the ID surface. Consequently, a request to use an alternative ID flaw depth sizing RMSE criteria is sought.

The licensee stated that the UT procedures, equipment, and personnel have been qualified in accordance with Appendix VIII for flaw depth sizing from the outer diameter (OD) surface, however, performing the UT from the OD would increase personnel total radiological dose exposure by 0.5 roentgen equivalent man (rem) which would be hardship.

The licensee stated that performing the examination from the ID surface of the weld reduces the overall exposure to radiation because the examination is performed using remotely operated UT system.

3.6 NRC Staff Evaluation

The NRC staff has evaluated this request pursuant to 10 CFR 50.55a(z)(2). The NRC staff focuses on (1) whether compliance with the specified requirements results in a hardship or unusual difficulty; (2) that the alternative RMSE is adequate; and (3) that licensee's proposed

alternative (i.e., accepting alternative RMSE, and obtaining the NRC approval for reactor startup in the event flaws are detected and depth measured greater than or equal to 50 percent through wall thickness) provides reasonable assurance of structural integrity and leak tightness of the welds. The NRC staff finds that if these three criteria are met then the requirements of 10 CFR 50.55a(z)(2) will also be met.

Hardship

In its evaluation, the NRC staff found that requiring the licensee to comply with the ASME Code, Section XI, Appendix VIII (Supplement 10 and 14) flaw depth sizing RMSE criteria for performance demonstration of the UT for examinations from the ID surface would result in hardship. The basis for the hardship is as follows:

- The NRC staff confirms that for more than a decade, industry has made great effort (repeated attempts and even equipment enhancements) to reduce the ID flaw depth sizing uncertainty, but none has achieved the ASME Code required RMSE of 0.125 inch.

- The NRC staff confirms that the inherent challenges for reducing the ID flaw depth sizing uncertainty are attributed to geometry and roughness of the welds' ID surface, multiple materials, and microstructural anisotropies. These conditions constitute unusual difficulties.

- The NRC staff confirms that industry has been successful in achieving the ASME Code RMSE of 0.125 inch for the OD flaw depth sizing performance demonstration. However, the volumetric examinations of the welds in this relief request by the qualified UT from the OD surface could expose the involved personnel to an additional, unnecessary radiation dose; an as low as reasonably achievable concern that constitutes a hardship.

Based on the above, the NRC staff determined that imposing the ASME Code requirements could result in a hardship and unusual difficulty for the facility.

Safety significance of alternative RMSE

In evaluating the licensee's proposed alternative performance demonstration criteria, the NRC staff assessed whether it appears that the proposed ID flaw depth sizing RMSE of 0.250 inch for large bore piping welds is adequate. The NRC staff found that:

- Since 2002, licensees have submitted relief requests to use alternative RMSE criteria for the UT procedure demonstration and personnel qualifications specifically related to the ID flaw depth sizing in the DM and/or austenitic butt welds in pressurized-water reactor (PWR) piping. The basis has been that licensees and/or inspection vendors have repeatedly attempted to qualify the UT procedures and personnel for ID flaw depth sizing in accordance with the ASME Code required RMSE of 0.125 inch, but none has been successful due to materials inhomogeneity/anisotropies and ID surface geometry and conditions.

- In 2011, the NRC and Electric Power Research Institute (EPRI) signed "Memorandum of Understanding (MOU) for Nondestructive Examination" to allow review/assessment of Performance Demonstration Initiative (PDI) program proprietary data, development of a technical basis to support utilizing alternative RMSE criteria for ID flaw depth sizing, and

subsequently an ASME Code action. In July 2012, NRC staff and EPRI personnel reviewed the PDI program proprietary data used in blind tests. This review was conducted to assess potentials for undersizing the depth of detected flaws as well as to verify the information and analysis presented by EPRI and the industry in the public meeting held between the NRC staff, PDI, EPRI, and industry representatives on March 16, and June 19, 2012 (ADAMS Accession Nos. ML12097A071 and ML12173A755, respectively). This collective assessment revealed that there is a potential to undersize and/or oversize the depth of flaws detected in the volumetric examinations. Based on this review, the NRC staff determined that until alternative screening criteria have been developed to justify the ID flaw depth sizing uncertainty, alternative RMSE criteria need to be submitted to the NRC for approval via a relief request process prior to implementation at plants.

- In 2013, EPRI published Technical Report No. 3002000612 "Materials Reliability Program: Technical Basis for Change to American Society of Mechanical Engineers (ASME) Section XI Appendix VIII Root-Mean-Square Error Requirement for Qualification of Depth-Sizing for Ultrasonic Testing (UT) Performed from the Inner Diameter (ID) of Large-Diameter Thick-Wall Supplement 2, 10, and 14 Piping Welds (MRP-373)" recommending the RMSE depth sizing criteria be changed from 0.125 inch (as required by the ASME Code) to 0.250 inch for the large bore PWR piping welds (a nominal wall thickness of at least 2.1 inch) for examinations from the ID. This suggests that an inspector qualified with a 0.25-inch RMSE is capable of accurately measuring depth of detected flaws. Subsequently, industry developed ASME Code Cases N-695-1 and N-696-1 using MRP-373 as a technical basis. On December 31, 2014, ASME approved Code Cases N-695-1 and N-696-1. It should be noted that since these two code cases have not yet been incorporated by reference into 10 CFR 50.55a by inclusion in RG 1.147, the NRC's approval is required prior to their use by licensees.

- January 8-9, 2014, public meetings were held for the purpose of Nondestructive Examination Technical Information Exchange between industry and NRC (Meeting Summary - ADAMS Accession No. ML14057A752 and NRC Presentation - ADAMS Accession No. ML14015A036). The next annual public meetings in this series were held January 13-15, 2015 (ADAMS Accession No. ML15056A302). During the 2015 discussions, the NRC staff acknowledged that a resolution had been reached to change the RMSE ID depth sizing criteria from 0.125 inch to 0.25 inch for PWR piping welds with nominal wall thickness of at least 2.1 inch provided that no flaws greater than or equal to 50 percent through wall thickness be left in service without NRC approval.

Based on the above collective efforts, the NRC staff determines that the licensee's proposed RMSE is acceptable because it provides reasonable assurance that personnel who perform examinations have been qualified to measure the depth of flaws with a reasonable accuracy.

In addition to the analysis described above, the NRC staff evaluated the safety significance of not allowing detected flaws with depths measured greater than or equal to 50 percent through wall thickness to be left in service without NRC approval. Although the NRC staff finds that the assertions and interpretations documented in MRP-373 are reasonable for procedures and personnel qualifications, there still exists concern about potentials for flaw undersizing during examinations of the welds due to their ID surface roughness and geometrical surface waviness. Therefore, the NRC staff determines that if a flaw is detected and its depth is measured to be greater than or equal to 50 percent through wall thickness and it is to remain in service without mitigation or repair, submitting a flaw evaluation supplemented with the information below for

the NRC review and approval prior to reactor startup is necessary to provide reasonable assurance of the structural integrity and leak tightness of the welds in this relief request. The required supplemental information that accompanies the flaw evaluation includes:

i. The inner profile of the weld, pipe, and nozzle in the region at and surrounding the flaw;

ii. An estimate of the percentage of potential surface areas with UT probe lift-off; and

iii. Information on the mechanism which caused the crack.

The NRC staff notes that these requirements are identical to the licensee's proposed alternative. Therefore, the NRC staff finds that the licensee's proposed alternative (i.e., use of ASME Code Cases N-695-1 and N-696-1 for performance demonstration, and obtaining NRC approval for restart in the event deep flaws are detected) provide reasonable assurance of structural integrity and leak tightness of the welds.

## 4.0 CONCLUSION

As set forth above, the NRC staff determines that the proposed alternative provides reasonable assurance of the structural integrity and leak-tightness of the subject welds, and complying with the specified requirement would result in hardship or unusual difficulty, without a compensating increase in the 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)(2). Therefore, the NRC staff authorizes the use of 2-TYP-4-RVSE-2 for the fourth 10 year ISI interval of BVPS-2, which is scheduled to start on August 29, 2018, and end on August 28, 2028.

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

Principal Contributor: A. Rezai

Date: March 27, 2018

SUBJECT: BEAVER VALLEY POWER STATION, UNIT NO. 2 – SAFETY EVALUATION OF PROPOSED ALTERNATIVE TO USE ASME CODE CASES N-695-1 AND N-696-1 IN LIEU OF CERTAIN REQUIREMENTS OF THE ASME CODE (EPID L-2017-LLR-0130) DATED MARCH 27, 2018

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