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

October 6, 2009

Mr. Peter P. Sena III
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 - RELIEF REQUEST NO. 2-TYP-3-RV-01 REGARDING ALTERNATIVE REPAIR METHODS FOR REACTOR VESSEL HEAD PENETRATIONS & J-GROOVE WELDS (TAC NO. MD9970)

Dear Mr. Sena:

By letter dated October 9, 2008, as supplemented by letter dated May 19, 2009, FirstEnergy Nuclear Operating Company (licensee) submitted a request for authorization of a proposed alternative to American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements associated with the repair of reactor vessel head penetrations and J-groove welds for Beaver Valley Power Station, Unit No. 2 for the remainder of the third 10-year inservice inspection (ISI) interval, scheduled to end in August 28, 2018. Specifically, the licensee requested relief from the requirements of ASME Code, Section III, NB-4131, NB-2538, and NB-2539 for the removal of base material defects prior to repair by welding and from NB-4451, NB-4452, and NB-4453 for the removal of weld material defects prior to repair by welding.

The Nuclear Regulatory Commission (NRC) staff has concluded that the proposed alternative to ASME Code, Section III, NB-4131, NB-2538, NB-2539, NB-4451, NB-4452, and NB-4453 will provide an acceptable level of quality and safety. Therefore, pursuant to Section 50.55a(a)(3)(i) of Part 50 of Title 10 of the *Code of Federal Regulations*, the NRC staff authorizes the proposed alternative for the remainder of the BVPS-2 third 10-year ISI interval, which ends August 28, 2018.

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 Beaver Valley Project Manager, Nadiyah Morgan, at (301) 415-1016.

Sincerely,

Nancy L. Salgado

Nancy L. Salgado, Chief
Plant Licensing Branch 1-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-412

Enclosure:
As stated

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING THE 10-YEAR INSERVICE INSPECTION PLAN INTERVAL

FOR RELIEF REQUEST NO. 2-TYP-3-RV-01

FIRSTENERGY NUCLEAR OPERATING COMPANY

FIRSTENERGY NUCLEAR GENERATION CORP.

OHIO EDISON COMPANY

THE TOLEDO EDISON COMPANY

BEAVER VALLEY POWER STATION, UNIT NO. 2

DOCKET NO. 50-412

1.0 INTRODUCTION

By letter dated October 9, 2008 (Agencywide Document Access and Management System (ADAMS) Accession No. ML082900209), as supplemented by letter dated May 19, 2009 (ADAMS Accession No. ML091420091), FirstEnergy Nuclear Operating Company (licensee) submitted a request for authorization of a proposed alternative to American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements associated with the repair of reactor vessel head penetrations and J-groove welds for Beaver Valley Power Station, Unit No. 2 (BVPS-2) for the remainder of the third 10-year inservice inspection (ISI) interval, scheduled to end in August 28, 2018. Specifically, the licensee requested relief from the requirements of ASME Code, Section III, NB-4131, NB-2538, and NB-2539 for the removal of base material defects prior to repair by welding and from NB-4451, NB-4452, and NB-4453 for the removal of weld material defects prior to repair by welding.

Previous examinations of the reactor vessel head penetration have resulted in performing repairs on 4 penetrations in the BVPS-2 reactor head. These repairs were implemented in accordance with BVPS-2 Relief Request No. BV3-RV-04 (ADAMS Accession No. ML030910023), which was approved by the Nuclear Regulatory Commission (NRC) for the second 10-year ISI interval that expired on August 28, 2008 (ADAMS Accession No. ML031340697). Due to the previous repair history of BVPS-2, Relief Request No. 2-TYP-3-RV-01 is appropriate to forego the need for an expedited request should repairs be required.

2.0 REGULATORY EVALUATION

In accordance with Section 50.55a(g)(4) of Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR), ASME Code, Class 1, 2, and 3 components must meet the requirements of Section XI, "*Rules for Inservice Inspection of Nuclear Power Plant Components*," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that all inservice examination and system pressure tests conducted during the first 10-year interval, and subsequent intervals, comply with the requirements in the latest edition and addenda of ASME Code, Section XI, incorporated by reference in 10 CFR 50.55a(b) on the date 12 months prior to the start of the ten year interval. For BVPS-2, the ASME Code of record for the third 10-year ISI interval, which began on August 29, 2008, is the 2001 Edition through the 2003 Addenda.

Alternatives to requirements may be authorized or relief granted by the NRC pursuant to 10 CFR 50.55a(a)(3)(i), 10 CFR 50.55a(a)(3)(ii), or 10 CFR 50.55a(g)(6)(i). In proposing alternatives or requests for relief, the licensee must demonstrate that: (1) the proposed alternatives would provide an acceptable level of quality and safety; (2) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety; or (3) conformance is impractical for the facility. Pursuant to 10 CFR 50.55a(g)(4)(iv), ISI items may meet the requirements set forth in subsequent editions and addenda of the ASME Code that are incorporated by reference in 10 CFR 50.55a(b), subject to the limitations and modifications listed therein, and subject to Commission approval. Portions of editions and addenda may be used, provided that all related requirements of the respective editions and addenda are met.

3.0 TECHNICAL EVALUATION

3.1 System/Component Affected

BVPS-2 reactor vessel head 2RCS-REV-21, penetration numbers 1 through 65.

3.2 Applicable Code Requirements

ASME Code, Section XI, 2001 Edition through 2003 Addenda, subparagraph IWA-4120 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 ASME Code, Section III, 1971 Edition through Summer 1972 Addenda. The licensee requests relief from subparagraphs NB-4131, NB-2538, NB-2539, which pertain to the removal of base material defects prior to repair by welding, and NB-4451, NB-4452, and NB-4553 which pertain to the removal of weld material defects prior to repair by welding. The licensee notes that the use of provisions of IWA-4340, "Mitigation of Defects by Modification" is prohibited per 10 CFR 50.55a(b)(2)(xxv).

3.3 Licensee's Proposed Alternative and Basis for Request

As an alternative to the defect removal requirements of ASME Code, Section XI and Section III, the licensee proposed the use of the embedded flaw repair process described in Westinghouse Electric Company Topical Report WCAP-15987-P, Revision 2-A (WCAP-15987), "Technical

Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations" (ADAMS Accession No. ML040290246) and the plant-specific Westinghouse Report WCAP-16158-P, "Technical Basis for Repair Options for Reactor Vessel Head Penetration Nozzles and Attachment Welds: Beaver Valley Unit 2" (ADAMS Accession No. ML082900209) for the repair of unacceptable indications in reactor vessel head penetrations and J-groove welds.

The NRC safety evaluation of WCAP-15987 (ADAMS Accession No. ML031840237) specified the use of "Flaw Evaluation Guidelines," sent by letter dated April 11, 2003, to the Nuclear Energy Institute (NEI) (ADAMS Accession No. ML030980322). In lieu of these guidelines, the licensee proposed to follow the criteria for flaw evaluation established in 10 CFR 50.55a(g)(6)(ii)(D), which specifies the use of Code Case N-729-1 with certain conditions, for reactor head penetrations and J-groove welds.

The licensee stated that the proposed alternative embedded flaw repair is considered permanent, since the embedded flaw is isolated from primary water by layers of Alloy 52M weldment. Alloy 52M weldment is considered resistant to primary water stress-corrosion cracking (PWSCC), therefore, a new PWSCC flaw cannot initiate and grow through the Alloy 52M weld metal to reconnect the primary water environment to the embedded flaw. Since the embedded flaw is isolated from the primary water environment, it can no longer propagate by PWSCC, and structural integrity of the remaining unflawed material is maintained.

The licensee also stated that the proposed alternative embedded flaw repair procedures will provide an acceptable level of quality and safety, thus should be authorized under 10 CFR 50.55a(a)(3)(i).

3.4 NRC Staff's Evaluation

The phenomenon of concern is PWSCC. PWSCC typically initiates in susceptible materials, such as Alloy 600 material and Alloy 82/182 weld materials, in areas of tensile stress and propagates in a controlled fashion in response to environmental conditions of time, temperature, stress, and a corrosive environment. The reactor vessel head penetrations and their associated J-groove attachment welds, where Alloy 600 and Alloy 82/182 are present and in contact with primary water, meet the conditions for potential PWSCC, thus may be susceptible to cracking and leaking of primary water if propagating cracks intersect the J-groove weld.

The proposed repair process involves embedding existing flaws in Alloy 600 penetration tubes and Alloy 82/182 J-groove welds by the depositing layers of Alloy 52M weld metal to isolate existing flaws and susceptible material from the primary water environment. When PWSCC initiated flaws are embedded in resistant material, these flaws are separated from the environmental influence of the primary water and further PWSCC does not occur. Experience in laboratory tests and in-service has shown that the nickel-based alloys with chromium content of 24% or greater, such as Alloy 52M weld material, display resistance to PWSCC. These observations are documented in WCAP-15987, Electric Power Research Institute (EPRI) Report "Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs (MRP-169)" (ADAMS Accession No. ML090360429), and the draft EPRI report "Materials Reliability Program: Resistance of Alloys 690, 152 and 52 to Primary Water Stress Corrosion Cracking (MRP-237)" (Proprietary).

3.4.1 Deviations from Accepted Repair Methodology and Flaw Evaluation

The proposed alternatives in BVPS-2 Relief Request No. 2-TYP-3-RV-01 are similar in technical content to those of the BVPS-2 Relief Request No. BV3-RV-04, which was authorized by the NRC for the BVPS-2 third 10-year ISI interval. Both relief requests were based on the technical requirements of WCAP-15987, which was generically approved for use by the NRC in a letter dated July 3, 2003. While the licensee intends to use the repair and inspection methodology of WCAP-15987, the following items deviate from the approved methodology.

3.4.2 Penetration Tube Inside Diameter Repair

The NRC staff has determined that the depth of excavation in the licensee's relief request is less than that specified in WCAP-15987. In response to the NRC staff's request for additional information (RAI) concerning the change in excavation depth, the licensee stated that the purpose of the excavation is to accommodate the application of two weld layers to isolate susceptible material from the environment. The NRC staff considered two aspects of the smaller excavation depth: weld residual stresses and weld dilution.

The coefficient of thermal expansion of the Alloy 52M weld metal is not listed in ASME Code Section II, Part D but, is approximately that of the equivalent base metal, Alloy 690, 8.2 E-6 in/in/degree Fahrenheit (F) at 600 °F. The Alloy 600 base metal is 7.8 E-6 in/in/degree F at 600 °F, a difference of about 5%. The relatively small deposited volume of weld metal and the small number of weld passes, along with the small difference in coefficient of thermal expansion of the base and weld metal will result in minimal residual stress in the weld and surrounding material. Since a component of the residual stress from the weld is tensile, reduction of the residual stress that results from the shallow excavation depth is desirable.

Another aspect of the shallow excavation depth and limited number of weld passes is weld dilution. Weld dilution occurs when the base metal melts during welding and mixes with the weld filler material, resulting in a weld metal chemistry that is intermediate in composition to the base and filler materials. The licensee stated in their RAI response concerning weld dilution, that the expected chemistry of the weld surface is that of a typical Alloy 52 weldment with no significant dilution. While the licensee stated that there is no significant weld dilution, the NRC staff estimated the chromium content of the deposited weld metal using a conservative value of weld dilution of 25%. The base metal, Alloy 600, has a minimum chromium content of 14.0% (SB-167, Alloy N06600 in ASME Code, Section II, Part B) and Alloy 52M weld metal has a minimum chromium content of 28.0% (UNS06054 in ASME Code Section II, Part C, SFA 5.14). Using the minimum chromium values for both Alloy 600 and Alloy 52M, the NRC staff calculates that the minimum chromium content in the first weld pass of Alloy 52M on Alloy 600 base metal would be 24.5% and a second pass would have a minimum of 27% chromium. Since the weld deposit for the proposed 0.125-inch excavation depth will have a chromium content of at least 24%, thus will be able to isolate susceptible material from the environment, and the residual stress will be smaller than that for the excavation depth specified in the WCAP-15987 Report, the NRC staff finds that the proposed 0.125-inch excavation with two weld passes of Alloy 52M depth will provide an acceptable level of quality and safety.

3.4.3 Penetration Tube Outside Diameter (OD) Repair Below the J-Groove Weld

The licensee stated that OD penetration tube axial and circumferential flaws below the J-groove weld will be sealed off with at least 2 layers of Alloy 52M weld material to isolate the flaws from the primary water environment. The NRC staff notes that the proposed number of weld layers is less than that specified in WCAP-15987. As previously discussed, the second Alloy 52M weld layer on Alloy 600 penetration tube base material is expected to have a chromium content in excess of the 24% believed necessary for PWSCC resistance, thus is sufficient to isolate the flaw from the environment. The NRC staff finds that two weld layers will provide an acceptable level of quality and safety.

3.4.4 ISI and Flaw Evaluation

The safety evaluation of WCAP-15987 specified the use of "Flaw Evaluation Guidelines." These guidelines are based on NRC guidance to address flaw evaluations for reactor pressure vessel head penetration nozzles which were referenced in NRC Order EA-03-009. NRC Order EA-03-009 and the First Revised Order EA-03-009 have been subsequently superseded by the requirements of 10 CFR 50.55a(g)(6)(ii)(D). The licensee proposed to follow the criteria established in 10 CFR 50.55a(g)(6)(ii)(D) for future inspections, which specifies the use of ASME Code Case N-729-1 subject to the conditions specified in paragraphs (2) through (6) of 10 CFR 50.55a(g)(6)(ii)(D). By letter dated May 19, 2009, in response to the NRC staff's RAI concerning post repair examination, the licensee stated, "Post repair examination will be performed using the requirements of Code Case N-729-1 with conditions as required by 10 CFR 50.55a(g)(6)(ii)(D) prior to return of service." The NRC staff finds the preservice and ISI procedures are in accordance with current NRC regulations, and therefore, are acceptable.

3.4.5 J-Groove Weld Repair

There is a potential for hot cracking when Alloy 52M is welded on stainless steel, which could have a sulfur content exceeding 0.01%. The specification for the ER308 stainless steel cladding material allows a maximum of 0.03% sulfur. By letter dated May 19, 2009, in response to the NRC staff's RAI concerning the potential for cracking when depositing Alloy 52M on high sulfur ER308 stainless steel, the licensee stated that four similar repairs have been performed on the J-groove welds of the present reactor head using Alloy 52M. After the previous weld repairs were performed, the welds were examined using the dye penetrant test, ultrasonic test, and eddy current test, and no indication of cracking was found. The NRC staff finds that the nondestructive examination (NDE), which is to be performed, will provide reasonable assurance that no flaws will remain in the final weld that are sufficient to invalidate the effectiveness of the weld overlay, thus the proposed J-groove weld repair and NDE procedures will provide an acceptable level of quality and safety.

4.0 CONCLUSION

Based on the above discussion, the NRC staff has concluded that the proposed alternative to ASME Code Section III, NB-4131, NB-2538, NB-2539, NB-4451, NB-4452, and NB-4453 will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternative for the remainder of the BVPS-2 third 10-year ISI interval, which ends August 28, 2018.

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: J. Wallace

Date: October 6, 2009

If you have any questions, please contact the Beaver Valley Project Manager, Nadiyah Morgan, at (301) 415-1016.

Sincerely,

/RA/

Nancy L. Salgado, Chief
Plant Licensing Branch 1-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-412

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