FENOC™
FirstEnergy Nuclear Operating Company

Beaver Valley Power Station
P.O. Box 4
Shippingport, PA 15077

Eric A. Larson
Site Vice President

724-682-5234
Fax: 724-643-8069

September 30, 2015
L-15-297

10 CFR 50.55a

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Beaver Valley Power Station, Unit No. 2
Docket No. 50-412, License No. NPF-73
10 CFR 50.55a Request for Alternative Repair Methods for Reactor Vessel Head Penetrations and J-Groove Welds (Request 2-TYP-3-RV-04)

In accordance with the provisions of 10 CFR 50.55a(z)(1), FirstEnergy Nuclear Operating Company (FENOC) hereby requests Nuclear Regulatory Commission (NRC) approval of a proposed alternative to certain requirements associated with reactor vessel head repairs for the Beaver Valley Power Station, Unit No. 2 (BVPS-2). The enclosure identifies the affected components, the applicable code requirements, and the description and basis of the proposed alternative.

By letter dated February 25, 2011 (Accession No. ML110470557), NRC staff approved alternative repair methods for reactor vessel head penetrations and J-groove welds for BVPS-2, as described in Request 2-TYP-3-RV-03 submitted on November 14, 2009 (Accession No. ML093220057), as supplemented by letters dated June 21, 2010 and August 13, 2010 (Accession Nos. ML101740436 and ML102300043, respectively). The only technical difference between the previously submitted request and the enclosed request is that preservice and inservice examinations for reactor vessel head penetration outside diameter and J-groove welds will be consistent with American Society of Mechanical Engineers Code Case N-729-1, which does not require eddy current testing.

FENOC requests approval of the proposed alternative by September 30, 2016.

There are no regulatory commitments contained in this submittal. If there are any questions or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at (330) 315-6810.

Sincerely,

Eric A. Larson

Enclosure:
Beaver Valley Power Station, Unit No. 2, 10 CFR 50.55a Request 2-TYP-3-RV-04, Revision 0

cc: NRC Region I Administrator
NRC Resident Inspector
NRC Project Manager
Director BRP/DEP
Site BRP/DEP Representative

Enclosure
L-15-297

Beaver Valley Power Station, Unit No. 2,
10 CFR 50.55a Request 2-TYP-3-RV-04, Revision 0

(6 Pages Follow)

Proposed Alternative
In Accordance with 10 CFR 50.55a(z)(1)

--Alternative Provides Acceptable Level of Quality and Safety--

1. ASME CODE COMPONENTS AFFECTED

Component Numbers:	2RCS-REV-21 (Reactor Vessel) Reactor Vessel Head Penetrations 1 through 65
Code Class:	Class 1
Examination Category:	B-P
Item Number:	B15.10
Description:	Alternative Repair Methods for Reactor Vessel Head Penetrations and J-groove Welds

2. APPLICABLE CODE EDITION AND ADDENDA

American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI, 2001 Edition through 2003 Addenda is the code of record for the inservice inspection and repair/replacement programs.

The reactor vessel Construction Code is ASME Section III, 1971 Edition through Summer 1972 Addenda.

3. APPLICABLE CODE REQUIREMENTS

IWA-4000 of ASME Section XI contains requirements for the removal of defects from and welded repairs performed on ASME components. The specific Code requirements for which use of the proposed alternative is being requested are as follows:

ASME Section XI, IWA-4421 states, that:

> Defects shall be removed or mitigated in accordance with the following requirements:
>
> (a) Defect removal by mechanical processing shall be in accordance with IWA-4462.
>
> (b) Defect removal by thermal methods shall be in accordance with IWA-4461.
>
> (c) Defect removal or mitigation by welding or brazing shall be in accordance with IWA-4411.
>
> (d) Defect removal or mitigation by modification shall be in accordance with IWA-4340.

Use of the “Mitigation of Defects by Modification” provisions of IWA-4340 is prohibited per 10 CFR 50.55a(b)(2)(xxv).

For the removal or mitigation of defects by welding, ASME Section XI, IWA-4411 states, in part, the following.

> Welding, brazing, and installation shall be performed in accordance with the Owner's Requirements and...in accordance with the Construction Code of the item...

The applicable requirements of the Construction Code required by IWA-4411 for the removal or mitigation of defects by welding from which relief is requested are as follows.

For defects in base material, ASME Section III, NB-4131 requires that the defects are removed, repaired, and examined in accordance with the requirements of NB-2500. These requirements include the removal of defects via grinding or machining per NB-2538 and, if necessary to satisfy the design thickness requirement of NB-3000, repair welding in accordance with NB-2539.

Similarly, with respect to defects in weld material, ASME Section III, NB-4451 requires that unacceptable defects in weld metal be eliminated and, when necessary, repaired in accordance with NB-4452 and NB-4453.

4. REASON FOR REQUEST

FirstEnergy Nuclear Operating Company (FENOC) conducts inspections of the Beaver Valley Power Station Unit No. 2 (BVPS-2) reactor vessel head in accordance with ASME Code Case N-729-1, with conditions as specified in 10 CFR 50.55a(g)(6)(ii)(D). To address any need to repair unacceptable indications in reactor head penetrations or J-groove welds, relief is requested from the requirements of ASME Code Section XI, IWA-4421, IWA-4411, and the applicable sections of the Construction Code.

Specifically, relief is requested 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. Relief is also requested from the requirements of ASME Code Section III, NB-4451, NB-4452, and NB-4453 for the removal of weld material defects prior to repair by welding.

5. PROPOSED ALTERNATIVE AND BASIS FOR USE

The Nuclear Regulatory Commission (NRC) Safety Evaluation for WCAP-15987 (Reference 1) specified the use of "Flaw Evaluation Guidelines," which was sent to the Nuclear Energy Institute (NEI) by letter dated April 11, 2003 (Reference 2). In lieu of these guidelines, FENOC proposes 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 conditions.

As an alternative to the defect removal requirements of ASME Section XI and Section III, FENOC proposes the use of the embedded flaw repair process described in WCAP-15987, Revision 2-A (Reference 3), for the repair of unacceptable indications in reactor vessel head penetrations and J-groove welds, as approved by the NRC (Reference 1). Design and implementation of the repairs will be consistent with WCAP-15987 and WCAP-16158-P, Revision 0 (Reference 4). Preservice inspections and inservice inspections of repairs will be consistent with ASME Code Case N-729-1. Pursuant to 10 CFR 50.55a(a)(z)(1), the alternative is proposed on the basis that it will provide an acceptable level of quality and safety while minimizing cumulative occupational radiation exposure [dose].

5.1 Reactor Vessel Head Penetration Inside Diameter (ID) Repair Methodology

Consistent with WCAP-15987 methodology, the following repair requirements are proposed for a reactor vessel head penetration ID repair.

An unacceptable axial flaw will be first excavated (or partially excavated) to a depth no greater than 0.125 inches. Although this depth differs from that specified in WCAP-15987, Revision 2-A, Section 2.2.1, the cavity depth is not a critical parameter in the implementation of a repair on the ID surface. The goal of the inlay is to isolate the susceptible material from the environment. The purpose of the excavation is to accommodate the application of weld layers to meet that requirement. The depth specified in WCAP-15987 is a nominal dimension and the depth needed to accommodate three weld layers while still maintaining the tube ID. Since only two weld layers will be applied, less excavation is required and 0.125 inches of excavation is all that is required. The smaller thickness of the cavity excavated for two layers would mean a slightly thinner weld, which would produce less residual stress.

The excavation will be performed using an electrical discharge machining process to minimize penetration tube distortion. After the excavation is complete, either an ultrasonic test (UT) or eddy current test (ECT) will be performed to ensure the entire flaw length is captured. Then, a minimum of two layers of Alloy 52 or 52M weld material will be applied to fill the excavation. The expected chemistry of the weld surface is that typical of Alloy 52 weldment with no significant dilution. Finally, the finished weld will be machined to restore the inside diameter and then a UT and surface examination to ensure acceptability.

Whenever an embedded flaw repair is planned for an inside diameter circumferential flaw, the NRC will be notified.

5.2 Reactor Vessel Head Penetration Outside Diameter (OD) and J-groove Weld Repair Methodology

Consistent with WCAP-15987 methodology, the following repair requirements are proposed for reactor vessel head penetration OD and J-groove weld repairs.

1. An unacceptable axial or circumferential flaw in a tube below a J-groove attachment weld will be sealed off with Alloy 52 or 52M weldment. Excavation or partial excavation of such flaws will not be required, since clearance is not a concern on the outside of a tube. The embedded flaw repair technique may be applied to OD axial or circumferential cracks below the J-groove weld because they are located away from the pressure boundary, and the proposed repair of sealing the crack with Alloy 690 weld material would isolate the crack from the environment as stated in Section 3.6.1 of the NRC staff safety evaluation for WCAP-15987.

2. Unacceptable radial flaws in the J-groove attachment weld will be sealed off with a 360 degree overlay of Alloy 52 or 52M covering the entire weld. No excavation will be required. The overlay will extend onto and encompass the outside diameter of the penetration tube.

The seal weld will extend beyond the Alloy 600 weld material by at least one half inch, as stated in the NRC safety evaluation for WCAP-15987.

3. Unacceptable axial tube flaws extending into the J-groove attachment weld will be sealed with Alloy 52 or 52M as in Item 1 above. In addition, the entire J-groove attachment weld will be overlaid with Alloy 52 or 52M to embed the axial crack in the seal weld on the penetration. The overlay will extend onto and encompass the outside diameter of the penetration tube. The seal weld will extend beyond the Alloy 600 weld material by at least one half inch, as stated in the NRC safety evaluation for WCAP-15987.

4. For weld overlays performed on the J-groove attachment weld, the interface boundary between the J-groove weld and stainless steel cladding will be located with a hand-held ferrite meter instrument that identifies this interface boundary. This technique has been successfully used at BVPS-2 for the positive identification of the weld clad interface to ensure that all of the Alloy 82 material of the J-groove weld is overlaid during the repair. Markings are made to locate the interface as well as a boundary of at least one half inch outboard of the stainless steel clad 182 interface.

5. Prior to application of three Alloy 52M repair weld layers on the clad surface, a minimum of three passes (one layer) of Alloy ER309L shall be installed at the periphery of the weld overlay (at the repair-to-clad interface).

   The Alloy ER309L weld passes ensure that the outer pass of the Alloy 52M embedded flaw weld overlay repair only contacts the Alloy ER309L weld deposit, and does not contact the original clad material. The Alloy ER309L weld passes are not permitted to come into contact with the Alloy 600 weld. Alloy 52M weld passes do not extend beyond the outermost edge of the Alloy ER309L weld passes. This ensures that the entirety of the outer-most edge of the Alloy 52M weld will rest on the surface of the barrier layer of the Alloy ER309L filler and does not contact the stainless steel cladding. However, if unacceptable indications are identified at the periphery of the embedded flaw weld overlay repair during final examination, and repair welding is required, Alloy 52M material may extend beyond the Alloy ER309L weld beads to accommodate the repair.

6. The embedded flaw repair weld will be three layers thick for applications to the J-groove attachment welds and at least two layers thick for application to base metal locations.

7. For all of the above flaw configurations, the finished repair will be examined in accordance with ASME Code Case N-729-1, with conditions as specified in 10 CFR 50.55a(g)(6)(ii)(D).

8. For all embedded flaw repairs, inservice inspections of the overlay and original penetration during subsequent outages will be performed in accordance with the requirements of Code Case N-729-1, with conditions as specified in 10 CFR 50.55a(g)(6)(ii)(D).

9. Whenever an embedded flaw repair is planned for an axial or circumferential flaw in a tube above the J-groove attachment weld, the NRC will be notified.

5.3 Technical Basis for Proposed Alternative

The purpose of the repair overlay welds is to embed and isolate identified flaws in the Alloy 600 reactor vessel head penetration tube and/or its Alloy 600 (Inconel 182) J-groove attachment weld. The repair overlay welds are not credited for providing structural strength to the original pressure boundary materials.

As discussed in WCAP-15987, the embedded flaw repair technique is considered a permanent repair for a number of reasons. As long as a primary water stress corrosion cracking (PWSCC) flaw remains isolated from the primary water (PW) environment, it cannot propagate. Alloy 690 and Alloy 52 are highly resistant to stress corrosion cracking, as demonstrated by multiple laboratory tests, as well as over 15 years of service experience in replacement steam generators. Since Alloy 52 weldment is considered highly resistant to PWSCC, a new PWSCC flaw cannot initiate and grow through the Alloy 52 repair weld layers to reconnect the PW environment with the embedded flaw.

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. As described in WCAP-13998, Revision 1 (Reference 5), Section 7, the hole drilling method of residual stress measurement was used to determine the buildup of residual stresses from welding on the reactor vessel closure head and penetration tube. This technique involves mounting a three strain gage rosette at the location where the measurement is required. A small hole is drilled at the center of the rosette and the relieved strain is measured by the three gages of the rosette. The relieved strain and elastic constants of the material and the constants for the rosette are used to calculate the residual stress. There are no other known mechanisms for significant flaw propagation in this region since cyclic fatigue loading is negligible. Therefore, fatigue driven crack growth is not a mechanism for further crack growth after the embedded flaw repair process is implemented.

The thermal expansion properties of Alloy 52 weld metal are not specified in the ASME Code, as is the case for other weld metals. In this case, the properties of the equivalent base metal (Alloy 690) should be used. For that material, the thermal expansion coefficient at 600 degrees Fahrenheit (F) is 8.2 E-6 inch/inch/degree F, as found in Section II part D of the Code. The Alloy 600 base metal has a coefficient of thermal expansion of 7.8 E-6 inch/inch/degree F, a difference of about 5 percent.

The effect of this small difference in thermal expansion is that the weld metal will contract more than the base metal when it cools, thus producing a compressive stress on the Alloy 600 tube or attachment weld. This beneficial effect has already been accounted for in the residual stress measurements reported in the technical basis for the embedded flaw repair, as noted in WCAP-15987.

The small residual stresses produced by the embedded flaw weld will act constantly, and, therefore, will have no impact on the fatigue effects in this region. Since the stress would be additive to the maximum and minimum stress, the stress range will not change, and the already negligible usage factor for the region will not change.

Use of the Alloy ER309L weld barrier for weld overlay repairs will reduce the contaminant level present during installation of the critical Alloy 52M outer pass. Specifically, only the first Alloy ER309L pass will be in full contact with the cladding. This first pass, due to its exposure to maximum substrate-related dilution, has the highest susceptibility to cracking. The second Alloy ER309L pass will be exposed to substantially lower substrate-related contaminant levels, by virtue of its overlap with the initial Alloy ER309L pass. The third Alloy ER309L weld pass will also benefit from reduced substrate-related contaminant exposure in the same manner. This Alloy ER309L weld sequence will reduce contaminant exposure and crack susceptibility at the outer edge of this weld region.

WCAP-16158-P provides the plant-specific analysis performed for BVPS-2 using the same methodology as WCAP-15987. This analysis provides the means to evaluate a broad range of postulated repair scenarios to the reactor vessel head penetrations and J-groove welds relative to ASME Code requirements for allowable size and service life. Non-destructive preservice and inservice inspections discussed below ensure that any initial embedded flaw growth due to a postulated fatigue mechanism remains bounded by the WCAP-16158-P analysis, thus ensuring the continued structural integrity of each embedded flaw repair until reactor vessel head replacement.

Prior to return to service, preservice inspections will be performed in accordance with ASME Code Case N-729-1, with conditions as required by 10 CFR 50.55a(g)(6)(ii)(D).

Inservice inspections of reactor vessel head penetrations and J-groove welds repaired utilizing the embedded flaw repair process, along with submission of any necessary reports, will be in accordance with 10 CFR 50.55a(g)(6)(ii)(D), which requires implementation of Code Case N-729-1, with certain conditions.

The above proposed alternative, as supported by the referenced generic and plant-specific technical bases, is considered to be an alternative to Code requirements that provides an acceptable level of quality and safety.

6. DURATION OF THE PROPOSED ALTERNATIVE

The duration of the proposed alternative is until the reactor vessel head is replaced.

7. REFERENCES

1. Letter from H. N. Berkow (U.S. NRC) to H. A. Sepp (Westinghouse Electric Company), "Acceptance for Referencing - Topical Report WCAP-15987-P, Revision 2, 'Technical Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations,' (TAC No. MB8997)," dated July 3, 2003, Accession Number ML031840237.
2. Letter from R. Barrett (U.S. NRC) to A. Marion (Nuclear Energy Institute), "Flaw Evaluation Guidelines," dated April 11, 2003, Accession Number ML030980322.
3. Westinghouse WCAP-15987-P, Revision 2-P-A, "Technical Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations," December 2003, Accession Number ML040290246.
4. Westinghouse WCAP-16158-P, Revision 0, "Technical Basis for Repair Options for Reactor Vessel Head Penetration Nozzles and Attachment Welds: Beaver Valley Unit 2," November 2003, Accession Number ML082900208.
5. WCAP-13998, Revision 1, "RV Closure Head Penetration Tube ID Weld Overlay Repair," November 1995.