August 2, 2004

Mr. L. William Pearce
Vice President
FirstEnergy Nuclear Operating Company
Beaver Valley Power Station
Post Office Box 4
Shippingport, PA 15077

SUBJECT: RELAXATION OF THE REQUIREMENTS OF ORDER EA-03-009, DATED FEBRUARY 11, 2003, REGARDING EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES FOR BEAVER VALLEY POWER STATION, UNIT NO. 2 (TAC NO. MC0237)

Dear Mr. Pearce:

The U.S. Nuclear Regulatory Commission (NRC) has approved, upon good cause shown and subject to the condition specified below, FirstEnergy Nuclear Operating Company's (FENOC's or the licensee's) request for relaxation of the specific requirements of Order EA-03-009, dated February 11, 2003, for Beaver Valley Power Station, Unit No. 2 (BVPS-2). That Order requires inspections of the reactor pressure vessel (RPV) and associated penetration nozzles at pressurized-water reactors. This relaxation is in response to your letter dated July 29, 2003, as supplemented by letters dated December 19, 2003, and January 27, 2004.

FENOC requested relaxation of the requirements for BVPS-2 to perform the ultrasonic testing (UT) and eddy current testing (ET) prescribed in Section IV, paragraphs C.(2)(b)(i) and C.(2)(b)(ii) of the Order regarding inspection of the bottom of the RPV head penetration nozzles. These requirements direct licensees of plants in the moderate susceptibility category to either ultrasonically test each RPV head penetration nozzle from 2 inches above the J-groove weld to the bottom of the nozzle; or, eddy current test or dye penetrant test the wetted surface of each J-groove weld and RPV head penetration nozzle base material to at least 2 inches above the J-groove weld. This relaxation allows FENOC to perform UT and ET examinations as described in the alternative proposed by the licensee such that the testing will be completed by one of the techniques or a combination of the techniques described in Section IV, paragraphs C.(2)(b)(i) and (ii) for individual head penetrations, and the unexamined area(s) below the J-groove weld(s) will be supported by plant-specific analyses that show the alternative provides an acceptable level of quality and safety.

Based on the enclosed safety evaluation, the NRC staff has found this request acceptable for BVPS-2 with the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs the licensee of an NRC-approved crack-growth formula. If the licensee's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating

cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

If you have any questions concerning this approval, please contact your NRC Project Manager, Mr. Timothy G. Colburn, at (301) 415-1402.

Sincerely,

/RA James W. Clifford for/

Cornelius F. Holden, Jr., Director
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-412

Enclosure: Safety Evaluation

cc w/encl: See next page

cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

If you have any questions concerning this approval, please contact your NRC Project Manager, Mr. Timothy G. Colburn, at (301) 415-1402.

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ORDER EA-03-009 RELAXATION REQUEST

ALTERNATE EXAMINATION COVERAGE

FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES

BEAVER VALLEY POWER STATION, UNIT NO. 2

FIRST ENERGY NUCLEAR OPERATING COMPANY

DOCKET NUMBER 50-412

1.0 INTRODUCTION

Nuclear Regulatory Commission (NRC) Order EA-03-009, issued on February 11, 2003 (the Order) Agencywide Documents Access and Management System (ADAMS) accession number ML030380470, requires specific examinations of the reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles of all pressurized-water reactor (PWR) plants. Section IV, paragraph F, of the Order states that requests for relaxation from the requirements of the Order associated with specific penetration nozzles will be evaluated by the NRC staff using the procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers, *Boiler and Pressure Vessels Code* (ASME Code), in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 50.55a(a)(3). Section IV, paragraph F, of the Order states that a request for relaxation regarding inspection of specific nozzles shall address the following criteria: (1) the proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or (2) compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

For Beaver Valley Power Station, Unit No. 2 (BVPS-2), and similar plants determined to have a moderate susceptibility to primary water stress corrosion cracking (PWSCC) in accordance with Section IV, paragraphs A and B, of the Order, the following inspections shall be performed such that at least the requirements of Section IV, paragraph C.(2)(a) or paragraph C.(2)(b) of the Order are performed each refueling outage. In addition, the requirements of Section IV, paragraph C.(2)(a) and Section IV, paragraph C.(2)(b) shall be performed at least once over the course of every two refueling outages. When the subject plant reaches the high susceptibility category, RPV and head penetration nozzle inspections shall be performed using the techniques of Section IV, paragraph C.(1)(a) and (b) every refueling outage. Section IV, paragraphs C.(2)(a) and (b) of the Order, are listed below:

(a) Bare metal visual [BMV] examination of 100% of the RPV head surface (including 360° around each RPV head penetration nozzle).

(b) Either:

(i) Ultrasonic testing of each RPV head penetration nozzle (i.e., nozzle base material) from two (2) inches above the J-groove weld to the bottom of the nozzle and an assessment to determine if leakage has occurred into the interference fit zone, OR

(ii) Eddy current testing or dye penetrant testing of the wetted surface of each J-groove weld and RPV head penetration nozzle base material to at least two (2) inches above the J-groove weld.

By letter dated July 29, 2003, as supplemented by letters dated December 19, 2003, and January 27, 2004, First Energy Nuclear Operating Company (FENOC or the licensee) requested relaxation to implement an alternative to the requirements of Section IV, paragraphs C.(2)(b)(i) and C.(2)(b)(ii), of the Order for RPV head penetration nozzles at BVPS-2. The BVPS-2 11th refueling outage is scheduled for the spring of 2005 as a moderate susceptibility plant and the 12th refueling outage is scheduled for the fall of 2006 as a high susceptibility plant. The susceptibility referred to is the susceptibility to PWSCC occurrence in Control Rod Drive Mechanism (CRDM) penetration nozzle materials and effective full power years (EFPY) refers to years at operating temperature.

2.0 NRC ORDER EA-03-009, RELAXATION REQUEST FOR EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES

2.1 Order Requirements for which Relaxation is Requested

Section IV, paragraph C.(2)(b) of the Order, requires, in part, that the following inspections be performed every other refueling outage for moderate susceptibility plants similar to BVPS-2, and each refueling outage for high susceptibility plants:

(i) Ultrasonic testing of each RPV head penetration nozzle (i.e., nozzle base material) from two (2) inches above the J-groove weld to the bottom of the nozzle and an assessment to determine if leakage has occurred into the interference fit zone, OR

(ii) Eddy current testing or dye penetrant testing of the wetted surface of each J-groove weld and RPV head penetration nozzle base material to at least two (2) inches above the J-groove weld.

The licensee has requested relief from Section IV, paragraph C.(2)(b)(i) and (ii), of the Order. The specific relaxation requested is identified below.

2.2 Licensee's Proposed Alternative

In its January 29, 2003, letter, the licensee seeks relaxation from the Order, where inspection coverage is limited at the bottom of the CRDM nozzles due to the design of the funnel attachment to the CRDM nozzles for nondestructive examination (NDE), including ultrasonic testing (UT), eddy current testing (ET), and dye penetrant testing (PT). On the outermost penetrations (62 through 69) available design information indicates that the length of tube

between the bottom of the weld and the beginning of the thread relief is reduced to a minimum of 0.8" on the downhill side. The licensee stated that the design details are not absolute and for this reason, the submittal will be supplemented with field evaluation data and an applicable supporting analysis to demonstrate acceptability of the unexamined portions of the CRDM nozzles. The alternative proposed by the licensee is that the testing will be completed by one of the techniques or a combination of the techniques described in Section IV, paragraphs C.(2)(b)(i) and (ii) for individual head penetrations, and the unexamined areas below the J-groove welds will be supported by plant-specific analyses that show the alternative provides an acceptable level of quality and safety.

2.3 Licensee's Basis for Proposed Alternative

The licensee stated the bottom end of the CRDM penetration nozzles at BVPS-2 are externally threaded and internally tapered, preventing UT or ET data acquisition in a zone 1.25" from the bottom of each nozzle. UT or ET of the lower portions of the nozzle that cannot be inspected due to geometry is not considered significant to PWSCC and the phenomena of concern is leakage past the J-groove welds and circumferential cracking in the CRDM nozzles above the J-groove welds. The unexamined area below the J-groove welds will be addressed in a supplemental submittal with supporting analysis to determine acceptability. The supporting analysis will be based on the BVPS-2 10th refueling outage field measurements of the actual unexamined areas.

Secondly, the presence of thermal sleeves in the vast majority of the CRDM penetrations prohibits PT examination of the tapered inner diameter (ID) portion of the CRDM tube. PT of threaded surfaces, like the tube outer diameter (OD), is difficult due to physical restraints and the need to properly clean the surface to provide accurate test results. Performing PT on the bottom nozzle area would require thermal sleeve removal, extensive manpower, and would result in significant radiation exposure to personnel, estimated to exceed 100 man-rem. The licensee also stated that varying nozzle configurations of the 65 CRDM penetration nozzles (thermal sleeves vs. open housings) and the vent line (interference fit vs. clearance fit) combined with the vendor's current probe design and inspection technology make it prudent to inspect individual penetrations using different inspection techniques. The licensee's position is that performing the required examinations with a combination of techniques on a per penetration basis does not compromise quality or safety.

3.0 EVALUATION

The NRC staff's review of this request was based on criterion (2) of paragraph F of Section IV of the Order, which states:

> Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

In its letter dated July 29, 2003, the licensee indicated that in order to comply with the requirements of Order EA-03-009 it would have to remove the CRDM nozzle thermal sleeves to perform surface examinations. The unexamined areas below the J-groove welds result from the externally threaded, internally tapered nozzle design, which precludes UT and ET. To remove the thermal sleeves and manually perform the surface examinations would result in a projected accumulated dose of 100 person-rem. The NRC staff concludes that the licensee

has demonstrated the hardship that would result from implementing examinations to the bottom end of these nozzles.

In its letter dated July 29, 2003, the licensee indicated that during its 10th refueling outage it will perform both a bare metal visual (BMV) examination of the RPV head and a UT examination per the requirements of the Order, Section IV, paragraphs C.(2)(a) and (b) and that "the inspections are not required to be completed until the next refueling outage [11th] per the frequency specified in the Order." It stated that given an acceptable visual examination per Section IV, paragraph C.2(a), NRC staff approval of the relaxation request pertaining to Section IV, paragraph C.2(b) was not required to support restart from the BVPS-2 10th refueling outage.

In its supplemental letter dated December 19, 2003, the licensee provided the field results showing the actual inspection distances achieved below the J-groove welds during its 10th refueling outage required by Section IV, paragraph C.2(b) of the Order. The NRC staff notes that these inspections were not required to be performed since a BMV had been accomplished that same outage and BVPS-2 is a moderate susceptibility plant. A drawing of a BVPS-2 CRDM penetration is shown below with the field measurements taken during the BVPS-2 10th refueling outage tabulated below. The drawing shows that the most limiting distance is on the downhill side of the J-groove weld where the nozzle distance is the shortest.

Figure 1: BVPS Unit 2 CRDM Penetration Nozzle Configuration
Outermost Penetrations

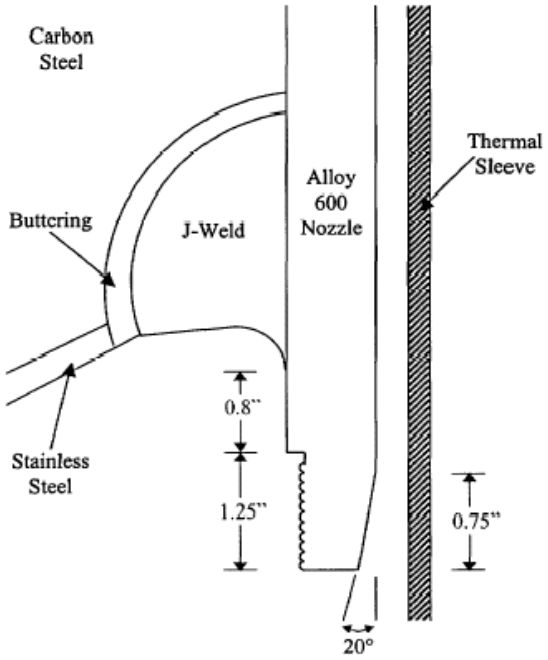

Figure #	Penetration Set	Applicable Geometry (degrees)	Postulated Through-Wall Crack Tip Distance Below Weld (in.)	EFPY for Crack Growth to Weld	Minimum Inspection Coverage Below Postulated Crack Tip (in.)
2	1-17	0	0.7	8.8	0.38
3	18-45	25.4	0.55	6.1	0.29
4	46-53	38.7	0.5	7.7	0.30
5	54-57	40	0.5	8.7	0.22
6	58-65	42.7	0.4	6.2	0.00*
*Only penetration #58 achieved no coverage below the postulated crack tip. For all other penetrations (59-65), examination coverage extended $\geq$0.08 in. below the postulated crack tip.					

From the table above the NRC staff notes that the licensee inspected further down the nozzle than the expected tip of the postulated flaw distance from the J-groove weld for the flaw growth analysis. This would make the total distances below the J-groove welds that were examined as crack free: 1.08 in., 0.84 in., 0.80 in., 0.77 in., and 0.4 in., respectively, for the penetrations listed above.

The phenomenon of concern is PWSCC, which typically initiates in the areas of highest stress. The area of CRDM penetrations that has the highest residual stress is the area adjacent to the J-groove attachment weld. Therefore, it is most likely that PWSCC will initiate in an area adjacent to the J-groove attachment weld. The intent of the Order, is that all licensees examine as far below the J-groove weld as is physically possible into the area of least stress where crack initiation is less likely. The table above provides sufficient information for the NRC staff to determine the distance from the bottom of the J-groove weld on the most limiting side, the area that was actually examined. Since the actual scan distances below the J-groove welds are known, the NRC staff can determine if the hoop stress analyses provided by the licensee are bounded by the areas examined. This method provides a more accurate assessment of the calculated time for a postulated crack in the unexamined area to reach the J-groove welds for each plant.

The licensee's inspection distances of the nozzle base material below the attachment weld is supported by the licensee's analysis which demonstrated that no flaw below that portion of the nozzle identified above would propagate to a level that would touch the toe of the J-groove weld within the next operating period. The licensee's flaw evaluation was performed by postulating an axial flaw in the area of missed coverage below the weld. The methodology was described in WCAP-16144-P, Rev. 0, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Beaver Valley Unit 2." The projected crack growth of a through-wall flaw in the CRDM penetration nozzles is the primary concern in evaluating the structural integrity of head penetrations. In some cases, the through-wall flaw

may be located sufficiently below the attachment weld that additional time may be required for the flaw to grow to the attachment weld. To provide a means to evaluate the duration of this additional time, a series of flaw tolerance charts for through-wall flaws were prepared by the licensee. Below is an example of one such flaw tolerance chart:

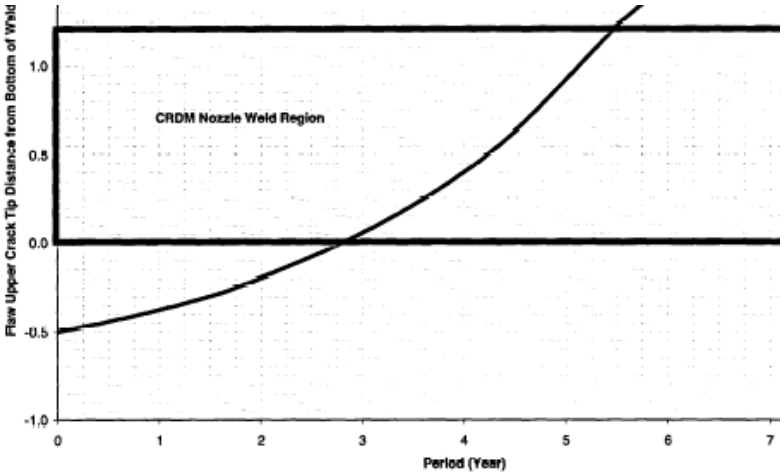

Figure 6-15 Through-Wall Axial Flaws Located in the 38.7 Degrees Row of Penetrations, Uphill Side - Crack Growth

The flaw tolerance charts and the plant-specific hoop stress distribution charts provided by the licensee in WCAP-16144-P, Rev. 0, indicate that the licensee will be able to operate 6.1 EFPY without an existing crack in the uninspected region propagating to the bottom of the J-groove welds, provided the minimum inspection distances below the weld are consistently achieved during the course of subsequent inspections.

The NRC staff notes that the stated EFPY of permitted operation in the table above is predicated on achievement of the minimum inspection distances below the weld as determined by the licensee's plant-specific analysis. The licensee has justified operation for the operating period specified under Section IV, paragraph C.(2) for a moderate susceptibility plant. The NRC staff concludes that the licensee may claim credit for satisfying the requirement under Section IV, paragraph C.(2)(b) per the Order, because the alternative performed is supported by the crack-growth evaluation. Furthermore, the NRC staff concludes that the licensee must perform a BMV examination per Section IV, paragraph C.(2)(a) during the BVPS-2 11th refueling outage in order to comply with the testing frequency requirements of the Order. The licensee stated that for the BVPS-2 12th refueling outage, the projected susceptibility is high. At that time, the NRC staff concludes that the testing frequency of Section IV, paragraph C.(1) shall apply and that the examinations under Section IV, paragraphs C.(2)(a) and (b) will be performed every refueling outage.

The licensee's analysis in WCAP-16144-P, Rev. 0, used the crack-growth formula in Electric Power Research Institute (EPRI) Report, Material Reliability Program (MRP) Report MRP-55, "Material Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material (MRP-55), Revision 1." The NRC staff has made a preliminary assessment of the crack-growth formula, but has not yet made a final determination on the acceptability of the subject industry report. Should the NRC

staff determine the crack-growth formula used by the licensee to be unacceptable, the licensee will be required to revise its analysis to incorporate an acceptable crack-growth formula as described below:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs the licensee of an NRC-approved crack-growth formula. If the licensee's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

Based upon the evaluation above, the NRC staff finds that the licensee's proposed alternative examination for BVPS-2 is acceptable until either the RPV head is replaced or until the inspection requirements of the Order are superceded, as it provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds. Further inspections to comply with the Order requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

4.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative examination of the CRDM nozzles for BVPS-2 provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds. Further inspections of these VHP nozzles in accordance with Section IV, paragraph C.(2)(b), of the Order, would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV, paragraph F, of the Order, the NRC staff authorizes the proposed alternative inspection for the CRDMs at BVPS-2 until the RPV head is replaced or until the inspection requirements of the Order are superceded, subject to the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the Order, within 30 days after the NRC informs the licensee of an NRC-approved crack-growth formula. If the licensee's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days

submit a letter to the NRC confirming that its analyses has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

Principal Contributor: T. Steingass

Date: August 2, 2004

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