FENOC

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L-08-204

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

Subject:
Beaver Valley Power Station, Unit No. 2
BV-2 Docket No. 50-412, License No. NFP-73
Reactor Head Inspection 60-Day Report for 2R13

During the recent Beaver Valley Power Station (BVPS) Unit No. 2 Refueling Outage (2R13), inspections of the reactor pressure vessel (RPV) head and associated penetration nozzles were performed in accordance with Nuclear Regulatory Commission First Revised Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors (the Order).

In accordance with the Order, Section IV.E, a report entitled "Evaluation Report for 2R13: Beaver Valley Power Station Unit 2 Reactor Vessel Head Penetration Inspections" is attached.

There are no regulatory commitments contained in this letter. If there are any questions or if additional information is required, please contact Mr. Thomas A Lentz, Manager - FENOC Fleet Licensing, at 330-761-6071.

Sincerely,

Peter P. Sena III

A101
NRR

Attachment:
Evaluation Report for 2R13: Beaver Valley Power Station Unit 2 Reactor Vessel Head Penetration Inspections

cc: Mr. S. J. Collins, NRC Region I Administrator
Mr. D. L. Werkheiser, NRC Senior Resident Inspector
Ms. N. S. Morgan, NRR Project Manager
Mr. D. J. Allard, Director BRP/DEP
Mr. L. E. Ryan (BRP/DEP)

Attachment
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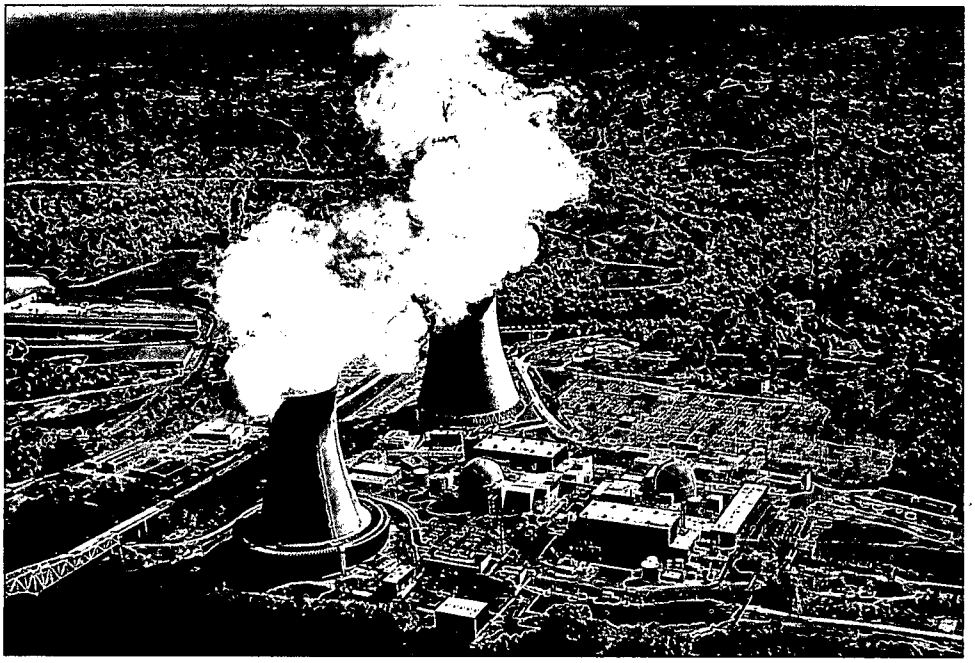


Evaluation Report for

2R13

Beaver Valley Power Station Unit 2

Reactor Vessel Head Penetration

Inspections

(Ref: First Revised Order EA-03-009)

Introduction:

Reactor Pressure Vessel (RPV) Head Inspections were performed at Beaver Valley Power Station (BVPS) Unit 2 during the 2R13 Refueling Outage in accordance with the First Revised Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors (the Order, Reference 1). The Order establishes criteria by which licensees must perform periodic inspections of the reactor vessel head. FirstEnergy Nuclear Operating Company (FENOC) provided a response to the Order for BVPS via letter L-04-030, dated March 5, 2004 (Reference 2).

For each inspection required in Paragraph IV.C and IV.D, Paragraph IV.E of the Order requires licensees to submit a report detailing the inspection results within sixty (60) days after returning the plant to operation. This report fulfills this requirement for the examinations required by IV.C. Visual inspections performed to identify potential boric acid leaks from pressure-retaining components above the RPV head required by Paragraph IV.D did not identify any evidence of leakage.

RPV Head Configuration:

The BVPS Unit 2 RPV head contains sixty-five (65) Alloy 600 penetration tubes that are interference fit in the reactor vessel head and attached with Alloy 182/82 partial penetration J-groove welds. The head also contains one Alloy 600 vent line that is clearance fit in the reactor vessel head and attached with an Alloy 182/82 partial penetration J-groove weld.

The 65 Control Rod Drive Mechanism (CRDM) penetration tubes measure 4.0 inches on the outside diameter (OD) and have an inside diameter (ID) dimension of 2.75 inches. The wall thickness is 0.625 inches. The RPV head vent line has a nominal OD dimension of 1.0 inch and a nominal ID dimension of 0.770 inches. (NOTE: The bottom of the RPV head vent line is flush with the attachment weld and inner head surface, thus, no OD wetted surface exists.)

Susceptibility Ranking:

The cumulative Effective Degradation Years (EDY) of the BVPS Unit 2 reactor head were calculated at the conclusion of Cycle 13 in accordance with Paragraph IV.A of the Order. The Unit 2 RPV head maintained one consistent bulk head temperature of 595°F for its operating history through Cycle 12, as reported in Table 2-1 of EPRI MRP-48 and validated by a BVPS/Westinghouse study using external thermocouple measurements obtained from the BVPS Unit 1 RPV head surface (the Units 1 and 2 RPV head configurations are equivalent).

Near the beginning of Cycle 13, Extended Power Uprate conditions began, with a 3% increase in power (the remaining 5% uprate to be implemented during Cycle 14). For conservatism, the full 8% uprated RPV head temperature was assumed from the implementation of the 3% uprate in the calculation of EDY through Cycle 13. The uprated RPV head temperature was calculated as part of the design considerations for Extended Power Uprate, producing a value for bulk RPV head temperature of 601.3°F The cumulative EFPY (Effective Full Power Years) for the Unit 2 RPV head under pre- and post-uprated conditions were calculated to be 15.43 and 1.40,

respectively. The summary of plant-specific parameters, therefore, used in the calculation of EDY for the Unit 2 RPV head through 13 cycles of operation are as follows:

Operating Period	EFPY	T_{head}
8/5/87 – 11/17/06	15.43	595°F
11/18/06 – 4/13/08	1.40	601.3°F

These plant-specific inputs were used to calculate EDY_{2R13} per the equation provided in Paragraph IV.A of the Order:

$$EDY = \sum_{j=1}^{n} \left\{ \Delta EFPY_j \exp\left[-\frac{Q_i}{R} \left(\frac{1}{T_{head,j}} - \frac{1}{T_{ref}} \right) \right] \right\}$$

$$EDY = \sum_{j=1}^{2} \left\{ (15.4338 years) \exp\left[-\frac{(50 kcal/mole)}{(1.103x10^{-3} kcal/mole°R)} \left(\frac{1}{(1054.67°R)} - \frac{1}{(1059.67°R)} \right) \right] \right\} +$$
$$\left\{ (1.3962 years) \exp\left[-\frac{(50 kcal/mole)}{(1.103x10^{-3} kcal/mole°R)} \left(\frac{1}{(1060.97°R)} - \frac{1}{(1059.67°R)} \right) \right] \right\}$$

$$EDY_{2R13} = 14.07$$

Both the calculated EDY of 14.07 and the previous repair history (during the 2R12 refueling outage) place the BVPS Unit 2 RPV Head in "High" susceptibility per the table in Paragraph IV.B of the Order.

Required Inspections:

As a "High" susceptibility plant, due to both calculated EDY and previous penetration repairs, the inspection requirements of Paragraph IV.C.(1) of the Order apply to the BVPS Unit 2 RPV head. The inspection requirements of Paragraph IV.C.(1) were met during the BVPS 2R13 refuel outage by the successful completion of RPV head inspections in accordance with the requirements detailed in Paragraphs IV.C.(5)(a) and IV.C.(5)(b), and Paragraph IV.C.(1), Footnote 3 of the Order.

Specifically, a visual inspection of the RPV head was performed, including bare metal visual examination of the RPV head surface and 360° around each RPV head penetration, in accordance with Paragraph IV.C.(5)(a) of the Order. Remote visual examinations were performed by Westinghouse/R. Brooks Associates and Wesdyne/FENOC VT-2 qualified personnel.

Under-head NDE examinations were performed in accordance with the requirements of Paragraph IV.C.(5)(b)(i) or (ii). (Note: The required examinations of each of the 65 CRDM penetrations were completed using a Time-of-Flight-Diffraction (TOFD) ultrasonic technique combined with 0-degree leak-path detection capability. Examinations of the RPV head vent

penetration and weld were completed using eddy current. Examination techniques were not combined on any one penetration; therefore, the requirements of Paragraphs IV.C.(5)(b)(iii) do not apply.)

For the CRDM examinations, the minimum examination coverage extended from 2 inches above the highest point of the root of the J-groove weld to 1 inch below the lowest point at the toe of the J-groove weld, or to the distances identified in the Supplement to the Order Relaxation Request for Beaver Valley Unit 2 (Reference 4), which was approved by NRC (Reference 5). As in the examination coverage determinations provided as part of that request, the extent of ultrasonic examination coverage was verified for each penetration by confirming that tube entry signals were evident in the eddy current and ultrasonic data, and that scan coverage elevations were in excess of 2.0 inches above the uppermost elevation of each weld.

All of the nondestructive examinations performed during 2R13 were conducted in accordance with site-specific field service procedures. All CRDM ultrasonic and eddy current examination techniques have been demonstrated through the Electric Power Research Institute / Materials Reliability Program (EPRI/MRP) protocol. In the absence of an EPRI/MRP protocol for the vent line applications, the examination procedures and techniques were demonstrated during internal Westinghouse Technical Justifications.

In addition to the ultrasonic and eddy current examinations performed, Footnote 3 of Paragraph IV.C.(1) of the Order requires that for RPV head penetration nozzles or J-groove welds repaired using a weld overlay, the weld overlay must be examined by either ultrasonic, eddy current, or dye penetrant testing. During the previous 2R12 refuel outage, weld overlays were applied to the tube OD and J-groove weld of three (3) penetrations (16, 56, and 61) identified as having relevant OD/J-weld initiated indications extending into the tube material. During the 2R13 inspections, liquid penetrant testing was performed on these weld overlay repairs as required by Footnote 3.

Inspection Results:

Visual Inspections (Paragraph IV.C.(5)(a))

VT-2 visual inspection of 360° around each of the 65 CRDM penetrations and the vent line showed no indication of penetration leakage characteristic of a through-wall leak. The carbon steel assessment performed on 100 percent of the RPV head carbon steel base metal inside the ventilation shroud found no degraded conditions on the RPV head surface.

Ultrasonic Examinations (Paragraph IV.C.(5)(b)(i))

Ultrasonic examination with leak-path detection capability was performed on the sixty-five CRDM penetrations in accordance with Paragraph IV.C.(5)(b)(i) of the Order. These examinations were performed using the Westinghouse 7010 Open-housing Scanner or Gapscanner Trinity Probes. Each examination technique simultaneously performs Time-of-Flight-Diffraction (TOFD) ultrasonic testing for the detection of axial or circumferential degradation in the tube material, 0° ultrasonic testing to identify potential leak paths, and eddy current surface examinations (the eddy current being supplemental to Paragraph IV.C.(5)(b)(i) requirements).

The TOFD ultrasonic examinations of the three repaired CRDM penetrations, Penetrations 16, 56, and 61 showed no apparent growth of the embedded flaws or new indications in the tube material.

The TOFD ultrasonic examinations of the other sixty-two CRDM penetrations identified one additional penetration, Penetration 51, as "special interest" requiring further evaluation.

> Ultrasonic examination of Penetration 51 identified an indication originating from the OD of the penetration at the toe of the J-groove weld. The indication was primarily circumferential in orientation, measuring approximately 0.280 inches long and 0.146 inches in depth, as measured from the OD surface of the tube. Comparison to the ultrasonic data from the Fall 2006 2R12 inspection determined that the indication had grown in depth by approximately 0.069 inches over the cycle. In the 2006 inspection, the indication did not meet the flaw characterization criteria to be called "relevant". Figure 1 shows a depiction of the flaw's relative orientation.
>
> Penetration 51 of the Unit 2 RPV head is one of four thermocouple penetrations on the outer periphery of the head, each with a guide funnel attached to the threaded bottom portion of the penetration. This configuration precludes examinations of the J-groove weld and tube OD with eddy current without first removing the guide funnel, and makes proper cleaning and adequate access for liquid penetrant examination difficult and dose intensive. Because of these limitations, and given the previous experience at Beaver Valley with CRDM penetration indications and repairs, the condition on Penetration 51 was addressed by foregoing additional nondestructive examination and instead performing an embedded flaw repair.

Ultrasonic leak-path assessments on all 65 CRDM penetrations identified no leak paths.

Supplementary eddy current examinations of the ID surface of all 65 CRDM penetrations identified No Detectable Degradation (NDD).

Eddy Current Examinations (Paragraph IV.C.(5)(b)(ii))

The head vent tube eddy current inspection was performed using an array of 16 plus-Point probes and a low frequency bobbin coil. The head vent weld eddy current examination was performed with an array of 28 plus-Point coils. Eddy current examinations of the head vent tube and weld identified no detectable degradation characteristic of Primary Water Stress Corrosion Cracking.

Liquid Penetrant Examinations Paragraph IV.C.(1), Footnote 3

Liquid penetrant examinations were completed on the Tube OD and J-groove weld surfaces repaired via weld overlay during 2R12 on Penetrations 16, 56, and 61. Following adequate, non-abrasive cleaning of the weld overlay repair surface, all of the final examinations achieved "PT White" with no relevant indications identified.

Penetration Repairs:

Following the examinations, a weld overlay repair was performed on Penetration 51 in accordance with Beaver Valley Relief Request BV3-RV-04 (Reference Letter L-03-065), which was approved by the NRC (SER dated May 13, 2003) and remains in effect for the current BVPS Unit 2 In-Service Inspection interval. The thermocouple guide funnel was removed from the penetration and not re-installed per a plant design change. The repair itself was performed using the embedded flaw repair technique, consisting of a three-pass Alloy 52M weld overlay of the J-groove weld and a two-pass overlay of the penetration tube OD. Post-repair liquid penetrant examinations of all repaired regions identified no indications (PT white).

Upon completion of the repair, ultrasonic and eddy current examinations were performed from the tube ID to verify that the repair process did not introduce any new flaws or adversely change the size or characteristics of the previously reported flaw. Analysis of the post-repair TOFD ultrasonic examination results revealed no new indications. Furthermore, the TOFD sizing results indicate the through-wall dimensions and lengths of the reflector did not change as a result of the repair process. Based on the TOFD ultrasonic examination results the applied repair process had no detrimental effect on the tube, did not result in any crack growth and did not result in the initiation of any additional cracking in the tube.

Summary:

Visual and under-head Inspections of all RPV Head Penetrations were completed in accordance with the First Revised NRC Order EA-03-009 (Reference 1) and the relaxation to the Order approved by the NRC (Reference 5). Visual Inspection of the RPV head surface showed no evidence of a through-wall RPV head penetration leak or RPV head degradation. Under-head ultrasonic inspections of RPV head penetrations revealed a relevant indication in the penetration tube of Penetration 51.

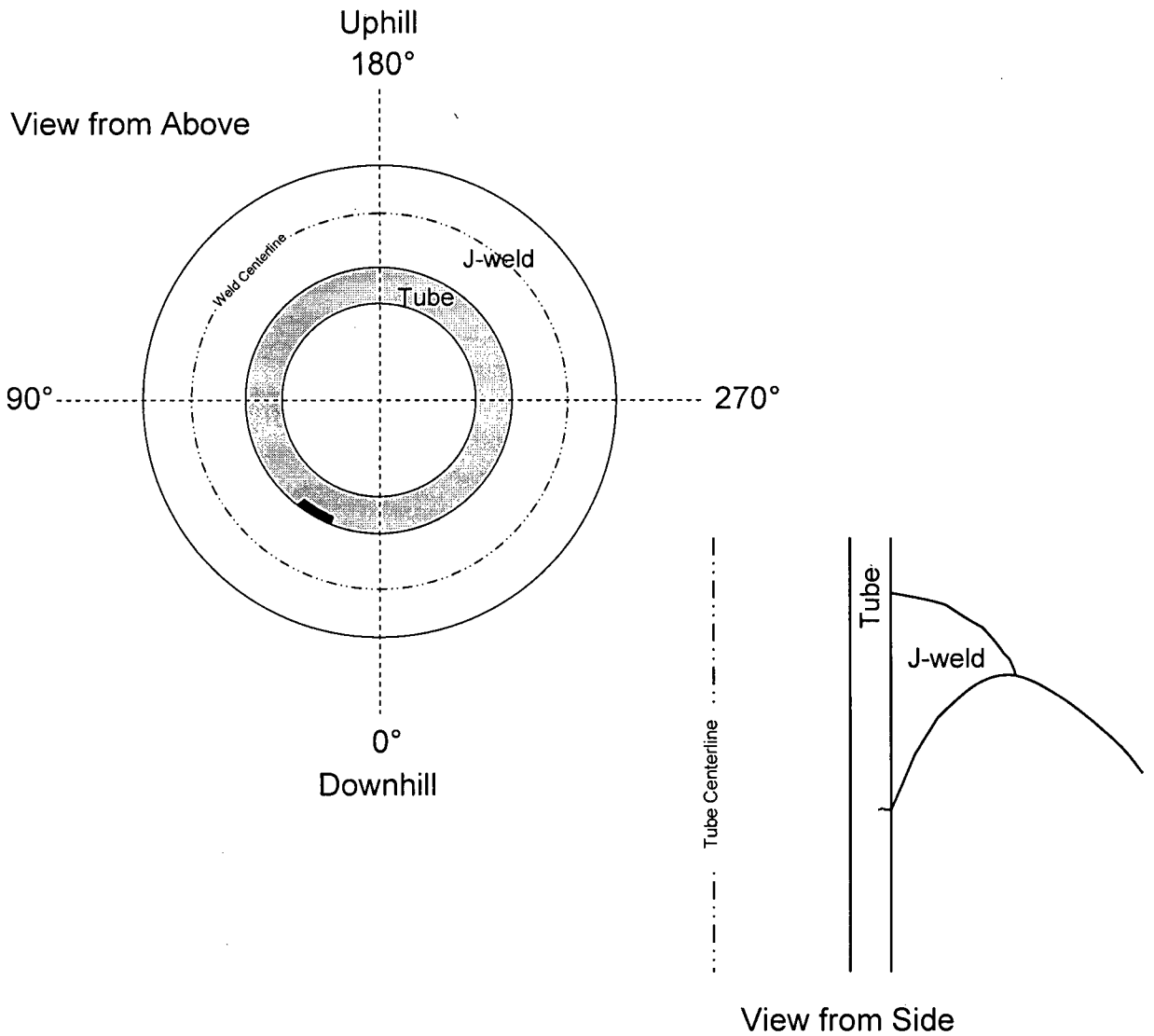
A repair was made to Penetration 51 using the embedded flaw repair technique per BVPS Relief Request BV3-RV-04 (Reference 7). A three layer Alloy 52M weld overlay was applied to the J-groove weld, and a two-pass weld overlay was applied to the OD of the tube. Post-repair liquid penetrant examinations of all repaired regions were satisfactory. Furthermore, post-repair eddy current and ultrasonic examination of the penetration confirmed no new flaws were created nor did the size and characteristics of the existing flaw change as a result of the repair process.

References:

1. Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors, February 20, 2004
2. L-04-030, BVPS Response to First Revised Order (EA-03-009), March 5, 2004
3. L-03-088, BVPS Unit 2 Order (EA-03-009) Relaxation Request, July 29, 2003

4. L-03-198, BVPS Unit 2 Supplement to Order (EA-03-009) Relaxation Request, December 19, 2003
5. NRC Safety Evaluation Report, BVPS Unit 2 Order (EA-03-009) Relaxation Request, August 2, 2004
6. L-03-065, Proposed Alternative Repair Methods for Reactor Vessel Head Penetrations (Relief Request No. BV3-RV-04), March 28, 2003
7. NRC Safety Evaluation Report, BVPS Relief Request No. BV3-RV-04, May 14, 2003

Figure 1: Penetration 51



Figures not to scale