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May 17, 2010
L-10-143

10 CFR 50.55a

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

SUBJECT:
Davis-Besse Nuclear Power Station
Docket No. 50-346, License No. NPF-3
Request for Additional Information Response and Supplement to 10 CFR 50.55a Request RR-A34 for Alternate Repair Methods for Reactor Pressure Vessel Head Penetration Nozzles (TAC No. ME3703)

By correspondence dated April 1, 2010 (Accession No. ML100960276), FirstEnergy Nuclear Operating Company (FENOC) submitted 10 CFR 50.55a request RR-A34, which requests Nuclear Regulatory Commission (NRC) approval of alternative methods to repair the reactor pressure vessel (RPV) head penetration nozzles at the Davis-Besse Nuclear Power Station (DBNPS). By correspondence dated April 16, 2010 (Accession No. ML101110149), FENOC provided a response to the April 9, 2010 NRC staff request for additional information (Accession No. ML100980486) to complete its review of RR-A34. A flaw evaluation for the J-groove weld of the repaired nozzles was also submitted by a FENOC letter dated April 21, 2010 (Accession No. ML101160438) in support of the NRC review of RR-A34.

Attachment 1 provides the additional information requested by the NRC staff during an April 23, 2010 telephone conference regarding the revised repair plan for RPV head penetration nozzle number 4 and a discussion of available ultrasonic and eddy current examination techniques considered. Attachment 2 provides a proposed alternative to surface examination prior to welding on RPV head penetration nozzle number 4, as discussed with the NRC staff on May 11, 2010. Attachment 3 provides the FENOC response to a written request for additional information provided on May 12, 2010.

As described in Attachment 1, the RPV head penetration nozzle number 4 repair plan involves application of Alloy 82 weld material at the triple-point before Alloy 52M weld material is applied. A fracture mechanics analysis, "DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Alternate Repair with Alloy 52M/82," was performed to account for the different weld material and provide justification, in accordance with Section XI,

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for operating with the postulated triple-point anomaly flaw in RPV head penetration nozzle number 4.

Weld flaw analyses for the triple point weld anomaly, "DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Repair," and J-groove weld, "DB-1 CRDM Nozzle J-Groove Weld Flaw Evaluation for IDTB Repair," provided with the April 16 and 21, 2010 letters, respectively, have been updated to include a new bounding head temperature for all nozzles.

A sketch showing the configuration of an assumed flaw and four stress profiles associated with the weld flaw analysis for the triple point weld anomaly are provided in response to the May 12, 2010 NRC staff request for additional information.

The aforementioned analyses, sketch and stress profiles are enclosed with this letter and contain proprietary information that is to be withheld from public disclosure pursuant to 10 CFR 2.390. Enclosures A, B, and C provide a nonproprietary version of the three analyses for full public disclosure. The entire sketch and stress profiles are considered proprietary, therefore, a nonproprietary copy of these documents is not provided. Enclosures D, E, F and G contain the AREVA affidavits to identify the reasons for withholding information. The proprietary version of the three analyses, sketch and stress profiles including sections to be withheld from public disclosure are provided as Enclosures H, I, J, K and L.

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 – Fleet Licensing, at 330-761-6071.

Sincerely,

Barry S. Allen

Barry S. Allen

Attachment:
1. Davis-Besse Nuclear Power Station 10 CFR 50.55a Request RR-A34 Supplement
2. Davis-Besse Nuclear Power Station 10 CFR 50.55a Request RR-A34 Supplement Alternative to Surface Examination Prior to Welding For Nozzle 4
3. Davis-Besse Nuclear Power Station Response to May 12, 2010 Request for Additional Information Related to 10 CFR 50.55a Request RR-A34, Alternative To Repair The Reactor Pressure Vessel Head Penetration Nozzles

Enclosures:

A. DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Alternate Repair with Alloy 52M/82 (Nonproprietary)
B. DB-1 CRDM Nozzle J-Groove Weld Flaw Evaluation for IDTB Repair (Nonproprietary)
C. DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Repair (Nonproprietary)
D. Affidavit for DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Alternate Repair with Alloy 52M/82
E. Affidavit for DB-1 CRDM Nozzle J-Groove Weld Flaw Evaluation for IDTB Repair
F. Affidavit for DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Repair
G. Affidavit for Triple Point Weld Anomaly Flaw Sketch and Stress Profiles
H. DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Alternate Repair with Alloy 52M/82 (Proprietary)
I. DB-1 CRDM Nozzle J-Groove Weld Flaw Evaluation for IDTB Repair (Proprietary)
J. DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Repair (Proprietary)
K. Triple Point Weld Anomaly Flaw Sketch (Proprietary)
L. Triple Point Weld Anomaly Stress Profiles (Proprietary)

cc: NRC Region III Administrator w/o Enclosures H through L
NRC Resident Inspector w/o Enclosures H through L
NRC Project Manager w/o Enclosures H through L
Utility Radiological Safety Board w/o Enclosures H through L

Additional information regarding repair plan changes needed to address the presence of contaminants encountered in the weld area on reactor pressure vessel (RPV) head penetration nozzle number 4 is provided in this attachment. A discussion of the available ultrasonic and eddy current examination techniques considered for application after the weld preparation machining operation is also provided in this attachment. This information supplements the FENOC 10 CFR 50.55a request letter dated April 1, 2010.

REPAIR PLAN CHANGES

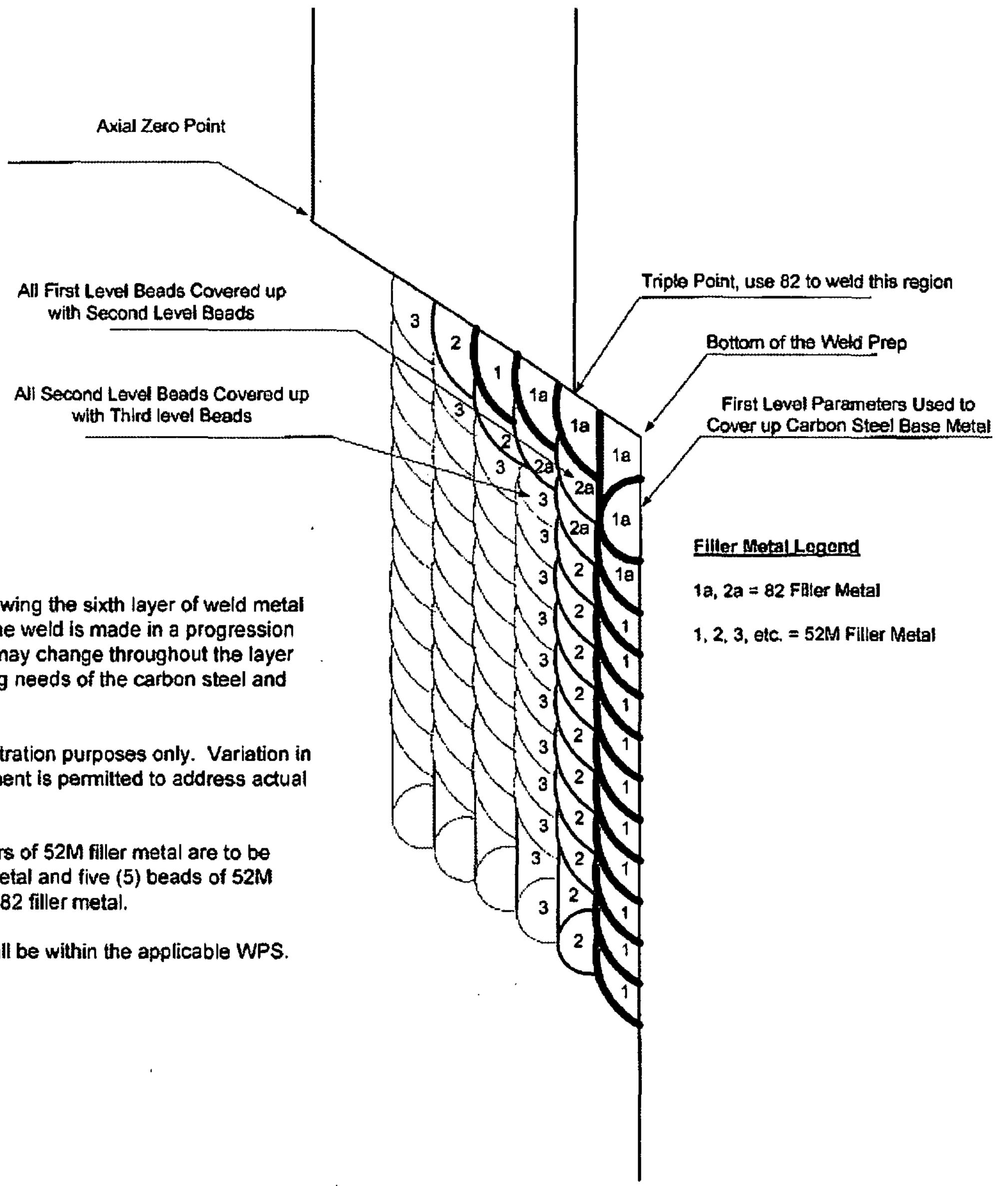
The basic steps for the inner diameter temper bead (IDTB) weld repair of RPV head penetration nozzles are listed in Section 4 of the attachment to the FENOC 10 CFR 50.55a request letter dated April 1, 2010. When welding the remaining portion of the RPV head penetration nozzle to the RPV head using Alloy 52M weld material as described in basic step 4, contaminants affecting the viscosity of the weld material puddle were encountered. The contaminants are not specifically known, but are thought to be boric acid and corrosion products as a result of reactor coolant system (RCS) leakage through the RPV head penetration nozzle number 4 crevice. Heat from the welding at the crevice or triple point location tends to draw contaminants out of the crevice into the weld puddle.

To address the presence of contaminants, the IDTB weld repair method for RPV head penetration nozzle number 4 was revised to include the following basic steps. These steps are to be performed to complete the partially completed Step 4, listed in the FENOC 10 CFR 50.55a request dated April 1, 2010.

1. Machine the RPV head penetration bore to remove previously deposited weld material (over size to a diameter of 4.165 inches, plus 0.100 inch or minus 0.050 inch), and to provide a surface suitable for nondestructive examination (NDE).
2. Clean the RPV head penetration bore and prepare the surface for nondestructive examination.
3. Perform liquid penetrant (PT) examination of the bored region and machined face of the RPV head penetration nozzle extending 1/2 inch above the weld preparation area. (As shown in Figure 3 of the attachment to FENOC 10 CFR 50.55a request dated April 1, 2010.) Where the surface examination is compromised by excessive bleed out, a VT-1 visual examination is to be performed utilizing requirements specified in the 10 CFR 50.55a request RR-A34 proposed alternative to surface examination for Nozzle 4.
4. Perform a thorough cleaning of the RPV head penetration to remove residual PT material.
5. Install cartridge heater assembly and heat nozzle to remove residual moisture in the RPV head penetration nozzle-bore annulus.

6. Perform a mechanical cleaning as required of the RPV head penetration nozzle and weld preparation area in preparation for welding.
7. Weld the remaining portion of the RPV head penetration nozzle to the RPV head by depositing Alloy 82 material weld beads, to be followed by Alloy 52M filler material as shown in the Weld Plan figure provided on Page 3 of 8.
8. Verify that sufficient weld has been deposited.

Welding of the remaining portion of the RPV head penetration nozzle to the RPV head was performed as described above and as shown in the IDTB Weld Plan figure on Page 3 of 8. Contaminants adversely affected the weld and welding was suspended. The weld has been removed by machining and the welding process described above (steps 1 through 8) will be repeated. To limit the potential for contaminants at the nozzle triple point, a VT-1 examination will be performed in lieu of the liquid penetrant examination. Upon completion of welding, nondestructive examination of the weld will be performed as described in the Figure 3 of the attachment to FENOC 10 CFR 50.55a request dated April 1, 2010. As stated in the April 1, 2010 letter, the ultrasonic examination is qualified to detect construction type flaws in the new weld and base metal interface beneath the new weld.



NOTES:

IDTB weld in progress showing the sixth layer of weld metal deposited. Even though the weld is made in a progression of flat layers, parameters may change throughout the layer to accommodate tempering needs of the carbon steel and heat affected zones.

Bead placement is for illustration purposes only. Variation in bead numbers and placement is permitted to address actual field conditions.

A minimum of five (5) layers of 52M filler metal are to be welded over the 82 filler metal and five (5) beads of 52M shall be welded below the 82 filler metal.

Heat input parameters shall be within the applicable WPS.

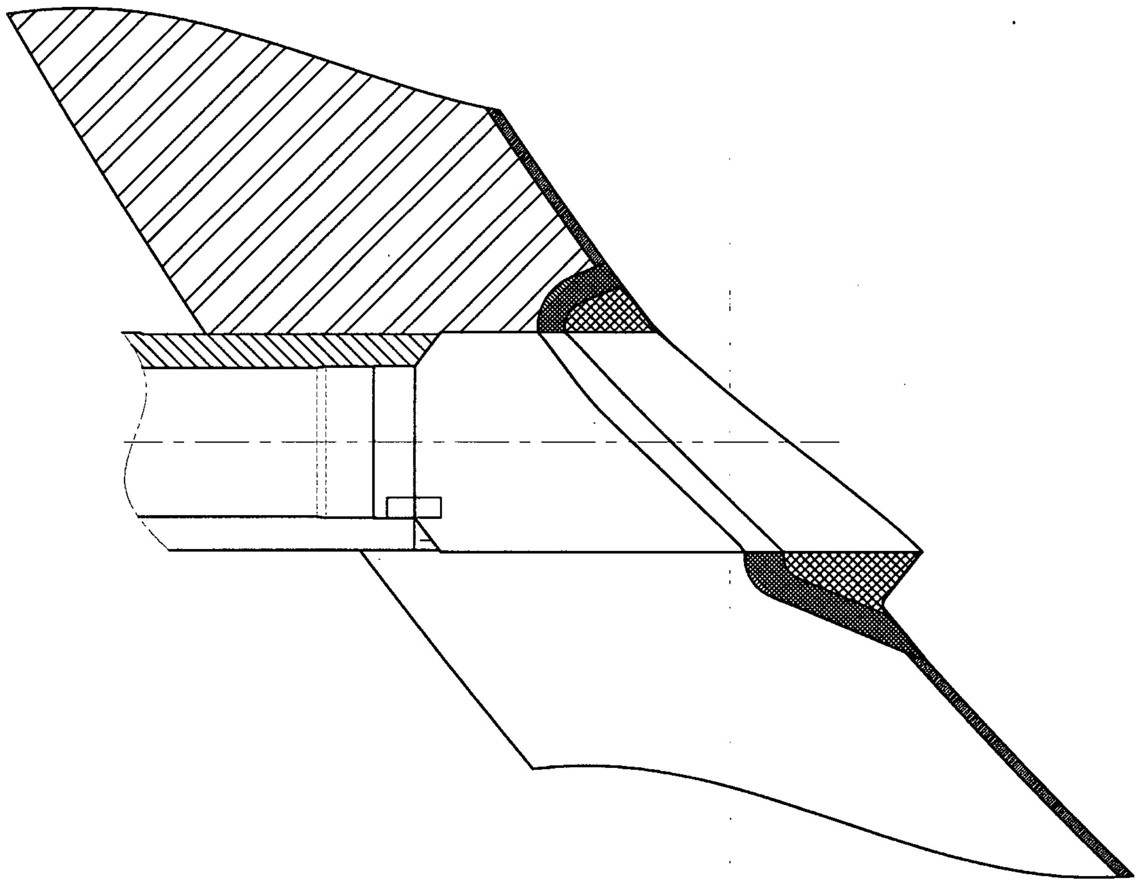
WELD PLAN

Ultrasonic and Eddy Current Examination

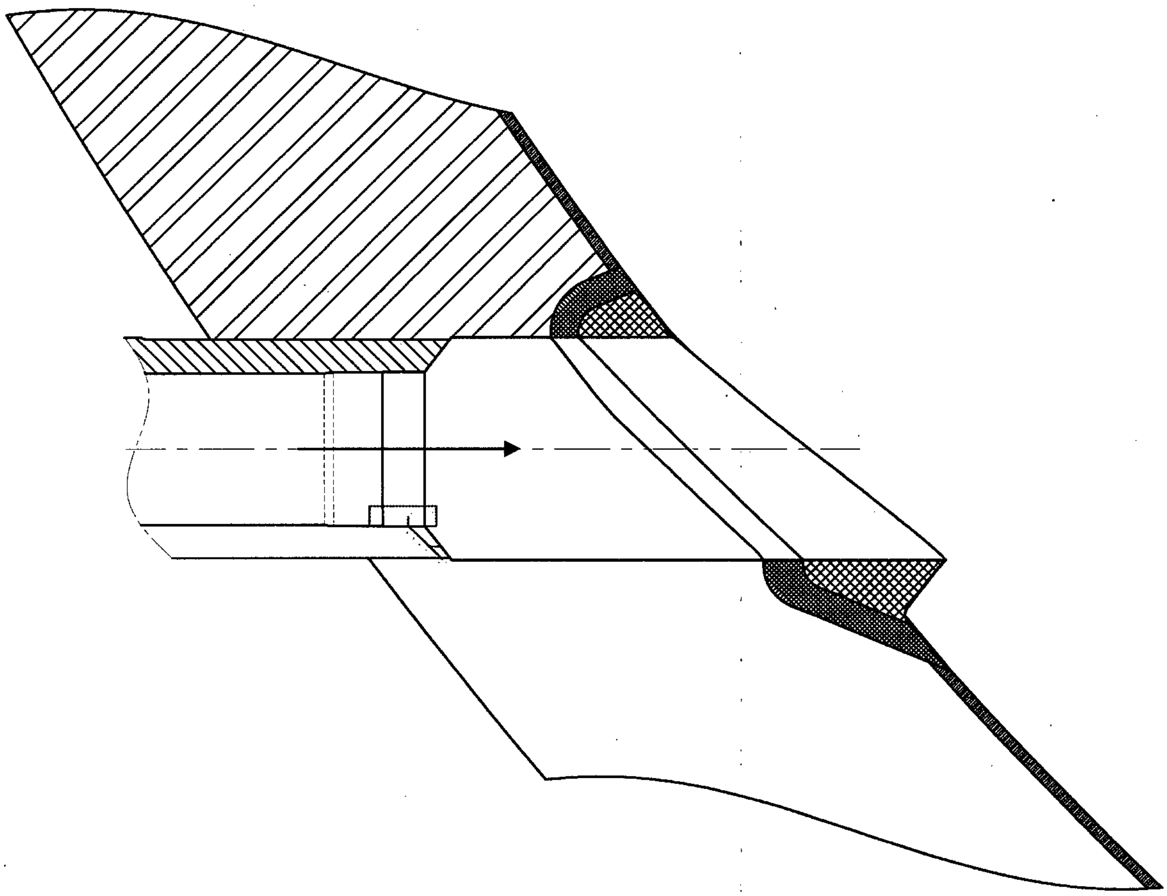
Ultrasonic and eddy current examination techniques considered for application after the nozzle weld preparation machining operation are discussed below. Based on the configuration of the weld preparation (face angle 37.5°) and the orientation of the expected flaw (laminar to inside diameter and outside diameter surfaces), the ultrasonic techniques currently employed at Davis-Besse Nuclear Power Station would not be sufficient to provide an adequate examination. Eddy current examination procedures and delivery equipment are not available for this application.

The current IDTB repair transducers are configured as 0°, 45°L (aimed up, down, clockwise, and counterclockwise), and 70°L (aimed up and down). The transducers which would interrogate the region would be the 0° and the downward aimed 45°L and 70°L inspection angles.

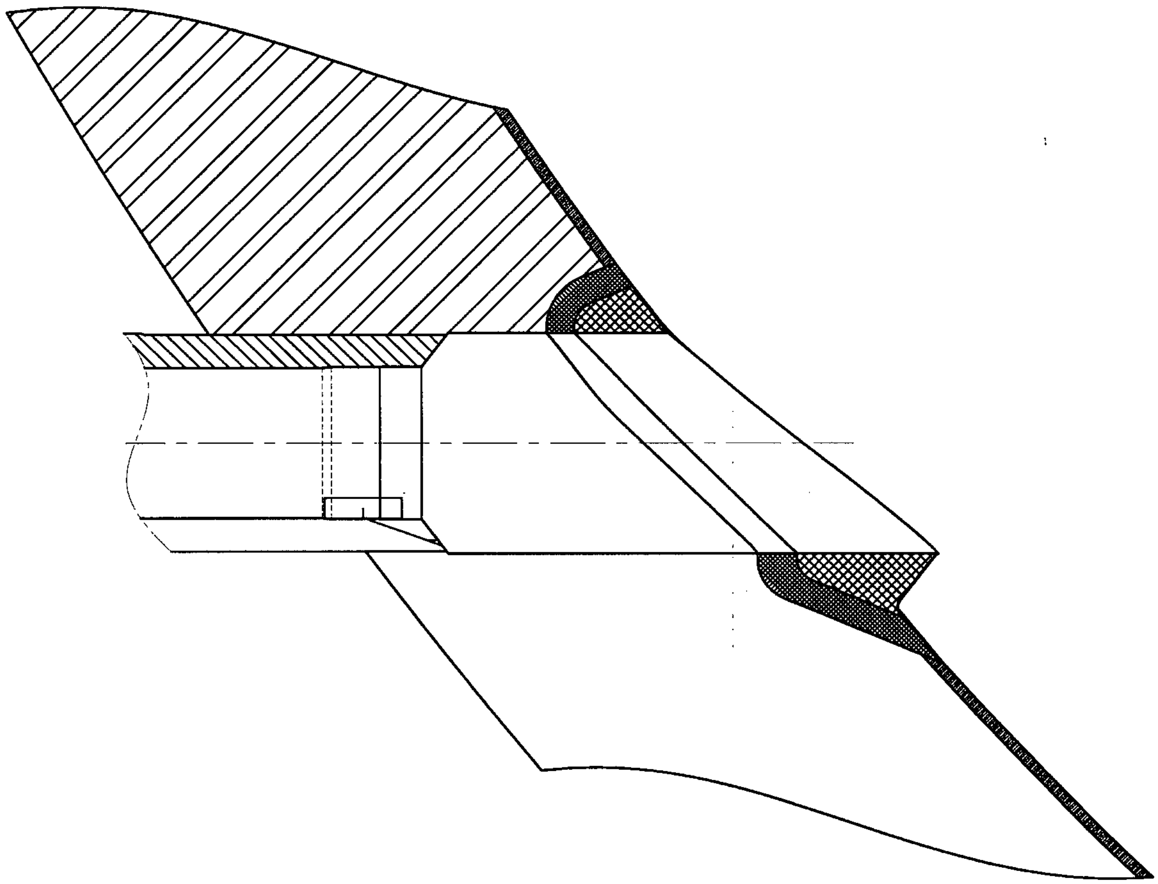
Based on the lamination configuration as it relates to the weld preparation, a 0° transducer would provide the greatest signal return. However, the installed weld preparation provides a limitation that prevents the 0° transducer from inspecting the region.



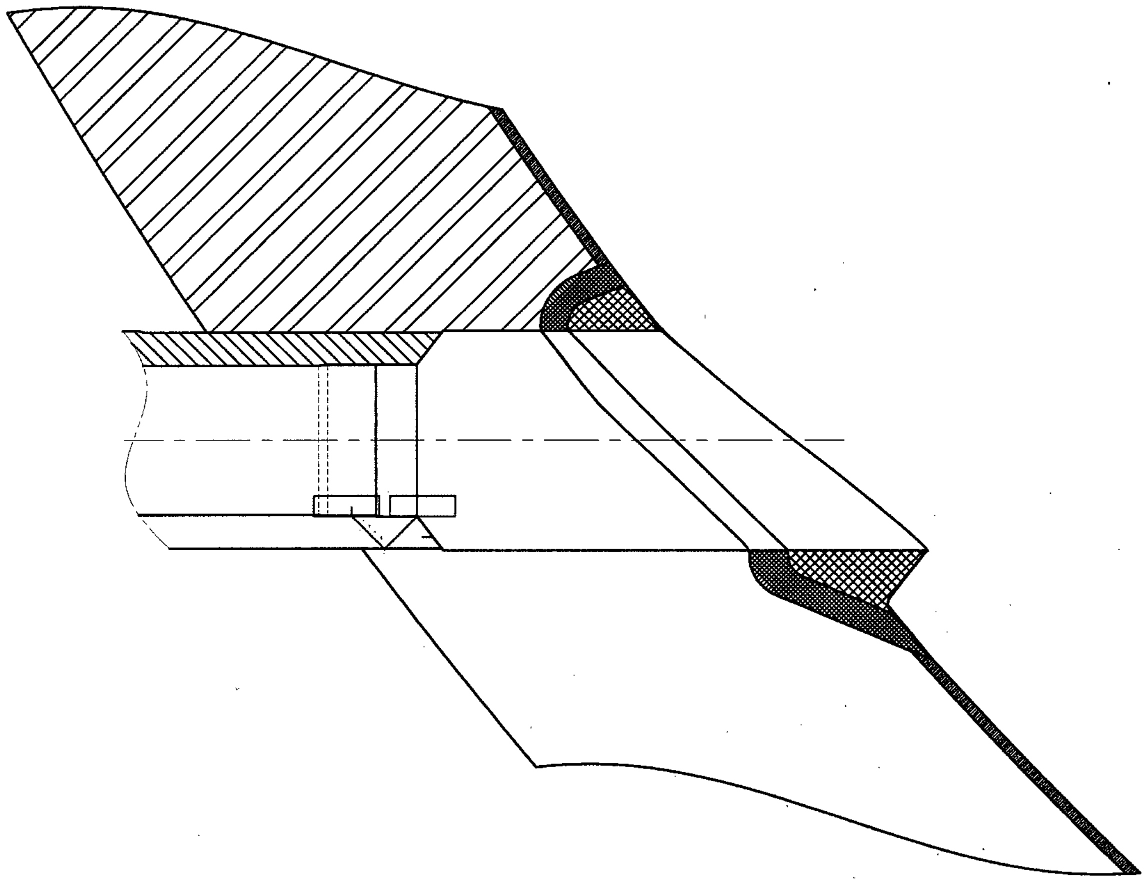
As illustrated above, the weld preparation produces a region that limits the examination volume. This is similar to the limitation that the finished IDTB creates, but larger. In the finished IDTB repair, the downward aimed angle beam transducers (45 and 70°L) are used to interrogate this area for defects (planar defects normal to the beam, that is, cracking, lack of fusion, and other things). While the use of the angle beam transducers can be used to insonify the region, the impinging beam would intercept the lamination at an angle that would not return a detectable signal (unlike a planar defect). The following figure depicts the 45°L intercept angle with respect to weld preparation and a lamination (arrow points down).



Although the 70°L transducer provides more standoff distance from the weld preparation, it is the off axis intercept angle that prevents adequate signal detection. The following figure shows a 70°L downward aimed inspection angle.



Another available ultrasonic technique utilizes the time of flight diffraction (TOFD) transducers. The lamination would produce a signal that would be detectable, but again the component geometry would interfere.



An ultrasonic technique (demonstrated) suited for the detection of laminations emanating from the weld preparation end is not currently available. The intent of the pre-roll ultrasonic examination was to detect indications in the region that the weld preparation was installed. This examination revealed no detectable indications.

In addition, there is no available procedure or delivery equipment available to perform an eddy current surface examination on the nozzle weld preparation area. Furthermore, the area on the nozzle weld preparation bevel, where the examination would need to be used, is in close proximity to the low alloy steel head penetration, which would also adversely affect the effectiveness of any eddy current examination.

An alternative to surface examination prior to welding is proposed for reactor pressure vessel (RPV) head penetration nozzle (here after referred to as nozzle) number 4. The proposed alternative described in this attachment supplements the proposed alternative described in the FirstEnergy Nuclear Operating Company (FENOC) 10 CFR 50.55a request letter dated April 1, 2010.

1.0 ASME CODE COMPONENTS AFFECTED

Components:	RPV Head Control Rod Drive Mechanism Penetration Nozzle 4
Code Class:	Class 1
Examination Category:	B-P
Code Item Number:	B4.20 (Code Case N-729-1)
Description:	Control Rod Drive Mechanism Housing
Size:	4 Inch Nominal Outside Diameter
Material:	Inconel SB-167

2.0 APPLICABLE CODE EDITION AND ADDENDA

Davis-Besse Nuclear Power Station In-Service Inspection and Repair/Replacement Programs:	American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section XI, 1995 Edition through 1996 Addenda
Davis-Besse Nuclear Power Station RPV Head Code of Construction:	ASME Code Section III, 1968 Edition, Summer 1968 Addenda

3.0 APPLICABLE CODE REQUIREMENTS

Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique, Section XI, Division 1," provides requirements for automatic or machine Gas Tungsten Arc Welding (GTAW) of Class 1 components without the use of preheat or postweld heat treatment.

Code Case N-638-1, paragraph 4.0(a) states:

> Prior to welding, a surface examination shall be performed on the area to be welded.

4.0 REASON FOR REQUEST

The lower portion of nozzle number 4 was removed by machining to an elevation above the J-groove weld containing unacceptable indications. This machining operation established the weld preparation area and exposed the triple point where the nozzle and low-alloy steel base material interface exists. During welding, contaminants affecting the viscosity of the weld puddle were encountered.

The nozzle was re-machined as described in Attachment 1. During liquid penetrant (PT) examination of the area to be welded, penetrant was drawn into the crevice at the triple point by the capillary action of the penetrant. When the penetrant developer was applied, excessive bleed out from the triple point crevice resulted in inadequate interpretation on adjacent areas of the nozzle bevel and bore surfaces in a circumferential band approximately 3/8 inch wide on the nozzle bevel surface and 3/8 inch on the bore surface adjacent to the crevice. It is believed that the heat of welding opened up the triple point area which permitted more penetrant to be drawn into the triple point crevice.

During re-welding of the nozzle to the RPV head, contaminants affecting the viscosity of the weld material puddle were again encountered. The contaminants are not specifically known, but are thought to be boric acid and corrosion products resulting from reactor coolant system leakage through the nozzle number 4 crevice as well as residue from the liquid penetrant examination process. Heat from welding at the crevice or triple point location tends to draw contaminants out of the crevice and into the weld puddle.

The VT-1 visual examination will be used on Nozzle 4 to examine the area to be welded in lieu of the surface examination required by Code Case N-638-1. This alternative is proposed to eliminate contaminants that may be introduced by the liquid penetrant examination process. Ultrasonic (UT) and eddy current examination techniques were considered, however, as discussed in Attachment 1, the available UT techniques were determined to be insufficient and there are no procedures and delivery equipment available to perform an eddy current surface examination on the nozzle weld preparation area.

5.0 PROPOSED ALTERNATIVE AND BASIS FOR USE

Code Case N-638-1, paragraph 4.0(a) requires that prior to welding, a surface examination be performed on the area to be welded. In lieu of surface examination, FENOC requests to use the VT-1 visual examination method to examine the area to be welded.

The VT-1 visual examination will meet the following requirements.

1. VT-1 visual examination shall be performed using a procedure that meets the requirements of IWA-2210 and shall be capable of resolving text with lower case

characters (for example, a, c, e, o) not exceeding a height of 0.044 inch (1.1 millimeters) at the examination distance. The maximum direct VT-1 visual examination distance shall not exceed 2 feet (610 millimeters).

2. VT-1 visual examination personnel shall be qualified in accordance with IWA-2300 and shall receive additional training in examination of weldments for fabrication conditions, including dimensional requirements and fabrication flaws.

3. Visual examination acceptance standards shall comply with the following:

    a. Linear indications are indications in which the length is more than three times the width. Rounded indications are circular or elliptical with length equal to or less than three times the width.

    b. Only indications with major dimensions greater than 1/16 inch (1.5 millimeters) shall be considered relevant. The following relevant indications are unacceptable.

        1. any cracks or linear indications

        2. rounded indications with major dimensions greater than 3/16 inch (5 millimeters)

        3. four or more rounded indications in a line separated by 1/16 inch (1.5 millimeters) or less edge to edge

        4. ten or more rounded indications in any 6 square inches (4000 square millimeters) of surface with major dimension of this area not to exceed 6 inches (150 millimeters) with the area taken in the most unfavorable location relative to the indication being evaluated.

These VT-1 visual examination requirements are equivalent to those specified in Code Case N-638-4 for performing VT-1 visual examinations when surface examination of the area to be welded is impractical. Draft Regulatory Guide DG-1192, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," June 2009 lists ASME Code Case N-638-4 as a conditionally accepted ASME Code Section XI code case. The conditions noted in the draft regulatory guide do not impact requirements for performing a VT-1 visual examination of the area to be welded when surface examination is impractical.

VT-1 visual examination is an acceptable alternative to the surface examination since:

1. The VT-1 visual examination will identify surface breaking indications on the area to be welded.

2. Prior to roll expansion, the nozzle tube was UT examined. This examination included the area requiring surface examination. No unacceptable indications in the nozzle tube base material were noted.

3. An initial PT was performed after the initial weld preparation machining operation and was acceptable per the acceptance criteria of ASME Code Case N-638-1, paragraph 4.0(e) and NB-5350.

4. Upon completion of the weld, the weld will be UT examined as described in Section 5.0 under the *Acceptance Examination Area* portion of the April 1, 2010 10 CFR 50.55a request. The UT examination will also cover the portion of the RPV head low alloy steel base material not examined by the pre-weld surface examination, to at least one-quarter inch depth.

With the UT and PT examinations already performed and the UT examination to be performed upon completion of the weld, the proposed alternative visual examination will provide assurance that the weld is acceptable and defects have not been induced in the low alloy steel RPV head material due to the welding process. Accordingly, the use of the alternative provides an acceptable level of quality and safety in accordance with 10 CFR 50.55a(a)(3)(i).

6.0 DURATION OF THE PROPOSED ALTERNATIVE

The provisions of this alternative are applicable to the third ten-year in-service inspection interval for the Davis-Besse Nuclear Power Station, which commenced on September 21, 2000 and will end on September 20, 2012.

The repairs installed in accordance with the provisions of this alternative shall remain in place for the design life of the repair.

FirstEnergy Nuclear Operating Company (FENOC) submitted 10 CFR 50.55a request RR-A34 by letter dated April 1, 2010 (Accession No. ML100960276). The letter requested NRC approval of alternative methods to repair the reactor pressure vessel head penetration nozzles (here after referred to as nozzle[s]) at the Davis-Besse Nuclear Power Station (DBNPS). By correspondence dated April 9, 2010 (Accession No. ML100980486), the Nuclear Regulatory Commission (NRC) staff issued a request for additional information (RAI) in order to complete the review of 10 CFR 50.55a request RR-A34. The FENOC letters dated April 16, 2010 (Accession No. ML101110149) and April 21, 2010 (Accession No. ML101160438) provided flaw evaluations for the postulated weld anomaly at the triple point of the repaired nozzles and for the J-groove weld of the repaired nozzles, respectively. By letter dated May 12, 2010, the NRC issued a RAI in order to complete its review of the previously submitted flaw evaluations and 10 CFR 50.55a request. The FENOC response to the May 12, 2010 NRC staff request is provided below. Each of the NRC staff's requests are presented in bold type, and are followed by the FENOC response.

1. **Page 3 of Relief Request RR-A34 states that "The 1992 edition of ASME Code Section III NB-5330(b) states: Indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length." The licensee proposed to use ASME Code Case N-638-1 to perform welding for the nozzle repair. Regulatory Guide 1.147, Revision 15, imposes a condition on Code Case N-638-1 which specifies that "...The acceptance criteria of NB-5330 in the 1998 edition through 2000 addenda of Section III apply to all flaws identified within the repaired volume."**

   (1) Specify the edition and addenda of the ASME Code that will be used.

   Response:

   American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section III, 1992 Edition, no Addenda is used for the performance of the ultrasonic (UT) examination as required by ASME Code Case N-416-3. ASME Code Section III, 1992 Edition, no Addenda (Required by ASME Code Case N-416-3) and ASME Code Section III, 1998 Edition including Addenda through 2000 (Required by Regulatory Guide 1.147 condition on use of ASME Code Case N-638-1), will be used for UT examination acceptance criteria.

   (2) Specify the subarticles of the ASME Code that the acceptance criteria will be based on.

Response:

Acceptance criteria will be in accordance with NB-5330, ASME Code Section III, 1992 Edition, no Addenda and NB-5330, ASME Code Section III, 1998 Edition including Addenda through 2000. The acceptance criteria for both of these code versions are equivalent. Welds with a solidification anomaly with length less than or equal to 0.1 inch will also be acceptable, if it exists, as described in the 10 CFR 50.55a request.

(3) Specify the ASME Code information for both the surface and volumetric examinations.

Response:

ASME Code Section III, 1992 Edition, no Addenda is used for the performance of the UT volumetric examination and liquid penetrant (PT) surface examination as required by ASME Code Case N-416-3.

ASME Code Section III, 1992 Edition, no Addenda (Required by ASME Code Case N-416-3) and ASME Code Section III, 1998 Edition including Addenda through 2000 (Required by Regulatory Guide 1.147 condition on use of ASME Code Case N-638-1), will be used for UT examination acceptance criteria. Welds with a solidification anomaly with length less than or equal to 0.1 inch will also be acceptable, if it exists, as described in 10 CFR 50.55a request RR-A34.

ASME Code Section III, 1992 Edition, No Addenda (Required by ASME Code Case N-416-3) will be used for PT examination acceptance criteria.

(4) Specify the ASME Code information for both the preservice and inservice inspections.

Response:

The PT examination performed following completion of the weld will serve as the preservice examination. The acceptance criteria for the preservice examination will be ASME Code Case N-729-1.

Future inservice inspections will be performed with the surface examination method in accordance with 10 CFR 50.55a request RR-A34. The acceptance criteria for the inservice examination will be ASME Code Case N-729-1.

2. As part of the above question, the NRC staff understands that the acceptance criteria for the surface examination in the 1989 edition of the ASME Code, Section III, will be used to disposition fabrication defects in the repaired nozzles because the design of the half nozzle was based on the 1989 edition of the ASME Code. Discuss why the design of the half nozzle repair did not use the 1995 edition of the ASME Code which is the code of record for the current third inservice inspection (ISI) interval.

Response:

The 1995 Edition/96 Addenda of ASME Code Section XI, subparagraph IWA-4410(a) states:

> Repair/replacement activities shall be performed in accordance with the Owner's Requirements and the original Construction Code of the component or system, except as provided in IWA-4410(b), (c), and (d).

The 1995 Edition/96 Addenda of ASME Code Section XI, subparagraph IWA-4410(b) states, in part:

> Later Editions and Addenda of the Construction Code or a later different Construction Code, either in its entirety or portions thereof, and Code Cases may be used, provided the substitution is as listed in IWA-4221(b).

Code Case N-416-3 will be used to satisfy pressure testing requirements subsequent to the repair. This Code Case specifies that nondestructive examination and acceptance criteria shall be in accordance with the 1992 Edition of ASME Code Section III. Code Case N-416-3 is identified as acceptable to the NRC for application in licensees' Section XI inservice inspection programs, in NRC Regulatory Guide 1.147, Revision 15.

Therefore although the design of the nozzle weld repair is to the 1989 Edition of the ASME Code, which is allowed by ASME Section XI 1995 Edition/96 Addenda, the surface examinations will be performed in accordance with the 1992 Edition of ASME Section III.

3. **In its response to RAI Question 12(2) regarding the ISI of the repaired nozzles dated April 16, 2010, the licensee stated that the ISI will include 1 or 1.5 inches of the remnant nozzles as shown in Figure 9 of RR-A34, depending on the angle of the nozzles with respect to the vessel head. The licensee stated further that although the examination does not completely encompass the rolled region of the nozzle, it does examine a significant portion of the rolled area. The examination will be performed with penetrant testing (PT). The NRC staff has questions regarding the adequacy of the ISI examination coverage of the repaired nozzles.**

   (1) Provide the stress profile (the worst case) of a remnant nozzle after it has been rolled, but before abrasive water jet is applied.

   Response:

   In lieu of providing the requested stress profile, the proposed examination area has been revised as described in the response to Item 3.(2) below.

(2) Identify the maximum vertical distance of the rolled region and the vertical-distance that will be examined with PT in ISI. Justify why it is acceptable not to examine the entire rolled region plus 0.5 inch on either end of the rolled region of the remnant nozzle.

Response:

The proposed examination area specified in Figure 9 of 10 CFR 50.55a request RR-A34, dated April 1, 2010, is superseded by the following proposed examination area. As an alternative to the ASME Code Case N-729-1, Table 1, Item B4.20 examination requirements as specified in Figure 2 of the ASME Code case, the examination area for the preservice examination following repair and for future inservice inspections shall include the wetted surface of the new weld from the toe of the weld up through 0.5 inches above the rolled region of the nozzle remnant. With this change the entire rolled region of the remnant nozzle will be examined.

4. Discuss the potential for general corrosion in the bore region of the reactor vessel head penetration where the nozzle has been removed as part of the proposed repair.

Response:

The corrosion in the bore region of the reactor pressure vessel (RPV) head penetrations where nozzle repair welds are being installed has been evaluated. This evaluation concludes that galvanic corrosion, hydrogen embrittlement, stress corrosion cracking and crevice corrosion are not expected to be a concern for the exposed low alloy steel head material. General corrosion of the exposed RPV head will occur and a general corrosion rate of 0.0035 inches per year at the exposed locations is estimated based on a 24-month fuel cycle (24-month operation followed by a 2-month shutdown). Based on a 4-year design life of the current RPV head, the anticipated loss of RPV head material is considered inconsequential.

5. Triple Point Weld Anomaly Flaw Evaluation, Page 8, Section 1.1. The licensee stated that a maximum 0.1 inch weld anomaly is assumed at the triple point of the repaired nozzles. Discuss whether the 0.1 inch flaw size bounds the actual weld anomalies that may be detected by ultrasonic testing in the repair of the control rod drive mechanism (CRDM) nozzles at DBPNS during this refueling outage.

Response:

The ultrasonic examination procedure for temper bead weld repairs was demonstrated on a mockup of the weld repair configuration. The mockup used electrodischarge machined (EDM) notches with depths of 0.050, 0.113, and 0.159 inches measured from the tube outside diameter to simulate the triple point anomaly. The ultrasonic examination procedure was able to detect and size the EDM notches, therefore 0.1 inch flaw sizes are detectable.

6. **Triple Point Weld Anomaly Flaw Evaluation, Page 10. For path 2, the licensee assumed a continuous cylindrical surface flaw propagating along the interface between the new Alloy 52M weld and low alloy steel head. Describe the shape or configuration of this flaw (e.g., an axially oriented flaw, a circumferentially oriented flaw, or a semi-circular planar flaw).**

   Response:

   The description of the flaw is provided on Page 10 of the document. To help describe the configuration of the postulated flaw, a sketch showing the flaw has been prepared. The Triple Point Weld Anomaly Flaw Sketch contains proprietary information that is to be withheld from public disclosure pursuant to 10 CFR 2.390. Enclosure G contains the AREVA affidavit to identify the reasons for withholding information, and the proprietary version of the sketch to be withheld from public disclosure is provided as Enclosure K.

7. **Triple Point Weld Anomaly Flaw Evaluation, Page 15, Section 4.2. Clarify whether the analysis include[s] stresses due to thermal expansion of the nozzle in the vessel head penetration bore, dead weight of the nozzle, seismic loads, and pressure. If not, provide justification.**

   Response:

   The stresses due to thermal expansion of the nozzle in the RPV head penetration bore and the effects of pressure are considered in the analysis. The effect of deadweight is conservatively ignored, since it results in compressive stresses in the inner diameter temper bead (IDTB) weld.

   The stresses in the IDTB weld due to the operating basis earthquake (OBE) are considered to be negligible for the following reasons: Previous evaluation of the Babcock & Wilcox designed control rod drive mechanism (CRDM) has shown that the radial gap that may form between the nozzle and the head is within a few thousandths of an inch. This is, in part, due to the interference fit design of the nozzle. Due to the limited displacement constraint of the nozzle relative to the head, the OBE loads are judged to be primarily taken up by the upper portion (outside diameter) of the head.

8. and 9. Triple Point Weld Anomaly Flaw Evaluation, Page 15, middle of the page. The licensee stated that component stresses for the two crack propagation paths were obtained from Reference 14. Reference 14 appears to be a generic analysis performed by AREVA for the temper bead welding which was issued in 2004. Explain how and why a generic analysis in Reference 14 is applicable to the plant-specific half-nozzle repair at DBPNS.

Response:

While Reference 14 is the IDTB design basis for several Babcock & Wilcox 177FA plants, it is not simply a generic analysis. Rather, it is an analysis that considers plant specific data for several plants including DBNPS (initially introduced in Revision 05). As additional plants were added to the list of those qualified for this repair, the calculation was revised to include any additional loads necessary to qualify the repair at that additional plant. As each revision was created, the envelope of the applicable loads either stayed the same or grew. Furthermore, a comparative assessment concluded that the ASME Code Section III qualification in Reference 14 continues to be applicable for the IDTB repair in the Midland head installed at DBNPS, despite some minor potential differences in geometry. Therefore, stresses from Revision 12 (the latest revision) of Reference 14 are appropriate for use in the Triple Point Weld Anomaly analysis.

10. **Triple Point Weld Anomaly Flaw Evaluation, Page 26, middle of the page. The licensee used a stress distribution based on a third order polynomial. The stresses represented by a third order polynomial may not be adequate, especially for welding residual stress. This approximation can underpredict the stresses on the crack face. Discuss the validity of using the third order approximation for the through wall thickness stress.**

    Response:

    Four stress profiles were used in the anomaly analysis. In each of the stress plots, the actual through-wall stresses (represented by diamond shaped points) are compared against the third-order curve-fit to the stresses (used in the analysis). For this application, the third-order curve-fit to the stresses provides a very good approximation of the actual through-wall stresses. The stress profiles are enclosed with this letter and contain proprietary information that is to be withheld from public disclosure pursuant to 10 CFR 2.390. Enclosure G contains the AREVA affidavit to identify the reasons for withholding information, and the proprietary version of the stress profiles to be withheld from public disclosure are provided as Enclosure L.

11. **Triple Point Weld Anomaly Flaw Evaluation, Page 37. Explain why the same fracture toughness value (K_{Ia}) of 200 ksi$\sqrt{in}$ is used for all postulated flaws along paths 1 and 2 even though the materials (Alloy 52M weld, Alloy 600 remnant nozzle, and low alloy steel reactor vessel) in which the flaws propagate in each of the paths are different and may have different fracture toughness.**

    Response:

    Alloy 600 and 52M materials are ductile materials and therefore brittle fracture is not a credible failure mechanism for these materials. Nonetheless, the fracture toughness of the low alloy steel at temperature is conservatively used even for these ductile materials. Sections 4.3.1 and 4.3.2, on Page 24 of Enclosure J, "DB-1 CRDM Nozzle Weld Anomaly Flaw evaluation of IDTB Repair," contain additional information.

12. J-Groove Weld Flaw Evaluation, Page 9. Provide references for the safety factors used in the elastic-plastic fracture mechanics analysis.

Response:

The J-groove weld analysis for DBNPS used flaw stability primary/secondary safety factors of 3.0/1.5 for normal operating and upset conditions and 1.5/1.0 for emergency and faulted conditions, and flaw extension primary/secondary safety factors of 1.5/1.0 for normal operating and upset conditions and 1.5/1.0 for emergency and faulted conditions.

Article H-6320 of ASME Code Section XI, 1995 Edition 1996 Addenda requires using a safety factor of 2.77 for normal operating (including upset and test conditions) and 1.39 for emergency and faulted conditions. The flaw stability safety factors used for the DBNPS analysis are therefore conservative relative to those specified in Article H-6320 of ASME Code Section XI.

Also, the NRC stated in a request for additional information related to Sequoyah and Watts Bar 10 CFR 50.55a requests (Accession No. ML073480424) that:

> The NRC staff has approved the use of a safety factor of 3.0 for primary stresses and 1.5 for secondary (residual plus thermal) stresses for operating conditions in CRDM repair relief requests at other nuclear plants.
>
> For a crack extension of 0.1 inch, the NRC staff has approved the use of a safety factor of 1.5 on primary stresses and 1.0 on secondary stresses at other nuclear plants.

The above excerpts from the Sequoyah and Watts Bar request for additional information response are applicable to DBNPS since both the Tennessee Valley Authority and FENOC 10 CFR 50.55a requests refer to the same elastic-plastic fracture mechanics methodology for qualifying remnant J-groove welds after inner diameter temper bead repairs to nozzles.

13. J-Groove Weld Flaw Evaluation, Page 11. Item 3 discusses a mapping procedure to transfer stresses from uncracked finite element stress analysis models in Figures 4-3 and 4-4 to the crack face of the crack model. The finite element model in Figures 4-3 and 4-4 include the original nozzle, not the half nozzle configuration after the repair. A more appropriate model would use the half nozzle configuration after the repair, calculate the loads and stresses from the repaired nozzle configuration, and apply the loads and stresses to the crack face. Justify why and how the finite element model in Figures 4-3 and 4-4 provides the appropriate loads and stresses to calculate the growth of a postulated flaw in the J-groove weld into the vessel head.

Response:

Figures 4-3 and 4-4 show the finite element model prior to removal of the nozzle to simulate the repair. The analysis simulated the entire fabrication history of the nozzle, including welding of the J-groove buttering, a post-weld heat treatment, welding of the J-groove partial penetration weld at the outmost CRDM nozzle, hydrostatic testing, operation at steady state temperature and pressure conditions, return to zero load conditions, removal of the original nozzle, and a second application of steady state loads. The stresses that were mapped to the crack model were obtained from the final repair configuration.

14. J-Groove Weld Flaw Evaluation, Page 11. Item 4.

(1) Describe how the final crack size is calculated with respect to the finite element model and crack growth calculation described in Section 2.1.

Response:

There is only one finite element crack model. The model depicted in Figure 2-2 was developed for the initial flaw size. Since it is computationally prohibitive to redefine the crack model for each increment of flaw growth, stress intensity factors from the crack model for the initial flaw size are updated at each increment of crack growth by the square root of the flaw size according to:

$$K_I(a_{i+1}) = K_I(a_i)\sqrt{\frac{a_{i+1}}{a_i}},$$

where a = flaw size

i = increment of crack growth

The incremental change in flaw size, $\Delta a = a_{i+1} - a_i$, is calculated from the fatigue crack growth model for each increment of stress intensity factor, $\Delta K = K_I(a_{i+1}) - K_I(a_i)$, from the initial flaw size to the final flaw size.

(2) Clarify the analytical methodology on page 11 regarding how the final crack model was constructed in Figure 2-2.

Response:

There is only one finite element crack model. The model depicted in Figure 2-2 was developed for the initial flaw size. The final flaw size is calculated by updating stress intensity factors from the initial flaw model by the square root of the flaw size for each increment of crack growth, as described in 14.(1) above.

15. J-Groove Weld Flaw Evaluation, Page 14. Figure 2-2 presents the finite element model for the final crack size which shows that half of the final crack (length) is located in the reactor vessel head shell and the other half is located

in the butter. However, based on the postulated initial flaw size of 2.035 inches, and the calculated final flaw size (proprietary information) as shown on page 36, the final flaw size cannot possibly have 50 percent of its length in the butter and 50 percent of its length in the reactor vessel shell.

(1) Explain the discrepancy between the final crack size model in Figure 2-2 and the calculated final flaw size on page 36.

Response:

The finite element crack model depicted in Figure 2-2 was developed for the initial flaw size. This model is used to calculate stress intensity factors at various positions along the crack front between the butter and head, using fan-shaped crack tip elements that wrap around the crack front. Half of the elements are in the butter and half are in the head. The crack is developed by removing circumferential displacement constraints on the crack face nodes in the weld and butter, but not in the head. The final flaw size is calculated by updating stress intensity factors from the initial flaw model by the square root of the flaw size for each increment of crack growth.

(2) Discuss the exact length of the final crack size that is located in the reactor vessel head.

Response:

The length of the final flaw size is equal to the length of the initial flaw size plus the sum of the incremental changes in flaw size calculated by fatigue crack growth. The final flaw size is interpreted to be the distance from the innermost corner of the J-groove weld to the position of the final crack on the bored surface of the head (that is, beyond the butter/head interface).

(3) Discuss the allowable flaw size of the reactor vessel head.

Response:

The allowable flaw size of the reactor vessel head would be that flaw size which produces no margin beyond the flaw stability or flaw extension safety factors used in the DBNPS nozzle J-groove weld elastic-plastic fracture mechanics analysis. The flaw stability safety margins are used in comparing the applied tearing modulus to the material tearing modulus, while the flaw extension safety margins are used in comparing the applied J-integral to the J-integral of the material at a 0.1 inch crack extension. Since the results of the analysis demonstrate that the material tearing modulus exceeds the applied tearing modulus and the applied J-integral is less than the material J-integral at a crack extension of 0.1 inch for the required safety factors at the final flaw size, the final flaw size is less than the allowable flaw size in the reactor vessel head.

16. J-Groove Weld Flaw Evaluation, in the flaw growth calculation on pages 32, 35, and 36, the initial flaw size was assumed as 2.035 inches.

(1) Discuss whether the initial flaw size of 2.035 inches is the same length as modeled in the finite element crack model as shown on page 12 (i.e., the crack tip is at the interface between the butter and the reactor vessel head).

Response:

The shape of the postulated flaw is illustrated in Figure 2-1 on Page 12 of the report. The postulated flaw, depicted by the cross hatched area in Figure 2-1, represents the initial flaw size, extending from the innermost corner to the butter/head interface. This J-shaped crack is arbitrarily characterized by the length of the crack along the bore. The length of this initial flaw is 2.035 inches, which is the initial flaw size mentioned on pages 32, 35, and 36.

(2) How is the initial flaw size derived?

Response:

The length of the initial flaw size (2.035 inches) was obtained from the finite element model (depicted in Figures 2-1 and 2-2 of the report) as the distance from the innermost corner to the butter/head interface.

17. J-Groove Weld Flaw Evaluation, Page 24. Confirm that the fatigue crack growth rate used in the analysis is based on the water environment.

Response:

The fatigue crack growth rate used in the analysis is based on the water environment as confirmed by the scaling constants used in the calculation provided by Article A-4300 of ASME Code Section XI, 1995 Edition, 1996 Addenda.

18. J-Groove Weld Flaw Evaluation, Discuss whether the crack model includes pressure loading on the crack face. If not, provide justification.

Response:

Crack face pressure is added to the residual and operational stresses as part of the stress mapping procedure.

19. J-Groove Weld Flaw Evaluation, Page 44, Section 6.0, states that the final flaw size in the reactor vessel head was determined by linear elastic fracture mechanics for 4 years of fatigue crack growth. However, it is shown on page 37 of the report, "DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Repair", submitted on April 16, 2010, that the flaw evaluation for the weld anomaly at the triple point was calculated for 25 years. Discuss the

discrepancy in the number of years (4 years vs. 25 years) assumed in the two flaw evaluations for the J-groove weld and weld anomaly at the triple point.

Response:

The remaining required design life of the current reactor vessel head is 4-years or 2-operating cycles. The weld anomaly flaw evaluation shows that it would take 25-years for the calculation described flaw to become unacceptable, which exceeds the 4-year remaining design life of the head. The J-groove flaw analysis was done to show that a postulated crack left in the J-groove weld remnant and weld butter would not result in an unacceptable flaw if it propagated into the low alloy steel head in 4-years.

20. **Provide a requirement for the performance of a pressure test after the reactor vessel head penetration nozzles are repaired.**

Response:

A system leakage test will be performed in accordance with Code Case N-416-3 following repairs.