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

September 20, 2010

Mr. Barry S. Allen
Site Vice President
FirstEnergy Nuclear Operating Company
Davis-Besse Nuclear Power Station
Mail Stop A-DB-3080
5501 North State Route 2
Oak Harbor, OH 43449-9760

SUBJECT: DAVIS-BESSE NUCLEAR POWER STATION, UNIT 1 - RELIEF REQUEST RR-A34, 10 CFR 50.55A REQUEST FOR ALTERNATE REPAIR METHODS FOR REACTOR PRESSURE VESSEL HEAD CONTROL ROD DRIVE MECHANISM PENTRATION NOZZLES (TAC NO. ME3703)

Dear Mr. Allen:

By letter to the U.S. Nuclear Regulatory Commission (NRC) dated April 1, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML100960276), as supplemented by letters dated April 16, 2010 (ADAMS Accession No. ML101110149), April 21, 2010 (ADAMS Accession No. ML101160438) and May 17, 2009 (ADAMS Accession No. (ML101400404, and electronic correspondence dated May 28, 2009 (ADAMS Accession No. ML101520113), the FirstEnergy Nuclear Operating Company (FENOC, the licensee), submitted a request to the NRC for the use of alternatives to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI requirements at Davis-Besse Nuclear Power Station, Unit 1 (DBNPS) associated with the reactor pressure vessel (RPV) head control rod drive mechanism (CDRM) penetration nozzle repairs.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3)(i), the licensee requested to use the proposed alternative on the basis that the alternative provides an acceptable level of quality and safety. The licensee requested NRC staff review and approval of Relief Request A34 (RR-A34) to repair of RPV head CRDM penetration nozzles at DBNPS.

On June 4, 2010, the NRC staff verbally authorized the use of RR-A34 (ADAMS Accession No. ML101600147, not publicly available). As part of the verbal authorization, the licensee committed to examine certain area of the repaired nozzles during the preservice and inservice inspection as discussed in the NRC staff memorandum dated June 14, 2010 (ADAMS Accession No ML101600147).

On the basis of its evaluation, the NRC staff has determined that RR-A34 will provide an acceptable level of quality and safety for the repair of the RPV head CRDM penetration nozzles. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of RR-A34, dated April 1, April 16, April 21, 2010, May 17, and May 28, 2009, and the commitment made on June 4, 2010, for the repair of the RPV head CRDM penetration nozzles for the third 10-year inservice inspection interval at the DBNPS).

If you have any questions, please contact the Davis-Besse Project Manager, Mr. Michael Mahoney, at 301-415-3867.

Sincerely,

Robert D. Carlson, Chief
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-346

Enclosure:
As stated

cc w/encl: Distribution via Listserv

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST RR-A34

ALTERNATE REPAIR METHODS FOR REACTOR PRESSURE VESSEL HEAD PENETRATION CONTROL ROD DRIVE MECHANISM NOZZLE

DAVIS-BESSE NUCLEAR POWER STATION, UNIT 1

FIRSTENERGY NUCLEAR OPERATING COMPANY

DOCKET NO. 50-346

1.0 INTRODUCTION

By letter dated April 1, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML100960276), FirstEnergy Nuclear Operating company (the licensee), requested U.S. Nuclear Regulatory Commission (NRC) review and approval of proposed alternatives in Relief Request A34 (RR-A34) to certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) for the repair of reactor pressure vessel (RPV) head control rod drive mechanism (CRDM) penetration nozzles at Davis-Besse Nuclear Power Station (DBNPS).

By letter dated April 16, 2010 (ADAMS Accession No. ML101110149), the licensee submitted its first response to the NRC staff's request for additional information (RAI) and its flaw evaluation for the triple point weld anomaly. By letter dated April 21, 2010, the licensee submitted its flaw evaluation for the J-groove weld (ADAMS Accession No. ML101160438).

By letter dated May 17, 2010 (ADAMS Accession Number ML101400402), the licensee provided a supplement to proposed relief request RR-A34 as a result of welding problems encountered at RPV head CRDM penetration nozzle number 4. In the letter, the licensee also provided second response to the second round of NRC staff's RAI and revised flaw evaluations for the triple point anomaly and the J-groove weld remnant.

By electronic correspondence dated May 28, 2010 (ADAMS Accession No. ML101520113), the licensee provided its third response to the third round of RAIs issued by the NRC staff to address several issues related to the inspection of the repaired nozzles and the examination results of nozzle number 4.

On June 4, 2010, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i), the NRC staff verbally authorized the use of RR-A34. As part of the verbal authorization, the licensee committed to expand the examination area of the repaired nozzles during the preservice and inservice inspection as summarized in the NRC staff memorandum dated June 14, 2010 (ADAMS Accession No. ML101600147, not publicly available).

During the current 16th refueling outage that began on February 28, 2010, the licensee inspected the RPV head penetration nozzles with insulation removed. Examination results at certain RPV head penetration nozzles did not meet the acceptance criteria. Therefore, the proposed alternatives in RR-A34 are to be used to repair the degraded penetration nozzles during the 2010 refueling outage.

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code, incorporated by reference in 10 CFR 50.55a(b), 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein.

The regulation at 10 CFR 50.55a(g)(6)(ii)(D), *Reactor vessel head inspections,* requires licensees of pressurized-water reactors to inspect their reactor vessel head penetration nozzles in accordance with ASME Code Case N-729-1 with conditions.

Pursuant to 10 CFR 50.55a(a)(3) alternatives to ASME Code requirements may be authorized by the NRC if the licensee demonstrates that: (i) the proposed alternatives provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The ASME Code of record for the third 10-year ISI interval at the DBNPS is the 1995 Edition through the 1996 Addenda of the ASME Code, Section XI.

3.0 TECHNICAL EVALUATION

3.1 Proposed Relief Request RR-A34

3.1.1 ASME Code Components Affected

Components:	Reactor Pressure Vessel Head Control Rod Drive Mechanism Penetration Nozzle Numbers 1 through 69
Code Class:	Class 1
Examination Category:	B-P
Code Item Number:	B4.20 (Code Case N-729-1, "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads With

	Nozzles Having Pressure-Retaining Partial-Penetration Welds, Section XI, Division 1")
Description:	Control Rod Drive Mechanism Housing
Size:	4 Inch Nominal Outside Diameter
Material:	Inconel SB-167

3.1.2 Applicable Code Edition and Addenda

Davis-Besse Nuclear Power Station Inservice Inspection and Repair/Replacement Programs: ASME Code Section XI, 1995 Edition through 1996 Addenda.

DBNPS RPV Head Code of Construction: ASME Code Section III, 1968 Edition, Summer 1968 Addenda.

3.1.3 Applicable Code Requirements

The licensee will repair the RPV head CRDM penetration nozzles in accordance with the following ASME Code requirements. However, the licensee requested relief from Items 6, 7, 8 and 13 below with the proposed alternatives.

1. The 1995 Edition and 1996 Addenda of ASME Code, Section XI, subparagraph IWA-4221(a) requires that an item to be used for repair and replacement activities meet the Owner's Requirements and the applicable Construction Code to which the original item was constructed, except as provided in IWA-4221(b) and (c).

2. The 1995 Edition and 1996 Addenda of ASME Code, Section XI, subparagraph IWA-4221(b) requires, in part, that the item may meet all or portions of the requirements of different Editions and Addenda of the Construction Code, or Section III when the Construction Code was not Section III, provided the requirements of IWA-4222 through IWA-4226, as applicable, are met.

3. The 1995 Edition and 1996 Addenda of ASME Code, Section XI, subarticle IWA-4400 provides welding, brazing, metal removal, and installation requirements related to repair and replacement activities.

4. The 1995 Edition and 1996 Addenda of ASME Code, Section XI, subparagraph IWA-4410(a) requires that repair and replacement activities 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).

5. The 1995 Edition and 1996 Addenda of ASME Code, Section XI, subparagraph IWA-4410(b) requires that 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).

6. The 1995 Edition and 1996 Addenda of ASME Code, Section XI, subparagraph IWA-4610(a) requires, in part, that thermocouples and recording instruments be used to monitor the process temperatures.

7. Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique", provides requirements for automatic or machine Gas Tungsten Arc Welding (GTAW) of Class 1 components without the use of preheat or post-weld heat treatment. Code Case N-638-1, paragraph 3.0(d), requires that the maximum interpass temperature for field applications be 350 degrees F regardless of the interpass temperature during qualification. Code Case N-638-1, paragraph 4.0(b) requires, in part, that the final weld surface and the band around the area defined in paragraph 1.0(d) be examined using a surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with the ASME Code, Section XI, Appendix I.

8. Code Case N-729-1, "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads With Nozzles Having Pressure-Retaining Partial-Penetration Welds", Figure 2 provides the examination volume for nozzle base metal and examination area for weld and nozzle base metal.

9. The 1995 Edition and 1996 Addenda of ASME Code Section XI, subparagraph IWA-4611.1(a) requires that "...Defects shall be removed or reduced in size in accordance with this Paragraph. ... the defect removal area and any remaining portion of the flaw may be evaluated and the component accepted in accordance with the appropriate flaw evaluation provisions of Section XI or the design provisions of the Owner's Requirements and either the Construction Code or Section III..."

10. The 1995 Edition and 1996 Addenda of ASME Code, Section XI, subarticle IWA-3300 requires characterization of flaws detected by inservice examination.

11. The 1995 Edition and 1996 Addenda of ASME Code, Section XI, subarticle IWB-3420 requires that each detected flaw or group of flaws shall be characterized by the rules of IWA-3300 to establish the dimensions of the flaws. These dimensions shall be used in conjunction with the acceptance standards of IWB-3500.

12. The 1995 Edition and 1996 Addenda of ASME Code, Section XI, subparagraph IWB-3142.4 requires that a component containing relevant conditions is acceptable for continued service if an analytical evaluation demonstrates the component's acceptability. The evaluation analysis and evaluation acceptance criteria shall be specified by the Owner. A component accepted for continued service based on analytical evaluation shall be subsequently examined in accordance with IWB-2420(b) and (c).

13. The 1992 Edition of ASME Code, Section III subparagraph NB-5330(b) requires that indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.

3.1.4 Proposed Alternative and Basis For Use

The licensee stated that due to risk of damage to the RPV head material properties or dimensions, it is not feasible to apply the post welding heat treatment requirements of the original Construction Code. As an alternative to the requirements of the Construction Code for the RPV head, the licensee proposes to perform the repair of the RPV head penetration nozzle using the inside diameter temper bead (IDTB) welding method to restore the pressure boundary of the degraded nozzles. The IDTB welding method is performed with a remotely operated weld tool, utilizing the machine Gas Tungsten-Arc Welding (GTAW) process and the ambient temperature bead method with 50 degrees Fahrenheit (F) minimum preheat and no post weld heat treatment. The repairs and examinations will be conducted in accordance with the 1995 Edition through the 1996 Addenda of ASME Code, Section XI, Code Case N-638-1, Code Case N-729-1, with the following alternative requirements.

3.1.4.1 Monitoring of Interpass Temperature

Code Case N-638-1, paragraph 3.0(d) requires that the maximum interpass temperature for field applications be 350 degrees F regardless of the interpass temperature during qualification and that all other requirements of the ASME Code, IWA-4000 must be met. IWA-4610(a) requires that thermocouples and recording instruments be used to monitor process temperatures. Direct interpass temperature measurement inside the nozzle bore is impractical during welding operations due to the physical configuration of the nozzle. As an alternative, the licensee proposed to determine the maximum interpass temperature by one of the following methods: (1) heat-flow calculations, or (2) measurement of the maximum interpass temperature on a test coupon that is no thicker than the item to be welded. The maximum heat input of the welding procedure shall be used in welding the test coupon.

3.1.4.2 Acceptance Examination Area

Code Case N-638-1, paragraph 4.0(b), requires, in part, that the final weld surface and the band around the area defined in paragraph 1.0(d) of the code case be examined using surface and ultrasonic methods. Code Case N-638-1, paragraph 1.0(d), defines the area requiring examination as the area to be welded and the band around the area of at least 1.5 times the component thickness or five inches, whichever is less. The licensee stated that the band around the area defined in paragraph 1.0(d) cannot be examined due to the physical configuration of the partial penetration weld. The alternative final examination of the new weld and immediate surrounding area within the bore will be sufficient to verify that defects have not been induced in the low alloy steel RPV head material due to the welding process and will assure integrity of the nozzle and the new weld. Figure 3 in RR-A34 identifies the alternative areas for liquid penetrant (PT) and ultrasonic (UT) examination of the modified RPV head penetration. Acceptance criteria for the UT examination will be in accordance with ASME Section III, NB-5330. The extent of the examination is consistent with Construction Code requirements.

The licensee proposed to ultrasonically scan from the inner diameter surface of the new weld and the adjacent portion of the nozzle bore, excluding the transition taper portion at the bottom of the weld. The volume of interest for the UT examination extends from at least one inch above the new weld and into the RPV head low alloy steel base material beneath the weld, to at least one-quarter inch depth. The PT examination area includes the weld surface and extends upward on the nozzle inside surface to include the area required for inservice inspection and at least one-half inch below the new weld.

Code Case N-638-1, Paragraph 4.0(b), requires that the specified volumetric examination be performed in accordance with Section XI, Appendix I. Paragraph 4.0(e) specifies volumetric examination acceptance criteria in accordance with the ASME Code, Section XI, IWB-3000. Paragraph IWB-3000 does not have any acceptance criteria that directly apply to the partial penetration weld configuration. Regulatory Guide 1.147, Revision 15, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," has conditionally approved Code Case N-638-1 with the condition that UT volumetric examinations be performed with personnel and procedures qualified for the repaired volume and qualified by demonstration using representative samples containing construction type flaws. As an alternative, the acceptance criteria of NB-5330 in the 1998 Edition through 2000 Addenda, Section III, will apply to all flaws identified within the repaired volume.

ASME Code Case N-416-3, "Alternative Pressure Test Requirement for Welded or Brazed Repairs, Fabrication Welds or Brazed Joints for Replacement Parts and Piping Subassemblies, or Installation of Replacement Items by Welding or Brazing, Class 1, 2, and 3, Section XI, Division 1," will be used to satisfy pressure testing requirements subsequent to the repair. This Code Case specifies that the nondestructive examination (NDE) and acceptance criteria shall be in accordance with the 1992 Edition of the ASME Code, Section III.

The ASME Code, Section III, NB-5245, requires incremental and final surface examination of partial penetration welds. Due to the welding layer disposition sequence (each layer is deposited parallel to the penetration centerline), the specific requirements of Paragraph NB-5245 cannot be met (i.e., no incremental PT). As an alternative to progressive surface examination, the licensee proposed to perform a final post-weld PT only and an UT examination as shown in Figure 3 of RR-A34.

3.1.4.3 <u>48-Hour Hold Time</u>

Code Case N-638-1, paragraph 4.0(b), requires that the final weld surface and the band around the area defined in paragraph 1.0(d) be examined using a surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. As an alternative, the licensee proposed to commence the 48-hour hold period upon completion of the third weld layer.

3.1.4.3 <u>Triple Point Weld Anomaly</u>

The 1992 Edition of the ASME Code, Section III, subparagraph NB-5330(b) requires that indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length. An artifact of the ambient temperature temper bead repair weld is an anomaly in the new weld at the triple point. The triple point is the location in the new weld configuration where the low alloy steel RPV head, the Alloy 600 nozzle, and the first Alloy 52M weld bead intersect. This anomaly consists of an irregularly shaped small void. Mock-up testing has verified that the anomalies are common and do not exceed 0.10 inches in length and are assumed to exist around the entire bore (360 degrees), at the triple point elevation, for purposes of the crack growth analysis. The proposed alternative permits anomalies at the triple point area to remain in service.

3.1.4.5 <u>Nondestructive Examinations</u>

Code Case N-729-1 provides requirements for the inservice inspection of RPV upper heads with nozzles having partial penetration welds. Code Case N-729-1, Table 1, Item B4.20, permits either volumetric or surface examination. The licensee proposed that preservice and inservice examinations of the repaired nozzles will be conducted by the surface examination method.

The licensee proposed not to examine the repaired nozzles according to Figure 2 of Code Case N-729-1. As an alternative, Figure 9 of RR-A34 will be used to establish the examination area for the preservice inspection following repair and for future inservice inspections. This examination area is equivalent to that required by Figure 2 of Code Case N-729-1 as it includes examination of the nozzle weld and an area above the nozzle weld.

3.1.5 Duration of the Proposed Alternative

The provisions of this alternative are applicable to the third ten-year inservice inspection interval for DBNPS, 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.

3.2 NRC STAFF EVALUATION

The NRC staff reviewed the following areas of the proposed half-nozzle repair relief request: installation procedures, design analyses, inspection requirements, and pressure test requirements.

3.2.1 Installation Procedures

The licensee will follow the installation steps to repair degraded RPV head penetration nozzles as described below:

1. Roll expand the candidate nozzle above the area of repair to stabilize the remnant portion of the nozzle in the RPV head CRDM penetration to prevent any movement when the nozzle is separated from the J-groove weld.

2. Remove portions of the nozzle above the J-groove weld containing unacceptable indications by machining. This machining operation also establishes the weld preparation area.

3. Examine the machined area of the nozzle by PT.

4. Weld the remnant nozzle to the RPV head using Alloy 52M weld material.

5. Machine the new weld/nozzle to provide a surface suitable for NDE.

6. Examine the new weld and adjacent area by PT and UT.

7. Abrasive water jet machining remediation on the portion of the remaining nozzle most susceptible to Primary Water Stress Corrosion Cracking (PWSCC). The abrasive water jet machining process removes a small amount of material thickness while imposing compressive residual stress on the nozzle surface.

The NRC staff was concerned about whether the roll expansion of the nozzle could be overextended by mistake beyond the RPV penetration bore which may overstress the remnant nozzle. By letter dated April 16, 2010, the licensee clarified that the effective length of the roll expansion region in the nozzle is 2-5/8 inches. The effective length of roll expansion starts

one-half inches below the nozzle cut and extends 2-1/8 inches above the nozzle cut. The roll expansion roller has a three-quarter-inch radius on each end that provides for a transition between the rolled region and the original nozzle inside diameter. The location of the roll expansion is established through field measurements and the dimensions that are monitored and controlled via the engineering change package. The roll expansion region is contained within the penetration bore and should not extend beyond the RPV head surface.
On March 19, 2010, the NRC staff observed the mock up of the half nozzle repair, including the roll expansion, in the licensee's contractor, AREVA, facility in Lynchburg Virginia. The NRC staff finds that the licensee has implemented measures to ensure that roll expansion will be performed properly to minimize the potential for overextension.

The NRC staff questioned why the PT and UT are performed before the abrasive water jet is applied to the remnant nozzle. PT and UT of the nozzle should be the last step to be performed (after the abrasive water jet is applied) in the repair process to ensure that the water jet will not damage the repaired nozzle. By letter dated April 16, 2010, the licensee stated that PT and UT of the new weld and adjacent area before the water jet process ensures that the weld area does not contain any unacceptable flaws. If weld repairs are required, it is preferred from a radiation dose and repair duration perspective to perform those repairs prior to abrasive water jet machining. Approximately 0.03 inches of material may be removed by the water jet machining process. Since this is less than 10 percent of the wall thickness (tube wall thickness is approximately 0.6 inches), surface examination is not required to be repeated as specified in the ASME Code, Section III, NB-4121.3(b). The NRC staff finds that because of the radiation dose concern the abrasive water jet is applied after PT and UT. Also the water jet will remove only 0.03 inch of nozzle material. Therefore, the NRC staff finds that the abrasive water jet may be applied after PT and UT.

3.2.2 Installation Issues and Modifications

3.2.2.1 Nozzle Number 4

When repairing nozzle number 4, the licensee encountered contaminants in the weld puddle which led to cracking in the weld. The licensee attributed the contaminants to boric acid and corrosion products resulting from reactor coolant system (RCS) leakage through the crevice between the RPV head penetration bore and the CRDM nozzle outside surface. 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 in nozzle number 4, the licensee supplemented the original RR-A34 with the following steps in the May 17, 2010, letter.

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 NDE.

2. Clean the RPV head penetration bore and prepare the surface for NDE.

3. Perform PT examination of the bored region and machined face of the RPV head penetration nozzle extending one-half inches above the weld preparation area. Where the surface examination is compromised by excessive PT bleed out, perform a visual (VT-1) examination

utilizing requirements specified in the RR-A34 proposed alternative to surface examination for nozzle number 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 in the May 17, 2010, letter.

8. Verify that sufficient weld has been deposited.

Upon completion of welding, the licensee will inspect the weld as described in Figure 3 of the attachment to RR-A34 dated April 1, 2010.

The licensee encountered cracking in the new weld of nozzle number 4 when using Alloy 52M weld metal, which is prone to fabrication defects. However, it is less susceptible to PWSCC than Alloy 82 weld metal. The licensee proposed to use Alloy 82 for the first few beads to cover the triple point and apply Alloy 52M on top of the Alloy 82. Alloy 82 is susceptible to PWSCC; however, it is a weld metal that is less prone to fabrication defects and contamination effects. The licensee's welding procedure required five layers of Alloy 52M weld filler metal to adequately cover the Alloy 82 filler metal. The licensee's intent was to achieve a minimum of five-layer cover of Alloy 52M over the Alloy 82 in the as-welded condition to prevent reactor coolant exposure of the Alloy 82 filler metal which is susceptible to PWSCC.

The average Alloy 82 and Alloy 52M layer thickness is 0.08 inches. The five layers of Alloy 52M would provide a cover thickness significantly more than 0.125 inch over the Alloy 82 filler metal after final machining and abrasive water jet remediation. The licensee included a revised welding drawing for nozzle number 4 in the electronic correspondence dated May 28, 2010. The NRC staff finds that the licensee provided sufficient weld thickness of Alloy 52M to isolate the Alloy 82 weld at the triple point.

3.2.2.2 Post-Weld Penetrant Testing

By the electronic correspondence dated May 28, 2010, the licensee stated that as a result of a question from the NRC inspector it was discovered that the post-weld PT examinations for ten nozzles did not have sufficient coverage in bands of the examination area due to the field of view on the camera versus the spacer used. This post-weld PT examination overlap issue affected nozzles numbers 10, 24, 28, 43, 51, 55, 58, 59, 61 and 67. This is documented in the site corrective action program under FENOC CR10-77201 (AREVA CR 2010-3544). As a result, the post-weld PTs for these nozzles were being re-performed. For nozzles numbers 51, 55, 58, 59, 61 and 67, abrasive water jet machining remediation had already been completed, and the licensee performed the PT after water jet remediation. The licensee stated that this revised procedure is contrary to the installation procedure provided in its relief request dated

April 1, 2010. Specifically, steps 6 and 7 on page 4 of the enclosure in the April 1, 2010, submittal will be reversed for these six nozzles. The licensee stated that the order of these two steps can be interchanged, as the material removed by the water jetting is minimal (approximately 0.030 inches) and the abrasive water jet machining remediation will not interfere with the subsequent surface examination (i.e., the abrasive water jet machining remediation is not considered a peening process). The NRC staff finds that performing PT after water jet remediation is acceptable even though this is a reversal of the proposed procedure because PT will provide a final verification of the integrity of the RPV head penetration bore and remnant nozzle.

3.2.2.3 Abrasive Water Jet Machining

The final repair step requires an abrasive water jet remediation process be applied to the inside wetted surface of the expanded portions of the CRDM nozzle susceptible to PWSCC. This process uses high pressure water with entrained abrasive material to remove a small amount of nozzle material while imposing a compressive residual stress on the inside nozzle surface. This step was necessary because the hydraulic expansion step may have increased the residual tensile stress in the nozzle material and without remediation it may have increased the materials susceptibility to PWSCC. In its April 16, 2010, letter, the licensee clarified that the abrasive water jet machining will extend to above the upper roll expansion transition region. Therefore, the weld and approximate 2 inches of the nozzle remnant inside diameter surface will receive abrasive water jet machining.

During the repair, the licensee encountered problems with abrasive water jet conditioning of CRDM penetration nozzle number 58. By the electronic correspondence dated May 28, 2010, the licensee clarified that of the three materials that are part of the CRDM penetration modification, reactor vessel head low Alloy steel base metal (SA-533, Grade. B, Class 1), CRDM Nozzle (Alloy 600), and weld filler material (Alloy 52M), only the CRDM nozzle Alloy 600 material is known to be susceptible to PWSCC. The repair to the IDTB weld in nozzle number 58 was limited to the Alloy 52M weld material. The machining hard stop, acting as a plug, was positioned so that the lower end extended down to just below the upper weld toe (the Alloy 600/Alloy 52M interface). The position of the hard stop prevented repair activities (cavity grinding and post-weld grinding) from contacting the Alloy 600 nozzle material. The NRC staff finds that the licensee's response clarifies the scope of abrasive water jet for nozzle number 58.

3.2.3 Design Analyses

The licensee performed the following analyses as part of technical basis to demonstrate the acceptability of the half-nozzle repair method. The first analysis discussed below is a flaw evaluation to demonstrate the structural integrity of the RPV head that may be affected by the degraded J-groove weld. The second analysis discussed below is the flaw evaluation of a weld anomaly at the triple point location of the new weld.

The NRC staff notes that the licensee did not submit its design analysis which should be performed in accordance with the ASME Code, Section III, NB-3000, because the licensee did not ask relief from the design rules of NB-3000. The ASME Section III design analysis demonstrates that the remnant nozzle will maintain its intended function and will not eject from the RPV head. The NRC staff has previously approved the design of the half-nozzle repair for other licensees. The following analyses are based on ASME Code, Section XI requirements and require plant-specific information.

3.2.3.1 J-Groove Weld Flaw Evaluation

By letter dated April 21, 2010, the licensee submitted the flaw evaluation for the J-groove weld AREVA Calculation 32-9134664-002, "DB-1 CRDM Nozzle J-Groove Weld Flaw Evaluation to IDTB [Inside Diameter Temper Bead] Repair". The proprietary version of the report is in ADAMS Accession Number ML101160438 (not publically available). The non-proprietary version of the report is in ADAMS Accession No. ML101160439.

The ASME Code, Section XI, IWB-3000 requires flaws to be characterized as an input parameter in the flaw evaluation. However, the J-groove weld is difficult to be examined with UT due to the compound curvature and fillet radius around the nozzle circumference. Therefore, it is impractical to characterize the flaw geometry that may exist in the J-groove weld. As these J-groove welds have not been and will not be examined, the licensee assumes the J-groove welds in the degraded CRDM nozzles are degraded.

The licensee postulated a worst-case initial flaw in the J-groove weld, calculated its growth, and evaluated acceptance of the final flaw size in accordance with the ASME Code, Section XI, IWB-3132.3 to demonstrate that the final flaw size will not affect the structural integrity of the reactor vessel head. The licensee assumed the entire J-groove weld is cracked with an initial flaw size of 2.035 inches. This is the distance from the innermost corner of the J-groove weld to the interface between the butter and reactor vessel head. The licensee used the fatigue crack growth rate 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 and 1996 Addenda.

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 the 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 RPV head (that is, extending from the butter/RPV head interface into the RPV head base metal).

By letter dated May 17, 2010, the licensee stated that it is computationally prohibitive to redefine the crack model for each increment of flaw growth; therefore, 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. The incremental change in flaw size is calculated from the fatigue crack growth model for each increment of stress intensity factor from the initial flaw size to the final flaw size.

The initial flaw size model is used to calculate stress intensity factors at various positions along the crack front between the butter and RPV head, using fan-shaped crack tip elements that wrap around the crack front. Half of the finite elements are in the butter and half are in the RPV head. The crack face pressure is added to the residual and operational stresses as part of the applied loading.

The NRC staff inquired about the allowable flaw size. By letter dated May 17, 2010, the licensee stated that 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 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. The licensee has demonstrated that the final flaw size is less than the allowable flaw size in the RPV head because 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 licensee stated that the J-groove weld analysis used flaw stability primary/secondary safety factors of 3.0 for the normal operating condition, 1.5 for the upset condition, 1.5 for the emergency condition, and 1.0 for the faulted condition. The safety factors for the flaw extension primary/secondary cases are 1.5 for the normal operating condition, 1.0 for the upset condition, 1.5 for the emergency condition, and 1.0 for the faulted condition. Article H-6320 of ASME Code, Section XI, 1995 Edition and 1996 Addenda requires a safety factor of 2.77 for normal operating (including upset and test conditions) and 1.39 for emergency and faulted conditions. The licensee stated that the flaw stability safety factors used for the analysis are, therefore, conservative relative to those specified in Article H-6320 of ASME Code Section XI.

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 for other nuclear plants such as Sequoyah and Watts Bar relief requests (Accession No. ML073480424). The licensee stated that the Sequoyah and Watts Bar relief request are applicable to Davis-Besse relief request because both relief requests refer to the same elastic-plastic fracture mechanics methodology for qualifying remnant J-groove welds after inner diameter temper bead repairs to CRDM nozzles.

By letter dated May 17, 2010, the licensee stated that the finite element 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 outermost 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.

By letter dated May 17, 2010, the licensee clarified that the remaining required design life of the current reactor vessel head is four years or two operating cycles. The weld anomaly flaw evaluation shows that it would take 25 years for the weld anomaly at the triple point to become unacceptable. However, the licensee's J-groove weld flaw analysis showed 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 four years. Therefore, the RPV head is acceptable for operation only for 4 more years after 2010.

By letter dated May 17, 2010, the licensee submitted revised J-groove weld flaw evaluation for nozzle number 4 because it experienced higher temperature than that used in the original flaw evaluation. The proprietary version of the revised report is in ADAMS Accession No. ML101400409 (not publicly available). The non-proprietary version of the revised report can be found in ADAMS Accession No. ML101400406.

The NRC staff finds that the licensee's elastic-plastic fracture mechanics calculation of the J-groove weld is acceptable because it follows the ASME Code, Section XI requirements and the NRC staff approved safety factors. The licensee has demonstrated that the structural integrity of the RPV head will be maintained because the final flaw size will be within the allowable flaw size.

3.2.3.2 Weld Anomaly Flaw Evaluation

By letter dated April 16, 2010, the licensee submitted Calculation 32-9134666-002, "DB-1 CRDM Nozzle Weld Anomaly Flaw Evaluation of IDTB Repair", proprietary version (ADAMS Accession Number ML101110150, not publically available) and non-proprietary version (ADAMS Accession No. ML101110148).

By letter dated May 17, 2010, the licensee submitted revised triple point flaw evaluation for nozzle number 4 because it experienced higher temperature than that of the original analysis. The proprietary version of the revised report is in ADAMS Accession Number ML101400408 (not publicly available). The non-proprietary version of the report is in ADAMS Accession No. ML101400405.

Also, in the May 17, 2010, letter, the licensee revised the triple point flaw evaluation for RPV head CRDM penetration nozzle number 4 because of the revision to the welding procedure to eliminate weld cracking at the triple point which occurred during initial welding attempts. The proprietary version of the revised report can be found in ADAMS Accession No. ML101400410 (not publicly available). The non-proprietary version of the revised report can be found in ADAMS Accession No. ML101400407.

The new weld that joins the remnant nozzle to the RPV head penetration bore may result in a weld solidification anomaly at the junction (i.e., the triple point) of the Alloy 600 tube, the low alloy steel of the RPV head, and the new Alloy 52M weld because of different cooling rates of these materials. The licensee performed a fracture mechanics analysis to justify, in accordance with the ASME Code, Section XI, for operating with the postulated weld anomaly at the triple point. The weld anomaly is modeled as a 0.10-inch, circular, crack-like defect, extending 360 degrees around the circumference of the nozzle at the triple point location. The anomaly is modeled as several flaws with two possible propagation paths, as discussed below.

The postulated flaw in propagation path number 1 is modeled to traverse the nozzle wall thickness from the nozzle outside diameter (OD) to inside diameter (ID). This is the shortest path through the nozzle wall, passing through the new Alloy 52M weld material. To be conservative, the licensee used Alloy 600 nozzle material properties or equivalent to ensure that another potential path through the heat affected zone between the new repair weld and the Alloy 600 nozzle material is bounded. The licensee postulated two types of flaws at the outside surface of the nozzle for flaw path number 1. A 360-degree continuous circumferential flaw, lying in a horizontal plane, is considered to be a conservative representation of crack-like defects that may exist in the weld anomaly. This flaw is subjected to axial stresses in the nozzle. An axially-oriented semi-circular outside surface flaw is also considered in the flaw evaluation because it would lie in a plane normal to the higher circumferential stresses. Both of these flaws would propagate toward the inside surface of the nozzle.

The postulated flaw in propagation path number 2 is modeled to extend down the outside surface of the repair weld between the new weld and the RPV head. A cylindrically oriented surface flaw is postulated to lie along this interface, subjected to radial stresses with respect to the nozzle. This flaw may propagate through either the new Alloy 52M weld material or the low alloy steel RPV head material.

The NRC staff asked the licensee to discuss whether the 0.1 inch flaw size bounds the actual weld anomalies that could be detected by UT and how the UT is qualified to detect such weld anomaly. By letter dated May 17, 2010, the licensee stated that the UT procedure for temper bead weld repairs was demonstrated on a mockup of the weld repair configuration. To simulate the triple point anomaly with planar characteristics, the mockup used electro-discharge 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 shape of this anomaly is usually volumetric but can have planar features. A volumetric triple point anomaly is more closely simulated with the side drilled holes in the calibration block.

The demonstration also includes a mockup of the temper bead weld repair for RPV head CRDM penetration nozzles. The configuration includes a carbon steel ring used to simulate the nozzle penetration bore in the vessel head. An Alloy 600 nozzle is positioned part way into the bore and attached with the temper bead Alloy 52M weld repair as will be done in the field for the repaired nozzles. The purpose of this mockup is to demonstrate that construction type flaws can be detected. Construction flaws that are simulated in the mockup include lack of bond flaws between weld beads and at the weld to carbon steel interface. Underbead cracking in the carbon steel material is also simulated beneath the weld. All of these flaws are simulated using 1/8-inch diameter flat bottom holes. An EDM notch is included in the mockup in the temper bead weld. This notch is to simulate lack of fusion.

The licensee stated that examination of the mockup for this demonstration did detect the presence of a triple point anomaly around the entire circumference, but it did not exhibit any planar characteristics and is very small. Destructive examinations performed during development of the temper bead weld repair process in 2001 revealed that the triple point anomaly is usually less than 0.030 inch in size. This demonstration was also successful in detecting the required calibration reflectors in the calibration block. The additional axial and circumferential EDM notches are also easily resolved with good signal to noise ratio. The simulated construction type flaws in the mockup are detected with good signal to noise ratio. A small triple point anomaly was also detected in the mockup and is typical of what can be expected in field installations.

The NRC staff finds that the licensee has demonstrated that its UT procedure can detect a 0.1-inch flaw at the triple point location. Therefore, the licensee's postulated initial flaw size of 0.1 inches is acceptable. Also, the mockup has shown that the weld anomaly would be less than 0.1 inches. Should the weld anomaly be measured greater than 0.1 inches, it is expected that the licensee would disposition the anomaly according to the ASME Code.

The NRC staff asked the licensee to clarify whether the analysis includes stresses due to thermal expansion of the nozzle in the vessel head penetration bore, dead weight of the nozzle, seismic loads, and pressure. By letter dated May 17, 2010, the licensee stated that 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 new weld. The licensee stated that the stresses in the new weld due to the operating basis earthquake (OBE) are considered to be negligible for the following reasons. Previous evaluations of the Babcock & Wilcox designed 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. The NRC staff finds that the licensee has considered necessary loadings on the postulated flaws and, therefore, the loadings applied in the flaw evaluation are acceptable.

To analyze the crack growth, the licensee obtained penetration nozzle stresses from a generic analysis which was issued by AREVA in 2004 for the temper bead welding. The NRC staff questioned the validity of applying stresses from a generic analysis to DBNPS. By letter dated May 17, 2010, the licensee stated that the generic analysis considered plant specific data for several plants including DBNPS. 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 to the generic analysis 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 the generic analysis continues to be applicable for the IDTB repair in the Midland RPV head installed at DBNPS, despite some minor potential differences in geometry. Therefore, stresses from the latest revision of the generic analysis are appropriate for use in the Triple Point Weld Anomaly analysis.

In the triple point weld anomaly flaw evaluation, the licensee used a stress distribution based on a third-order polynomial. The NRC staff believes that stresses represented by a third order polynomial may not be adequate, especially for modeling welding residual stress. This approximation for the through-wall thickness stress may under-predict the stresses on the crack face in certain situations. By letter dated May 17, 2010, the licensee stated that four stress profiles were used in the anomaly analysis. In each of the stress plots, the actual through-wall stresses are compared against the third-order curve-fit to the stresses that were 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 NRC staff notes that the issue of whether the third or fourth-order polynomial stress approximation should be used is still in debate in the industry. The ASME Code, Section XI permits the third-order polynomial. The NRC staff raises the issue to bring the awareness of potential under-prediction. The NRC staff finds that for DBNPS the third-order polynomial fits the applied stresses. Therefore, the NRC staff finds that the third-order polynomial approximation is acceptable for this case.

The NRC staff asked the licensee to explain why the same fracture toughness value (Kla) of 200 ksi√in is used for all postulated flaws along paths 1 and 2 even though the affected materials (Alloy 52M weld, Alloy 600 remnant nozzle, and low alloy steel reactor vessel) in which the flaws propagate have different fracture toughness. By letter dated May 17, 2010, in response to NRC's RAI Question number 11, the licensee stated that 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.

This analysis is prepared in accordance with the ASME Code, Section XI, and demonstrates that for the intended service life of the repair, the fatigue crack growth is acceptable and the crack-like indications remain stable. This satisfies the Section XI criteria but does not include consideration of stress corrosion cracking such as PWSCC. Since the crack-like defects are not exposed to the primary coolant and the air environment is benign for the materials at the triple point, the time dependent crack growth rates from PWSCC are not applicable. The NRC staff agrees that crack growth from PWSCC is not applicable for the triple point weld anomaly because the weld anomaly is isolated from primary water by the new weld metal.

By letter dated April 16, 2010, the licensee stated that its flaw evaluation demonstrates that the 0.10-inch weld anomaly is acceptable for a 25-year design life of the half-nozzle repair. Although the design life of the weld repairs is 25 years, the actual life is only intended to be four years from implementation of the modifications, since it is expected the RPV head will be replaced at that time.

The NRC staff finds that the flaw evaluation has demonstrated that a 0.10-inch weld anomaly is acceptable to remain in service for greater than a four-year design life for the nozzle repair. Significant fracture toughness margins are obtained for both of the flaw propagation paths considered in this analysis. The minimum calculated fracture toughness margins are significantly greater than the required margin of $\sqrt{10}$ per Paragraph IWB-3612 of Section XI. Fatigue crack growth is minimal. The maximum final flaw size is significantly less than allowed for both flaw propagation paths.

3.2.3.3 <u>Remnant J-Groove Weld Analysis</u>

The licensee evaluated the potential for debris from a degraded J-groove weld of a repaired nozzle falling into the reactor core region. The loose-part scenario may affect the operation of the control rod (e.g., stuck control rods) or damage reactor vessel internals and, therefore, needs to be evaluated. The licensee postulated radial cracks to occur in the weld due to the dominance of hoop stresses at this location. The licensee stated that the possibility of occurrence for transverse cracks that could intersect the radial cracks is considered remote. There are no forces that would drive a transverse crack. The radial cracks would relieve the potential transverse crack driving forces. Hence, it is unlikely that a series of transverse cracks could intersect a series of radial cracks resulting in any fragments becoming dislodged.

The licensee also evaluated the potential consequences of nozzle fragmentation and determined that there is a high probability that any fragmentation would enter the top of the column weldments and likely be stopped on one of the casting plates. This might preclude complete insertion of the control rod. However, the licensee stated that plant safety analyses have considered one stuck control rod. According to the licensee, the likelihood of weld material debris resulting in the obstruction of more than one control rod to insert was judged to be of such low probability that the proposed repair technique does not pose a safety risk. The licensee also evaluated a loose part of similar size on the reactor coolant system, including effects on plant equipment. The presence of the small amount of material evaluated was concluded to have no consequence of significance to plant equipment that could adversely affect the health and safety of the public.

On the basis of the licensee's evaluation, the NRC staff finds that the probability of a loose-part from degraded J-groove weld affecting the safe operation of the plant is insignificant.

3.2.3.4 Corrosion Analysis of the CRDM Penetration Bore

The NRC staff requested the licensee evaluate 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. By letter dated May 17, 2010, the licensee stated that the corrosion in the bore region of the 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.

The NRC staff finds that the licensee has demonstrate that the corrosion of the RPV penetration bore of the repaired nozzles is insignificant. Therefore, the half-nozzle repair will not affect the structural integrity of the RPV penetration bore of the repaired nozzles.

3.2.4 Inspection Requirements

3.2.4.1 Preservice Examination

By letter dated April 16, 2010, the licensee stated that the preservice and inservice examinations will be performed in accordance with ASME Code Case N-729-1 with conditions in accordance with 10 CFR 50.55a(g)(6)(D) in conjunction with the inspection area described in the relief request.

The proposed relief request requires a preservice examination after the new weld is deposited to join the remnant nozzle to the RPV penetration bore. The coverage of the preservice examination is shown in Figure 3 of RR-A34. The preservice examination will be performed by PT and UT. The licensee stated that UT is qualified to detect flaws in the new weld to the maximum practical extent and approximately 70 percent of the new weld surface will be UT scanned. By letter dated April 16, 2010, the licensee stated that the UT is qualified to ASME Section III, NB-5112 and Section V, Article 1, T-150. Additionally, a mockup was used to demonstrate the procedure on construction type flaws as required by NRC Regulatory Guide 1.147, Revision 15, for the conditional acceptance of Code Case N-638-1.

The NRC staff was concerned that UT cannot provide a 100-percent examination coverage of the new weld. By letter dated April 16, 2010, the licensee stated that RR-A34 Section 5, Figures 4 through 8, depict an approximation of the UT volume coverage of the new weld using the different UT scans and angles. The licensee stated further that much of the weld volume and heat affected zone have been covered by UT, and the final surface PT is performed. The licensee concluded that the proposed PT and UT to be performed are superior to the progressive PT as specified in the ASME Code, Section III, NB-5245. The NRC staff finds that even though the proposed UT could not achieve a100-percent examination coverage, the licensee's proposed PT and UT is adequate to detect fabrication defects during preservice examination.

The NRC staff was concerned with the examination coverage of the rolled region of a remnant nozzle to ensure that the rolling process will not cause cracking. By letter dated April 16, 2010, the licensee stated that prior to roll expansion, the portion of the nozzle subject to rolling is UT examined to assure the repair is being performed on sound nozzle base material. After welding, the area from 0.25 inches above the roll transition down through the roll transition to 0.5 inches below the toe of new weld is examined by liquid penetrant. This area is also subject to the abrasive water jet machining operation to reduce the susceptibility of the Alloy 600 material to primary water stress corrosion cracking. The NRC staff finds that inspecting the area 0.25 inches above the rolled region is not adequate. By letter dated May 17, 2010, the licensee increased the examination coverage from 0.25 inches to 0.5 inches above the rolled region.

The NRC staff finds that the preservice examination coverage is acceptable because it covers the areas and regions of the remnant nozzle and penetration bore to ensure their structural integrity, i.e., 0.5 inches above the rolled region of the remnant nozzle, the remnant nozzle itself, the new weld, and the 0.5-inch region below the new weld toe.

3.2.4.2 Inservice Examination

The ISI will be based on surface examinations and its coverage is shown in Figure 9 of the original relief request dated April 1, 2010. The NRC staff finds that performing the surface examination in lieu of the volumetric examination of the repaired nozzles during future ISI is acceptable per the requirements of 10 CFR 50.55a(g)(6)(ii)(D). However, the NRC staff questioned the adequacy of the ISI examination coverage in Figure 9 of the original relief request.

By letter dated May 17, 2010, the licensee stated that the proposed examination area specified in Figure 9 of RR-A34, dated April 1, 2010, is superseded by the following proposed examination area. 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.

In addition, in the electronic correspondence dated May 28, 2010, the licensee stated that if PT is used, the examination will be in accordance with Code Case N-729-1 and the relief request. In addition, the licensee has updated its ISI database to ensure the PT will include the area 1/4 inch below the toe of the weld. If other surface or volumetric examination techniques (e.g. eddy current or UT) are developed and qualified per Code Case N-729-1, the qualified examination area would include, as a minimum 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. The NRC staff finds the licensee's response dated on May 17 and May 28, 2010, inadequate because it would not inspect the 0.25-inch region below the new weld if "...other surface or volumetric examination techniques (e.g. eddy current or UT) are developed and qualified per Code Case N-729-1...". The NRC staff believes that the 0.25-inch region below the new weld should be inspected per Figure 2 of Code Case N-729-1.

On June 4, 2010, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff verbally authorized the use of relief request RR-A34. As part of the verbal authorization the licensee committed to examine the 0.25-inch region below the toe of the new weld during the ISI as discussed in the NRC staff memorandum dated June 14, 2010.

The NRC staff finds that the ISI examination coverage is acceptable because it covers all the area and regions of the remnant nozzle and RPV head penetration bore to ensure its structural integrity, i.e., the 0.5-inch region above the rolled region of the remnant nozzle, the remnant nozzle itself, the new weld, and the 0.25 inch region below the toe of the new weld.

The licensee stated that the ISI frequency of the repaired nozzles will be every refueling outage in accordance with 10 CFR 50.55a(g)(6)(ii)(D)(5). The NRC staff finds that it is appropriate that the repaired nozzles will be examined every refueling outage.

3.2.4.3 <u>ASME Code Examination Requirements</u>

The NRC staff asked the licensee to clarify the edition and addenda of the ASME Code that will be used for the examinations. By letter dated May 17, 2010, the licensee stated that the ASME Code Section III, 1992 Edition, no Addenda is used for the performance of the UT examination as required by ASME Code Case N-416-3. The acceptance criteria in subarticle NB-5330 of the ASME Code, Section III, 1992 Edition, no Addenda, and ASME Code, Section III, 1998 Edition including Addenda through 2000 as required by Regulatory Guide 1.147 condition on use of ASME Code Case N-638-1, will be used to disposition indications detected by UT. The acceptance criteria for both of these code versions are equivalent.

The ASME Code Section III, 1992 Edition, no Addenda, as required by ASME Code Case N-416-3, will be used for PT examination acceptance criteria. The licensee stated that the PT examination performed following completion of the weld will serve as the preservice examination. The acceptance criteria of ASME Code Case N-729-1 will also be used for the preservice examination.

Future inservice inspections will be performed with the surface examination method in accordance with Relief Request RR-A34. The acceptance criteria for the inservice examination will be based on ASME Code Case N-729-1. 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. The NRC staff asked the licensee to explain 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 ISI interval. By letter dated May 17, 2010, the licensee stated that the 1995 Edition, 1996 Addenda of ASME Code, Section XI, subparagraph IWA-4410(a) states that 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, 1996 Addenda of the ASME Code, Section XI, subparagraph IWA-4410(b) states, in part, that 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).

The licensee stated further that ASME 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 the ASME Code, Section III. The NRC has approved the use of ASME Code Case N-416-3 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 Code, Section XI 1995 Edition and 1996 Addenda, the surface examinations will be performed in accordance with the 1992 Edition of the ASME Code, Section III.

The NRC staff finds that the licensee has clarified the appropriate edition and addenda of the ASME Code to use for the PSI and ISI.

3.2.4.4 Pressure Test Requirements

By letter dated May 17, 2010, the licensee stated that a system leakage test will be performed in accordance with ASME Code Case N-416-3 following repairs. In a teleconference held on May 24, 2010, the licensee clarified further that as part of the system leakage test, it will perform a visual (VT-2) examination from outside the service structure of the RPV. The NRC staff noted that this visual examination will not be able to observe the surface of the RPV head directly. The NRC staff believes that indirect observation may not be sufficient for the CRDM nozzle repairs at DBNPS because of the following concerns. (1) The licensee repaired a relatively larger number of CRDM nozzles which increases possibility for fabrication defects that may be missed by nondestructive examination. (2) The welding problems encountered at CRDM nozzle number 4 create the possibility for unforeseen fabrication defects. (3) A VT-2 examination from the outside service structure may not be able to detect small leakage from a through-wall fabrication defect in a repaired nozzle. For these reasons, the NRC staff requested the licensee perform a direct visual examination of the bare metal RPV head surface through one or more access openings of the support structure around the RPV head during the system leakage test to provide an additional defense in-depth assurance and increase confidence in these nozzle repairs.

By electronic correspondence dated May 28, 2010, the licensee responded that in lieu of the progressive surface examination required by ASME Code, Section III, NB-5245, a surface examination and an ultrasonic examination, qualified to detect flaws in the new weld and base material, is performed on the partial penetration weld. This UT examination exceeds construction code requirements and along with the PT examination of the weld area provides a high degree of confidence in the integrity of the repair weld.

The licensee stated further that pressure testing requirements will be met by the completion of a VT-2 examination that will be conducted in accordance with the requirements of the ASME Code, Section XI, IWA-5000 and Code Case N-416-3. The ASME Code, Section XI, IWA-5000, permits a VT-2 examination with insulation installed. As specified in IWA-5242, the licensee will conduct the VT-2 examination at the lowest elevation where leakage from repaired nozzles may be detectable. Examination of the surrounding area such as floor areas, equipment surfaces or underneath components is required. The licensee will conduct a remote VT-2 examination by examining the refueling canal floor in the area of the RPV flange. A direct VT-2 examination of the RPV insulation joints from under the reactor vessel will also be performed. Together, the NDE and pressure test visual examination will provide a high level of confidence in the integrity of the CRDM nozzle repairs.

The CRDM penetrations are located within the service structure below the insulation package of the RPV. The licensee stated that access to this area is available through inspection ports. However, during the system leakage test, the Reactor Coolant System is at normal operating temperature and pressure (approximately 532 degrees Fahrenheit and 2150 psig) with all insulation in place as permitted by IWA-5000. This insulation covers the inspection ports. Opening the inspection ports would require removal of the insulation and the hot inspection ports. Air emitted from the ports could approach 500 degrees F. Inspection would be difficult and access would require personnel to be in close proximity to the hot surfaces creating an industrial safety hazard.

The licensee contends that the benefit of this direct visual examination is considered to be limited given the additional level of NDE and pressure test visual examination noted above. However, In addition to the VT-2 examination discussed above, the licensee intends to perform a visual inspection for leakage from the reactor vessel head through an inspection port to the extent that access and environmental conditions permit.

The NRC staff finds that the licensee will perform a direct visual inspection through an inspection port to the extent that conditions permit. This visual inspection is in addition to the visual examination from outside service structure of the RPV. Therefore, the NRC staff finds that the licensee's pressure test procedure is acceptable.

5.0 CONCLUSION

On the basis of its evaluation, the NRC staff has determined that relief request A34, dated April 1, 2010 as supplemented by letters dated April 16, 2010, April 21, 2010 and May 17, 2010 and electronic correspondence dated May 28, 2010, will provide an acceptable level of quality and safety for the repair of the RPV head CRDM penetration nozzles. The repaired nozzles are acceptable for operation for 4 years based on the evaluation of J-groove weld remnant crack evaluation performed. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of RR-A34, dated April 1, April 16, April 21, May 17, and May 28, 2010, and the commitment made on June 4, 2010, for the repair of the RPV head penetration nozzles for the third 10-year inservice inspection interval at DBNPS.

The relief request is authorized for the third 10-year inservice inspection interval which commenced on September 21, 2000 and will ends on September 20, 2012.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

6.0 REFERENCES

1. Electric Power Research Institute (EPRI) Report GC-1 11050, November 1998, "Ambient Temperature Preheat for Machine GTAW Temper Bead Applications," EPRI, Palo Alto, CA, and Structural Integrity Associates, Inc., San Jose, CA.

2. EPRI Report 1013558, Temperbead Welding Applications, 48-Hour Hold Requirements for Ambient Temperature Temperbead Welding, EPRI, Palo Alto, CA and Hermann & Associates, Key Largo, FL, December 2006.

Principal Contributor: JTsao, NRR

Date: September 20, 2010

If you have any questions, please contact the Davis-Besse Project Manager, Mr. Michael Mahoney, at 301-415-3867.

Sincerely,

/RA/

Robert D. Carlson, Chief
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-346

Enclosure:
As stated

cc w/encl: Distribution via Listserv

DISTRIBUTION:
PUBLIC
LPL3-2 R/F
RidsRgn3MailCenter Resource
Resource RidsAcrsAcnw_MailCTR
Resource RidsNrrDorlLpl3-2 Resource
Resource RidsNrrDciCptb Resource
RidsNrrPMMMahoney Resource
SBagley, EDO, RIII
RidsNrrLATHarris Resource
RidsOgcRp Resource
JTsao, NRR

ADAMS Accession No. ML102571569 NRR-028 *By memo dated

OFFICE	NRR/LPL3-2/PM	NRR//LPL3-2/LA	NRR/DCI/CPNB/BC	NRR/LPL3-2/BC
NAME	MMahoney	THarris	TLupold	RCarlson
DATE	09/16/10	09/16/10	09/02/10*	09/20/10

OFFICIAL RECORD COPY