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Docket Number 50-346

License Number NPF-3

Serial Number 2765

February 26, 2002

United States Nuclear Regulatory Commission  
Attention: Document Control Desk  
Washington, D.C. 20555-0001

Subject: Request for Relief from American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Inservice Inspection Requirements at the Davis-Besse Nuclear Power Station – Third Ten-Year Interval (RR-A20 Revision)

Ladies and Gentlemen:

The purpose of this letter is to revise relief request RR-A20 for the Davis-Besse Nuclear Power Station, Unit 1 (DBNPS) Third Ten-Year Inservice Inspection Interval as a result of discussions held with the NRC staff by telephone on February 12, 2002. This relief request was originally transmitted, with relief request RR-A21, to the NRC by FirstEnergy Nuclear Operating Company (FENOC) letter Serial Number 2750, dated January 11, 2002. It proposes alternatives to ASME Code Section XI repair requirements to the Reactor Vessel Closure Head Control Rod Drive Mechanism nozzle penetrations should repairs be necessary.

Attachment 1 provides the revised relief request RR-A20 and replaces the version previously transmitted by letter Serial Number 2750. Review and approval of the attached relief request is requested by March 1, 2002.

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If you have any questions or require additional information, please contact Mr. David H. Lockwood, Manager-Regulatory Affairs, at (419) 321-8450.

Very truly yours,

A handwritten signature in black ink, appearing to read "J.W. Byrnes". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

Attachments

cc: J.E. Dyer, Regional Administrator, NRC Region III  
S.P. Sands, DB-1 NRC/NRR Project Manager  
C.S. Thomas, DB-1 Senior Resident Inspector  
Utility Radiological Safety Board

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Attachment 1  
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DBNPS ISI Program – Third Ten-Year Interval  
Relief Request RR-A20

(34 Pages Follow)

**FIRSTENERGY NUCLEAR OPERATING COMPANY  
DAVIS-BESSE UNIT 1  
THIRD 10-YEAR INSERVICE INSPECTION INTERVAL  
RELIEF REQUEST RR-A20**

**System/Component(s) for Which Relief is Requested:**

Davis-Besse Nuclear Power Station, Unit 1 Reactor Vessel Closure Head (RVCH) Control Rod Drive Mechanism (CRDM) nozzle penetrations. There are 69 CRDM nozzle penetrations welded to the RVCH. The ASME Boiler and Pressure Vessel (B&PV) Code Class is Class 1.

**Code Requirement:**

IWA-4400 of the 1995 Edition through the 1996 Addenda of ASME Section XI provides welding, brazing, metal removal, and installation requirements related to repair/replacement activities.

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).

IWA-4410(c) states: "Alternatively, the applicable requirements of IWA-4600 may be used for welding ....."

IWA-4600(b) states: "When post weld heat treatment is not to be performed, the following provisions may be used.

- (1) The welding methods of IWA-4620, IWA-4630, or IWA-4640 may be used in lieu of the welding and nondestructive examination requirements of the Construction Code or Section III, provided the requirements of IWA-4610 are met.

IWA-4630 provides requirements for welding on dissimilar metal welds made without the specified post weld heat treatment.

**Code Requirement from Which Relief is Requested:**

Because of the risk of damage to the RVCH material properties or dimensions, it is not feasible to apply the post welding heat treatment requirements of the original Construction Code. The alternative temper bead methods for dissimilar metal welds (IWA-4610, IWA-4611, and IWA-4630) of the 1995 Edition through the 1996 Addenda of ASME Section XI require elevated temperature preheat and post weld soaks that will result in increased radiation dose to repair personnel.

As an alternative to the requirements of IWA-4600, FirstEnergy Nuclear Operating Company (FENOC) proposes to perform the repair of the RVCH CRDM nozzle penetrations with a remotely operated weld tool, utilizing the machine Gas Tungsten-Arc Welding (GTAW) process and the ambient temperature bead method with 50°F minimum preheat and no post weld heat treatment. The repairs will be conducted in accordance with the 1995 Edition through the 1996 Addenda of ASME Section XI and the alternative requirements discussed below. Relief is requested in accordance with 10 CFR 50.55a (a)(3)(i).

Table 1 provides a comparison of the Section XI Code Requirements to the requirements for the ambient temper bead repair method as proposed in this relief request. Table 1 also identifies those Code Requirements from which relief is requested.

### **Alternative Welding Method:**

FENOC plans to perform Control Rod Drive Mechanism (CRDM) repairs by welding the Reactor Pressure Vessel (RPV) head (P-No. 3 base material) and CRDM nozzle (P-No. 43 base material) with filler material F-No. 43. The proposed alternative to the applicable portions of ASME Section XI is the application of the methodology for ambient temperature temper bead repair outlined in Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Techniques." FENOC is not requesting approval to use Code Case N-638 for this application, but to apply its methodology to a partial penetration weld, which is not specifically addressed by the Code Case. Since the methodology was originally written to address repairs to full penetration welds in reactor vessels, and the application for the Davis-Besse Nuclear Power Station (DBNPS) involves making new partial penetration welds in the RVCH, some of the Code Case N-638 requirements either do not apply or require substitution of equivalent requirements applicable to partial penetration welds. Therefore, the following text has been prepared using Code Case N-638 methodology as a template, with specific criteria applicable to the CRDM nozzle repairs identified and appropriately dispositioned. Clarifications to the Code Case template are made in *italics font*.

### **1.0 GENERAL REQUIREMENTS:**

- (a) The maximum area of an individual weld based on the finished surface will be less than 100 square inches, and the depth of the weld will not be greater than one-half of the ferritic base metal thickness.
- (b) Repair/replacement activities on a dissimilar-metal weld are limited to those along the fusion line of a nonferritic weld to ferritic base material on which 1/8 inch or less of nonferritic weld deposit exists above the original fusion line.

- (c) If a defect penetrates into the ferritic base material, repair of the base material, using a nonferritic weld filler material, may be performed provided the depth of repair in the base material does not exceed 3/8 inch.
- (d) Prior to welding, the area to be welded and a band around the area of at least 1½ times the component thickness (or 5 inches, whichever is less) will be at least 50°F.

*Preheat temperature will be monitored using either Thermocouples (TCs) or contact pyrometer(s) placed at a readily accessible location(s) on the RVCH exterior surface.*

- (e) Welding materials will meet the Owner's Requirements and the Construction Code and Cases specified in the repair/replacement plan. Welding materials will be controlled so that they are identified as acceptable until consumed.
- (f) Peening may be used, except on the initial and final layers.

*Peening will not be used. However, the weldment final surface will be abrasive water jet conditioned following final NDE.*

## **2.0 WELDING QUALIFICATIONS:**

The welding procedures and the welding operators shall be qualified in accordance with Section IX and the requirements of paragraphs 2.1 and 2.2.

### **2.1 Procedure Qualification:**

- (a) The base materials for the welding procedure qualification will be the same P-Number and Group Number as the materials to be welded. The materials shall be post weld heat treated to at least the time and temperature that was applied to the material being welded.
- (b) Consideration will be given to the effects of welding in a pressurized environment. If they exist, they shall be duplicated in the test assembly.

*The nozzle repair will not be performed in a pressurized environment. Therefore, this requirement is not applicable.*

- (c) Consideration will be given to the effects of irradiation on the properties of material, including weld material for applications in the core belt line region of the reactor vessel. Special material requirements in the Design Specification will also apply to the test assembly materials for these applications.

*No repair welding will be performed in the core belt line region of the reactor vessel. Therefore, this requirement has been considered, but is not applicable.*

- (d) The root width and included angle of the cavity in the test assembly will be no greater than the minimum specified for the repair.
- (e) The maximum interpass temperature for the first three layers of the test assembly will be 150°F.
- (f) The test assembly cavity depth will be at least one-half the depth of the weld to be installed during the repair/replacement activity, and at least 1 inch. The test assembly thickness will be at least twice the test assembly cavity depth. The test assembly will be large enough to permit removal of the required test specimens. The test assembly dimensions surrounding the cavity will be at least the test assembly thickness, and at least 6 inches. The qualification test plate will be prepared in accordance with Figure 1.
- (g) Ferritic base material for the procedure qualification test will meet the impact test requirements of the Construction Code and Owner's Requirements. If such requirements are not in the Construction Code and Owner's Requirements, the impact properties shall be determined by Charpy V-notch impact tests of the procedure qualification base material at or below the lowest service temperature of the item to be repaired. The location and orientation of the test specimens shall be similar to those required in subparagraph (i), but shall be in the base metal.
- (h) Charpy V-notch tests of the ferritic weld metal of the procedure qualification shall meet the requirements as determined in subparagraph (g) above.

*No ferritic weld material will be used. Therefore, this requirement is not applicable.*

- (i) Charpy V-notch tests of the ferritic heat-affected zone (HAZ) will be performed at the same temperature as the base metal test of subparagraph (g) above. Number, location, and orientation of test specimens will be as follows:
  - 1. The specimens will be removed from a location as near as practical to a depth of one-half the thickness of the deposited weld metal. The test coupons for HAZ impact specimens will be taken transverse to the axis of the weld and etched to define the HAZ. The notch of the Charpy V-notch specimens will be cut approximately normal to the material surface in such a manner as to include as much HAZ as possible in the resulting fracture. When the material thickness permits, the axis of a

specimen will be inclined to allow the root of the notch to be aligned parallel to the fusion line.

2. If the test material is in the form of a plate or a forging, the axis of the weld will be oriented parallel to the principal direction of rolling or forging.
  3. The Charpy V-notch test will be performed in accordance with SA-370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products. Specimens will be in accordance with SA-370, Figure 11, Type A. The test will consist of a set of three full-size 10 mm x 10 mm specimens. The lateral expansion, percent shear, absorbed energy, test temperature, orientation and location of all test specimens will be reported in the Procedure Qualification Record.
- (j) The average values of the three HAZ impact tests will be equal to or greater than the average values of the three unaffected base metal tests.

## **2.2 Performance Qualification:**

Welding operators will be qualified in accordance with ASME Section IX.

## **3.0 WELDING PROCEDURE REQUIREMENTS:**

The welding procedure shall include the following requirements:

- (a) The weld metal will be deposited by the automatic or machine GTAW process.
- (b) Dissimilar metal welds shall be made using A-No. 8 weld metal (QW-442) for P-No. 8 to P-No. 1, 3, or 12(A, B or C) weld joints or F-No. 43 weld metal (QW-432) for P-No. 8 or 43 to P-No. 1, 3, or 12(A, B, or C) weld joints.

*The machine GTAW process will be used. Dissimilar metal welds will be made using F-No. 43 weld metal (QW-432) for P-No. 43 to P-No. 3 weld joints. ERNiCrFe-7 filler metal is considered F-No. 43 in Code Case 2142-1.*

- (c) The area to be welded will be buttered with a deposit of at least three layers to achieve at least 1/8 inch overlay thickness as shown in Figure 2, steps 1 through 3, with the heat input for each layer controlled to within  $\pm 10\%$  of that used in the procedure qualification test. Particular care will be taken in placement of the weld layers at the weld toe area of ferritic material to ensure that the HAZ and ferritic weld metal are tempered. Subsequent layers will be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification. For similar-metal welding, the completed weld shall have at least one layer of weld reinforcement deposited. This reinforcement



shall be removed by mechanical means, so that the finished surface is essentially flush with the surface surrounding the weld (Fig. 3).

*The final two sentences, including Fig. 3 of the paragraph above are not applicable since no similar-metal welding will be performed.*

- (d) The maximum interpass temperature for field applications will be 350°F regardless of the interpass temperature during qualification.

*The maximum interpass temperature will be 350°F, verified by calculation rather than thermocouple measurement.*

- (e) Particular care will be given to ensure that the weld region is free of all potential sources of hydrogen. The surfaces to be welded, filler metal, and shielding gas shall be suitably controlled.

#### **4.0 EXAMINATION:**

- (a) Prior to welding, a surface examination will be performed on the area to be welded.
- (b) The final weld surface and the band around the area defined in Paragraph 1.0 (d) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for a least 48 hours. The ultrasonic examination shall be in accordance with NB-5000 of the 1992 Edition of ASME Section III.

*The final weld will be examined using the liquid penetrant and ultrasonic examination methods. The band around the area defined in paragraph 1.0 (d) cannot be examined due to the physical configuration of the partial penetration weld. Liquid penetrant (PT) examination coverage will include the final weld surface and base metal at least ½ inch around the nozzle. Ultrasonic examination (UT) will include the base metal ½ inch above the weld and the weld surface not including the taper. Liquid penetrant (PT) examination coverage is shown in Figures 5 and 6. Ultrasonic examination (UT) examination coverage is shown in Figures 7 through 12 for the various ultrasonic scans.*

- (c) Areas from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method.

*Thermocouples or contact pyrometer(s) will be used to monitor preheat temperature. Interpass temperature measurement will not be performed. Preheat temperature monitoring will take place outside the 1½ T band on readily accessible closure head exterior surface(s).*

- (d) Nondestructive Examination (NDE) personnel will be qualified in accordance with IWA-2300 or NB-5500.

- (e) Surface examination acceptance criteria shall be in accordance with NB-5340 or NB-5350, as applicable. Ultrasonic examination acceptance shall be in accordance with IWB-3000. Additional acceptance criteria may be specified by the Owner to account for differences in weld configuration.

*The acceptance criteria of the 1992 Edition of ASME Section III is used in accordance with Code Case N-416-1. Code Case N-416-1 is approved in NRC Regulatory Guide 1.147, Revision 12.*

*The surface examination acceptance criteria will be in accordance with NB-5350 of the 1992 Edition of ASME Section III.*

*The ultrasonic examination acceptance criteria will be in accordance with NB-5330 of the 1992 Edition of ASME Section III.*

## **5.0 DOCUMENTATION:**

Repairs will be documented on Form NIS-2.

### **Basis for Relief:**

The repair process will consist of the following activities:

- (a) Using a remote tool from below the RVCH, each nozzle requiring repair will first receive a roll expansion into the RVCH base material to insure that the nozzle will not move during the repair operations.
- (b) A semi-automated machining tool operating underneath the RVCH will remove the entire lower portion of the CRDM nozzle to a depth above the existing J-groove partial penetration weld. The machining tool will also perform the CRDM nozzle repair weld preparation. The operation will sever the existing J-groove partial penetration weld from the CRDM nozzles.
- (c) The machined surface will be cleaned, and then examined using liquid penetrant (PT).
- (d) The repair weld will be performed with a remotely operated machine GTAW weld head, using the ambient temperature temper bead process to install the new ERNiCrFe-7 (Alloy 52) pressure boundary weld between the shortened nozzle and the inside bore of the RVCH base material, with 50°F minimum preheat temperature.
- (e) The final weld face, not including the taper transition, will be machined and/or ground.

- (f) The final weld will be liquid penetrant and ultrasonically examined prior to the abrasive water jet conditioning, to preclude masking by the abrasive water jet process.
- (g) The final inside diameter surface of the CRDM nozzle near the new weld and the new weld will then be conditioned by abrasive water-jet conditioning to create a final surface that is in compression, to produce optimum resistance to primary water stress corrosion cracking.

The CRDM nozzle repair configuration described above is illustrated in Figures 3 and 4.

#### Code Case 2142-1

ASME Code Case 2142-1 establishes the uniform chemical and material properties and the classification of the weld material with respect to its welding characteristics. Code Case 2142-1 establishes the F-No. for the American Welding Society (AWS) specification AWS A5.14 and Unified Numbering System (UNS) designation UNSN06052 conforming to Inconel 52 as F-No. 43 for both procedure and performance qualification purposes. These specifications and F-No. assignments completely describe this material for welding purposes as similar in their welding characteristics to other Code approved nickel based weld metals.

The material properties of the existing Alloy 600 (182 weld material) material were compared to the new proposed Alloy 690 (52 weld material). The thermal expansion coefficient of 52 weld material is somewhat higher than the coefficient for 182 weld material (at 600°F, the difference is about 4%), however, the modulus of elasticity is lower for the 52 weld material than the 182 weld material. Since the thermal stress is a function of the product of modulus of elasticity and thermal expansion coefficient ( $\sigma = E\alpha\Delta T$ ), the effects tend to cancel each other (at 600°F for example, the difference in the products is only 2%).

An evaluation of the weld dilution concluded that the percentage of chromium in the deposited welds exceeded 22%. Materials with chromium concentrations above 22% have demonstrated resistance to Primary Water Stress Corrosion Cracking (PWSCC). In summary, the chromium content of all repaired surfaces containing the proposed Alloy 690 material, considering chromium dilution, will exceed that of the original Alloy 600 material, and thus afford superior corrosion resistance.

#### IWA-4610(a) - Thermocouples

IWA-4610(a) requires that thermocouples and recording instruments be used to monitor the metal temperature during welding.

The RVCH preheat temperature will be essentially the same as the reactor building ambient temperature. Therefore, RVCH preheat temperature monitoring in the weld region and using thermocouples is unnecessary and would result in additional personnel dose associated with thermocouple placement and removal. Consequently, preheat temperature verification by contact pyrometer on accessible areas of the RVCH is sufficient.

In lieu of using thermocouples for interpass temperature measurements, calculations show that the maximum interpass temperature will never be exceeded based on a maximum allowable low welding heat input, weld bead placement, travel speed, and conservative preheat temperature assumptions. The calculation supports the conclusion that using the maximum heat input through the third layer of the weld, the interpass temperature returns to near ambient temperature. Heat input beyond the third layer will not have a metallurgical affect on the low alloy steel HAZ.

The calculation is based on a typical inter-bead time interval of five minutes. The five minute inter-bead interval is based on:

- 1) the time required to explore the previous weld deposit with the two remote cameras housed in the weld head,
- 2) time to shift the starting location of the next weld bead circumferentially away from the end of the previous weld-bead, and
- 3) time to shift the starting location of the next bead axially to insure a 50% weld bead overlap required to properly execute the temper bead technique.

A welding mockup on the full size Midland RVCH, which is similar to the DBNPS RVCH, was used to demonstrate the welding technique described herein. During the mockup, thermocouples were placed to monitor the temperature of the head during welding. Thermocouples were placed on the outside surface of the closure head within a 5 inch band surrounding the CRDM nozzle. Three other thermocouples were placed on the closure head inside surface. One of the three thermocouples was placed 1½ inches from the CRDM nozzle penetration on the lower hillside. The other inside surface thermocouples were placed at the edge of the 5 inch band surrounding the CRDM nozzle, one on the lower hillside, the second on the upper hillside. During the mockup, all thermocouples fluctuated less than 15°F throughout the welding cycle. Based on past experience, it is believed that the temperature fluctuation was due more to the resistance heating temperature variations than the low heat input from the welding process. For the Midland RVCH mockup application 300°F minimum preheat temperature was used. Therefore, for ambient temperature conditions used for this repair, maintenance of the 350°F maximum interpass temperature will certainly not be a concern.

RVCH preheat temperature monitoring in the weld region and using thermocouples is unnecessary and would result in additional personnel dose associated with thermocouple placement and removal.

IWA-4610(b)/IWB-4633.2(c)

The welding procedure has been qualified in accordance with the requirements of paragraphs 2.0 and 2.1 specified in the Alternative Welding Method.

Qualification of a P-No. 3 base material to P-No. 43 base material with F-No. 43 filler material welding procedure will be performed in accordance with QW- 424 of ASME Section XI prior to performing repair welding.

Quality temper bead welds, without preheat and post weld heat treatment, can be made based on welding procedure qualification test data derived from the machine GTAW ambient temperature temper bead welding process. The proposed alternative welding method will be used to make welds of P-No. 3 RVCH material to P-No. 43 CRDM nozzle material using F-No. 43 filler material.

Results of procedure qualification work undertaken to date indicate that the process produces sound and tough welds. For instance, typical tensile test results have been ductile breaks in the weld metal.

As shown below, the Framatome-ANP Procedure Qualification Record (PQR ) 55-PQ7164 using P-No. 3, Group No. 3 base material exhibited improved Charpy V-notch properties in the HAZ from both absorbed energy and lateral expansion perspectives, compared to the unaffected base material.

**Properties of PQR 55-PQ7164**

PQR 55-PQ7164	Unaffected Base Material	HAZ
50°F absorbed energy (ft-lbs)	69, 55, 77	109, 98, 141
50°F lateral expansion (mils)	50, 39, 51	59, 50, 56
50°F shear fracture (%)	30, 25, 30	40, 40, 65
80°F absorbed energy (ft-lbs)	78, 83, 89	189, 165, 127
80°F lateral expansion (mils)	55, 55, 63	75, 69, 60
80°F shear fracture (%)	35, 35, 55	100, 90, 80

The absorbed energy, lateral expansion, and percent shear were significantly greater for the HAZ than the unaffected base material at both test temperatures. It is clear from these results that the GTAW temper bead process has the capability of producing acceptable repair welds.

Framatome-ANP has previously qualified the GTAW temper bead process in support of ASME approval of Code Case N-606-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature GTAW Temper Bead Technique for Boiling Water Reactor (BWR) CRD Housing/Stub Tube Repairs." The qualifications were performed at room temperature with cooling water to limit the maximum interpass temperature to a maximum of 100°F. The qualifications were performed on the same P-No. 3 Group No. 3 base material as proposed for the

CRDM repairs, using the same filler material (i.e. Alloy 52 AWS Class ERNiCrFe-7) with similar low heat input controls as will be used in the repairs. Also, the qualifications did not include a post weld heat soak.

The Welding Procedure Qualifications supporting the applicable Welding Procedure Specifications (WPSs) to be used in the repair weld are for P-No. 3 Group No. 3 base material welded with F-No. 43 filler metal and P-No. 43 to P-No. 43 base material welded with F-No. 43 filler metal. The use of these WPSs for welding P-No. 43 to P-No. 3 Group No. 3 with F-No. 43 filler metal (i.e. dissimilar metal welding) is justified based on the following. In addition, a procedure for welding P-No. 3 base material to P-No. 43 base material with F-No. 43 filler material will be qualified prior to repair welding.

- (1) PQR 55-PQ7164, as discussed above, supporting the ambient temperature temper bead WPS for welding, was a groove weld performed using F-No. 43 filler metal on P-No. 3 Group No. 3 base material.
- (2) The PQR 55-PQ7164 groove (cavity) in the P-No. 3 Group No. 3 base material coupon was 2¾ inches deep with a ¾ inch wide root and 30° side bevels (60° included angle). All the effects of welding to the P-No. 3 base material with F-No. 43 filler metal have been verified by full thickness transverse tensile tests and full thickness transverse side bends.
- (3) The PQR's for supporting the WPS for welding P-No. 43 to P-No. 43 were groove welds performed using F-No. 43 filler metal on P-No. 43 base material.
- (4) One of the PQR's for welding the P-No. 43 base material with F-No. 43 filler metal is a full penetration groove weld between two (2) P-No. 43 pipes having outside diameters of 4.45 inches and wall thickness of 0.307 inches. All the effects of welding to the P-No. 43 base material with F-No. 43 filler metal have been verified by full thickness transverse tensile tests and full width face and root bends in accordance with ASME Section IX.
- (5) The other PQR for welding the P-No. 43 base material with F-No. 43 filler metal is a full penetration groove weld between two (2) P-No. 43 pipes having 20½ inches outside diameter and wall thickness of 2.35 inches. All the effects of welding to the P-No. 43 base material with F-No. 43 filler metal have been verified by full thickness transverse tensile tests and full thickness transverse side bends in accordance with ASME Section IX.

Based on FRA-ANP prior welding procedure qualification test data using machine GTAW ambient temperature temper bead welding, quality temper bead welds can be performed with 50°F minimum preheat and no post weld heat treatment.

IWA-4610(a)- Preheat Temperature / IWB-4633.2(d) – Post Weld Heat Treatment

The IWA 4600 temper bead welding procedure requires a 350°F preheat and a post weld soak at 300°F for 4 hours for P-No. 3 material. Typically these kinds of preheat and post weld soak are used to mitigate the effects of the solution of atomic hydrogen in ferritic materials prone to hydrogen embrittlement cracking. The susceptibility of ferritic steels is directly related to their ability to transform to martensite with appropriate heat treatment. The P-No. 3 material of the RVCH is able to produce martensite from heating and cooling cycles associated with welding. However, the proposed alternative temper bead procedure utilizes a welding process that is inherently free of hydrogen. The GTAW process relies on bare welding electrodes with no flux to trap moisture. An inert gas blanket positively shields the weld and surrounding material from the atmosphere and moisture it may contain. To further reduce the likelihood of any hydrogen evolution or absorption, the alternative welding procedure requires particular care to ensure the weld region is free of all sources of hydrogen. The GTAW process will be shielded with welding grade argon (99.9996% pure) which typically produces porosity free welds. The gas would have no more than 1 PPM of hydrogen (H<sub>2</sub>) and no more than 0.5 PPM of water vapor (H<sub>2</sub>O). A typical argon flow rate would be about 15 to 50 CFH and would be adjusted to assure adequate shielding of the weld without creating a venturi affect that might draw oxygen or water vapor from the ambient atmosphere into the weld.

IWA-4634:

IWA-4634 requires the preheated band be examined by the liquid penetrant method after the completed weld had been at ambient temperature for at least 48 hours. The weld shall also be volumetrically examined.

The band around the area defined in paragraph 1.0 (d) cannot be nondestructive examined due to the physical configuration of the partial penetration weld. The purpose for the examination of the band is to assure all flaws associated with the weld repair area have been removed or addressed. The exposed ferritic steel portion of the CRDM penetration plus the weld preparation bevel on the lower end of the remaining portion of the CRDM nozzle as well as the adjacent portion of the CRDM nozzle inside diameter immediately above the weld preparation is liquid penetrant examined prior to welding (See Figure 5). This examination provides assurance that no flaws exist on the surfaces in the bore in the region to be welded. The final examination of the new weld repair and immediate surrounding area within the band will be sufficient to verify that defects have not been induced in the low alloy reactor vessel head material due to the welding process. Liquid penetrant (PT) coverage is shown in Figure 6.

NB-5245:

Code Case N-416-1 is used for pressure testing the repair weld. Code Case N-416-1, which is approved in NRC Regulatory Guide 1.147, Revision 12, allows a system leakage test in lieu of a hydrostatic test as required by ASME Section XI provided the weld receives nondestructive examination in accordance with ASME Section III, 1992 Edition. Paragraph NB-5245 of ASME Section III requires incremental and final surface examination of partial penetration welds. Due to the welding layer disposition sequence (i.e. each layer is deposited parallel to the penetration centerline), the specific requirements of NB-5245 cannot be met. The Construction Code requirement for progressive surface examination was because volumetric examination is not practical for conventional partial penetration weld configurations. In this case, the repair weld is suitable, except of the taper transition, for ultrasonic examination and a final surface examination can be performed.

The effectiveness of the UT techniques to characterize weld defects has been qualified by demonstration on a mockup of the ambient temperature temper bead welding process involving the same materials used for repair. Notches were machined into the mockup at the triple point region of depths of 0.10 inch, 0.15 inch, and 0.25 inch in order to quantify the ability to characterize the depth of penetration into the nozzle. The depth characterization is done using tip diffraction UT techniques that have the ability to measure the depth of a reflector relative to the nozzle bore. Each of the notches in the mockup could be measured using the 45-degree transducer. During the examination, longitudinal wave angle beams of 45 degrees and 70 degrees are used. These beams are directed along the nozzle axis looking up and down. The downward looking beams are effective at detecting the anomaly because of the impedance change at the triple point. The 45-degree transducer is effective at depth characterization by measuring the time interval to the tip of the reflector relative to the transducer contact surface. The 70-degree longitudinal wave provides additional qualitative data to support information obtained with the 45-degree transducer. Together, these transducers provide good characterization of any weld anomalies. These techniques are routinely used for examination of austenitic welds in the nuclear industry for flaw detection and sizing.

In addition to the 45 and 70-degree beam angles described above, the weld is also examined in the circumferential direction using 45 degree longitudinal waves in both the clockwise and counterclockwise directions to look for transverse fabrication flaws. A 0-degree transducer is also used to look radially outward to examine the weld and adjacent material for laminar type flaws and evidence of under bead cracking.

Ultrasonic examination (UT) will be performed scanning from the ID surface of the weld, excluding the transition taper portion at the bottom of the weld and adjacent portion of the CRDM nozzle bore. The UT is qualified to detect flaws in the repair weld and base metal interface in the repair region, to the maximum practical extent.



The UT transducers and delivery tooling are capable of scanning from cylindrical surfaces with inside diameters near 2.75 inches. The UT equipment is not capable of scanning from the face of the taper. The scanning is performed using 0° L-wave, 45° L-wave, and 70° L-wave transducers to scan the area of interest. Approximately 70% of the weld surface will be scanned by UT. Approximately 83% of the RVCH ferritic steel heat affected zone will be covered by UT. The UT coverage volumes are shown in Figures 7 through 12 for the various scans.

### Occupational Exposure

Recent experience gained from the performance of manual repairs at other plants' CRDM nozzles indicated that more remote automated repair methods were needed to reduce radiation dose to repair personnel and still provide acceptable levels of quality and safety. Since FENOC recognizes the importance of ALARA principles, this remote repair method has been developed for the possibility of CRDM nozzle flaws requiring repair at the DBNPS.

This approach for repair of CRDM nozzle flaws requiring repair will significantly reduce radiation dose to repair personnel while still maintaining acceptable levels of quality and safety. The total radiation dose for the proposed remote repair method is projected at 7 to 8 Rem per nozzle. In contrast, using manual repair methods would result in a total radiation dose of approximately 30 Rem per nozzle.

### Summary

Relief is requested to be granted by NRC in accordance with 10 CFR 50.55a(a)(3)(i). The proposed alternative welding method is an acceptable alternative to the temper bead welding process described in the 1995 Edition through the 1996 Addenda of ASME Section XI and will produce sound, permanent repair welds and an acceptable level of quality and safety.

### **Implementation Schedule:**

Unacceptable flaws detected during inspections of the DBNPS CRDM nozzles during the Third 10-Year Inservice Inspection Interval will be repaired using the machine GTAW Ambient Temperature Temper Bead technique, with a 50°F minimum preheat and no post weld heat treatment as described in this relief request.

**Table 1**  
Comparison of Section XI Code Requirements to RR-A20 Methodology  
ASME Section XI 1995 Edition through 1996 Addenda

Paragraph or Subparagraph	Requirement	Alternative
IWA-4400	WELDING, BRAZING, METAL REMOVAL, AND INSTALLATION	
IWA-4410	General Requirements	
IWA-4410(a)	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).	No alternative to IWA-4410(a) or IWA-4410(c) is requested.
IWA-4410(c)	Alternatively, the applicable requirements of IWA-4600 may be used for welding, ....	
IWA-4600	ALTERNATIVE WELDING METHODS	
IWA-4600(b)	When post weld heat treatment is not to be performed, the following provisions may be used. (1) The welding methods of IWA-4620, IWA-4630, or IWA-4640 may be used in lieu of the welding and nondestructive examination requirements of the Construction Code or Section III, provided the requirements of IWA-4610 are met.  Note: IWA-4630 is applicable to Dissimilar Materials	No alternative is requested
IWA-4610	General Requirements for All Materials	
• IWA-4610(a)	The area to be welded plus a band around the area of at least 1-½ times the component thickness or 5 in., whichever is less shall be preheated and maintained at a minimum temperature of 350°F for the SMAW process and 300°F for the GTAW process during welding. The maximum interpass temperature shall be 450°F. Thermocouples and recording instruments shall be used to monitor the process temperatures. Their	1) Relief is requested from preheat requirements 2) Relief is requested from the use of thermocouples and recording instruments to monitor the process temperature.



Paragraph or Subparagraph	Requirement	Alternative
IWA-4611	<b>Metal Removal</b>	
IWA-4611.1	<b>General Requirements</b>	
<ul style="list-style-type: none"> <li>IWA-4611.1(a)</li> </ul>	Defects shall be removed or reduced in size in accordance with this Paragraph. The component shall be acceptable for continued service if the resultant section thickness created by the cavity is at least the minimum design thickness. If the resulting section thickness is less than the minimum design thickness, the component shall be corrected by repair/replacement activities in accordance with this Article. Alternatively, 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.	The alternative to evaluate flaws remaining in the J-groove weld to the provisions of Section XI is applicable to this alternative. However, the J-groove weld flaws cannot be fully characterized as required for evaluation in accordance with the standards of IWB-3500. Relief from characterizing flaws in accordance with IWA-3300 is requested in Relief Request RR-A21.
IWA-4611.1(b)	The original defect shall be removed: (2) when welding is required in accordance with IWA-4630 or IWA-4640, and the defect penetrates base material.	The proposed alternative is in compliance with this Code paragraph. Although a flaw may remain in the existing J-groove weld, the machining operation removes the CRDM nozzle to a depth above the existing J-groove partial penetration weld. This operation severs the existing J-groove partial penetration weld from the CRDM nozzle.
IWA-4611.2	<b>Thermal Removal Process</b>	This Code Requirement is not applicable to the proposed alternative.
IWA-4611.3	<b>Mechanical Removal Processes</b>	
IWA-4611.3(a)	If a mechanical removal process is used in an area where welding is not to be performed, the area shall be faired in to the surrounding area.	The proposed alternative is in compliance with this Code paragraph.
IWA-4611.3(b)	Where welding is to be performed, the cavity shall be ground smooth and clean with beveled sides and edges rounded to provide suitable accessibility for welding.	The proposed alternative is in compliance with this Code paragraph. The machining operation is considered equivalent to grinding.
IWA-4611.4	<b>Examination Following Metal Removal</b>	
IWA-4611.4(a)	After final grinding, the affected surfaces, including surfaces of cavities	The proposed alternative is in compliance with this Code

Paragraph or Subparagraph	Requirement	Alternative
IWA-4611.4(b)	<p>prepared for welding, shall be examined by the magnetic particle or liquid penetrant method to ensure that the indication has been reduced to an acceptable limit in accordance with IWA-3000. This examination is not required when defect elimination removes the full thickness of the weld and back side of the weld joint is not accessible for removal of examination materials.</p> <p>Indications detected as a result of the excavation that are not associated with the defect being removed shall be evaluated for acceptability in accordance with IWA-3000.</p>	<p>paragraph.</p> <p>The proposed alternative is in compliance with this Code paragraph.</p>

Paragraph or Subparagraph	Requirement	Alternative
IWA-4630	Dissimilar Materials	The proposed alternative is in compliance with this Code paragraph except where relief is noted below.
IWA-4631	General Requirements	
IWA-4631(a)	Repair/replacement activities on welds that join P-No. 8 or P-No. 43 material to P-No. 1, 3, 12A, 12B, and 12C material may be made without the specified post weld heat treatment, provided the requirements of IWA-4631(b) and IWA-4632 through IWA-4634 are met.	
IWA-4631(b)	Repair/replacement activities in accordance with this paragraph are limited to those along the fusion line of a nonferritic to ferritic base material where 1/8 in. or less on nonferritic weld deposit exists above the original fusion line after defect removal. If the defect penetrates into the ferritic base material, welding of the base material may be performed in accordance with IWA-4633 provided the depth of the weld in the base material does not exceed 3/8 in. The repair/replacement activity performed on a completed joint shall not exceed one-half the joint thickness. The surface of the completed weld shall not exceed 100 sq. in.	
IWA-4632	Welding Procedure Qualification	The proposed alternative is in compliance with this Code paragraph.
IWA-4632(a)	The test assembly cavity depth shall be at least one-half the depth of the weld installed during the repair/replacement activity but not less than 1 in. The test assembly thickness shall be at least twice the test assembly cavity depth. The test assembly shall be large enough to permit removal of the required test specimens. The test assembly dimensions surrounding the cavity shall be at least the test assembly thickness, but not less than 6 in. The qualification test place shall be prepared in accordance with Fig. IWA-4622.1.	
IWA-4632(b)	The ferritic base material and HAZ shall meet the requirements of IWA-4622.	The proposed alternative is in compliance with this Code paragraph.
IWA-4633	Welding Procedure	This Code Requirement is not applicable to the proposed alternative.
IWA-4633.1	Shielded Metal-Arc Welding	

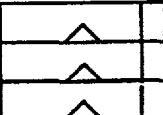
Paragraph or Subparagraph	Requirement	Alternative
IWA-4633.2	<b>Gas Tungsten-Arc Welding.</b> The procedure shall include the requirements of IWA-4633.2(a) through (e).	The proposed alternative is in compliance with this Code paragraph except where relief is noted.
• IWA-4633.2(a)	The weld shall be made using A-No. 8 weld metal (QW-422) for P-No. 8 to P-No. 1 or P-No. 3 weld joints or F-No. 43 to P-No. 1 or P-No. 3 weld joints.	The Reactor Vessel Closure Head (P-No. 3 base material) is welded to the CRDM nozzle (P-No. 43 base material) using ERNiCrFe-7 weld filler material. ERNiCrFe-7 filler material is designated as F-No. 43 in Code Case 2141-1. Code Case 2141-1 has not been approved by the NRC in Regulatory Guides. Therefore, relief to use Code Case 2141-1 is requested.
IWA-4633.2(b)	The weld metal shall be deposited by the automatic or machine gas tungsten arc weld process using cold wire feed.	The proposed alternative is in compliance with this Code paragraph.
• IWA-4633.2(c)	The cavity shall be buttered with the first six layers of weld metal as shown in Fig. IWA-4633.2-1, Steps 1 through 3, with the weld heat input for each layer controlled to within $\pm 10\%$ of that used in the procedure qualification test. Subsequent layers shall be deposited with a heat input equal to or less than that used for layers beyond the sixth in the procedure qualification (See Fig. IWA-4633.2-1, Step 4). The completed weld shall have at least one layer of weld reinforcement deposited and then this reinforcement shall be removed by mechanical means, making the finished surface of the weld substantially flush with the surface surrounding the weld.	Relief is requested from this Code Requirement. The proposed welding process provides an alternative method for the deposition of the weld material.
• IWA-4633.2(d)	After completion of welding, or when at least 3/16 in. of weld metal has been deposited, the weld area shall be maintained at a minimum temperature of 300°F for a minimum of 2 hr in P-No. 1 materials. For P-No. 3 materials, the holding time shall be a minimum of 4 hr.	Relief is requested from this Code Requirement. No heat treatment is required by the proposed alternative welding method.
IWA-4633(e)	Subsequent to the above heat treatment, the balance of the welding may be performed at maximum interpass temperature of 350°F.	The proposed alternative is in compliance with this Code paragraph

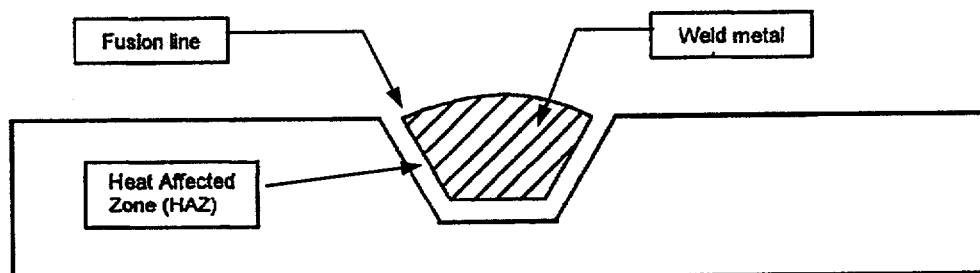
Paragraph or Subparagraph	Requirement	Alternative
<ul style="list-style-type: none"> <li>IWA-4634</li> </ul>	<p><b>Examination</b></p> <p>The weld as well as the preheated band shall be examined by the liquid penetrant method after the completed weld has been at ambient temperature for at least 48 hr. The weld shall be volumetrically examined.</p>	<p>Relief is requested from this Code Requirement. The entire preheated band specified in IWA-4610(a) is not liquid penetrant examined following welding.</p>
<p>IWA-4540</p> <p>IWA-4540(a)</p>	<p><b>Pressure Testing of Class 1, 2, and 3 Items</b></p> <p>After welding on a pressure retaining boundary or installation of an item by welding or brazing a system hydrostatic test shall be performed in accordance with IWA-5000.</p>	<p>A system leakage test will be conducted in accordance with Code Case N-416-1. Code Case N-416-1 is approved in NRC Regulatory Guide 1.147.</p> <p>Code Case N-416-1 requires NDE be performed in accordance with the methods and acceptance criteria of the applicable Subsection of the 1992 Edition of Section III.</p>
<ul style="list-style-type: none"> <li>NB-5245 (1992 Edition)</li> </ul>	<p><b>Partial Penetration Welded Joints</b></p> <p>Partial penetration welded joints, as permitted in NB-3352.4(d), and as shown in Figs. NB-4244(d)-1 and NB-4244(d)-2, shall be examined progressively using either the magnetic particle or liquid penetrant methods. The increments of examination shall be the lesser of one-half of the maximum welded joint dimension measured parallel to the center line of the connection or ½ in. (13 mm). The surface of the finished welded joint shall also be examined by either method.</p>	<p>Relief is requested from this Code Requirement. The final weld, except for the taper transition will receive an ultrasonic examination. The final weld will also receive a liquid penetrant examination.</p>



Paragraph or Subparagraph	Requirement	Alternative
<p>NB-5330 (1992 Edition)</p> <ul style="list-style-type: none"> <li>NB-5330(b)</li> </ul>	<p><b>Ultrasonic Acceptance Standards</b></p> <p>Indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.</p>	<p>An artifact of the ambient temperature temper bead weld repair is an anomaly in the weld at the triple point. The triple point is the point in the repair weld where the low alloy reactor vessel head, the Alloy 600 nozzle, and the first Alloy 52 weld bead intersect. Relief to accept the triple point anomaly is requested in Relief Request RR-A21.</p>

- Relief from this Code Paragraph is Requested

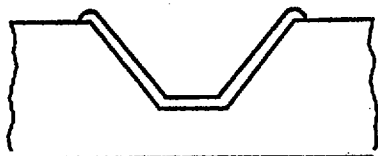
Discard		
Transverse Side Bend		
Reduced Section Tensile		
Transverse Side Bend		
		HAZ Charpy V-Notch
Transverse Side Bend		
Reduced Section Tensile		
Transverse Side Bend		
Discard		



GENERAL NOTE: Base metal Charpy impact specimens are not shown. This figure illustrates a similar-metal weld.

#### QUALIFICATION TEST PLATE

**Figure 1**



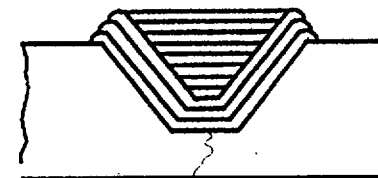
Step 1: Deposit layer one with first layer weld parameters used in qualification.



Step 2: Deposit layer two with second layer weld parameters used in qualification. NOTE: Particular care shall be taken in application of the second layer at the weld toe to ensure that the weld metal and HAZ of the base metal are tempered.



Step 3: Deposit layer three with third layer weld parameters used in qualification. NOTE: Particular care shall be taken in application of the third layer at the weld toe to ensure that the weld metal and HAZ of the base metal are tempered.



Step 4: Subsequent layers to be deposited as qualified, with heat input less than or equal to that qualified in the test assembly. NOTE: Particular care shall be taken in application of the fill layers to preserve the temper of the weld metal and HAZ.

GENERAL NOTE: The illustration above is for similar-metal welding using a ferritic filler material. For dissimilar-metal welding, only the ferritic base metal is required to be welded using steps 1 through 3 of the temperbead welding technique.

#### AUTOMATIC OR MACHINE (GTAW) TEMPERBEAD WELDING

Figure 2

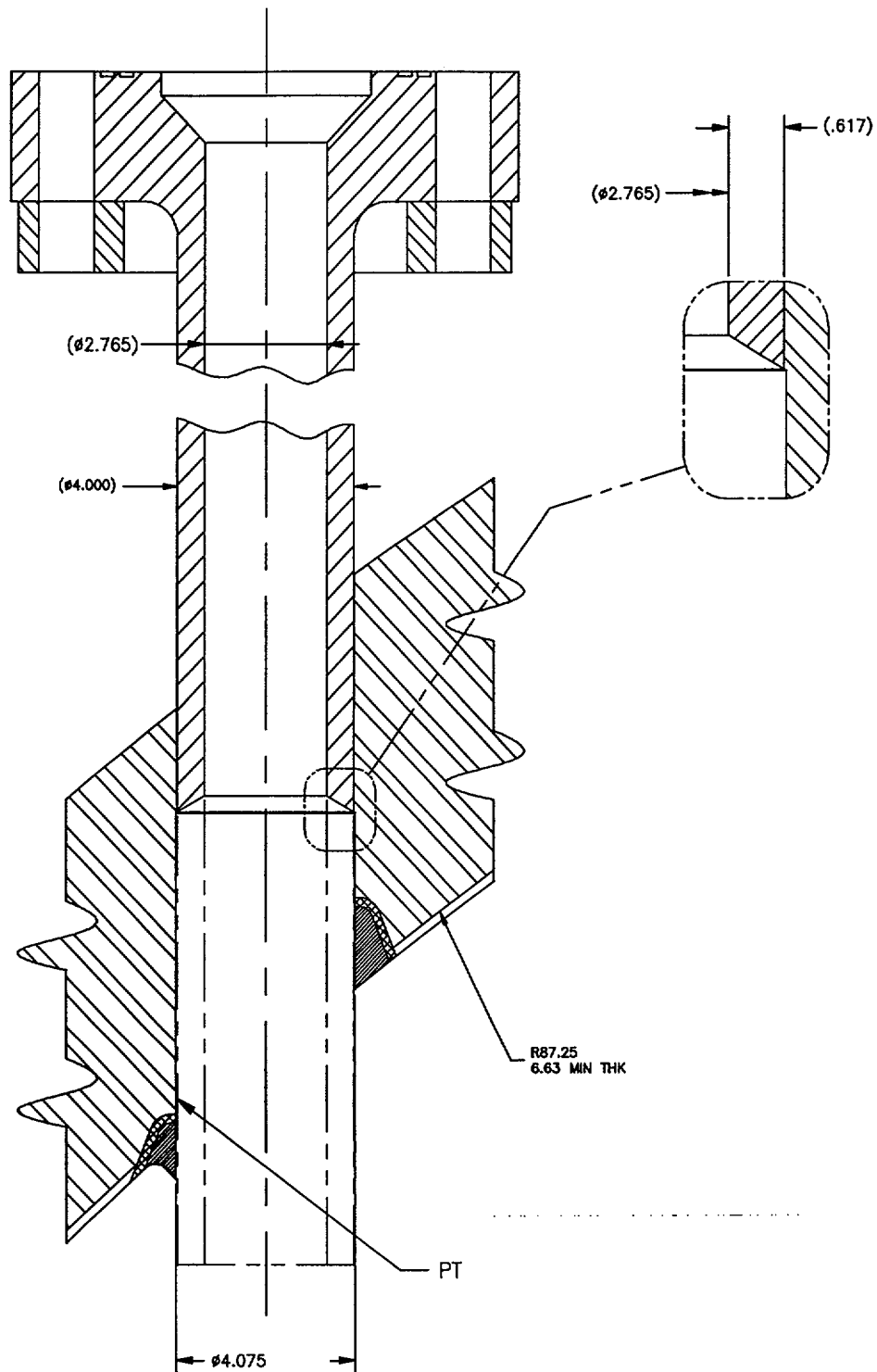


Figure 3  
CRDM Machining

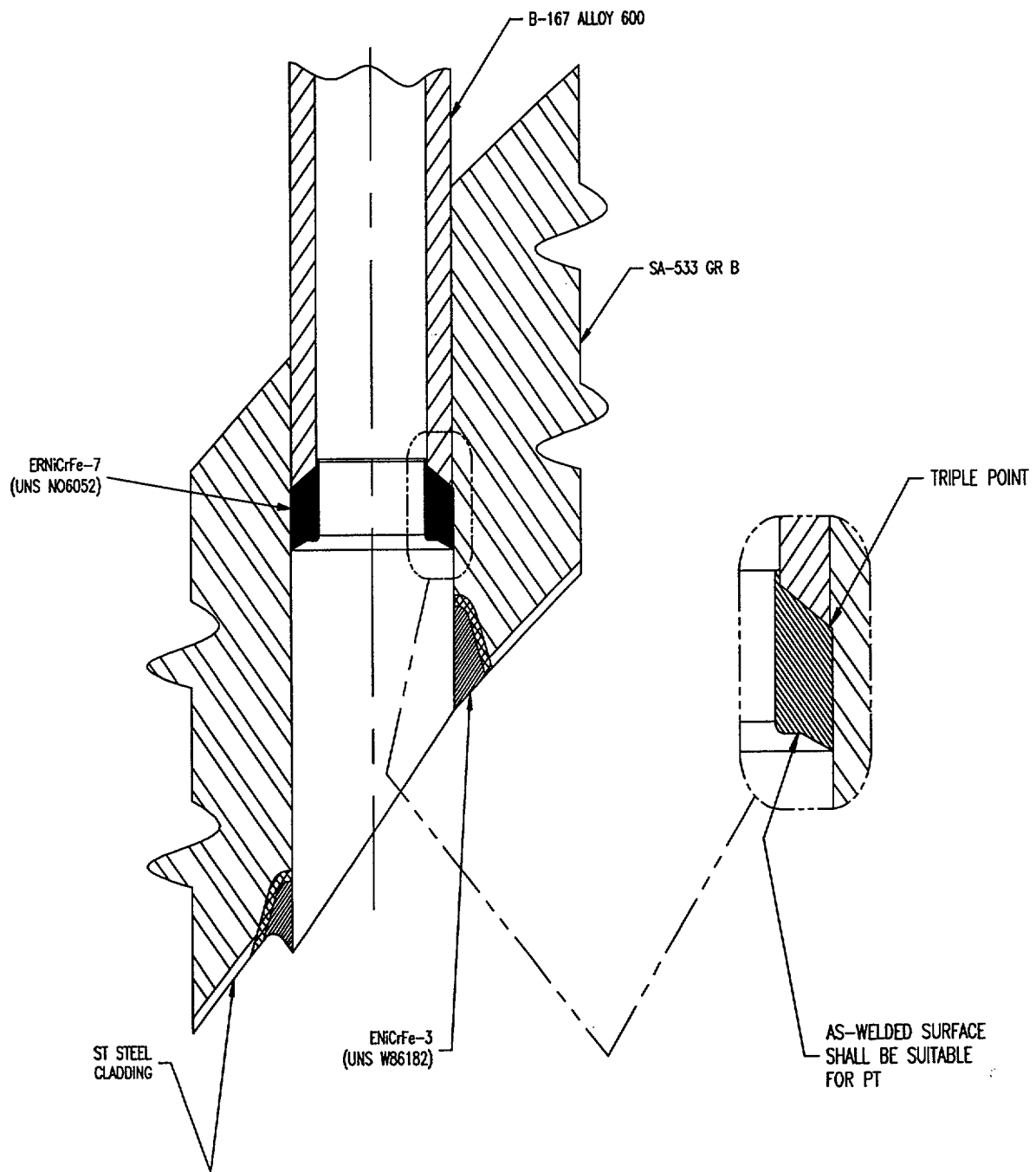


Figure 4  
New CRDM Pressure Boundary Weld

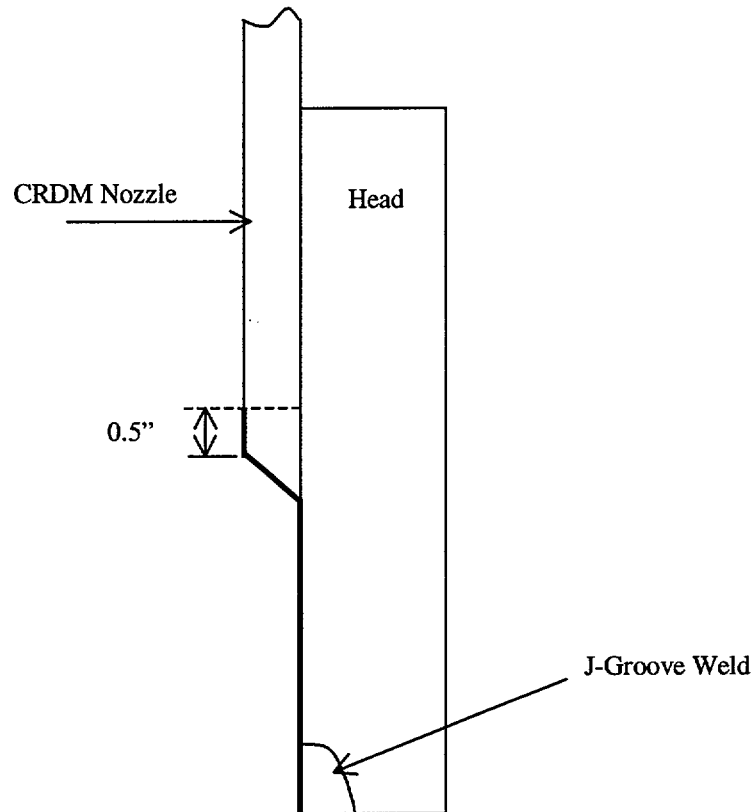


Figure 5  
CRDM Temper Bead Weld Repair,  
PT Coverage Prior to Welding

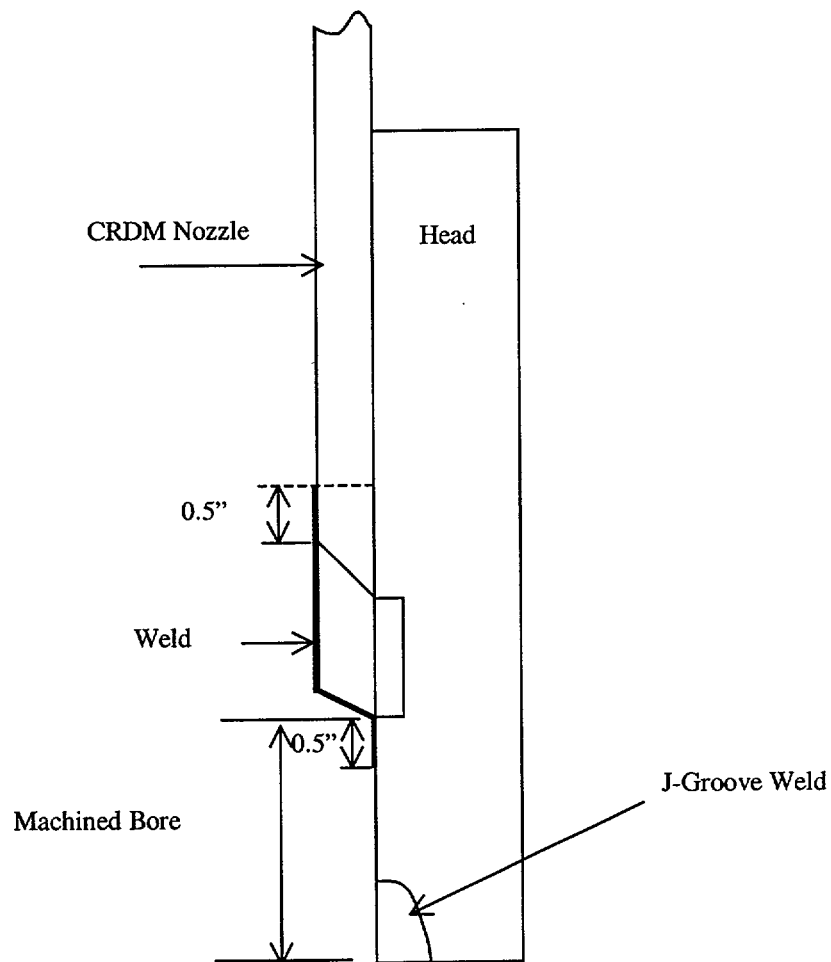


Figure 6  
CRDM Temper Bead Weld Repair,  
PT Coverage After Welding

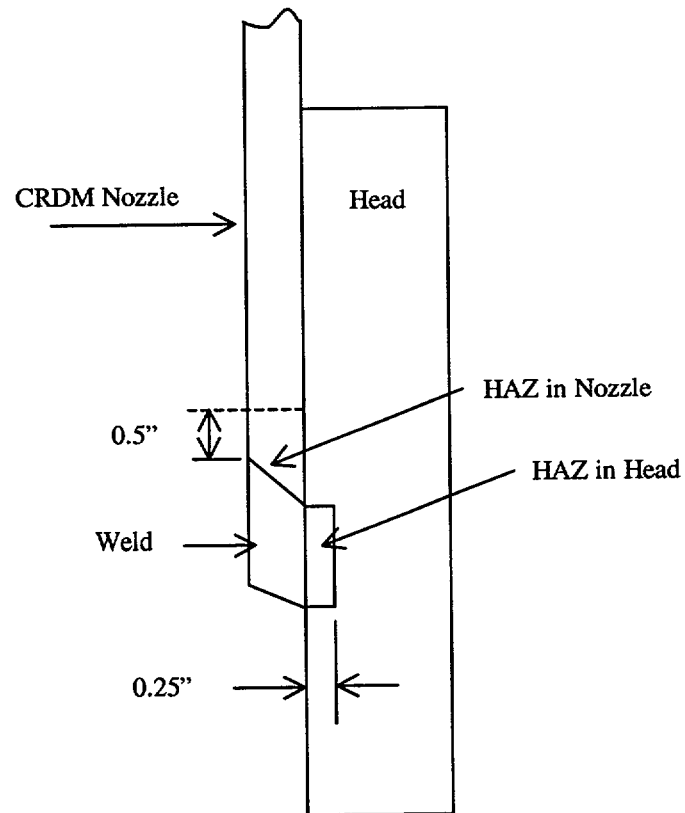


Figure 7  
CRDM Temper Bead Weld Repair  
Areas to be Examined



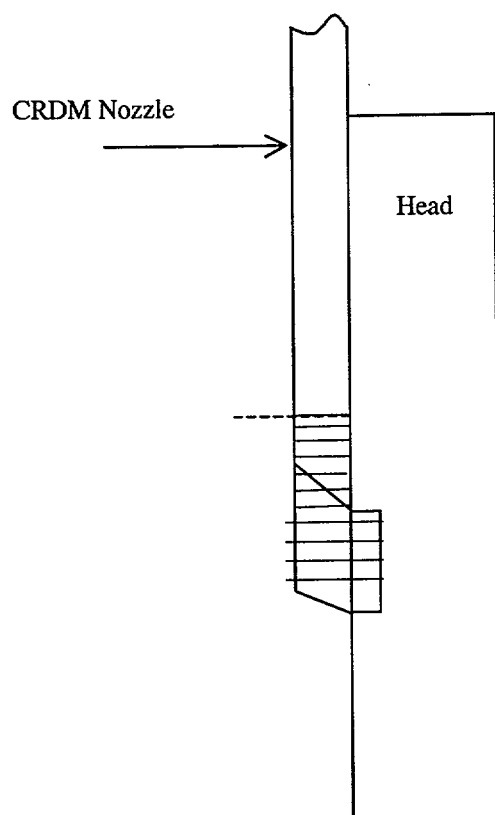


Figure 8  
CRDM Temper Bead Weld Repair,  
UT 0 degree and 45L Beam Coverage  
Looking Clockwise and Counter-clockwise

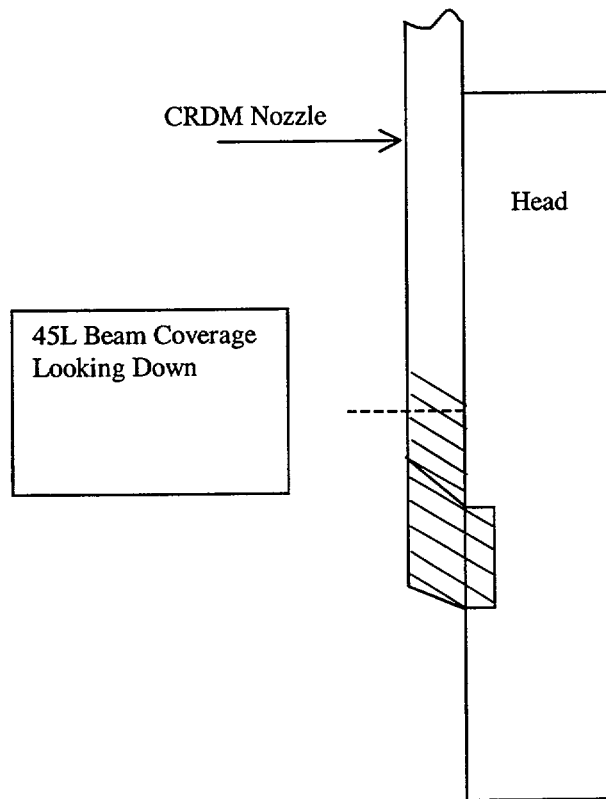


Figure 9  
CRDM Temper Bead Weld Repair,  
45L UT Beam Coverage Looking Down

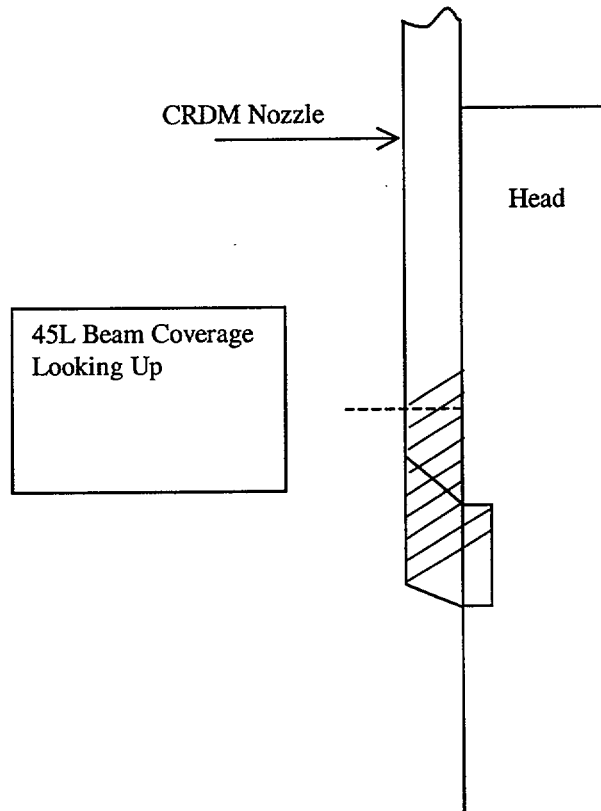


Figure 10  
CRDM Temper Bead Weld Repair,  
45L UT Beam Coverage Looking Up

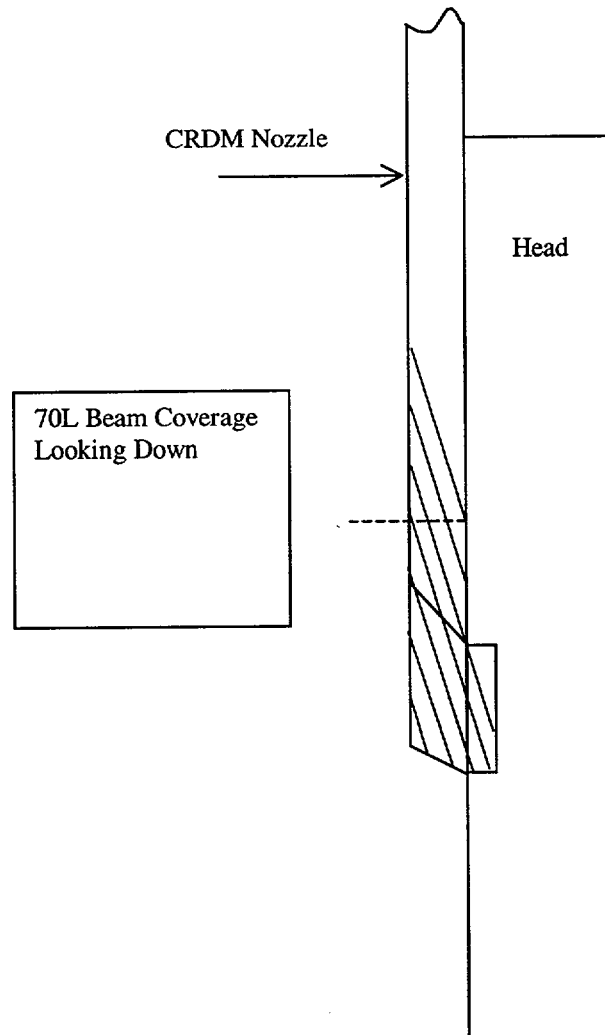
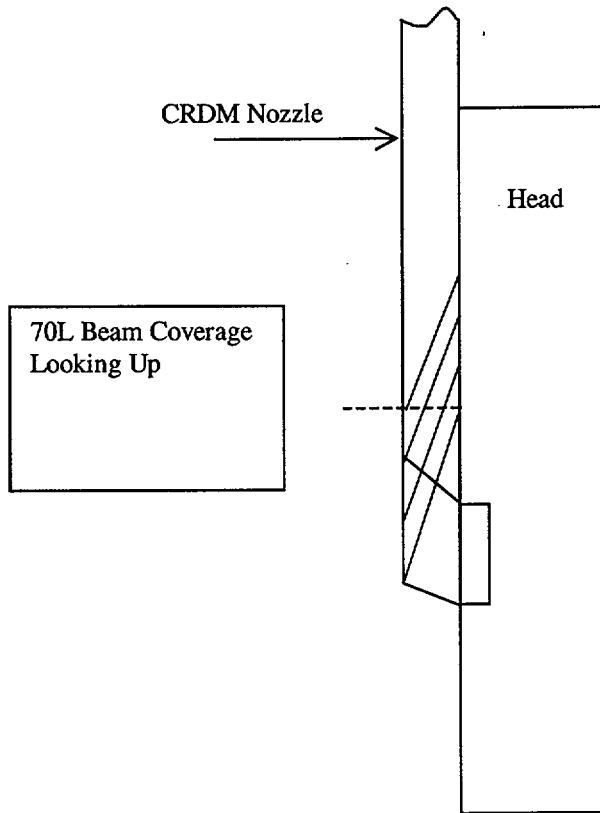


Figure 11  
CRDM Temper Bead Weld Repair,  
70L UT Beam Coverage Looking Down



**Figure 12**  
**CRDM Temper Bead Weld Repair,**  
**70L UT Beam Coverage Looking Up**

Docket Number 50-346  
License Number NPF-3  
Serial Number 2765  
Attachment 2  
Page 1 of 1

### **COMMITMENT LIST**

The following list identifies those actions committed to by the Davis-Besse Nuclear Power Station (DBNPS) in this document. Any other actions discussed in the submittal represent intended or planned actions the DBNPS. They are described only for information and are not regulatory commitments. Please notify the Manager - Regulatory Affairs (419-321-8450) at the DBNPS of any questions regarding this document or associated regulatory commitments.

#### **COMMITMENTS**

#### **DUE DATE**

None