FENOC
FirstEnergy Nuclear Operating Company

Davis-Besse Nuclear Power Station
5501 North State Route 2
Oak Harbor, Ohio 43449-9760

Howard W. Bergendahl
Vice President - Nuclear

419-321-8588
Fax: 419-321-8337

Docket Number 50-346

License Number NPF-3

Serial Number 2750

January 11, 2002

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

Subject: Requests for Relief from American Society of Mechanical Engineers Boiler and Pressure Vessel Code Inservice Inspection Requirements at the Davis-Besse Nuclear Power Station – Third Ten-Year Interval (RR-A20 and RR-A21)

Ladies and Gentlemen:

The purpose of this letter is to request the NRC grant relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, 1995 Edition through 1996 Addenda, for the Davis-Besse Nuclear Power Station, Unit 1 (DBNPS), pursuant to 10 CFR 50.55a(a)(3)(i) and 10 CFR 50.55a(g)(6)(i).

During the 13th Refueling Outage (13RFO), scheduled to start no later than February 16, 2002, the DBNPS will be conducting qualified visual and non-destructive examinations of 100% of the Control Rod Drive Mechanism (CRDM) nozzles and penetrations. In the event that these examinations reveal flaws that require repair, the DBNPS is planning to use the methods described in the attached relief requests for the nozzle repairs. The planned repair is similar to those performed at the Oconee Nuclear Station, Units 2 and 3, the Crystal River Unit 3 (CR-3), and Three Mile Island, Unit 1.

The repair process will remove the portion of the CRDM nozzle that extends below the inner surface of the reactor pressure vessel (RPV) head. The new weld application surface will be prepared at a point above the heat affected zone of the original pressure boundary weld and within the RPV head nozzle bore through which the nozzle is installed. The new nozzle-to-head weld will be installed within the RPV head nozzle bore by remote machine welding. The original weld will not be part of the new pressure boundary weld. The original weld will be left in place at the juncture of the RPV head nozzle bore to RPV head inside surface and analyzed for acceptability.

A047

Relief Request RR-A20 (Attachment A) proposes to perform the repair with a remotely operated welding tool, using the machine Gas Tungsten-Arc Welding process and the ambient temperature temper bead method with 50°F minimum preheat temperature and no post weld heat treatment. No interpass temperature monitoring is proposed. Non-destructive examinations are proposed to not require incremental and surface examination of the repair.

Relief Request RR-A21 (Attachment 2) proposes that, if necessary, in lieu of fully characterizing the existing cracks, worst-case assumptions be used to conservatively estimate the crack extent and orientation. This may be necessary to maintain As-Low-As-Reasonably-Achievable (ALARA) objectives in the event destructive examination to characterize the cracks, as committed in DBNPS letter Serial Number 2747, dated November 30, 2001, cannot be performed because of ALARA concerns. In addition, RR-A21 provides the evaluation of the acceptability of the triple point anomaly that will remain following repair.

Review and approval of the attached relief requests is requested by February 8, 2002, 2001.

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,

Attachments

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

Docket Number 50-346
License Number NPF-3
Serial Number 2750
Attachment 1
Page 1

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

(35 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 ± 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 with the exception that only P-No. 3 material and F-No. 43 material were contained in the welding procedure qualification test, not P-No. 3, P-No. 43 and F-No. 43 as required by QW-424 of ASME Section IX. The results and justification for this testing are summarized below. In addition, a mockup containing P-No. 3, P-No 43, and F-No. 43 materials equivalent to the materials combined in the RVCH, CRDM nozzle, and repair weld will be tested. The test results from this assembly will be provided to the NRC by April 26, 2002.

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 for 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:

(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.

(6) Furthermore, from a practical perspective, due to the size of the groove (cavity) used in PQR 55-PQ7164, and the weld deposition sequencing used, the effects of welding P-No. 43 to P-No. 43 with F-No. 43 filler metal can be

considered to have been evaluated (F-No. 43 to F-No.43) by this PQR and the effects of welding P-No. 43 to P-No. 3 Group No. 3 base material can be considered to have been evaluated by this PQR.

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_2) and no more than 0.5 PPM of water vapor (H_2O). 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 IWA-4410 IWA-4410(a) IWA-4410(c)	WELDING, BRAZING, METAL REMOVAL, AND INSTALLATION General Requirements 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). Alternatively, the applicable requirements of IWA-4600 may be used for welding, ...	No alternative to IWA-4410(a) or IWA-4410(c) is requested.
IWA-4600 IWA-4600(b)	ALTERNATIVE WELDING METHODS 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 • IWA-4610(a)	General Requirements for All Materials 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
	attachment and removal shall be in accordance with Section III.	
• IWA-4610(b)	The welding procedure and the welders or welding operators shall be qualified in accordance with Section IX and the additional requirements of this Subarticle.	Relief is requested from this Code Requirement. The welding procedure has been qualified in accordance with the requirements of paragraphs 2.0 and 2.1 specified in the Alternative Welding Method with the exception that only P-No. 3 material and F-No. 43 material were contained in the welding procedure qualification test, not P-No. 3, P-No. 43 and F-No. 43 as required by QW-424 of ASME Section IX.
IWA-4610(c)	The neutron fluence in the weld area shall be taken into account when establishing the weld metal composition limits.	The proposed alternative is in compliance with this Code paragraph.

Paragraph or Subparagraph	Requirement	Alternative
IWA-4611	Metal Removal	
IWA-4611.1	General Requirements	
• IWA-4611.1(a)	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	Thermal Removal Process	This Code Requirement is not applicable to the proposed alternative.
IWA-4611.3	Mechanical Removal Processes	
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	Examination Following Metal Removal	
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
	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.	paragraph.
IWA-4611.4(b)	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.	The proposed alternative is in compliance with this Code paragraph.

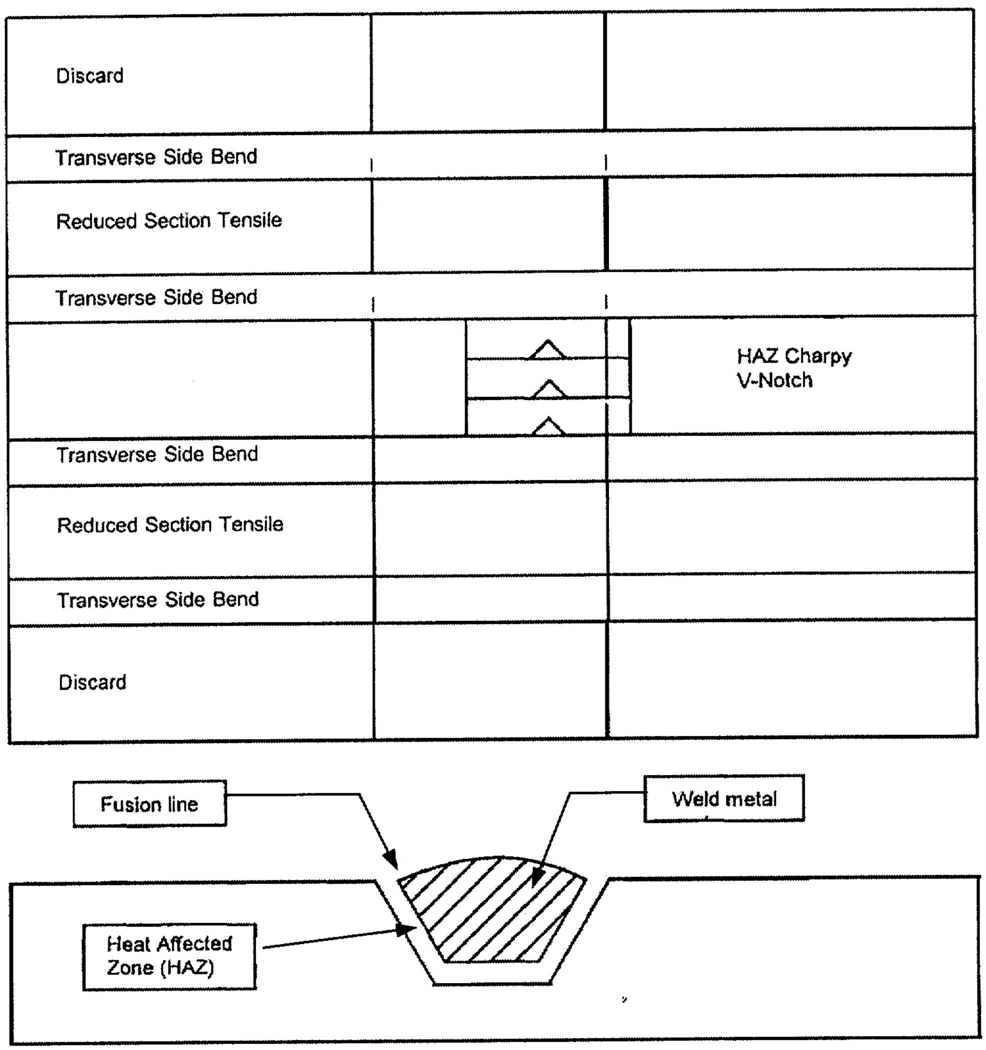
Paragraph or Subparagraph	Requirement	Alternative
IWA-4630	Dissimilar Materials	
IWA-4631	General Requirements	
IWA-4631(a)	Repair/replacement activities on welds that join P-No. 8 or P-No. 43 material to P-No. 1, 3, 12A, 12B, and 12C material may be made without the specified post weld heat treatment, provided the requirements of IWA-4631(b) and IWA-4632 through IWA-4634 are met.	The proposed alternative is in compliance with this Code paragraph except where relief is noted below.
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.	The proposed alternative is in compliance with this Code paragraph.
IWA-4632	Welding Procedure Qualification	
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 a 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.	The proposed alternative is in compliance with this Code paragraph.
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	
IWA-4633.1	Shielded Metal-Arc Welding	This Code Requirement is not applicable to the proposed alternative.

Paragraph or Subparagraph	Requirement	Alternative
IWA-4633.2	**Gas Tungsten-Arc Welding.** 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 ±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 my be performed at maximum interpass temperature of 350°F.	The proposed alternative is in compliance with this Code paragraph

Paragraph or Subparagraph	Requirement	Alternative
• IWA-4634	Examination 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.	Relief is requested from this Code Requirement. The entire preheated band specified in IWA-4610(a) is not liquid penetrant examined following welding.
IWA-4540 IWA-4540(a)	Pressure Testing of Class 1, 2, and 3 Items 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.	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. 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.
• NB-5245 (1992 Edition)	**Partial Penetration Welded Joints** 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.	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.

Paragraph or Subparagraph	Requirement	Alternative
NB-5330 (1992 Edition) • NB-5330(b)	**Ultrasonic Acceptance Standards** Indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.	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.

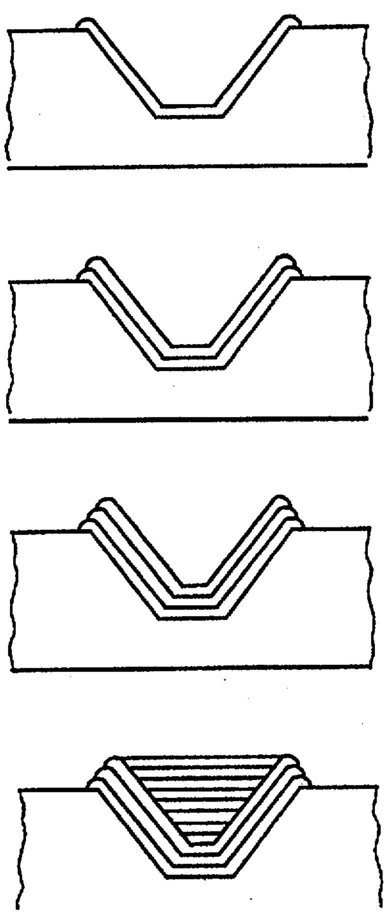
- Relief from this Code Paragraph is Requested



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

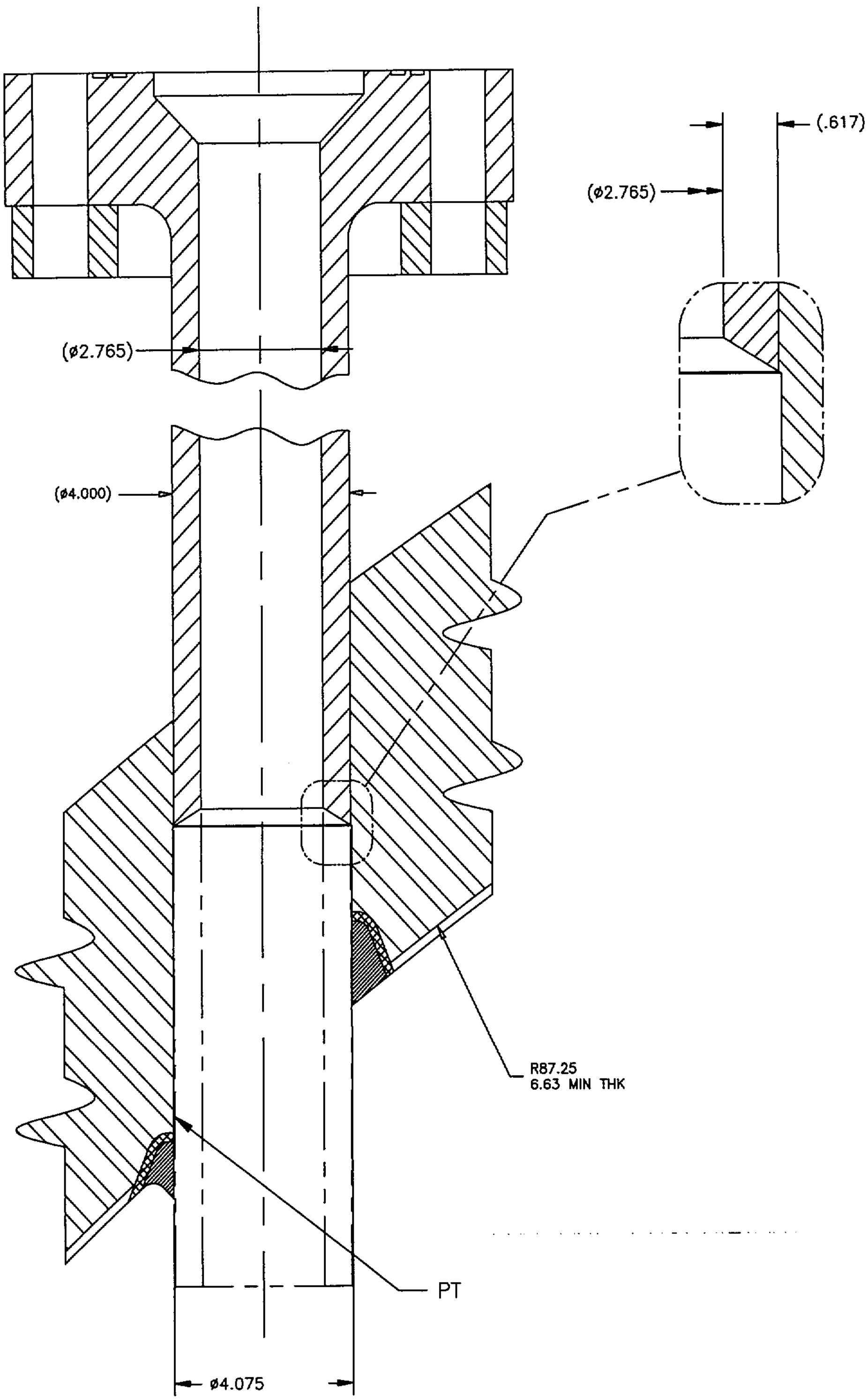


Figure 3
CRDM Machining

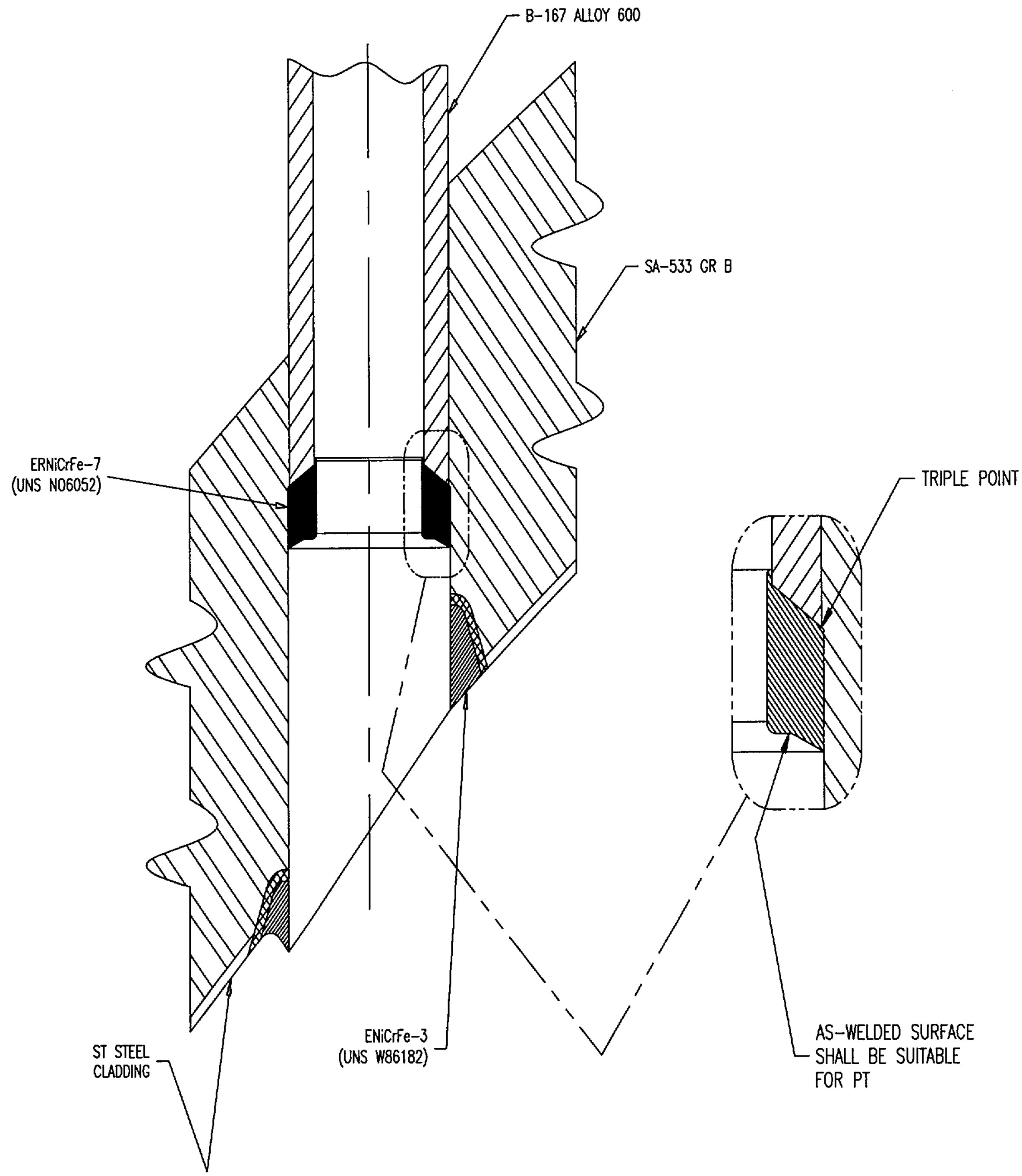


Figure 4
New CRDM Pressure Boundary Weld

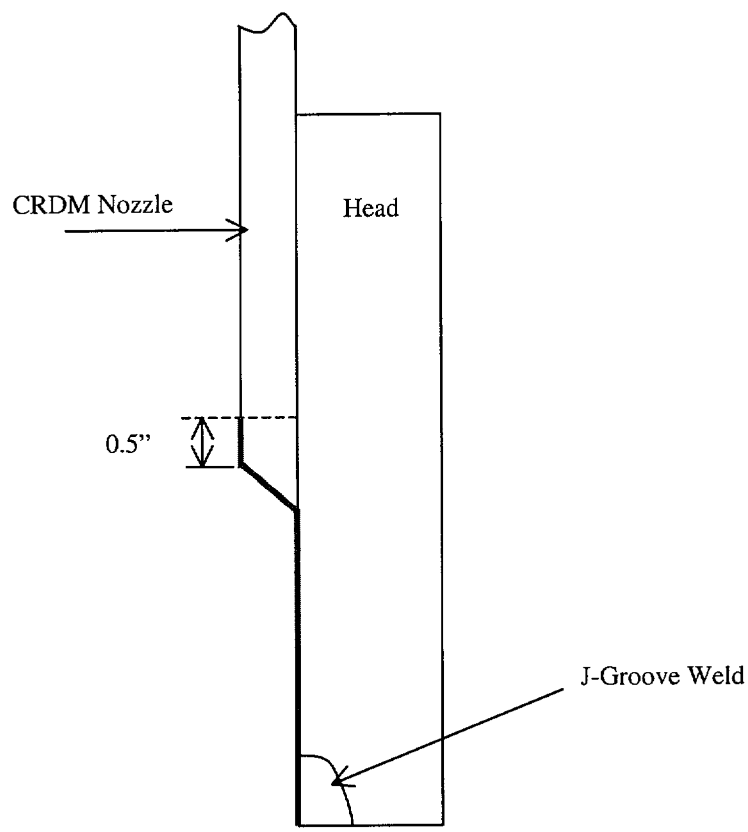


Figure 5
CRDM Temper Bead Weld Repair,
PT Coverage Prior to Welding

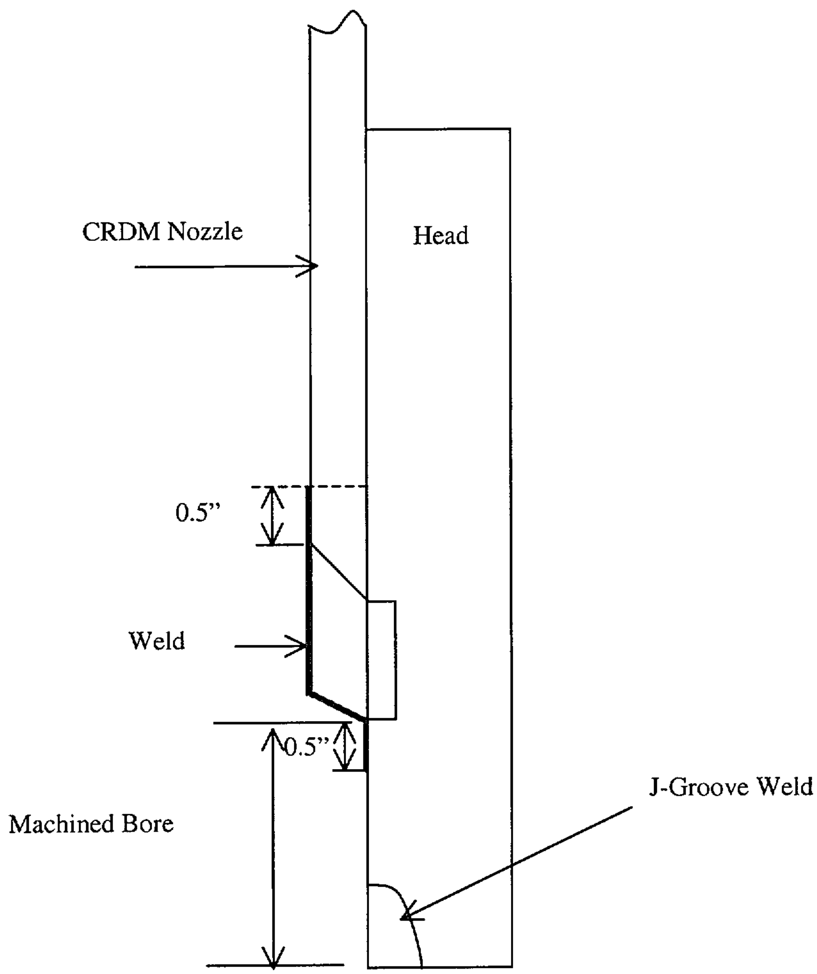


Figure 6
CRDM Temper Bead Weld Repair,
PT Coverage After Welding

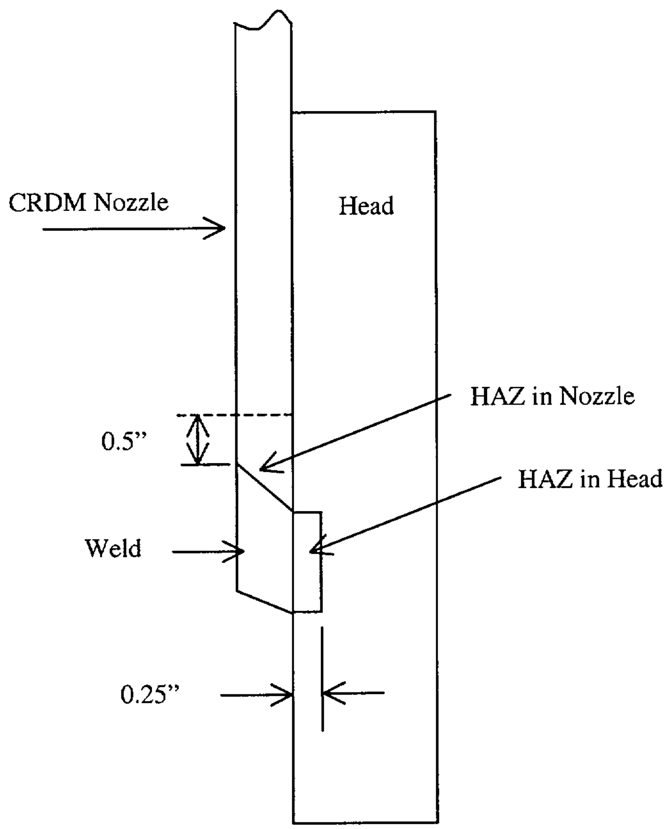


Figure 7
CRDM Temper Bead Weld Repair
Areas to be Examined

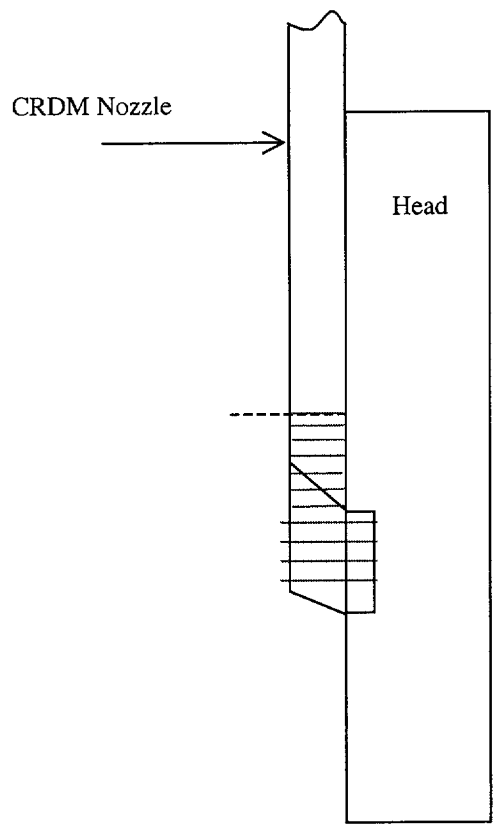


Figure 8
CRDM Temper Bead Weld Repair,
UT 0 degree and 45L Beam Coverage
Looking Clockwise and Counter-clockwise

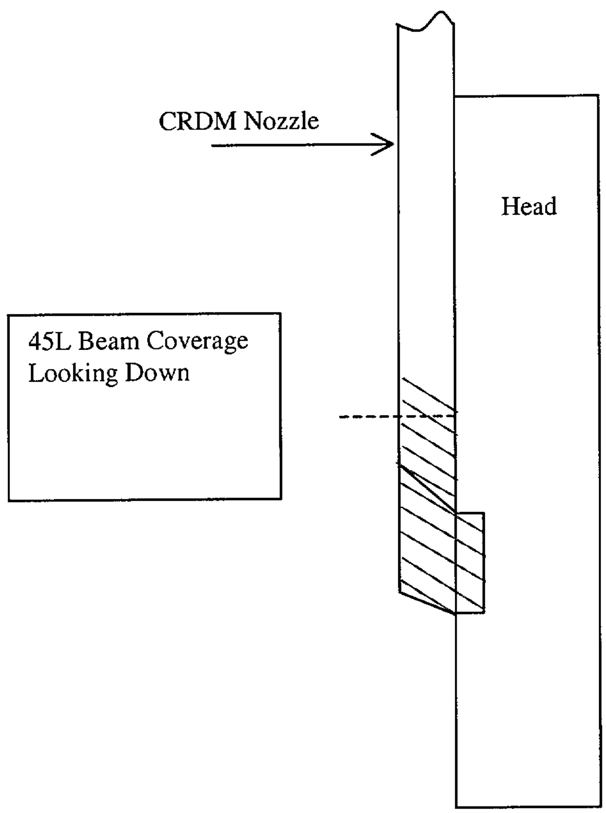


Figure 9
CRDM Temper Bead Weld Repair,
45L UT Beam Coverage Looking Down

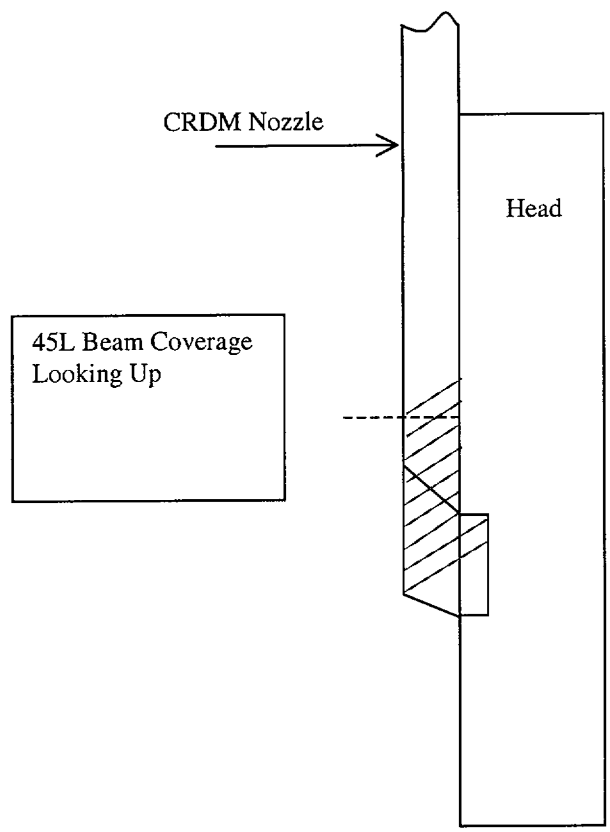


Figure 10
CRDM Temper Bead Weld Repair,
45L UT Beam Coverage Looking Up

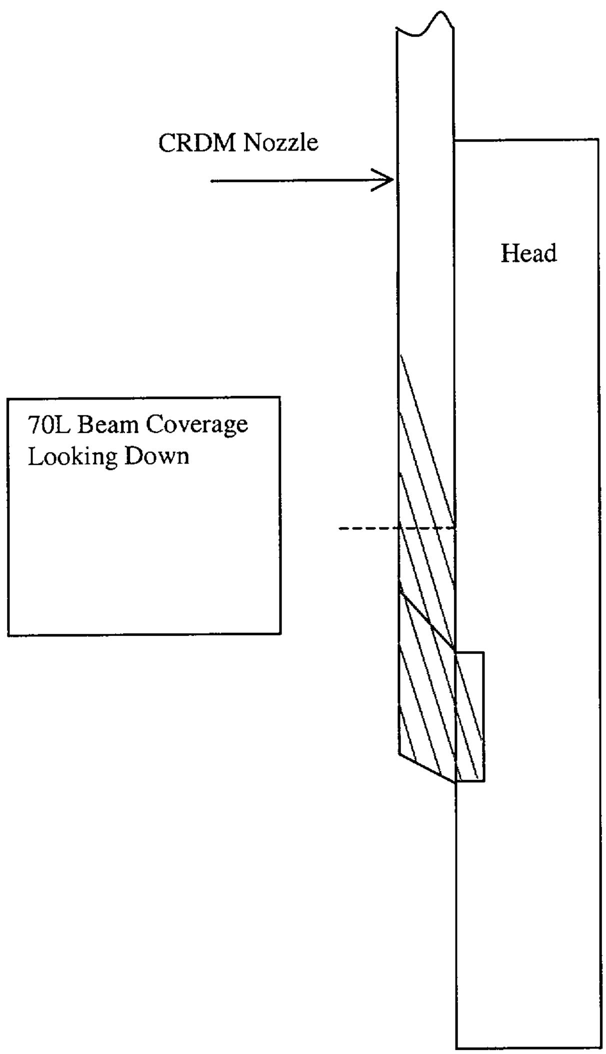


Figure 11
CRDM Temper Bead Weld Repair,
70L UT Beam Coverage Looking Down

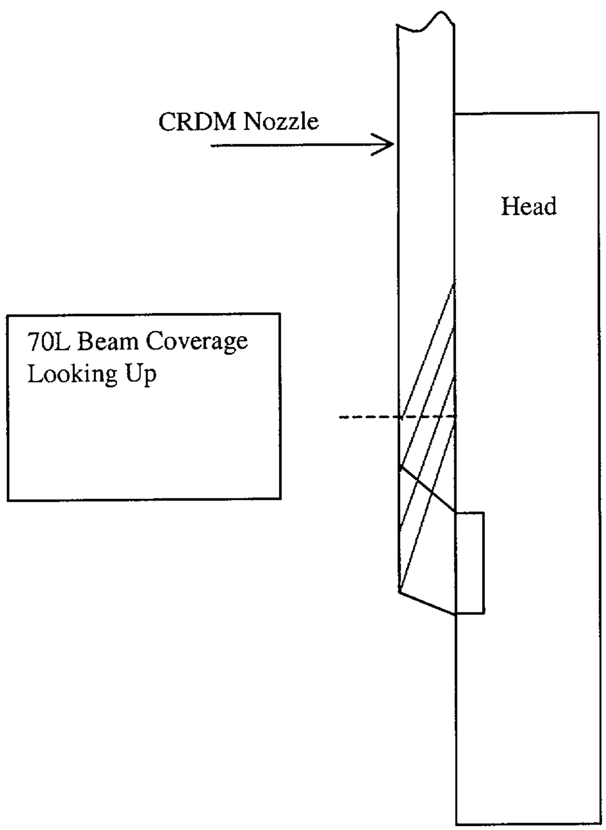


Figure 12
CRDM Temper Bead Weld Repair,
70L UT Beam Coverage Looking Up

DBNPS ISI Program – Third Ten-Year Interval
Relief Request RR-A21

(10 Pages Follow)

FIRSTENERGY NUCLEAR OPERATING COMPANY
DAVIS-BESSE UNIT 1
THIRD 10-YEAR INSERVICE INSPECTION INTERVAL
RELIEF REQUEST RR-A21

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-4611.1(a) of the 1995 Edition through the 1996 Addenda of ASME Section XI requires in part that "Defects shall be removed or reduced in size in accordance with this Paragraph." Furthermore, IWA-4611.1(a) allows that "...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."

IWA-3300 of the 1995 Edition through the 1996 Addenda of ASME Section XI requires characterization of flaws detected by inservice examination.

IWB-3420 of the 1995 Edition through the 1996 Addenda of ASME Section XI requires each detected flaw or group of flaws 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.

IWB-3142.4 of the 1995 Edition through the 1996 Addenda of ASME Section XI requires that a component accepted for continued service based on analytical evaluation shall be subsequently examined in accordance with IWB-2420(b) and (c).

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

Code Requirement from Which Relief is Requested:

The FirstEnergy Nuclear Operating Company (FENOC) requests the NRC grant relief for the Davis-Besse Nuclear Power Station (DBNPS) in accordance with 10 CFR 50.55a(g)(6)(i) from performing flaw characterization as required by IWA-3300 and IWB-3420. Following the repair of the CRDM nozzles, it is assumed that flaws will remain in the original CRDM to RVCH J-groove weld. During the repair process, FENOC will remove portions of the original J-groove weld to limit the size of the flaws that remain. As an alternative and in lieu of fully characterizing the existing cracks, FENOC proposes to utilize worst-case assumptions to conservatively estimate the crack extent and orientation. This will provide a reasonable assurance of maintaining the RVCH structural integrity.

FENOC requests the NRC grant relief in accordance with 10 CFR 50.55a(g)(6)(i) from IWB-3142.4. IWB-3142.4 requires that components found acceptable for continued service by analytical evaluation be subject to successive examination. Analytical evaluation of the worst case flaw in the J-groove weld will be performed, as stated above, to demonstrate the acceptability for continued operation. However, because of the impracticality of performing any subsequent examination that would be able to characterize any remaining flaw, successive examination will not be performed because there will be no baseline data for comparison. A reasonable assurance of the RVCH structural integrity is maintained without the successive examination by the fact that evaluation will have shown the worst case flaw to be acceptable for continued operation.

FENOC requests the NRC grant relief in accordance with 10 CFR 50.55a(a)(3)(i) from NB-5330(b). The new pressure boundary weld that will connect the remaining portion of the CRDM nozzle to the low alloy RVCH contains a material "triple point". The triple point is at the root of the weld where the Alloy 600 CRDM nozzle will be welded with Alloy 690 (52/152) filler metal to the SA-533 Grade B, Class 1 Mn-Mo low alloy RVCH. (See Figures 1 and 2). Experience has shown that during solidification of the Alloy 690 weld filler material, a lack of fusion (otherwise known as a welding solidification anomaly) area may occur at the root of the partial penetration welds. However, this will still provide an acceptable level of quality and safety.

Because of the acceptability of the presence of the triple point anomaly, FENOC requests the NRC grant relief from IWB-3142.4 in accordance with 10 CFR 50.55a(a)(3)(i) for the successive examination of the anomaly. As stated previously, the presence of the anomaly has been evaluated to provide an acceptable level of quality and safety. Elimination of successive examination of the anomaly is justified based on the anomaly's acceptability, and provides an acceptable level of quality and safety.

Basis for Relief:

Inspections of the RVCH performed in accordance with the DBNPS response to NRC Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," may discover small amounts of boron emanating from the CRDM nozzle interface with the outside radius of the RVCH or subsequent NDE may confirm the presence of flaws which may require repairs.

Experience gained from the repairs to the Oconee Unit 1 and Unit 3 CRDM nozzles indicated that removal and repair of the defective portions of the original J-groove partial penetration welds were time consuming and radiation dose intensive. The previous repairs indicated that more remote automated repair methods were needed to reduce radiation dose to repair personnel. For the DBNPS repairs, a remote semi-automated repair method is planned for each nozzle requiring repair. Using a remote tool, each nozzle requiring repair will first receive a roll expansion into the RVCH base material to ensure that the nozzle will not move during subsequent repair operations. Second, a semi-automated machining tool from underneath the RVCH will remove the lower portion of the nozzle to a depth above the existing J-groove partial penetration weld. This operation will sever the existing J-groove partial penetration weld from the CRDM nozzle. Third, a chamfer will be machined into the end of the CRDM nozzle in preparation for the repair weld. Fourth, a semi-automated weld tool, utilizing the machine Gas Tungsten-Arc Welding (GTAW) process, will then be used to install a new Alloy 690 pressure boundary weld between the shortened nozzle and the inside bore of the RVCH base material (See Figures 1 and 2). Finally, the original J-groove weld is chamfered to assure the remaining weld metal is thinner than the maximum allowable flaw size. NB-3352.4(d)(3) of the 1989 Edition of ASME Section III requires that the corners of the end of each nozzle to be rounded to a radius of ½ t_n or ¾ inch whichever is smaller. The functionally equivalent 1/8 inch minimum chamfer discussed above will be used in lieu of the radius.

It is intended, as part of the new repair methodology and to reduce radiation dose to repair personnel, that the original J-groove partial penetration welds will be left in place. These welds will no longer function as pressure boundary CRDM nozzle to closure head welds. However, the possible existence of cracks in these welds mandates that the flaw growth potential be evaluated.

IWA-3300/IWA-3420/IWA-3142.4 – Flaw Characterization

The requirements of IWA-4611.1 allow two options for determining the disposition of discovered cracks. The subject cracks are either removed as part of the repair process or left as-is and evaluated per the rules of IWB-3600.

The assumptions of IWB-3600 are that the cracks are fully characterized in order to compare the calculated crack parameters to the acceptable parameters addressed in IWB-3500. In the alternative being proposed, the acceptance of the postulated crack is calculated based on the two inputs of expected crack orientation and the geometry of the weld. Typically, an expected crack orientation is evaluated based on prevalent stresses at the location of interest. In these welds, operating stresses were obtained using finite element analysis of the RVCH. Since hoop stresses were calculated to be the dominant stress, it is expected that radial type cracks (with respect to the penetration) will occur. Using worst case (maximum) assumptions with the geometry of the as-left weld, the postulated crack was assumed to begin at the intersection of the RVCH inner diameter surface and the CRDM nozzle bore and propagate slightly into the RVCH low alloy steel. The depth and orientation are worst-case assumptions for cracks that may occur in the remaining J-groove partial penetration weld configuration.

The original CRDM nozzle to closure head J-groove weld is extremely difficult to examine ultrasonically (UT) due to the compound curvature and fillet radius as can be seen in Figures 1 and 2. These conditions preclude ultrasonic coupling and control of the sound beam needed to perform flaw sizing with reasonable confidence in the measured flaw dimension. Therefore, it is impractical to, and presently no NDE technology has been identified that can, characterize the flaw geometry that may exist therein. Not only is the configuration not conducive to UT, but the dissimilar metal interface between the Alloy 600 weld and the low alloy steel RVCH increases the UT difficulty. Furthermore, due to limited accessibility from the RVCH outer surface and the proximity of adjacent nozzle penetrations, it is impractical to scan from this surface on the RVCH base material to detect flaws in the vicinity of the original weld. FENOC proposes to accept these flaws by analysis of the worst case that might exist in the J-groove weld. Since the worst case condition has been analyzed as describe below, no future examinations of these flaws is planned.

As previously discussed, after the boring and removal of the nozzle end, the remaining weld will be chamfered to assure the remaining weld metal is thinner than the maximum allowable flaw size. Since it has been determined that through-wall cracking in the J-groove weld will most likely accompany a leaking CRDM nozzle, it must be assumed that the "as-left" condition of the remaining J-groove weld includes degraded or cracked weld material.

A fracture mechanics evaluation was performed to determine if degraded J-groove weld material could be left in the RVCH, with no examination to size any flaws that might remain following the repair. Since the hoop stresses in the J-groove weld are generally about two times the axial stress at the same location, the preferential direction for cracking is axial, or radial relative to the nozzle. It was postulated that a radial crack in the Alloy 182 weld metal would propagate by Primary Water Stress Corrosion Cracking (PWSCC) through the weld and butter, to the interface with the low alloy steel head. It is fully expected that such a crack would then blunt and arrest at the butter-to-head interface. On the uphill side of the nozzle, where the hoop stresses are highest and the area of the J-groove weld is largest, a radial crack depth extending from the corner of the weld to the low alloy steel head would be very deep, up to and about 1¾ inch at the outermost row of nozzles.

Ductile crack growth through the Alloy 182 material would tend to relieve the residual stresses in the weld as the crack grew to its final size and blunted. Although residual stresses in the head material are low, it was assumed that a small flaw could initiate in the low alloy steel material and grow by fatigue. It was postulated that a small flaw in the head would combine with a large stress corrosion crack in the weld to form a radial corner flaw that would propagate into the low alloy steel head by fatigue crack growth under cyclic loading associated with heat-up and cool-down.

Residual stresses were not included in the flaw evaluations since it was demonstrated by analysis that these stressed are compressive in the low alloy steel base material. Any residual stresses that remained in the area of the weld following the boring operation would be relieved by such a deep crack, and therefore need not be considered.

Flaw evaluations were performed for a postulated radial corner crack on the uphill side of the head penetration, where stresses are the highest and the radial distance from the inside corner to the low alloy steel base metal (crack depth) is the greatest. Hoop stresses were used since they are perpendicular to the plane of the crack. Fatigue crack growth, calculated for 20 years of operation, was minimal (about 0.032 inch), and the final flaw size met the fracture toughness requirements of the ASME Code using an upper shelf value of 200 ksi$\sqrt{}$in for ferritic materials.

Based on the analysis performed, it is acceptable to leave the postulated cracks in the attachment (J-groove) and buttering. The calculations performed show the remaining flaws within the base material are acceptable for 20 years. The only driving mechanism for fatigue crack growth of the base material is heat-up/cool-down cycles (6 heat-up/cool-down cycles conservatively assumed per year). The fracture mechanics evaluation assumes a radial (with respect to the penetration center line) crack exists with a length equal to the partial penetration weld preparation depth. Based on industry experience and operating stress levels, there is no reason for service related cracks to exist in the ferritic material.

Removal of the cracks in the existing J-groove partial penetration welds would incur excessive radiation dose for repair personnel. With the installation of the new pressure boundary welds previously described, the original function of the J-groove partial penetration welds is no longer required. It is well understood that the cause of the cracks in the J-groove welds is PWSCC. As shown by industry experience, the low alloy steel of the RVCH impedes crack growth by PWSCC. FENOC believes the alternative described will provide a reasonable assurance of the RVCH structural integrity when compared to the Code requirements in IWB-3500 to characterize the cracks in service. Using flaw tolerance techniques, it has been determined that the assumed worst-case crack size would not grow to an unacceptable depth into the RVCH low alloy steel. Thus the RVCH can be accepted per the requirements of IWA-4611.1.

Based on extensive industry experience and Framatome-ANP direct experience, there are no known cases where flaws initiating in an Alloy 82/182 weld have propagated into the ferritic base material. The surface examinations performed associated with flaw removal during recent repairs at Oconee 1 and 3 on RVCH CRDM penetrations, Catawba 2 steam generator channel head drain connection penetration, ANO-1 hot leg level tap penetrations, and the V.C. Summer Hot Leg pipe to primary outlet nozzle repair (Reference MRP-44: Part I: Alloy 82/182 Pipe Butt Welds, EPRI, 2001. TP-1001491) all support the assumption that the flaws would blunt at the interface of the NiCrFe weld to ferritic base material. Additionally, the Small Diameter Alloy 600/690 Nozzle Repair Replacement Program (CE NSPD-1198-P) provides data that shows PWSCC does not occur in ferritic pressure vessel steel. Based on industry experience and operation stress levels there is no reason for service related cracks to propagate into the ferritic material from the Alloy 82/182 weld.

An additional evaluation was made to determine the potential for debris from a cracking J-groove partial penetration weld. As noted above, radial cracks were postulated to occur in the weld due to the dominance of hoop stresses at this location. This possibility of occurrence of 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.

These evaluations provide a reasonable assurance for ensuring that the RVCH remains capable of performing its design function for 20 years, with flaws existing in the original J-groove weld. For the reasons described above, areas containing flaws accepted by analytical evaluation will not be reexamined as required by IWB-3142.4 since the subsequent examinations are impractical to perform. Because of the acceptability of the flaws, granting relief to eliminate successive examination will not affect assurance that the RVCH remains capable of performing its design function.

NB-5330(b)/IWB-3142.4 – Triple Point Anomaly

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 head, the Alloy 600 nozzle and the first Alloy 52 weld bead intersect. Welding solidification is an inherent problem when using high NiCr alloys in the presence of a notch located at the so-called triple point. NB-5330(b) of the 1992 Edition of ASME Section III stipulates that no lack of fusion area be present in the weld. A fracture mechanics analysis was performed to provide justification, in accordance with ASME Section XI, for operating with the postulated weld anomaly described above. The anomaly was modeled as a 0.1 inch semi-circular "crack-like" defect 360° around the circumference at the triple point location. Postulated flaws could be oriented within the anomaly such that there are two possible flaw propagation paths, as discussed below.

Path 1:

Flaw propagation path 1 that traverses the CRDM tube wall thickness from the OD of the tube to the ID of the tube. This is the shortest path through the component wall, passing through the new Alloy 690 weld material. However, Alloy 600 tube material properties or equivalent were used to ensure that another potential path through the HAZ between the new repair weld and the Alloy 600 tube material is bounded.

For completeness, two types of flaws were postulated at the outside surface of the tube. A 360 degree continuous circumferential flaw, lying in a horizontal plane, was considered to be a conservative representation of crack-like defects that may exist in the weld anomaly. This flaw was subjected to axial stresses in the tube. An axially oriented semi-circular outside surface flaw was also considered since it would lie in a plane normal to the higher circumferential stresses. Both of these flaws would propagate toward the inside surface of the tube.

Path 2:

> Flaw propagation path 2 runs down the outside surface of the repair weld between the weld and the RVCH. A semi-circular cylindrically oriented flaw was postulated to lie along this interface, subjected to radial stresses with respect to the tube. This flaw may propagate through either the new Alloy 690 weld material or the low alloy steel RVCH material.

The results of the analysis demonstrated that a 0.10 inch weld anomaly is acceptable for a 20 year design life of the CRDM ambient temperature temper bead weld repair. Significant fracture toughness margins were obtained for both of the flaw propagation paths considered in this analysis. The minimum calculated fracture toughness margins, 10.8 for path 1 and 25.2 for path 2, 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 0.1003 inch considering both flaw propagation paths. A limit load analysis was also performed considering the ductile Alloy 600/Alloy 690 materials along flaw propagation path 1. The analysis showed limit load margins of 9.83 and 6.95 for normal/upset conditions and emergency/faulted conditions, respectively. These are significantly greater than the required margins of 3.0 and 1.5 for normal/upset and emergency/faulted conditions, respectively, per paragraph IWB-3642 of ASME Section XI.

This evaluation was prepared in accordance with ASME Section XI and demonstrated that for the intended service life of the repair, the fatigue crack growth was acceptable and the crack-like indications remained stable. These two findings satisfied the Section XI criteria but do not include considerations of stress corrosion cracking such as primary water stress corrosion cracking (PWSCC) or residual stresses. However, 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 regardless of residual stresses.

Residual stresses also require consideration for ductile tearing when operating stresses are superimposed. The residual stress field by itself cannot promote ductile tearing or it would not be stable during welding. The anomalies have been shown to be stable by welding mockups simulating the actual geometry and materials. Even though the residual stresses for this type of weld would be very complex, it is apparent that by the size of the weld and the nature of the restraint that the residual stresses would have limited effect on driving a crack. The weld residual stresses are not like piping thermal expansion stresses where there may be considerable stored energy in long runs of pipe. The weld residual stresses are imposed by the inability of the weld bead to shrink to a nominal strain condition upon cooling. The attachment of the weld to the surrounding material generally promotes tensile stresses in the bead upon cooling. Even though the stresses are generally at the yield strength, the accompanying strains are not large due to the limited size of beads and in this case the total size of the weld.

It is concluded that the residual stress field would produce a minimal ductile tearing driving force in the Ni-Cr-Fe materials that are extremely crack tolerant when not in an aggressive environment. The ASME Section XI evaluation performed is adequate, residual stresses need not be considered because PWSCC effects are not applicable, and the geometry is not conducive to sustained ductile tearing. Accordingly, the proposed alternative provides an acceptable level of quality and safety.

For the reasons described above, the areas containing the triple point anomaly accepted by analytical evaluation will not be reexamined as required by IWB-3142.4. The evaluation of the triple point anomaly has shown it to be acceptable, and elimination of successive examinations as required by the ASME B&PV Code is justified and provides an acceptable level of quality and safety.

Elimination of the weld triple point anomaly would require use of an entirely different process than proposed for use at the DBNPS. The only qualified method currently available would involve extensive manual welding that would result in radiation doses estimated to be on the order of 30 rem per nozzle as compared to the 7 to 8 rem estimated for each nozzle repaired by the proposed process.

Alternative Examination Criteria:

The planned repair for the CRDM nozzles does not include removal of the cracks discovered in the remaining J-groove partial penetration welds. Therefore, per the requirements of IWA-4611.1, the cracks must be evaluated using the appropriate flaw evaluation rules of ASME Section XI. No additional inspections are planned to characterize the cracks. Thus, the actual dimensions of the flaw will not be fully determined as required by IWA-3300. In lieu of fully characterizing the existing cracks, FENOC has used worst-case assumptions to conservatively estimate the crack extent and orientation. The postulated crack extent and orientation has been evaluated versus the rules of IWB-3600.

If a triple point anomaly occurs in any of the repair welds, it must be evaluated using the appropriate flaw evaluation rules of Section XI. Calculations have been completed which justify this welding solidification anomaly. No additional inspections of this anomaly are planned.

Implementation Schedule:

The alternative examination requirements will be applied to CRDM nozzles that require repair during the Third 10-Year Inservice Inspection Interval.

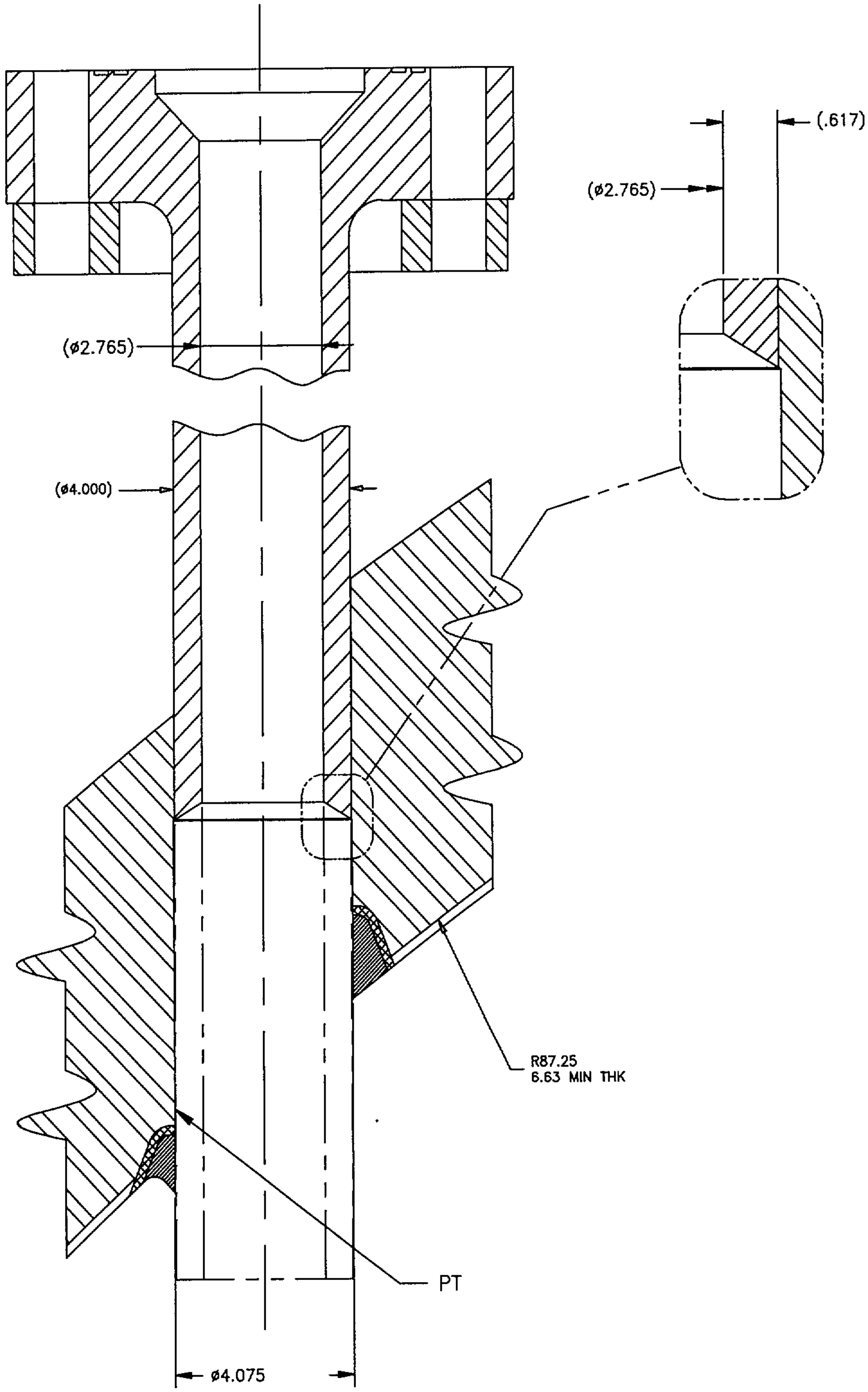


Figure 1
CRDM Machining

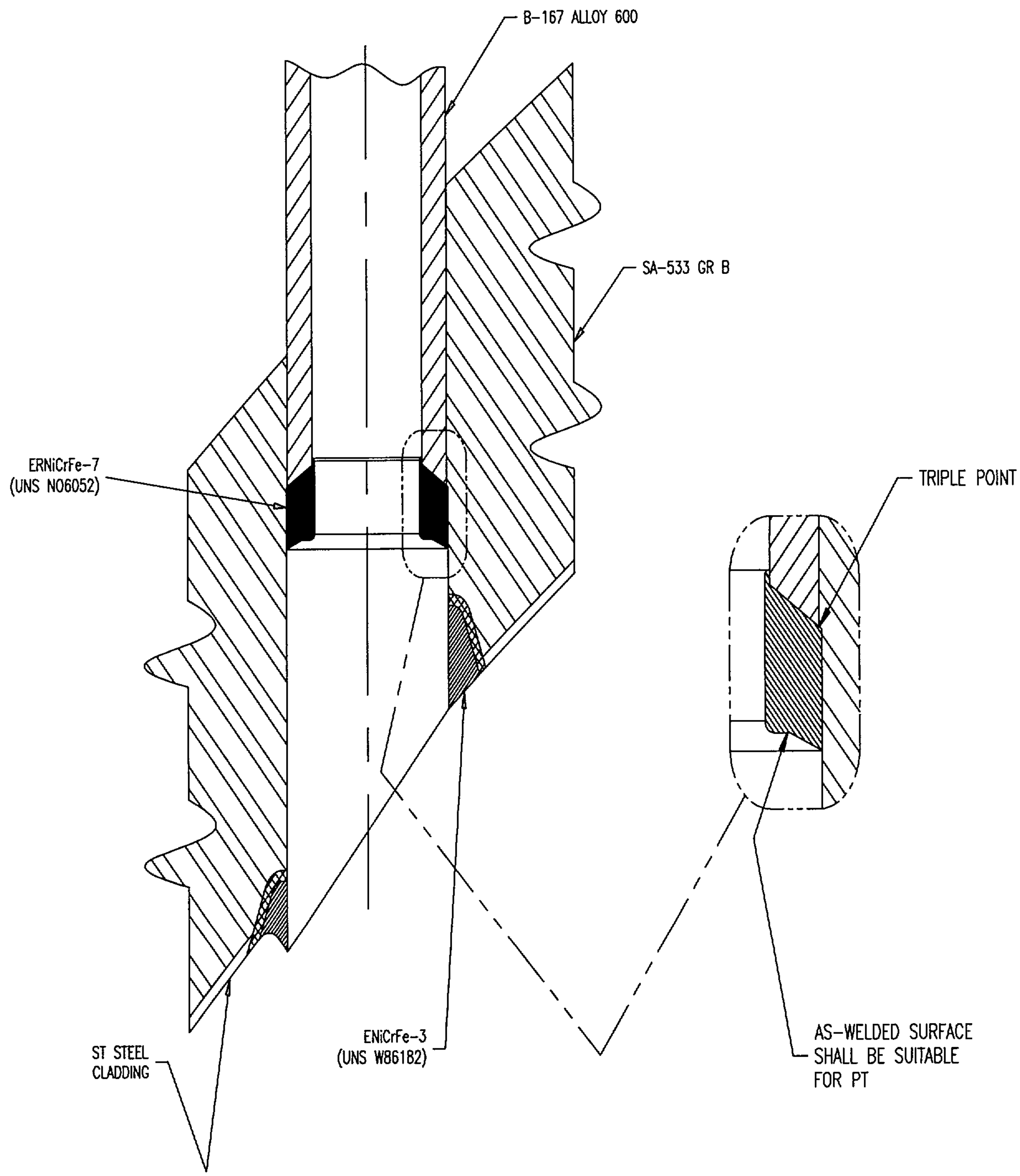


Figure 2
New CRDM Pressure Boundary Weld

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
A mockup containing P-No. 3, P-No 43, and F-No. 43 materials equivalent to the materials combined in the RVCH, CRDM nozzle, and repair weld will be tested. The test results from this assembly will be provided to the NRC.	April 26, 2002