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

Subject: 10 CFR 50.55a Requests for Alternative Pursuant to 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-A23 and RR-A24)

Ladies and Gentlemen:

The purpose of this letter is to request NRC approval of alternatives to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) for the Davis-Besse Nuclear Power Station, Unit 1 (DBNPS) Third Ten-Year Inservice Inspection Interval pursuant to 10 CFR 50.55a(a)(3)(i). The attached requests propose alternatives to ASME Code Section XI repair requirements for the Reactor Vessel Closure Head Control Rod Drive Mechanism nozzle number 2 penetration.

Review and approval of the attached requests for alternative is requested by May 16, 2002. 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
C.S. Thomas, DB-1 Senior Resident Inspector
Utility Radiological Safety Board

DBNPS ISI Program – Third Ten-Year Interval
Relief Request RR-A23

(31 Pages Follow)

**FIRST ENERGY NUCLEAR OPERATING COMPANY**
**DAVIS-BESSE UNIT 1**
**THIRD 10-YEAR INTERVAL**
**RELIEF REQUEST RR-A23**

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

Reactor Vessel Closure Head (RVCH) Control Rod Drive Mechanism (CRDM) nozzle penetrations. There are 69 CRDM nozzle penetrations welded to the RVCH. The ASME 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 Requirements 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 weld heat treatment requirements of the original Construction Code. The alternative temper bead methods for dissimilar metal welds (IWA-4610 and IWA-4630) of the 1995 Edition through the 1996 Addenda of ASME Section XI require elevated temperature preheat and post weld soaks that would result in increased radiation dose to repair personnel due to the need to install heat treatment equipment.

As an alternative to the requirements of IWA-4600, the 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. Table 1 provides a comparison of the proposed repair activities to the ASME Section XI Code requirements. As noted in Table 1, relief is requested from the following Code requirements.

- IWA-4610(a) – Thermocouples
- IWA-4610(b) – Interpass Temperature
- IWA-4632(b) – Charpy Impact Testing
- IWA-4633.2(c) – Ambient Temperature Temper Bead Welding in accordance with the methodology of Code Case N-638
- IWA-4610(a) - Preheat Temperature/ IWA-4633.2(d) – Postweld Hydrogen Bake
- IWA-4634 – Examination
- NB-5245 - Partial Penetration Weld Joints

**Alternative Welding Method (N-638 Methodology and Alternatives):**

The FENOC plans to perform Control Rod Device Mechanism (CRDM) nozzle penetration repairs by removing the CRDM nozzle by mechanical means and welding the Reactor Pressure Vessel Closure Head (RVCH) (P-No. 3 base material) and a CRDM nozzle plug (P-No. 43 base material) with F-No. 43 filler material. 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. The 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 Davis-Besse 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.*

## 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.

*Welding 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 1inch. 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.

*The requirements of NB-4335 of the 1989 Edition of ASME Section III will be used to verify the impact properties of the ambient temperature temper bead welding process.*

### 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 (ERNiCrFe-7) for P-No. 43 to P-No. 3 weld joints. SB-564 UNS N06690 (NiCrFe Alloy 690) is considered P-No. 43 in Code Case N-474-2. Code Case N-474-2 is approved in NRC Regulatory Guide 1.85, Revision 31.*

(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. The maximum interpass temperature used for the welding procedure qualification was <100°F.*

(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). If thermocouples are used and welded to the surface, the area from which the thermocouple is removed will be ground and examined using a surface examination method.*

(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.

*The records required by IWA-6000 will be generated.*

**Basis for Relief:**

The repair process will consist of the following activities:

a) The degraded area will be blended by abrasive grinding and then the surfaces examined using liquid penetrant (PT). As left dimensions will be taken of the blended area.

b) The entire RVCH nozzle bore, with the exception of the J-weld groove weld, will then examined using PT.

c) An Alloy 690 plug will then machine fit and inserted into the RVCH nozzle bore.

d) The Alloy 690 plug will be welded to the RVCH nozzle bore with a remotely operated machine GTAW weld head. The ambient temperature GTAW temper bead process will apply ERNiCrFe-7 (Alloy 52) filler metal and 50°F minimum preheat temperature. No post-weld hydrogen bake will be used.

e) The final weld face, not including the taper transition, will be machined and/or ground suitable for inspection.

f) Following a Code-required 48 hour hold period, the final weld will be PT and ultrasonically (UT) examined.

g) A 1/8 inch minimum chamfer will be ground at the bottom end of the RVCH nozzle bore in the remnant of the original CRDM nozzle to RVCH J- groove weld. The original J-groove weld is chamfered to assure the remaining weld metal is no greater than the maximum Code-allowable flaw size.

The installation of the CRDM nozzle penetration plug is illustrated in Figures 3 and 4.

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 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 Davis-Besse 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 not be a concern.

RVCH interpass 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) – Interpass Temperature

The P-No. 43 to P-No. 3 welding procedure has a maximum interpass temperature of 350°F. The welding procedure was qualified with an interpass temperature less than 100°F. Per QW-256 of ASME Section IX an increase greater than 100°F is an supplementary essential variable. The procedure qualification requirements recommended in Code Case N-638 imposes a 150°F maximum interpass temperature during the welding of the procedure qualification. This requirement restricts base metal heating during qualification that could produce slower cooling rates that are not achievable during field applications. However, this requirement does not apply to field applications as a 350°F maximum interpass temperature is a requirement in Section 3.0 of the Code Case N-638. The higher interpass temperature is permitted because it would only result in slower cooling rates which could be helpful in producing more ductile transformation products in the heat affected zone. As indicated previously, the actual interpass temperature in situ will be near the preheat temperature.

IWA-4632(b) – Charpy Impact Testing

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 the requirements of NB-4335 of the 1989 Edition of ASME Section III were used to verify the Charpy impact properties of the ambient temperature temper bead welding process.

During the Charpy impact testing portion of the qualification process, the reference temperature ($RT_{NDT}$) was determined to be -30°F. At $RT_{NDT}$ +60°F temperature (+30°F), the average of the HAZ absorbed energy Charpy impact tests was greater than the average of the base material. However, the average of the mils lateral expansion for the HAZ was less than the average values for the base material. Additional Charpy V-notch tests were conducted on the HAZ material as permitted by NB-4335.2 to determine an additive temperature to the $RT_{NDT}$ temperature. The average mils lateral expansion for the HAZ at +35°F was equivalent to the unaffected base material at +30°F. These test results require an adjustment temperature of 5°F to the $RT_{NDT}$ temperature for base material on which welding is performed.

Based on the criteria established in BAW-10046A, Methods of Compliance with Fracture Toughness and Operational Requirements of 10 CFR 50, Appendix G, the controlling item in the closure head assembly is the reactor closure head flange forging. This value is established to be +60°F for the $RT_{NDT}$ for the reactor closure head flange forging. The $RT_{NDT}$ established for the reactor closure head center disc plate was +40°F. The same value was established for all the plate materials of the B&WOG plants as established in BAW-10046A. Since the welding will be done on the closure head center disc plate, the new $RT_{NDT}$ for this item would be + 45°F which is still less than+60°F for the flange so therefore no impact on the technical specifications relevant to the closure head component will occur.

The 1989 Edition of ASME Section III is referenced in 10 CFR 50.55a(b)(1). No limitations or modifications regarding the use of NB-4335 are noted in 10 CFR 50.55a.

<u>IWA-4633.2(c) – Ambient Temperature Temper Bead Welding in accordance with the methodology of Code Case N-638</u>

Framatome-ANP has qualified the Machine GTAW of P-No. 3, low alloy steel base materials to P-No. 43 NiCrFe alloy base materials with the "Ambient Temperature Temper Bead Weld Technique" in accordance with the rules of ASME Section IX including the qualification requirements of Code Case N-638. The qualifications were performed at room temperature with water backing on the backside of the weld to maintain 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. Based on FRA-ANP welding procedure qualification test data using machine GTAW ambient temperature temper bead welding, quality temper bead welds using the deposition sequence described in the proposed Alternative Welding Method can be performed with 50°F minimum preheat and no post weld heat treatment.

<u>IWA-4610(a)- Preheat Temperature / IWA-4633.2(d) – Postweld Hydrogen Bake</u>

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 which typically produces porosity free welds. Argon flow rates are 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 - Examination

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 plug as well as the adjacent portion of the plug 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 steel reactor vessel head material due to the welding process. Liquid penetrant (PT) coverage is shown in Figure 6.

NB-5245 Partial Penetration Weld Joints

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 was for progressive surface examination 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-degree L-wave, 45-degree L-wave, and 70-degree 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.

The qualified volumetric UT examination will interrogate the surface that would have been examined by the progressive liquid penetrant surface examinations. Therefore, there is adequate assurance that any defects that could be present will be evaluated and/or repaired as necessary.

## 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 CRDM nozzle flaws requiring plugging.

This approach 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 location.

**Conclusions:**

Relief is requested to use alternatives 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 thereby ensure an acceptable level of quality and safety as required by 10 CFR 50.55a(a)(3)(i).

**Table 1 – Comparison of Repair Activities to Section XI Code Requirements**

| Code Paragraph | Code Requirement | Comparison |
|---|---|---|
| IWA-4100 | GENERAL REQUIREMENTS | The proposed alternative is in compliance with this Code paragragph. |
| IWA-4200 | ITEMS FOR REPAIR/REPLACEMENT ACTIVITIES | The proposed alternative is in compliance with this Code paragragph. |
| IWA-4300 | DESIGN | The proposed alternative is in compliance with this Code paragragph. The modification is in accordance with ASME Section III NB-3000 and ASME Section XI IWB-3000. |
| 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). | The proposed alternative is in compliance with this Code paragragph. |
| IWA-4410(c) | Alternatively, the applicable requirements of IWA-4600 may be used for welding, .... | The proposed alternative is in compliance with this Code paragragph. |
| IWA-4430 | Storage and Handling of Welding Material | The proposed alternative is in compliance with this Code paragragph. |
| IWA-4440 | Welding and Welder Qualification (Including Welding Operators) | The proposed alternative is in compliance with this Code paragragph. |
| IWA-4600 | ALTERNATIVE WELDING METHODS | |
| IWA-4600(b) | When post weld heat treatment is not to be performed, the following provisions may be used.<br>(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.<br>Note: IWA-4630 is applicable to Dissimilar Materials | The proposed alternative is in compliance with this Code paragragph. |

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| **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 attachment and removal shall be in accordance with Section III. | 1) Relief is requested from preheat requirements<br>2) Relief is requested from the use of thermocouples and recording instruments to monitor the process temperature. |
| • 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. | 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 the requirements of NB-4335 of the 1995 Edition through the 1996 Addenda of ASME Section III were used to verify the Charpy impact properties of the ambient temper bead welding process. The base material is SB-564 UNS N06690 and is specified as P-No. 43 in Code Case N-474-2 which has been accepted in NRC Regulatory Guide 1.85. The weld metal is SFA-5.14 UNS N06052 and is specified as F-No. 43 in the 2001 Edition of ASME Section IX. An increase in the interpass temperature greater than 100°F is a supplementary essential variable per QW-256 of ASME Section IX. The 350°F interpass temperature is greater than 100°F over that which was used in the ASME Section IX welding procedure qualification process.<br><br>Relief is requested from the Section IX welding procedure qualification requirements related to interpass temperature. |
| 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. Neutron fluence is not an issue at the location where the activity will be performed. |

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| 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. The evaluation is performed to meet the requirements of IWB-3142.4<br>1. Relief from characterizing flaws in accordance with IWA-3300 is requested in Relief Request RR-A24.<br>2. Relief from performing successive inspections in accordance with IWB-3142.4 is requested |
| IWA-4611.1(b) | The original defect shall be removed:<br>(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. |

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| IWA-4611.4 | Examination Following Metal Removal | |
| IWA-4611.4(a) | After final grinding, the affected surfaces, including surfaces of cavities 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. | The proposed alternative is in compliance with this Code 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. |
| 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. |
| 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. | Relief is requested from this Code Requirement. The Charpy impact tests were conducted in accordance with NB-4335 of the 1995 Edition through the 1996 Addenda of ASME Section III. |

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| IWA-4633 | Welding Procedure | |
| IWA-4633.1 | Shielded Metal-Arc Welding | This Code Requirement is not applicable to the proposed 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 plug (P-No. 43 base material) using SFA 5.14 ERNiCrFe-7 weld filler material. The plug material is SB-564 UNS N06690 which is designated as P-No. 43 for welding procedure qualification per Code Case N-474-2. Code Case N-474-2 is listed as acceptable in NRC Regulatory Guide 1.85. The weld metal is SFA-5.14 UNS N06052 and is specified as F-No. 43 in the 2001 Edition of ASME Section IX. |
| 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 to use the alternative welding method described in this relief request. |
| • 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 to use the alternative welding method described in this relief request. |
| IWA-4633.2(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 |
| • IWA-4634 | Examination<br>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. |

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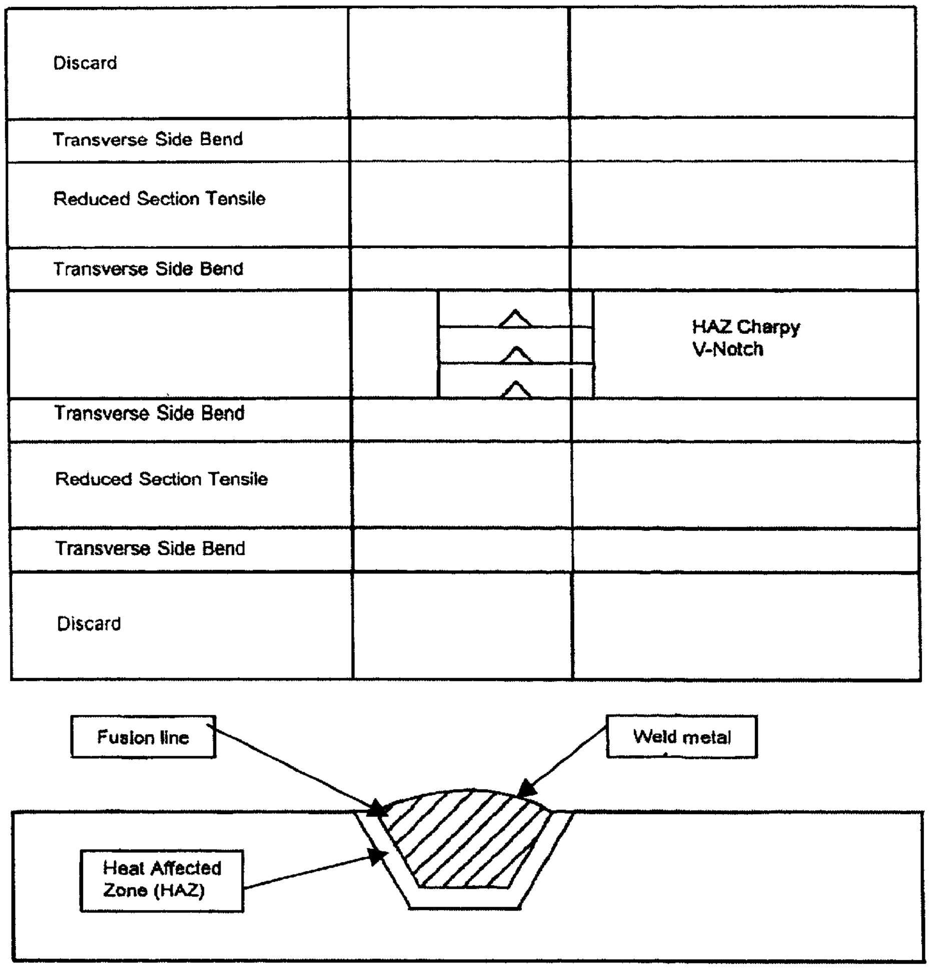
| IWA-4500 | EXAMINATON AND TEST | The proposed alternative is in compliance with this Code paragraph |
| **IWA-4530** | **PRESERVICE INSPECTION AND TESTING**<br>When portions of items requiring preservice or inservice inspection are affected by repair/replacement activities, or for items being installed, including welded joints made for installation of items, preservice inspections shall be performed in accordance with IWB-2200, IWC-2200, IWD-2200, IWE-2200, IWF-2200, or IWL-2200 prior to return of the system to service. The preservice inspection may be performed either prior to or following the pressure test required by IWA-4540. | The proposed alternative is in compliance with this Code paragraph. Preservice examination is not applicable to this repair as the repair weld is not covered by any Table IWB-2500-1 Code Category. |
| IWA-4540<br><br>IWA-4540(a) | Pressure Testing of Class 1, 2, and 3 Items<br><br>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. | The proposed alternative is in compliance with this Code paragraph. Code Case N-416-1 is applicable to pressure testing for this repair. |
| • NB-5245 (1992 Edition) | **Partial Penetration Welded Joints**<br>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. | 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.<br><br>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. |
| NB-5330 (1992 Edition)<br><br>• NB-5330(b) | **Ultrasonic Acceptance Standards**<br><br>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 steel reactor vessel head, the Alloy 690 plug, and the first Alloy 52 weld bead intersect. Relief to accept the triple point anomaly is requested in Relief Request RR-A24. |

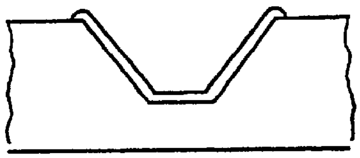
- Relief from this Code Paragraph is Requested



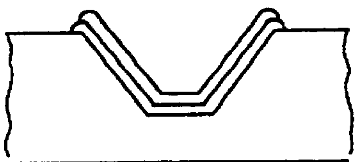

GENERAL NOTE: Base metal Charpy impact specimens are not shown. This figure illustrates a similar-metal weld.

QUALIFICATION TEST PLATE

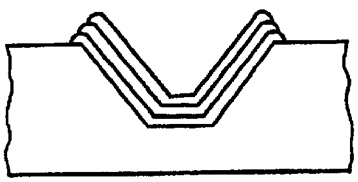
**Figure 1**



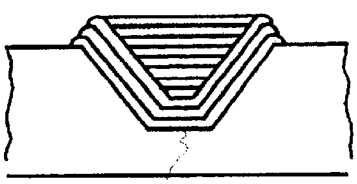
Step 1: Deposit layer one with first layer weld parameters used in qualification.



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**

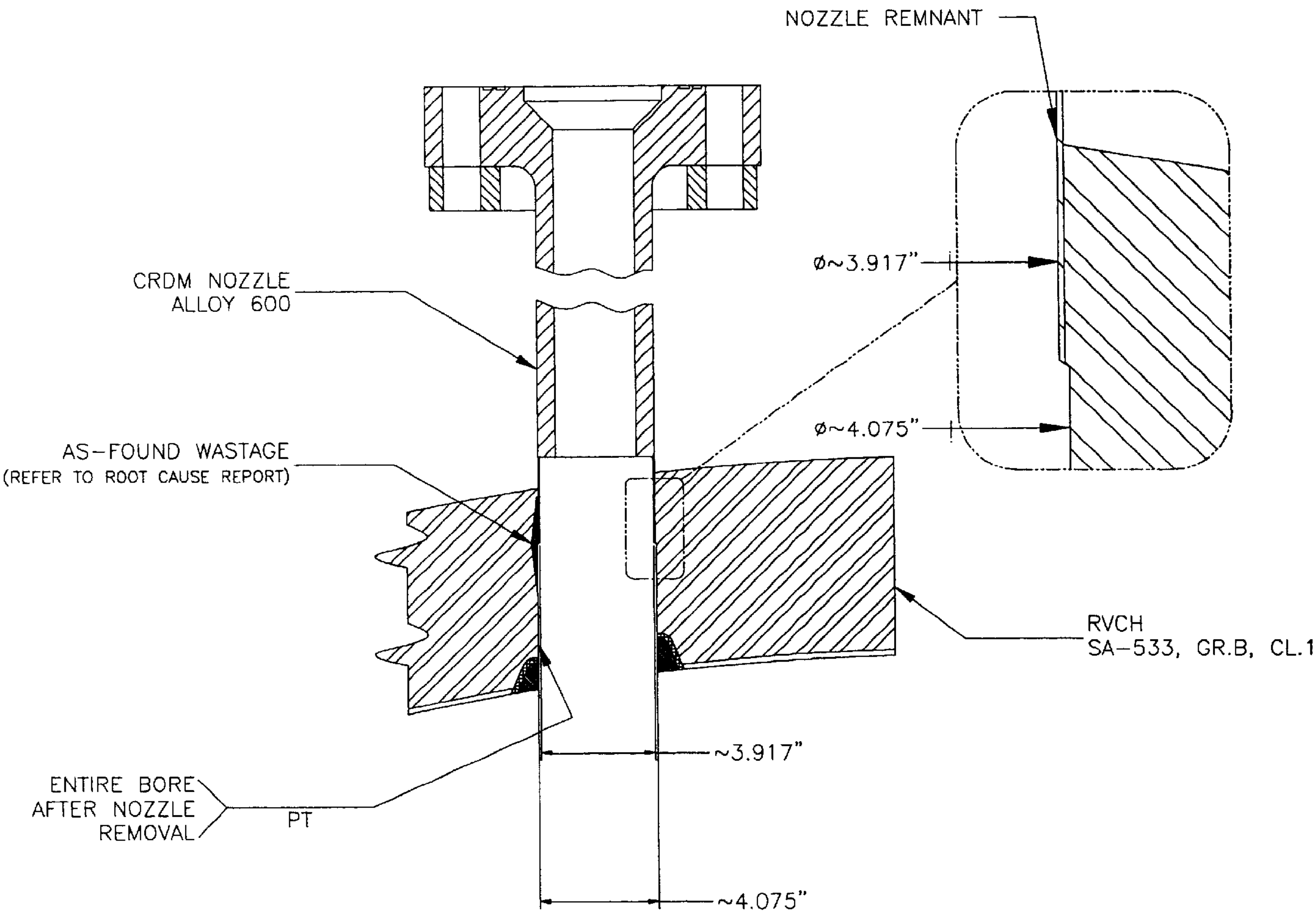



**Figure 3**

BORE AND REMOVE NOZZLE

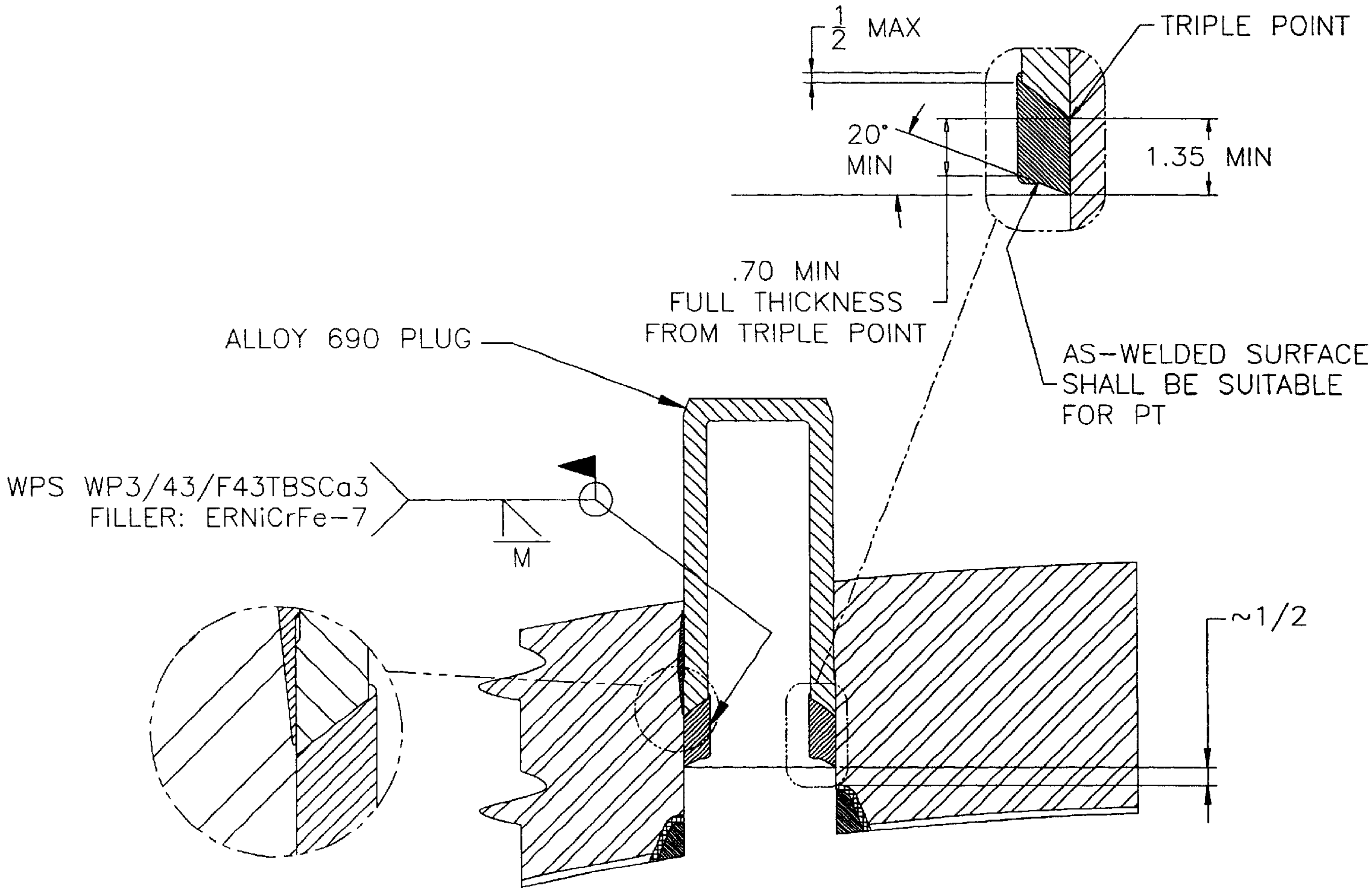



**Figure 4**

INSERT PLUG, TEMPERBEAD WELD

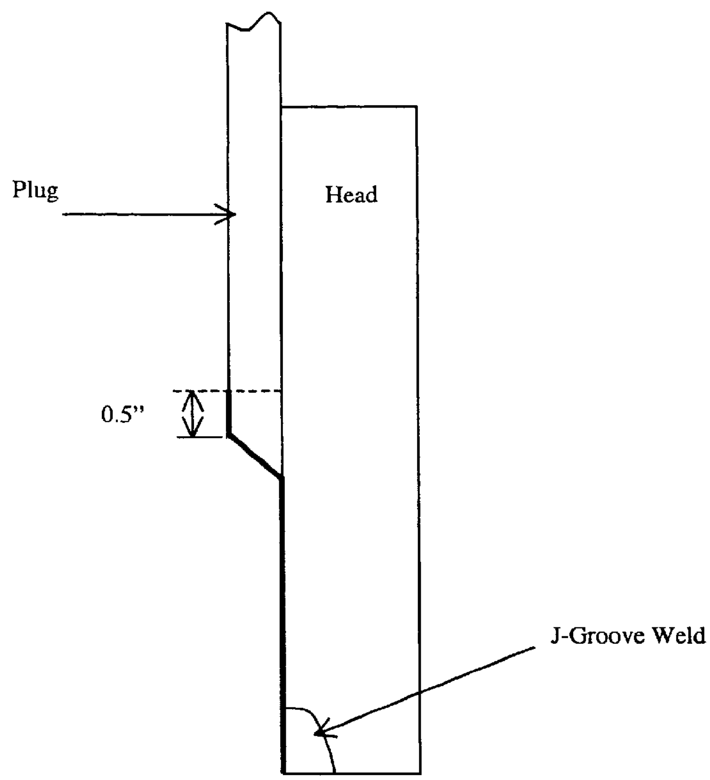



Figure 5
Plug Temper Bead Weld Repair,
PT Coverage Prior to Welding

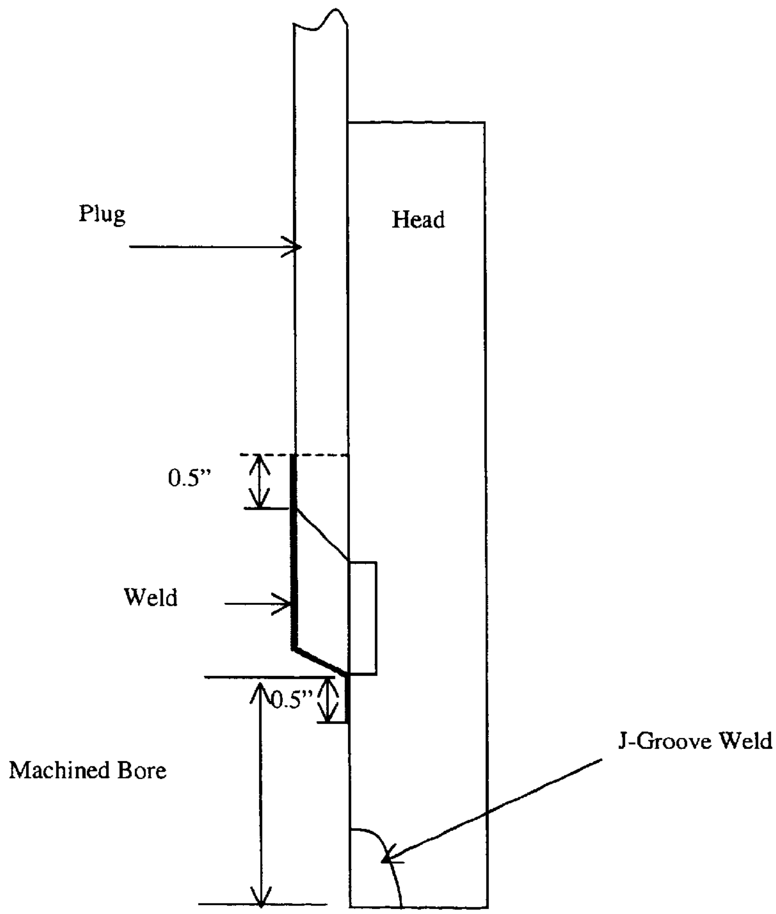



Figure 6
Plug Temper Bead Weld Repair,
PT Coverage After Welding

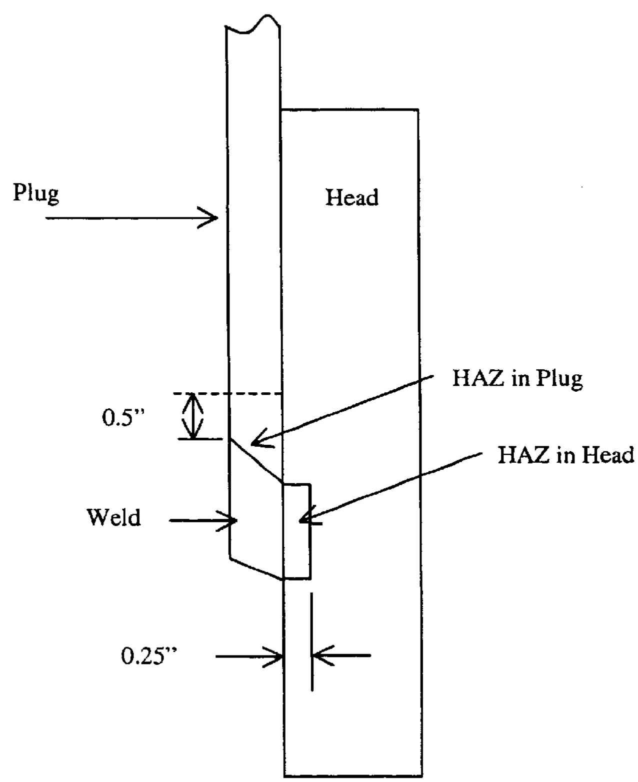



Figure 7
Plug Temper Bead Weld Repair
Areas to be Examined

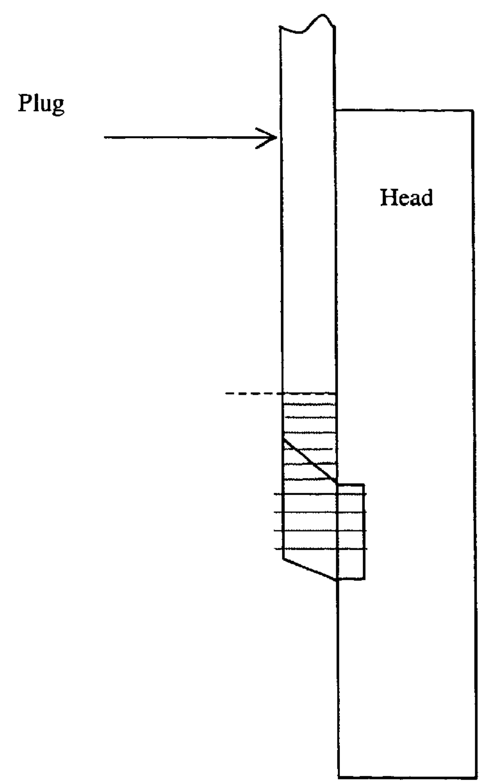



Figure 8
Plug Temper Bead Weld Repair,
UT 0 degree and 45L Beam Coverage
Looking Clockwise and Counter-clockwise

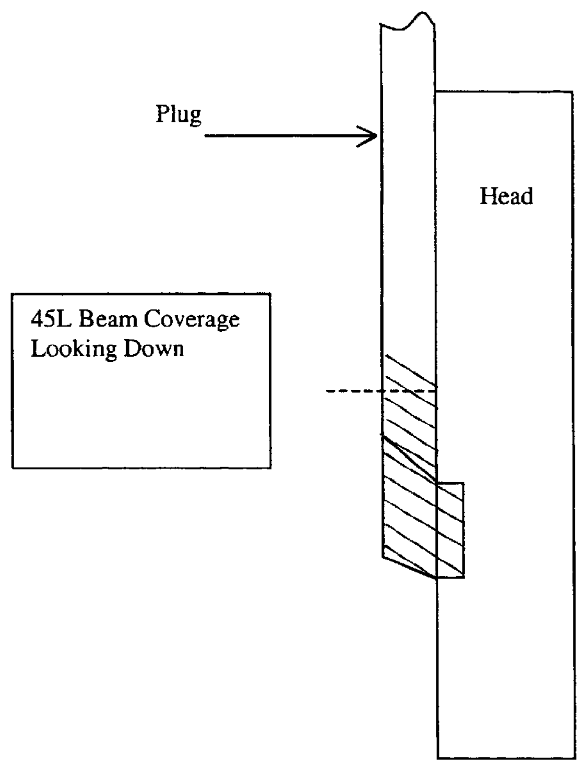



Figure 9
Plug Temper Bead Weld Repair,
45L UT Beam Coverage Looking Down

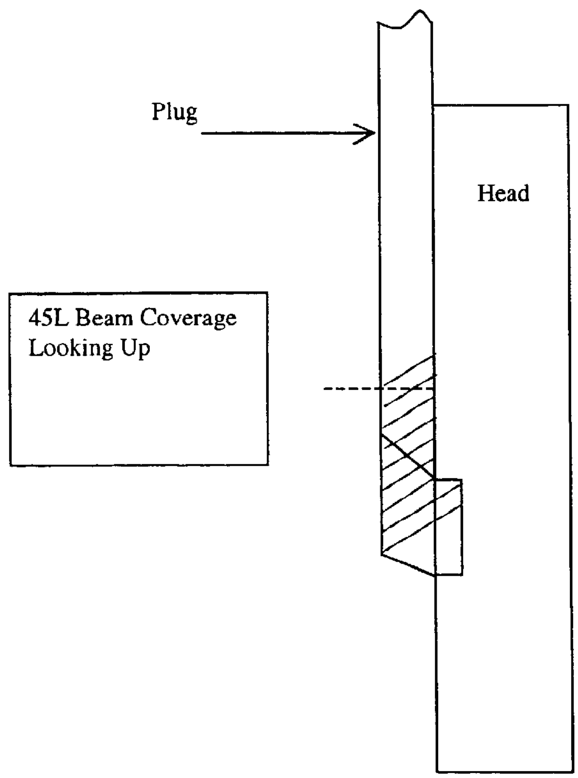



Figure 10
Plug Temper Bead Weld Repair,
45L UT Beam Coverage Looking Up

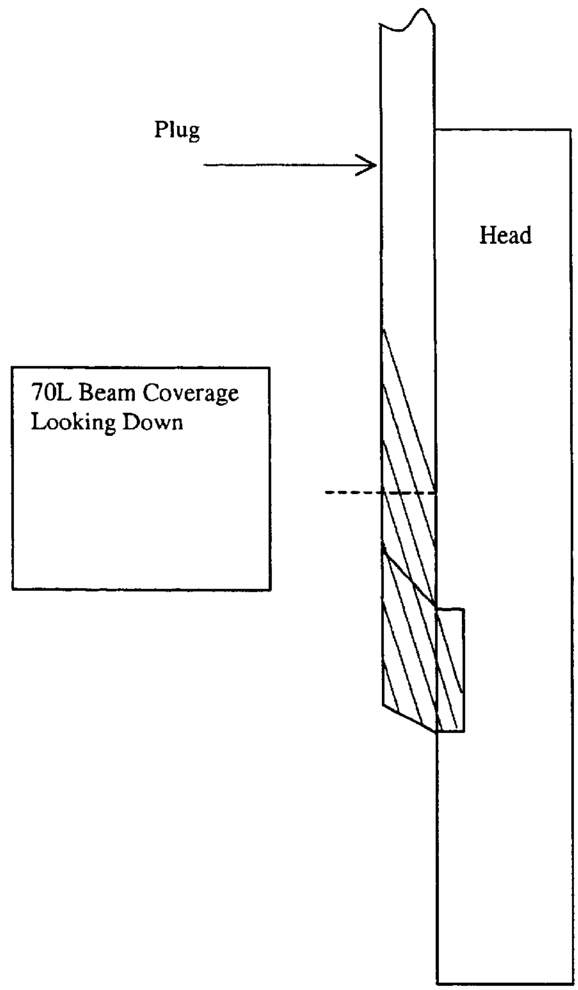



Figure 11
Plug Temper Bead Weld Repair,
70L UT Beam Coverage Looking Down

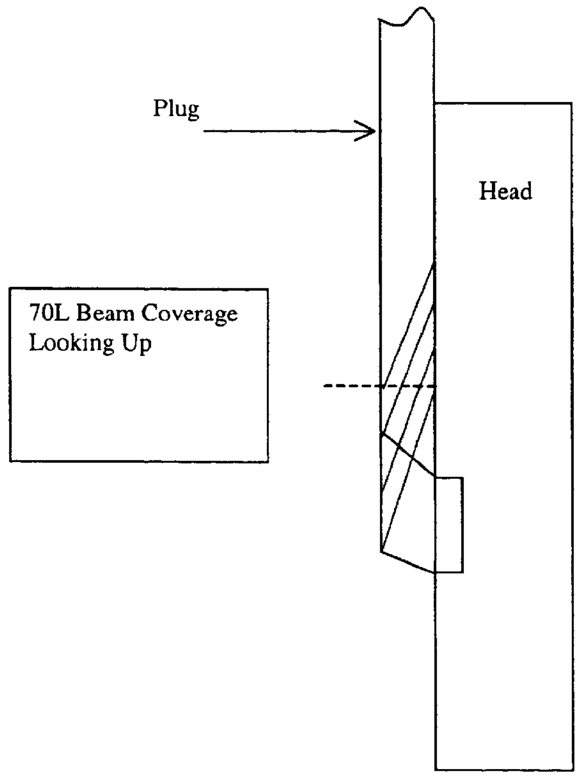



**Figure 12**
**Plug Temper Bead Weld Repair,**
**70L UT Beam Coverage Looking Up**

License Number NPF-3
Docket Number 50-346
Serial Number 2783
Attachment 2
Page 1 of 1

DBNPS ISI Program – Third Ten-Year Interval
Relief Request RR-A24

(10 Pages Follow)

**FIRST ENERGY NUCLEAR OPERATING COMPANY**
**DAVIS-BESSE UNIT 1**
**THIRD 10-YEAR INTERVAL**
**RELIEF REQUEST RR-A24**

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

Reactor Vessel Closure Head (RVCH) Control Rod Drive Mechanism (CRDM) nozzle penetrations. There are 69 CRDM nozzle penetrations welded to the RVCH. The ASME 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 Requirements from Which Relief is Requested:

The FENOC requests relief to use an alternative to IWA-3300 and IWB-3420 in accordance with 10 CFR 50.55a (a)(3)(ii) for flaw characterization. Following the plugging of the CRDM penetration, it is assumed that flaws will remain in the original CRDM to RVCH J-groove weld. During the repair process, the FENOC will remove portions of the original J-groove weld to limit the size of the flaws that remain. In lieu of fully characterizing the existing cracks, the FENOC proposes to utilize worst-case assumptions to conservatively estimate the crack extent and orientation.

The FENOC requests relief to use an alternative to IWB-3142.4 in accordance with 10 CFR 50.55a(a)(3)(ii). 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 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.

The FENOC requests relief to use an alternative to NB-5330(b) in accordance with 10 CFR 50.55a(a)(3)(i).. The new pressure boundary weld that will connect the CRDM nozzle penetration plug to the low alloy steel RVCH contains a material "triple point". The triple point is at the root of the weld where the Alloy 690 CRDM nozzle plug will be welded with Alloy 52 filler metal to the SA-533 Grade B, Class 1 Mn-Mo ferritic low alloy steel RVCH. (See Figures 1 and 2). Experience has shown that during solidification of the Alloy 52 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.

**Basis for Relief:**

Inspections of the RVCH performed in accordance with the Davis-Besse response to NRC Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," have identified CRDM nozzle penetrations which need to be plugged. FENOC plans to perform Control Rod Device Mechanism (CRDM) repairs by welding the RVCH (P-No. 3 base material) and a CRDM nozzle penetration plug (P-No. 43 base material) with filler material F-No. 43.

The repair process will consist of the following activities:

a) The degraded area will be blended by abrasive grinding and then the surfaces examined by liquid penetrant (PT). As left dimensions will be taken of the blended area.

b) The entire RVCH nozzle bore, with the exception of the J-weld groove weld, will then examined using PT.

c) An Alloy 690 plug will then be machined to fit and inserted into the RVCH nozzle bore.

d) The Alloy 690 plug will be welded to the RVCH nozzle bore with a remotely operated machine GTAW weld head, using the ambient temperature GTAW temper bead process with ERNiCrFe-7 (Alloy 52) filler metal and 50°F minimum preheat temperature. No post-weld hydrogen bake will be used.

e) The final weld face, not including the taper transition, will be machined and/or ground.

f) Following a Code-required 48 hour hold period, the final weld will be PT and ultrasonically (UT) examined.

g) A 1/8 inch minimum chamfer will be ground at the bottom end of the RVCH nozzle bore in the remnant of the original CRDM nozzle to RVCH J- groove weld. The original J-groove weld is chamfered to assure the remaining weld metal will be no greater than the maximum Code-allowable flaw size.

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 RVCH welds. However, the possible existence of cracks in these welds mandates that the flaw growth potential be evaluated.

*IWA-3300/IWB-3420/IWB-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 will be 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 will be obtained using finite element analysis of the RVCH. Since hoop stresses will be 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 will be 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. The 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, 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 may occur, 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 will be 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 will be 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 plug, 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 RVCH base material are low, it will be assumed that a small flaw could initiate in the low alloy steel material and grow by fatigue. It will be 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 will not be included in the flaw evaluations since it will be demonstrated by analysis that these stresses 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 will be 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 will be used since they are perpendicular to the plane of the crack. Fatigue crack growth, to be calculated for 15 years of operation, will be minimal , and the final flaw size will be shown to meet 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 to be performed, it will be acceptable to leave the postulated cracks in the attachment (J-groove) and buttering. The calculations will show the remaining flaws within the base material are acceptable for 15 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 will assume a radial (with respect to the penetration center line) crack exists with a length equal to the remaining partial penetration weld preparation depth after chamfering. 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. The FENOC believes the alternative described will provide an acceptable level of quality and safety when compared to the Code requirements in IWB-3500 to characterize the cracks in service. Using flaw tolerance techniques, it will be determined that the assumed worst-case crack size would not grow to an unacceptable depth into the RVCH low alloy steel. Thus the RVCH will be shown to be acceptable 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 will provide an acceptable level of safety and quality in ensuring that the RVCH remains capable of performing its design function for 15 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. The results of this analysis will be available for NRC review at the DBNPS site and submitted as a part of the ISI Summary report required by IWA-6000.

*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 steel head, the Alloy 690 plug and the Alloy 52 weld bead intersects. 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 will be performed to provide justification, in accordance with ASME Section XI, for operating with the postulated weld anomaly described above. The anomaly will be modeled as a 0.1 inch semi-circular "crack-like" defect 360 degrees 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 plug wall thickness from the OD of the plug to the ID of the plug. This is the shortest path through the component wall, passing through the new Alloy 690 weld material. However, Alloy 690 material properties or equivalent will be used to ensure that another potential path through the HAZ between the new repair weld and the Alloy 690 material is bounded.

For completeness, two types of flaws will be postulated at the outside surface of the plug. A 360 degree continuous circumferential flaw, lying in a horizontal plane, will be considered to be a conservative representation of crack-like defects that may exist in the weld anomaly. This flaw will be subjected to axial stresses in the plug. An axially oriented semi-circular outside surface flaw will also be 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 plug.

Path 2:

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

The results of the analysis will demonstrate that a 0.10 inch weld anomaly is acceptable for a 15 year design life of the CRDM ambient temperature temper bead weld repair.

Significant fracture toughness margins will be obtained for both of the flaw propagation paths considered in this analysis. The minimum calculated fracture toughness margins will be shown to be 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 will not be significantly greater than the original assumed flaw size considering both flaw propagation paths. A limit load analysis will also be performed considering the ductile Alloy 690 materials along flaw propagation path 1. The analysis will show limit load margins for normal/upset conditions and emergency/faulted conditions that 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 will be prepared in accordance with ASME Section XI and will demonstrate that for the intended service life of the repair, the fatigue crack growth will be acceptable and the crack-like indications will remain stable. These two findings will satisfy the Section XI criteria but will 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 to be performed will be adequate, residual stresses need not be considered because PWSCC effects are not applicable, and the geometry is not conducive to sustained ductile tearing.

For the reasons described above, the areas containing flaws that will be shown acceptable by analytical evaluation will not be reexamined as required by IWB-3142.4. . The results of this analysis will be available for NRC review at the DBNPS site and submitted as a part of the ISI Summary report required by IWA-6000.

Elimination of the weld triple point anomaly would require use of an entirely different process that proposed for use at Davis-Besse. 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 plug as compared to the 7 to 8 REM estimated for each plug repaired by the proposed process.

**Conclusion:**

Relief is requested to use an alternative in accordance with 10 CFR 50.55a(a)(3)(i) from characterizing any remaining defects in the remaining portion of the J-groove weld. The planned repair for the CRDM nozzles does not include removal of the cracks discovered in the remaining J-groove partial penetration welds. 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 performed an evaluation per IWA-4611.1 using 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. The results of this evaluation demonstrate that the assumed worst-case crack is acceptable. The proposed alternative bounding flaw evaluation is an acceptable method to access any remaining flaws in this case, and, thereby, ensure that the structural integrity of the RVCH will continue to provide an acceptable level of quality and safety. The results of this analysis will be available for NRC review at the DBNPS site and submitted as a part of the ISI Summary report required by IWA-6000.

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. The results of this analysis will be available for NRC review at the DBNPS site and submitted as a part of the ISI Summary report required by IWA-6000.

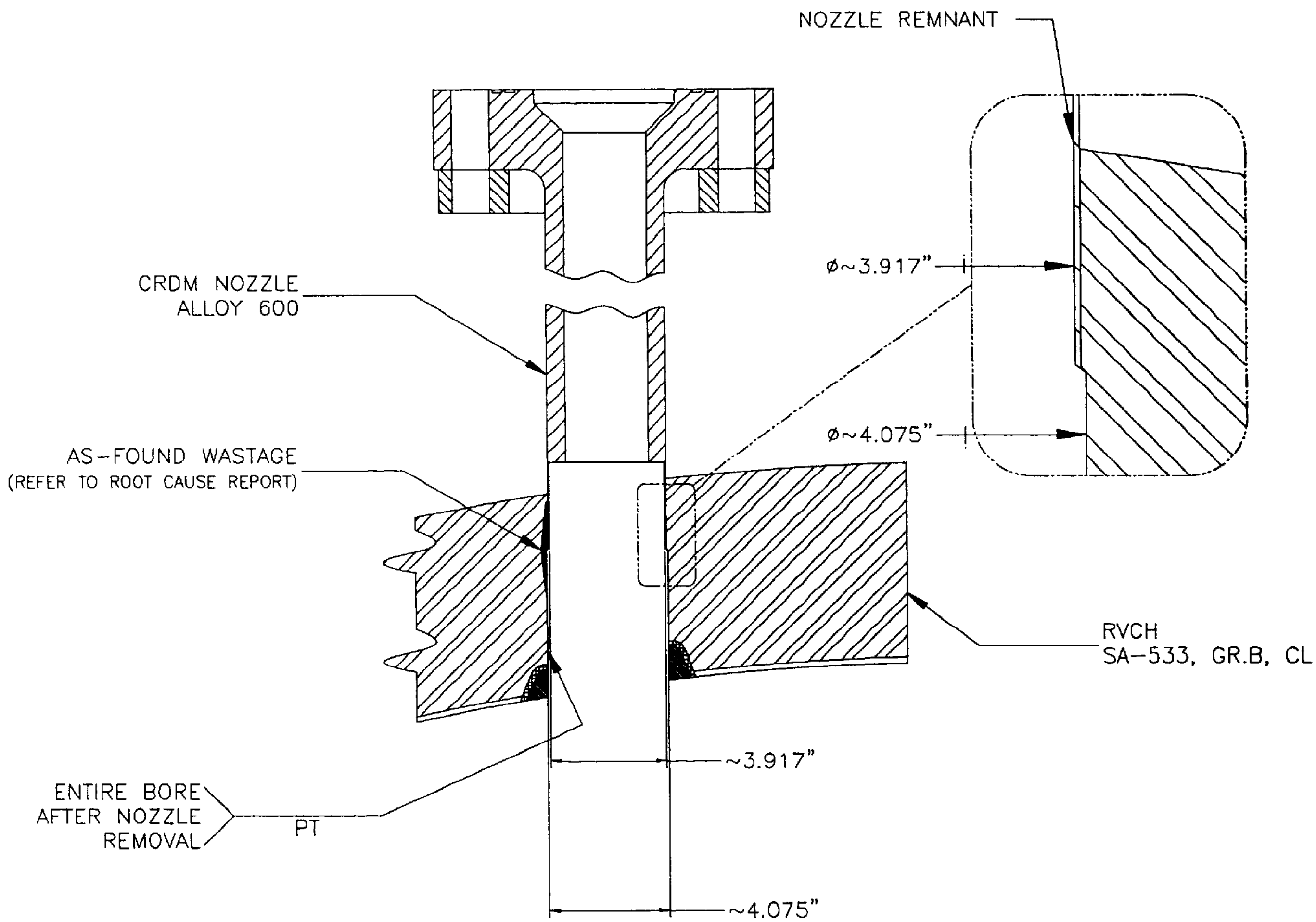



**Figure 1**

BORE AND REMOVE NOZZLE

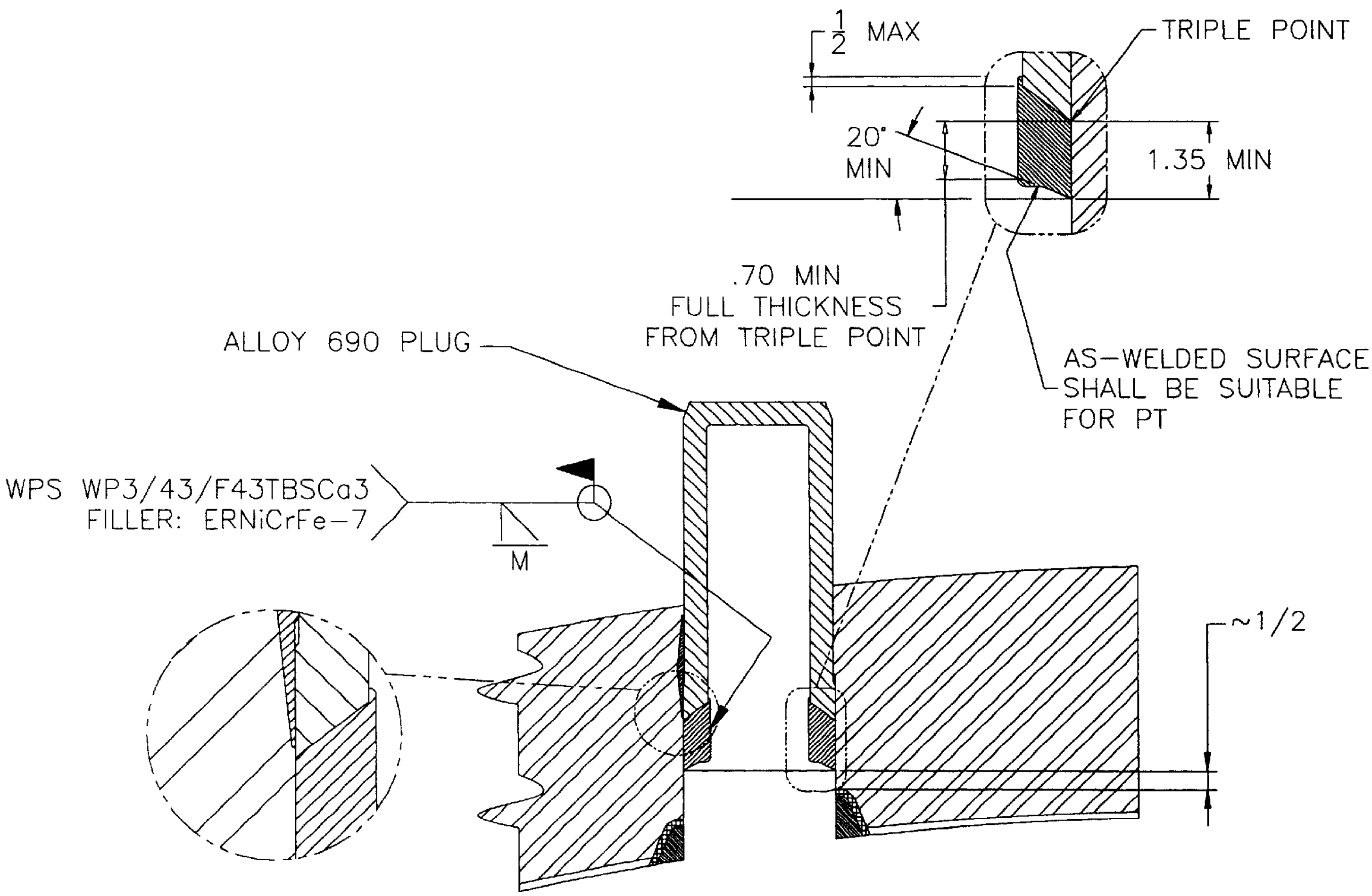



**Figure 2**

INSERT PLUG, TEMPERBEAD 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 |
|---|---|
| None | |