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CNRO-2002-00052

October 28, 2002

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

SUBJECT: Entergy Operations, Inc.
Proposed Alternative to ASME Examination Requirements for Repairs Performed on Reactor Vessel Head Penetrations

Arkansas Nuclear One, Unit 1
Docket No. 50-313
License No. DPR-51

REFERENCE: Entergy Operations, Inc. Letter No. 1CAN090202 to the NRC, "Entergy 30-Day Response to NRC Bulletin 2002-02 for Arkansas Nuclear One, Unit 1," " dated September 9, 2002

Dear Sir or Madam:

Pursuant to 10 CFR 50.55a(a)(3)(ii), Entergy Operations, Inc., (Entergy) proposes alternatives to the requirements of ASME Sections III and XI as applied to reactor pressure vessel (RPV) nozzles. These requests, contained in Enclosures 1 and 2 as Request Nos. ANO1-R&R-003, Rev. 0 and ANO1-R&R-004, Rev. 0, respectively, apply to Arkansas Nuclear One, Unit 1 (ANO-1).

In accordance with Entergy's response to NRC Bulletin 2002-02 (see referenced letter), ANO-1 has completed inspecting RPV head nozzle penetrations during the current refueling outage at ANO-1, which began October 4, 2002. Entergy plans to use the methods described in ANO1-R&R-003 and ANO1-R&R-004 for nozzle repairs. These requests are similar to those previously submitted by Duke Energy Corp. for Oconee Nuclear Station, Unit 2 on September 5, 2002.

The proposed repair process removes the portion of the RPV head penetration nozzle that extends below the inner surface of the RPV head. A new weld application surface is prepared at a point above the heat affected zone (HAZ) of the original pressure boundary weld within the penetration through which the nozzle is installed. A new nozzle-to-head weld is then installed within the head penetration by remote machine welding. With this repair, the original weld is not part of the new pressure boundary weld. The original weld is left in place at the junction of the head nozzle penetration to head inside surface and analyzed for acceptability.

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Request No. ANO1-R&R-003, Rev. 0 (Enclosure 1) proposes performing the repair with a remotely operated weld tool utilizing the machine Gas Tungsten-Arc Welding (GTAW) process and the ambient temperature temper bead method with 50°F minimum preheat temperature and no post weld heat treatment.

Request No. ANO1-R&R-004, Rev. 0 (Enclosure 2) proposes an alternative to the requirement to evaluate actual flaw characteristics as defined in ASME Section XI, IWA-3300(b), IWB-3142.4, and IWB-3420. In lieu of fully characterizing the remaining cracks, Entergy proposes to utilize worst-case assumptions to conservatively estimate the crack extent and orientation. ***As stated in ANO1-R&R-004, Entergy commits to performing inspections of any repaired nozzles during the next refueling outage (1R18).***

Entergy requests that the NRC staff authorize use of ANO1-R&R-003 and ANO1-R&R-004 as soon as possible since repairs using this process are underway. Entergy is targeting completing repairs by November 12, 2002. ***Following NRC approval, Entergy will incorporate ANO1-R&R-003 and -004 into the ANO-1 Inservice Inspection Plan.***

Should you have any questions regarding this letter, please contact Guy Davant at (601) 368-5756.

This letter contains two commitments as denoted above in bold, italicized text.

Very truly yours,

M. A. Krupa

MAK/GHD/bal

Enclosures: 1. Request for Alternative ANO1-R&R-003, Rev. 0
2. Request for Alternative ANO1-R&R-004, Rev. 0

cc: Mr. C. G. Anderson (ANO)
Mr. W. R. Campbell (ECH)
Mr. G. A. Williams (ECH)

Mr. T. W. Alexion, NRR Project Manager (ANO-2)
Mr. R. L. Bywater, NRC Senior Resident Inspector (ANO)
Mr. E. W. Merschoff, NRC Region IV Regional Administrator
Mr. W. D. Reckley, NRR Project Manager (ANO-1)

ENCLOSURE 1

CNRO-2002-00052

REQUEST FOR ALTERNATIVE
ANO1-R&R-003, Rev. 0

ENTERGY OPERATIONS, INC.
ARKANSAS NUCLEAR ONE, UNIT 1
3rd 10-YEAR INTERVAL
REQUEST No. ANO1-R&R-003, Rev. 0

REFERENCE CODE:

The original code of construction for Arkansas Nuclear One, Unit 1 (ANO-1) is ASME Section III 1965 Edition with Addenda through Summer, 1967. The components (including supports) may meet the requirements set forth in subsequent editions and addenda of the ASME Code incorporated by reference in 10 CFR 50.55a(b) subject to the limitations and modifications listed therein and subject to NRC approval. The codes of record for the repairs described within this request are the 1989 Edition of ASME Section III and 1992 Edition of ASME Section XI codes. ANO-1 is in its third (3rd) 10-Year Inservice Inspection interval.

I. System/Component(s) for Which Relief is Requested

a) Name of component:
Reactor Pressure Vessel Closure Head (RVCH) nozzles (There are 69 nozzles welded to the RVCH.)

b) Function:
These welds serve as the pressure boundary weld for the RVCH nozzle and RVCH.

c) ASME Code Class:
The RVCH and RVCH nozzles are ASME Class 1.

d) Category:
Examination Category B-E, Pressure Retaining Partial Penetration Welds in Vessels; Item No. B4.12

II. Code Requirement

The 1992 Edition of ASME Section XI, paragraph IWA-4170(b) states:

> "Repairs and installation of replacement items shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later editions and addenda of the construction code or of Section III, either in their entirety or portions thereof, and Code Cases may be used. If repair welding cannot be performed in accordance with these requirements, the applicable alternative requirements of IWA-4200 and IWA-4400 or IWA-4500 may be used."

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 paragraph NB-4622 of the 1989 ASME Section III Code to the RVCH. The alternative temper bead methods (IWA-4500 and NB-4622.9, NB4622.10 or NB-4622.11) offered by ASME Section III and ASME Section XI require elevated temperature preheat and post weld soaks that will result in added radiation dose to repair personnel.

As an alternative to the requirements of NB-4622, Entergy Operations, Inc. (Entergy) proposes to perform the repair with a remotely operated weld tool, utilizing the machine Gas Tungsten-Arc Welding (GTAW) process and the ambient temperature temper bead method with 50°F minimum preheat temperature and no post weld heat treatment (PWHT). The repairs will be conducted in accordance with the 1992 Edition of ASME XI (as applicable), the 1989 Edition of Section III (as applicable), and alternative requirements discussed below.

Entergy has determined that compliance with the specified requirements would result in unusual difficulty or hardship without a compensating increase in the level of quality.

III. Code Requirements for Which Alternatives are Requested

The current ANO-1 refueling outage (1R17) began October 4, 2002. During this refueling outage, Entergy examined RVCH nozzles in accordance with ANO-1's response to NRC Bulletin 2002-02. This examination identified RVCH nozzles that have indications of flaws requiring repair. The use of any of the alternatives permitted by the applicable ASME Codes for repairs will result in increased radiation dose with no compensating increase in quality or safety. The PWHT parameters required by NB-4622 would be difficult to achieve on a RVCH in containment and would pose significant risk of distortion to the geometry of the RVCH and RVCH nozzles. In addition the existing J-groove welds would be exposed to PWHT for which they were not qualified. This request applies to any nozzle requiring repair by the methods described herein.

Therefore, pursuant to 10 CFR 50.55a(a)(3)(ii), Entergy requests relief to use an ambient temperature temper bead method of repair as an alternative to the requirements of the 1989 Edition of ASME Section III, NB-4622. As an alternative to these requirements, the requirements of, "Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique," (Attachment 1) will be used. A list of the most applicable articles, subarticles, paragraphs, and subparagraphs of ASME Section III and Section XI is given below. Where the Code requirements will not be met, the alternative or reference to the alternative is given in italic print.

NB-4331 establishes the requirement that all welding procedure qualification tests be in accordance with the requirements of ASME Section IX as supplemented or modified by the requirements of NB-4331.

The welding procedure has been qualified in accordance with the requirements of paragraphs 2.0 and 2.1 of Attachment 1. These two paragraphs are modeled on ASME Code Case N-638 and include the additional requirements of ASME Section III Paragraph NB-4335.2. No alternative to the requirements of NB-4331 is needed or proposed.

NB-4622.1 establishes the requirement for PWHT of welds including repair welds. *In lieu of the requirements of this subparagraph, Entergy proposes to utilize a temper bead weld procedure obviating the need for post weld stress relief.*

NB-4622.2 establishes requirements for time at temperature recording of the PWHT and their availability for review by the Inspector. This requirement of this subparagraph will not apply because the proposed alternative does not involve PWHT.

NB-4622.3 discusses the definition of nominal thickness as it pertains to time at temperature for PWHT. The subparagraph is not applicable in this case because the proposed alternative involves no PWHT.

NB-4622.4 establishes the holding times at temperature for PWHT. The subparagraph is not applicable in this case because the proposed alternative involves no PWHT.

NB-4622.5 establishes PWHT requirements when different P-number materials are joined. This subparagraph is not applicable because the proposed alternative involves no PWHT.

NB-4622.6 establishes PWHT requirements for non-pressure-retaining parts. The subparagraph is not applicable in this case because the potential repairs in question will be to pressure retaining parts. Furthermore, the proposed alternative involves no PWHT.

NB-4622.7 established exemptions from mandatory PWHT requirements. NB-4622.7(a) through NB-4622.7(f) are not applicable in this case because they pertain to conditions that do not exist for the proposed repairs. NB-4622.7(g) discusses exemptions to weld repairs to dissimilar metal welds if the requirements of NB-4622.11 are met. *As described below, the ambient temperature temper bead repair is being proposed as an alternative to the requirements of NB-4622.11.*

NB-4622.8 establishes exemptions from PWHT for nozzle-to-component welds and branch connection-to-run piping welds. NB-4622.8(a) establishes criteria for exemption of PWHT for partial penetration welds. This is not applicable to the proposed repairs because the criteria involve buttering layers at least 1/4 inch thick, which will not exist for the welds in question. NB-4622.8(b) also does not apply because it discusses full penetration welds and the welds in question are partial penetration welds.

NB-4622.9 establishes requirements for temper bead repairs to P-No. 1 and P-No. 3 materials and A-Nos. 1, 2, 10, or 11 filler metals. The subparagraph does not apply in this case because the proposed repairs will involve F-No. 43 filler metals using GTAW instead of Shielded Metal Arc Welding (SMAW).

NB-4622.10 establishes requirements for repair welding to cladding after PWHT. The subparagraph does not apply in this case because the proposed repair alternative does not involve repairs to cladding.

NB-4622.11 discusses temper bead weld repair to dissimilar metal welds or buttering.

The ambient temperature temper bead repair is being proposed as an alternative to the requirements of subparagraph NB-4622.11. As described below, elements of NB-4622.11 are incorporated into the proposed alternative.

- NB-4622.11(a) requires surface examination prior to repair in accordance with NB-5000. The proposed alternative will include surface examination prior to repair consistent with NB-5000.

- NB-4622.11(b) contains requirements for the maximum extent of repair including a requirement that the depth of excavation for defect removal not exceed 3/8 inch in the base metal. The proposed alternative includes the same limitations on the maximum extent of repair.

- NB-4622.11(c) discusses the repair welding procedure and requires procedure and welder qualification in accordance with ASME Section IX and the additional requirements of Article NB-4000. The proposed alternative will satisfy this requirement. In addition, NB-4622.11(c) requires that the Welding Procedure Specification (WPS) include the following requirements:

  - NB-4622.11(c)(1) requires the area to be welded be suitably prepared for welding in accordance with the written procedure to be used for the repair. The proposed alternative will satisfy this requirement.

  - NB-4622.11(c)(2) requires the use of the SMAW process with covered electrodes meeting either the A-No. 8 or F-No. 43 classifications. *The proposed alternative utilizes GTAW with weld filler metals meeting F-No. 43 classifications.*

  - NB-4622.11(c)(3) discusses requirements for covered electrodes pertaining to hermetically sealed containers or storage in heated ovens. These requirements do not apply because the proposed alternative uses weld filler metals that do not require storage in heated ovens since weld GTAW bare filler metals will not pick up moisture from the atmosphere.

  - NB-4622.11(c)(4) discusses requirements for storage of covered electrodes during repair welding. These requirements do not apply because the proposed alternative utilizes bare weld filler metals, which do not require any special storage conditions to prevent the pick up of moisture from the atmosphere.

  - NB-4622.11(c)(5) requires preheat to a minimum temperature of 350°F prior to repair welding, a maximum interpass temperature of 450°F and that thermocouples and recording instruments shall be used to monitor the metal temperature during welding.

    The proposed ambient temperature temper bead alternative does not require an elevated temperature preheat and interpass will be limited to 350°F. Because of the massive structure involved in the assembly, the absence of preheat and the complex configuration, thermocouples will not be used to monitor metal temperature.

  - NB-4622.11(c)(6) establishes requirements for shielded metal arc electrode diameters for the first, second, and subsequent layers of the repair weld and requires removal of the weld bead crown before deposition of the second layer. Because the proposed alternative uses the machine GTAW process, the requirement to remove the weld crown of the first layer is unnecessary and the proposed alternative does not include the requirement.

  - NB-4622.11(c)(7) requires the preheated area to be heated to 450°F to 660°F for four (4) hours after a minimum of 3/16 inch of weld metal has been deposited. *The proposed alternative does not require this heat treatment because the use of the extremely low hydrogen GTAW temper bead procedure does not require the hydrogen bake-out.*

- NB-4622.11(c)(8) requires welding subsequent to the hydrogen bake out of NB-4622.11(c)(7) be done with a minimum preheat of 100°F and maximum interpass temperature of 350°F. *The proposed alternative limits the interpass temperature to a maximum of 350°F and requires the area to be welded be at least 50°F prior to welding.* These limitations have been demonstrated to be adequate for the production of sound welds.

- NB-4622.11(d)(1) requires a liquid penetrant examination after the hydrogen bake out described in NB-4622.11(c)(7). The proposed alternative does not require the hydrogen bake-out because it is unnecessary for the very low hydrogen GTAW temper bead welding process.

- NB-4622.11(d)(2) requires liquid penetrant and radiographic examinations of the repair welds after a minimum time of 48 hours at ambient temperature. Ultrasonic inspection is required if practical. The proposed alternative includes the requirement to inspect after a minimum of 48 hours at ambient temperature.

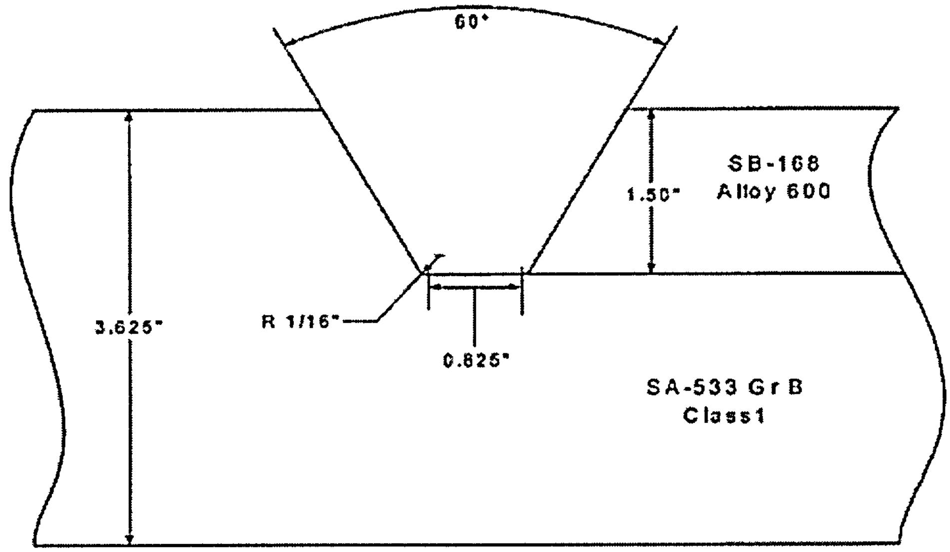
  Because the proposed repair welds are of a configuration that cannot be radiographed, final inspection will be by liquid penetrant and ultrasonic inspection.

- NB-4622.11(d)(3) requires that all nondestructive examination be in accordance with NB-5000.

  The proposed alternative will comply with NB-5000 except that the progressive liquid penetrant inspection required by NB-5245 will not be done. In lieu of the progressive liquid penetrant examination, the proposed alternative will use liquid penetrant and ultrasonic examination of the final weld.

- NB-4622.11(e) establishes the requirements for documentation of the weld repairs in accordance with NB-4130. The weld repair will be documented in accordance with NB-4130.

- NB-4622.11(f) establishes requirements for the procedure qualification test plate relative to the P-No. and Group Number and the postweld heat treatment of the materials to be welded. The proposed alternative meets and exceeds those requirements in that the root width and included angle of the cavity are stipulated to be no greater than the minimum specified for the repair. In addition, the location of the V-notch for the Charpy test is more stringently controlled in the proposed alternative than in NB-4622.11(f). A 60 degree included angle was used with a 5/8-inch wide root in the PQR test assembly as shown in the sketch below taken from Framatome-ANP Procedure Qualification Record (PQR) 7183. The Charpy specimen locations were controlled by tilting them in such a way that the root of the notch was in the HAZ.



Weld sample used for PQR 7183

- NB-4622.11(g) establishes requirements for welder performance qualification relating to physical obstructions that might impair the welder's ability to make sound repairs, which is particularly pertinent to the SMAW manual welding process. The proposed alternative involves a machine GTAW process and requires welding operators be qualified in accordance with ASME Section IX. The use of a machine process eliminates concern about obstructions, which might interfere with the welder's abilities since these obstructions will have to be eliminated to accommodate the welding machine.

NB-4453.4 of Section III requires examination of the repair weld in accordance with the requirements for the original weld. The welds being made per the proposed alternatives will be partial penetration welds as described by NB-4244(d) and will meet the weld design requirements of NB-3352.4(d). For these partial penetration welds, paragraph NB-5245 requires a progressive surface examination [liquid penetrant test (PT) or magnetic particle test (MT)] at the lesser of ½ the maximum weld thickness or ½ inch as well as a surface examination on the finished weld.

For the proposed alternative, the repair weld will be examined by a liquid penetrant and ultrasonic examination no sooner than 48 hours after the weld has cooled to ambient temperature in lieu of the progressive surface exams required by NB-5245.

IV. Basis for Relief

During the current refueling outage at ANO-1, inspection of the RVCH nozzles using the ultrasonic examination method (UT) has revealed indications of pressure boundary degradation requiring repair as described above.

Experience gained from the performance of repairs to RVCH nozzles at ANO-1 and throughout the industry indicate that remote automated repair methods are needed to reduce radiation dose to repair personnel. Additionally, achieving and maintaining the required preheat and post weld soak temperatures is time consuming and radiation dose intensive.

So, for the current repairs at ANO-1, a remote semi-automated repair method utilizing a qualified machine GTAW ambient temperature temper bead process is planned for each nozzle that requires repair. Using a remote tool from above the RVCH, each of the subject nozzles will first receive a roll expansion into the RVCH base material. The roll expansion ensures that the nozzle will not move during the repair operations. Second, an 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 subject RVCH nozzles and machine a bevel onto the end of the nozzles in preparation for the repair weld (see Figure 1). Third, a weld tool, utilizing the GTAW-machine process, will be used to install a new pressure boundary weld between the shortened nozzle and the inside bore of the RVCH base material (see Figure 2).

This approach for repairing RVCH nozzles will significantly reduce radiation dose to repair personnel while still maintaining acceptable levels of quality and safety. The total radiation dose (assuming two nozzles for estimation purposes) for the proposed remote repair method is projected to be about 10 REM. Entergy estimates the dose accumulated to provide access, install heating pads and perform the preheat and post weld heat treatment required by the construction code would total an additional 15 REM. In contrast, using manual repair methods would result in a total radiation dose of approximately 60 REM.

The automated repair method described above leaves a strip of low alloy steel exposed to the primary coolant. The effect of corrosion on the exposed area, both reduction in RVCH thickness and primary coolant ferric (Fe) release rates, will be evaluated by Framatome-ANP. This calculation will show that the general corrosion of the low alloy steel base material will be insignificant for the remaining life of the RVCH. The estimate will be based on extensive industry data and Framatome-ANP experience. It is estimated that the Fe release from a total of 69 repaired RVCH nozzles will be less than 15% of the total Fe release from all other sources. Entergy has determined that this extremely low rate of material loss and Fe release rates provide an acceptable level of safety. In addition, the ANO-1 RVCH will be replaced in Fall 2005 during 1R19.

An analysis of the new pressure boundary welds, using a 3-dimensional model of a RVCH nozzle located at the most severe hillside orientation will be performed. The software program ANSYS (general purpose finite element program that is used industry wide) will be utilized for this analysis. Per Framatome-ANP internal procedures, the ANSYS computer code is independently verified as executing properly by the solution of verification problems using ANSYS and then comparing the results to independently determined values.

The analytical model will include the RVCH, RVCH nozzle, repair weld and remnant portions of the original Alloy 600 welds. The model will be analyzed for thermal transient conditions as contained in the Reactor Coolant Functional Specifications. The resulting maximum thermal gradients will be applied to the model along with the coincident internal pressure values. The ANSYS program will then calculate the stresses throughout the model (including the repair welds). The stresses will be post-processed by ANSYS routines to categorize stresses into categories that are consistent with the criteria of the ASME Code.

The calculated stress values will be compared to the ASME Code, Section III, NB-3000 criteria for:

- Design Conditions
- Normal, Operating, and Upset Conditions
- Emergency Conditions
- Faulted Conditions
- Testing Conditions

A very conservative stress concentration factor (SCF) of 4.0 will be assumed for the new pressure boundary weld.

A primary stress analysis for design conditions will be performed. A maximum Primary General Membrane Stress Intensity (P_m) will be calculated and shown to be less than the maximum allowed by the ASME Code.

The maximum cumulative fatigue usage factor will be calculated for the point at the intersection of the bottom of the repair weld and the penetration bore and the crevice between the RVCH nozzle outside surface and the RVCH bore. Allowable years of future plant operation will be based on the maximum allowed ASME Code usage factor criterion of 1.0. It is anticipated that the limiting location for this value is the point at the intersection of the bottom of the repair weld and the penetration bore. At the bottom of the crevice between the RVCH nozzle outside surface and the RVCH bore, the calculated fatigue usage factor for 40 years of future operation is not expected to be limiting to the fatigue life of the repair.

Justification for Using the Proposed Alternatives

<u>NB-4331</u>

As described below under NB-4622, the characteristics of the weld proposed for this repair have been well defined by research and qualification for this and similar applications.

<u>NB-4622</u>

The proposed alternative requires the use of an automatic or machine GTAW temper bead technique without the specified preheat or post weld heat treatment of the Construction Code. The proposed alternative will include the requirements of paragraphs 1.0 through 5.0 of Attachment 1, "Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique." The alternative will be used to make welds joining P-No. 3, RVCH material to P-No. 43 RVCH 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 PQR 7164 using P-No. 3, Group No. 3 base material exhibited improved Charpy V-notch properties in the HAZ from both an absorbed energy and lateral expansion perspective as compared to the unaffected base material. PQR 7183, using P-No. 3 Group No. 3 base material and P-43 base material exhibited slightly degraded impact properties in the weld heat affected zone. An evaluation to address the affect of the degraded impact properties will be performed as described below (under Properties of PQR 7183).

Properties of PQR 7164

	Absorbed energy (ft-lbs @ 50°F)	Lateral expansion (mils @ 50°F)	Shear fracture (% @ 50°F)	Absorbed energy (ft-lbs @ 80°F)	Lateral expansion (mils @ 80°F)	Shear fracture (% @ 80°F)
Unaffected Base Material	69, 55, 77	50, 39, 51	30, 25, 30	78, 83, 89	55, 55, 63	35, 35, 55
HAZ	109, 98, 141	59, 50, 56	40, 40, 65	189, 165, 127	75, 69, 60	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.

Properties of PQR 7183

Unaffected Base Material			Heat Affected Zone		
Absorbed energy (ft-lbs @ 30°F)	Lateral expansion (mils @ 30°F)	Shear fracture (% @ 30°F)	Absorbed energy (ft-lbs @ 35°F)	Lateral expansion (mils @ 35°F)	Shear fracture (% @ 35°F)
59, 54, 61	53, 51, 47	20, 30, 20	95, 84, 95	49, 52, 50	45, 35, 55

The results of this second PQR require that the RT_{NDT} temperature of the base material be adjusted in accordance with the rules of NB-4335.2. This adjustment temperature increases the RT_{NDT} of the RVCH by 5°F. Entergy will evaluate the impact of the 5°F RT_{NDT} adjustment temperature on the RVCH against the fracture toughness requirements of 10 CFR50 Appendix G and existing Technical Specification Pressure-Temperature limits for the RVCH and reactor coolant system. However, it is expected that this minor degradation will have no effect on the safe operation of the RVCH or Technical Specification Pressure-Temperature limits.

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 Machine 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-3 Group-3 base material as proposed for the RVCH nozzle 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 WPS 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. 3 to P-No. 43 base material welded with F-No. 43 filler metal. The use of this WPS, 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:

- 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 wire on P-No. 3 Group No. 3 base material. 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 degree side bevels (60 degree included angle). All the effects of welding to the P-3 base material with F-No. 43 filler metal have been verified by full thickness transverse tensile tests and full thickness transverse side bends.

- The PQR 55-PQ7183 is similar except that one side of the weld was P-43 material and the groove was 1½ inches deep.

The NB-4622 temper bead procedure requires a 350°F preheat and a post weld soak at 450° - 660°F for 4 hours for P-No. 3 materials. Typically, these kinds of restrictions 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 the 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 filler metals 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 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. The gas would typically have no more than 1 ppm of hydrogen (H_2) and no more than 1 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.

Entergy has concluded that quality temper bead welds can be performed with 50°F minimum preheat and no post heat treatment based on ASME committee approval of Code Case N-638 and Framatome-ANP prior welding procedure qualification test data using machine GTAW ambient temperature temper bead welding. The proposed alternative ambient temperature temper bead weld technique (Attachment 1) provides a technique for repairing flaws in the RVCH penetration to vessel head J-groove welds within 1/8-inch of the ferritic base metal that will produce sound and permanent repairs and that the procedure is an alternative to Code requirements that will provide an acceptable level of quality and safety.

<u>NB-4622.11(c)(5)</u>

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

In lieu of using thermocouples for interpass temperature measurements, calculations will be performed to 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 will support the conclusion that, when 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 effect on the low alloy steel HAZ.

The calculation will be 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 ANO-1 RVCH, was used to demonstrate the welding technique described herein. During the mockup, thermocouples were placed to monitor the temperature of the closure head during welding. Thermocouples were placed on the outside surface of the closure head within a 5-inch band surrounding the RVCH nozzle. Three other thermocouples were placed on the closure head inside surface. One of the three thermocouples was placed 1½ inches from the RVCH nozzle penetration, on the lower hillside. The other inside surface thermocouples were placed at the edge of the 5-inch band surrounding the RVCH 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.

<u>NB-4622.11(d)(2)/ NB-4622.11(d)(3)/NB-4453.4</u>

UT will be performed in lieu of radiographic testing (RT) due to the repair weld configuration. Meaningful RT cannot be performed as can be seen in the applicable attached figures. The weld configuration and geometry of the penetration in the head provide an obstruction for the x-ray path and interpretation would be very difficult. UT will be substituted for the RT and qualified to evaluate defects in the repair weld and at the base metal interface. This examination method is considered adequate and superior to RT for this geometry. The new structural weld is sized like a coaxial cylinder partial penetration weld. ASME Code Section III construction rules require progressive PT of partial penetration welds. The Section III original requirements for progressive PT were in lieu of volumetric examination. Volumetric examination is not practical for the conventional partial penetration weld configurations. In this case the weld is suitable, except for the taper transition, for UT and a final surface PT will be performed.

The effectiveness of the UT techniques to characterize the weld defects has been qualified by demonstration on a mockup of the repair temper bead weld involving the same materials used for repair. Notches were machined into the mockup at 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 defects near the root of the weld because of the impedance change at the triple point (intersection of weld material, penetration tube, and vessel head). 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 possible defects. 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.

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. Approximately 70% of the weld surface will be scanned by UT. Approximately 83% of the RVCH ferritic steel HAZ will be covered by the UT. The transducers to be used are shown in Table 1. The UT coverage volumes are shown in Figures 5 through 10 for the various scans. Additionally, the final modification configuration and surrounding ferritic steel area affected by the welding is either inaccessible or extremely difficult to access, to obtain the necessary scans.

UT of the repair weld and HAZ are limited by the repair configuration. As can be observed from Figure 2, the RVCH nozzle weld repair configuration limits access to the ferritic steel base material above the weld as well as scanning from the taper at the bottom of the weld. See also Figures 5 through 10 and Table 1.

The PT examination extent is consistent with the Construction Code requirements. The final modification configuration and surrounding ferritic steel area affected by the welding is either inaccessible or extremely difficult to access.

PT examination of the entire ferritic steel bore will be performed after removal by boring of the lower end of the existing RVCH nozzle prior to welding.

As can be observed from Figures 2, 3, and 4 the configuration of the new RVCH nozzle repair configuration limits access to the ferritic steel base material. The ferritic steel base material area above the new weld is inaccessible due to the RVCH nozzle. The ferritic steel base material below the new weld and within ½ inch of the bottom weld toe will be PT examined subsequent to welding.

The welding head has video capability for torch positioning and monitoring during welding. The operator observes the welding operation as well as observing each bead deposited prior to welding the next bead. The video clarity and resolution is such that the welding operator can observe a ½ mil diameter color contrast wire.

Based on the above information, it may be concluded that using the proposed alternative ambient temperature temper bead weld technique (Attachment 1) is an acceptable alternative to Code requirements and will produce sound, permanent repair welds and an acceptable level of quality and safety.

V. Duration of the Proposed Alternative

Entergy is planning to replace the ANO-1 RVCH during the Fall 2005 refueling outage (1R19).

A Framatome-ANP evaluation will be performed to determine the time for a crack to grow 75% through-wall in the Alloy 600 nozzle material above the repair weld. The evaluation will consider RVCH nozzles both in the as-repaired condition and following abrasive water jet (AWJ) remediation. The evaluation will be for initiation and crack growth due to primary water stress corrosion cracking (PWSCC). With AWJ mitigation, the estimated corrosion time to breach the AWJ compressive residual stress layer and the estimated crack growth time to 75% through-wall is expected to yield 14.6 effective full power years (EFPY) estimated service life. The current schedule includes AWJ for the ANO-1 RVCH repairs.

Flaw growth rates for evaluation will be assumed to follow a 4 mm/year rate, which bounds any variation in flaw growth through the Alloy 600 material as a result of the weld repair.

Given these expected results, the proposed inspection schedules given above and the planned replacement date for the ANO-1 RVCH, the proposed alternatives to the ASME code requirements are justified.

The proposed alternatives are applicable to the repairs and examinations after repair to any ANO-1 RVCH nozzles. This request is applicable to RVCH repairs performed during the current refueling outage only.

VI. Implementation Schedule

This Request for Alternate is associated with the repair of RVCH nozzles with leaks or other unacceptable conditions that were identified during the current refueling outage which began October 4, 2002.

TABLE 1

ANO-1 PENETRATION Replacement Weld UT Search Unit Transducer Characteristics				
Angle/Mode	**Freq.**	**Size**	**Focal Depth**	**Beam Direction**
0° L-wave	2.25 MHz	0.15" x 0.30"	0.45"	N/A
45° L-wave	2.25 MHz	0.30" x 0.20"	0.45"	Axial
70° L-wave	2.25 MHz	0.72" x 0.21"	0.69"	Axial
45° L-wave (effective)	2.25 MHz	0.30" x 0.20"	0.45"	Circ.

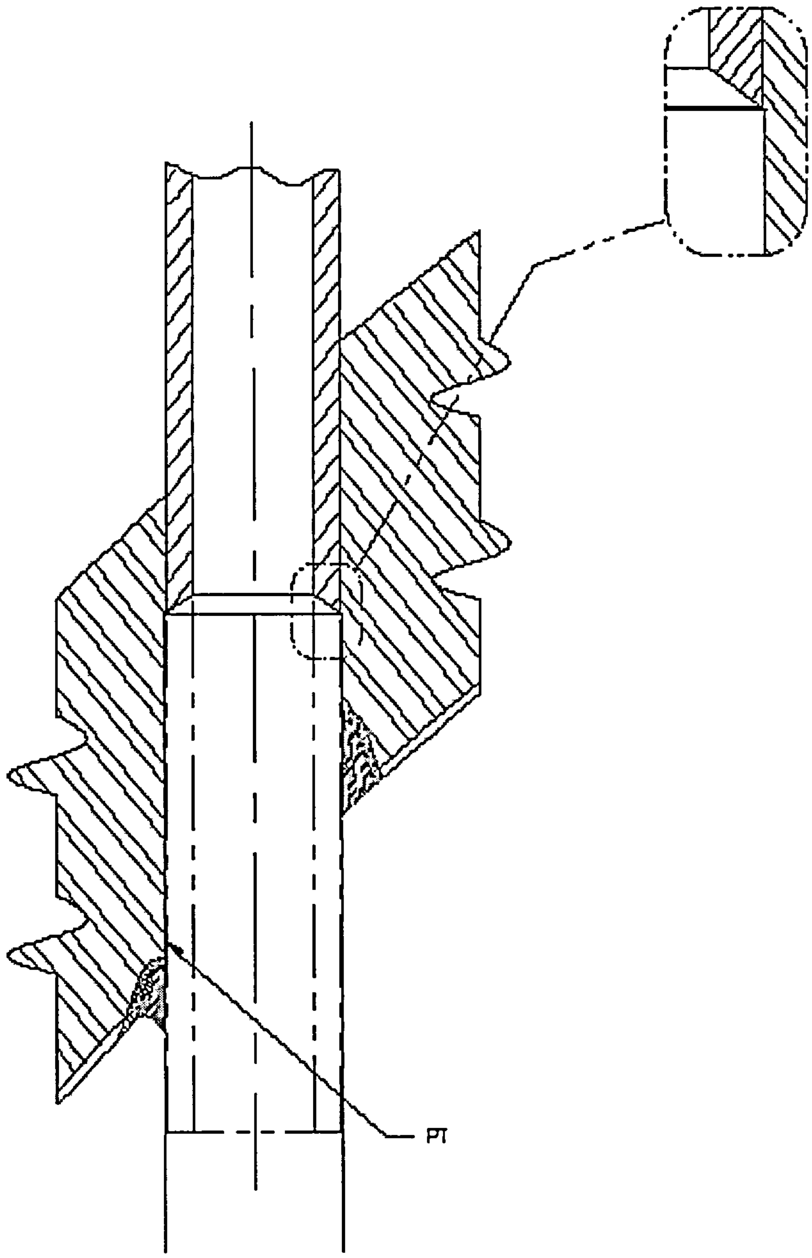


Figure 1
New ANO-1 RVCH Nozzle

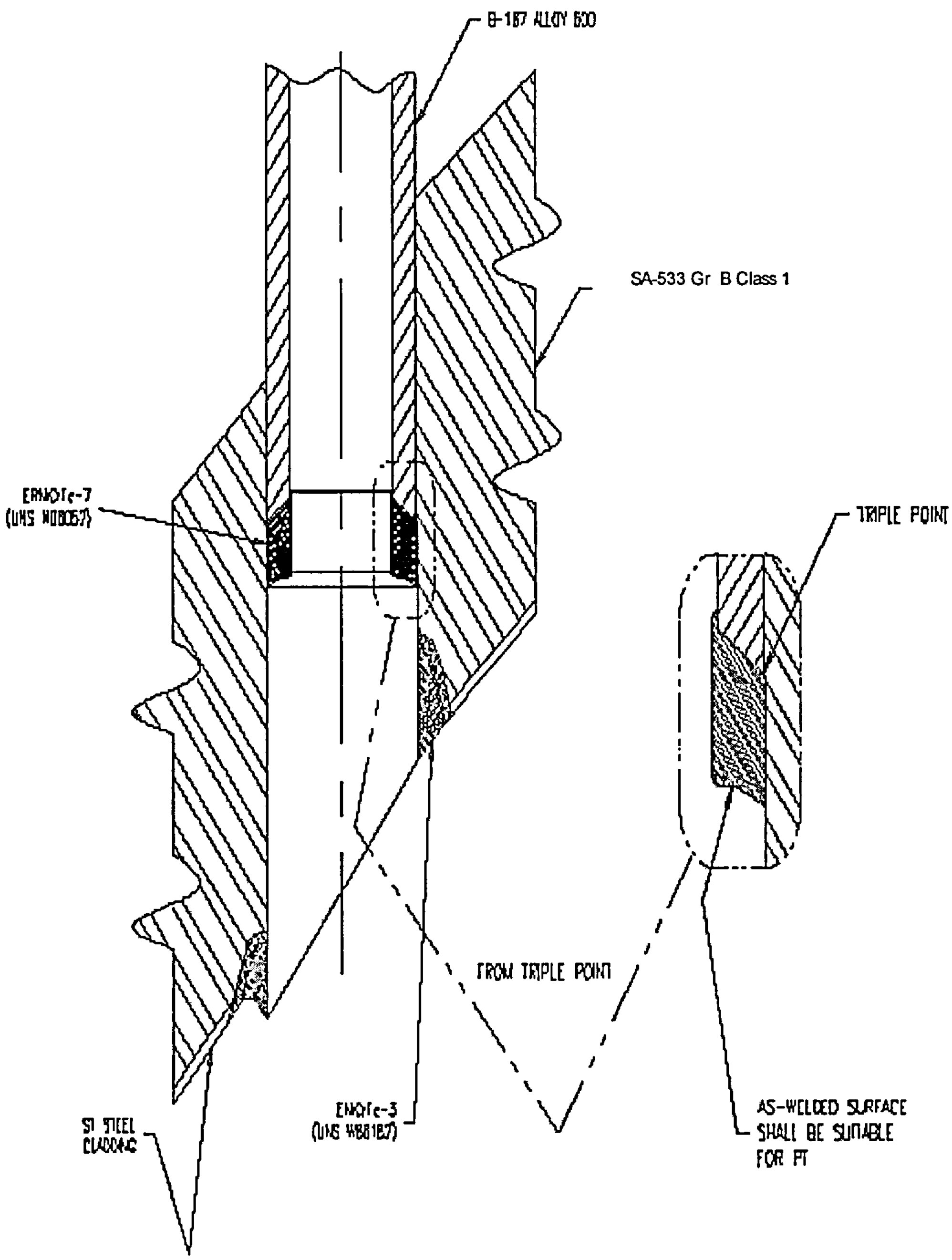


Figure 2
New ANO-1 RVCH Nozzle Pressure Boundary Weld

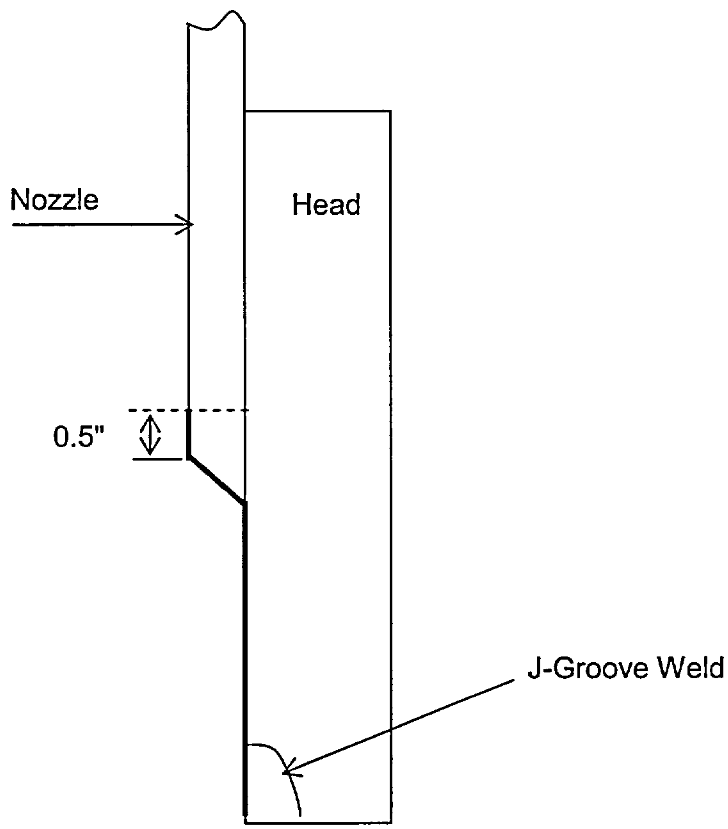


Figure 3
ANO-1 RVCH Nozzle Temper Bead Weld Repair
PT Coverage Prior to Welding

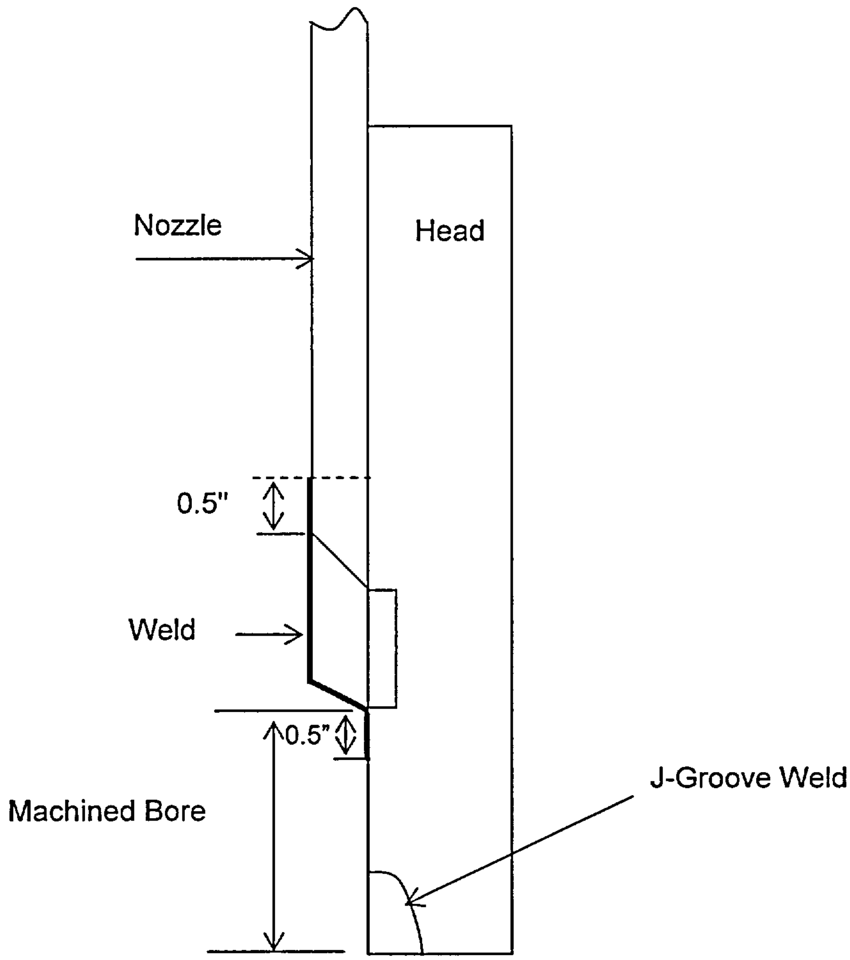


Figure 4
ANO-1 RVCH Nozzle Temper Bead Weld Repair
PT Coverage after Welding

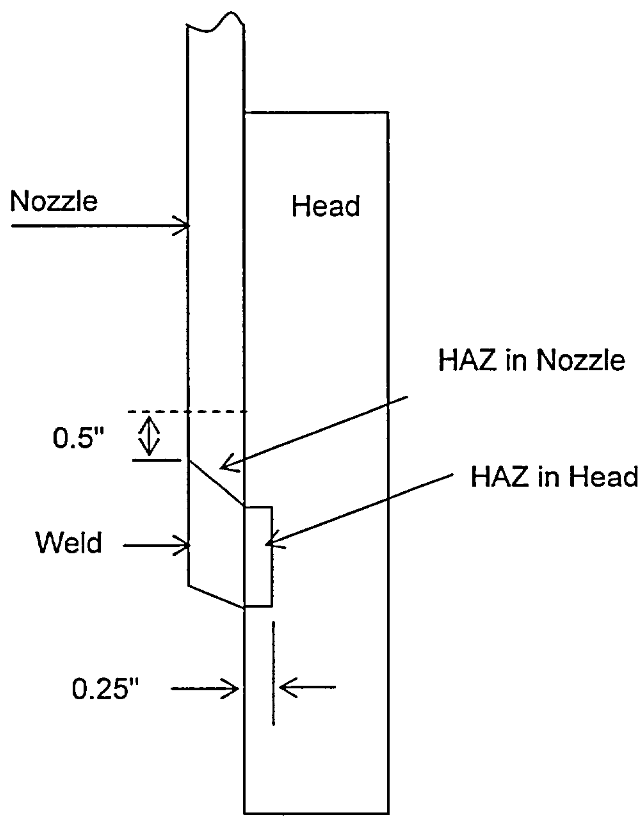


Figure 5
ANO-1 RVCH Nozzle Temper Bead Weld Repair
Areas to be Examined

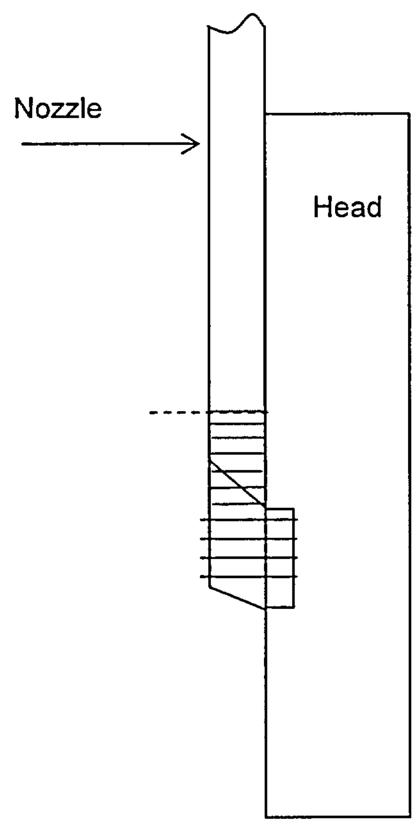


Figure 6
ANO-1 RVCH Nozzle Temper Bead Weld Repair
UT 0 degree and 45L Beam Coverage
Looking Clockwise and Counter-Clockwise

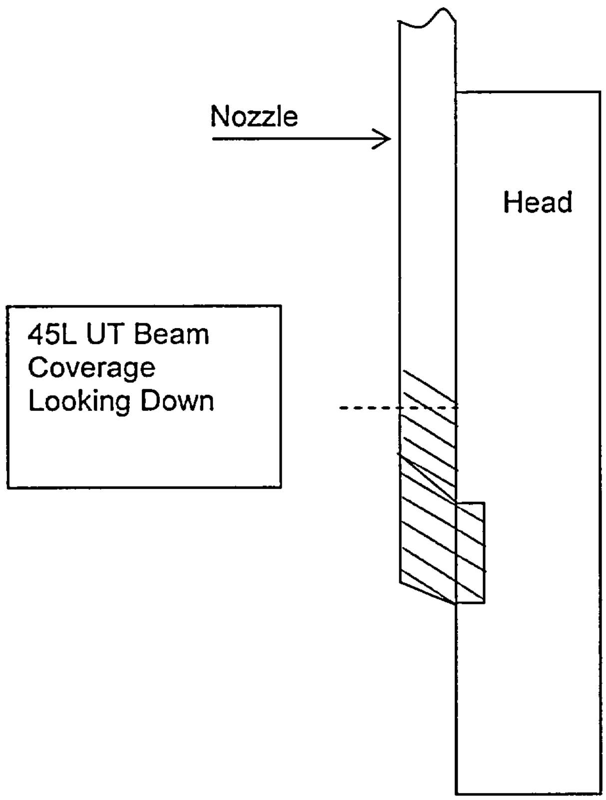


Figure 7
ANO-1 RVCH Nozzle Temper Bead Weld Repair
45L UT Beam Coverage Looking Down

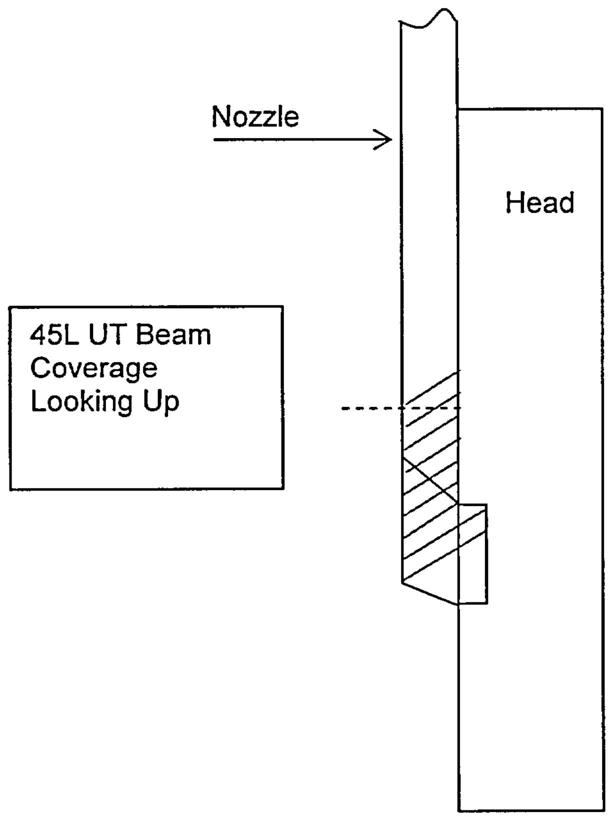


Figure 8
ANO-1 RVCH Nozzle Temper Bead Weld Repair
45L UT Beam Coverage Looking Up

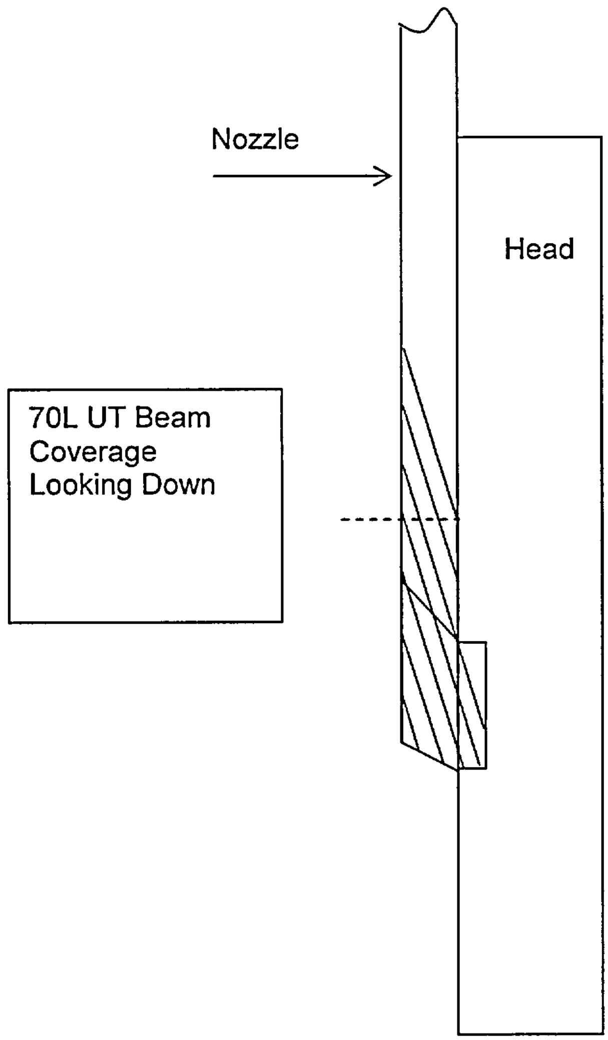


Figure 9
ANO-1 RVCH Nozzle Temper Bead Weld Repair
70L UT Beam Coverage Looking Down

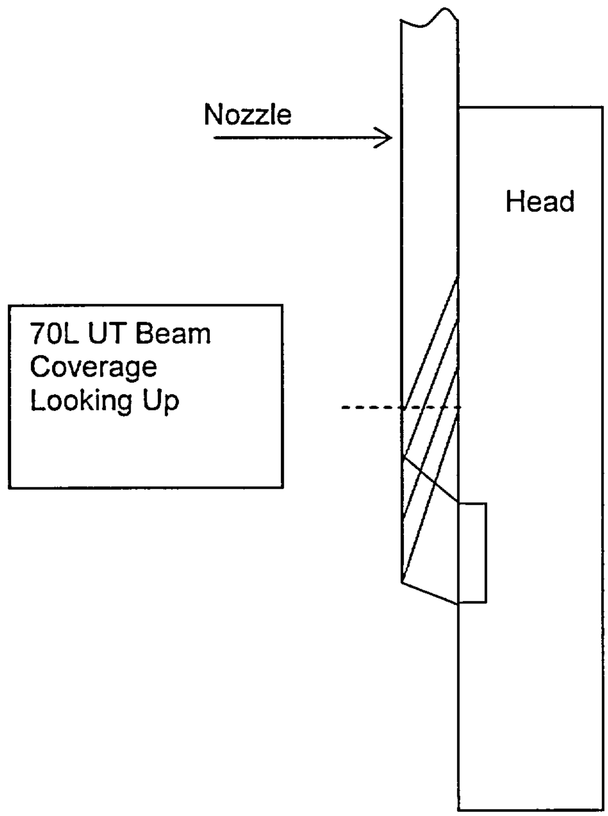


Figure 10
ANO-1 RVCH Nozzle Temper Bead Weld Repair
70L UT Beam Coverage Looking Up

REQUEST NO. ANO1-R&R-003

ATTACHMENT 1

DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD TECHNIQUE

DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD TECHNIQUE

Entergy plans to perform RVCH nozzle repairs by welding the RVCH (P-No. 3 base material) and nozzle (P-No. 43 base material) with filler material F-No. 43, in accordance with the following:

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.

(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 will not be used, however, the weldment final surface will be abrasive water jet conditioned.

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 ferritic steel base material for the welding procedure qualification is P-No. 3 Group No. 3 which is the same P-No. and Group No. as the low alloy steel closure head base material to be welded. The base material shall be postweld heat treated to at least the time and temperature that was applied to the materials being welded. The filler metal is F-No. 43.

(b) The root width and included angle of the cavity in the test assembly will be no greater than the minimum specified for the repair.

(c) The maximum interpass temperature for the first three layers of the test assembly will be 150°F.

(d) The ferritic steel P-No. 3 Group No. 3 base material 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 A-1.

(e) 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 (f) below, but shall be in the base metal.

(f) 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 (e) 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. Specimens will be in accordance with SA-370, Figure 11, Type A. The test will consist of a set of three full-sized 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.

(g) 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.

(h) If the average Charpy V-notch lateral expansion for the heat affected zone of 2.1(g) above is less than that for the unaffected base material, and the qualification test meets the other criteria of acceptance, the Charpy V-notch test results may be recorded on the Welding Procedure Qualification Record. Data shall then be obtained as specified in 2.1(i) below to provide an additive temperature for any base material for which the welding procedure is being qualified, and shall be included. Alternatively, the welding procedure qualification may be rewelded and retested.

(i) The data for use in 2.1 (h) above shall be developed by performing additional Charpy V-notch tests on either the welding procedure qualification heat affected zone or the unaffected base material, or both, at temperatures which provide lateral expansion values equal to or greater than 35 mils. The average lateral expansion data for the heat affected zone and the unaffected base material shall be plotted on a lateral expansion-temperature chart. The temperatures at which these two sets of data exhibit a common lateral expansion value equal to or greater than 35 mils shall be determined. The determined temperature for the unaffected base material shall be subtracted from the similarly determined temperature for the heat affected zone. This difference shall be used in 2.1 (h) above as the adjustment temperature. The adjustment temperature shall be added to the highest nil ductility temperature (RT_{NDT}) temperature for all of the base material to be welded by this procedure in production. If the temperature difference is zero or is a negative number, no adjustment is required for the base material to be welded in production.

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 machine GTAW process.

(b) Dissimilar metal welds shall be made using F-No. 43 weld metal (QW-432) for P-No. 43 to P-No. 3 weld joints.

(c) The ferritic steel 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 A-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 the ferritic material to ensure that the ferritic HAZ is tempered. Subsequent layers will be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification.

(d) The maximum interpass temperature for field applications will be 350°F regardless of the interpass temperature during qualification. The new weld is inaccessible for mounting thermocouples near the weld. Therefore, thermocouples will not be used to monitor interpass temperature. Preheat temperature will be monitored using contact pyrometers, on accessible areas of the closure head external surface(s).

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 adjacent HAZ shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours.

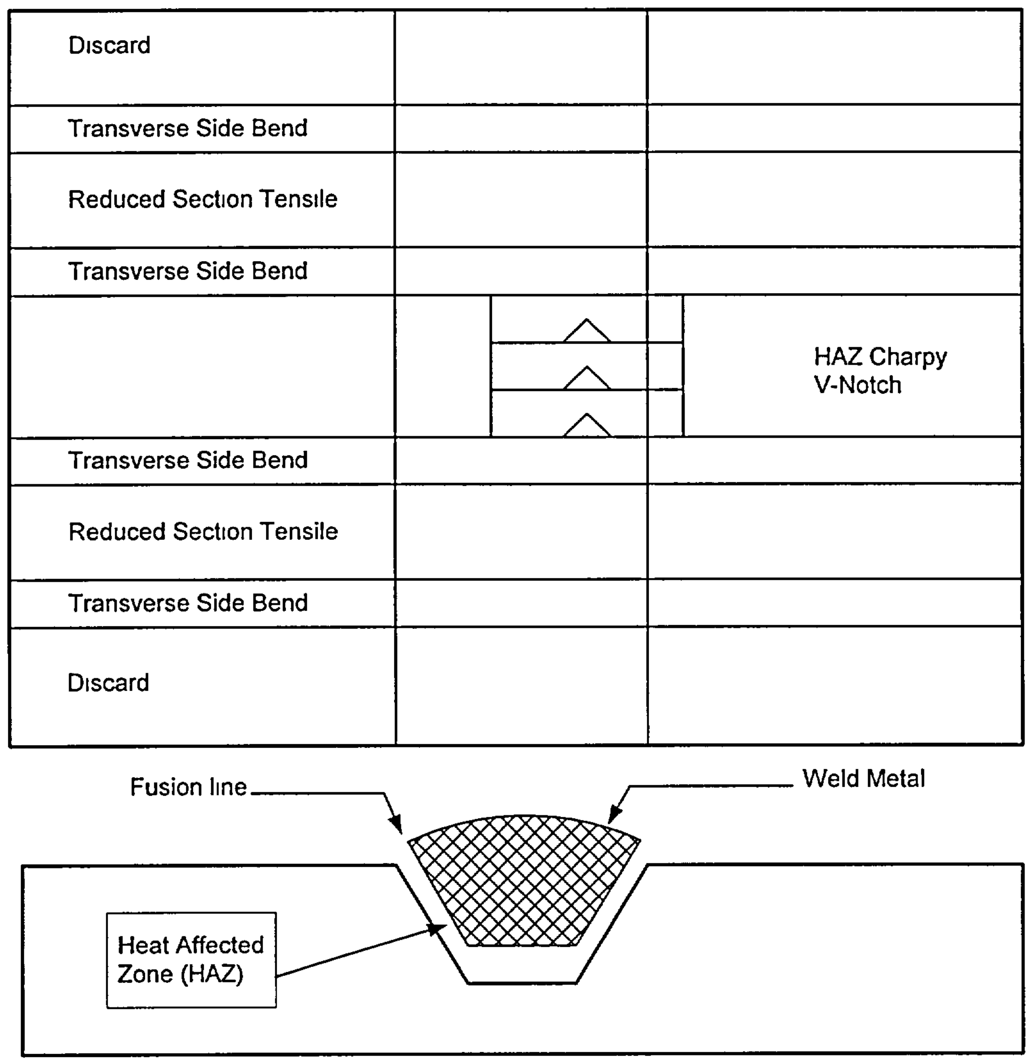
(c) The purpose for the examination of the band is to assure all flaws associated with the weld repair area have been removed or addressed. However, the band around the area defined in paragraph 1.0(d) cannot be examined due to the physical configuration of the partial penetration weld. The final examination 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 RVCH material due to the welding process. Liquid penetrant (PT) coverage is shown in Figures 3 and 4. Ultrasonic testing (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 RVCH 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 examination extent is consistent with the Construction Code requirements.

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

(e) Surface examination acceptance criteria will be in accordance with NB-5350. Ultrasonic examination acceptance criteria will be in accordance with NB-5330.

5.0 Documentation

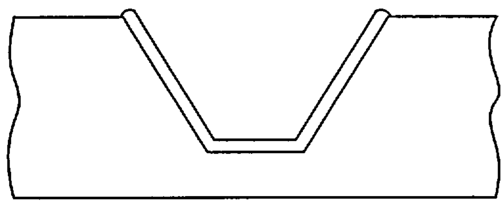
Repairs will be documented on Form NIS-2. Alternatively, repairs may be documented on Form NIS-2A as described in Code Case N-532 if prior approval is obtained from the NRC.



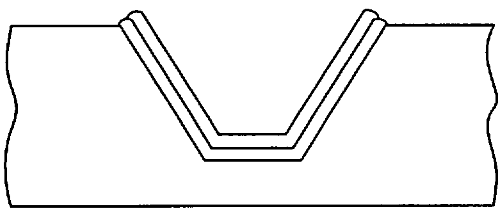
GENERAL NOTE. Base Metal Charpy impact specimens are not shown.

QUALIFICATION TEST PLATE

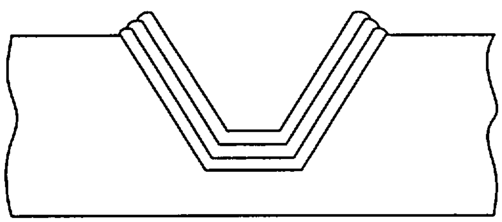
FIGURE A-1



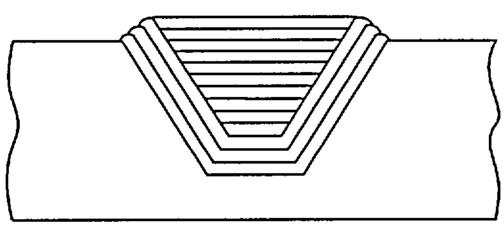
Step 1: Deposit layer one with first layer weld parameters used in qualification



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: For dissimilar-metal welding, only the ferritic base metal is required to be welded using Steps 1 through 3 of the temper bead welding technique

AUTOMATIC OR MACHINE GTAW TEMPER BEAD WELDING

FIGURE A-2

ENCLOSURE 2

CNRO-2002-00052

REQUEST FOR ALTERNATIVE
ANO1-R&R-004, Rev. 0

ENTERGY OPERATIONS, INC.
ARKANSAS NUCLEAR ONE, UNIT 1
3rd 10-YEAR INTERVAL
REQUEST No. ANO1-R&R-004, Rev. 0

REFERENCE CODE:

The original code of construction for Arkansas Nuclear One, Unit 1 (ANO-1) is ASME Section III, 1965 Edition with Addenda through Summer, 1967. The components (including supports) may meet the requirements set forth in subsequent editions and addenda of the ASME Code incorporated by reference in 10 CFR 50.55a(b) subject to the limitations and modifications listed therein and subject to NRC approval. The codes of record for the repairs described within this request are the 1989 Section III and 1992 Section XI codes. ANO-1 is in its third (3rd) 10-Year Inservice Inspection interval.

I. System/Component(s) for Which Relief is Requested

a) Name of component:
Reactor Pressure Vessel Closure Head (RVCH) nozzles (There are 69 nozzles welded to the RVCH.)

b) Function:
These welds serve as the pressure boundary weld for the RVCH nozzle and RVCH.

c) ASME Code Class:
The RVCH and RVCH nozzles are ASME Class 1.

d) Category:
Examination Category B-E, Pressure Retaining Partial Penetration Welds in Vessels; Item No. B4.12

II. Current Code Requirement and Relief Request:

IWA-4310 requires in part that "Defects shall be removed or reduced in size in accordance with this Paragraph." Furthermore, IWA-4310 allows that "...the defect removal and any remaining portion of the flaw may be evaluated and the component accepted in accordance with the appropriate flaw evaluation rules of Section XI." The ASME Section XI, IWA-3300 rules require characterization of flaws detected by inservice examination.

Pursuant to 10 CFR 50.55a(g)(5)(iii), relief is requested from ASME XI IWA-3300 (b), IWB-3142.4 and IWB-3420, which require flaw characterization.

Subarticle IWA-3300 contains criteria for characterizing flaws. None of the nondestructive evaluation techniques that can be performed on the remnant of the J-groove weld that will be left on the RVCH can be used to characterize flaws in accordance with any of the paragraphs or subparagraphs of IWA-3300. In lieu of those requirements, a conservative worst case flaw shall be assumed to exist and appropriate fatigue analyses will be performed based on that flaw.

Subsubparagraph IWB-3142.4 allows for analytical evaluation to demonstrate that a component is acceptable for continued service. It also requires that components found acceptable for continued service by analytical evaluation be subject to successive examination during the next three inspection periods. Analytical evaluation of the worst case flaw referred to above will be performed to demonstrate the acceptability of continued operation. However, because of the impracticality of performing any subsequent inspection that would be able to characterize any remaining flaw, successive examination will not be performed. In any event, RVCH replacement is planned for refuel outage 1R19 in Fall 2005, which will occur before the end of the next inspection period obviating the need for successive inspections of the J-weld remnant.

Paragraph IWB-3420 requires the characterization of flaws in accordance with the rules of IWA-3300. As previously stated, characterization in accordance with those rules is impractical. As an alternative, a conservative, worst case flaw will be assumed to exist and will be evaluated to establish the minimum remaining service life of the RVCH.

Section III Subsection NB-5330(b) requires that "Indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length."

Entergy is requesting relief from the requirements of NB-5330(b). The new pressure boundary weld that will connect the remaining portion of the RVCH nozzles to the low alloy RVCH contains a material "triple point." The triple point is at the root of the weld where the Alloy 600 nozzle will be welded with Alloy 690 (52) filler material to the SA-533 Grade B, Class 1 Mn-Mo low alloy steel plate (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.

Entergy has determined that compliance with the specified requirements would result in unusual difficulty or hardship without a compensating increase in the level of quality.

III. Alternate Criteria for Acceptability

In lieu of the requirements of IWA-3300, per 10 CFR 50.55a(a)(3)(ii) the following alternative is proposed:

The planned repair for the subject RVCH nozzles does not include removal of any cracks discovered in the remaining J-groove partial penetration welds. Therefore, per the requirements of IWA-4310, the cracks must be evaluated using the appropriate flaw evaluation rules of 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, Entergy will use worst-case assumptions to conservatively estimate the crack extent and orientation. The postulated crack extent and orientation will be evaluated using the rules of IWB-3600.

If a weld triple point anomaly occurs in any of the repair welds, it must also be evaluated in accordance with the appropriate flaw evaluation rules of Section XI. Calculations will be completed to justify this welding solidification anomaly.

IV. Basis for Relief

Inspections of the RVCH during the ANO-1 refueling outage (1R17), which began October 4, 2002, were performed in accordance with previous commitments. These inspections may identify conditions that indicate a need to repair flaws discovered in the RVCH penetrations. The use of any of the alternatives permitted by the applicable ASME Codes for repairs will result in increased radiation dose with no compensating increase in quality or safety. The PWHT parameters required by NB-4622 would be difficult to achieve on a RVCH in containment and would pose significant risk of distortion to the geometry of the RVCH and vessel head penetrations. In addition the existing J-groove welds would be exposed to PWHT for which they were not qualified. This request applies to repair of any or all of the noted penetrations and to others that may be identified by subsequent inspections during the outage.

Industry experience gained from earlier repairs of RVCH nozzles indicate that removal and repair of the defective portions of the original J-groove partial penetration welds were time consuming and radiation dose intensive. The prior repairs indicated that more automated repair methods were needed to reduce radiation dose to repair personnel. For the present ANO-1 repairs, a remote semi-automated repair method will be used for each of the subject nozzles. Using a remote tool from above the RVCH, each of the nozzles subject to this repair will first receive a roll expansion into the RVCH base material to insure 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 subject RVCH nozzles. Third, 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). It was intended, as a part of the new repair methodology and to reduce radiation dose to repair personnel that the original J-groove partial penetration welds would be left in place. These welds will no longer function as pressure boundary RVCH nozzle to RVCH welds. However, the possible existence of cracks in these welds mandates that the flaw growth potential be evaluated.

The requirements of IWA-4310 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 repair design specifies the inside corner of the J-groove weld be progressively chamfered from the center to outermost penetrations to maintain an acceptable flaw size. Section III paragraph NB-3352.4(d)(3) requires that the corners of the end of each nozzle to be rounded to a radius of ½ t_n. or ¾ inch which ever is smaller. A 1/8 inch minimum chamfer considered equivalent to the radius specified in NB-3352.4(d)(3) will be incorporated on the bottom corner of the repaired RVCH nozzle penetrations in lieu of the radius. The radius is specified to reduce the stress concentration that might occur at a sharp corner; however, since the original partial penetration weld that remains in this area is analyzed assuming through weld cracks exist therein the presence or absence of a radius or chamfer at this location is not significant with respect to stress concentration. The primary purpose of the chamfer is to assure that any remaining cracks are no larger than those assumed for the analysis.

The assumptions of IWB-3600 are that the cracks are fully characterized to be able 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 are obtained using finite element analysis of the RVCH. Since hoop stresses will be the dominant stress as determined by calculations, 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 RVCH 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 nozzle-to-RVCH weld configuration is extremely difficult to UT due to the compound curvature and fillet radius as can be seen in Figures 1 and 2. These conditions preclude ultrasonic couplıng and control of the sound beam in order to perform flaw sizing with reasonable confidence in the measured flaw dimension. Therefore it is impractical, and presently, the technology does not exist, to characterize flaw geometries that may exist therein. Not only is the configuration not conducive to UT but the dissimilar metal interface between the Ni-Cr-Fe 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. Entergy proposes to accept these flaws by analysis of the worst case that might exist in the J-groove. Since the worst case condition is to be analyzed as described 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 RVCH 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 will be performed to determine if degraded J-groove weld material could be left in the vessel, 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 RVCH. It is fully expected that such a crack would then blunt and arrest at the butter-to-head interface. In the worst case, on the uphill side of the nozzle, where the hoop stresses are highest and the area of the J-groove weld is the largest, a radial crack depth extending from the corner of the weld to the low alloy steel RVCH would be very deep, up to about 1-3/8 inch at the outermost row of nozzles after chamfering.

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 material are low, it will be conservatively 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

RVCH could result from a large stress corrosion crack in the weld to form a radial corner flaw that would propagate into the low alloy steel RVCH by fatigue crack growth under cyclic loading conditions associated with heatup and cooldown. Residual stresses will not be included in the flaw evaluations since it will be demonstrated by analysis that these stresses are compressive at the postulated crack tip in the low alloy steel base metal. 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 RVCH 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 will be calculated for a sufficient number of operating cycles to support operation until the RVCH is replaced in 2005. The analysis is required to demonstrate compliance with the fracture toughness requirements of the ASME Code using an upper shelf value of 200 ksi/in for ferritic materials.

The described analysis will determine the acceptability of leaving the postulated cracks in the attachment weld (J-groove) and buttering. The calculations will show the remaining flaws within the base material are acceptable for a number of heat-up/cool-down cycles that will exceed the number of heat-up/cooldown cycles expected to occur prior to replacement of the RVCH. The only driving mechanism for fatigue crack growth of the base material is heat-up/cool-down cycles. The fracture mechanics evaluation will assume a radial (with respect to the penetration centerline) crack exists with a length equal to the partial penetration weld preparation depth plus an additional distance into the RVCH low alloy steel where the residual stresses become compressive. Based on industry experience and operating stress levels, there is no reason for service related cracks to exist in the ferritic material.

An additional evaluation will be performed to determine the potential for debris from a cracking J-groove partial penetration weld. As noted above, radial cracks will be postulated to occur in the weld due to the dominance of the hoop stress at this location. The 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.

The cited evaluations will provide an acceptable level of safety and quality in insuring that the RVCH remains capable of performing its design function for a sufficient number of heat-up/cool-down cycles to support two (2) operating cycles, 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. Additionally, Entergy plans to replace the ANO-1 RVCH during 1R19 currently scheduled for Fall 2005.

In the case of the RVCH inside diameter (ID) temper bead repair the term "anomaly" is applied to the unusual solidification patterns that result along the low alloy steel / Alloy 600/Filler Metal 52 interface of the repair weld. The anomalies originate along the low alloy steel (RVCH) to Alloy 600 (original nozzle) interface where melting occurs and generally extend back towards the center of the weld bead. These anomalies are typical for welds that involve a "lap joint" type interface, such as typical partial penetration weld geometries, in the weld joint design. Cross sections of nickel alloy welds made utilizing similar joint designs with Alloy 600 base materials and Alloy 82 filler metals have exhibited these phenomena consistently.

This phenomenon is compounded by the different solidification rates for the base materials and weld metal used in performing the repair. Other suspected factors in the anomaly occurrence are the size of the interface gap, gap cleanliness and position of the welding arc relative to the edge of the interface. The molten weld puddle simply freezes back to each side of the interface and follows the interface into the weld as solidification of the weld puddle take place. Weld root anomalies have been observed on several mockups with configurations simulating the repair weld. UT methods have been developed based on the characteristics of this anomaly so that verification to the prescribed acceptance criteria can be performed. The defect is treated like a crack, which is worst case. Two types of flaws are common in this area. The first is localized melting away of the feathered end of the beveled nozzle weld prep leaving occasional small voids. The second type flaw is caused due to an inherent problem during solidification of high Ni-Cr alloys in the presence of a notch such as a partial penetration weld. This type of flaw is in fact often called a "solidification anomaly" to differentiate it from what it is not – a crack.

IWA-4170 mandates that the repair design meets the original construction code or the adopted ASME Section III Code. As noted, the 1989 ASME Section III code has been adopted for qualification of the described repairs. Subsection NB-5330(b) stipulates that no lack of fusion area be present in the weld. A fracture mechanics analysis will be performed to demonstrate compliance with Section XI of the ASME Code, for operating with the postulated weld anomaly described above. The anomaly is modeled as a 0.1 inch semi-circular "crack-like" defect, 360 degrees around the circumference at the "triple point" location. Full-size mockups using coupons from the Midland RVCH were metallographically evaluated. Both flaw types were occasionally found as expected and were less than the analyzed maximum allowed of 0.100".

Based on the fact that this anomaly is predictable as discussed herein, the anomaly can be detected by UT within the prescribed acceptance criteria and evaluated for fatigue and flaw growth using applicable ASME III and XI methods, the intent of the ASME codes will be met. The ASME III analysis conservatively assumes a reduction in weld cross sectional area due to the anomaly and the ASME XI analysis assumes the anomaly is a crack-like defect.

The results from future examinations will be compared to the original preservice UT data to determine whether any changes have occurred.

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 RVCH tube wall thickness from the outside diameter (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 are 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 are postulated at the outside surface of the tube. A 360 degree continuous circumferential flaw, lying in a horizontal plane, is considered to be a conservative representation of crack-like defects that may exist in the weld anomaly. This flaw is subjected to axial stresses in the tube. An axially oriented semi-circular outside surface flaw is 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 RVCH. A semi-circular cylindrically oriented flaw is 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 result of the analysis will be required to demonstrate that a 0.10 inch weld anomaly is acceptable for a design life of the RVCH ID temper bead weld repair that is beyond 2005 when the ANO-1 RVCH is scheduled to be replaced. Residual stresses and stresses due to operation will be considered. Significant fracture toughness margins are expected for both of the flaw propagation paths considered in the analysis. The minimum calculated fracture toughness margins are required to be greater than the required margin of 10 per Section XI IWB-3612. Based on similar analysis, fatigue crack growth is expected to be minimal. The maximum final flaw size will be small considering both flaw propagation paths. A limit load analysis will also be performed considering the ductile Alloy 600/Alloy 690 materials along flaw propagation path 1. The analysis is required to show limit load margins for normal/upset conditions and emergency/faulted conditions greater than the required margins of 3.0 and 1.5 for normal/upset conditions and emergency/faulted conditions, respectively, per Section XI, IWB-3642.

Acceptance of the repair will be based on this evaluation in accordance with ASME Section XI and will demonstrate that for the intended service life of the repair, the fatigue crack growth is acceptable and the crack-like indications remain stable. These two findings will satisfy the Section XI criteria but do not include considerations of stress corrosion cracking such as PWSCC.

Since the crack-like indications in the weld triple point anomaly 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 from PWSCC is not applicable.

As required by ASME Section XI, the results of the analysis will determine the maximum design life which is expected to be greater than the two (2) operating cycles that will occur before the RVCH is replaced in Fall 2005.

For the reasons described above, areas of J-welds containing flaws accepted by analytical evaluation will not be reexamined as required by IWB-3142.4. Additionally, Entergy has planned to replace the ANO-1 RVCH in Fall 2005 which occurs prior to the expiration of the next inspection period. However, because of the solidification anomalies that may occur in the new repair, Entergy proposes that these weld(s) be volumetrically examined during the next refuel outage for comparison with the baseline data collected after their installation.

Justification for Granting Relief

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 subject J-groove welds is PWSCC. As shown by industry experience, the low alloy steel of the RVCH impedes crack growth by PWSCC. Entergy believes the alternative will provide an acceptable level of quality and safety when compared to the code requirements in IWB-3500 to characterize the cracks left in service. Using flaw tolerance techniques and an assumed worst-case crack size, the analysis will be required to demonstrate that unacceptable flaw growth into the RVCH does not occur within the next two operating cycles. Thus, the RVCH can be accepted per the requirements of IWA-4310.

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 penetrations, Catawba 2 steam generator channel head drain connection penetration, ANO-1 hot leg level tap penetrations and the VC 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 NPSD-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.

Elimination of the weld triple point anomaly would require use of an entirely different process than that proposed for use on ANO-1. The only qualified method currently available would involve extensive manual welding that would result in radiation doses estimated to be in excess of 30 REM per nozzle as compared to the 5 REM estimated for each nozzle repaired by the proposed process. Compliance with the specified Code requirements would result in excessive radiation exposure: a hardship or unusual difficulty without a compensating increase in the level of quality and safety.

V. Duration of the Proposed Alternative

Due to repairs to the ANO-1 RVCH and PWSCC concerns throughout the nuclear industry, Entergy is planning to replace the RVCH in Fall 2005 during refueling outage 1R19.

During the next refuel outage (1R18), Entergy will perform visual inspections of the RVCH and volumetric examinations of those nozzles repaired with the process described in this request. The inspection schedule is based on the service life of the repairs described herein. A Framatome-ANP evaluation will determine the time for a crack to grow 75% through-wall in the Alloy 600 nozzle material above the repair weld. The evaluation will consider RVCH nozzles both in the as-repaired condition and following abrasive water jet (AWJ) remediation. The evaluation will be for initiation and crack growth due to PWSCC. With AWJ mitigation, the estimated corrosion time to breach the AWJ compressive residual stress layer and the estimated crack growth time to 75% through-wall is expected to yield 14.6 effective full power years (EFPY) estimated service life. The current schedule includes AWJ for the ANO-1 RVCH nozzle repairs.

Flaw growth rates for evaluation will be assumed to follow the 4 mm/year rate, which bounds any variation in flaw growth through the Alloy 600 material as a result of the weld repair.

Given these results, the proposed inspection schedules given above and the planned replacement date for the ANO-1 RVCH, the proposed alternatives to the ASME code requirements are justified. The proposed alternatives are applicable to the repairs and examinations after repair to any ANO-1 RVCH nozzle.

VI. Implementation Schedule

This Request for Alternate is associated with the repair of RVCH nozzles with leaks or other unacceptable conditions that were identified during the current refueling outage which began October 4, 2002.

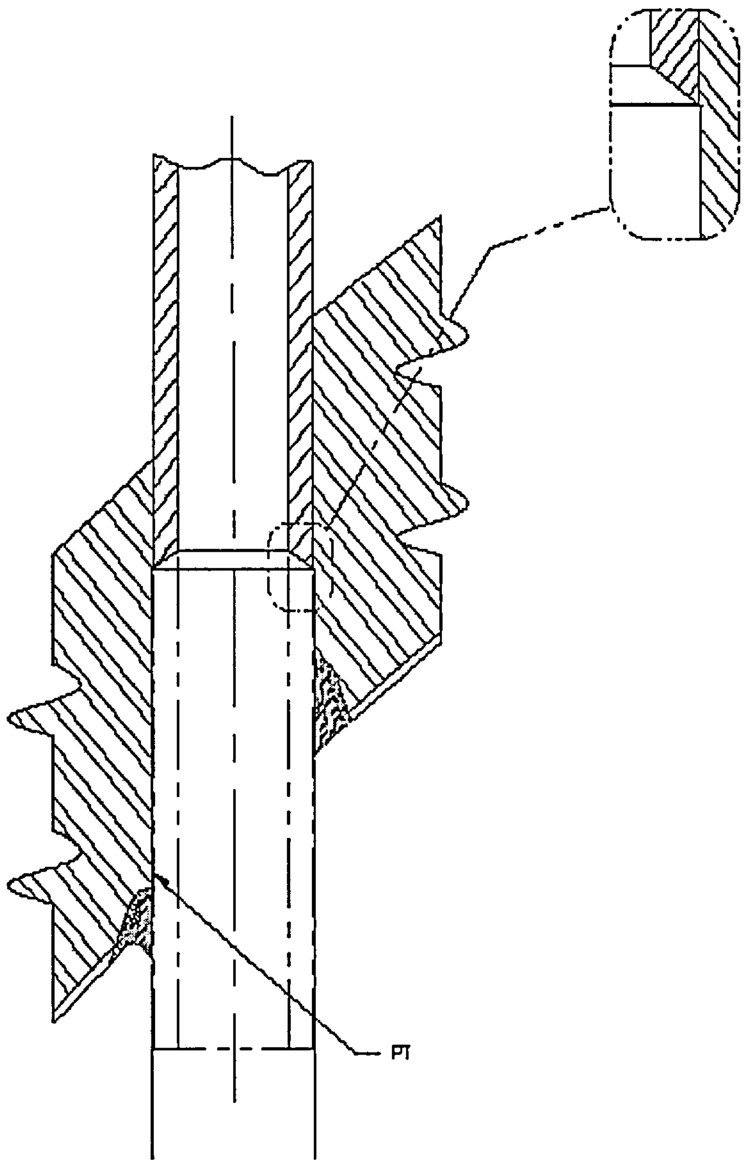


FIGURE 1
New ANO-1 RVCH Nozzle

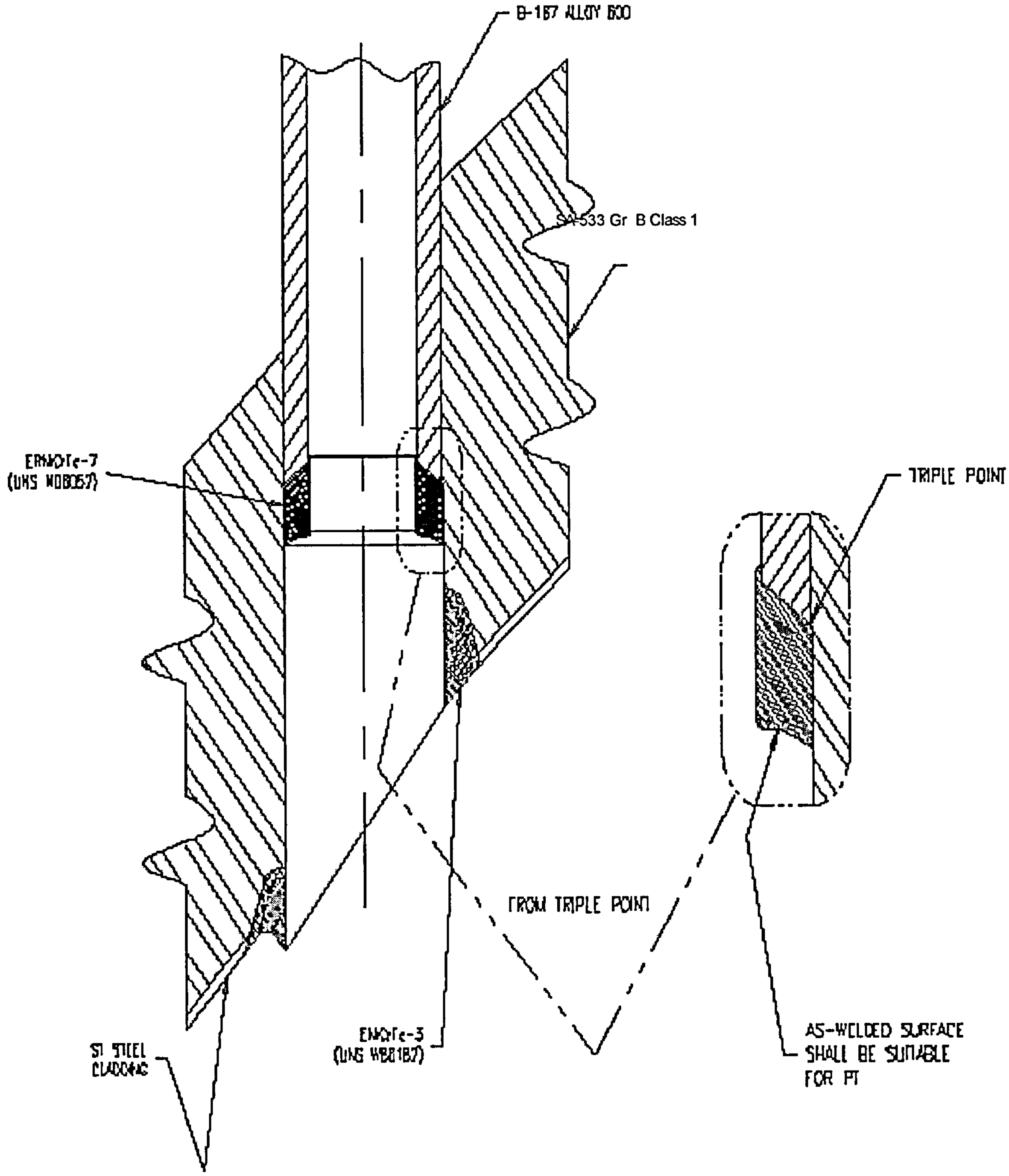


FIGURE 2
ANO-1 New RVCH Pressure Boundary Welds