



Palo Verde Nuclear
Generating Station

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10 CFR 50.55a

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102-04873-CDM/SAB/RJR
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U.S. Nuclear Regulatory Commission
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Rockville, MD. 20852

Reference Letter 102-04705-CDM/SAB/RJR, "Proposed Alternative Repair Method for Reactor Vessel Head Penetrations – Relief Request No. 18," dated May 22, 2002

Dear Sirs:

**Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. STN 50-528/529/530
Resubmittal of 10 CFR 50.55a Alternative Repair Request for
the Second 10-Year Interval of the Inservice Inspection Program
(Relief Request 18)**

Pursuant to 10 CFR 50.55a(a)(3)(i), APS is proposing alternatives to the gas-tungsten arc welding (GTAW) machine temper bead welding requirements of IWA-4500 and IWA-4530 of ASME Section XI. This request is for Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3 during the second 10-Year interval of the Inservice Inspection Program.

Relief Request No. 18 was originally submitted in the referenced letter which was based on technical justification from a generic Westinghouse topical. As a result of discussions with Westinghouse and NRC personnel on August 26, 2002, it was determined that a complete resubmittal of Relief Request No. 18 would be made without reliance on the generic Westinghouse topical.

Specifically, APS is requesting authorization to use an ambient temperature automatic or machine GTAW temper bead process for certain repairs to J-groove welds on the Reactor Vessel Head Penetrations. The repair welds performed using an ambient temperature temper bead procedure, which utilizes an automatic or machine GTAW process exhibits mechanical properties equivalent or better than those of the surrounding base material.

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U.S. Nuclear Regulatory Commission
PVNGS Units 1, 2, and 3, Docket Nos. STN 50-528/529/530
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The details of this 10 CFR 50.55a request are provided in the enclosure to this letter.

APS requests the Staff's review of the proposed relief request prior to April 2003.
Should APS identify the need to perform repairs using the proposed relief request as a
result of the Reactor Vessel Head inspections being performed in Unit 3 in March 2003,
APS may request expedited approval of this Code alternative request.

Should you have any questions, please contact Thomas N. Weber at (623) 393-5764.

Sincerely,



Enclosure: Resubmittal of 10 CFR 50.55a Alternative Repair Request for the Second
10-Year Interval of the Inservice Inspection Program (Relief Request 18)

CDM/SAB/RJR/kg

cc: E. W. Merschoff
J. N. Donohew
N. L. Salgado

**Resubmittal of 10 CFR 50.55a Alternative Repair Request
for the Second 10-Year Interval of the Inservice Inspection
Program (Relief Request 18)**

**10 CFR 50.55a Alternative Repair Request for PVNGS Units 1, 2, and 3
2nd 10-Year Interval of the Inservice Inspection Program**

Relief Request 18

I. ASME Code Component(s) Affected

Component number: B4.12, B4.11
Description: Control Element Drive Mechanism nozzle penetration (97)
Reactor Head Vent nozzle penetration (1)

Code Class: 1

II. Applicable Code Addition and Addenda

Second 10-year inservice inspection interval code for Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3: The American Society of Mechanical Engineers (ASME) Code, Section XI, 1992 Edition, 1992 Addenda.

Construction code for PVNGS Units 1, 2, and 3: ASME Section III, 1971 Edition, 1973 Winter Addenda.

Installation code for PVNGS Units 1, 2, and 3: ASME Section III, 1974 Edition, 1975 Winter Addenda.

III. Applicable Code Requirement

Subarticle IWA-4170(b) of ASME Section XI, 1992 Edition, 1992 Addenda 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 requirements of IWA-4200, IWA-4400, or IWA-4500 may be used."

IWA-4500 of ASME Section XI establishes alternative repair welding methods for performing temper bead welding. According to IWA-4500(a), "Repairs to base materials and welds identified in IWA-4510, IWA-4520, and IWA-4530 may be made by welding without the specified postweld heat treatment requirements of the Construction Code or Section III, provided the requirements of IWA-4500(a) through (e) and IWA-4510, IWA-4520, or IWA-4530, as applicable, are met."

IWA-4530 applies to dissimilar materials such as welds that join P-Number 43 nickel alloy to P-Number 3 low alloy steels. According to IWA-4530, "Repairs to welds that join P-No. 8 or P-No. 43 material to P-Nos. 1, 3, 12A, 12B, and 12C material may be made without the specified postweld heat treatment, provided the requirements of IWA-4530 through IWA-4533 are met. Repairs made to this paragraph are limited to

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those along the fusion line of a nonferritic weld to ferritic base material where 1/8 in. or less of nonferritic weld deposit exists above the original fusion line after defect removal.”

Temper bead repairs of the Reactor Pressure Vessel (RPV) head penetration nozzle J-welds are performed in accordance with IWA-4500 and IWA-4530 whenever the repair cavity is within 1/8-inch of the ferritic base materials of the RPV head. When the Gas Tungsten Arc Welding (GTAW) process is used in accordance with IWA-4500 and IWA-4530, then temper bead welding is performed as follows:

- Only the automatic or machine GTAW process using cold wire feed can be used. Manual GTAW cannot be used.
- A minimum preheat temperature of 300°F is established and maintained throughout the welding process. Interpass temperature cannot exceed 450°F.
- The weld cavity is buttered with at least six (6) layers of weld metal.
- Heat input of the initial six layers is controlled to within +/-10% of that used for the first six layers during procedure qualification testing.
- After the first six weld layers, repair welding is completed with a heat input that is equal to or less than that used in the procedure qualification for weld layers seven and beyond.
- Upon completion of welding, a postweld soak or hydrogen bake-out at 300°F (minimum) for a minimum of 4 hours is required.
- Preheat, interpass, and postweld soak temperatures are monitored using thermocouples and recording instruments.
- The repair weld and preheated band are examined in accordance with IWA-4533 after the completed weld has been at ambient temperature for 48 hours.

IV. Proposed Alternative

A. Background

The RPV head penetration nozzles at PVNGS Units 1, 2, and 3 are considered to have a moderate susceptibility to Primary Water Stress Corrosion Cracking (PWSCC). This is based upon a susceptibility ranking of greater than 5 effective full power years (EFPY) but less than 30 EFPY from the Oconee Nuclear Station 3 time-at-temperature condition.

Should repair welding of RPV head penetration nozzle J-welds encroach (within 1/8-inch) on the ferritic base material of the RPV head, temper bead weld repairs

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would be required. See the following figures for additional details.

- Figure 1: Typical RPV Head Penetration Nozzle
- Figure 2: Example Repair of an RPV Head Penetration Nozzle J-Weld

B. Proposed Alternative

Pursuant to 10CFR50.55a(a)(3)(i), APS proposes alternatives to the GTAW-machine temper bead welding requirements of IWA-4500 and IWA-4530 of ASME Section XI. Specifically, APS proposes to perform ambient temperature temper bead welding in accordance with Attachment 1 to this letter, “Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique,” as an alternative to IWA-4500 and IWA 4530.

APS has reviewed the proposed ambient temperature temper bead welding techniques of Attachment 1 against the GTAW-machine temper bead welding requirements of IWA-4500 and IWA-4530. This review was performed to identify differences between Attachment 1 and IWA-4500 and IWA-4530. Based upon this review, APS proposes alternatives to the following ASME Section XI requirements of IWA-4500 and IWA-4530:

1. **IWA-4500(a)** specifies that repairs to base materials and welds identified in IWA-4530 may be performed without the specified postweld heat treatment of the construction code or ASME Section III provided the requirements of IWA-4500 and IWA-4530 are met. IWA-4530 includes temper bead requirements applicable to the Shielded Metal Arc Welding (SMAW) and the machine or automatic GTAW processes. As an alternative, APS proposes to perform temper bead weld repairs using the ambient temperature temper bead technique described in Attachment 1. Only the machine or automatic GTAW process can be used when performing ambient temperature temper bead welding in accordance with Attachment 1.
2. **IWA-4500(d)(2)** specifies that if repair welding is to be performed where physical obstructions impair the welder’s ability to perform, the welder shall also demonstrate the ability to deposit sound weld metal in the positions, using the same parameters and simulated physical obstructions as are involved in the repair. This limited accessibility demonstration applies when manual temper bead welding is performed using the SMAW process. It does not apply to “welding operators” who perform machine or automatic GTAW welding from a remote location. (This distinction is clearly made in IWA-4500 and IWA-4530.) Because the proposed ambient temperature temper bead technique described in Attachment 1 utilizes a machine GTAW welding process, limited access demonstrations of “welding operators” are not required. Therefore, the requirement of IWA-4500(d)(2) does not apply.

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3. **IWA-4500(e)(2)** specifies that the weld area plus a band around the repair area of at least 1½ times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 300°F for the GTAW process during welding; maximum interpass temperature shall be 450°F. As an alternative, APS proposes that the weld area plus a band around the repair area of at least 1½ times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 50°F for the GTAW process during welding; maximum interpass temperature shall be 150°F for the 1/8-inch butter thickness (first three weld layers as a minimum) and 350°F for the balance of welding.
4. **IWA-4500(e)(2)** specifies that thermocouples and recording instruments shall be used to monitor process temperatures. As an alternative, APS proposes to monitor preheat and interpass temperatures using an infrared thermometer.
5. **IWA-4500(e)(2)** specifies that thermocouple attachment and removal shall be performed in accordance with ASME Section III. Because APS will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the thermocouple attachment and removal requirements of IWA-4500(e)(2) do not apply.
6. **IWA-4532.1** establishes procedure technique requirements that apply when using the SMAW process. Because the proposed ambient temperature temper bead technique of Attachment 1 utilizes the machine or automatic GTAW welding process, the SMAW temper bead technique requirements of paragraph IWA-4532.1 do not apply.
7. **IWA-4532.2** establishes procedure technique requirements that apply when using the GTAW process but do not address joint design qualification of the repair cavity. As an alternative, APS proposes to qualify the joint design of the proposed repair cavity by requiring that the root width and included angle of the repair cavity in the test assembly be no greater than the minimum specified for the repair.
8. **IWA-4532.2(c)** specifies that the repair cavity shall be buttered with the first six layers of weld metal in which the heat input of each layer is controlled to within +/-10% of that used in the procedure qualification test, and heat input control for 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. As an alternative, APS proposes to butter the weld area with a minimum of three layers of weld metal to obtain a minimum butter thickness of 1/8-inch. The heat input of each weld layer in the 1/8-inch thick buttered section shall be controlled to within +/-10% of that used in the procedure qualification test. The heat input for subsequent weld layers shall not exceed the heat input used for layers beyond the 1/8-inch thick buttered section (first three weld layers) in the procedure qualification.

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9. **IWA-4532.2(c)** specifies that the completed weld shall have at least one layer of weld reinforcement deposited and then this reinforcement shall be removed by mechanical means. As an alternative, the proposed ambient temperature temper bead technique does not include a reinforcement layer.

10. **IWA-4532.2(d)** specifies that, after at least 3/16-inch of weld metal has been deposited, the weld area shall be maintained at a temperature of 300°F (minimum) for a minimum of four (4) hours (for P-No. 3 materials). As an alternative, the proposed ambient temperature temper bead technique does not include a postweld soak.

11. **IWA-4532.2(e)** specifies that after depositing at least 3/16-inch of weld metal and performing a postweld soak at a minimum temperature of 300°F, the balance of welding may be performed at an interpass temperature of 350°F. As an alternative, APS proposes that an interpass temperature of 350°F may be used after depositing at least 1/8-inch of weld metal without a postweld soak.

12. **IWA-4533** specifies the following examinations shall be performed after the completed repair weld has been at ambient temperature for at least 48 hours:
(a) the repair weld and preheated band shall be examined by the liquid penetrant method; (b) the repaired region shall be examined by the radiographic method, and if practical, (c) by the ultrasonic method. APS will perform the liquid penetrant examination of the completed repair weld and preheated band as required by IWA-4533. As an alternative to the volumetric examination of IWA-4533, APS proposes the following examinations for repair welds in RPV penetration nozzle J-welds.
 - Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III. The liquid penetrant examinations will be performed in accordance with NB-5000. Acceptance criteria shall be in accordance with NB-5350.

This request for alternative is specific to localized weld repair of RPV head penetration nozzle J-welds where 1/8-inch or less of Inconel weld metal exists between the J-weld repair cavity and the ferritic base material of the RPV head. See Figures 1 and 2. Flaws in the J-weld will be removed prior to performing any temper bead repairs in accordance with this relief request.

V. Basis of Alternative for Providing Acceptable Level of Quality and Safety

The RPV heads are manufactured from P-Number 3, Group 3 low alloy steels. If repairs are performed in accordance with ASME Section III, APS would have two options: (1) perform a weld repair that includes a postweld heat treatment (PWHT) at 1100°F – 1250° F in accordance with NB-4622.1; or (2) perform a

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temper bead repair using the SMAW process in accordance with NB-4622.11. Each option is discussed below.

1. PWHT of the RPV head is an impractical option that would permanently damage the RPV head assembly. ASME Section III NB-4600 requires PWHT to be performed at 1100° - 1250°F. PWHT of the RPV head will result in ovalization and misalignment of CEDM penetrations and changes in clearances.
2. NB-4622.11 provides temper bead rules for repair welding of dissimilar materials using the SMAW process. Because NB-4622.11 does not include temper bead rules for the machine or automatic Gas Tungsten Arc Welding (GTAW) process, a manual temper bead process must be used. However, a manual SMAW temper bead repair is not a desirable option due to radiological considerations. First of all, scaffolding must be built and resistant heating blankets, thermocouples, and insulation must be installed. Secondly, the manual SMAW temper bead welding process is a time and dose intensive process. Each weld layer is manually deposited in a high dose and high temperature (350°F) environment. The manual SMAW temper bead process of NB-4622.11 also requires that the weld crown of the first weld layer be mechanically removed by grinding. Upon completing repair welding, resistant heating blankets, thermocouples, insulation, and scaffolding must be removed. Thermocouples and heating blanket mounting pins must be removed by grinding. The ground areas must be subsequently examined by the magnetic particle or liquid penetrant examination.

APS estimates that the dose associated with an SMAW temper bead repair on the RPV head to be at least 20 to 25 REM more than the proposed method of repair per weld repair. In addition, APS estimates the dose associated with the set-up and disassembly of the elevated preheat and postweld soak to be at least 15 REM.

APS has not requested an alternative to NB-4622.11; rather, this request proposes an alternative to IWA-4500 and IWA-4530. Owners are allowed by ASME Section XI IWA-4170(b) and IWA-4500(a) to perform temper bead repairs of dissimilar materials. IWA-4170(b) and IWA-4500(a) provide requirements and controls for performing such repairs.

IWA-4500 and IWA-4530 of ASME Section XI establish requirements for performing temper bead welding of "dissimilar materials". According to IWA-4530, either the automatic or machine GTAW process or SMAW process may be used. When using the machine GTAW process, a minimum preheat temperature of 300°F must be established and maintained throughout the welding process while the interpass temperature is limited to 450°F. Upon completion of welding, a postweld soak is performed at 300°F (minimum) for a minimum of 4 hours.

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The IWA-4500 and IWA-4530 temper bead welding process is a time and dose intensive process. Resistant heating blankets are attached to the RPV head; typically a capacitor discharge stud welding process is used. Thermocouples must also be attached to the RPV head using a capacitor discharge welding process to monitor preheat, interpass, and postweld soak temperatures. Prior to heat-up, thermal insulation is also installed. Upon completion of repair welding (including the postweld soak), the insulation, heating blankets, studs, and thermocouples must be removed from the RPV head. Thermocouples and stud welds are removed by grinding. Ground removal areas are subsequently examined by the liquid penetrant or magnetic particle method. A significant reduction in dose could be realized by utilizing an ambient temperature temper bead process. Because the ASME Code does not presently include rules for ambient temperature temper bead welding, APS proposes the alternative described in Section IV. B.

A. Evaluation of the Ambient Temperature Temper Bead Technique

Research by the Electric Power Research Institute (EPRI) and other organizations on the use of an ambient temperature temper bead operation using the machine GTAW process is documented in EPRI Report GC-111050. According to the EPRI report, repair welds performed with an ambient temperature temper bead procedure utilizing the machine GTAW welding process exhibit mechanical properties equivalent or better than those of the surrounding base material. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this process.

The effects of the ambient temperature temper bead welding process of Attachment 1 on mechanical properties of repair welds, hydrogen cracking, and restraint cracking are addressed below.

1. Mechanical Properties

The principal reasons to preheat a component prior to repair welding is to minimize the potential for cold cracking. The two cold cracking mechanisms are hydrogen cracking and restraint cracking. Both of these mechanisms occur at ambient temperature. Preheating slows down the cooling rate resulting in a ductile, less brittle microstructure thereby lowering susceptibility to cold cracking. Preheat also increases the diffusion rate of monatomic hydrogen that may have been trapped in the weld during solidification. As an alternative to preheat, the ambient temperature temper bead welding process utilizes the tempering action of the welding procedure to produce tough and ductile microstructures. Because precision bead placement and heat input control is characteristic of the machine GTAW process, effective tempering of weld heat affected zones is possible without the application of preheat. The temper bead

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procedure is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered heat affected zone such that the desired degree of carbide precipitation (tempering) is achieved. The resulting microstructure is very tough and ductile.

The IWA-4530 temper bead process also includes a postweld soak requirement. Performed at 300°F for 4 hours (P-Number 3 base materials), this postweld soak assists diffusion of any remaining hydrogen from the repair weld. As such, the postweld soak is a hydrogen bake-out and not a postweld heat treatment as defined by the ASME Code. At 300°F, the postweld soak does not stress relieve, temper, or alter the mechanical properties of the weldment in any manner.

Section 2.1 of Attachment 1 establishes detailed welding procedure qualification requirements. For base materials, filler metals, restraint, impact properties, and other procedure variables. The qualification requirements of Section 2.1 provide assurance that the mechanical properties of repair welds will be equivalent or superior to those of the surrounding base material. It should also be noted that the qualification requirements of Section 2.1 of Attachment 1 are identical to those in IWA-4530. Ambient temperature temper bead WPS 3-43/52-TB MC-GTAW-N638 was qualified in accordance with Attachment 1. Based upon the procedure qualification test results, the impact properties of the base material heat affected zone were superior to those of the unaffected base material. The mechanical testing results for the procedure qualification are summarized in Section V.C.

2. Hydrogen Cracking

Hydrogen cracking is a form of cold cracking. It is produced by the action of internal tensile stresses acting on low toughness heat affected zones. The internal stresses are produced from localized build-ups of monatomic hydrogen. Monatomic hydrogen forms when moisture or hydrocarbons interact with the welding arc and molten weld pool. The monatomic hydrogen can be entrapped during weld solidification and tends to migrate to transformation boundaries or other microstructure defect locations. As concentrations build, the monatomic hydrogen will recombine to form molecular hydrogen – thus generating localized internal stresses at these internal defect locations. If these stresses exceed the fracture toughness of the material, hydrogen induced cracking will occur. This form of cracking requires the presence of hydrogen and low toughness materials. It is manifested by intergranular cracking of susceptible materials and normally occurs within 48 hours of welding.

IWA-4500 establishes elevated preheat and postweld soak requirements.

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The elevated preheat temperature of 300°F increases the diffusion rate of hydrogen from the weld. The postweld soak at 300°F was also established to bake-out or facilitate diffusion of any remaining hydrogen from the weldment. However, while hydrogen cracking is a concern for SMAW which uses flux covered electrodes, the potential for hydrogen cracking is significantly reduced when using the machine GTAW welding.

The machine GTAW welding process is inherently free of hydrogen. Unlike the SMAW process, GTAW welding filler metals do not rely on flux coverings that are susceptible to moisture absorption from the environment. Conversely, the GTAW process utilizes dry inert shielding gases that cover the molten weld pool from oxidizing atmospheres. Any moisture on the surface of the component being welded will be vaporized ahead of the welding torch. The vapor is prevented from being mixed with the molten weld pool by the inert shielding gas that blows the vapor away before it can be mixed. Furthermore, modern filler metal manufacturers produce wires having very low residual hydrogen. This is important because filler metals and base materials are the most realistic sources of hydrogen for automatic or machine GTAW temper bead welding. Therefore, the potential for hydrogen induced cracking is greatly reduced by using machine GTAW process.

3. Cold Restraint Cracking

Cold cracking generally occurs during cooling at temperatures approaching ambient temperature. As stresses build under a high degree of restraint, cracking may occur at defect locations. Brittle microstructures with low ductility are subject to cold restraint cracking. However, the ambient temperature temper bead process is designed to provide a sufficient heat inventory so as to produce the desired tempering for high toughness. Because the machine GTAW temper bead process provides precision bead placement and control of heat, the toughness and ductility of the heat affected zone is typically superior to the base material. Therefore, the resulting structure is tempered to produce toughness that is resistant to cold cracking.

In conclusion, no elevated preheat or postweld soak above ambient temperature is required to achieve sound and tough repair welds when performing ambient temperature temper bead welding using the machine GTAW process. This conclusion is based upon strong evidence that hydrogen cracking will not occur with the GTAW process. In addition, automatic or machine temper bead welding procedures without preheat will produce satisfactory toughness and ductility properties both in the weld and weld heat affected zones. The results of previous industry qualifications and repairs further support this conclusion. The use of an ambient temperature temper bead welding procedure will improve the feasibility of performing

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localized weld repairs with a significant reduction in radiological exposure.

B. Evaluation of Proposed Alternatives to ASME Section XI, IWA-4500 and IWA-4530

1. According to **IWA-4500(a)**, repairs may be performed to dissimilar base materials and welds without the specified postweld heat treatment of ASME Section III provided the requirements of IWA-4500 and IWA-4530 are met. The temper bead rules of IWA-4500 and IWA-4530 apply to dissimilar materials such as P-No. 43 to P-No. 3 base materials welded with F-No. 43 filler metals. When using the GTAW-machine process, the IWA-4500 and IWA-4530 temper bead process is based fundamentally on an elevated preheat temperature of 300°F, a maximum interpass temperature of 450°F, and a postweld soak of 300°F. The proposed alternative of Attachment 1 also establishes requirements to perform temper bead welding on dissimilar material welds that join P-No. 43 to P-No. 3 base materials using F-No. 43 filler metals. However, the temper bead process of Attachment 1 is an ambient temperature technique which only utilizes the GTAW-machine or GTAW-automatic process. The suitability of the proposed ambient temperature temper bead technique is evaluated in this section. The results of this evaluation demonstrate that the proposed ambient temperature temper bead technique provides an acceptable level of quality and safety.
2. According to **IWA-4500(e)(2)**, the weld area plus a band around the repair area of at least 1-1/2 times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 300°F for the GTAW process during welding while the maximum interpass temperature is limited to 450°F. The ambient temperature temper bead technique of Attachment 1 also establishes a preheat band of at least 1½ times the component thickness or 5 inches, whichever is less. However, the ambient temperature temper bead technique requires a minimum preheat temperature of 50°F, a maximum interpass temperature of 150°F for the first three layers, and a maximum interpass temperature of 350°F for the balance of welding. The suitability of an ambient temperature temper bead technique with reduced preheat and interpass temperatures is addressed in Section V.A.
3. According to **IWA-4500(e)(2)**, thermocouples and recording instruments shall be used to monitor process temperatures. As an alternative to IWA-4500(e)(2), APS proposes to monitor preheat and interpass temperatures using an infrared thermometer. Infrared thermometers are hand-held devices that can be used to monitor process temperature from a remote location. To determine the preheat and interpass temperatures during the welding operation, the infrared thermometer is pointed at a target location adjacent to the repair weld. The target location is identified by a circle consisting of eight laser spots. A single laser spot in the center

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of the circle identifies the center of the measurement area. As the distance (D) from the object being measured increases, the diameter of the target location or "spot size" (S) also increases. The optics of the infrared thermometer sense emitted, reflected, and transmitted energy from the target location that is collected and focused onto a detector. The infrared thermometer's electronics translate the information into a temperature reading that is displayed on the unit. The infrared thermometer measures the maximum, minimum, differential, and average temperatures across the target location. This data can be stored and recalled until a new measurement is taken. APS plans to use an infrared thermometer such as the Raytek Raynger ST80 (or equivalent). The Raytek Raynger ST80 infrared thermometer measures temperatures from -25°F to 1400°F over the target location with the following accuracy: +/- 3°F over the 0°F - 73°F temperature range and +/-1% of reading or 2°F, whichever is greater, above 73°F. Display resolution is 0.1°F. The distance (D) to "spot size" (S) is 50:1 for the Raytek Raynger ST80 infrared thermometer. Since the "distance" (D) to the target location on the RPV penetration nozzle or J-weld is estimated to range from 3 feet to 6 feet, the "spot size" (S) will also range from 0.72 inch to 2.22 inches. The infrared thermometer will be appropriately calibrated prior to use.

4. **IWA-4532.2** establishes procedure technique requirements but do not address joint design access qualification of the repair cavity. As an alternative to IWA-4532.2, APS proposes to qualify the root width and included angle of the proposed repair cavity. Paragraph 2.1(c) of Attachment 1 requires that the root width and included angle of the repair cavity in the test assembly be no greater than the minimum specified for the repair. This requirement ensures that the welding procedure is only used in repair cavity configurations where it has demonstrated capability (i.e. sufficient access to deposit root passes, tie-in to the beveled or tapered walls of the repair cavity, provide appropriate tempering, and ensure complete weld fusion).

5. According to **IWA-4532.2(c)**, the repair cavity shall be buttered with six layers of weld metal in which the heat input of each layer is controlled to within +/-10% of that used in the procedure qualification test, and heat input control for 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. As an alternative to IWA-4532.2, APS proposes to butter the repair cavity or weld area with at least three layers of weld metal to obtain a minimum butter thickness of 1/8-inch. The heat input of each layer in the 1/8-inch thick buttered section shall be controlled to within +/-10% of that used in the procedure qualification test. The heat input for subsequent weld layers shall not exceed the heat input used for layers beyond the 1/8-inch thick buttered section (first three weld layers) in the procedure qualification. When using the ambient temperature

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temper bead technique of Attachment 1, the machine GTAW process is used. Machine GTAW is a low heat input process that produces consistent small volume heat affected zones. Subsequent GTAW weld layers introduce heat into the heat affected zone produced by the initial weld layer. The heat penetration of subsequent weld layers is carefully applied to produce overlapping thermal profiles that develop a correct degree of tempering in the underlying heat affected zone. When welding dissimilar materials with nonferritic weld metal, the area requiring tempering is limited to the weld heat affected zone of the ferritic base material along the ferritic fusion line.

After buttering the ferritic base material with at least 1/8-inch of weld metal (first 3 weld layers), subsequent weld layers should not provide any additional tempering to the weld heat affected zone in the ferritic base material. Therefore, less restrictive heat input controls are adequate after depositing the 1/8-inch thick buttered section. It should also be noted that IWA-4530 does not require temper bead welding except "where 1/8-inch or less of nonferritic weld deposit exists above the original fusion line after defect removal". The proposed heat input techniques of Attachment 1 were utilized in the qualification of Welding Procedure Specification (WPS) 3-43/52-TB MC-GTAW-N638. Based on Charpy V-notch testing of the procedure qualification test coupon, impact properties in weld heat affected zone were superior to those of the unaffected base material. Therefore, the proposed heat input controls of Attachment 1 provide an appropriate level of tempering. Test results of the WPS qualification are provided in Section V.C.

6. According to **IWA-4532.2(c)**, at least one layer of weld reinforcement shall be deposited on the completed weld and with this reinforcement being subsequently removed by mechanical means. In the proposed alternative of Attachment 1, the deposition and removal of a reinforcement layer is not required. A reinforcement layer is required when a weld repair is performed to a ferritic base material or ferritic weld using a ferritic weld metal. On ferritic materials, the weld reinforcement layer is deposited to temper the last layer of untempered weld metal of the completed repair weld. Because the weld reinforcement layer is untempered (and unnecessary), it is removed. However, when repairs are performed to dissimilar materials using nonferritic weld metal, a weld reinforcement layer is not required because nonferritic weld metal does not require tempering. When performing a dissimilar material weld with a nonferritic filler metal, the only location requiring tempering is the weld heat affected zone in the ferritic base material along the weld fusion line. However, the three weld layers of the 1/8-inch thick butter section are designed to provide the required tempering to the weld heat affected zone in the ferritic base material. Therefore, a weld reinforcement layer is not required. While APS recognizes that IWA-4532.2(c) does require the

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deposition and removal of a reinforcement layer on repair welds in dissimilar materials, APS does not believe that this reinforcement layer is necessary. This position is supported by the fact that ASME Code Case N-638 only requires the deposition and removal of a reinforcement layer when performing repair welds on similar (ferritic) materials. Repair welds on dissimilar materials are exempt from this requirement.

7. According to **IWA-4532.2(d)**, the weld area shall be maintained at a minimum temperature of 300°F for a minimum of 4 hours (for P-No. 3 materials) after at least 3/16-inch of weld metal has been deposited. In the proposed alternative of Attachment 1, a postweld soak is not required. The suitability of an ambient temperature temper bead technique without a postweld soak is addressed in Section V.A.
8. According to **IWA-4532.2(e)**, after depositing at least 3/16-inch of weld metal and performing a postweld soak at a minimum temperature of 300°F, the balance of welding may be performed at an interpass temperature of 350°F. As an alternative, APS proposes that an interpass temperature of 350°F may be used after depositing at least 1/8 inch of weld metal without a postweld soak. The proposed ambient temperature temper bead process of Attachment 1 is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered heat affected zone such that the desired degree of carbide precipitation (tempering) is achieved. The resulting microstructure is very tough and ductile. This point is validated by the qualification of WPS 3-43/52-TB MC-GTAW-N638. Based on Charpy V-notch testing of the procedure qualification test coupon, impact properties in weld heat affected zone were superior to those of the unaffected base material. Test results of the WPS qualification are provided in Section IV.C. The suitability of an ambient temperature temper bead technique without a postweld soak is addressed in Section V.A.
9. **IWA-4533** specifies that the repair weld shall be volumetrically examined by the radiographic method, and if practical, by the ultrasonic method after the completed repair weld has been at ambient temperature for at least 48 hours. As an alternative to the volumetric examinations of IWA-4533, APS proposes the examinations of repair welds in RPV penetration nozzle J-welds described below. The suitability of the alternative examinations is addressed in Section V.D.
 - Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III. The liquid penetrant examinations will be performed in accordance with NB-5000. Acceptance criteria shall be in accordance with NB-5350.

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C. Mechanical Properties of WPS 3-43/52-TB MC-GTAW-N638

WPS 3-43/52-TB MC-GTAW-N638 was qualified in accordance with Attachment 1. The welding procedure qualification test assembly was 3 inches thick and consisted of SA-533, Grade B, Class 1 (P-No. 3, Group 3) and SB-166, N06690 (P-No. 43) base materials. Prior to welding, the SA-533, Grade B, Class 1 portion of the test assembly was heat treated for 40 hours at 1,200°F. The repair cavity in the test assembly was 1.5 inches deep. The test assembly cavity was welded in the 3G (vertical) position using ERNiCrF3-7 (F-No. 43) filler metal. Results of the welding procedure qualification were documented on procedure qualification record PQR 707. Results of mechanical testing – tensile testing, bend testing, Charpy V-notch testing, and drop weight testing – are summarized below. WPS 3-43/52-TB MC-GTAW-N638 will be used to perform the repair welding activities described in Section IV.B.

- Tensile test specimens exhibited a tensile strength that exceeded 80,000 psi and were acceptable per ASME Section IX. The bend testing was also acceptable. Test results are as follows:

Tensile Test Results

Specimen No.	Tensile Specimen	Actual Tensile Strength	Failure
Test 1-1	0.505" Turned Specimen	86,600 psi	Ductile/Base
Test 1-2	0.505" Turned Specimen	84,500 psi	Ductile/Base
Test 2-3	0.505" Turned Specimen	82,400 psi	Fusion Line
Test 2-4	0.505" Turned Specimen	86,600 psi	Ductile/Weld Metal

Bend Test Results

Specimen Type and Figure No.	Result
Side Bend 1 QW-462.2	Acceptable
Side Bend 2 QW-462.2	Acceptable
Side Bend 3 QW-462.2	Acceptable
Side Bend 4 QW-462.2	Acceptable

- Drop weight and Charpy V-notch testing of the SA-533, Grade B, Class 1 "unaffected" base material was performed. Based upon drop weight testing of the SA-533, Grade B, Class 1 "unaffected" base material, a nil ductility transition temperature (T_{NDT}) of -50°F was established. Charpy V-notch testing was also performed at +10°F. All three Charpy V-notch specimens exhibited at least 35 mils and 50 ft-lbs. Based upon the above testing, an RT_{NDT} of -50°F was established for the SA-533, Grade B, Class 1 base material. Test results are as follows:

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Drop Weight Test: Unaffected Base Material

Specimen ID	Specimen Type	Test Temperature	Drop Weight Break	T _{NDT}
DW1	P-3	-40°F	No	-50°F
DW2	P-3	-40°F	No	-50°F

Charpy V-Notch Tests: Unaffected Base Material

Specimen ID	Test Temperature	Absorbed Energy (ft-lbs)	Lateral Expansion(mils)	% Shear Fracture
1	+10°F	59.0	50.0	60.0
2	+10°F	51.0	43.0	50.0
3	+10°F	50.0	45.0	50.0
Average	+10°F	53.3	46.0	53.3

- Charpy V-notch testing of the SA-533, Grade B, Class 1 heat affected zone was also performed at +10°F. The absorbed energy, lateral expansion, and percent shear fracture of the heat affected zone test specimens were compared to the test values of the unaffected base material specimens. The average values of the three heat affected zone specimens were greater than those of the unaffected base material specimens. Based upon these results, it is clear that the proposed ambient temperature temper bead process improved the heat affected zone properties. Test results are as follows:

Charpy V-Notch Tests: Heat Affected Zone

Specimen ID	Test Temperature	Absorbed Energy (ft-lbs)	Lateral Expansion(mils)	% Shear Fracture
1	+10°F	85.0	65.0	90.0
2	+10°F	136.0	64.0	75.0
3	+10°F	124.0	49.0	30.0
Average	+10°F	115.0	59.3.0	65.0

Supplemental microstructural evaluations were also performed on the test coupon weld of the procedure qualification. Microstructural evaluations consisted of micro-hardness testing (Vickers) and metallography. Vickers micro-hardness testing was performed at three different locations:

- 0.125 inch below the surface of the weld,
- 0.625 inch below the surface of the weld, and
- 0.125 inch above the root of the weld.

Micro-hardness test values are provided in the table below.

Metallography was performed at 100X and 500X magnifications. According to CONAM Laboratory Report #2333, "There were a few colonies of

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tempered martensite observed near the root of the weld. These seem to be associated with the slight banding present in the base material. There was no indication of untempered martensite. The remaining areas of the heat affected zone consist of a mixed microstructure of by-products of high temperature pearlite degeneration, bainite and a small amount of ferrite.” Regarding the presence of carbides, the CONAM report stated, “There was no evidence of massive carbides or carbide networks.”

Vickers Micro-Hardness Tests Results

Weld Zone Location	0.125"		0.625"		0.125"	
	From Surface		From Surface		Above Weld Root	
	Filar	Vickers	Filar	Vickers	Filar	Vickers
Unaffected Base Material	182	224	184	219	182	224
	182	224	185	217	176	240
	183	222	186	214	174	245
	182	224	186	214	181	226
	184	219	182	224	178	234
	184	219	187	212	173	248
HAZ Grain Coarsened Region	167	266	162	283	150	330
	165	273	164	276	144	358
	165	273	169	260	144	358
HAZ Adjacent to Fusion Line	163	279	161	287	149	334
	161	287	161	287	147	343
	159	293	164	276	147	343
Weld Metal	183	222	187	212	190	205
	189	208	192	201	189	208
	184	219	185	217	186	214
	184	219	185	217	182	224
	189	208	183	222	182	224
	193	199	184	219	179	232

D. Suitability of Alternative Nondestructive Examinations (NDE)

IWA-4533 specifies that the repaired region shall be examined by the radiographic method, and if practical, by the ultrasonic method. The NDE requirements of IWA-4533 were established based upon a temper bead weld repair to butt welds. Figures IWA-4532.1-1 and IWA-4532.2-1 clearly indicate this. While the requirement to perform a radiographic examination, and if practical, an ultrasonic examination of a butt weld between a nozzle and pipe is appropriate, these examinations are not appropriate for weld repairs of RPV head penetration nozzle J-welds. See Figures 1 and 2.

1. Impracticality of Volumetric Examinations

Radiographic examination of weld repairs of RPV head penetration nozzle J-welds is not practical. Meaningful radiographic examination cannot be performed due to the weld configuration and access limitations. The weld

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configuration and geometry of the penetration in the head provide an obstruction for the radiography and interpretation would be very difficult. Ultrasonic examination of the J-weld would also be impractical.

2. Suitability of Proposed Alternative

As an alternative to radiographic and ultrasonic examinations, APS proposes to perform a progressive liquid penetrant of the J-weld repair weld in accordance with NB-5245 of ASME Section III. It should be noted that ASME Section III does not require volumetric examination of J-welds. According to NB-3352.4(d)(1), "partial penetration welds used to connect nozzles as permitted in NB-3337.3 shall meet the fabrication requirements of NB-4244(d) and shall be capable of being examined in accordance with NB-5245." NB-4244(d) establishes fabrication details for nozzles welded with partial penetration welds as shown in Figures NB-4244(d)-1 and NB-4244(d)-2.

According to NB-5245, "Partial penetration welds, as permitted in NB-3352.4(d), and as shown in Figures NB-4244(d)-1 and NB-4244(d)-2, shall be examined progressively using either the magnetic particle or liquid penetrant method. The increments of examination shall be the lesser of one-half of the maximum weld dimension measured parallel to the centerline of the connection or ½-inch. The surface of the finished weld shall also be examined by either method."

The partial penetration J-welds of the RPV head penetration nozzles were designed and fabricated in accordance with NB-3352.4(d) and NB-4244(d). Therefore, according to NB-3352.4(d), the code required examination for these partial penetration J-welds is a progressive liquid penetrant examination performed in accordance with NB-5245. A volumetric examination is not required.

VI. CONCLUSION

10 CFR 50.55a(a)(3) states:

"Proposed alternatives to the requirements of paragraphs (c), (d), (e), (f), (g), and (h) of this section or portions thereof may be used when authorized by the Director of the Office of Nuclear Reactor Regulation. The applicant shall demonstrate that:

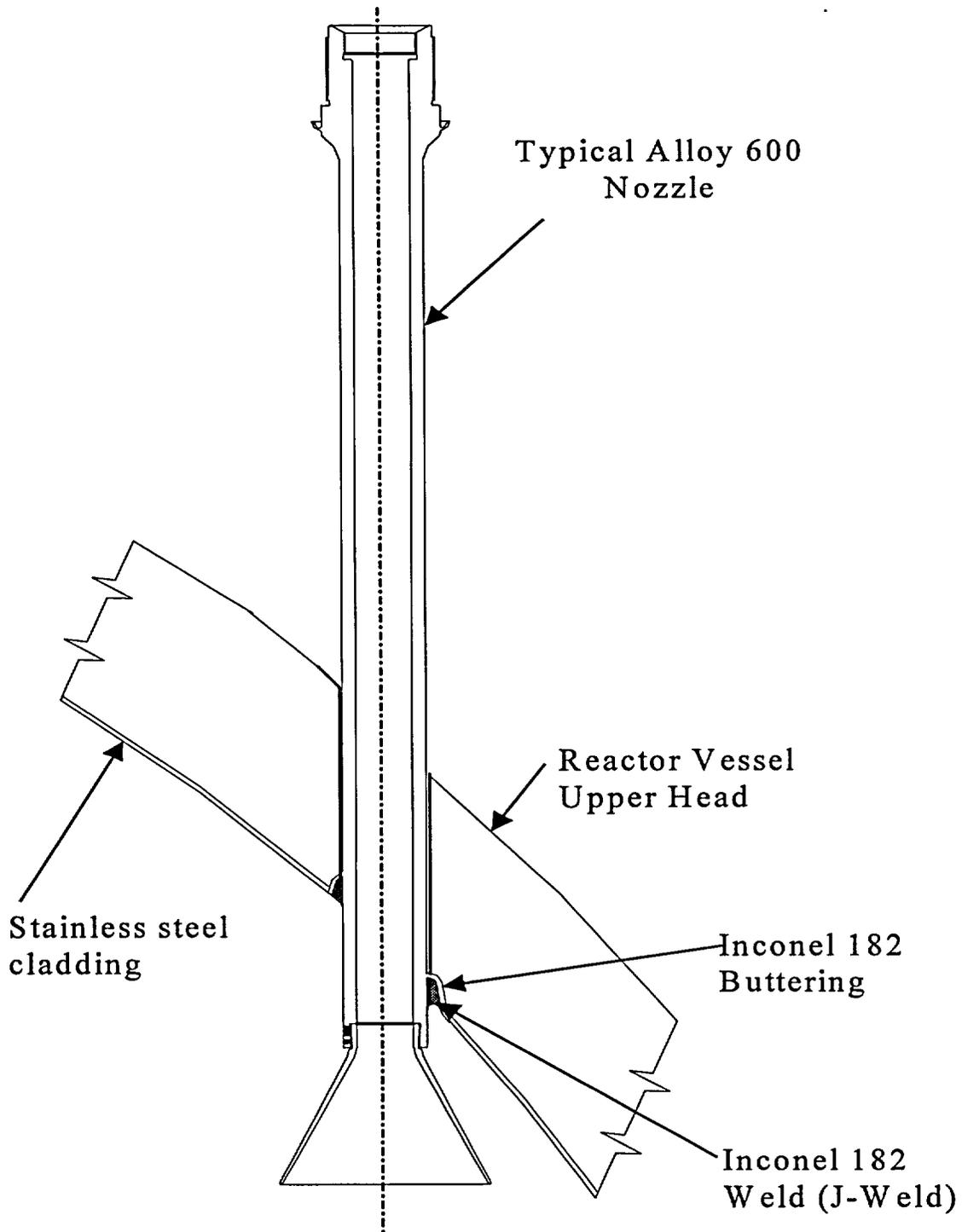
- (i) The proposed alternatives would provide an acceptable level of quality and safety, or
- (ii) Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety."

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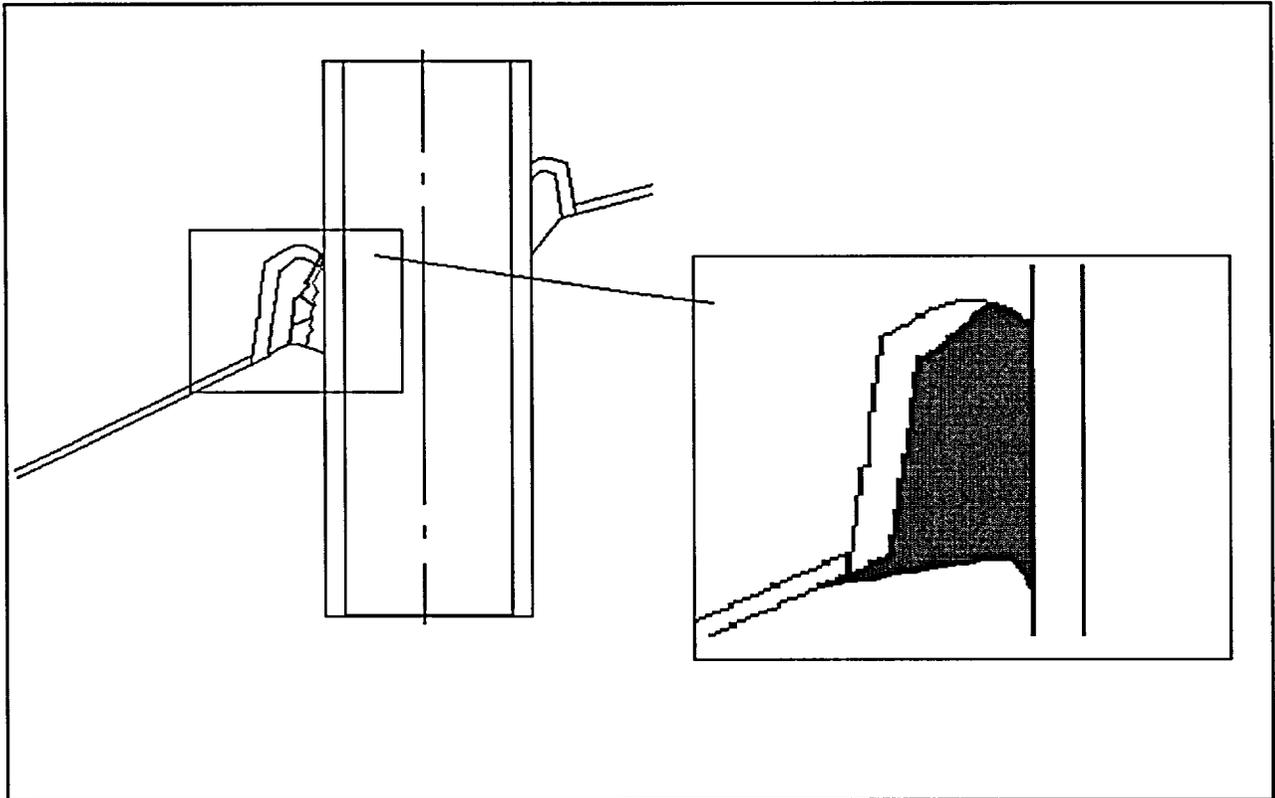
APS believes that compliance with the repair rules as stated in Reference 1 and as described in Section III of this request would result in unwarranted damage to the RPV head assembly. The proposed alternative discussed in Section IV would provide an acceptable level of quality and safety without exposing the head to potential ovalization and misalignment of the CEDM penetrations. Additionally, the work required to meet the current Code repair method, automatic or machine GTAW temper bead with 300°F minimum preheat and 300°F post weld hydrogen bake-out, would be extremely difficult and the radiation exposures for set-up, monitoring, and removal of the required equipment is unjustified. Using the proposed method of repair, it is estimated that approximately 15 person-rem could be saved on each required repair. Therefore, we request that the proposed alternative be authorized pursuant to 10 CFR 50.55a(a)(3)(i).

VII. References

1. ASME Section XI, 1992 Edition, 1992 Addenda
2. ASME Section III, 1971 Edition, Winter 1973 Addenda
3. ASME Section III, Subsection NB, 1971 Edition, Summer 1973 Addenda
4. ASME Section III, Subsection NB, 1974 Edition, Winter 1975 Addenda
5. ASME Section XI Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique"
6. EPRI Report GC-111050, "Ambient Temperature Preheat for Machine GTAW Temper Bead Applications"
7. Letter 102-04603-CDM/SAB/RJR, "Response to NRC Bulletin 2001-01; Circumferential Cracking of VHP Nozzles," dated September 4, 2001
8. CONAM Inspection Laboratory Report #2333, dated July 23, 2002



Typical RPV Head Penetration Nozzle
FIGURE 1



Example Repair of an RPV Head Penetration Nozzle J-Weld

FIGURE 2

ATTACHMENT 1

**RELIEF REQUEST 18
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE
MACHINE GTAW TEMPER BEAD TECHNIQUE**

**DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE
MACHINE GTAW TEMPER BEAD TECHNIQUE**

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. Repair/replacement activities on nonferritic base materials where the repair cavity is within 1/8-inch of a ferritic base material may also be performed.
- (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 temperature of 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) The area prepared for welding shall be suitably prepared for welding in accordance with a written procedure.

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 irradiation on the properties of material, including weld material for applications in the core belt line region of the reactor vessel. Special material

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requirements in the Design Specification will also apply to the test assembly materials for these applications.

- (c) The root width and included angle of the cavity in the test assembly will be no greater than the minimum specified for the repair.
- (d) The maximum interpass temperature for the first three layers or as required to achieve the 1/8-inch butter thickness in the test assembly will be 150°F. For the balance of the welding, the maximum interpass temperature shall be 350°F.
- (e) The test assembly cavity depth will be at least one-half the depth of the weld to be installed during the repair/replacement activity, and at least 1 inch. The test assembly thickness will be at least twice the test assembly cavity depth. The test assembly will be large enough to permit removal of the required test specimens. The test assembly dimensions surrounding the cavity will be at least the test assembly thickness, and at least 6 inches. The qualification test plate will be prepared in accordance with Figure 1.
- (f) 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 (h) below, but shall be in the base metal.
- (g) Charpy V-notch tests of the ferritic weld metal of the procedure qualification shall meet the requirements as determined in subparagraph (f) above.
- (h) 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 (f) 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

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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-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.
 - (i) The average values of the three HAZ impact tests will be equal to or greater than the average values of the three unaffected base metal tests.

2.2 Performance Qualification:

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

3.0 WELDING PROCEDURE REQUIREMENTS:

The welding procedure shall include the following requirements:

- (a) The weld metal shall be deposited by the automatic or machine GTAW process using cold wire feed.
- (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 area to be welded will be buttered with a deposit of at least three layers to achieve at least 1/8-inch butter thickness as shown in Figure 2, steps 1 through 3, with the heat input for each layer controlled to within $\pm 10\%$ of that used in the procedure qualification test. Particular care will be taken in placement of the weld layers at the weld toe area of the ferritic base material to ensure that the HAZ is tempered. Subsequent layers will be deposited with a heat input not exceeding

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that used for layers beyond the third layer (or as required to achieve the 1/8-inch butter thickness) in the procedure qualification.

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

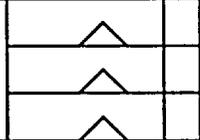
4.0 EXAMINATION:

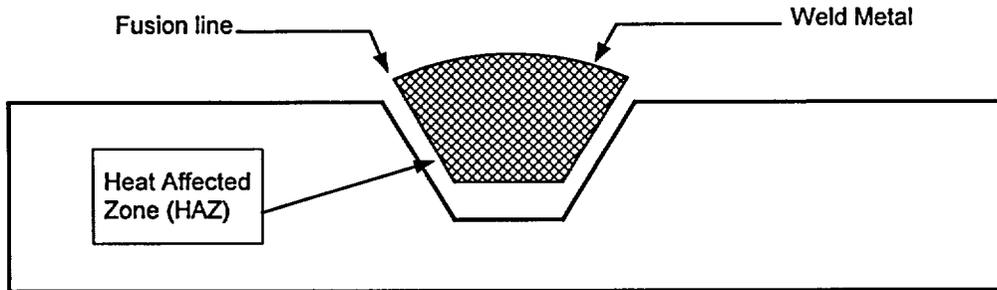
- (a) Prior to welding, a surface examination will be performed on the area to be welded.
- (b) Repair welds in RPV penetration nozzle J-welds shall be examined as follows:
 - Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III. After the completed repair weld has been at ambient temperature for at least 48 hours, repair welds including the preheat band (1.5 times the component thickness or 5 inches, whichever is less) around the repair weld shall be examined by the liquid penetrant method. The liquid penetrant examinations will be performed in accordance with ASME Section III, NB-5000. Acceptance criteria shall be in accordance with NB-5350.
- (c) NDE personnel performing liquid penetrant examination will be qualified and certified in accordance with NB-5500.

5.0 DOCUMENTATION

Use of this request shall be documented on 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.

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

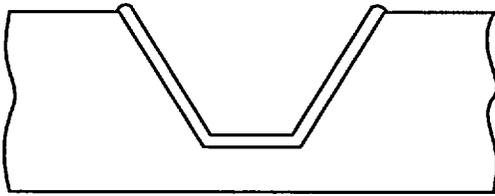


GENERAL NOTE: Base Metal Charpy impact specimens are not shown.

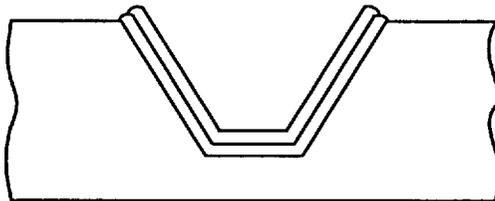
Figure 1 - QUALIFICATION TEST PLATE

DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD TECHNIQUE

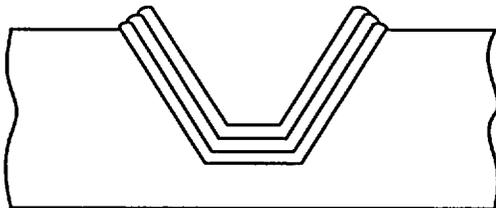
Duration of Proposed alternative



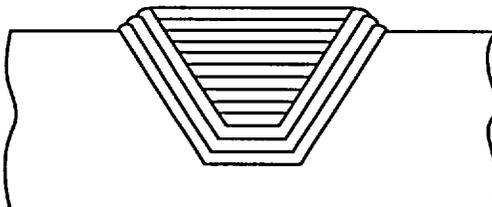
Step 1: Deposit layer one with first layer weld parameters used in qualification.



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.

Figure 2 - AUTOMATIC OR MACHINE GTAW TEMPER BEAD WELDING

APS requests the relief through the end of the 2nd inservice inspection interval for each unit or until the ASME Code Component is replaced with a component of a different Code.