APS

Palo Verde Nuclear
Generating Station

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10 CFR 50.55a

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102-04941-CDM/SAB/RJR
May 15, 2003

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-37
11555 Rockville Pike
Rockville, MD. 20852

Dear Sirs:

**Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. STN 50-528/529/530
10 CFR 50.55a Alternative Repair Request for the Second 10-Year Interval of the Inservice Inspection Program: Relief Request 23, Pressurizer Heater Sleeves**

Pursuant to 10 CFR 50.55a(a)(3)(i), Arizona Public Service (APS) Company 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.

Specifically, APS is requesting authorization to use an ambient temperature automatic or machine GTAW temper bead process during modification of the pressurizer heater sleeves (nozzles) at PVNGS. The welds used to build-up an external weld pad will be performed using an ambient temperature temper bead procedure. This procedure utilizes an automatic or machine GTAW process to make welds that exhibit mechanical properties equivalent or better than those of the surrounding base material. This request is similar to the request made by Entergy Operations, Inc. which was approved by the NRC on April 16, 2003.

APS has previously performed this modification to two of the Unit 2 pressurizer heater sleeves using a non-temper bead repair weld. This process required both preheat and postweld heat treatment. Based on this experience, it is estimated that applying the Code required preheat and postweld heat treatment for the remaining 34 sleeves in the Unit 2 pressurizer would result in an additional 60 man-rem of exposure (180 man-REM for 3 units).

APS requests approval of the relief through the end of the 2nd inservice inspection interval for each unit. APS also requests that the Staff's review of the proposed relief

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request be completed prior to September 15, 2003, to support the planned modifications of the Unit 2 pressurizer heater sleeves during the fall 2003 refueling outage. The details of this 10 CFR 50.55a request are provided in the enclosure to this letter.

No commitments are being made to the NRC in this letter. Should you have any questions, please contact Thomas N. Weber at (623) 393-5764.

Sincerely,

David Mauldin

Enclosure: Alternative Repair Request: Relief Request 23, Pressurizer Heater Sleeves

CDM/SAB/RJR

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

ENCLOSURE

Alternative Repair Request:
Relief Request 23, Pressurizer Heater Sleeves

Background Information

The existing pressurizer heater sleeves are made from Inconel 600 material and are susceptible to primary water stress corrosion cracking (PWSCC). The pressurizer head is manufactured from P-Number 3, Group 3 low alloy steel. Each pressurizer has 36 heater sleeves (nominal dimensions: 1.66" outside diameter (OD) and .192" wall thickness) which are attached to the lower pressurizer head by partial penetration welds made at the pressurizer inside diameter (ID) surface (see Figures 1 and 2).

The replacement sleeves are made from thermally treated SB-167, Inconel 690 material. The new sleeves will be attached from the OD surface of an Inconel 52 temper bead weld pad that will be deposited over the pressurizer SA-508 Class 2 (P3) material (see Figure 3).

Installation will be done according to following major steps;

1) Remove the existing heater.
2) Remove the existing Inconel 600 sleeve to a predetermined length in the heater sleeve bore hole by machining.
3) Build-up an approximately ½" thick Inconel 52 weld pad (using the ambient temperature temper bead method) around the heater sleeve bore hole.
4) Perform required ultrasonic testing (UT) & liquid penetrant testing (PT) of the pad after 48-hour wait at ambient temperature.
5) Cut a partial penetration weld prep in the pad
6) Insert 690 sleeve in the heater sleeve bore hole and weld it to the pad. Perform progressive PT during this welding.

The main purpose of this relief request is to obtain relief from preheat and postweld baking requirements of The American Society of Mechanical Engineers (ASME) Section XI Code for temper bead welding of the Inconel 52 pad.

Precedent

APS' relief request is based, in part, on the recently approved (April 16, 2003) request made by Entergy Operations Inc. for repairs to the reactor pressure vessel head to control rod drive mechanism welds. Entergy's relief for use of an alternative method to the temper bead welding requirements of ASME Code, Section XI, IWA-4500 and IWA-4530 is similar to the alternative method being proposed by APS for use in the modification of pressurizer heater sleeves.

The difference in APS' proposed alternative is that the examination of the ambient temperature temper bead welds will be performed using ultrasonic examination in accordance with the 1996 Addenda of the ASME Code Section XI.

I. ASME Code Component(s) Affected

Component number: B4.20
Description: Pressurizer Heater Sleeve, 36 per Unit.
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, and 1973 Winter Addenda.

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

III. Applicable Code Requirements for Welding Inconel 52 Temper Bead Pad

Sub-article 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."

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

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, "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.

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(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.

8. **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, APS' proposed ambient temperature temper bead technique does not include a reinforcement layer.

9. **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, APS' proposed ambient temperature temper bead technique does not include a postweld soak.

10. **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.

11. **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 radiographic examination of IWA-4533, APS proposes ultrasonic examination of the pad build-up.

V. <u>Basis of Alternative for Providing Acceptable Level of Quality and Safety</u>

The pressurizer head is manufactured from P-Number 3, Group 3 low alloy steel. 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 at 1100°F – 1250°F in accordance with NB-4622.1; or (2) perform a temper bead repair using the SMAW process in accordance with NB-4622.11. Each option is discussed below.

1. Postweld heat treatment (PWHT) of the pressurizer head is an impractical option that could cause ovalization and misalignment of penetrations, permanently damaging the pressurizer lower head including the heater support assembly. ASME Section III NB-4600 requires PWHT to be performed at 1100° - 1250°.

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 GTAW process, a manual SMAW temper bead process must be used. However, a manual SMAW temper bead repair is not a desirable option due to radiological considerations. First, 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, and insulation 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 a manual SMAW temper bead repair to be at least 35 to 45 REM more per unit than the proposed machine GTAW method of 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 60 REM per unit. The total dose savings are projected to be 95-105 REM per unit if the proposed alternative is implemented.

APS is not requesting 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.

The IWA-4500 and IWA-4530 temper bead welding process is a time and dose intensive process. Resistant heating blankets are attached to the pressurizer head; by typically using a capacitor discharge stud welding process. Thermocouples must also be attached to the pressurizer head using a capacitor discharge welding process to monitor pre-heat, 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 pressurizer 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 welding technique described in Attachment 1.

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 technique 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 that are 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 the weld heat affected zones is possible without the application of preheat. The ambient temperature temper bead 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 for 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 repaired welds will be equivalent or superior to those of the surrounding base material. Welding Services Incorporated welding procedure specification (WPS) for the ambient temperature temper bead process (WPS 03-03-T-801) 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 provided in Section V.C. WPS 03-03-T-801 will be used to perform the welding activities described in Section IV.

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-up 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. The elevated pre-heat 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 process.

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. 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 weld wires that have 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. Restraint Cracking

   Restraint 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 machine GTAW process (Reference 6). 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 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 machine GTAW 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 machine GTAW or automatic GTAW 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 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 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 was previously 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 infrared thermometer will be appropriately calibrated prior to use.

The use of thermocouples and recording instruments is only required by ASME Sections III and XI when performing either postweld heat treatment operations or traditional temper bead welding operations with elevated preheat and postweld soak temperatures. The use of thermocouples and recording instruments is not required by ASME Section XI Code Case N-638 for monitoring welding process temperatures. Code Case N-638 is the basis for APS' proposed alternative.

Per paragraph 1(d) of Attachment 1 of this request, the minimum welding temperature is 50°F. The containment temperatures are not expected to be less than the required 50°F during the welding operations, which would be conducted in the spring or fall. However, to ensure compliance with the minimum requirement of the Welding Procedure Specification, APS will verify the temperature prior to welding.

4. 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(c), 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 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 WPS 03-03-T-801. Based on Charpy V-notch testing of the procedure qualification test coupon, impact properties in the 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 03-03-T-801 qualification are provided in Section V.C.

5. According to **IWA-4532.2(c)**, at least one layer of weld reinforcement shall be deposited on the completed weld and this reinforcement is 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. 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 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 further 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 in the Code Case.

6. 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 was previously addressed in Section V.A.

7. 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 was validated during the qualification of WPS 03-03-T-801. 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. The test results of WPS 03-03-T-801 qualification are provided in Section IV.C. The suitability of an ambient temperature temper bead technique without a postweld soak was previously addressed in Section V.A.

8. **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 radiographic examination of IWA-4533, APS proposes using the ultrasonic examination method.

   Radiographic examination is impractical since the pressurizer vessel ID surface is inaccessible for positioning the gamma source. Ultrasonic examination is another acceptable volumetric NDE method to assure weld quality and the 1996 Addenda of ASME Section XI (approved by the NRC) provides such an option. The ultrasonic examination will be performed in accordance with NB-5000 and acceptance criteria will be in accordance with NB-5330.

C. Mechanical Properties of WPS 03-03-T-801

WPS 03-03-T-801 was qualified in accordance with Attachment 1. The welding procedure qualification test plate was 3.5 inches thick, of SA-533, Grade B, Class 1 (P-No. 3, Group 3) material. Prior to welding, the SA-533, Grade B, Class 1 plate was heat treated for 48 hours at 1125°F. The repair cavity in the test plate was 1.25 inches deep. The test plate 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 03-03-T-801. Results of mechanical testing - tensile testing, bend testing, Charpy V-notch testing, and drop weight testing - are summarized below. All the test results meet ASME requirements. WPS 03-03-T-801 will be used to perform the welding activities described in Section IV.

The results are as follows:

Tensile Test (QW-150)

Specimen No.	Width (in.)	Thickness (in.)	Area (in^2)	Ultimate Total Load Lb. (PSI)	Ultimate Unit Stress (PSI)	Type of Failure & Location
1	0.748	1.304	0.975	85,600	88,000	Ductile (Weld)
2	0.758	1.253	0.949	85,000	89,500	Ductile (BM)

Tensile test specimens exhibited a tensile strength that exceeded 80,000 psi and are acceptable per ASME Section IX. Charpy V-notch tests and bend tests comply with the Section XI and Section IX requirements.

Guided Bend Tests (QW-160)

Type & Figure No.	Results
Side Bend No. 1 (QW-462.2)	Acceptable
Side Bend No. 2 (QW-462.2)	Acceptable
Side Bend No. 3 (QW-462.2)	Acceptable
Side Bend No. 4 (QW-462.2)	Acceptable

Toughness Tests (QW-170)

Specimen No.	Notch Location	Notch Orientation	Test Temp (°F)	Impact Values			Drop Weight Testing Base Metal	
				Ft. Lbs.	% Shear	Mils	Break	No Break
BM-1	BM	See Note	0	142	58	84	-80°F	-40°F
BM-2	BM	See Note	0	160	73	100	-60°F	-40°F
BM-3	BM	See Note	0	184	100	96	-50°F	
BM Average				**162**	**77**	**93.3**		
HAZ-1	HAZ	See Note	0	246	100	90		
HAZ-2	HAZ	See Note	0	>300 [2]	100 [2]	126 [2]		
HAZ-3	HAZ	See Note	0	234	100	82		
HAZ Average				**260**	**100**	**99.3**		

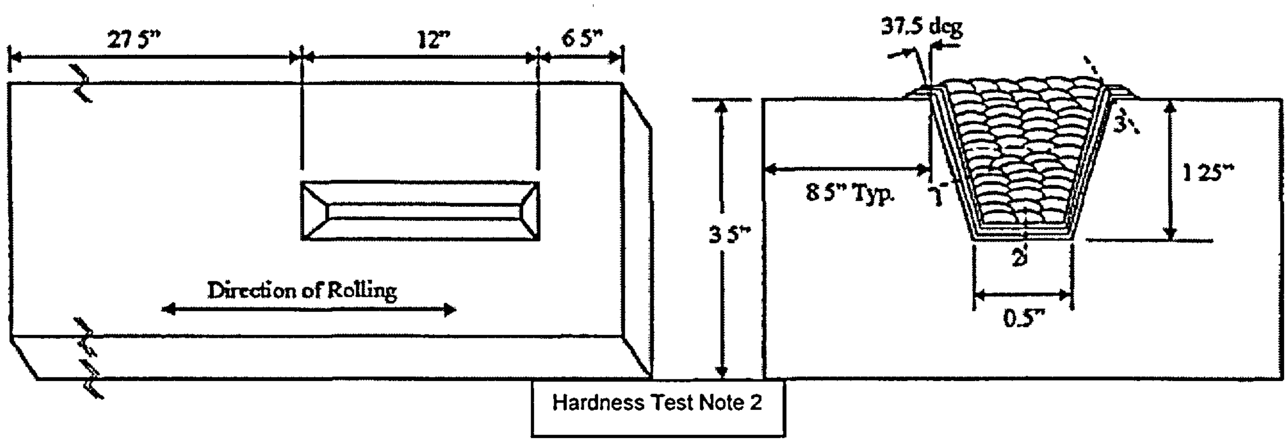
1 HAZ Impact specimens were removed from a location as near as practical to a depth of 1/2 the thickness of the deposited weld metal. Impact testing of Inco 52 filler material is not required. Plate direction of rolling is parallel to the axis of the weld. Three full-size 10 mm x 10 mm specimens were tested. Test samples were removed in accordance with ASME Code Case N-638, Figure 1.

2 Impact specimen HAZ-2 did not break as a result of its exceptional toughness. The listed value of 100% shear is estimated, based on the fact that HAZ specimens 1 and 2, both of which broke during Charpy testing, exhibited 100% shear. 126 mils lateral expansion is calculated by extrapolation, using the absorbed energy values from HAZ specimens I and 3 and the corresponding lateral expansion values. This extrapolation incorporates a measure of conservatism in that it assumes breakage at 300 ft-lbs., whereas actual absorbed energy was greater than the test machine's 300 R-lb. capacity.

Hardness Test[1]

Area	Depth (in.)	Line No. 1[2]	Line No. 2[2]	Line No. 3[2]
BASE METAL	0.250	95 HRB	91 HRB	97 HRB
	0.200	99 HRB	91 HRB	20 HRC
	0.150	97 HRB	93 HRB	97 HRB
	0.100	96 HRB	95 HRB	22 HRC
	0.050	30 HRC	38 HRC	30 HRC
	Interface[3]	37 HRC	30 HRC	30 HRC
WELD	Tempered Zone[4]	95 HRB	97 HRB	91 HRB
	0.050	91 HRB	95 HRB	87 HRB
	0.100	93 HRB	24 HRC	91 HRB
	0.150	95 HRB	99 HRB	82 HRB
	0.200	94 HRB	96 HRB	94 HRB
	0.250	98 HRB	96 HRB	87 HRB

1. Testing was performed in accordance with ASTM E384-89 (97) with values converted to Rockwell per ASTM E140-97.
2. Microhardness testing was performed on the weld/base material cross section in the three locations shown in the sketch.
3. Measurements were taken on base metal at a location 0.010" from weld/base metal interface.
4. Measurements taken in the center of the tempered zone of the weld material.



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."

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 pressurizer head assembly. The proposed alternative discussed in Section IV would provide an acceptable level of quality and safety without exposing the head to potential distortion of the sleeves and heater support structure. 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 personnel radiation exposures resulting from the set-up, monitoring, and removal of the required equipment is unjustified. It is estimated that a total dose savings of 95-105 REM per unit could be realized if this alternative is implemented during the build-up of the weld pad. Therefore, APS requests that the proposed alternative be authorized pursuant to 10 CFR 50.55a(a)(3)(i).

APS requests approval of this relief through the end of the 2nd inservice inspection interval for each unit.

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"

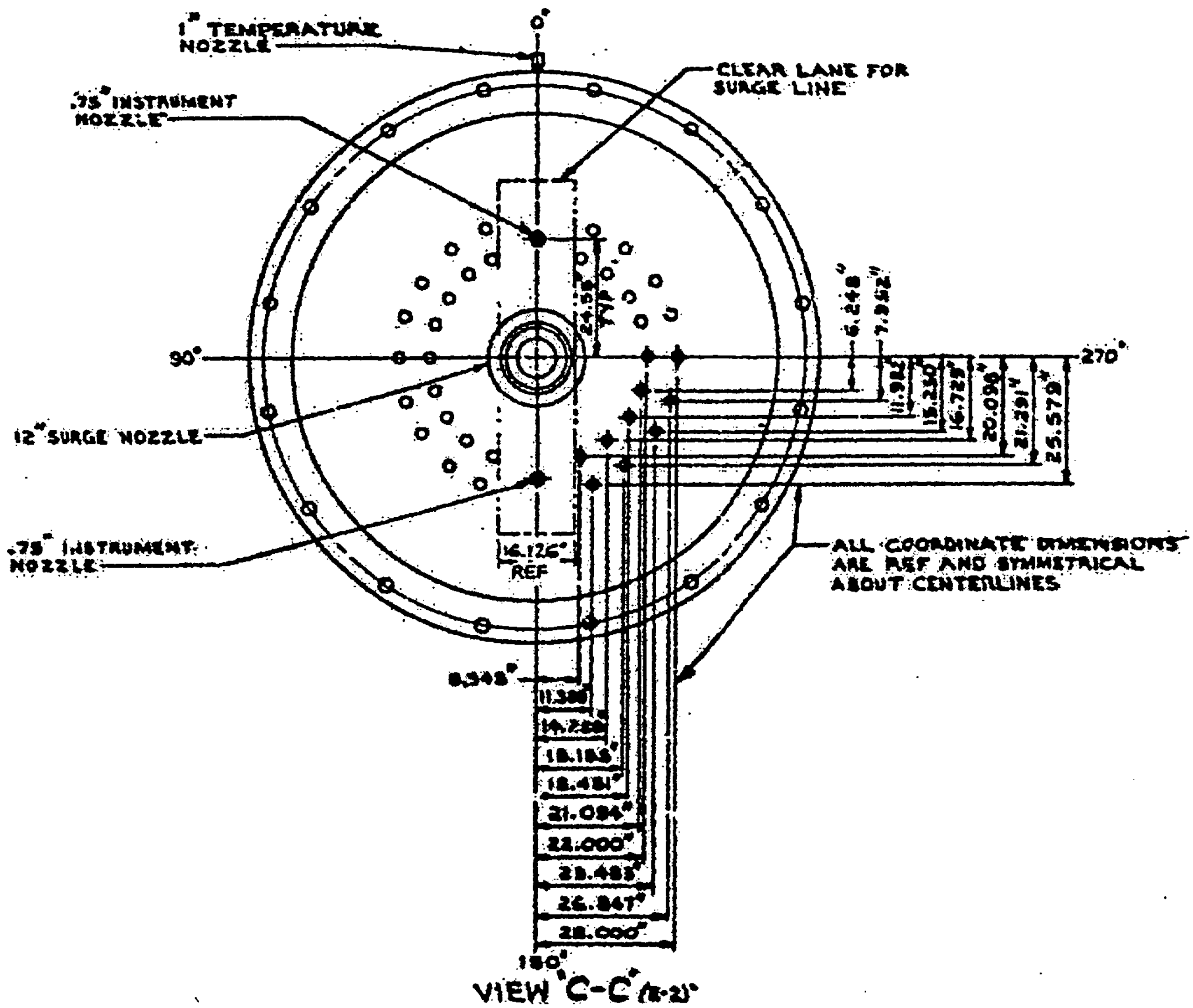


Figure 1

Pressurizer Heater Sleeve Arrangement at Lower Head

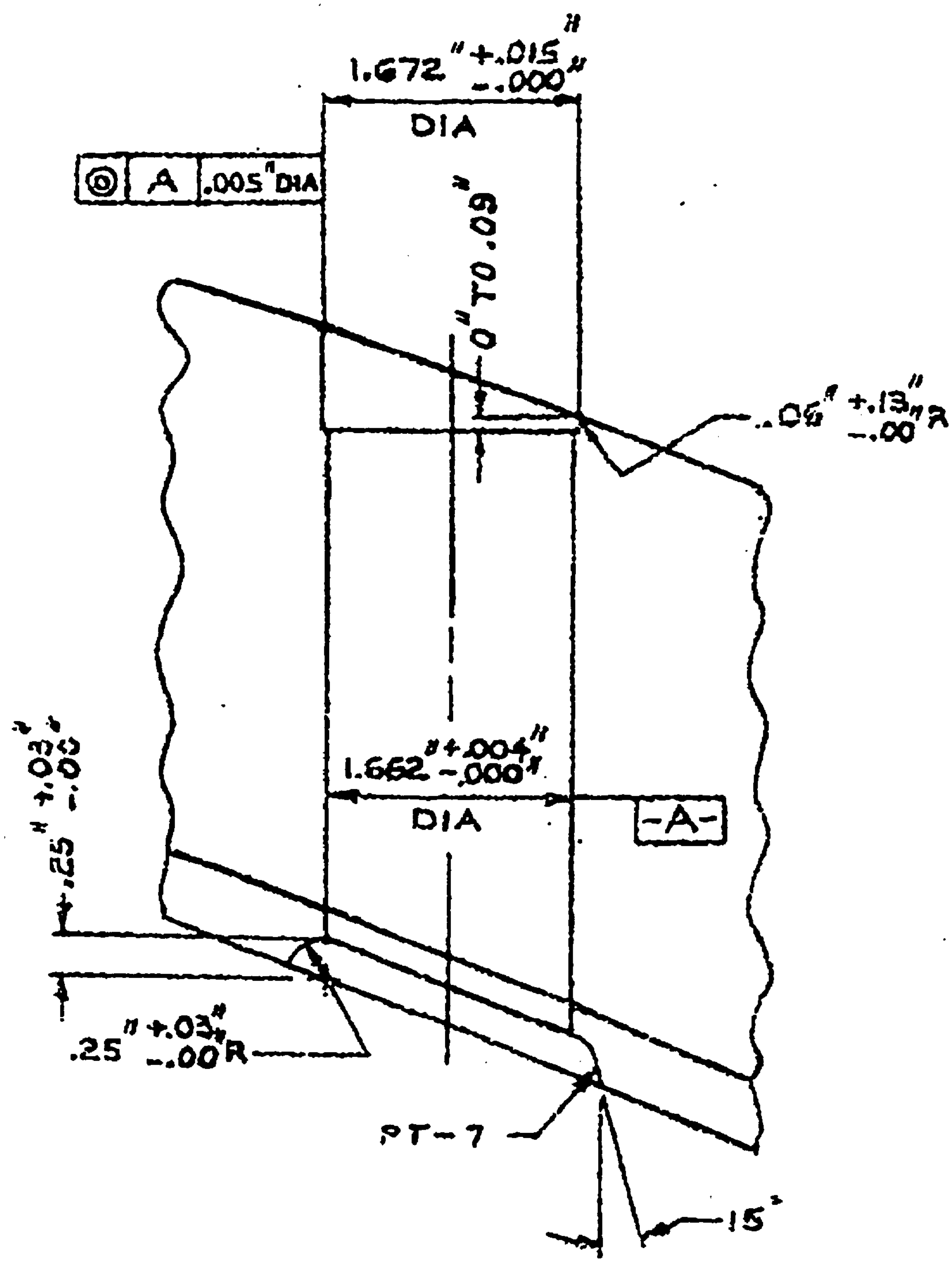


Figure 2

Original Weld Details for Welding Pressurizer Heater Sleeves to the Bottom Head

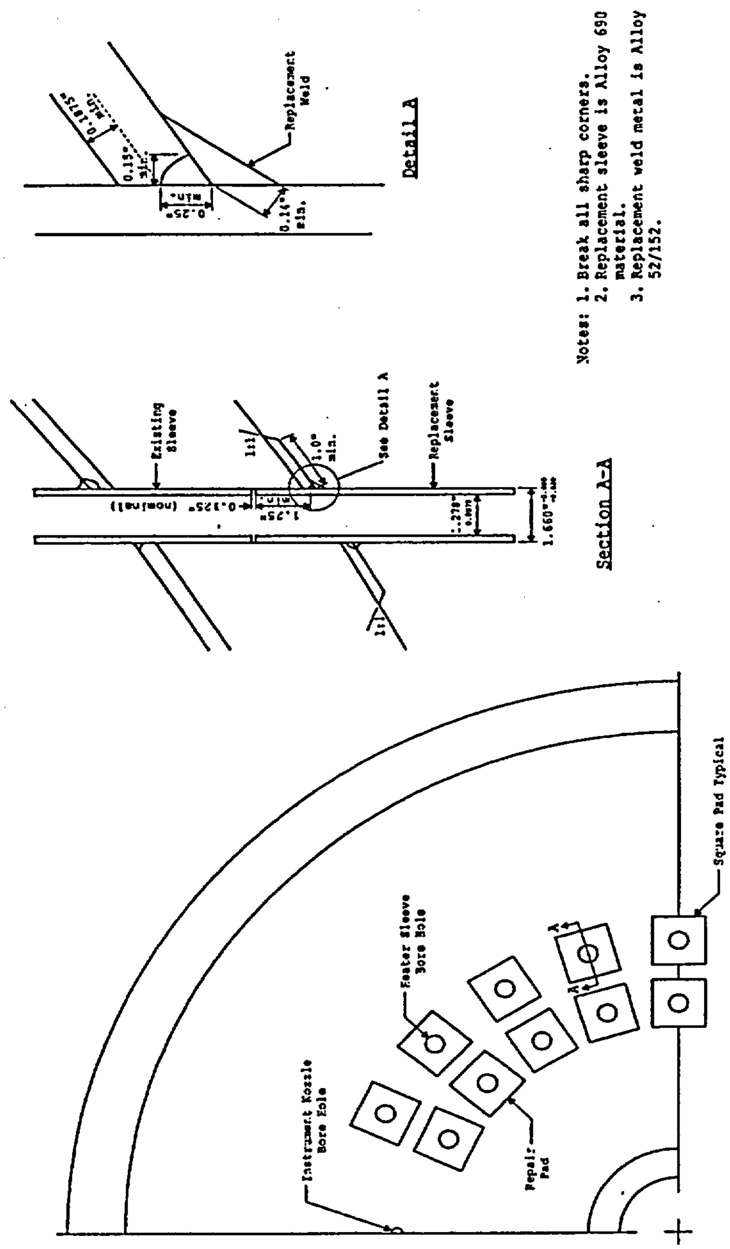


Figure 3

Welding Details for New Inconel Pressurizer Heater Sleeves

ATTACHMENT 1
RELIEF REQUEST 23

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 shall be less than 100 square inches, and the depth of the weld shall 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) shall be at least 50°F.

(e) Welding materials shall meet the Owner's Requirements and the Construction Code and Cases specified in the repair/replacement plan. Welding materials shall 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 ASME 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 shall 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 shall be given to the effects of irradiation on the properties of material, including weld material for applications in the core belt line region of the reactor vessel. Special material requirements in the Design Specification shall also apply to the test assembly materials for these applications.

(c) The root width and included angle of the cavity in the test assembly shall 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 shall be 150°F. For the balance of the welding, the maximum interpass temperature shall be 350°F.

(e) The test assembly cavity depth shall 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 shall be at least twice the test assembly cavity depth. The test assembly shall be large enough to permit removal of the required test specimens. The test assembly dimensions surrounding the cavity shall be at least the test assembly thickness, and at least 6 inches. The qualification test plate shall be prepared in accordance with Figure 1.

(f) Ferritic base material for the procedure qualification test shall 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) shall be performed at the same temperature as the base metal test of subparagraph (f) above. Number, location, and orientation of test specimens shall be as follows:

1. The specimens shall 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 shall be taken transverse to the axis of the weld and etched to define

the HAZ. The notch of the Charpy V-notch specimens shall 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 shall 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 shall be oriented parallel to the principal direction of rolling or forging.

3. The Charpy V-notch test shall be performed in accordance with SA-370. Specimens shall be in accordance with SA-370, Figure 11, Type A. The test shall 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 shall be reported in the Procedure Qualification Record.

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

2.2 Performance Qualification:

Welding operators shall 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 shall 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 ± 10% of that used in the procedure qualification test. Particular care shall 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 shall be deposited with a heat input not exceeding 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 shall be 350°F regardless of the interpass temperature during qualification.

(e) Particular care shall 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:

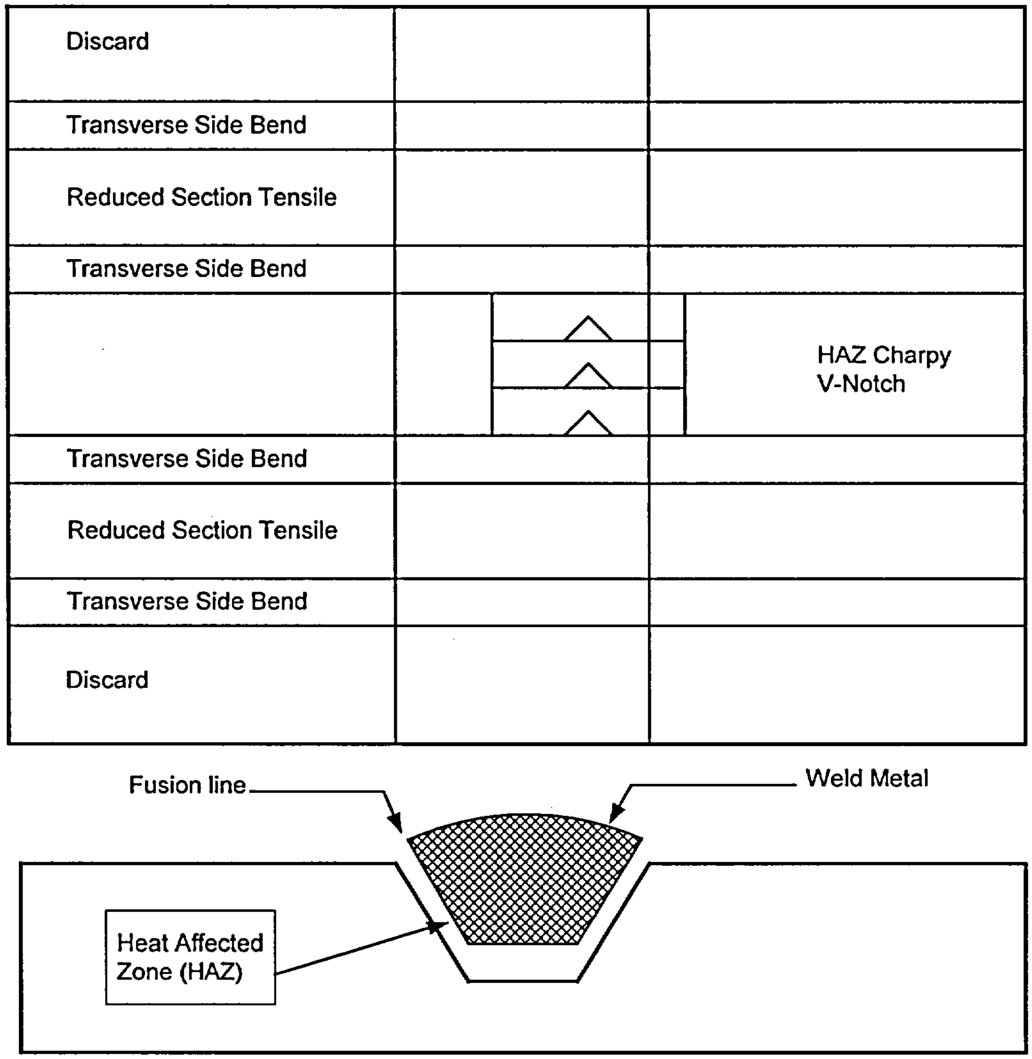
(a) Prior to welding, a surface examination shall be performed on the area to be welded.

(b) Repair welds (Temper bead weld pads) shall be examined by ultrasonic methods in accordance with NB-5000.

(c) NDE personnel performing liquid penetrant examination shall be qualified and certified in accordance with NB-5500.

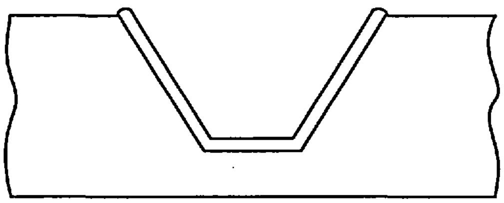
5.0 DOCUMENTATION

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.

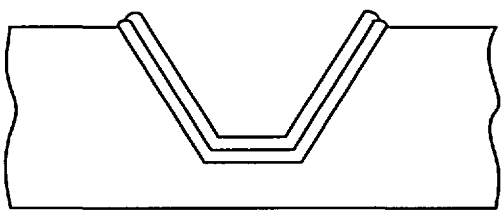


GENERAL NOTE: Base Metal Charpy impact specimens are not shown.

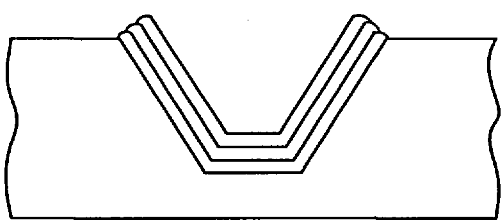
Figure 1 - QUALIFICATION TEST PLATE



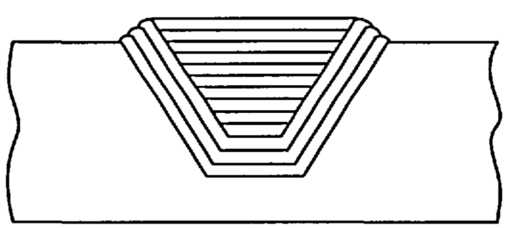
Step 1: Deposit layer one with first layer weld parameters used in qualification.



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