July 30, 2003

Mr. Gregg R. Overbeck
Senior Vice President, Nuclear
Arizona Public Service Company
P. O. Box 52034
Phoenix, AZ 85072-2034

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 - RELIEF REQUEST NO. 23 RE: ALTERNATIVE TO TEMPER BEAD WELDING REQUIREMENTS FOR INSERVICE INSPECTION PROGRAM (TAC NOS. MB8973, MB8974 AND MB8975)

Dear Mr. Overbeck:

By letter dated May 15, 2003 (102-04941), you submitted Relief Request 23 and requested relief from requirements in the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (the ASME Code) for the Palo Verde Nuclear Generating Station (PVNGS), Units 1, 2, and 3. In your request, you proposed an alternative to the gas-tungsten arc welding (GTAW) machine temper bead welding requirements of IWA-4500 and IWA-4530 of ASME Code Section XI for pressurizer heater sleeve welds.

Based on the enclosed Safety Evaluation, the NRC staff concludes that the proposed alternative GTAW temper bead welding process for pressurizer heater sleeve welds provides an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternative in Relief Request 23 to the GTAW-machine temper bead welding requirements of IWA-4500 and IWA-4530 of ASME Code Section XI at PVNGS, Units 1, 2, and 3 for the second 10-year inservice inspection (ISI) interval.

Sincerely,

/RA/

Stephen Dembek, Chief, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. STN 50-528, STN 50-529,
and STN 50-530

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

INSERVICE INSPECTION PROGRAM RELIEF REQUEST NO. 23

ARIZONA PUBLIC SERVICE COMPANY, ET AL.

PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3

DOCKET NOS. STN 50-528, STN 50-529, AND STN 50-530

1.0 INTRODUCTION

The Inservice Inspection (ISI) of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Class 1, 2, and 3 components is to be performed in accordance with Section XI of the ASME Code and applicable edition and addenda as required by 10 CFR 50.55a(g), except where specific relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). Section 10 CFR 50.55a(a)(3) of Title 10 of the *Code of Federal Regulations* (10 CFR), states in part that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if the licensee demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, “Rules for Inservice Inspection of Nuclear Power Plant Components,” to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The ISI code of record for Palo Verde Nuclear Generating Station, Units 1, 2 and 3 second 10-year ISI interval is the 1992 Edition, 1992 Addenda of Section XI of the ASME Code.

By letter dated May 15, 2003, Arizona Public Service (APS) requested approval to utilize an alternative method to the temper bead welding requirements of ASME Section XI, IWA-4500 and IWA-4530 for pressurizer heater sleeve welds. Attachment 1 to the May 15, 2003, letter provides the general welding qualification, welding procedure, surface and weld repair examination, and documentation requirements for the dissimilar metal welding using ambient temperature machine gas-tungsten arc welding (GTAW) temper bead technique.

2.0 INSERVICE INSPECTION PROGRAM RELIEF REQUEST 23, REPAIR OF PRESSURIZER HEATER SLEEVE WELDS

2.1 ASME Code Component Affected

Component Number: B4.20
Description: Pressurizer Heater Sleeve, 36 per Unit
ASME Code Class: 1

2.2 Code Requirements for which Relief is Requested

As stated by the licensee in Section III of the enclosure to its letter dated May 15, 2003:

> 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[s] 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 are limited to those along the fusion line of a nonferritic weld to ferritic base material where 1/8-inch or less of nonferritic weld deposit exists above the original fusion line after defect removal.]
>
> [Temper bead repairs of pressurizer heater sleeve nozzle are performed in accordance with IWA-4500 and IWA-4530 whenever the repair cavity is within 1/8-inch of the ferritic base materials.] 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.

2.3 Licensee's Proposed Alternative to Code

As stated by the licensee in Section IV of the enclosure to its letter dated May 15, 2003:

> Pursuant to 10 CFR 50.55a(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 [(i.e., Relief Request 23)].
>
> APS has reviewed the proposed ambient temperature temper bead welding techniques of Attachment 1[, to the May 15, 2003 letter,] 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 [using preheat and post bake operations]. As an alternative, APS proposes to perform temper bead weld

repairs using the ambient temperature temper bead technique [without any preheat and post bake operations] 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 [required] 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's 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.

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.

The licensee stated during a teleconference on May 28, 2003, that the proposed repairs are to be performed after draining the pressurizer.

2.4 Licensee's Basis for Relief

As stated by the licensee in Section V of the enclosure to its letter dated May 15, 2003:

> The IWA-4500 and IWA-4530 temper bead welding process is a time and [radiation] dose intensive process. Resistance 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 [(MT)] 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 [to the letter dated May 15, 2003, which is described in Section 2.3 above].
>
> 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[, "Ambient Temperature Preheat for Machine GTAW Temper Bead Applications," dated November 1998]. 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 [to] 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 [cold] restraint cracking are addressed below.
>
> 1. Mechanical Properties
>
> The principal [reason] 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 [due to a high degree of restraint]. Both of these mechanisms occur at ambient temperature. Preheating slows down the cooling rate resulting in a ductile, less brittle micro structure 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 micro structures. Because precision bead placement and heat input control [are characteristics] of the machine GTAW process, effective tempering of 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 micro structure 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.

[Attachment 1 to the letter dated May 15, 2003,] establishes detailed welding procedure qualification requirements for base materials, filler metals, restraint, impact properties, and other procedure variables. The qualification requirements [...] provide assurance that the mechanical properties of repaired welds will be equivalent or superior to those of the surrounding base material. [...] [It should also be noted that these qualification requirements are identical to those in IWA-4530. Based upon procedure qualification test results, the impact properties of the base material heat affected zone were greater than those of the unaffected base material.]

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 micro structure 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 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 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. [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 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 [the] machine GTAW process.

3. [Cold] Restraint Cracking

[Cold] 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 micro structures with low ductility are subject to cold restraint cracking [due to a high degree of restraint]. 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 [...]. 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.

3.0 STAFF EVALUATION

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, to the APS letter dated May 15, 2003, also establishes requirements to perform temper bead welding on dissimilar metal welds that join P-No. 43 to P-No. 3 base metals 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.

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. This is suitable because the heat penetration of subsequent weld layers is carefully applied to produce overlapping thermal profiles that develop an acceptable degree of tempering in the underlying heat affected zone (HAZ). This is further demonstrated in EPRI report GC-111050, wherein repair welds performed with an ambient temperature temper bead procedure utilizing the machine GTAW welding process exhibit mechanical properties equivalent to 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. Based on this data the interpass temperature specified in Attachment 1 is acceptable.

Also, 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.

The preheat temperature will be 50°F (minimum) prior to depositing the first weld layer. For the first three layers, the interpass temperatures will be at least 50°F but less than 150°F. The interpass temperature of each remaining layer will be at least 50°F but less than 350°F prior to depositing the subsequent weld layers. The preheat temperature required for this welding is 50°F. This temperature is to be maintained on a weldment inside a building which normally is above this temperature. Therefore, preheat measurement by this alternate method is acceptable. The maximum interpass temperatures required for this welding (150°F for the first three layers, and a maximum interpass temperature of 350°F for the balance of welding), can easily be measured with this type of device. Also, the large mass of the pressurizer head coupled with the low heat input GTAW process will keep the interpass temperature from even approaching the maximum interpass temperatures. So it is unlikely that these welds will ever exceed these temperatures and with the alternate temperature measurement methods, a close control will be maintained on these temperatures. Therefore, this type of temperature measurement is acceptable.

IWA-4532.2 establishes procedure technique requirements but does 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. 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). The alternate exceeds Code requirements and is acceptable.

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 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 HAZs. Subsequent GTAW weld layers introduce heat into the HAZ 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 HAZ. When welding dissimilar materials with nonferritic weld metal, the area requiring tempering is limited to the weld HAZ 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 HAZ 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 Specifications to be used for this repair. Based on Charpy V-notch testing of the

procedure qualification test coupon, impact properties in weld HAZ were greater than those of the unaffected base material. Therefore, the proposed heat input controls of Attachment 1 provide an appropriate level of tempering and the proposed alternate is acceptable.

According to IWA-4532.2(c), at least one layer of weld reinforcement shall be deposited on the completed weld 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 HAZ 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 HAZ in the ferritic base material. Therefore, a weld reinforcement layer is not required.

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. Non-ferritic filler metals, such as, the F-No. 43 filler metal do not undergo a phase change at elevated temperature and therefore do not require a postweld heat treatment. Since the last layer of weld metal is a non-ferritic metal being deposited over two previous non-ferritic weld filler metal layers, the need for a tempering layer and its removal is unnecessary. Therefore, deletion of this requirement is acceptable.

According to IWA-4532.2(d), the weld area shall be maintained at a temperature of 300°F (minimum) for a minimum of 4 hours (for P-No. 3 materials) after at least 3/16-inch of weld metal has been deposited. According to IWA-4532.2(e), after depositing at least 3/16-inch of weld metal and performing a postweld soak at 300°F (minimum), the balance of welding may be performed at an interpass temperature of 350°F. In the proposed alternative of Attachment 1, a postweld soak is not required and APS also 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 welding technique of Attachment 1 is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered HAZ and the desired degree of tempering is achieved. The use of the automatic or machine GTAW process utilized for temper bead welding allows for precise control of heat input, bead placement, and bead size and contour. The resulting micro structure is tough and ductile.

Based on Charpy V-notch testing of the procedure qualification test coupon, impact properties in the weld HAZ were greater than those of the unaffected base material. Therefore, the proposed heat input controls of Attachment 1 provide an appropriate level of tempering. The use of a GTAW temper bead welding technique to avoid the need for postweld heat treatment is based on research that has been performed by EPRI and other organizations. The research demonstrates that carefully controlled heat input and bead placement allows subsequent welding passes to relieve stress and temper the HAZ of the base material and preceding weld

passes. Data presented in the EPRI report show the results of acceptable procedure qualifications performed with 300°F preheats and 500°F preheats, as well as with no preheat and postheat. In addition, many acceptable Procedure Qualification Records and Welding Procedure Specifications presently exist which have been utilized to perform numerous successful repairs which indicate that the use of the ambient GTAW temper bead welding technique is an acceptable approach. From this data, it can be shown that adequate toughness can be achieved in base metal and HAZs with the use of a GTAW temper bead welding technique. The temper bead process has been shown effective by research, successful procedure qualifications, and many successful repairs performed since the technique was developed. Therefore, the alternative temperature proposal is acceptable.

The licensee stated that ASME Section III does not require volumetric examination of J-groove welds. Subparagraph NB-3352.4(d)(1) states that 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-5245 establishes that partial penetration welds shall be examined progressively using either the magnetic particle or dye penetrant (testing) examination (PT).

The NRC staff concludes that using progressive PT is consistent with the weld construction nondestructive examination (NDE) methodology to assure sound welds are deposited, which is acceptable to the staff.

Finally, the NRC staff concludes that sufficient information is present in EPRI Report GC-111050 to indicate that both cold and delayed hydrogen cracking is unlikely. The progressive PT will provide assurance that each weld pass will meet the ASME Code acceptance criteria and the final PT will assure any delayed cracking will be detected should it occur. Based on the above discussion, the staff concludes that the alternative NDE provides reasonable assurance of the structural integrity of the weld.

4.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative to use GTAW ambient temperature temper bead welding for pressurizer heater sleeve nozzle weld repairs as stated in Relief Request 23 provides an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff authorizes the proposed alternative to the GTAW-machine temper bead welding requirements of IWA-4500 and IWA-4530 of ASME Section XI at the Palo Verde Nuclear Generating Station, Units 1, 2 and 3 for the second 10-year ISI interval.

All other requirements of the ASME Code, Section III and XI for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

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