10 CFR 50.55a

aps

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

Dear Sirs:

Subject: **Palo Verde Nuclear Generating Station (PVNGS)**
Unit 3
Docket No. 50-530
American Society of Mechanical Engineers (ASME) Code, Section XI, Request for Approval of an Alternative to Flaw Removal and Characterization - Relief Request 51

Pursuant to 10 CFR 50.55a(a)(3)(i), Arizona Public Service Company (APS) requests NRC approval of Relief Request 51, which proposes an alternative to the ASME Code requirements of Section XI related to axial flaw indications identified in a Unit 3 reactor vessel bottom mounted instrument (BMI) nozzle. Specifically, APS is proposing a half-nozzle repair and a flaw evaluation as alternatives to the requirements for flaw removal of IWA-4421 and for flaw characterization of IWA-3300.

No commitments are being made to the NRC by this letter.

APS requests approval of this relief request prior to entry in Mode 2, Startup, at the completion of the current Unit 3 refueling outage, currently scheduled for November 23, 2013. Should you need further information regarding this relief request, please contact Robert K. Roehler, Licensing Section Leader at (623) 393-5241.

Sincerely,

JJC/RKR/DCE/hsc

Enclosure: Relief Request 51 Proposed Alternative in Accordance with 10 CFR 50.55a(a)(3)(i)

cc:	M. L. Dapas	NRC Region IV Regional Administrator
	J. K. Rankin	NRC NRR Project Manager for PVNGS
	M. A. Brown	NRC Senior Resident Inspector for PVNGS

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Enclosure

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10 CFR 50.55a(a)(3)(i)

Background Information

On October 6, 2013, Unit 3 reactor vessel (RV) bottom mounted instrumentation (BMI) nozzle number (#) 3 exhibited small white deposits around the annulus. These were later determined to be boric acid. The deposits were discovered while performing planned visual examinations pursuant to ASME Code Case N-722-1, *Additional Examinations for PWR Pressure Retaining Welds in Class 1 Components Fabricated With Alloy 600/82/182 Materials,* in accordance with 10 CFR 50.55a, *Codes and Standards.*

Ultrasonic (UT) and eddy current (ECT) examinations inside the bore of the BMI nozzle #3 were performed. The ultrasonic examinations identified and characterized a group of axially-oriented flaws associated with the nozzle that appear to have originated in the toe of the J-groove weld on the outside diameter (O.D.) of the BMI nozzle. The longest flaw was approximately 1.88 inches long and the deepest flaw penetrated approximately 0.378 inches into the 1.125 inch nozzle wall. No circumferential flaws were identified. The UT examination inside the bore could not reliably detect or characterize flaws beyond the O.D. of the nozzle to any measurable depth into the J-groove weld. No flaws were identified in the nozzle I.D. as a result of the ECT examination.

A helium leak test, which pressurized the nozzle from below the RV, produced bubbles from a single point near the toe of the J-groove weld, immediately adjacent to the O.D. of the nozzle inside the RV. The point that the bubbles appeared was determined to be the entry point of reactor coolant system (RCS) water leakage path through the nozzle axial flaws to the outside of the RV.

Ultrasonic and eddy current examinations of the 60 remaining BMI nozzles in Unit 3 verified that there were no unacceptable indications in those nozzles.

To restore the RV pressure boundary, a half-nozzle repair of BMI nozzle #3 replaced the lower portion of the nozzle. The repair moves the BMI nozzle penetration pressure boundary from the J-groove weld inside the RV to a J-groove weld outside the RV. This new J-groove weld joins a new Alloy 690 part-length bottom half-nozzle to an Alloy 52M ambient temperature temper bead weld pad deposited on the outer diameter of the reactor vessel bottom shell. The temper bead weld pad is addressed in ASME Boiler and Pressure Vessel (B & PV) Code Case N-638-4, which is conditionally accepted in Regulatory Guide 1.147, *Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1*, Revision 16. The temper bead weld pad conforms to the conditions required by Regulatory Guide 1.147 for application of Code Case N-638-4.

The details of the half-nozzle repair are provided in Attachment 1, Half-Nozzle Repair Details.

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1. **ASME Code Components Affected**

Components:	Reactor Vessel (RV) Bottom Mounted Instrumentation (BMI) Nozzle Penetration
Code Class:	Class 1
Examination Category:	B-P (Class 1 PWR Components Containing Alloy 600/82/182)
Code Item Number:	B15.80
Description:	RV BMI Nozzle Penetration #3
Size:	3 inch Nominal Nozzle O.D. at the BMI Nozzle-to-RV J-groove Weld
Material:	SB-166 Alloy 600 Nozzle and ERNiCr-3/ENiCrFe-3 Alloy 82/182 Buttering and Weld

There are 61 BMI nozzles welded to the inside surface of the RV with partial penetration J-groove welds.

2. **Applicable Code Edition and Addenda**

Palo Verde Nuclear Generating Station, Unit No. 3, Inservice Inspection Program (ISI) – Third Interval, ending January 11, 2018: American Society of Mechanical Engineers Boiler and Pressure Vessel Code Section XI, 2001 Edition including Addenda through 2003 (Reference 1) as supplemented by 10 CFR 50.55a(g)(6)(ii)(E), *Reactor Coolant Pressure Boundary Visual Inspections.*

3. **Applicable Code Requirements**

Section XI, Article IWA-4000 provides requirements for repair/replacement activities

IWA-4421 states, in part:

> Defects shall be removed or mitigated in accordance with the following requirements...

IWA-4422.1(a) states, in part:

> A defect is considered removed when it has been reduced to an acceptable size ...

IWA-4422.1(b) states, in part :

> Alternatively, the defect removal area and any remaining portion of the defect may be evaluated and the component accepted in accordance with the appropriate flaw evaluation provisions of Section XI ...

Section XI, Article IWA-3000 provides standards for examination evaluation.

IWA-3100(a) states, in part:

> Evaluation shall be made of flaws detected during an inservice examination as required by IWB-3000 for Class 1 pressure retaining components....

IWA-3300(b) states, in part:

> Flaws shall be characterized in accordance with IWA-3310 through IWA-3390, as applicable.

Section XI, Article IWB-3000 provides acceptance standards for Class 1 components

IWB-3420 states:

> Each detected flaw or group of flaws shall be characterized by the rules of IWA-3300 to establish the dimensions of the flaws. These dimensions shall be used in conjunction with the acceptance standards of IWB-3500.

Section XI, Article IWB-2000 provides examination and inspection requirements for Class 1 components.

IWB-2420(b) states, in part:

> If a component is accepted for continued service in accordance with IWB-3132.3 or IWB-3142.4, the areas containing flaws or relevant conditions shall be reexamined during the next three inspection periods listed in the schedule of the inspection program of IWB-2400...

4. Reason for Request

Arizona Public Service Company (APS) conducted visual examinations of the RV BMI nozzle penetrations at the beginning of the Palo Verde Nuclear Generating Station (PVNGS) Unit 3 Refueling Outage (3R17). These examinations revealed evidence of leakage in the annulus at BMI nozzle penetration #3. Ultrasonic and eddy current examinations were conducted in the nozzle bore using a UT/ECT probe combination. The UT examination identified a group of axially (lengthwise) oriented cracks at the O.D. of the nozzle. No circumferential cracks were identified. Metallurgical analyses are being performed to evaluate the cause of the axial-oriented cracks, which appear to be predominantly the result of primary water stress corrosion cracking (PWSCC). To evaluate the extent of the condition, UT and ECT examinations were conducted in the nozzle bore of each of the remaining 60 BMI nozzle penetrations. The examinations verified there were no unacceptable indications in the other 60 nozzle penetrations.

Due to radiological considerations, repair of the original BMI nozzle and J-groove weld presented unique technical challenges. A half-nozzle design repair was implemented such that the original BMI nozzle and J-groove weld no longer perform a pressure boundary function. APS is requesting to leave the upper portion of the original BMI nozzle and the J-groove weld containing the axial flaws in place (remnant nozzle and remnant weld). A fracture mechanics evaluation was performed to demonstrate the acceptability of the flaws and potential propagation into the RV low alloy steel, for a duration of one operating fuel cycle, Unit 3 Cycle 18 (U3C18). The effect of the planned boat sample was considered in the evaluation. The fracture mechanics evaluation is included as Attachment 2, Flaw Fracture Mechanics Evaluation to Support Restart, to this enclosure.

Flaw initiation and/or growth (axially and radially) in the remaining Alloy 600 nozzle material is not a concern from a code perspective since the remnant nozzle no longer performs a pressure boundary function and is physically separated from the new Alloy 690 half-nozzle. The remnant nozzle and weld will continue to have a structural function in support of the operability of the in-core instrumentation (ICI) cable. The remnant nozzle functions as a guide and external protection sheath for the ICI cable during its core insertion and during subsequent power operations. APS evaluated these functions for PVNGS Unit 3 (Reference 6) and determined that the nozzle remnant will continue to maintain its structural integrity during the one operating fuel cycle applicable to this relief request.

While the axial flaws in the BMI nozzle were characterized, UT examination of the remnant J-groove weld is not feasible because of its configuration. This precludes accurate reflective measurement needed to perform flaw characterization and sizing. If UT examination of the remnant J-groove weld were attempted from the outside surface of the RV, the J-groove buttering interface would provide an acoustic mismatch that would limit this examination. These conditions make accurate detection, characterization, and sizing of flaws in the remnant J-groove weld problematic.

Currently, there is no qualified or demonstrated UT technique for examination of the remnant J-groove welds, buttering, or adjacent low-alloy steel RV material from either the inside or outside of the RV. Radiography of this area is also precluded because of the inability to position either a source or film inside the RV. Additionally, other non-destructive examination (NDE) methods, such as liquid penetrant, magnetic particle, and eddy current would not provide useful volumetric information.

The proposed alternative being requested is for acceptance by analytical evaluation, based on an analysis postulating a maximum flaw in the remnant J-groove weld and butter, in accordance with IWB-3142.4.

Accordingly, this relief request seeks approval to leave the remnant J-groove weld at Penetration #3 in place without NDE characterization of embedded flaws. The request also seeks approval to leave the remnant BMI nozzle in place with its characterized axial flaws without being repaired. The supporting basis is provided in the loose parts discussion below.

5. Proposed Alternative and Basis for Use

APS is proposing an alternative in accordance with 10 CFR 50.55a(a)(3)(i). The alternative consists of two main points:

1. A completed half nozzle repair at BMI nozzle #3 using PWSCC resistant material which relocates the pressure boundary weld from inside the reactor vessel to outside the reactor vessel.

   The half nozzle repair is an industry standard, ASME Code compliant repair method that adds a PWSCC resistant Alloy 52M weld pad on the outside of the reactor vessel using ambient temperature temper bead welding in accordance with ASME Code Case N-638-4. A new PWSCC resistant Alloy 690 half-nozzle is attached to the weld pad using a partial-penetration J-groove weld. The half-nozzle repair of BMI nozzle penetration #3 will not remove the flaws in the original J-groove weld or Alloy 600 nozzle material near this weld. Crack propagation into the vessel wall can be addressed by analysis since low-alloy base material is not susceptible to PWSCC and flaws will blunt at the interface of the low-alloy base material and the J-groove weld.

2. Since current NDE procedures are not capable of sizing the extent of crack growth into the PWSCC susceptible weld material, the flaw evaluation postulated a maximum bounding flaw that propagates radially through the J-groove weld, buttering, and clad into the low-alloy base material to a depth conservative with respect to one operating fuel cycle.

   The results of the evaluation were found to be acceptable and the evaluation is provided in Attachment 2 to this enclosure.

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Summary

APS determined an alternative, in the form of a relief request as allowed by 10 CFR 50.55a(a)(3)(i), is needed to address ASME Code requirements. The relief request will permit characterized flaws in the remnant nozzle and uncharacterized flaws in the remnant J-groove weld to remain in place.

The alternative proposed by APS is a completed half-nozzle repair using PWSCC resistant material. The half nozzle repair is an industry standard, ASME Code compliant, repair method that relocates the pressure boundary weld from the inside to the outside of the reactor vessel. The proposed alternative also consists of a fracture mechanics evaluation of a postulated maximum flaw that could exist in the remnant J-groove weld at BMI nozzle penetration #3. Industry experience and the APS analyses demonstrate that potential PWSCC would arrest at the weld-to-low-alloy steel RV base material interface. The current evaluation demonstrates that the flaw will remain acceptable over the next operating fuel cycle.

This provides an acceptable level of quality and safety in accordance with 10 CFR 50.55a(a)(3)(i).

Other Considerations

Boat Sample

A boat sample, to remove approximately 0.4 cubic inches of material from the affected region of the BMI and J-groove weld, is planned. The boat sample will be obtained using electrostatic discharge machining in accordance with Section XI Article IWA-4461. The removal of the material has been considered in, and does not affect the outcome of, the one cycle fracture mechanics evaluation (Attachment 2). Similarly, the boat sample's effect on the structural integrity of the nozzle remnant is negligible.

Loose Parts

APS also considered whether the remnant nozzle, with the existing flaws, could become dislodged from the RV. A PWSCC crack growth analysis of the largest and deepest axial flaws in the BMI nozzle was performed (Reference 6). The crack growth for the postulated flaw was conservatively calculated based on the worst stress distribution through the BMI nozzle wall thickness for all the analyzed BMI nozzles in Reference 2. Potential nozzle loss of structural integrity, due to loss of ligaments from various cracks, is not anticipated within one operating fuel cycle. In addition, a large reduction of the residual stresses present in the nozzle is expected to arrest crack growth in proportion to the distance from the weld. Additionally, crack growth in the nozzle downward is limited by the length of the gap created by the half-nozzle repair. Therefore, based on the conservatively derived crack growth projection of the flaw(s) and the rigidity provided by the engagement into the RV bore, the effects of the flaws on the overall structural integrity of the remnant nozzle and J-groove are deemed acceptable, for one operating fuel cycle. The remnant nozzle will not become dislodged and will maintain its overall structural integrity to support ICI operability. Refer to Attachment 1, Half-Nozzle Repair Details, for the remnant nozzle dimensions considered in the evaluation.

Exposed Low Alloy Steel Base Material

The BMI nozzle repair leaves a small portion of low alloy steel in the RV exposed to primary coolant. An evaluation has been performed for the potential corrosion concerns at the RV low alloy steel wetted surface. Galvanic corrosion, hydrogen embrittlement, and PWSCC are not expected to be a concern for the exposed low alloy steel base metal. General corrosion and crevice corrosion of the exposed low alloy steel base metal were evaluated. The corrosion of the exposed base metal has negligible impact on the RV and has been shown by analysis (Reference 5) to be acceptable for the remainder of 60 year life of the plant, and therefore, acceptable for the one operating fuel cycle duration of this relief request.

6. Duration of Proposed Alternative

The duration of the request is for the duration of the next Unit 3 operating fuel cycle (U3C18). Analyses completed prior to startup support a remaining service life continuing through U3C18.

7. Precedents

South Texas Project Unit 1 – Request for Relief From ASME Section XI Requirements Associated with Characterizing Flaws in Bottom Mounted Instrument Penetration Welds (Relief Request RR-ENG-2-33), June 25, 2003, ADAMS Accession Number ML 031780006

Palo Verde Nuclear Generating Station, Units 1, 2, and 3 - Relief Request No. 29 Re: Remnant Sleeve(s) Flaw Evaluation, November 5, 2004, ADAMS Accession Number ML 043130170

8. References

1. Section XI, *Rules for Inservice Inspection of Nuclear Power Plant Components, 2001 Edition, including Addenda through 2003*
2. Dominion Engineering, Inc., Calculation No: C-7789-00-2, *Palo Verde Bottom Head Instrumentation Nozzle Stress Analysis*
3. Westinghouse Document SFAD-13-130, Rev 0-A, *Fuel and CEA Assessment based on Loose Weld Material at Palo Verde Unit 3*

4. AREVA Document 32-9212915-001, *Palo Verde Unit 3 – Instrument Nozzle Repair Section III One Cycle Justification*
5. AREVA Document 51-9213061-001, *Corrosion Evaluation for Palo Verde Unit 3 Reactor Vessel Bottom Mounted Instrument Nozzle Modification*
6. Westinghouse Document CVER-13-289, Revision 1, *Palo Verde Bottom Mounted Instrumentation (BMI) Nozzles Structural Integrity Assessment and Lack of Fusion Analysis*

9. ATTACHMENTS

Attachment 1 - Half-Nozzle Repair Details

Attachment 2 - Flaw Fracture Mechanics Evaluation to Support Restart

ATTACHMENT 1 – Half-Nozzle Repair Details

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Original Bottom Mounted Instrument (BMI) Nozzle #3
The original nozzle at BMI penetration #3 is Alloy 600 material and has an inner diameter of 0.75 inches, an outer diameter of 3 inches. The nozzle is welded to the inner surface of the reactor vessel. The exterior portion of the nozzle extends approximately 9 inches below the reactor vessel where it is welded to the 0.75 inch, schedule 80 instrument guide tube. The upper portion extends approximately 20 inches above the J-groove weld. The instrument guide tube extends to the seal table located in the reactor cavity. The RCS pressure boundary is formed by the J-groove weld between the nozzle and the reactor vessel and the nozzle to instrument guide tube weld.

Repair
The half-nozzle repair relocated the nozzle pressure boundary from the inner reactor vessel to the outside of the vessel. The existing Alloy 600 nozzle was cut within the reactor vessel wall and approximately five inches of the remnant nozzle portion will remain inside the RV BMI penetration. A new Alloy 690 nozzle was inserted in place of the bottom portion of the original nozzle with was removed. The Alloy 690 nozzle inner and outer diameters are nominally 0.75 inches and 3 inches, respectively (unchanged from original design). A J-groove weld joined the new half-nozzle to a new Alloy 52M ambient temperature temper bead weld pad.

The ambient temperature temper bead weld pad was constructed in accordance with ASME Code Case N-638-4 and the code case conditions required by Regulatory Guide 1.147. The code case conditions were met as follows:

1. The gas tungsten arc machine welding method for the ambient temperature bead weld pad was successfully demonstrated in advance by UT examination using a mockup implanted with fabrication-type flaws.

2. Because of radiological conditions, heat flow calculations were performed in lieu of monitoring preheat and interpass temperatures.

To facilitate the repair installation, a portion of the existing ICI guide tube was cut and later re-installed and welded to the new Alloy 690 nozzle.

With the installed repair, the new RCS pressure boundary for this penetration is formed by the J-groove weld between the Alloy 690 outer nozzle and the temper bead weld pad and by the welds between the nozzle and the ICI guide tube.

Upon completion of the repair, the remnant nozzle and J-groove weld serve as an attachment to the reactor vessel and no longer serve as the RCS pressure boundary for this penetration.

See Figure 1 for BMI nozzle penetration #3 configuration.

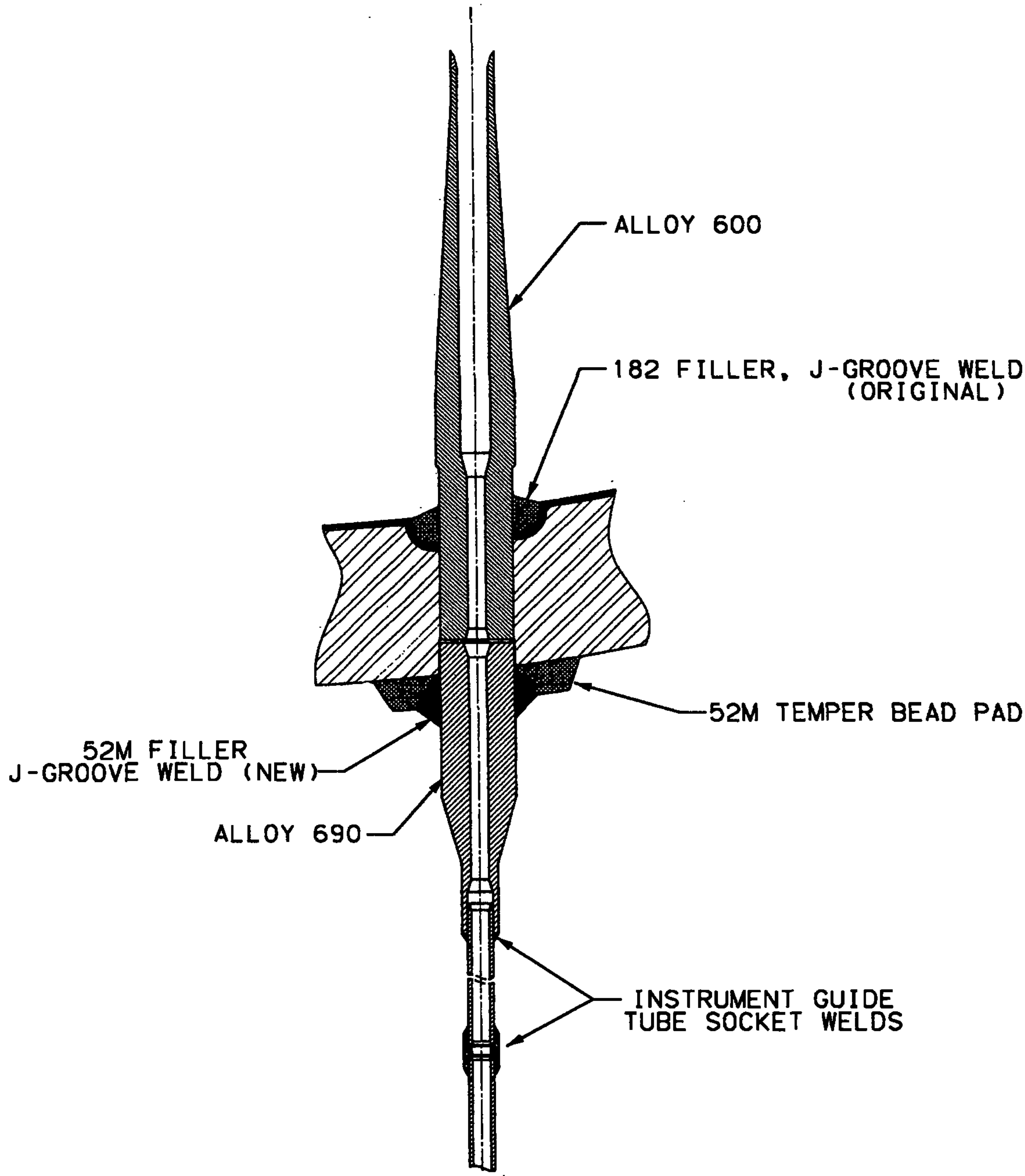

Figure 1 –Half-Nozzle Repair Details