



A subsidiary of Pinnacle West Capital Corporation

Palo Verde Nuclear  
Generating Station

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102-06558-DCM/RAS/CJS  
August 1, 2012

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

Dear Sirs:

**Subject: Palo Verde Nuclear Generating Station (PVNGS)  
Units 1, 2, and 3  
Docket Nos. STN 50-528, 529, and 530  
Relief Request 48 - Proposed Alternative to American Society of  
Mechanical Engineers (ASME) Boiler and Pressure Vessel Code,  
Section III - Phased Array Ultrasonic Examination Techniques (PAUT)  
in lieu of Radiography**

Pursuant to 10 CFR 50.55a(a)(3) Arizona Public Service Company (APS) requests the Nuclear Regulatory Commission (NRC) approval of Relief Request 48, under subparagraph (i), that the alternative would provide an acceptable level of quality and safety. APS proposes an alternative examination technique to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code), Section III, and requests NRC approval.

Specifically, APS requests an alternative to the ASME Code, Section III, which requires that ASME Class 2 carbon steel circumferential pipe weld joints be examined utilizing radiographic examination techniques to satisfy nondestructive examination requirements. The proposed alternative utilizes Phased Array Ultrasonic Examination Techniques (PAUT). The supporting basis for this relief is contained in the Enclosure to this letter.

The Enclosure to this letter contains *Relief Request 48, Proposed Alternative to ASME Section III*, which also includes Attachment 1, *APS Specimens Summary* and Attachment 2, *APS Proposed Alternative Comparison to Code Case N-659-2*. APS requests approval of this relief request by February 1, 2013, to support Unit 1 refueling outage 17 (1R17).

A member of the **STARS** (Strategic Teaming and Resource Sharing) Alliance

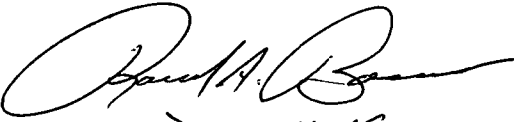
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NRR

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U.S. Nuclear Regulatory Commission  
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There are no commitments being made in this letter. Should you need further information regarding this relief request, please contact Russell A. Stroud, Licensing Section Leader, at (623) 393-5111.

Sincerely,



FOR D. C. MMS

DCM/RAS/CJS/hsc

Enclosure: Relief Request 48, Proposed Alternative to American Society of  
Mechanical Engineers (ASME) Section III

cc: E. E. Collins Jr. NRC Region IV Regional Administrator  
L. K. Gibson NRC NRR Project Manager for PVNGS  
M. A. Brown NRC Senior Resident Inspector for PVNGS

**ENCLOSURE**  
**Relief Request 48**  
**Proposed Alternative to**  
**American Society of Mechanical Engineers (ASME)**  
**Section III**

**Proposed Alternative  
in Accordance with 10 CFR 50.55a(a)(3)(i)  
Alternative Provides an Acceptable Level of Quality and Safety**

**American Society of Mechanical Engineers (ASME) Code Components Affected**

Alternative ultrasonic (phased array) examination is requested for use during repair and replacement activities on ASME Class 2 circumferential piping butt welds. The specific components are limited to carbon steel base and filler material with wall thickness equal to or greater than 0.337 inches and diameters equal to or greater than 6 inches nominal pipe size. In addition, the geometry must allow 100% examination coverage of the weld and ½" of base material on each side.

**Applicable Code Additions and Addenda**

The third 10-year Inservice Inspection interval code for Palo Verde Nuclear Generating Station (PVNGS) for Units 1, 2, and 3 is the American Society of Mechanical Engineers (ASME) Code, Section XI, 2001 Edition through the 2003 Addenda.

The Construction Code for Palo Verde Nuclear Generating Station was ASME Section III 1974 Edition through the Winter 1975 Addenda.

**Applicable Code Requirement**

The 2001 Edition 2003 Addenda of ASME Section XI, paragraph IWA-4221 (Construction Code and Owner's Requirements) requires the owner to use the requirements of the construction code for repair and replacement activities. The examination requirements for ASME Section III, Class 2 circumferential butt welds are contained in the ASME Code, Section III, paragraph NC-5200. The requirement is to perform radiographic examinations of these welds using the acceptance standards specified in paragraph NC-5300.

ASME Section III Code Case N-659-2 documents alternative examination requirements in the form of ultrasonic examination requirements, but is not currently accepted for use in Regulatory Guide 1.84, *Design, Fabrication, and Materials Code Case Acceptability, ASME Section III*.

**Reason for Request**

The reasons for this relief request are grouped into two areas; personnel safety and outage support. The use of the phased array ultrasonic examination techniques will eliminate the personnel safety risk of radiological exposure associated with radiography. Specifically, the planned and accidental exposure associated with transporting, positioning, and exposing a source for the radiographic examinations are removed. Industry operating experience indicates that overexposures occur in the radiography industry. In addition to this personnel

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safety risk reduction, there is an anticipated overall reduction in dose for the examinations. This is realized by the use of an automated scanner, remote analysis processes, and the limited number of personnel needed to perform the examinations. The phased array ultrasonic examination technique (PAUT) crew size would be 1 or 2; whereas, the radiography crews range from a minimum of 5 to upwards of 15.

With regard to outage support, the use of PAUT will reduce the time associated with a given weld examination and subsequent documented examination results. In addition, other outage activities in the area are not impacted during the examination. The PAUT examinations can be performed as soon as the weld joint surface is prepared. There is also a reduction in overall outage risk by eliminating the need to stop and start critical maintenance and operations tasks affected by the radiographic exclusion area. Additional savings are realized by eliminating the need for large amounts of support from radiation protection, boundary guards, and other support personnel. The current planned scope for Unit 1 Refueling Outage 17 (1R17) includes economizer feedwater piping replacement in containment.

**Proposed Alternative and Basis For Relief**

PVNGS is proposing encoded phased array ultrasonic examination technique in lieu of the Code required radiographic examination. Similar techniques are being utilized throughout the nuclear industry for examination of dissimilar metal welds, overlaid welds, as well as other applications; including B31.1 piping replacements. This proposed relief request alternative includes requirements that provide an acceptable level of quality and safety. The capability of the alternative technique is comparable to the examination methods documented in the ASME Code Sections III, VIII, and IX, and associated code cases (references 3, 5, 6, 8, 9, 10, 11 and 12) utilizing ultrasonic examinations for weld acceptance.

*Proposed Alternative*

APS is proposing to perform phased array ultrasonic examinations and to utilize Code Case N-659-2 with conditions as documented below and in Attachment 2.

Several key variables are being proposed to support the basis for this relief. Many of these are considered conservative at this time; but are considered to be good practice for initial technique implementation. These additional key variables are as follows:

- Procedures will utilize ASME Section V, Article 4 (2001 Edition 2003 Addenda)
  - Procedure demonstration will utilize Code Case N-659-2 paragraph (d)
  - The demonstration will be required for each nominal diameter and thickness
  - The demonstration will document the requirements of Table T-421
- Personnel will be qualified as noted in Code Case N-659-2
  - Analysis personnel will demonstrate detection and sizing
- Acceptance criteria will be ASME Section III (2001 Edition 2003 Addenda)

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- Weld caps will be ground flush with the pipe
- The volume (Figure 1 of Attachment 2) will be scanned in all 4 directions
- 100% coverage (calculated with the 45 degree beam)
- Volume will be scanned with a 0 degree but may be manual (not encoded)
- Phased array scanning will be automated (encoded)
- A linear or raster scan pattern (as demonstrated) will be used
- The data will be recorded for analysis and storage
- All welds will receive a surface (PT or MT) examination
- The preservice examinations will be performed per ASME Section XI (reference 4)

*Basis*

The overall basis for this relief is that PAUT is equivalent to or superior for detecting and sizing critical (planar) flaws as compared to the required radiographic examination. In this regard, the basis for the proposed alternative was developed from numerous Codes, Code Cases, associated industry experience, articles, and the results of RT and PAUT examinations of APS flawed specimens.

APS developed a set of actual (not implanted) weld flawed specimens. The carbon steel flawed specimen set ranged in diameters from 4" thru 32", with wall thickness from 0.432" thru 2". The specimen set list is summarized in Attachment 1, along with the flaw types associated with each. This specimen set contains circumferential butt welds utilizing both GTAW and SMAW welding processes and actual fabricated flaws. The number of flaws totaled over 60 and included porosity, incomplete fusion, incomplete penetration, slag, and cracking. The specimens also included areas of concavity and root and counterbore geometrical indications. All specimens were radiograph examined in accordance with ASME Section III procedures and then scanned with the proposed PAUT.

The results of the APS flawed specimen evaluation of RT versus PAUT are consistent with other literature (References 2, 7 and 14). The results show that the PAUT detected all the indications noted by the radiographic examinations; plus several additional indications not identified by radiography. These additional indications were evaluated mainly as areas of incomplete fusion. In addition, several weld and adjacent base metal cracks in the required volume were identified on the PAUT, where none were noted utilizing the radiography technique.

**Duration of Propose Alternative**

APS requests approval of this relief for the remainder of the 3<sup>rd</sup> ISI 10 year interval for all 3 units.

### **Commitments**

No commitments are being made in this request.

### **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.”

The proposed alternative discussed in this relief request provides an acceptable level of quality and safety pursuant to paragraph (i).

### **Precedents**

Oconee Relief Request 2006-ON-001, dated June 20, 2006; requested relief on butt welds between the Pressurizer Level and Sample Tap nozzles and their respective Safe Ends. The reason for the relief was based on the difficulty to perform the code required radiography. The alternative was to perform ultrasonic examination per similar requirements to Code Case N-659-0.

Callaway Relief Request ET 06-0029, dated September 1, 2006; requested relief on main steam and feedwater piping welds being replaced due to flow assisted corrosion. The reason for the relief was based on the acceptability of the proposed ultrasonic examination alternative process, radiation exposure reduction, outage costs and duration, and radiography exposure risk.

### **References**

1. ASME Section III Code Case N-659-2, dated June 9, 2008; *Use of Ultrasonic Examination in Lieu of Radiography for Weld Examination Section III, Divisions 1 and 3*
2. Pacific Northwest National Laboratory Report PNNL-19086, *Replacement of Radiography with Ultrasonics for the Nondestructive Inspection of Welds – Evaluation of Technical Gaps – An Interim Report*, dated April 2010

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**Relief Request 48**  
**Proposed Alternative to ASME Section III**

3. ASME B31.1, Case 168, dated June 1997; *Use of Ultrasonic Examination in Lieu of Radiography for B31.1 Application*
4. ASME Section III and XI 2001 Edition through 2003 Addenda
5. ASME Section III Code Case N-818, dated December 6, 2011; *Use of Analytical Evaluation approach for Acceptance of Full Penetration Butt Welds in Lieu of Weld Repair*
6. ASME Code Case 2235-9, dated October 11, 2005; *Use of Ultrasonic Examination in Lieu of Radiography Section I, Section VIII, Divisions 1 and 2, and Section XII*
7. Journal of Pressure Vessel Technology, *Technical Basis for ASME Section VIII Code Case 2235 on Ultrasonic Examination of Welds in Lieu of Radiography*; Rana, Hedden Cowfer and Boyce, Volume 123, dated August 2001
8. ASME Code Case 2326, dated January 20, 2000; *Ultrasonic Examination in Lieu of Radiographic Examination for Welder Qualification Test Coupons Section IX*
9. ASME Code Case 2541, dated January 19, 2006; *Use of Manual Phased Array Ultrasonic Examination Section V*
10. ASME Code Case 2558, dated December 30, 2006; *Use of Manual Phased Array E-Scan Ultrasonic Examination Per Article 4 Section V*
11. ASME Code Case 2599, dated January 29, 2008; *Use of Linear Phased Array E-Scan Ultrasonic Examination Per Article 4 Section V*
12. ASME Code Case 2600, dated January 29, 2008; *Use of Linear Phased Array S-Scan Ultrasonic Examination Per Article 4 Section V*
13. ASME Section XI Code Case N-713, dated November 10, 2008; *Ultrasonic Examination in Lieu of Radiography*
14. EPRI presentation, dated May 2010; *Ultrasonic Capability study for reduction of weld repair during the construction-UT Technical Presentation*



**ATTACHMENT 1**

**APS Specimens Summary**

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4/18/18 10:14 AM

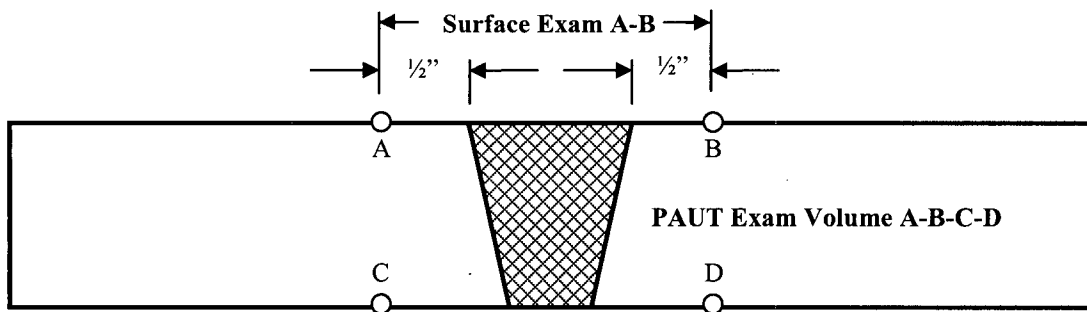
Coupon Details						RT Review					PT
Coupon	Dia	Sch	T	Matl	Weld Processes	Porosity	Slag	IF	IP	Concavity	crack areas
4-160-CS	4"	160	0.531"	CS	GTAW/SMAW	1		1	1		1
6-80-CS	6"	80	0.432"	CS	GTAW/SMAW	1	1	4	1	1	1
6-120-CS	6"	120	0.562	CS	GTAW/SMAW	1	1	2	1		1
6-XXS-CS	6"	XXS	0.864"	CS	GTAW/SMAW	1	1	3	1		1
8-80-CS	8"	80	0.500"	CS	GTAW/SMAW	1	2	2	1		
8-120-CS	8"	120	0.719"	CS	GTAW/SMAW	1		3	1		1
10-60-CS	10"	60	0.500"	CS	GTAW/SMAW	1	2		1		2
10-120-CS	10"	120	0.844"	CS	GTAW/SMAW	1	1	1	1	1	
12-100-CS	12"	100	0.844"	CS	GTAW/SMAW		1		1		
14-100-CS	14"	100	0.938"	CS	GTAW/SMAW		1		1		
16-80-CS	16"	80	0.844"	CS	GTAW/SMAW		1		1		
24-100-CS	24"	100	1.531"	CS	GTAW/SMAW	1	4	1	1	1	2
32-2-CS	32"	NA	2" min	CS	GTAW/SMAW	1	1		1	1	1

**ATTACHMENT 2**

**APS Proposed Alternative Comparison to Code Case N-659-2**

**ATTACHMENT 2**  
**APS Proposed Alternative Comparison to Code Case N-659-2**

Code Case N-659-2 Use of Ultrasonic Examination in Lieu of Radiography For Weld Examination Section III, Division 1	APS Proposed Alternative (if different than the code case)
<p><i>Inquiry:</i> Under what conditions and limitations may an ultrasonic examination be used in lieu of radiography where radiography is required by NB-5200, NC-5200, ND-5200, WB-5200 or WC-5200, and substitution of ultrasonic examination would not otherwise be permitted?</p>	_____
<p><i>Reply:</i> It is the opinion of the Committee that all welds may be examined using the ultrasonic (UT) method in lieu of the radiographic (RT) method, provided that all of the following requirements are met:</p>	<p>APS is proposing the use of encoded phased array ultrasonic examination techniques (PAUT).</p>
<p>(a) The ultrasonic examination area shall include 100% of the volume of the entire weld, plus 1/2 in. (13 mm) of each side of the welds. The ultrasonic examination area shall be accessible and scanned by angle beam examination in four directions, two directions perpendicular to the weld axis and two directions parallel to the weld axis. Where perpendicular scanning is limited on one side of the weld, a technique using the second leg of the V-path may be credited as access for the second perpendicular examination direction provided that the detection capability of that technique is included in the procedure demonstration described in (c) and (d).</p>	<p>APS proposes to use the specifications of this paragraph using the PAUT technique.</p> <p>APS proposes to use this alternative only where 100% coverage of the weld and 1/2" on each side can be achieved. Note Figure 1 below. Coverage will be calculated with the 45 degree beam in all four scanning directions.</p> <p>APS proposes to prepare all welds flush to facilitate scanning and evaluation.</p> <p>APS proposes that each weld where this relief will be utilized will require a surface examination with MT or PT examination techniques.</p>



**Figure 1**  
**Required Examination Area and Volume**

APS Proposed Alternative Comparison to Code Case N-659-2

<p align="center"><b>Code Case N-659-2 Use of Ultrasonic Examination in Lieu of Radiography For Weld Examination Section III, Division 1</b></p>	<p align="center"><b>APS Proposed Alternative (if different than the code case)</b></p>
<p>(b) In accordance with (a) above the ultrasonic examination shall be performed in accordance with Section V, Article 5 up to and including the 2001 Edition or Article 4 for later Edition and Addenda. A straight beam and two angle beams having nominal angles of 45 and 60 deg should generally be used; however, other pairs of angle beams may be used provided the measured difference between the angles is at least 10 deg. Alternatively, ultrasonic examination that includes a straight beam may be performed by a procedure qualified in accordance with the performance demonstration methodology of Section XI, Appendix VIII provided the entire volume of the weld examination is included in the demonstration.</p>	<p>APS proposes utilizing a procedure prepared in accordance with the 2001 Edition through 2003 Addenda of ASME Section V Article 4.</p> <p>The PAUT technique will utilize examination angles as a minimum of 40 thru 70 degrees</p> <p>The weld volume will also be scanned with a 0 degree. This scan may be manual and does not need to be recorded.</p> <p>The straight beam alternative noted will not be utilized.</p>
<p>(c) A written procedure shall be followed. The procedure shall be demonstrated to perform acceptably on a qualification block or specimen with both surface and subsurface flaws as described in (d).</p>	<p>This demonstration will be required for each nominal pipe diameter and thickness</p> <p>The essential and non essential requirements noted in ASME Section V Table T-421 will be documented for each demonstration.</p>
<p>(d) The qualification block material shall conform to the requirements applicable to the calibration block. The material from which blocks are fabricated shall be one of the following: a nozzle dropout from the component; a component prolongation; or material of the same material specification, product form, and heat treatment condition as one of the materials joined. For piping, if material of the same product form and specification is not available, material of similar chemical analysis, tensile properties, and metallurgical structure may be used. Where two or more base material thicknesses are involved, the calibration block thickness shall be of a size sufficient to contain the entire examination path. The qualification block configuration shall contain a weld representative of the joint to be examined, including thickness and for austenitic materials, the same welding process. The qualification blocks shall include at least two planar flaws in the weld, one surface and one subsurface oriented parallel to the fusion line, no larger in the through-wall direction than the diameter of the applicable side-drilled hole in the calibration block shown in Fig. T-542.2.1 of Section V, Article 5, for Editions and Addenda through the 2001 Edition and T-434.2.1 of Article 4 for later Editions and Addenda and no longer than the shortest unacceptable elongated discontinuity length listed in NB-5330, NC-5330, ND-5330, WB-5330 or WC-5330 for the thickness of the weld being examined. Where a Section XI, Appendix VIII, performance demonstration methodology is used, supplemental qualification to a previously approved procedure may be demonstrated through the use of a blind test with appropriate specimens that contain a minimum of three different construction type and fabrication-type flaws distributed throughout the thickness of the specimen.</p>	<p>The qualification blocks and associated flaws noted in (d) will be utilized for procedure demonstration.</p>

APS Proposed Alternative Comparison to Code Case N-659-2

Code Case N-659-2 Use of Ultrasonic Examination in Lieu of Radiography For Weld Examination Section III, Division 1	APS Proposed Alternative (if different than the code case)
(e) This Case shall not be applied to weld examination volumes that include cast products forms or corrosion resistant-clad austenitic piping butt welds.	No exceptions
(f) A documented examination plan shall be provided showing the transducer placement, movement and component coverage that provides a standardized and repeatable methodology for weld acceptance. The examination plan shall also include ultrasonic beam angle used, beam directions with respect to weld centerline, and volume examined for each weld.	The examination plan will be an included procedure requirement, and an as-built sketch will be provided for each weld examined.
(g) The evaluation and acceptance criteria shall be in accordance with NB-5330, NC-5330, ND-5330, WB-5330 or WC-5330, as acceptable. Any flaws characterized as surface-connected cracks, lack of fusion, or lack of penetration may be evaluated by a supplemental surface examination (MT or PT) performed in accordance with NB-5000, NC-5000, ND-5000, WB-5000 or WC-5000, as applicable.	APS is requesting relief for ASME Class 2 circumferential piping welds only, and will not apply this to Class 1 or 3.  Acceptance criteria will be per ASME Section III 2001 Edition 2003 Addenda.
(h) For welds subject to inservice ultrasonic examination, the examination and evaluation shall also meet the requirements of the applicable Edition of Section XI for preservice examination.	Pre-Service Examinations will be in addition to the proposed PAUT examinations.
(i) The ultrasonic examination shall be performed using a device with an automated computer data acquisition system.	No exceptions
(j) Data shall be recorded in unprocessed form. A complete data set with no gating, filtering, or thresholding for response from examination volume in (a) shall be included in the data record.	No exceptions
(k) Personnel who acquire and analyze UT data shall be qualified and trained using the same type of equipment as in (i), and demonstrate their capability to detect and characterize the flaws using the procedure as described in (c).	No exceptions for acquisition personnel.  For analyst, APS is proposing the following:
<ol style="list-style-type: none"> <li>1. Analyst's performance demonstration will utilize data acquired with the demonstrated procedure (note paragraph (d) above).</li> <li>2. For detection, the minimum number of flawed and unflawed grading units and associated minimum detection criteria noted in ASME Section XI table VIII-S2-1 will be met. Based on the data being recorded and the ability to plot/record the actual locations, the size of the grading units will be as follows:               <ol style="list-style-type: none"> <li>a. The flawed grading units will be ¼" longer (each side) than the actual flaw length</li> <li>b. The unflawed grading units will be a minimum 1"</li> </ol> </li> <li>3. At least 2 of the flaws will meet the size requirements noted in (d) above.</li> <li>4. For sizing, the flawed grading units noted above will all be required to meet the following:               <ol style="list-style-type: none"> <li>a. The flaws will be sized as being equal to or greater than their actual length</li> <li>b. The flaws will be properly categorized as surface or subsurface</li> </ol> </li> </ol>	

APS Proposed Alternative Comparison to Code Case N-659-2

Code Case N-659-2 Use of Ultrasonic Examination in Lieu of Radiography For Weld Examination Section III, Division 1	APS Proposed Alternative (if different than the code case)
<i>(l)</i> Review and acceptance of the procedure by the Authorized Nuclear Inspector is required.	No exceptions
<i>(m)</i> All other related requirements of the applicable subsection shall be met.	No exceptions
<i>(n)</i> Flaws exceeding the acceptance criteria referenced in this Case shall be repaired, and the weld subsequently reexamined using the same ultrasonic examination procedure that detected the flaw.	No exceptions
<i>(o)</i> This Case number shall be recorded on the Data Report.	No exceptions