February 23, 2005

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 (PALO VERDE), UNIT 2 - RELAXATION REQUEST FROM U.S. NUCLEAR REGULATORY COMMISSION (NRC) FIRST REVISED ORDER EA-03-009 RE: REACTOR PRESSURE VESSEL (RPV) HEAD INSPECTIONS (TAC NO. MC2389)

Dear Mr. Overbeck:

On February 11, 2003, the NRC issued Order Modifying Licenses (Effective Immediately) EA-03-009 (Order) requiring specific inspections of the RPV head and associated penetration nozzles at pressurized water reactors. The NRC issued an errata to the Order on March 14, 2003, to correct an administrative part of the Order related to requests for relaxation of the Order requirements. On February 20, 2004, the NRC issued the First Revised Order Modifying Licenses (First Revised Order), which supersedes and revises certain inspection aspects of the original Order.

Section IV, Paragraph F of the First Revised Order states that relaxation requests associated with specific penetration nozzles will be evaluated by the NRC staff using its procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) in accordance with Section 50.55a(a)(3) of Title 10 of the *Code of Federal Regulations* (10 CFR).

Sections IV, Paragraphs A and B of the First Revised Order provide criteria to categorize each plant's RPV head with respect to its susceptibility to primary water stress corrosion cracking (PWSCC). For plants like Palo Verde, Units 1, 2, and 3, with RPV heads categorized as highly susceptible to PWSCC, Section IV.C.(1) of the First Revised Order requires that the RPV head penetration nozzles be inspected each refueling outage as prescribed in Sections IV.C.(5)(a) and IV.C.(5)(b).

By letter dated March 19, 2004, as supplemented by letters dated April 16, April 22, April 28, July 1, and November 24, 2004, Arizona Public Service Company (APS or the licensee) submitted a relaxation request for the RPV head control element drive mechanism (CEDM) nozzles from the requirements of Section IV.C.(5)(b) of the First Revised Order for Palo Verde Unit 2. The relaxation request was made pursuant to the procedure specified in Section IV, Paragraph F of the First Revised Order. Specifically, APS stated that compliance with the First Revised Order would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

In a letter dated November 8, 2004, the NRC staff authorized the same proposed relaxation request and alternative inspection for Palo Verde, Units 1 and 3, for an operating time of 1.7 effective full power years (EFPYs) of operation after each successful inspection of the

CEDM nozzles. Each successful inspection will allow Palo Verde, Units 1 and 3, to operate for an additional 1.7 EFPYs, for the life of the First Revised Order.

As documented in the enclosed Safety Evaluation (SE), the NRC staff concludes that the licensee's proposed alternative examination of the CEDM nozzles for Palo Verde, Unit 2, provides reasonable assurance of the structural integrity of the RPV head and vessel head penetration nozzles and welds for an operating time of 1.7 EFPYs of operation after each successful inspection of the CEDM nozzles. A successful inspection is defined as inspecting the minimum required nozzle distances (as discussed in the enclosed SE) for all CEDM nozzles in accordance with the First Revised Order. Therefore, each successful inspection will allow Palo Verde, Unit 2, to operate for an additional 1.7 EFPYs, for the life of the First Revised Order.

The NRC staff's SE concludes that APS has demonstrated good cause for the requested relaxation for the specified operation periods because compliance with the First Revised Order for Palo Verde, Unit 2, CEDM nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Therefore, pursuant to Section IV, Paragraph F of the First Revised Order, the NRC staff authorizes the proposed relaxation and alternative inspection for Palo Verde Unit 2 for the periods specified above, subject to the condition outlined in the conclusion section of the enclosed SE. The licensee agreed to this condition in their letter dated April 16, 2004.

You should be aware that, when vessel head inspections are performed using ASME Code requirements, acceptance criteria, or qualified personnel, those activities and all related activities fall within the jurisdiction of the ASME Code. Therefore, Order-related inspection activities may be subject to third party review, including those by the Authorized Nuclear Inservice Inspector.

Sincerely,

/RA/

Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. STN 50-529

Enclosure: Safety Evaluation

cc w/encl: See next page

CEDM nozzles. Each successful inspection will allow Palo Verde, Units 1 and 3, to operate for an additional 1.7 EFPYs, for the life of the First Revised Order.

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Sincerely,
/RA/
Herbert N. Berkow, Director
Project Directorate IV
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Office of Nuclear Reactor Regulation

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Enclosure: Safety Evaluation

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

FACILITY OPERATING LICENSE NO. NPF-51

ARIZONA PUBLIC SERVICE COMPANY, ET AL.

PALO VERDE NUCLEAR GENERATING STATION, UNIT 2

DOCKET NO. STN 50-529

1.0 INTRODUCTION

U.S. Nuclear Regulatory Commission (NRC) First Revised Order Modifying Licenses EA-03-009 (hereinafter referred to as Order), issued on February 20, 2004, requires specific examinations of the reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles of all pressurized water reactor plants. Section IV, Paragraph F, of the Order states that requests for relaxation of the Order associated with specific penetration nozzles will be evaluated by the NRC staff using the procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code in accordance with Section 50.55a(a)(3) of Title 10 of the *Code of Federal Regulations* (10 CFR). Section IV, Paragraph F, of the Order states that a request for relaxation regarding inspection of specific nozzles shall address the following criteria: (1) the proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or (2) compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Section IV, Paragraph C.(1) of the Order requires that Palo Verde Nuclear Generating Station (Palo Verde), Units 1, 2, and 3, and similar plants determined to have a high susceptibility to primary water stress corrosion cracking (PWSCC), in accordance with Section IV, Paragraphs A and B of the Order, perform the following inspections every refueling outage in accordance with Section IV, Paragraphs C.(5)(a) and C.(5)(b) of the Order:

(a) Bare metal visual examination of 100 percent of the RPV head surface (including 360E around each RPV head penetration nozzle). For RPV heads with the surface obscured by support structure interferences which are located at RPV head elevations downslope from the outermost RPV head penetration, a bare metal visual inspection of no less than 95 percent of the RPV head surface may be performed provided that the examination shall include those areas of the RPV head upslope and downslope from the support structure interference to identify any evidence of boron or corrosive product. Should any evidence of boron or corrosive product be identified, the licensee shall examine the RPV head surface under the support structure to ensure that the RPV head is not degraded.

(b) For each penetration, perform a nonvisual NDE [non-destructive examination] in accordance with either (i), (ii), or (iii):

(i) Ultrasonic testing of the RPV head penetration nozzle volume (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0 inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater. In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

(ii) Eddy current testing [ET] or dye penetrant testing [PT] of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0 inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater.

(iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces, and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric exam on a nozzle with a surface examination may be performed with the following requirements:

1. On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.

2. On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed.

By letter dated March 19, 2004, as supplemented by letters dated April 16, April 22, April 28, July 1, and November 24, 2004, Arizona Public Service Company (APS or the licensee) submitted a relaxation request for the RPV head control element drive mechanism (CEDM) nozzles from the requirements of Section IV, Paragraph C.(5)(b) of the First Revised Order for Palo Verde, Unit 2. The relaxation request was made pursuant to the procedure specified in Section IV, Paragraph F of the First Revised Order. Specifically, APS stated that compliance with the First Revised Order would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

In a letter dated November 8, 2004, the NRC staff authorized the same proposed relaxation request and alternative inspection for Palo Verde, Units 1 and 3, for an operating time of 1.7 effective full power years (EFPYs) of operation after each successful inspection of the CEDM nozzles. Each successful inspection will allow Palo Verde, Units 1 and 3, to operate for an additional 1.7 EFPYs, for the life of the First Revised Order. Therefore, the evaluation contained below is limited to Palo Verde, Unit 2, only.

2.0 RELAXATION REQUEST FOR PROPOSED ALTERNATE INSPECTION FOR RPV HEAD PENETRATION NOZZLES, ORDER EA-03-009

2.1 Order Requirements for which Relaxation is Requested

Section IV.C.(1) of the Order requires, in part, that the inspections discussed in Section 1.0 of this Safety Evaluation (SE) be performed, using the techniques of paragraphs IV.C.(5)(a) and IV.C.(5)(b), every refueling outage for high susceptibility plants similar to Palo Verde, Unit 2.

The licensee has requested relaxation from Section IV, Paragraph C.(5)(b) of the Order. The specific relaxation requested is identified below.

2.2 Licensee's Proposed Alternative

The licensee seeks relaxation from the Order where inspection coverage is limited due to the design of the funnel attachment to the CEDM nozzles for NDE, including ultrasonic testing (UT), ET, and PT.

The licensee proposes to examine each CEDM nozzle from 2 inches above the top of the attachment weld to the minimum required inspection distances identified in Table 1 of the November 24, 2004, submittal (repeated below). The licensee stated that site procedures will require inspection of each CEDM nozzle as far down as practical, but will in all cases be equal to or greater than the minimum required inspection distances.

Table 1. Palo Verde, Unit 2, CEDM Nozzle Minimum Required Inspection Coverage

Stress Level for Lower Crack Extremity = 0 ksi			
Nozzle Angle (E)	Penetration No. Applicability	Minimum Inspection Coverage Required Below the Weld on the Downhill Side (in)	EFPY for Upper Crack Tip to Reach the Bottom of Weld
0	1	0.45	1.7
7.5	2-21	0.45	1.7
28.0	22-45	0.45	1.8
35.7	46-55, 57-85, 90-97	0.40	1.7
35.7	56	0.36	No Propagation Predicted
51.5	86-89	0.35	1.9

Where the requirement to inspect one inch below the toe of the weld cannot be met, fracture mechanics analysis has been performed by the licensee to demonstrate that postulated cracks in the uninspected area will not propagate to the bottom of the J-groove weld before the next inspection, which will be about 1.35 effective full-power years (EFPYs) for the next cycle of operation for Palo Verde, Unit 2. Note that for Penetration No. 56, finite element stress analysis (discussed below) demonstrates that none of the postulated through-wall flaws in the regions not inspected for this penetration would propagate.

2.3 Licensee's Basis for Proposed Alternative

The licensee stated that compliance with the Order would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The licensee stated that the design of the funnel attachment to the CEDM nozzles, which consists of a threaded connection with plug weld, and the as-welded condition of nozzle J-groove weld fillet sizes, prevents compliance with the requirement to perform UT to 1.0 inch below the lowest point of the toe of the J-groove weld for all CEDM nozzles. The licensee also stated that experience gained from the previous UT examinations of the CEDM nozzles completed at Palo Verde in response to Bulletins 2001-01, 2002-01, 2002-02, and Order EA-03-009 have shown that scanning becomes impractical and ineffective from slightly above the top of the nozzle's chamfer face to the bottom of the nozzle. According to the licensee, UT scans in this area do not yield useful data because of the geometry of the nozzle and funnel and the multiple signals reflected back by the threaded surfaces.

The licensee stated that it had assessed the other testing options provided in the Order. Option IV.C(5)(b)(ii), which allows ET or PT testing of the wetted surface in question, would result in significant radiological exposure to personnel if this testing were conducted for all CEDM nozzles. The high exposures, at least 30 times the dose of the proposed alternative,

would be a result of the manual processes needed to performing surface examinations on the outside diameter of the CEDM nozzles, due to the location and proximity of the funnels to each other and limited space. The licensee indicated that it would have to develop new, remote tooling or remove and reinstall a large number of funnels. Option IV.C(5)(b)(iii), which allows a combination of (i) and (ii) to cover equivalent volumes, surfaces, and leak paths of the RPV head penetration nozzle base material and J-groove weld, was not considered an option by the licensee since it had already decided to conduct volumetric examinations of the CEDM nozzles.

3.0 EVALUATION

The NRC staff's review of this relaxation request was based on Criterion (2) of Section IV, Paragraph F of the Order which states:

> Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

In its letter dated March 19, 2004, the licensee indicated that hardship would result from meeting the requirements of the Order, due to the location and proximity of the funnels to each other and limited space. To perform a surface examination on the outside of the CEDM nozzles would be a high dose manual process and that it would need to develop new, remote tooling or remove and reinstall a large number of funnels. With respect to the licensee's rationale for hardship due to the time constraints to develop new, remote tooling, the NRC staff noted that this same rationale was used by the licensee in its March 21, 2003, and April 2, 2003, letters requesting relaxation from the requirements of the Order Modifying Licenses (Effective Immediately) EA-03-009 dated February 11, 2003, for Palo Verde Unit 3. The NRC staff no longer accepts this rationale as the basis for hardship because sufficient time has passed to develop the tooling and the licensee has not provided any evidence of planning progress in its April 22, 2004, response to the NRC staff's request for additional information on this issue. However, considering that the results of the hoop stress analyses provided by the licensee are bounded by the examined areas below the J-groove welds, and the low stress levels in the unexamined areas, no commensurate increase in quality and safety would be obtained by performing the remote surface examination.

In its supplemental letter dated April 16, 2004, the licensee provided a more in-depth analysis of the dose estimate. The total dose to perform the surface examination manually is estimated by the licensee to be about 48 man rem. The licensee also indicated that it would examine each CEDM nozzle from two inches above the top of the J-groove welds to as far down the nozzles as physically possible. Within the context of the licensee's proposed alternative examination of the RPV head penetration nozzles, the NRC staff concludes that the licensee has demonstrated the hardship that would result from implementing examinations to the bottom end of these nozzles.

In its March 19, 2004, letter, the licensee indicated that it had evaluated the other testing options available to them under the Order, specifically under Section IV, Paragraphs C.(5)(b)(ii) and (iii). The NRC staff does not agree with the licensee's position that inspection option IV.C.(5)(b)(iii), which allows a combination of (i) and (ii) to cover equivalent volumes, surfaces and leak paths of the RPV head penetration nozzle base material and J-groove weld, does not apply since the licensee is performing a volumetric examination. Option IV.C.(5)(b)(iii)

is a viable option because the licensee, by seeking relaxation, is not meeting the requirements of (i) or (ii). In its April 16, 2004, supplemental letter, the licensee responded to this position by stating that it was modifying its request for relaxation to include the testing requirements under Section IV, Paragraphs C.(5)(b)(i), (ii), and (iii). The NRC staff agrees that these are the appropriate sections from which to request relaxation since a combination of techniques may be applied to obtain the coverage requirements of the Order. The NRC staff concludes that the hardship rationale discussed previously applies and that the licensee has demonstrated the hardship that would result from implementing examinations to the bottom end of all 97 CEDM nozzles.

The phenomenon of concern is PWSCC, which typically initiates in the areas of highest stress. The area of CEDM penetrations that has the highest residual stress is the area adjacent to the J-groove attachment weld. Therefore, it is most likely that PWSCC will initiate in an area adjacent to the J-groove attachment weld. The licensee proposed to examine no less than the minimum distance (specified in the table in Section 2.2 of this SE) of the nozzle base material below the attachment weld to the top of the chamfer above the threads.

The licensee's minimum inspection zone is defined as that distance of the nozzle base material below the J-groove weld for which a postulated flaw located below that portion of the nozzle that was not inspected, would not propagate to a level adjacent to the J-groove weld within the next operating period. The licensee's flaw evaluation was performed by postulating a through-wall axial flaw in the area of missed coverage below the weld. The methodology was described in Topical Report (TR) WCAP-15817-P, Revision 1, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Palo Verde Units 1 and 2," dated October 2003. This report was provided by the licensee in its March 19, 2004, application. This TR identified the conservatisms embedded in the flaw evaluation for the 0 ksi stress case (the most conservative initial assumption for initial crack growth) as:

1. The postulated axial flaw is assumed to be a through-wall flaw with its upper crack tip assumed to be located at the end of the inspection zone while its lower crack tip is assumed to be located where the hoop stress drops below 0 ksi on either the inside or outside surface of the CEDM penetration nozzle.

2. For comparison purposes, the minimum inspection coverage for the case with the stress level of the lower crack tip at 20 ksi was provided. The stress level of 20 ksi is a conservative value below which PWSCC initiation is unlikely.

The flaw evaluation methodology described above used the as-designed J-groove weld configurations, which is conservative. For one of the penetration nozzles in the Unit 2 RPV head, Penetration No. 56, conducting fracture mechanics analysis using the as-designed J-groove weld configuration did not provide adequate assurance that a crack could not propagate into the J-groove weld. By supplemental letter dated November 24, 2004, the licensee submitted a finite element stress analysis for this penetration using the as-built J-groove weld dimensions. The results of the analysis indicate that the magnitude of the hoop stresses at the inner diameter and outer diameter of the nozzle is lower than the as-designed values. In addition, the extent of the tensile stress area below the weld is also smaller than the as-designed values. The licensee's finite element stress analysis support their conclusion that since the areas not inspected have compressive stresses, there is insufficient tensile stresses to cause axial crack propagation to the J-groove weld. Based on the data provided by the

licensee, the NRC staff concludes that there is reasonable assurance that if a flaw existed in the uninspected areas of the subject CEDM location at its most limiting side, it would not grow.

As stated earlier, the licensee committed to determine that the minimum distances listed in the table in Section 2.2 above are examined in accordance with the requirements of the Order. If the licensee is unable to perform an ultrasonic examination of these minimum required distances below the J-groove weld, the licensee committed in their letter dated April 28, 2004, to perform a qualified surface examination below the affected nozzle J-groove welds to as low as practical on the affected CEDM nozzle inner diameter and outer diameter surfaces prior to plant startup.

On this basis, the NRC staff agrees that the EFPY values contained in Table 1 in Section 2.2 of this SE are appropriate for establishing the minimum time between inspections of the CEDM nozzles. The minimum EFPY value in Table 1 is 1.7 EFPYs; therefore, the NRC staff concludes that relaxation from the Order for 1.7 EFPYs is justified for Palo Verde, Unit 2.

The NRC staff concludes that the licensee's proposed alternative examination of the CEDM nozzles for Palo Verde, Unit 2, provides reasonable assurance of the structural integrity of the RPV head, and VHP nozzles and welds for an operating time of 1.7 EFPYs of operation after each successful inspection of the CEDM nozzles. A successful inspection is defined as inspecting the minimum required nozzle distances (as listed in the table in Section 2.2 above) for all CEDM nozzles in accordance with the Order. Therefore, each successful inspection will allow Palo Verde, Unit 2, to operate for an additional 1.7 EFPYs, for the life of the Order.

3.1 Evaluation Condition

The licensee's analysis in TR WCAP-15817-P used the crack growth formula in Electric Power Research Institute Material Reliability Program report MRP-55, "Material Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material (MRP-55), Revision 1." The NRC staff has made a preliminary assessment of the crack growth formula, but has not yet made a final determination on the acceptability of the subject industry report. Should the NRC staff determine the crack growth formula used by the licensee to be unacceptable, the licensee will be required to revise its analysis to incorporate an acceptable crack growth formula as described below.

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs the licensee of an NRC-approved crack growth formula. If the licensee's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack growth rate formula.

The licensee agreed to this condition in its letter dated April 16, 2004.

4.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative examination of the CEDM nozzles for Palo Verde, Unit 2, provides reasonable assurance of the structural integrity of the RPV head, and VHP nozzles and welds for an operating time of 1.7 EFPYs of operation after each successful inspection of the CEDM nozzles. A successful inspection is defined as inspecting the minimum required nozzle distances (as listed in the table in Section 2.2 above) for all CEDM nozzles in accordance with the Order. Therefore, each successful inspection will allow Palo Verde, Unit 2, to operate for an additional 1.7 EFPYs, for the life of the Order.

Further inspections of these VHP nozzles in accordance with Section IV, Paragraph C.(5)(b), of the Order would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV, Paragraph F, of the Order, the NRC staff authorizes the proposed alternative inspection for the CEDMs at Palo Verde, Unit 2, for 1.7 EFPYs of operation after each successful inspection of the CEDM nozzles, for good cause shown, subject to the condition specified in Section 3.1 of this SE.

Principal Contributor: Mel Fields

Date: February 23, 2005