APS

EA-03-009

Palo Verde Nuclear Generating Station

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102-05101- CDM/TNW/RJR
May 3, 2004

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

References:
1. APS letter 102-05075-CDM/SAB/RJR, "Relief Request No. 25 – Request for Relaxation of First Revised NRC Order EA-03-009, Section IV.C.(5)(b) Requirements for CEDM Nozzles," dated March 19, 2004.
2. APS letter 102-05086-CDM/SAB/RJR, "Response to Request for Additional Information – Request for Relaxation of First revised NRC Order EA-03-009, Section IV.C.(5)(b) Requirements for CEDM Nozzles," dated April 16, 2004.
3. APS letter 102-05094-CDM/SAB/RJR, "Second Request for Additional Information – Request for Relaxation of First revised NRC Order EA-03-009, Section IV.C.(5)(b) Requirements for CEDM Nozzles – Relief Request No. 25," dated April 22, 2004.
4. APS letter 102-05099-CDM/SAB/RJR, APS' Commitment for CEDM Nozzle Inspections for First Revised NRC Order EA-03-009," dated April 28, 2004.
5. APS letter 102-05100-CDM/TNW/RJR, "Additional Information Request for CEDM Nozzle Inspections for First Revised NRC Order EA-03-009," dated April 29, 2004.

Dear Sirs:

**Subject:** **Palo Verde Nuclear Generating Station (PVNGS)**
**Units 1, 2 and 3**
**Docket No.s STN 50-528, 50-529 and 50-530**
**Revised Analysis Information for CEDM Nozzle Inspections for First Revised NRC Order EA-03-009**

In Reference 1, Arizona Public Service Company (APS) requested relaxation of the requirements of Order Section IV.C.(5)(b). In References 2, 3, 4 and 5, APS

A101

provided responses to NRC questions regarding the relaxation request for the CEDM nozzles. In a telephone call on April 30, 2004, the NRC requested that an analysis be performed to substantiate that the distances inspected for penetrations 84, 87, and 93 were acceptable.

The requested analysis was completed for penetrations 84, 87, and 93 and verifies that a crack in the uninspected region of these nozzles will not propagate to the weld within one cycle of operation. The analysis has been included as an enclosure to this letter.

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

Sincerely,

David Mauldin

Enclosure Westinghouse letter LTR-PAFM-04-35, "Revised Analysis for Palo Verde Unit 1 CEDM Penetrations 84, 87, and 93."

CDM/STNW/RJR

cc: J. E. Dyer
B. S. Mallett
M. B. Fields
N. L. Salgado

**Enclosure**

**Westinghouse Letter LTR-PAFM-04-35**
**Revised Analysis for Palo Verde Unit 1**
**CEDM Penetrations 84, 87, and 93**

Westinghouse

To: Jim Olszewski

cc: Seth Swamy, Jim Compas

Date: May 3, 2004

From:

Ext: 724-722-6030

Fax: 724-722-5597

Your ref:

Our ref: LTR-PAFM-04-35

Subject: Revised Analysis for Palo Verde Unit 1 CEDM Penetrations 84, 87 and 93

Additional crack growth calculations were performed for Penetration No. 84, 87 and 93 based on the actual achieved inspection coverage and the as-built penetration nozzle dimensions. Instrumentation measurement uncertainty of ±0.04" has also been taken into account in the calculations. The following summarizes the input, assumptions, methodology and the results of the crack growth calculations.

Please transmit the attached information (page 2 to 4) to APS in a project letter.

Author: ______________________________

C. K. Ng[1], Piping Analysis & Fracture Mechanics

Verifier: ______________________________________

Santit Jirawongkraisorn[1], Piping Analysis & Fracture Mechanics

[1] Official Record Electronically Approved in EDMS 2000

Additional crack growth calculations were performed for Penetration No. 84, 87 and 93 based on the actual achieved inspection coverage and the as-built penetration nozzle dimensions. Instrumentation measurement uncertainty of ±0.04" has also been taken into account in the calculations. The following summarizes the input, assumptions, methodology and the results of the crack growth calculations.

Initial Flaw Size and Configuration

The upper extremity of the initial flaw is assumed to be located at the end of the inspection zone. The lower extremity of the initial flaw is conservatively assumed to be located at the bottom of the nozzle. The initial flaw depth is assumed to be 90% of nozzle wall thickness.

An estimate of the initial surface crack length, at the inside surface of the nozzle, from the chamfer to the bottom of the remaining threaded nozzle is calculated as follows:

Initial Surface Crack Length (in) =
(PT examined covered distance OD + 1/8") – (ID covered distance by UT – 0.04")

It is assumed that the PT surface examination stopped at a distance approximately 1/8" from the bottom of the weld. In addition, the NDE uncertainty of 0.04" is subtracted from the UT inspection coverage.

Based on the above the Initial Surface Crack Length for each nozzle is:

Nozzle 84 flaw length = ( 1.0" + 1/8" ) – ( 0.28" – 0.04" ) = 0.885"

Nozzle 87 flaw length = ( 0.8" + 1/8" ) – ( 0.20" – 0.04" ) = 0.765"

Nozzle 93 flaw length = ( 0.7" + 1/8" ) – ( 0.36" – 0.04" ) = 0.505"

The initial flaw size and configuration is summarized below:

| Penetration Nozzle No. | Nozzle Angle (°) | Actual UT Coverage (in) | Distance of Upper Crack Extremity Below the Weld (in) | Initial Surface Crack Length (in) |
|---|---|---|---|---|
| 84 | 35.7 | 0.28 | 0.24 | 0.885 |
| 87 | 51.5 | 0.20 | 0.16 | 0.765 |
| 93 | 35.7 | 0.36 | 0.32 | 0.505 |

Methodology

A hypothetical 90% through-wall inside axial surface flaw was postulated below the weld in the region of the penetration nozzle not inspected. The 90% through-wall flaw was assumed based upon a successful liquid penetrant surface examination being performed by APS personnel. For a flaw with a depth of 90% through-wall, it is assumed that it would become a through-wall crack first before propagating upwards towards the bottom of the weld. The methodology used in the crack growth calculation is the same as that used in WCAP-15817-P Rev. 1 except the hoop stress values used in the calculation were revised to reflect more representative conditions. Two approaches were used to determine a more realistic loading in the crack growth calculation.

Approach 1: Residual Hoop Stress Limited to Yield Strength
The calculation of stress intensity values used to calculate the Primary Water Stress Corrosion Cracking (PWSCC) crack growth rate is dependent on the estimated residual stresses of the nozzle as a result of welding. In a recent workshop conducted by the Pressure Vessel Research Council (PVRC) on the subject of residual stresses, it was identified that most Finite Element Analysis codes overestimated residual stresses. In general, the peak residual hoop stresses at the weld are highly localized and may exceed the base material yield strength. However, the residual stresses at the base material are at or below the yield strength in the vicinity of the weld and drop in magnitude through the thickness of the base material. Therefore based on this finding, the peak hoop stresses at either the outside or inside surface used in determining the stress intensity factors are limited to an upper bound value which is equivalent to the nozzle yield strength of 53 ksi.

Approach 2: Average Hoop Stress Along Crack Surface
The hoop stress used in WCAP-15817-P Rev. 1, Appendix B, is based on the maximum stress at the upper extremity of the assumed through-wall crack which is then conservatively applied along the entire crack surface to calculate the crack stress intensity factor. By reviewing the inside and outside surface hoop stress distribution below the weld, it is evident that the previous methodology is very conservative. Therefore the average hoop stress along the crack surface is calculated and used in determining the stress intensity factor.

Crack Growth Results

Using the same methodology as in WCAP-15817-P Rev. 1 for the surface flaw crack growth calculation, the time required for the surface flaw (90% through-wall) to become a through-wall flaw is shown below:

| | Required Service Life (EFPY) | | |
|---|---|---|---|
| Description | Penetration 84 | Penetration 87 | Penetration 93 |
| Surface Flaw to Thru-wall Flaw (0.9t) | 0.46 | 0.39 | 0.46 |

By taking into account the time for the through-wall flaw to reach the bottom of the weld, the total time required for the hypothetical flaw to reach the bottom of the weld is:

| | Approach 1 | Approach 2 |
|---|---|---|
| Penetration Nozzle No. | Remaining EFPY | Remaining EFPY |
| 84 | 1.5 | 3.2 |
| 87 | 1.5 | 2.6 |
| 93 | 2.5 | 4.0 |

Additional Conservatism

The following conservatism is inherent in the crack growth calculation:

- The vessel head temperature for the current fuel cycle is 595°F and 597°F was used to determine the crack growth rate.
- Standard Steel is the supplier for the Palo Verde CEDM material. The crack growth amplitude shown in Table 5-3 of MRP-55 Rev.1 for Standard Steel material is $9.09 \times 10^{-13}$ (SI units). A value of $2.67 \times 10^{-12}$ (SI units) recommended in MRP-55 Rev. 1 is more conservative than the actual value for the material used in the PVNGS nozzles and was used in the calculation. Therefore the crack growth analysis is conservative.
- The Effective Full Power Years (EFPY) scheduled for the upcoming Unit 1 cycle 12 is 493 days or 1.35 EFPY.
- There is nearly universal agreement that high stresses, on the order of the material yield strength, are necessary to initiate PWSCC. There is no known case of stress corrosion cracking of Alloy 600 below the yield stress. Typical yield strengths for wrought Alloy 600 head penetration nozzles are in the range of 37 ksi to 65 ksi. Weld metal yield strengths are generally higher. The stress level of 20 ksi is a conservative value below which PWSCC initiation is extremely unlikely. Therefore the assumption of any PWSCC crack initiation in the region of the penetration nozzle with a stress level of 20 ksi or less is conservative.