UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 25, 1993

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

Mr. William F. Conway
Executive Vice President, Nuclear
Arizona Public Service Company
P.O. Box 53999
Phoenix, Arizona 85072-3999

Dear Mr. Conway:

SUBJECT: STEAM GENERATOR TUBE EVALUATION - PALO VERDE NUCLEAR GENERATING STATION (TAC NO. M86178)

This letter provides our preliminary assessment of the tube cracks being found in the Palo Verde Unit 2 steam generators and their potential implications for Palo Verde Units 1 and 3. As background, our letter to you dated June 8, 1993, enclosed a letter dated June 4, 1993, from the NRC staff's expert consultant on eddy current testing, Caius Dodd of the Oak Ridge National Laboratory. This letter provided Mr. Dodd's findings stemming from a visit to the Palo Verde site with Kenneth J. Karwoski of the NRC staff on May 4 through May 7, 1993, to review the inspection program being implemented at Palo Verde Unit 2. Mr. Dodd has elaborated on his conclusions in a letter to us dated June 14, 1993, which is enclosed. Mr. Dodd's conclusions are preliminary, pending the ongoing examinations of pulled tube specimens from Palo Verde Unit 2.

The degradation of concern at Palo Verde Unit 2 is intergranular stress corrosion cracking (IGSCC) and associated intergranular attack (IGA) initiating from the outer diameter surface of the tubing. These cracks are being found at the various tube supports and in the free spans between the supports. In general, these cracks are not constrained against rupture by adjacent support structures. These cracks can be quite long (up to 17 inches) and can develop to the point of rupture without significant precursor leakage if not detected by inservice inspection. Such cracks, if not adequately controlled through inservice inspection and/or preventive measures, could provide a mechanism for multiple tube ruptures during postulated accidents.

APS has performed a 100% sample inspection of the steam generator tubes over their full length using an eddy current bobbin probe. A key point to be noted, however, is that the tube that ruptured at Palo Verde Unit 2 in March 1993 exhibited no observable bobbin signal on the differential or absolute channels during the previous refueling outage inspection. Thus, it can be assumed that cracks at Palo Verde Unit 2 not detectable by bobbin probes during a given refueling outage

corrosion cracking of the Inconel 600 tubing. Resin fines (from the demineralizers) found in the steam generator represent a potential source for contaminants in the bulk water.

The Palo Verde Unit 1 and Unit 3 steam generators are believed to be similar in both mechanical design and in thermal-hydraulic performance as Palo Verde Unit 2. In view of the degradation problems and resulting rupture event at Unit 2, APS is requested to assess the implications of the Unit 2 inspection results to Units 1 and 3. This should include a comparative assessment of Palo Verde Units 1 and 3 with Palo Verde Unit 2 in terms of steam generator and secondary plant design and experience, operational practices, water chemistry control and performance, potential sources of contaminants in the feedwater, hideout return levels, pilgering noise levels, and previous steam generator tube inspection results.

As part of your evaluation of the tube integrity issue, you are also requested to include a safety assessment of continued operation of Units 1 and 3 with potentially degraded tubes. This evaluation should consider tube failure scenarios including initiating events of a single tube rupture, multiple tube ruptures, and the potential for induced single and multiple tube ruptures due to secondary side depressurization transients, e.g., a main steamline break.

As guidance for this assessment, the staff notes the generic safety assessment performed in support of interim steam generator plugging criteria for Westinghouse plants. This evaluation is contained in Section 4 of the NRC's June 1, 1993, draft task group report, "Voltage-Based Interim Plugging Criteria for Steam Generator Tubes," available in the Public Document Room. The staff believes that the approach taken in this report is appropriate for assessing the risk significance of degraded tubes.

However, it will be necessary to significantly modify the evaluation for application to Palo Verde. Items expected to impact this assessment would include differences in the Palo Verde systems relative to those assumed in the generic study, especially the lack of a pressurizer power operated relief valve (PORV) and lower shutoff head ECCS pumps, the plant-specific EOPs, and the probability of tube failure given the potential that the degradation mode present at Palo Verde Unit 2 also exists at Palo Verde Units 1 and 3.

inspection can potentially rupture without significant precursor leakage prior to the next refueling outage inspection, given the crack growth rates at this unit.

Eddy current testing has only limited capabilities at this time to detect stress corrosion cracks. Mr. Dodd estimates the threshold depth at which cracks can be reliably detected with eddy current testing to be about 70% through-wall with the bobbin probe. This includes consideration of the noise in the eddy current response due to the pilgering process employed during tube fabrication. Eddy current rotating pancake coil (RPC) probes appear to provide a somewhat more sensitive test for the cracks at Palo Verde Unit 2 than can be achieved with the bobbin probe. Mr. Dodd estimates the threshold depth for reliable detection to about 50% through-wall with the RPC probe. These detection threshold estimates are preliminary and are based on Mr. Dodd's experience rather than on Palo Verde data. Recently obtained information from the ongoing examinations of the pulled tube specimens from Palo Verde Unit 2 indicate that two cracks not detected in the field by the bobbin probe exhibit maximum depths of 61% and 57%, respectively. The average depths of these cracks are 42% and 44%, respectively. Both of these cracks were detected in the field with RPC.

Crack indications found with the bobbin probe are mostly located in a broad crescent-shaped region near the top of the tube bundle where heavy deposits have formed on the tubes. Thermal-hydraulic analyses indicate that this crescent-shaped region correlates to the region of the bundle with relatively high quality steam and associated high potential for deposition of impurities. You have performed supplementary inspections of all tubes in this crescent region between the eighth support plate and batwing support with the more sensitive RPC probe. These inspections identified approximately 13 indications not detected during the bobbin probe inspection. APS is inspecting only a sample of tubes outside the crescent region with the RPC probe.

The adequacy of the inspection program being implemented at Palo Verde Unit 2 remains a key issue to be resolved. In particular, a technical basis to support the scope of inspections to be performed with the rotating pancake coil (RPC) probe needs to be developed. The assessed adequacy of the inspection program must include consideration of the threshold depth at which cracks can be detected with bobbin and RPC probes, respectively, the various factors contributing to the cracking at Palo Verde Unit 2, crack growth rates, and your plans for future operation of Palo Verde Unit 2 (such as how long the plant will be operated prior to its next steam generator tube inspection).

The specific root causes of the cracks at Palo Verde Unit 2 have not yet fully been confirmed. However, based on the early investigations, general contributing factors may include the thermal-hydraulic environment; namely, steam blanketing in the upper part of the tube bundle, leading to heavy deposits on the tubes from impurities in the water. The heavy deposits on the tubes may provide a concentrating medium for contaminants such as sulfates which may in turn lead to intergranular attack and intergranular stress

As for schedular matters, we expect that you will address the basic questions raised in this letter regarding the eddy current inspection program on Unit 2 as part of your ongoing root cause investigation and include the responses in your root cause reports which we are beginning to receive. As for your assessment of the implications on Units 1 and 3, this information should be provided by July 26, 1993.

Please contact us should you have any questions regarding this request.

Sincerely,

Original signed by:

Charles M. Trammell, Senior Project Manager
Project Directorate V
Division of Reactor Projects III/IV/V
Office of Nuclear Reactor Regulation

Enclosure:
C. Dodd letter of June 14, 1993

cc w/enclosure:
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C. Dodd letter of June 14, 1993

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