Arizona Public Service Company

June 21, 1984
ANPP-29810-TDS/TRB

U. S. Nuclear Regulatory Commission
Region V
Creekside Oaks Office Park
1450 Maria Lane - Suite 210
Walnut Creek, CA 94596-5368

Attention: Mr. T. W. Bishop, Director
Division of Resident
Reactor Projects and Engineering Programs

Subject: Final Report - DER 83-66
A 50.55(e) Reportable Condition Relating to Unit 1 Auxiliary Feedwater Pump
File: 84-019-026; D.4.33.2

Reference: A) Telephone Conversation between P. Narbut and R. Tucker on October 11, 1983
B) ANPP-28199, dated November 8, 1983 (Interim Report)
C) ANPP-28615, dated January 13, 1984 (Time Extension)
D) ANPP-29128, dated March 22, 1984 (Time Extension)
E) ANPP-29625, dated May 31, 1984 (Time Extension)

Dear Sir:

Attached is our final written report of the Reportable Deficiency under 10CFR50.55(e), referenced above.

Very truly yours,

E. E. Van Brunt

E. E. Van Brunt, Jr.
APS Vice President
Nuclear Production
ANPP Project Director

50-528

EEVB/TRB:db
Attachment

cc: See Page Two

1/1
IE-27

cc: Richard DeYoung, Director
Office of Inspection and Enforcement
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

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FINAL REPORT - DER 83-66
DEFICIENCY EVALUATION 50.55(e)
ARIZONA PUBLIC SERVICE COMPANY (APS)
PVNGS UNITS 1, 2, 3

1. Description of Deficiency

After hot functional testing, the electric motor driven Auxiliary Feedwater Pump 1-M-AFB-P01 was found to have an impeller wear ring, which had fractured into several pieces. Some pieces were trapped within the pump, and others had passed through the pump. Minor internal pump damage was noted, but the pump did not seize or overheat. Also, no excessive vibration was noted.

An inspection of all wear rings on all (including turbine driven) Auxiliary Feedwater Pump rotating elements, including the spare element, was initiated.

The rotating elements of three pumps (1-M-AFA-P01, 1-M-AFB-P01 and 1-M-AFN-P01) were removed and disassembled. The wear rings were loosened (standard shop practice may include heating with a blow torch when necessary, pried off and examined for cracks using dye penetrant (PT). Cracking was discovered in all three pumps. A summary of test results is given in Appendix 1.

In order to verify the cracking was not solely due to heating and mechanical damage during the removal process, the wear rings on pump 2-M-AFN-P01 were examined by PT prior to removal from the rotating impeller assembly (only the ring surface furthest from the impeller was examined.) Cracking was again noted. The rings were removed from the impeller assembly for a full-surface PT analysis. This investigation verified that removal did produce some cracking and that cracks also existed prior to the removal process.

A PT examination of all accessible ring surfaces prior to removal from the impeller assembly was conducted on the wear rings of pumps 2-M-AFA-P01, 2-M-AFB-P01, 3-M-AFA-P01 and the spare rotating element. The examination revealed cracking as before.

The original wear rings are hard, brittle, martensitic steel fabricated from AISI 440A centrifugally cast steel, which has the following properties:

Chromium - 16.0% to 18.0% by wt.

Carbon - 0.60% to 0.75% by wt.

Hardness - 510 HB (600F tempering)

Yield Strength - 200,000 psi

Elongation - less than 1% in 2 inches

Reduction of Area - less than 1%

All of the tested rotating elements, except the spare, had varied histories with pumped water. Pump 1-M-AFB-P01 had approximately 360 operating hours at PVNGS with 52 starts. The three Unit 3 pumps have pumped water during factory performance tests but have not been in water at PVNGS. Two Unit 2 pumps have operated, although all three have been in water at PVNGS.

Metallurgical and microscopic examinations of the original ring material (AISI 440A) indicates the root cause of cracking is excessive stresses due to localized frictional overheating during pump operation, probably during acceleration to speed. The overheating further embrittles the ring by creating a thin area of umtempered martensite.

The supplier recommended the wear ring be changed to AISI 420 wrought steel, which has the following properties:

Chromium - 12.0% to 14.0% by wt.

Carbon - 0.15% by wt. (min.)

Hardness - 500 HB (600F tempering)

Tensile Strength - 230,000 psi

Yield Strength - 195,000 psi

Elongation - 8% in 2 inches

Reduction of Area - 25%

This material is a hard martensitic steel with much higher ductility than the original ring material.

An extensive test program was initiated to verify that the supplier's recommendation for a change in wear ring material would preclude wear ring failure. Four samples of the proposed replacement material (AISI 420) were tested per ASTM F519 at oxygen levels of 0.03 ppm and 1.0 ppm (approx.) to determine susceptibility to hydrogen embrittlement in water similar to the design pumpage. These four samples were stressed to 194,500, 177,500, 140,000 and 113,600 psi respectively for 150 hours during each test. No failures occurred.

Pump 1-M-AFB-P01 was reassembled with wear rings fabricated from AISI 420 wrought steel and subjected to fifty-two (52) starts and stops, as well as operation at both minimum flow and design flow (approx.) conditions. The maximum continuous run time, at both the lowest and highest flow rates, was forty-eight (48) hours. The rotating element was visually inspected, and the accessible surfaces of the wear rings were PT examined. No cracks were found, no abnormal wear was noted and no galling was observed.

II. Analysis of Safety Implications

All pumps with operating history had wear rings with incipient cracks. Since the wear rings are brittle, crack propagation to failure is likely. Although the pump did not fail (seize or overheat) it is possible that a piece of ring could wedge in the pump and prevent a start. The absence of one or more rings decreases the pump head and may preclude it from delivering sufficient water to the steam generator under design conditions. Therefore, this condition is judged reportable under 10CFR Part 50.55(e) as a substantial safety hazard.

Furthermore, this condition constitutes a defect in a basic component which was installed and operated, the failure of which could have affected the integrity of the reactor coolant boundary. Therefore, this condition also qualifies as reportable under 10CFR Part 21.

III. Corrective Action

A. Specification Change Notice No. 3545 to Purchase Order 10407-13-MM-021 was issued to:

1. Change the pump wear ring material to AISI 420 wrought steel.

2. Enhance the QC program for the wear rings to include:

a. Certified material test reports.

b. Dye penetrant (PT) test reports.

c. Heat treatment reports.

B. All of the Auxiliary Feedwater Pumps (for Units 1, 2, and 3) have been returned to the pump manufacturer for rework per the above specification change.

C. Bingham-Willamette Co. (BWC) advised the NRC of a 10CFR Part 21 noncompliance by letter dated November 8, 1983. A copy of this final report will be forwarded to BWC for their information.

APPENDIX 1

SUMMARY OF TEST RESULTS

Pump	Test Results
1-M-AFA-P01	One ring with one linear cracks after ring removal
1-M-AFB-P01	Original failure plus two rings with linear cracks (3 on one ring) after ring removal
1-M-AFN-P01	One ring with one linear cracks after removal
2-M-AFN-P01	Three rings with one linear and one ring cracked halfway before removal
2-M-AFA-P01	Seven of 14 rings with linear cracks (7 on one ring) before ring removal
2-M-AFB-P01	Three of 14 rings with linear cracks (4 on one ring) before ring removal
3-M-AFA-P01	Six of 14 rings with linear cracks (23 on one ring) before removal
3-M-AFN-P01	One ring with 2 linear cracks before removal
Spare Element	No linear cracks before removal