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Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
10 CFR 21; Byron Jackson River Water Pump Couplings
Supplemental Information

United States Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555
Attn: Director, Office of Nuclear Reactor Regulations

Gentlemen:

On November 21, 1991, Duquesne Light Company submitted a 10 CFR Part 21 report concerning the Beaver Valley Unit #1 River Water Pump couplings supplied by Byron Jackson. Attached is the final report on this issue, based on supplemental information.

Should you have any further questions regarding this matter, we will be pleased to discuss them with you.

Very truly yours,

T. P. Noonan
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JJM/sl

Attachment

IE19
1/1

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10 CFR Part 21
BVPS Unit 1 - Byron Jackson River Water Pump Couplings
Supplemental Information

Final Report on the Failure of Byron Jackson River Water Pump Couplings

INTRODUCTION

The conditions which caused the failure of the river water pump (WR-P-1A) coupling and the degradation of a second coupling from the 1B river water pump (WR-P-1B) at Unit 1 are summarized in this report. Also included are the conclusions of the investigation. The cause of failure was the lack of material toughness. Operating conditions combined with low toughness may have hastened the initial failure, but the degraded coupling found in "1B" pump confirmed the cause to be material related.

DISCUSSION

During a startup of the 1A River Water Pump (WR-P-1A) on June 20, 1991, the pump failed to produce flow. An investigation was initiated and revealed a mechanical failure of the shaft coupling. A failure analysis was initiated to determine the root cause.

The analysis report [Reference No. 1] contains the results of the failure analysis, the material characterization of the failed coupling and the test results from the five additional couplings taken from service on "1A" pump. Three of these additional couplings were from the same heat and routing slip number as the failed coupling, Heat #821336, R/S 164340-10. The report establishes that all the couplings of that lot, Heat #821336, R/S 16430, had been embrittled. The measured energy absorption from Charpy V Notch (CVN) testing was 8ft-lbs maximum for this heat of material. Other heats of coupling material exhibited energy absorption of 10ft-lbs minimum. Lack of toughness, consequently, caused the failure of the coupling fabricated from the embrittled heat.

Examination of the purchasing records revealed that other couplings from the suspect lot were received and installed. The couplings of all three river water pumps were examined and suspect material was removed from service. One additional coupling was identified as Heat #821336, R/S 164340-11, from pump WR-P-1B. After removal, a circumferential crack was found mid-length on the coupling approximately 2 inches long. Additional testing was done to confirm the cause of failure and attempt to establish the temper sensitivity of the material. The analysis [Reference No. 2] concluded that the material was embrittled and the failure mode was similar to that of the coupling from WR-P-1A.

Charpy impact test specimens, taken from the second failed coupling, were re-heat treated to simulate the typical processing given the couplings. A series of additional impact specimens were re-heat treated and tempered at various temperatures between 500°F and 1200°F. The results of the testing confirmed that the coupling material, ASTM A-276 Type 410, responded to the heat treatment as predicted by published data [Reference No. 3].

Hardness tests were also plotted for the reheat treated samples to correlate anticipated toughness with the hardness in laboratory treated material. Compared to this correlation, the toughness seen in the failed couplings corresponds to the top of the vendor specified hardness range of 26 Rc to 34 Rc. The recorded hardness of 29 Rc, which is at the middle of the specification range, predict a slightly high toughness. However, given the inaccuracy for the low number of samples tested, the slope of the impact energy versus temper temperature curve in this region, and the slower cooling rates expected for actual processing, the results of the embrittled material are consistent with the laboratory results.

CONCLUSIONS

The evaluations support the conclusions that:

1. The couplings failed in service due to a lack of toughness. Both failures occurred in material with a measured energy absorption of 8ft-lbs or less using a 7mm X 10mm CVN specimen. Toughness is independent of hardness and could vary significantly with uniform hardness, depending on the material processing and chemistry.

2. Couplings fabricated from heats other than 821336 exhibited toughness values in excess of 10ft-lbs. No failures have occurred with these other heats, thus providing a benchmark for acceptable minimum toughness requirements to meet service conditions.

3. The coupling material met the vendor specifications and responded to heat treatment as expected when compared to published industry data. However, a material which meets ASTM A-276, heat treated to 26 Rc to 34 Rc, and does not possess the required toughness could fail in the river water pump application.

REFERENCES:

[1] "Metallurgical Analysis of Shaft Couplings from Beaver Valley Power Station", J. N. DuPont and A. O. Benscoter, Lehigh University, Energy Research Center, September 25, 1991.

[2] "Analysis of a Cracked Shaft Coupling from the Beaver Valley Power Station, Part 2-Failure Analysis and Verification of Heat Treatment", J. N. DuPont and A. O. Benscoter, Lehigh University, Energy Research Center March 18, 1992.

[3] "Aerospace Structural Metals Handbook", 1980 Edition, Vol. 2, Battelle's Columbus Laboratories, Columbus, Ohio, Code 1401, p26.