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IN 86-19

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, D.C. 20555

March 21, 1986

IE INFORMATION NOTICE NO. 86-19: REACTOR COOLANT PUMP SHAFT FAILURE AT CRYSTAL RIVER

Addressees:

All nuclear power reactor facilities holding an operating license (OL) or a construction permit (CP).

Purpose:

This information notice provides notification of failure of reactor coolant pump shafts manufactured by Byron-Jackson (BJ) Company. It is expected that recipients will review the information for applicability to their facilities and consider actions, if appropriate, to detect a similar problem at their facilities. However, suggestions contained in this notice do not constitute NRC requirements; therefore, no specific action or written response is required.

NRC is continuing to obtain and evaluate pertinent information. If specific actions are determined to be required by NRC, an additional communication will be issued.

Description of Circumstances:

On January 1, 1986, the Crystal River Unit 3 (CR-3) reactor tripped because of low flow in reactor coolant system loop A. Just before the reactor trip occurred, the reactor coolant pump (RCP) motor frame vibration monitor showed high vibration. This was followed by a RCP thrust bearing upper shoes high temperature alarm (which activates at temperatures greater than 185°F). The licensee manually tripped the RCP motor, which resulted in a reactor trip. On January 4, 1986, the licensee entered the reactor building to inspect the RCP and found no evidence to indicate that the pump had sustained damage.

On January 6, 1986, the licensee began preliminary troubleshooting on loop A RCP motor shaft, coupling, and seal cover. Following these checks, the pump shaft was uncoupled from the motor and an unsuccessful attempt was made to rotate the pump shaft. Also, various attempts to raise the shaft with hydraulic pressure failed.

On January 14, 1986, an ultrasonic examination of the shaft in place identified a major reflector at a distance of approximately 50 in. from the top. The reflector was evident throughout the entire circumference of the shaft. Finally, on January 15, 1986, after having lifted the RCP motor and removed other interferences, the licensee removed the upper shaft remnant from the pump. Preliminary visual inspection of the removed shaft section showed that the fracture occurred in the location of a machined, flat-bottom circumferential groove measuring approximately 0.375 in. x 0.200 in. This groove is located just below the multigroove section on the shaft that is identified as a thermal barrier.

Other operating units with essentially identical pumps are Davis-Besse and Arkansas Unit 1. Both these sites have been notified of the findings at Crystal River. At Davis-Besse, currently in an extended outage, the licensee performed similar UT examinations and reports confirmed cracking in one shaft, with probable cracks in the other three. The licensee has ordered four replacement shafts. Arkansas Unit 1 has also ordered four replacement shafts (about 12 week delivery) and plans to continue in operation pending delivery. Midland Units 1 and 2 have the same pumps, but work is currently suspended on these partially constructed facilities.

Discussions with cognizant Crystal River personnel disclosed that currently the groove in question serves no functional purpose on the shaft assembly. It is NRC's understanding that this groove was intended for a split ring that was deleted by a design change after the groove had been machined in the shaft. All four pumps at CR-3 have shafts with this machined-in groove. Following verification of the shaft's failure, the licensee conducted an ultrasonic examination of the three remaining RC pump shafts and determined that the shaft in RCP B exhibited circumferential crack indications in the same location as RCP A. The indications exceeded minimum calibration notch depth dimensions of 0.226 in. and were noted from 180° to 200° around the circumference. Subsequently, PT confirmed the crack in the pump B shaft. Ultrasonic examination of the C and D pump shafts showed indications of cracks. As a result, all four shafts are being replaced.

The failed shaft(s) were made from precipitation hardening stainless steel material produced to ASTM Specification A461-65 Grade 660 requirements and inspected per ASME Section III (68,S69), paragraph N-322.1, N-627.

Currently, the licensee attributes the shaft failure on pump A at Crystal River to residual fabrication stresses coupled with thermal stresses from cool seal water injection. The pump B shaft crack is being attributed to local assembly weld stresses compounded by thermal stresses. The shaft material is difficult to weld successfully.

A metallurgical investigation is being conducted by Babcock and Wilcox (B&W), Lynchburg, Virginia, to determine the cause of failure. Region II metallurgical staff is following up this investigation. To date, the only information from this investigation is that in pump A all four socket head capscrews that join the shaft and impeller were found to be broken. Two alignment pins were not broken. Further information on shaft B is not yet available, other than the cap screws on pump B assembly were either cracked or broken.

The cap screw failures are attributed to intergranular stress corrosion cracking (IGSCC).

A similar event involving the capscrews in a BJ pump at the Palisades nuclear plant is discussed in Information Notice 85-03 and Supplement 1 to that information notice. The pumps at Palisades are a different size from those at Crystal River, but the designs are apparently similar.

At Palisades, the shaft did not fail but separated from the impeller. The shaft is normally secured by eight sockethead capscrews and four alignment pins. All eight capscrews and two of the four alignment pins were broken. The two other pins were distorted. The cause of failure was stated to be insufficient preload on the capscrews caused by rough threads, which resulted in the prescribed tightening torque not achieving the desired preload.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact the Regional Administrator of the appropriate regional office or this office.

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Attachment: List of Recently Issued IE Information Notices

LIST OF RECENTLY ISSUED IE INFORMATION NOTICES

Information Notice No.	Subject	Date of Issue	Issued to
86-18	NRC On-Scene Response During A Major Emergency	3/26/86	All power reactor facilities holding an OL or CP
86-17	Update Of Failure Of Automatic Sprinkler System Valves To Operate	3/24/86	All power reactor facilities holding an OL or CP
86-16	Failures To Identify Containment Leakage Due To Inadequate Local Testing Of BWR Vacuum Relief System Valves	3/11/86	All power reactor facilities holding an OL or CP
86-15	Loss Of Offsite Power Caused By Problems In Fiber Optics Systems	3/10/86	All power reactor facilities holding an OL or CP
86-14	PWR Auxiliary Feedwater Pump Turbine Control Problems	3/10/86	All power reactor facilities holding an OL or CP
86-13	Standby Liquid Control System Squib Valves Failure To Fire	2/21/86	All BWR facilities holding an OL or CP
86-12	Target Rock Two-Stage SRV Setpoint Drift	2/25/86	All power reactor facilities holding an OL or CP
86-11	Inadequate Service Water Protection Against Core Melt Frequency	2/25/86	All power reactor facilities holding an OL or CP
84-69 Sup. 1	Operation Of Emergency Diesel Generators	2/24/86	All power reactor facilities holding an OL or CP
86-10	Safety Parameter Display System Malfunctions	2/13/86	All power reactor facilities holding an OL or CP

OL = Operating License
CP = Construction Permit