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Information Notice No. 93-68: Failure of Pump Shaft Coupling Caused by Temper Embrittlement During Manufacture

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

September 1, 1993

INFORMATION NOTICE 93-68: FAILURE OF PUMP SHAFT COUPLING CAUSED BY
TEMPER EMBRITTLEMENT DURING MANUFACTURE

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to problems caused by temper embrittlement of American Iron and Steel Institute Type 410 stainless steel couplings supplied by Byron Jackson. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

On June 20, 1991, a river water pump shaft coupling at Beaver Valley Nuclear Power Plant, Unit 1, failed during operation when a large section of one end of the coupling broke away from the rest of the coupling. This coupling, which was threaded internally, was used to join two shafts of a Byron Jackson vertical circulator river water pump. During its investigation of the failure, the licensee found that two more couplings from the same pump (river water pump 1A) had cracks. All three of the Unit 1 pump shafts had at least one of the defective couplings. The licensee at Beaver Valley noted that increased vibration levels on pump 1A caused by a worn bearing, pump shaft misalignment or both contributed to the failure.

All of these couplings were part of a group of 13 couplings that had been acquired in 1977 from Byron Jackson under the same purchase order. However, the licensee was only able to locate six of the couplings for examination and surmised that the rest were used and had been disposed of during routine maintenance. All of these couplings had been fabricated from the same heat treatment batch of Type 410 stainless steel (steel heat number HT821336).

Metallurgists at Lehigh University conducted a root cause analysis of the damaged Unit 1 couplings and concluded that failure was caused by the low

impact strength of the couplings due to temper embrittlement resulting from

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improper heat treatment. They also concluded that all of the couplings from this heat of steel were temper embrittled. Under NRC contract, Brookhaven National Laboratory conducted a detailed metallurgical failure analysis of the broken coupling taken from pump 1A. Brookhaven similarly concluded that the failure was caused by temper embrittlement of the Type 410 stainless steel brought about by improper heat treatment of the coupling during manufacture.

In 1992, three couplings in Beaver Valley Unit 2 river water pumps were found to have cracks: two in pump 2A and one in pump 2C. These pumps together with the couplings were also supplied by Byron Jackson. The Unit 2 couplings are keyed sleeves instead of threaded couplings. The cracks were located in the corners of the keyway slots. Lehigh University metallurgists examined these couplings and found them to be temper embrittled also. However, the Unit 2 couplings were produced from material with a heat number (heat number 72337) different from that of the damaged couplings previously found in the Unit 1 pumps.

Discussion

The Brookhaven analysis of the first failed coupling included impact tests on subsized Charpy V notch samples that were machined from the coupling material. These samples were about 7.5 mm [0.295 in.] thick and 10 mm [0.394 in.] wide. Two of these samples were treated at 704°C [1300°F] for 1 hour and oil quenched. In its report, Brookhaven concluded that the impact energy of the as-received material was extremely low (11 to 20 joules [8 to 15 ft-lbf]) and was markedly increased (+136 to +163 joules [+100 to +120 ft-lbf]) after corrective heat treatment.

The Beaver Valley licensee also reported that Charpy impact tests on material from the damaged Unit 1 couplings indicated low measured energy absorption values of 11 joules [8 ft-lbf] or less using a 7 mm by 10 mm specimen. The licensee replaced all of the failed and questionable couplings used on the river water pumps of both units with couplings that had been screened for toughness and proper heat treatment on the basis of impact properties. The licensee also modified the purchase specifications for the couplings to include minimum impact energy requirements for the coupling material. The licensee issued a 10 CFR Part 21 notification to the NRC on November 1, 1991, regarding the Unit 1 Byron Jackson river water pump couplings and a 10 CFR Part 21 notification on October 29, 1992, regarding the Unit 2 failures.

The NRC staff understands that Byron Jackson vertical circulator pumps with coupling configurations similar to those at Beaver Valley are commonly used. Because couplings manufactured from two different heats of Type 410 stainless steel have been found with temper embrittlement at Beaver Valley, Byron Jackson stainless steel couplings at other locations also may have low impact strength due to temper embrittlement. Pump shafts containing temper.

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embrittled couplings could fail during operation if the pump has worn

bearings, the pump shaft is misaligned, or shaft motion is impeded by silt or debris ingestion.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact the technical contact listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

/s/'d by BKGrimes

Brian K. Grimes, Director
Division of Operating Reactor Support
Office of Nuclear Reactor Regulation

Technical contact: James A. Davis, NRR
(301) 504-2713

Attachment:
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