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October 12, 1984
5211-84-2258

Office of Nuclear Reactor Regulation
Attn: J. F. Stolz, Chief
Operating Reactor Branch No. 4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Stolz:

Three Mile Island Nuclear Station, Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
Failure Analysis of the "B" Reactor Coolant Pump (RCP) Shaft

This letter is provided in partial response to your September 21, 1984 request for additional information on the "B" reactor coolant pump. GPUN believes that this letter and the attached documents respond completely to items 1 and 2 in your letter, and to item 3 with respect to the pump shaft crack. As discussed with H. Silver of your staff on October 5, GPUN intends to complete its response to items 3-6 by October 26, 1984.

As we stated in our letter of April 10, 1984, the pump shaft failure does not appear to be in any way related to the sulfur-induced intergranular attack experienced by the steam generator tubes. The crack morphology exhibits all the characteristics of classic fatigue. The damage noted on the RCP "B" impeller blades has been attributed, as you state yourself, to cavitation damage, and as such is also unrelated to any chemical attack. The impeller is a casting, and the shaft is constructed of a stabilized (not sensitized) stainless steel. Thus neither would be expected to be susceptible to sulfur-induced intergranular stress-assisted cracking.

The attached Babcock & Wilcox document, RDD:84:5183-06:01, "TMI-1 Reactor Coolant Pump Shaft Failure Analysis," provides all test results and conclusions on the evaluation of the pump shaft failure. This document ultimately concludes that the apparent cause of the shaft failure is high

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cycle fatigue. Surface wear, fretting, local residual stresses and the surface finish may have been factors leading to crack initiation. The higher stresses associated with cold pump operation are believed to have contributed to the time of crack initiation and rate of growth. The attached detailed evaluation of the stresses at the area of the crack, Structural Integrity Associates "Fatigue and Fracture of TMI-1 Reactor Coolant Pump Shaft Failure," further supports this conclusion. For the surface conditions and residual stresses believed to be present at the "B" RCP pinhole where the crack originated, crack initiation and growth such as that actually seen are predicted.

GPUN feels that the additional information provided at this time further supports the conclusion of our April 10, 1984 letter that there are no safety issues associated with the reactor coolant pump shaft cracking.

Sincerely,

H.D. Hukill
Director, TMI-1

HDH/gjl/0117A

Enclosure

cc: R. Conte
W. Hazleton
H. Silver w/o enclosure
P. Courtland

Attachment 1

Executive Summary

Report: Fatigue and Fracture of TMI-1 Reactor Coolant Pump Shaft Failure, SIR-84-028, by Structural Integrity Associates, 10/5/84.

Discovery of the Failure

TMI-1 was in cold shutdown in January, 1984 with primary system pressure at 315 psig with one reactor coolant pump, 1B, (RCP-1B) running to enhance reactor coolant system layup conditions. On January 27, 1984, vibration on the pump increased from the typical 9-12 mils to 12-15 mils peak to peak. Another step increase to 19 mils in vibration occurred on January 30, 1984. This step increase was followed by a continuous increase in vibration to the 24 to 28 mil range on January 31, 1984. The RCP-1B was shut down on January 31, 1984 for detailed evaluation. Ultrasonic examination of the pump shaft by GPUN suggested the presence of a discontinuity above the impeller taper fit. Disassembly of the pump by GPUN revealed the presence of an extensive circumferential crack under the thermal sleeve.

Evaluation Results

- o TMI-1 RC pump shaft 1B failed in high cycle fatigue
- o Cracking initiated as a result of single pump operation
- o Multipump operation will propagate cracks initiated by single pump operation, but at a much lower rate.
- o Shaft loading is higher than previously believed, possibly due to a near resonance of the shaft with the second mode natural frequency.
- o Fatigue strength reduction occurred as a result of uncontrolled welding and poor machining.

Conclusions

If the fabrication process employed on shaft 1B was common to all Westinghouse pump shafts, then

- o Shafts A & C may also contain cracks at this time.
- o The replacement shaft may not be more resistant to cracking than the original.

The impact on operation is that

- o During normal multi-pump operation, the time between instrument indication of high vibration and separation of the pump shaft into two pieces is at least 1000 hours.
- o Varied hours of operation for individual pumps precludes the possibility of simultaneous failure of two or more pump shafts.