GPU Nuclear

GPU Nuclear Corporation
Post Office Box 480
Route 441 South
Middletown, Pennsylvania 17057-0191
717 944-7621
TELEX 84-2386
Writer's Direct Dial Number:

April 10, 1984
5211-84-2088

Office of Nuclear Reactor Regulation
Attn: John F. Stolz, Chief
Operating Reactors Branch No. 4
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sir:

Three Mile Island Nuclear Station, Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
TMI-1 Reactor Coolant Pump

On February 10, 1984, the TMI-1 reactor coolant system was drained to investigate a high vibration of the "B" reactor coolant pump. The cause of the vibration problem is apparently a fatigue crack of the pump shaft. This letter is intended to provide you with operating data available, results of inspections and analyses of the pump, and schedule for return to service. This information is being provided in light of your apparent interest in the pump repair and because of the potential impact of restart schedule. The pump damage has no safety significance.

The reactor coolant pumps are considered non-nuclear safety related components, except for their role as part of the reactor coolant pressure boundary. The RCPs, with their protection systems and associated support systems, will withstand a sudden stopping due to seizure after a shaft break or other cause without resulting in failure of the reactor coolant pressure boundary.

Regarding impact on core flow, existing instrumentation provides the capability to detect vibration changes before radical failure of the shaft. However, in addition, pump shaft failure is bounded by the existing locked rotor safety evaluation. Previous industry failures demonstrate the ability for safe shutdown in the event of a cracked shaft. Therefore, the pump damage is not viewed as a safety concern for the present cold shutdown operation or for future power operation.

A001
1/1

OPERATING DATA:

The plant was in cold shutdown with primary pressure established at 315 psig to allow operation of one reactor coolant pump (RCP-1B) to enhance reactor coolant system layup conditions. Composite vibration of 9 to 12 mils peak to peak had been recorded until 2200 hours on January 26, 1984. On January 27, 1984, the peak to peak vibration increased to the 12 to 15 mil range. On January 30, 1984, the vibration level took another step increase to a maximum of 19 mils with a continued increase of vibration to the 24 to 28 mil range on January 31, 1984. The pump was shut down on January 31, 1984.

Vibration analysis indicated an abnormally high vibration response at two times the operating speed (2360 R.P.M.). Balance weights were added to reduce the high vibration at the operating speed, 1180 R.P.M. The composite vibration dropped to the 18 to 22 mil range with a substantial decrease in the running speed vibration (from 16 - 20 mil range to 7.5 to 12 mils). The 2x or (2360 R.P.M.) response increased from (7.5 - 8.2 mils) to (8.7 to 9.5 mils). Operation of the motor alone did not reveal any abnormal vibration at the operating speed or two times operating speed.

An ultrasonic inspection of the pump shaft was performed which indicated an area of discontinuity above the impeller taper fit.

Analysis of available vibration and UT data, plus failure history of other Westinghouse Model 93A pumps suggested that the pump shaft was cracked in the vicinity of a 3/8" drilled hole in the shaft at the thermal sleeve location.

None of the other three TMI-1 reactor coolant pumps exhibited the high vibration amplitude at two times the operating speed which is believed to be symptomatic of a shaft crack.

Pump Inspection

The pump was dismantled and examined for any abnormalities that may have contributed to the sudden change in vibration magnitude. Rubbing contact between the rotating impeller and the diffuser adapter lower stationary labyrinth indicated abnormal pump rotor flexibility below the pump radial bearing. A crack was located in the shaft under the thermal barrier shaft sleeve. Preliminary visual inspections indicate that the crack is approximately 13 5/8" long, generally circumferential, and extends from a 3/8" drilled hole (in shaft) to and through the thermal sleeve shaft shoulder. The axial extent of the crack is approximately 1/2 inch. The crack is located about 117.3 inch from the motor end of the shaft. It is visible but of a "tight" nature, fairly straight, with little branching. This type of crack is generally associated with fatigue.

Degradation of the impeller was observed, typical of that caused by cavitation and fluid separation effects. Erosion was observed on all seven vanes, initiating on the pressure side of the vane. On six vanes, the erosion had penetrated completely through.

No unusual corrosion product buildup was observed in the vicinity of the pump impeller or shaft.

Evaluation and Analyses Shaft Crack

Shaft Crack

If, as expected, failure analysis ultimately confirms that this is a fatigue crack, it is a type normally associated with high cycle low stress bending fatigue and located at a stress riser.

A Westinghouse pump of similar design has had a similar shaft failure at Northern States Power Prairie Island #2 with the crack origin in the 3/8" pin hole used for the thermal sleeve anti-rotation pin. Analysis of the Prairie Island #2 failure indicated the failure was attributed to a combination of the following:

1. Localized stress concentration at the 3/8" drilled hole in the shaft.

2. Maximum rotating bending stress at single pump operation at cold system conditions.

3. High localized tensile residual stress at the pin welds in the thermal sleeve.

Impeller Vane Erosion

Cavitation/Separation damage of impeller inlet vanes is often attributed to operation with insufficient NPSH or runout flow beyond the pump best efficiency point. In this case, the pump was operating with runout flow due to the single pump mode, but NPSH requirements defined by the pump manufacturer were met.

Enhanced video plus still photographs of the RCP1A, C, D impeller eye (taken in the cold leg piping) do not show any evidence of damage on the visible side of the vanes. Some metal removal on the underside of each vane is possible. Superficial cavitation/separation damage of the inlet impeller vanes will not degrade the pump hydraulic performance or substantially alter the structural integrity of the impeller. Confirmation will be provided by flow testing after return to service.

Current and Future Actions

A sample which includes the cracked region has been cut from the shaft and will be subjected to a detailed laboratory examination, including evaluation of potential corrosion effects. Results of the laboratory analysis are expected to be available to GPU in mid-May.

Ultrasonic examination is being performed on the RCP1A, C, and D shafts using the techniques developed in the course of examination of RCP-1B. These

techniques are adequate for detecting shaft damage similar to that found in RCP-1B. RCP-1A, C, and D will also be checked for alignment.

RCP-1B is being reassembled using a new rotating element from GPUN spares storage including shaft, impeller, shaft sleeves, pump half coupling and coupling spacer. The complete rotor had been dynamically balanced by Westinghouse. A new radial bearing is also being installed. Anticipated date of reassembly is April 16, 1984.

All pumps will be balanced prior to operation and will continue to be monitored for vibration, including periodic analysis of the two times operating speed component of vibration.

We expect that completion of current and future actions will confirm operability of all reactor coolant pumps. Return of all four pumps to operation by mid-April will permit performance of hot functional testing in mid-May, and initial criticality as scheduled for June 1, 1984.

Sincerely,

H. D. Hukill
VP-TMI-1