Consumers Power Company

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Nuclear Reactor Regulation
US Nuclear Regulatory Commission
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PALISADES PLANT - EVALUATION OF DEFECTS FOUND IN PRIMARY COOLANT PUMP IMPELLER

During the 1983 refueling outage, the reactor core and internals were completely removed to facilitate visual inspection of the reactor vessel. During this inspection, a piece of metal was discovered lying on the bottom of the vessel. The piece was retrieved, and tentatively identified as a piece of a primary coolant pump impeller vane. Subsequent boroscopic inspection revealed that the subject piece of metal had come from the impeller of "C" Primary Coolant Pump (P-50C).

The pump manufacturer, Byron Jackson, determined the broken section resulted from a small object striking the impeller vane, causing a small crack to initiate and propagate (due to fatigue) until the piece finally broke loose. An adjacent vane has an indication which appears to be the results of the object striking the surface. Such an object could have been deflected by the adjacent vane into the vane tip creating the initial crack.

The Primary Coolant Pump (P-50C) was subsequently disassembled to facilitate removal of the damaged impeller. With the impeller removed, the decision was made to replace the impeller with a spare rather than repair the defect. Inspection of the disassembled pump revealed small cracks in the pump case diffuser vanes. These cracks were determined to have resulted from fatigue, and are considered very minor in nature. These cracks initiated at the tip of the diffuser case vanes and propagated into an area of increasing vane thickness where they have arrested. Repair of these cracks is not considered necessary.

Inspection of the damaged impeller revealed several cracks in the impeller vanes adjacent to the impeller hub. The visual inspection conducted indicated the cracks were through-wall in nature, and at least two of the four cracks had enough metal separation to allow light to pass through.

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Evaluation by the pump manufacturer, Byron Jackson, indicates that cracks present in the impeller vanes adjacent to the hub were caused by internal shrinkage that occurred in the casting process. The substantial difference in volume and cross sectional area between the hub and vane at this location creates a high potential for shrinkage to occur. The internal shrinkage weakened the vane in this area, allowing fatigue cracks to initiate and propagate. The fatigue cracks would likely extend only up to the point where the vane edge leaves the hub section, and arrest themselves as the cross sectional areas of the hub and vanes become more uniform.

In order for impeller failure to occur, secondary cracks would have to occur and propagate in such a manner to cause a piece of the vane to break loose. Byron Jackson states that the probability of secondary cracks forming is remote. If secondary cracks were to form, however, causing a piece to break free, the piece would be relatively small in size. This is based on the length of the longest known indication in the removed P-50C impeller (approximately 4.5 inches), which is believed to be the extent of the crack's propagation. The high horsepower of the pump motor would tend to deform either the piece itself or the vane tip of the impeller and allow the piece to pass through the diffuser opening without causing the rotor to lock or the pump's shaft to break.

Analysis by Byron Jackson further indicates that if a piece were to break loose from the impeller, the potential imbalance condition would not be transferred to the motor flywheel. The resulting vibration would instead be dampened out by the hydrostatic bearing, the mechanical seal and the shaft coupling. The design of the pump would thus preclude a flywheel seizure. Based on this analysis, Byron Jackson has concluded that indications of the type observed in the vanes adjacent to the impeller hub of Primary Coolant Pump P-50C do not affect the original pump design operating specification. The probability of a locked rotor, shaft break or flywheel seizure event is, therefore, not increased. Consequently, operation of pumps with postulated cracks of a similar nature is considered acceptable.

At the recommendation of Byron Jackson, Consumers Power Company will perform a remote visual examination of the three remaining in-service primary coolant pump impellers for macro cracks originating in the vane-to-hub area, and also for secondary cracks which could initiate and propagate from the original crack. If technologically feasible, the remote inspection will be conducted during the next refueling outage while fuel is maintained in the reactor vessel. If the conditions required to maintain fuel in the reactor vessel also preclude performance of the remote inspection, the inspection will be performed during the first refueling outage in which all fuel is removed from the reactor vessel.

Additionally, metallurgical analysis of the defective impeller removed from Primary Coolant Pump P-50C is recommended by Byron Jackson, in order to confirm the cause of the impeller cracks. Consumers Power Company will perform the recommended metallurgical analysis prior to conducting repairs of the impeller. Once repaired, the impeller will be maintained as a spare for possible future use.

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