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March 11, 1994

U. S. Nuclear Regulatory Commission
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Washington, D.C. 20555

Subject: Docket No. 50-361
Evaluation of Unit 2 Reactor Coolant Pump Operation
San Onofre Nuclear Generating Station, Unit 2

Reference: Licensee Event Report 3-93-006, San Onofre Nuclear Generating Station

As discussed in the referenced report, during the recent Cycle 7 refueling outage, Edison discovered and corrected problems with Unit 3 reactor coolant pump (RCP) motor bearings. To evaluate the potential for similar problems at Unit 2, Edison completed the enclosed RCP motor bearing mounting plate assessment report. This report supports the conclusion that the Unit 2 RCP's are performing satisfactorily. Additionally, degradation of RCP motor bearings can be identified by existing monitoring instrumentation. Therefore, additional actions, other than monitoring, are not required at this time.

During the next Unit 2 outage of sufficient duration, Edison will inspect the Unit 2 RCP's for problems similar to those experienced at Unit 3 and will complete maintenance if required.

If you have any questions, please contact me.

Sincerely,

R M Rosenblum

Enclosure: As stated

cc: K. E. Perkins, Jr., Acting Regional Administrator, NRC Region V
J. Sloan, NRC Senior Resident Inspector, Units 2 and 3
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MEMORANDUM FOR FILE

February 16, 1994

SUBJECT: Revision 1 to Memorandum for File, "Assessment of loose lower Reactor Coolant Pump (RCP) Motor Bearing for SONGS Unit 2", dated January 31, 1994.

PURPOSE

This assessment is being prepared to address the effects of a potentially loose lower motor bearing mounting plate on the operating Reactor Coolant Pumps in SONGS Unit 2.

HISTORY

While completing repairs on RCP 3P002 during the recent Unit 3 Cycle 7 refueling outage, it was discovered that one lower motor bearing pad had become loose. The motor bearings consist of six tilting disc pads which are adjusted with a jackscrew located directly behind each pad. During the outage work, Edison noted that one jackscrew had become loose. This allowed one of the bearing pads to travel away from the motor shaft and, as a result, would no longer support the motor shaft. This is further discussed in Root Cause Report RCE 94-002.

Following the discovery of the loose jackscrew, Edison decided to inspect two other RCP's (3P003 and 3P004) for similar problems. Specifically, Edison disassembled the motor oil drip pans and uncoupled the motor from the pump to complete bearing alignment checks. This inspection revealed that the lower motor bearing on 3P002 was loose. (Note that 3P001 was not inspected as bearing alignment checks had already been performed when the lower motor bearing was completely disassembled during the Cycle 7 maintenance activities and therefore, was not considered to be a potential problem.) While performing the maintenance activities on 3P003, it was found that its lower motor bearing mounting plate was loose and had moved to a position that prevented the motor shaft from being centered in the stator/frame. Upon further inspection, it was discovered two of the twelve 3/4" mounting bolts were missing and the remaining ten bolts were loose.

The lower motor bearing mounting plate on 3P003 was repositioned to allow centering of the shaft in the stator/frame. The two missing bolts were replaced and all bolts were torqued to secure the mounting plate into this position. This discovery was made after the same work was completed on the other RCPs (3P002 and 3P004). After the discovery of the loose mounting plate on 3P003, the other pumps (3P001, 3P002 and 3P004) were disassembled as required to allow access for reinspection of the lower motor bearing mounting plate bolted joint. The mounting plate on 3P001 was found to be tight, 3P002 was found to be loose, and 3P004's mounting plate bolts were required to be tightened approximately 1/12 of one turn to achieve full torque on its fasteners.

DISCUSSION

Pump Configuration:

The RCP assembly is a vertical pump assembly with a vertical single stage centrifugal pump. The motor and pump are connected by a removable spool piece. There are two radial bearings and a dual acting thrust bearing in the motor. The pump employs a hydrostatic bearing incorporated into the impeller. The RCP shaft seal package is located between the lower motor bearing and the pump.

The lower motor bearing mounting plate is installed in the frame from the top before the rotor is installed in the frame. The motor frame has a machined register into which the bearing mounting plate fits. The gap between the frame and the plate is approximately 0.100" with electrically insulating materials between all mating surfaces. Both vertical and horizontal surfaces have insulating material between them and insulating sleeves and washers are used on the fasteners. The thickness of the insulating material is approximately the same as the radial gap between the bearing mounting plate and the motor frame and, consequently, will allow only very minor movements of the plate.

If the bolts became loose enough to relax the clamping force on the joint, the plate would be allowed to move within the clearance of the register. If the bolts were to become loose enough to fall they would land in the Appendix R oil drip pans and be contained within the gravity drain system.

The RCP speed sensing system consists of a toothed disk mounted to the shaft and electrical speed probes attached to the mounting plate and provide input to the Core Protection Calculator (CPC). The gap between the probe and toothed disk is approximately 0.050". In order for an RCP speed sensor to be damaged, the RCP shaft must be displaced by approximately 0.050" without the mounting being moved. In this unlikely event the probe would either be mechanically damaged and fail or the electrical coupling between the toothed disk and speed probe would be lost. If the RCP speed signal from both probes is lost, the CPC's would generate a reactor trip.

Vibration Monitoring:

All of the RCPs have been provided with single plane vibration monitoring capability. The vibration monitoring package consists of two proximity probes and a keyphasor probe. These sensors or instruments are connected to a communication processor (one for each Unit) that continuously monitors each parameter for an off normal condition on the RCPs. These signals are then multiplexed to a dedicated computer that continuously collects data which can be displayed upon user request. This equipment is used to provide continuous monitoring of overall vibration displacement and filtered displacements at 1X and 2X running speed, associated phase angles for the filtered readings, and shaft orbits for all of the RCPs. Additionally, the system also provides for various trending capabilities of these parameters. The trending options for the RCPs include the capability of capturing system transients, such as a RCP start or shutdown, and various longer trending options of maintaining data from a 24 hour period up to 12 week intervals.

Seal Design/Monitoring:

The retrofit seal package was designed as a joint effort by Sulzer-Bingham and Edison. The new seal was designed with the benefit of years of operating experience that was provided by the seal vendor and the experience accumulated at SONGS. Numerous features are employed in this new seal to provide a robust design with a high degree of reliability. One of the most important features is that this seal design incorporates three seals in series, each of which is designed to withstand full system pressure. A fourth seal, known as the vapor seal, which can also withstand full reactor coolant system pressure, was also included in the new seal design to further increase the design margin of this seal package.

The RCP seals are all instrumented with numerous sensors. The seal faces are cooled by a continuous flow of RCS fluid. This fluid flow is known as RCP controlled bleed off (CBO). Both the CBO temperature and CBO flow rate are monitored. Additionally, the individual pressures between each seal "stage" are monitored. All of these parameters are provided with alarms (either by control board instruments or computer generated alarms) to alert the control room operators of any off normal conditions.

Further Investigation:

A computer simulation of the RCP assembly has been prepared by the pump vendor and was modified to simulate the relaxation in the stiffness of the lower motor bearing. The model was prepared to help further understand the dynamic response of pump/motor system. The computer simulation was used to model the incident that occurred while attempting to return RCP 3P002 to service.

The design bearing gaps in the motor radial bearings (upper and lower) and the hydrostatic bearing in the pump are 0.004" and 0.030", respectively. The lateral clearance in the RCP seal, between the rotating shaft sleeves and stationary secondary shaft sleeves, is 0.070". Preliminary results have shown that with the allowable vibration levels, the rotating and non-rotating seal sleeves will not make contact. This is true only when the three bearings in the pump/motor system are aligned concentrically within tolerance, unlike the gross misalignment found on 3P002.

Preliminary results from the modified computer model indicate that the orbital shape which one might expect to observe at the proximity probes does not change substantially from conditions of full support to complete loss of the bolted joint. However, the mean position of the shaft orbit shifts from a fully constrained bearing to one with no support.

Since dynamic vibration information is most likely to change only after rubbing has already occurred, a more appropriate parameter to trend would be shaft centerline positioning. The preliminary results of the modified computer model support this conclusion. The vibration monitor has the ability to determine bearing eccentricity (static shaft centerline displacement) using information from the two proximity probes installed on each RCP. Since the shaft bearings have a fairly small gap when compared to the shaft seal lateral clearance, a fairly large movement is required to allow a rub to occur and begin to change the vibration signatures. Monitoring shaft centerline position would provide the earliest indication of any trend in the bearing support system.

Operating History:

As stated above, the lower motor bearing mounting plate for 3P003 was found with the clamping bolts loose. Since no maintenance was performed on this joint during this outage (prior to discovery) it can be concluded that this joint was in this condition prior to this refueling outage. Vibration data on this pump prior to the outage was approximately 6 mils direct (or overall) on both probes and there was no apparent seal stress or degradation. The seal in 3P003 was replaced during the previous (U3C6) refueling outage and had performed satisfactorily and as such was not replaced during this outage.

The vibration levels of 3P003 following the restart of the Unit was approximately the same as that prior to the outage and all were within expected values. The only maintenance on this pump during this outage was to realign the lower motor mounting plate and secure it in place with no appreciable change in vibration levels noted.

The seal package for the RCPs has a very good operating history and has exhibited high reliability. As an example, the seal package installed in RCP 2P002 during the Unit 2 Cycle 6 refueling outage developed a problem very early in the cycle that culminated in one completely failed stage. However, due to the multiple stage design of the seal package, the Unit was allowed to run for the remainder of the fuel cycle and the RCP seal functioned properly without further incident. The failed seal was further tested and withstood two reactor trip transients (4/24/92 and 7/31/92) without any further degradation. This occurrence is an example of the seal design's performance capability and is a testament to its reliability.

CONCLUSION

Based on vibration data for 3P003 (before and after the U3C7 refueling outage) and the condition of the lower motor radial bearing mounting plate that existed prior to U3C7 refueling outage, it is reasonable to believe that the loss of the lower motor bearing support is not a problem likely to lead to seal damage or a reactor trip.

Continuous vibration monitoring will be used to detect changes in a RCP bearing support system that could be detrimental to the seal. Indications that will be monitored are shaft centerline position, displacements and phase angles. The shaft centerline displacement measurement will effectively indicate a change in the bearing support system. A change in vibration displacement could be indicative of a change in the shaft bearing support system but will most likely be an indicator only after shaft rubbing has begun to occur. A change in phase angle would indicate a change in the shaft "high spot" position (relative to the keyphasor) that might be caused by a rub.

It can be concluded, therefore, that with satisfactory RCP seal parameters, vibration levels, and an absence of a bearing eccentricity trend, continued operation of Unit 2 is warranted. Furthermore, by continually monitoring the above parameters a condition that could cause seal degradation would be detected and measures taken to correct the problem or shutdown the unit before damage to the seal would occur.

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