ENCLOSURE 1 TO ATTACHMENT 3

ENGINEERING EVALUATION REGARDING SHORT TERM DRY-RUN OF RUBBER COLUMN BEARINGS

JP04-20 REV. 02

COOPER NUCLEAR STATION
NRC DOCKET 50-298, DPR-46

Johnston Pump Company

Engineering Evaluation Regarding Short Term Dry-run of Rubber Column Bearings

Cooper Nuclear Station, Nebraska Public Power District

Byron Jackson 28KXL 1-STG, Chattanooga Service Center

Report Serial No.: JP04-20 Rev. 02

Originating Department:
Engineering Dept., Brookshire

Revision No.: 02

Prepared By: Michael Cugal, PE

Initial: Michael Cugal rev 2 8/15/04

Date: 07/16/04

Checked By: Lanka Pannila, P.E.

Initial: [signature] 8/15/04

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Engineering Evaluation on Short-term Dry-run			
Job Number		**Customer**	NPPD – Cooper Nuclear Station
Pump Size and Model	BJ 28KXL 1-STG	**Project Manager**	Jerry Harrelson

1. Introduction

The purpose of this report is to provide an engineering evaluation of the following question:

Given conditions that existed at Cooper Nuclear Station(1), will the Service Water pumps(2) continue to function 48 hours after Gland Water flow is reduced to zero flow for 90 minutes and then restored to normal?

(1) During January 21, 2004 - February 11, 2004:

River water level 875.5 MSL - 877.5 MSL.
Service water temperature <45°F.
Pump running at capacity (5500 gpm).
Average discharge pressure 50 psig average.
Gland water flow ~6-8 gpm to the enclosing tube (16-24 psi).
Vibration (IST) normal.

(2) Byron Jackson 28KXL 1-Stage VCT pumps with 1180 rpm, 300 Hp Motors.

The following material conditions existed as of February 2003: 1). New pump assembly, packing, coupling, shafts, cutlass bearings, and impeller. 2). Rebuilt outer column, discharge nozzle, registers, and spider bushing supports.

2. Discussion

Background

The function of the Gland Water flow is to provide clean water lubrication to the pump's stuffing box area, and column bearings during the pump operation.

In vertical pumps, the column bearings provide "bumper" bearing support. Due to negligible pressure differences across the bearings, they do not behave as typical hydrostatic bearings. However, a thin fluid film between the bearing and the shaft results in some bearing damping and fluid stiffness.

For the subject pump, at the given river level, if the gland water flow is stopped, the top 7 bearings (including the stuffing box bearing) would not receive the lubrication. The bottom 5 bearings (3 bottom column bearings and 2 bowl bearings) would be submerged in the pumping fluid.

In order to provide the answer to the posed question, we undertook the following steps:

Prepared By	Checked By	Report No.	Date	Revision	Rev. Date	Rev. By
Mike Cugal	Lanka Pannila	JP04-20	07/16/04	02	08/05/04	MC

1. Technical assessment by the Johnston Pump engineering staff.
2. General review and study of the field repair history of similar cases.
3. Rotor dynamics analysis.

2.1 Technical assessment

After the gland flow is stopped, the packing box area will not receive proper lubrication and cooling flow, and the top 6 column bearings will not receive lubrication. The packing box bearing will heat up due to contact from the shaft. The effect of this could depend on the amount and force of the contact with the rotating shaft. If the shaft rotates without much wobble, it is conceivable that damage to the bearing or shaft can be minimal. If the shaft contacts the stuffing box bearing constantly, the packing gland will get over-heated and dry, and the bearing clearance will increase.

A typical vertical shaft is in tension and, in theory, it will rotate freely without any contact if the alignment and register fits are true and no manufacturing and machining tolerances exist. In real operation, however, the residual unbalance of the rotor, some hydraulic unbalance, allowable manufacturing tolerances, and the natural frequency of the rotor could cause the rotor to wobble and contact the column bearings. If lubrication to the bearings is not present, we can foresee local heating of the rubber bearings and weakening of the rubber material. The constant contact with the shaft could result in loss of the bearing material. The severity of the material loss would highly depend on the nature and amount of contact. However, we do believe that in general the bearing clearances will increase significantly due to the contact of the shaft.

When the bearing clearances increase, the pump can experience higher vibration of the pump shaft and possibly the pump structures in general. The severity and effect of the vibration are difficult to predict, but a catastrophic pump failure within 90 minutes of operation without the gland water supply and subsequent 48 hours of operation with the gland water supply is not likely to happen due to the vibration from increased bearing clearances.

There is a remote chance of a pump shaft seizure when it is operated without lubrication against rubber bearings. However, the probability of a seizure is very low if the pump does not have to stop and restart.

2.2 Field repair history

We were not able to locate any written repair report that dealt with the exact nature of this case. No record was found where the exact duration of the dry-running was documented. Our assessment was based on verbal communications with various Johnston Pump service centers. In most cases, operating pumps without lubrication to the rubber bearings resulted in severe damage to the column bearings and shafts. In some cases of pump failure, the shaft was seized, but the duration of the operation seemed to have been longer than a day or so. In these cases, the gland water supply was not restored.

Our interviews with senior field service technicians resulted in similar conclusions. In their experience, when the gland water supply is stopped, the rubber bearings get over-heated, and in some cases they have seen smoke coming out of the column. In most cases, the pump will begin to vibrate, and eventually it will be pulled for a repair. There were some cases where one or two bearings were completely damaged and pumps operated for over 48 hours. The general opinion of the service technicians is that the pump could have survive the 90 minutes of dry-operation though the bearings may have gotten severely damaged, and operation of the pump for the subsequent 48 hours with re-introduction of the gland water supply would have been possible.

2.3 Rotor dynamics analysis

We believe that the loss of gland water supply will cause loss of bearing damping effect (by losing the fluid film between the bearing and shaft) and could open up the running clearances (which will change the bearing stiffness). In order to study the rotor dynamics behavior in more detail, we conducted a lateral rotor dynamics analysis (report JP04-18).

Due to time constraints and the unavailability of some pertinent geometry information (i.e. motor rotor details), we had to use this study diligently. Our conclusions from the analysis are as follows:

- It is quite typical for a vertical pump rotor system to have a number of critical speeds that are close to the excitation frequency. Such a case was proven to be true in this analysis. In this study, we focused on the modal shapes of the rotor in order to study the effect of the shaft and bearing contact.
- The baseline analysis (pump in normal operating condition with gland water supply) indicated that there is indeed a natural frequency mode within 4.5% of the running frequency. The mode shape, however, indicated that the shaft and the inner column deflect in the same phase, providing a non-contacting mode (refer to report JP04-18).
- The worst case analysis (pump without gland water supply and assuming all 7 top bearings are lost and do not provide any bearing support) indicated that a higher mode natural frequency is near the running speed (within 6 %), and that the deflection mode of the shaft and inner column are not in the same phase. This would indicate a contact between the shaft and bearing, and that severe damages to the bearings can be expected.
- Based on the mode shape analysis, we believe that the worst case scenario would not happen during the pump operation. The mode shape indicated that two bearings may have come in severe contact with the shaft, but not all dry-running bearings would have been damaged.

Our conclusion based on the rotor analysis is that when the pump is run dry some shaft contact with the bearings will occur. Based on the modal shape in the worse case scenario, we believe that contact will be made on some of the bearings, but loss of all column bearing support is not likely to happen.

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Based on the modal shape analysis, the inner column mode shape was detected near the running speed. If the inner column fails, the result could be a re-supply of the lubrication to the column bearings as the discharge pressure pushes the fluid into the column. This would become somewhat beneficial in this case (depending on the nature of the failure), as it would introduce the lubrication and damping back to the column bearings.

3.0 Summary and conclusions

It is general knowledge and recommended practice never to operate a vertical pump with rubber bearings without proper lubrication. We wish to clearly state that the evaluations and statements of this report regarding this issue does not change such views. We also wish to state that the statements and summary of this report are intended only to share our views on this particular operation case, and we do not recommend or accept any future operation of the pump without the gland water supply for any length of time without a change to the existing pump bearing design.

Our database search and study of past field service records (written and verbal) did show that some damage to the bearings and/or shaft can occur due to the lack of pump gland water supply. However, we do not have conclusive data which indicates a catastrophic pump failure would have resulted within 90 minutes of operation without the gland water supply and subsequent 48 hours with re-supply of gland water. Our rotor dynamics analysis indicated that it is highly unlikely to damage all top rubber bearings subjected to the dry-running condition.

We believe that given the ample motor horsepower and the good existing maintenance practice in this case (alignment, good fits and registers, etc.), the pump could have survived the 90 minutes of "dry" operation. When the gland water supply was re-introduced, the pump could have operated (possibly with higher vibration and some damaged bearings) for an additional 48 hours.

ATTACHMENT 3	LIST OF REGULATORY COMMITMENTS©

Correspondence Number: NLS2004106

The following table identifies those actions committed to by Nebraska Public Power District (NPPD) in this document. Any other actions discussed in the submittal represent intended or planned actions by NPPD. They are described for information only and are not regulatory commitments. Please notify the Licensing & Regulatory Affairs
Manager at Cooper Nuclear Station of any questions regarding this document or any associated regulatory commitments.

COMMITMENT	COMMITTED DATE OR OUTAGE
None	