Reducing Motor Bearing Failures – Modified Lubrication Procedures Improve Reliability at TVA

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Overgreasing rolling element bearings in motors has been an industry problem for several years. More motors have bearing failures due to overgreasing than from undergreasing. For the nuclear power generation industry in particular, the Nuclear Regulatory Commission (NRC) provided guidance and direction through the development of Information Notice 88-012, issued in July 1988, to address this problem. The method delivered mixed performance results for the amount of resources that companies have had to devote to motor relubrication, motivating some organizations to develop additional improvements.

One such improvement, developed through a coordinated effort between the Electric Power Research Institute (EPRI) and several utilities, has produced the “Electric Motor Predictive and Preventive Maintenance Guide,” NP-7502, which provides guidance on how to regrease motors, when to add grease and how much grease to add. However, while NP-7502 is a useful guideline, it cannot be applied to resolve the issue of overgreasing motors that are already in service and already have an unknown quantity of grease in the bearing cavity. Consequently, even with NP-7502 guidance, overlubrication of greased bearings could still be a problem.

Current Status

All of TVA’s nuclear sites use NP-7502 for regreasing guidelines. Practices used prior to the adoption of the new guideline resulted in overfilling several motors. Subsequent actions required by NP-7502 served to further pressurize grease cavities of the bearing housings, in some cases to the extent that bearing shields were pressed into the ball cage of the rolling elements, resulting in the failure of shields and bearings.
In cases where the bearing did not include the use of a shield, sufficient grease pressurization of the cavities occurred, causing grease to pass through the rolling elements and between the air gap between the inner bearing cap and the shaft into the windings. This led to windings and insulation becoming covered with grease, which led to motor failure or degraded operation.
An example of a bearing failure due to bearing shields being pushed into the raceway as a consequence of overgreasing is shown in Figure 1.

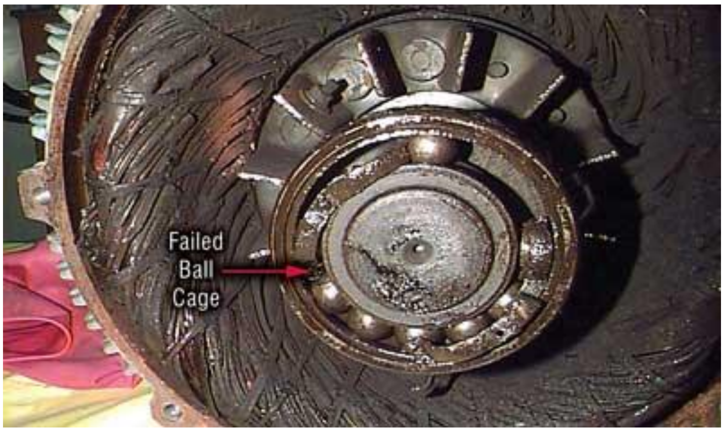

Figure 1.

This was a control rod drive (CRD) fan motor at Watts Bar Nuclear Plant. The bearing experienced a ball cage failure due to the bearing shield (Figure 2) being pushed down on the ball cage due to overpressurization of the grease cavity.

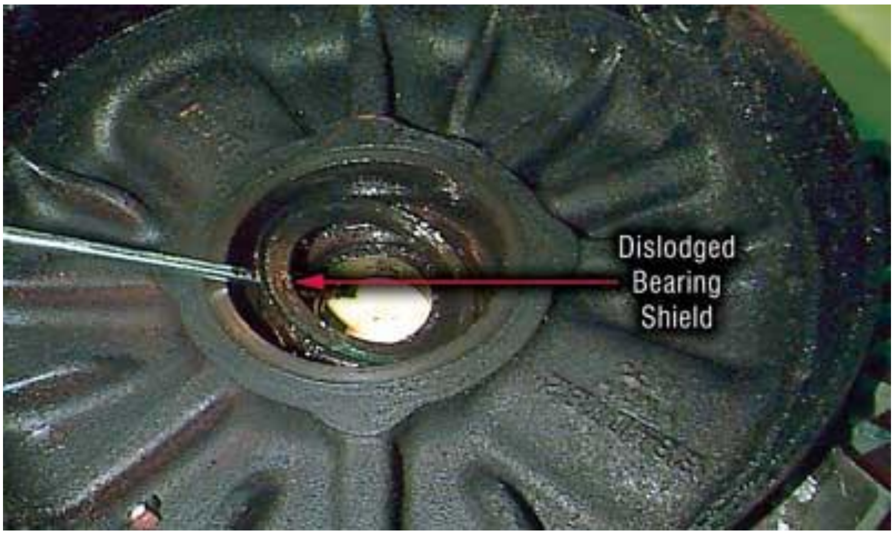

Figure 2.
End bell with bearing shield that has become dislodged from the bearing.

Approximately 90 percent of grease-lubricated motors within the power generation industry have the shield configuration shown in Figure 3.

Click here to see Figure 3.

As illustrated, the grease enters and exits from the same side of the bearing cavity. This means that, using the existing relubrication standard, if the bearing grease cavity becomes overfilled with grease, or the existing grease in the cavity hardens in place, the elevated grease pressure generated by the addition of new grease will force the shield into the ball cage and rolling elements leading to premature bearing failure. In the absence of shields, grease passes through the rolling elements of the bearing, fills up the inner bearing cap grease cavity and eventually is forced through the air gap of the inner bearing cap and the shaft. The grease then becomes deposited on the motors and windings. This can lead to a premature winding failure. TVA Nuclear has experienced both of these types of failures.

Present Method of Relubrication in TVA

The normal sequence to regrease a motor is as follows:
If possible, the bearing should be at a stable, normal operating temperature, making the grease less viscous.

Remove the drain plug and any hardened grease.
Clean the grease (zerk) fitting before attaching the grease gun.
Use the regreasing guidance provided by EPRI NP-7502 for the grease fill quantity and regreasing frequency.

After regreasing is complete, leave the drain plug out and operate the motor under normal bearing operating temperatures for at least one hour. This allows the grease to thermally expand and vent out the port, relieving any excess pressure in the cavity.

After thermal expansion is complete, clean the excess grease and reinstall the drain plug.
This sequence requires several hours with operational support to grease and operate each motor. With the

large number of motors within TVA that require lubrication, there is considerable cost associated with motor lubrication. Additionally, even when the sequence is followed precisely, a bearing cavity may still become overfilled throughout the life of the bearing. This is further complicated if the existing quantity of grease in the grease cavity for a motor is unknown.

Proposed Change to Eliminate Overpressurization

To eliminate overgreasing and to reduce maintenance and operational support time to perform regreasing, existing relief ports and hydraulic fill fittings are replaced with relief valves and a pressure-controlled grease-fill fitting. The new method incorporates the new fittings as follows:
Install a pressure-sensitive (20 psi differential) grease-fill fitting that will not allow the cavity to be pressurized beyond 20 psi. This should minimize excessive pressure buildup on the bearing shield while the motor is being regreased.

Install a grease-relief valve-fitting to take the place of the grease drain plug. The grease-relief valve will open between 1 and 5 psi and will minimize risk of over-pressurization of the grease cavity from re-lubrication and thermal expansion of the grease (while running the motor).

Follow the regreasing guidance of EPRI NP 7502, “Electric Motor Predictive and Preventive Maintenance Guide,” Appendix B. This information may be obtained from EPRI - Nuclear Maintenance Applications Center in Charlotte, North Carolina. Contact project manager Wayne Johnson at 704-547-6100.

For motors with housings around a cooling fan on one end bell, install an extension tube (NPT pipe nipple) at the drain plug. The extension tube should be long enough to clear the housing. The grease-relief valve should be installed at the end of the pipe tube.

For nuclear operations, the change in fill and drain plug fittings has been discussed with the environmental qualification (EQ) representatives to ensure acceptability for use in EQ motor applications. There were no EQ or seismic concerns raised for the use of these fittings on EQ motors.

Hydraulic Shut-Off Grease Fittings

These fittings are intended to prevent overlubrication and overpressurization of bearing shields. The design provides for pressure-specific shut-off (for example, 20 psi). At the given shut-off pressure, the grease flow will stop. When pressure falls below the maximum, the grease flow can resume. The typical design includes a 60-degree angle and a 1/8-inch PTF male pipe thread. They are available from various manufacturers in various quantities. McMaster Carr provides this unit in packages of 10 for approximately $0.35 each.

Pressure-Relief Vent Fittings

These fittings are intended to work as pressure-relief valves. Any time the pressure rises above the designed limit (for example, 1 to 5 psi), the unit will open, venting pressure. After pressure is relieved, the fitting will close to form a seal. McMaster Carr provides this unit in 3 sizes, 0.125, 0.25, and 0.50-inch OD with NPT threads, in packages of 10 for up to $0.70 for the 0.50-inch fittings.

Benefits

The cumulative savings between operation reliability, reduction in manpower requirements for operations and maintenance, and the reduced radiation dose exposure in the nuclear environment will be significant. Improvements in reliability realized from the enhancement include: reduction of motor bearing failures from cavity overpressurization and subsequent collapse of the grease shield, improved flushing of contaminants and debris from the housing, and improved lubricant quality through reduced churning.

Additional improvements in utilizing manpower include:

1. Reduced motor bearing failure
2. Reduced damage to windings and insulation
3. Improved contaminant flush
4. Reduced lubricant degradation due to churning
5. Reduced risk of radiation exposure.

In conclusion, because the addition of the fittings does not change the motor design or its operational characteristics, the motor’s original design is maintained and documentation for new procedures development will be minimal.

Sidebar:

Overgreasing of Electric Motor Bearings

In NRC Information Notice No. 88-12, the U.S. Nuclear Regulatory Commission lists the following steps to correct or prevent motor overgreasing and related problems:

1. Review motor lubrication procedures to ensure that they identify the type and quantity of grease to use, the specific fill and drain nozzles to uncap and the length of time motors should run with drain plugs off after greasing the bearings.

2. To prevent foreign materials from contaminating the grease, ensure that grease containers are covered during periods of storage, and that nozzles and grease fittings are cleaned.

3. Determine the optimum quantity and correct type of grease required for each motor by examining the manufacturer’s recommendations and by monitoring the behavior of grease added to motors.

Consider using prelubricated sealed bearings in applications where relubrication is difficult, where contaminants can adulterate the grease or where overgreasing might damage safety systems.

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