

# ELIMINATING OIL LEAKS BY OPTIMIZING BEARING CASE OIL LABYRINTHS

by

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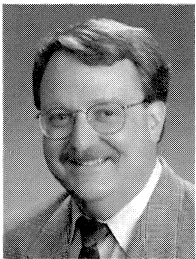
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*Maintenance Superintendent. Farmland is one of the nation's largest manufacturers of nitrogen-based fertilizers and Enid is the largest facility in the Farmland system. Throughout his career, Mr. Krieser has received training in vibration, oil analysis, infrared thermography, and other reliability based maintenance techniques, which are an integral part of the maintenance program at Enid. He is a charter member of the Oklahoma Predictive Maintenance Users Group (OPMUG), a user forum for predictive related maintenance issues, technology, and techniques.*

## ABSTRACT

Many pieces of rotating equipment experience oil leaks. Any piece of equipment with oil fed bearings, such as turbines, motors,

gearboxes, and compressors, are susceptible to oil leaks from the bearing case seals. Usually these seals are of the labyrinth type and their designs have remained unchanged for years. Examination of this seal, the bearing case design, and the lube system can point to possible causes for leaks. Once it has been determined that system and installation problems have been addressed, it is time to evaluate the seal design. This paper presents an introduction to the causes of oil leaks and some items to consider with the lube system. Seal installation is covered, along with possible intermediate fixes and other topics. A more thorough discussion of the labyrinth oil seal is then included, covering existing design deficiencies and optimized seal design parameters. Case histories are presented, illustrating the points covered.

## INTRODUCTION

In these days of high tech aerodynamics, state-of-the-art rotordynamics capabilities, and modern polymer seal internal labyrinths, it can be amazingly frustrating for the rotating equipment engineer to still be faced with the task of combating oil leaks. Of course these leaks need to be dealt with due to the very real fire hazard potential, along with the danger of oil coated surfaces and the time and money spent cleaning up this wasted oil, which then needs to be replenished. Also, the environmental impact of waste oil containment and disposal is always a consideration when dealing with machinery oil leaks. Quite often the cause of the leak is simple, but elusive. Items such as scraping too much clearance into the seals at installation, overzealous use of sealing compounds on splitlines, plugged vents, etc., can be hard to pinpoint once the machine is up and running.

The following discussion will address these concerns and the fact that on the larger rotating equipment with babbitted bearings, the problem is usually keeping the oil in the bearing case and not keeping the elements out of the bearing case, contaminating the oil. Cary (1991) discusses how water leaking into the bearing case can be a very real and serious problem. The most common machine experiencing this problem is the single stage steam turbine with carbon ring packing. Coleman (1988) goes into great detail on solving the water contamination problem, and Morris, et al. (1993), discuss eliminating carbon rings and replacing them with dry gas seal technology. While this is a serious problem, it has been treated very well already, and is beyond the scope of the present paper.

The authors will attempt to use the experience of a user and an engineered parts supplier to walk through the steps of dealing with an oil leak. This will include trying to determine the cause of the leak, trying intermediate fixes to stop the leak, and then bringing in the engineered parts supplier to custom design the oil seal for maximum sealing capability, while staying with conventional labyrinth technology.

### Motor in a Louisiana Chemical Plant

Six “identical” 2500 hp motors in this chemical plant were all experiencing the same problem; oil was being ingested into the motor, causing severe electrical problems. Figure 11 is a drawing of the original seal and the redesigned seal in the bearing case. Note that the bearing is oil ring fed; no pressurized oil is present. Oil is leaking through the seal and into the motor.

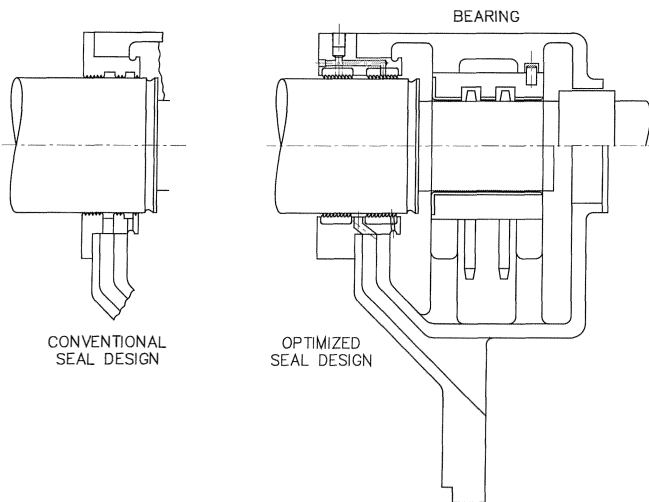


Figure 11. Drawing of 2500 HP Motor Bearing Case, Showing Ring Fed Journal Bearing, Original Design Oil Laby, and Redesigned Laby.

Windage caused by the motor right next to this seal caused a low-pressure region that sucked the oil out of the bearing case. There was not enough room to add a baffle between the seal and the motor, but attempts were made to reduce the windage with internal modifications. The seal was also redesigned to some extent, but this proved unsuccessful.

A photograph of the newly optimized seal is shown in Figure 12. Note that the flange of the seal is thicker. It was decided to increase the seal thickness toward the motor in this area. This almost doubled the axial length of the seal. This increase in length was used to install two separate seal areas with a purge between them. In this case, the seal body was made of bronze and the seal inserts were made of an engineered thermoplastic. The thermoplastic was used because it was thought that the shaft may have made contact with the seal during its warmup period. If the tooth clearance could remain unchanged during this short period, it would help with the long-term operation of the seal.

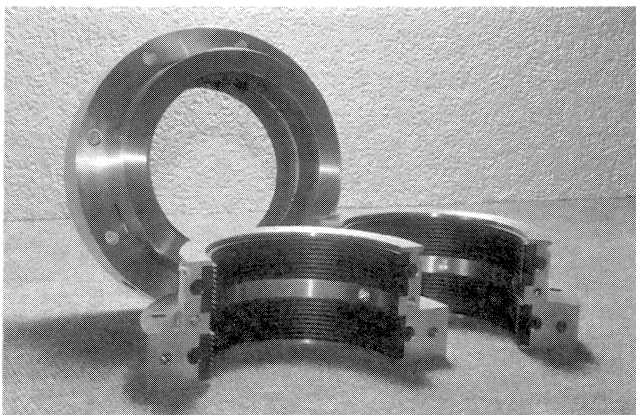


Figure 12. Photograph of Two Custom Designed Seals Used to Stop Oil Leaks in a 2500 HP Motor.

Other design modifications included the use of a wind back bore, more and better-designed teeth, and a modified installation procedure. The fit diameter of the seal was left undersized, so the seal could be centered at installation prior to tightening the flange bolts. Centering the seal makes it more efficient and also minimizes the chance of rotor to stator contact.

This seal worked as desired in the first motor and each subsequent motor, until all six were upgraded. This is a case where the user had tried several fixes and had specific input with the engineered parts supplier during the design process. The final seal design, once the user feedback was included, ended up being quite a bit different from the original redesign proposed.

### CONCLUSIONS

We have attempted to discuss some of the more common oil leak problems faced today. By reviewing certain common problem areas, one can address oil leaks by investigating the more prevalent causes and can possibly answer questions such as “why did the leak start with the bearing change out?” or “How come we didn’t have a leak with the old gear coupling.” Quite often these questions are addressed and fixes are attempted, but the leak still occurs, it is then that the use of an optimized seal should be considered. In the above case histories, since several fixes had already been attempted, it can be concluded that the existing seal design was inadequate for the service. Since the optimized seal solved the problem, the root cause of the oil leaks was the seal design.

Optimizing the seal as outlined in this paper has proven to work in every application it has been tried in to date. This amounts to literally dozens of successfully applied seals in motors, gearboxes, compressors, and turbines. This design concept has even been used to improve seals in centrifuges and to separate bearing and compressor oil in a flooded screw compressor.

The wind back concept has been used for years in the automotive industry with much success in transmission sealing. In turbomachinery, it makes sense to take advantage of shaft rotation and centrifugal forces while optimizing laby tooth geometry and quantity, to solve problem leakage addressed over the years in automotive applications and ignored by most turbomachinery OEMs.

Consideration was given to including a “rule of thumb” section to help with diagnosing leakage problems. It was decided, however, that each application is unique and trying to put together a general-purpose checklist proved impracticable. Likewise, a design guide for the optimized seal proved impractical, since each application has its own unique design limitations. Instead, we hope the information as presented will be general enough to help with a variety of oil leakage problems.

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