PROTECTING BEARINGS FROM DUST AND WATER.

ABSTRACT

Protecting bearing from dust and water. Protection methods like labyrinth rings, rubber seals, felt seals and shaft mechanical seals are described. Choice of the appropriate shaft seal and seal configurations to protect against dust and water ingress is critical. Numerous shaft seal designs suited to contaminated conditions are reviewed. Keywords: Particles, contamination, bearing, shaft, grease barrier, breather.

Dusty surroundings are one of the most difficult environments for bearings. In equipment handling powders or in processes generating dust the protection of bearings against contamination by fine particles requires special consideration.

BEARING HOUSINGS

Bearings are contained within a housing from which a shaft extends. The shaft entry into the housing offers opportunity for dust (and moisture) to enter the bearing. The shaft seal performs sealing of the gap between the housing and shaft. Choice of the appropriate shaft seal and seal configurations to protect against dust ingress is critical.

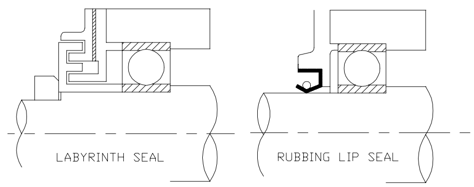

Figure No. 1. Shaft Bearing Housing Seals

Bearing housing seals for dusty environments may be either a labyrinth type or a rubbing seal type. The labyrinth type requires a straight shaft running true. Rubbing seals are the more common and allow for some flexing of the shaft. The sketches below are conceptual examples of each type of seal. When setting a lip seal into place to prevent dust ingress insure the sealing lip faces outward.

In situations of high dust contamination there may be a need to redesign the shaft seal arrangement for better dust protection than provided in standard housings. Some ideas which can reduce dust ingress into bearing housings are to :

i. provide two or more seals in parallel. Bearing housings can usually be purchased with combination seals as standard.

ii. retain the housing shaft seals but change from a greased bearing in the housing to one which is sealed and greased for life. If contamination were to get past the shaft seals, the bearing's internal seals would protect it.

iii. stand the bearing off the equipment to create a gap between the end of the equipment and the bearing housing while sealing the shaft at the equipment.

iv. put in a felt seal wipe between the housing and the wall of the equipment to rub the shaft clean. Install of a mechanical seal in very harsh environments.

v. install a grease barrier chamber sandwiched between two seals. This barrier is separate to the bearing housing and acts as the primary seal for the bearing. Grease pumped into the chamber will flush out past the seals.

vi. replace the grease barrier chamber instead with an air pressurised chamber.

vii. shield the bearing housing from dust with use of a specially fabricated rubber shroud encapsulating the housing and wiping the shaft or fit a rubber screen with a hole wiping the shaft over the opening emitting the dust.

viii. flush the bearing with grease by pumping excess grease into the housing and allowing the grease to be forced past the shaft seals or through a purposely drilled 15mm hole in the housing. The hole must be on the opposite side of the bearing to the grease nipple, at the bottom of the bearing housing when in service and between the bearing and seal.

ix. Mechanical seals can be fitted to the shaft with the stationary seal sitting toward the machine and the rotating seal mounted back along the shaft. Combinations of other seals and wipers can also be used in conjunction with the mechanical seal. Mount the auxiliary seals so they see the dust/water first and keep the mechanical seal as the last line of protection.

Some conceptual examples are shown in Figure No. 2.

ASSEMBLY

The process of assembling a bearing into the housing must be spotlessly clean. If contamination occurs at the time the housing is assembled no amount of external protection will stop the bearing from premature failure. When assembling bearings into housings make sure that:

i. your hands have been washed.

GREASE – USE THE RIGHT ONE FOR THE JOB.

ABSTRACT

Grease – use the right one for the job. The classification, selection and application of greases. Greases are designed for specific applications and if used in the wrong service they will not be effective. Compare the properties of greases and check those used in your equipment are suited to the service. Keywords: base oil, thickener, additives, friction.

LUBRICATING GREASES BASED ON MINERAL AND SYNTHETIC OILS
Classification, Selection and Application

As long ago as 1400 BC., the Egyptians used greases made of olive oil and lime to lubricate their wooden wagon axles. With the beginning of the Industrial Age, the development of modern greases progressed from sodium greases (1872) through calcium and aluminium greases (1882), to calcium complex soap greases (1940) and lithium soap greases by Shell in 1942.

The first aluminium, barium and lithium complex soap lubricating greases were patented in 1952. Since then, a large number of lubricating grease patents have been granted, due to the large number of thickeners, base oils, and additives that can be used. New or improved lubricating grease production processes were also developed.

The quantity of lubricating greases sold in Australia amounts to approximately 13 million kilograms in 1994 - is only a small fraction of the total lubricant consumption of 500 million Litres.

The situation is similar in other industrialised countries. The relatively small proportion of grease sales belies the enormous importance of lubricating greases for business and technology, which can be attributed to the high level of quality they have achieved and the performance characteristics which have resulted. Metal soap greases are the clear leaders in grease sales statistics, while non-soap greases as a group are of little importance in quantitative terms.

In engineering terms, however, and in terms of "modern and intelligent lubricating grease design," non-soap greases, for example those containing synthetic organic thickeners and synthetic base oils, are more modern, promising products.

Classification of Lubricating Greases

The classification of lubricating greases is not uniformly regulated. Because of the versatility and the variations in their composition, greases are essentially classified on the basis of their base oil or thickener.

THICKENER	SHELL EXAMPLE	SPECIAL PROPERTIES
LITHIUM SOAP	ALVANIA EP2	ALL ROUND PERFORMER, COST EFFECTIVE
MIXED SOAP (Ca & Li)	SUPERPLANT M	GOOD WATER RESISTANCE & MECHANICAL STABILITY
LITHIUM COMPLEX	LITHPLEX L & M	EXCELLENT ALL ROUND PERFORMER ESPECIALLY FOR HIGH TEMPERATURES.
CLAY (BENTONITE)	DARINA M & R2	GOOD HIGH TEMPERATURE GREASE, OTHERWISE OF LITTLE USE.
POLYUREA	STAMINA U2	EXCELLENT ALL ROUND PERFORMER WITH LONG LIFE, LATEST TECHNOLOGY IN GREASE..
CALCIUM	GRAPHITE GREASE 3	GOOD WATER RESISTANCE.
WAX	PETROLEUM JELLY	PHARMACEUTICAL USE.

Base Oils

The oil present in a lubricating grease is referred to as its base oil. The proportion of base oil can vary depending on the type and quantity of thickener and the intended application of the grease. For most greases, the base oil content is between 85% and 97%.

The type of base oil give a grease some of its typical characteristics.

Thickeners

S P H E R I C A L   R O L L E R   B E A R I N G S

ABSTRACT
Spherical roller bearings. These bearings are popular because they can take very heavy loads and are self-aligning. Their design allows them to take combined loads in both the radial and axial direction acting together. Keywords: misalignment, radial load, axial load, bearing housing.

Each roller is loosely retained in place within a cage that goes full circle between the raceways. Figure 1 shows a simplified drawing of a spherical roller bearing (SRB) on a shaft under deflection.

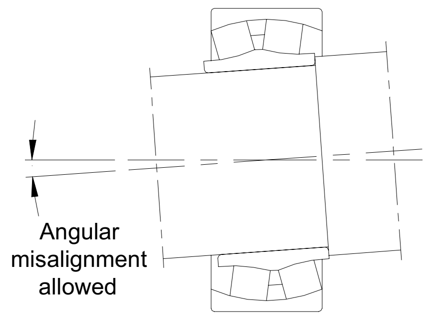

Figure 1 A Spherical Roller Bearing on a Shaft.

The shape of the rolling elements gives the bearings their name. The contact surface is the curved portion of a sphere and the curvature allows the carrying of axial loads. The axial load carrying capacity is less than that of an angular contact bearing but unlike angular contact bearings (unless paired back-to-back or face-to-face), SRB's can take axial loads in both directions.

SRB's permit misalignment between the inner and outer races. The bearing takes up the misalignment by allowing the rollers to pivot in the raceways. Because the bearing races can rock independently SRB's cannot resist a moment load (a load that is acting to tilt or snap the shaft). Double row angular contact or taper roller bearing can be used in such situations.

Misalignment can arise from the operating load causing bending, it can also arise when bearing housings are not machined at a single setting and from the self-load of a shaft and attached components if bearings are mounted far apart. The fact they are forgiving of slight alignment errors makes them a good selection for equipment expected to experience vibration.

For vibrating machinery (e.g. vibrating screens) the bearings are provided with an extra guide ring that runs between the rollers along their inside ends and keeps them square to the race. This center guide increases the bearings working life by reducing roller chattering on the raceways.

The bearings come with factory set internal clearances and no preload is required. Preload is the purposeful application of a force on the bearing to insure the rollers a properly contacting the raceways. Because the clearances are factory set it is important to select the right bearing clearance for the application - especially where the bearing runs hot.

Insuring bearings are well lubricated is always a critical requirement. SRB's can be lubricated by grease or by oil. In difficult service they will need extra attention to insure the lubrication is actually getting into the running area. To accommodate this, the larger sized bearings from the quality bearing manufacturers have a grease groove machined into the outside of the outer race with several grease holes through the race into the running area. Insure the bearing housing grease nipples are located directly over the grease groove.

If the bearing is oil lubricated in an oil bath insure the oil level always contacts the lowest roller as it comes around so the roller can splash lubricate its fellow rollers and the raceways. Do not over fill the oil bath because when the rollers come around they will have to force their way through the oil and this causes additional heat. The oil level should be no higher than midway up the most bottom roller as it comes around the raceways.

To insure the rolling elements will actually rotate as they come into the loading zone of the bearing there must be a sufficient minimum load. Since SRB's cannot be preloaded the load must come from the shaft and the attached components. The bearing supplier can perform calculations to confirm the in-service bearing load. If the self-load is insufficient then an extra radial load will need to be applied. This can be by increasing belt or chain tension or purposely increasing the torque on the shaft.

Mike Sondalini - Maintenance Engineer

Dirty oil spells rapid death for hydraulic machinery and lubricated equipment. Fine tolerance equipment can have clearances between parts of 5 to 10 microns (0.005 – 0.01 mm, 0.0002" - 0 0.0004"). Solid particles larger than the clearance gap will jam into the space. The solid particles will further be broken-up and mangled while ripping out more material from the surfaces. In equipment with larger tolerances the oil film between parts can get as thin as 3 – 5 micron. Solid particles larger than the oil film will be broken up into smaller pieces and produce more solids contamination. Figure No. 1 shows a shaft in a journal bearing lubricated by oil. In the drawing the solid particles are larger than the oil film thickness and when they enter the bearing pressure zone at the bottom of the shaft they will tear into the metal, be broken up and make more particles that cause further wear.

Solids suspended in oil are like grinding paste. They scour and gouge surfaces; block oil passages and makes the oil more viscous. The longer the oil is left dirty the faster the rate of failure. Even expensive synthetic oil is of no use if it is contaminated by solid particles. Though synthetic oil has better high temperature and surface tension characteristics than mineral oil all advantages are lost if the synthetic oil is so contaminated that it is destroying the machine. The only solution is to keep the oil clean by filtration.

OIL ANALYSIS – MEASURING CONTAMINATION

Oil samples can be taken and analysed in a laboratory. The analysis can measure a large range of parameters and factors that influence oil quality. Typically these include tests that quantify:

- The number and size of particles.
- The types and quantity of contaminants present.
- The condition of the additives in the oil.
- Changes to oil chemistry caused by the working environment.
- The amount of water present.
- The oil's viscosity (slipperiness).

It is not necessary to do all tests on all oils in all situations. The selection of the type of analysis depends on the oil and where it is used. The oil used in combustion engines, gearboxes, hydraulic systems and gas turbines is not the same and the conditions under which it operates are different in each situation. For example soot would be present in internal combustion engines but it would not be present in gearboxes. There is no value in paying money to measure the amount of soot in a gearbox. But the amount of soot in a diesel engine's oil is of critical importance.

Testing laboratories are required to follow internationally recognised procedures when measuring oil contamination. Equipment used to measure contaminants is also to be calibrated to recognised international standards. However, just as there are clean and dirty maintenance shops, there are clean and dirty laboratories. Results from laboratories without good calibration procedures and sample hygiene practices or from people that don't fully understand the equipment and procedures should not be trusted.

Not all solid particle counting laboratory equipment can count particles down to very fine sizes. Results from these laboratories would give false figures showing less contamination at low micron sizes than was actually present. Some laboratories use equipment and methods that do not count particles larger than 100 micron (0.004"). Results from these laboratories would show incorrect large particle counts. In future these large particles would be smashed-up and broken down and the resulting smaller particles would quickly contaminate the oil.

If the sample itself is too heavily contaminated then optical counting methods cannot be used because the light emitted by the analyser will not pass through the sample in the same way the equipment was calibrated to receive. Optical counters can mistakenly count water droplets as solid particles. At times it can be necessary to confirm laboratory results by alternate means to prove the results are reliable.

SAMPLING CLEANLINESS

The method and cleanliness by which an oil sample is taken has a critical effect on the accuracy of the laboratory results. If the sample is falsely contaminated by mistakenly taking it from the wrong point or in the wrong way, or if the sample taking equipment or method introduce contaminants, then false contamination levels will be reported.

A good sample is one that is cleanly taken from the circulating oil flow. The proper sample taking method and procedure should be agreed with the laboratory and if necessary the laboratory should be asked to provide training for the sample takers.

HOW CLEAN SHOULD OIL BE?

Many original equipment manufacturers have accepted the indisputable evidence from numerous field and laboratory trials that oil cleanliness has a major effect on wear within their equipment. Some of them are now specifying how clean must be the oil used in their equipment if warranty claims are to be honoured. For example Caterpillar specify new oil to have a particle count of ISO 16/13. If new oil is above this level of contamination they will not warranty their equipment. When new oil from a leading international oil manufacturer was tested before putting it into new Caterpillar equipment the solid particle contamination was found to be 17/14. This was new oil from a never previously opened container. In this case the new oil had to be further filtered to bring it to below the required specification.

Table No. 2 is a list the recommended target oil contamination levels for close tolerance equipment from a survey of hydraulic oil equipment and oil filter manufacturers.

Component	< 3000 psi	> 3000 psi
Fixed displacement pumps		
Vane	17/14	16/13
Gear	17/15	16/13
Piston	16/14	15/13
Variable displacement pumps		
Vane	15/13	-
Piston	15/13	14/12
Valves		
Directional	18/15	17/14
Proportional	16/13	15/12