General Training Pty Ltd

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Roller Bearings and Their Lubrication.

Training For Plant and Equipment Operators, Maintainers and, Technicians.




Objective

This training teaches users and maintainers of roller bearings about their lubrication, how the lubricant works, what causes it to go wrong and what is necessary to keep it in good condition.

Outcomes of the Training

This training makes trainees clear and knowledgeable in the proper lubrication and care of roller bearings. It gives them in-depth knowledge of equipment lubrication and the factors that affect it. They will use their new know-how to better operate, tend, lubricate and maintain roller bearings.

Training Contents

- Purpose of Lubrication.
- The principles of lubrication.
- Important parts of lubricants.
- In-service design and use.
- Good lubrication conditions.
- Most likely failure modes, their causes and what to do about them.
- On-Site, workshop or test bench observations of an equipment installation.
- Conduct site tests and trails on the equipment operation.
    - Compare the installation to the minimum design required.
    - Predict effect of changes.
    - Observe actual changes.
    - Identify impact of changes to the equipment operation.
- Learning Assessment
    - Explain purpose and use of equipment.
    - Identify how the equipment achieves its purpose.
    - Specify the required operating conditions for proper performance.
    - List what failures are possible at the workplace and how to fix them.
    - Training Supervisor reviews.

Time Required

The training takes one hour to complete for literate people with some industry experience.

Roller Bearings and Their Lubrication.

Purpose of the Lubrication

Lubricants are typically used to allow a moving part to slide over another part without contacting each other. The lubricant lays in-between the parts and keeps them separate. Oil lubricants have the added advantage of removing heat as they flows past a surface.

At close magnification, all machine parts are manufactured with surface roughness. If two parts touch each other, the first contact is made by the high points of roughness. If one of the parts was moving, its high points would smash into the high points of the other and material would be ripped out from both. Figure 1 shows an exaggerated representation of surface roughness.

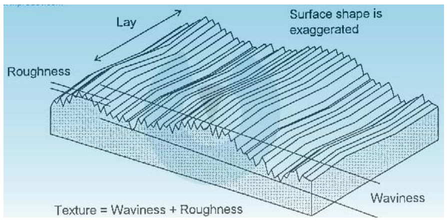


Figure 1 Surface Roughness

To keep moving parts, such as shafts and bearings, apart lubricant is injected between the surfaces. The lubricant puts a film between the parts so that when one moves over the other the film is wide enough to prevent contact. Figure 2 shows two parts, one of which is moving. In-between the two parts is a lubricant film that separates the high points of surface roughness in each. The parts can now move without one damaging the other.

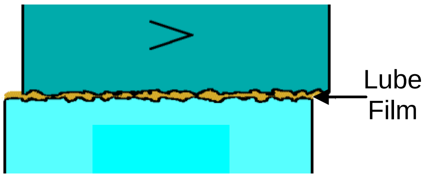


Figure 2 Lubricant Film Between Moving Surfaces

Principles of How Roller Bearing Lubrication Works

Roller bearings trap a thin lubricant film between the rolling element and the race on which they roll. The thin film keeps the two parts separated through a mechanism known as hydrodynamic lubrication. Figure 3 shows the principle of hydrodynamic lubrication. When a lubricant film is present and one part moves over the other, the lubricant gets wedged between the two parts. The 'wedge' acts to squeeze the parts apart and they ride over each other on a pressurised layer of lubricant.

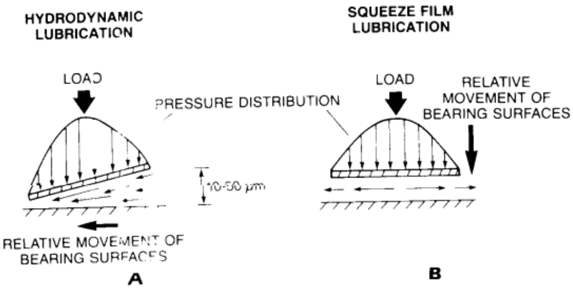


Figure 3 Hydrodynamic Lubrication

A secondary lubrication mechanism also occurs in which the loaded part acts to squeeze the lubricant away from the supporting surface. The lubricant internal tension holds it together and presents a resistance to the squeezing action.

In the case of roller bearings, as the rolling element moves along the race it creates a pressure 'wedge' of lubricant in front of itself. Figure 4 explains how hydrodynamic lubrication and squeeze lubrication work together in rolling element bearings.

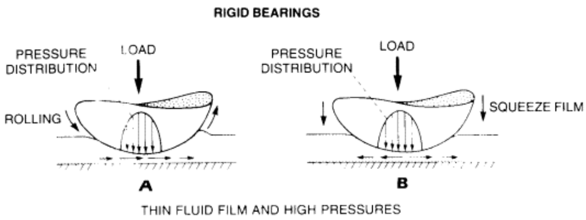


Figure 4 Roller Bearing Lubrication

The lubricant is a critical element in good roller bearing operation. It must retain its lubricating properties in a range of operating conditions. For it to form a layer that continually separates the parts it must be clean, it must retain its internal tension and cohesiveness, (its willingness to remain together) while still lubricating the parts.

Important Parts of Lubricants

Lubricants used in roller bearings are usually oil or grease.

Oils
Most oils are refined (separated and cleaned) hydrocarbon (oil-based) chemicals with selected additives introduced to give them certain properties. These are known as mineral oils. There are other oils known as synthetic oils which are made from the same base hydrocarbon stock as 'normal' oil, but chemically treated and recombined synthetically in ways that deliver improved lubricating performance.

Greases
The oil present in lubricating grease is known as its base oil. The proportion of base oil depends on the use of the grease. For most grease, the base oil content is between 85% and 97%. Added to the base oil are soap or non-soap thickeners, which give grease its paste form. To the grease is added additives to counteract wear and corrosion, provide additional friction reducing effects, improve the adhesion of the grease, and prevent damage under start-up conditions.

Additives used in grease are -

- Extreme Pressure additives (E.P) protect metal surfaces against cold welding.
- Anti-wear additives reduce wear of metal surfaces.
- Corrosion inhibitors protect against corrosive attack on bearings or metallic surfaces.
- Anti-oxidants (anti-aging) delay oxidative decomposition.
- Friction-reducing additives (friction modifiers) reduce friction under start-up conditions
- Adhesion improvers (tackifiers) improve surface adhesion.

Advantages of Grease Lubrication over Oil Lubrication -

- Bearing housing design is simplified.
- Simpler maintenance.
- Reduced risk of lubricant leakage and simpler shaft seal designs.
- Can act as a sealant by purging grease (labyrinth).
- Low bearing temperatures can be achieved at high revolutions with high-speed greases metered-in after a running-in period.

Advantages Oil Lubrication over Grease Lubrication -

- Improved heat dissipation is possible.
- Contaminants are removed away from around the bearing.
- Higher speeds are possible with oil injection and oil/air lubrication.

In-Service Design and Use

The pressurised lubricant slips in-between the roller and the races and lifts the roller from the raceways a very small amount. This stops the parts touching and wearing each other out. The roller deforms slightly from the pressure and allows the lubricant space to pass. Figure 5 is an illustration of the lubricant wedge that develops between the parts of a roller bearing in motion.

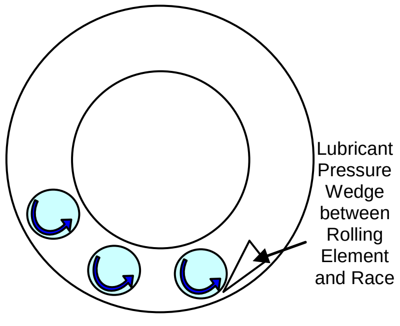


Figure 5 Creation of a Lubricant Wedge

If roller bearings are to roll around the bearing races on a thin film of lubricant, without making direct contact and wearing away, it is necessary to keeping the lubricant film thick and healthy. This means keeping the lubricant cool so it does not get too hot and thin-out, and so reducing the film thickness. It also means keeping the lubricant contamination-free of dirt, water, chemicals and other incompatible lubricants mixing with it.

Oil Slinger on a Gear
Figure 6

The lubricant must get to the bearing rollers and races. Most oiled bearings get lubricated by running the rollers through an oil bath and coating them in oil, or an internal slinger on a shaft picks up oil from the bath and throws it around inside the housing. This is called splash lubrication. Figure 6 shows an oil slinger for splash lubrication.

Greased bearings have grease sitting around the lower rollers, up to about half the height of the bearing. Gradually the oil in the grease runs out ad goes to the bottom of the bearing, thus lubricating the roller and races.

<u>Good Lubrication Conditions</u>

<u>Lubricant Health</u>

Dirty oil spells rapid death for bearings. The rolling elements have extremely small clearances to the races. 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 material from the surfaces.

Figure 7 shows a shaft in a journal within an oil lubricated bearing housing. The solid particles are larger than the oil film thickness. When they enter the bearing pressure zone at the bottom of the shaft they will tear into the metal, get broken up and make more particles that cause further wear.

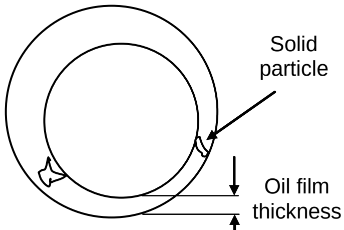
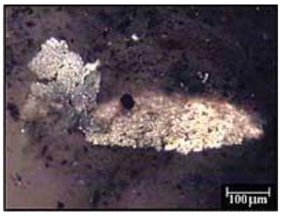


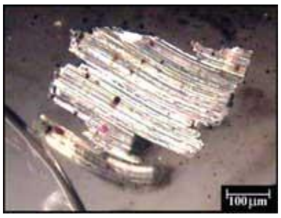
Figure 7 Particles in Lubricant

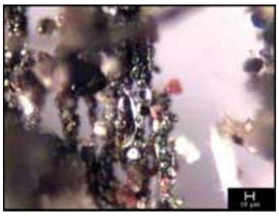
Solids suspended in oil or grease is like grinding paste. The solids scour and gouge surfaces; block oil passages and makes the oil or grease thicker and slower to move. The longer the lubricant is left dirty the faster the failure. If you want extremely low wear rates and long equipment life the evidence indicates that oil needs to be filtered so that the large wear particles are removed and few small wear particles remain. Or the oil and grease are replaced often so that contamination is not left near the bearing.

Numerous tests on a range of oil lubricated equipment (e.g. truck engine) have been conducted that confirmed filtering oil and removing particles deliver exceptionally long equipment life. The more care you take of oil cleanliness, the longer your equipment will last - and it is not just a little bit longer, it is many times longer! The operators and maintainers who pay the most attention to getting their oil clean get the elite performance.

The elite maintenance performers monitor the oil or grease and pay attention to rising contamination during the early equipment life run-in phase. A study by SKF, the bearing makers, on gearboxes showed that hard particles went from a count of 100 per ml on start-up to about 8000 after 5 hours, to 10,000 per ml after 38 hours. So change or filter your oil in the early stages after commissioning. Then look after it during operation. If metal particles, sand,







Wear Debris
Figure 8

dirt, etc get into bearing clearances they will grind and groove their way through the lubrication circuit and the machine parts.

Figure 8 shows images of wear particles taken from used grease. The lower picture shows a slice of metal cut from the machine. The middle picture shows a wear particle with grooves proving it was jammed under a moving part. The top image shows a flat, plate-like, metal wear particle.

The technique of Wear Debris Analysis (Analytical Ferrography) is a well known condition monitoring technique. The method indicates the health of equipment by the study of particles worn away from parent surfaces. The continuous trending of wear particle count and close analysis of their form and composition permits monitoring of the condition of equipment components, including bearings, to provide early warning of failure. Wear debris analysis identifies the material and the cause of its presence. It can identify danger of failure earlier than bearing vibration monitoring. The technique holds good for both oil and grease samples.

Wear particle counts can be done with optical equipment (microscope, light extinction), with an electron-scanning microscope (ESM) or by sifting through filters and screens. Counting standard ISO 4406 is used internationally to rate solids contamination of oils. This standard classifies the cleanliness of oil and provides a basis to define acceptable solids contamination.

Possible Failure Modes Causes, Prevention and Corrective Actions

Lack of Lubrication

The right amount of lubrication is very important. If a bearing is over-lubricated, the bearing roller can be pushed excessively by the lubricant into the race and roller cage causing additional wear. On the other hand, if there is not enough lubricant, the bearing will rub on the solid surface and again cause friction and wear.

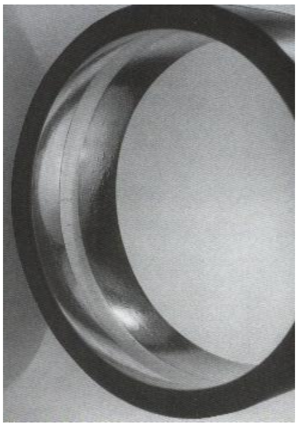


Figure 9 Polished race from lack of lubrication

Figure 9 shows a spherical roller bearing race polished by the roller running over it because there was not enough lubricant to keep the roller separated from the race. This bearing would have run hot from the friction and may even have been squealing as it turned.

To prevent under-lubrication get the bearing manufacture to specify how much lubricant is to be added to the bearing after a given period of operation.

Over Lubrication

Excess lubrication gets in the way of the roller and it has to churn and force its way through the lubricant. This extra work generates heat which then heats the bearing and housing. Over lubrication often happens when a bearing is greased with a grease gun pumped too many times or when too much oil is added to a housing or gearbox.

To prevent excessive lubrication get the bearing manufacture to specify how much lubricant is to be added to the bearing after a given period of operation. Oil levels in oil-filled bearing housings should just lap to the middle of the roller at its lowest point of rotation. Greased bearing housings must have a way to purge excess grease either past the shaft seal or out a purge hole in the housing.

Moisture Contamination

The job of a lubricant is to keep metal surfaces apart. If the lube layer thins because of the presence of moisture metal surfaces will smash together and rip each other to pieces. This will introduce solids contamination and make the lube film hot. The lube film is filled with solid metal particles which heats and thins the lube further and the metal shearing gets worse. The metal surfaces can even weld together from the heat caused by the friction.

Clean, dry oil can extend equipment life between failures up to 8 - 10 times the normal operating life. Timken, the bearing manufacturer, reports that reducing water levels from 100 ppm (parts per million) to 25 ppm increases bearing life 2 times. British hydraulics research indicate that if solids contamination with particles larger than 5 micron (0.005 mm or 0.0002”) is reduced from of 5,000 – 10,000 particles per millilitre of oil to 160 – 320 particles, machine life increased 5 times.

Moisture must never be allowed into a bearing. Keep it clean and dry! The table below shows how bearing life is affected horribly by water. Oil with water in it is cloudy and by the time you notice the cloudiness the damage is already done!

Water Percent in Oil	Percent Bearing Life Remaining
0.01%	100%
0.05%	38%
0.15%	20%

It is common in industry to use hoses to wash-down and this water goes into gearboxes, motors and bearing housing through failed seals. Totally ban hosing down and compressed air blow down. Replace it with brush down and wipe cloths.

Introduced Contamination

The greatest destruction of lubrication is done through poor handling and storage practices. Hospital quality cleanliness is the best protection against introduced contamination.

The storage room must be spotless. Transfer and drainage equipment must be as clean as restaurant knives and forks. The lubricant containers, lids and seal tops must be dinner plate finish. Keep the lubricant covered. Don’t place unused, excess lubricant back in a container – it is too late, it is already contaminated! Absolutely no dirty hands and dirty tools with clean lubricant or when touching bearings! Only clean hands and clean tools touch bearings!

Clean the lube point nipple on the machine spotless before inserting more clean lubricant. Unless the lubricant is clean and the bearing is spotless the machine’s early destruction is certain.

If necessary start your lubricant store over again! Get everyone together and explain the life-and-death requirements for clean oil and grease. Research and write lubricant storage and handling procedures and train everyone in them. Make your supervisors responsible for cleanliness of the store and the use of the procedures. Only utterly clean lube is allowed to go into bearings.

Wrong or Degraded Lubricant

The right lube viscosity at the operating temperature for the load and shaft speed is a must! Only clean lube with the correct specification for the bearing at its operating conditions is acceptable. When the bearing lube deteriorates get rid of it and replace it afresh or clean it up. Keep process chemicals and water out by replacing seals when they leak, using labyrinth seals with a flush or installing stationary/rotary seals.

How do you know the lubricant's condition, contaminants and quality at any point in time? You don't unless you sample it and test it for suitability to continue in service. If you are not sure whether it should continue in service you are right! Get rid of it or clean it up. The cost of doing either is a lot less than a breakdown.

Shaft sealing is critical to success. Do everything necessary to keep moisture, process chemicals, dirt and dust from getting into the lubricant. Some options are to add more seals, change styles of seal, flush with grease using automatic dispensers, put positive air pressure in the seal area.

On-Site Test, Workshop or Lab Test of an Installation and Learning Assessment

It is now time to do some 'hands-on' training in the field, or on the test-bench. To thoroughly understand this topic it is best to see what happens in a working situation and make and controlled changes. You will learn how to better run a thing well if you understand its workings. Locate suitable lubricated equipment in your plant or spares that you will be allowed to inspect.

1. If available locate a manufacture's operating manual for equipment that has bearings in it at your workplace or find it on-line over the Internet. Take the time to read the section on bearing care and lubrication. Secondly get hold of an old roller bearing and old bearing housing or plumber block that you can inspect and strip apart.

2. Hand-sketch below how one of the bearing, shaft and seals are arranged in the old housing and show where the lubricant sits when the equipment is stopped. Describe in the area under the sketch box how the bearing is lubricated and how it is protected from contamination.

3. Close Inspection

3.1. Open up the bearing housing or plumber block and look inside. If that is not possible get a manufacturer's manual for the equipment. Using the manufacture's manual, or information from other sources, name and describe each part.

3.2. Write a short description of how the shaft seal is built and how it is designed to work.

3.3. When is the lubricant first put on the bearing and how much lubricant is applied?

4. If at all possible, and once you have supervisor permission, operate a small piece of lubricated equipment to see what effects happen during operation. If you cannot operate a real item of equipment, then describe as best you can using information from your reading and discussion with others, what will happen to the lubricant as the item is run-up from a clod start.

4.1. Start-Up Conditions.

Describe what happens to the lubricant inside the equipment as it goes from a cold start-up to normal running temperature. What can you see, hear and feel during running of the equipment?

4.2. Condition Monitoring.

Describe the ways that lubricant condition is monitored at your workplace. Describe what is done to decide when it is time to change oil or grease in the equipment at your workplace.

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5. Possible Modes of Failure

5.1. List the ways that lubricants have failed to perform properly at your workplace. Talk to the experienced operators and maintainers if necessary.

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5.2. Getting the Equipment Back to Proper Operation.

For each failure mode listed above, describe in detail what needs to be done to correct them.

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This is the end of this training. Please record the following details and hand your answers back to the supervisor in charge of this training.

Trainee ________________________________ **Signature** ____________________________
(Print Name) (Trainee)

Supervisor ______________________________ **Signature** ____________________________
(Print Name) (Supervisor)

Assessment Result: Pass ☐ Repeat ☐

Completion Date ____________________ 'Pass' recorded in the Trainee's training records ☐