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Technical Article

Bearing Killers:
Preventing Common Causes of Bearing System Damage



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Bearing Killers:

Preventing Common Causes of Bearing System Damage

Abstract

Bearing killers are conditions that can cause damage to a bearing system and a premature end to its useful life. When a bearing doesn't reach its maximum life, one or more of these conditions is often the reason. The four most common are:

- Inadequate lubrication
- Contamination
- Overload
- Improper handling and installation

These conditions affect a wide variety of bearing types, including cylindrical, spherical, needle, tapered and ball designs.

The consequences of bearing damage in industrial equipment can be significant, including:

- Injury to plant personnel
- Reduced operating efficiency
- Cost to repair or replace bearings
- Cost to repair or replace other components – such as housings or shafts – that may be damaged by malfunctioning bearings through vibration or high temperatures
- Unplanned equipment downtime

For bearing systems to reach maximum life – and to avoid serious consequences from malfunctioning bearings – it's important that plant managers and technicians understand how to monitor and prevent conditions that damage bearings.



Inadequate Lubrication

The vast majority of bearing damage can be attributed to inadequate lubrication, which can be classified into eight basic categories: overfilling, underfilling, incorrect specification, mixing or incompatibility, incorrect lubrication systems and intervals, deteriorated grease or oil, water contamination and debris contamination.

Work with the OEM and bearing supplier to specify the right lubricant amount, type, grade, supply system, replenishment cycle, viscosity and additives. Lubricants should be properly engineered for each bearing system based on history, loading, speeds, sealing systems, service conditions and expected life.

Manufacturers or distributors should provide detailed recommendations on storage conditions, maximum shelf life, delivery systems, filtration levels and other precautions. Consultation is recommended if any conditions change during operation, even those that appear less significant.

Mixing different grades and brands of greases or oils can be disastrous. Lubricants must be completely compatible to function properly over time. Because of significant chemical differences in formulation (thickening agents, base oils, additives, etc.), some lubricants cannot be mixed with others.

Before changing a lubricant, always qualify compatibility with the lubricant suppliers. In some cases, special testing may be required. If you get the green light to proceed, allow for sufficient time to remove all old lubricant from the system. Also, it is a good time to review the condition of lines, connectors, distributors, pumps and seals, and address corrective actions.

Once the lubricant has been selected and applied, always monitor it and the bearings for signs of trouble.

A common method is periodic or continuous temperature monitoring. If bearings are operating at higher than 180° F degrees, be aware that oil service life can decrease drastically, even with oxidation inhibitors. High operating temperatures may be caused by high ambient or process temperatures or by severe operating conditions that increase rolling contact friction. Conversely, very low ambient temperatures

also will challenge the lubricant, causing it to thicken and potentially flow improperly. Check with your bearing supplier for the acceptable range of operating temperatures.

If bearing lubrication is in any way inadequate, the result may lead to damage. Damage varies greatly in appearance. Here are four progressive levels of damage:

- Discoloration is a darkening of the metal that occurs when metal-to-metal contact results in excessive bearing temperature. In particular, look for discoloration of the races and the rollers. In mild cases, the discoloration is from the lubricant staining the bearing surfaces. In severe cases, the metal itself is discolored from high heat.

- Scoring or peeling of any kind or degree is an indication of a serious lubrication-related problem and requires immediate attention. Look for marks cut into the metal or the metal peeling away.

- Localized scoring is due to localized high temperature, breakdown of lubricating film and direct mechanical contact of components. In tapered roller bearings, this might manifest as scoring of the large roller end and guiding rib of rings.

- Total bearing lockup may occur when high localized heat or cumulative wear produces major change to the original bearing geometry or mounted internal clearance. Skewing of the rollers, destruction of the cage, metal transfer, increased torque or power loss and complete bearing seizure (Figure 1) can result.

If any of these conditions are observed, consult with a bearing service engineer to help diagnose the equipment, lubricant and bearing condition and to support damage root cause analysis. In most cases, the bearings will need to be repaired before they can be reinstalled and placed in operation again.



Figure 1:
Total bearing lockup.



Contamination

Foreign particles are another common source of trouble in bearings. Even small amounts of minute foreign particles – dust, dirt, debris – can disrupt the oil film, resulting in damage to the bearing surface and reduced service life. Water is particularly damaging to lubricant. As little as 1 percent water in grease or oil can have a significant impact on bearing life.

In guarding against contamination, seals are critical. First, it's important to choose the proper seals. Consult manufacturers to ensure a proper match between the seal and the application. Your supplier will need to understand equipment performance, assembly requirements, lubricant system, shaft orientation and other environmental factors. The type of seal, the materials that the seal is constructed from, and how the seal is mounted are all vital.

Here are some general suggestions for selecting and maintaining seals:

- Use only seals suitable for the environmental and machine operating conditions.
- Implement external shields or procedures to avoid debris buildup on or around seals.
- Routinely check radial lip seal condition for flexibility, hardening or cracking, and shaft contact.
- Look for signs of leaking and replace damaged seals as soon as possible.
- Avoid purging excessive grease past lip seals. Seal lips can lose contact and effectiveness.
- Take care when using water, steam or compressed air spray equipment for periodic external cleaning. Many rotating seals are not designed to resist steam or direct impingement of high-pressure sprays. It is very easy to damage the seal and force contaminants into otherwise clean equipment.



- When disassembling large equipment, avoid lifting with chains, wire rope or dirty slings that might score sealing surfaces.

- If the rubbing surfaces are worn, resurface and grind them to original specifications for finish and diameter.

In addition, reduce contamination by following three best practices:

- When bearings are removed for inspection, wash and dry them. After washing and drying – or whenever bearings are put into storage – they should be coated with oil or another preservative and wrapped in protective paper.

- Routinely collect and test oil or grease samples. Ideally, you want to see consistent properties in the oil or grease. If solid particles are present, determine the potential source and take corrective action.

- It's best not to rely on filters alone to manage contamination. In harsh environments, where filters may be under heavy demands, technicians will need to plan carefully for regular inspection and/or replacement of filter elements.

When foreign particles do contaminate bearings, they may cause a range of damage. Fine foreign material in the bearing, for example, can cause excessive abrasive wear. Sand, fine metal from grinding or machining, and fine metal or carbides from gears will wear or lap the rolling elements and races. Abrasive wear also can affect other machine elements or accelerate seal wear, degrading performance. Improper initial cleaning of housings and parts, ineffective filtration or improper filter maintenance can allow abrasive particles to accumulate.

Hard particles rolling through the bearing may cause pitting and bruising of the rolling elements and races. Metal chips or large particles of dirt remaining after machining operation due to improperly cleaned housings can initiate early fatigue damage. Internal debris contamination causes include wear from gears, splines, seals, clutches, brakes, joints, housings not properly cleaned, and damaged or spalled components. These hard particles travel within the

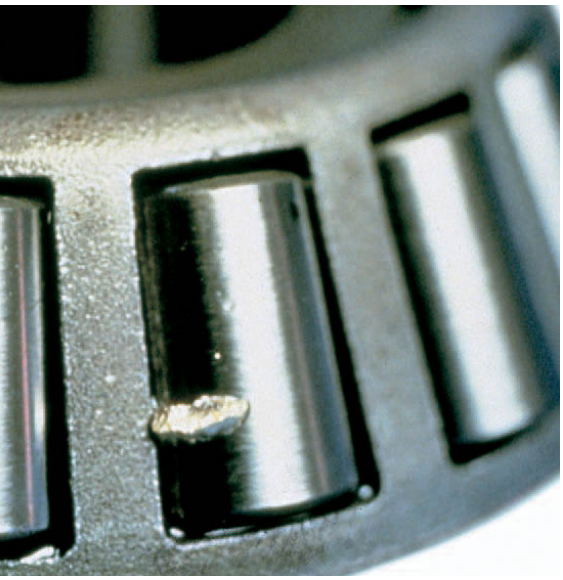


Figure 2:
Grooving.

lubrication, through the bearing and eventually bruise the surfaces. Raised metal around the dents that act as surface-stress risers cause premature spalling and reduced bearing life.

Grooving is caused by extremely heavy wear from chips or metal particles. These contaminants become wedged in the soft cage material and can cause grooves in the rolling elements (Figure 2). This condition results in improper rolling contact geometry and can reduce service life.

Etching or corrosion is one of the most serious problems encountered in bearings (Figure 3). The controlled surface finish on races and rolling elements makes them susceptible to corrosion damage from moisture and water if not adequately protected. Etching is often caused by condensate collecting in the bearing housing due to temperature changes or improper storage conditions. Equipment left idle for significant periods can be susceptible to this type of damage, which is insidious and can quickly propagate to severe spalling damage.



Figure 3:
Etchingor corrosion.

Overload

When bearings are forced to operate beyond rated design limits in terms of load, speed or temperature, it is called overload. The greater the overload, the greater the decrease in bearing life. Surrounding components may also be affected. In extreme cases, fracturing of the bearing components can occur.

While overload can result from improper operation, it also can result from a mismatch between the bearing design and the application. When selecting the proper bearing design for the application, the OEM and bearing manufacturer will consider operating temperature, rate of temperature change, type and degree of potential contamination, operating speeds and acceleration, vibration and more.

Warning signs of overload include noise or vibration, system temperature rising, metallic chips in the lubricant and filters, and diminished system performance.

One indication of overload is fatigue spalling – pitting or flaking away of bearing materials (Figure 4). Spalling primarily occurs on the races and the rolling elements of the bearing.

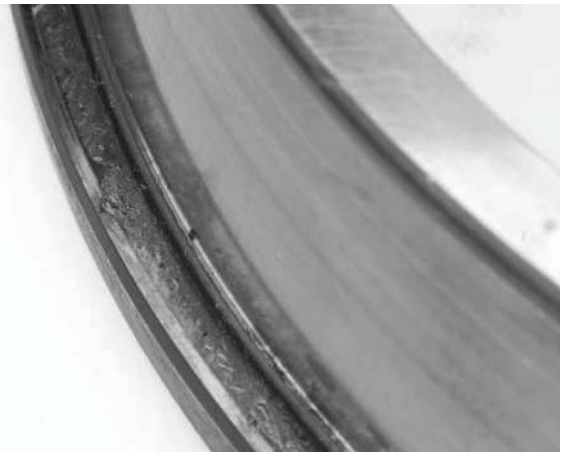


Figure 4:
Overload.

Other indications of overload are:

- Roller fracture (Figure 5)
- Peeling
- Outer ring subcase fracture
- Hard lines or evidence of plastic deformation at the edges of the roller and non-ribbed raceway contacts. These hard lines appear black and can be felt with a fingernail or sharp-tipped tool.
- Metal deformation into the undercuts of ribbed raceways

If you observe any of these signs of damage due to overloading, the bearings must be repaired or replaced, or you run the risk of further damage and more serious consequences.



Figure 5:
Roller fracture.

Improper Handling and Installation

Technicians should be sure to employ the proper methods and tools when handling and installing bearings. Bearings are highly engineered components and even the smallest denting or nicking can undermine performance and reliability.

Until bearings are ready for installation, keep them stored in the anti-corrosive protective wrapping. Many cases of premature bearing damage can be traced to improper storage practices. Always use clean tools in a clean environment. And do not wipe away the preservative on the bearing. One common error is wiping away the preservative applied by the bearing manufacturer and removing protective packaging. If, for any reason, the bearing must be removed from the original packaging, take care to apply preservatives and ensure that the parts are well wrapped. Bearing manufacturer service representatives can assist with best practices.

Record keeping is also important. Keep a record of all maintenance activity, noting the date, equipment model and serial number, bearing assembly and serial number (if applicable), and manufacturer. Include comments regarding housing or shaft reconditioning and other components that were replaced.



Figure 6:
Use proper devices and methods during handling and installation.

These records can be essential when establishing trends in bearing performance, defining service intervals and planning future maintenance. Records are also the baseline for troubleshooting equipment performance issues and related bearing damage analysis.

Take care to avoid damage to bearing components – especially cages – by using appropriate devices and methods during handling and through the installation process (Figure 6). Note that cages are usually made of mild steel, bronze or brass and can be easily damaged by improper handling or installation, resulting in premature bearing performance problems.

When driving outer-races out of housings or wheel hubs, careless handling can result in burrs or high spots in the outer-race seats. If a tool gouges the housing seat surface, it will leave raised areas around the gouge. If these high spots are not reworked (scraped or ground down) before the outer-race is reinstalled, the high spot will transfer through the outer-race and cause a corresponding high spot in the outer-race inside diameter. This increases local rolling-contact stress and can result in decreased fatigue life, localized spalling or, in extreme conditions, component fracture. The immediate effect of the gouges and deep nicks can include roughness, vibration and noise in the bearing.

Below are specific types of damage that may result from improper handling, installation or removal. Each may be very serious. If you discover damage of this kind, replace or repair the component and identify the root cause.

- Outer-ring denting
- Fractured inner-ring rib
- Broken rib on outer-race
- Roller spaced nicking
- Dent or depression on raceways (brinelling)

Bearing installation starts with paying careful attention to fits, alignment and bearing setting. For bearing fit, the manufacturer's recommendation should be followed to ensure proper bearing performance.

Signs of Bearing Deterioration

Damaged bearings provide warnings:

- *Vibrations – whether felt by hand or measured with a frequency analyzer*
- *Abnormal noises*
- *Displacement of rotational centerline*
- *Running temperature increase*
- *Odd smells*
- *Lubricant deterioration, metal in lubricant or lubricant discoloration*
- *Lubricant leakage*
- *Visual discovery during routine maintenance check*

Proper alignment during installation is important because a statically misaligned bearing will shorten life if the bearing capability is exceeded. Service life reduction will depend on the degree of misalignment. If misalignment is excessive, load distribution within the bearing will not be distributed along the rolling elements and races as intended, and will be concentrated on only a portion of the rollers or balls and races, potentially resulting in early fatigue of the metal. Abutting surfaces, the seats and shoulders, and corresponding fillets and undercuts are sized for appropriate support and transmission of forces. These must be within specified limits set by the bearing manufacturer.

Bearing setting includes proper assignment of free and mounted radial internal clearance (RIC), axial endplay or, in some equipment, axial preload. Incorrect clearance can result in a variety of conditions that include increased torque, stress, cage damage or overheating.

Conclusion

Bearing damage on a large scale is less common today, thanks to improvements in machine design, and education and training of original equipment manufacturers and users. Also, operators are increasingly diligent in bearing handling, monitoring and maintenance of equipment, lubrication and seals.

Yet the need to understand key causes of bearing damage – and how to prevent them – is no less urgent. Take care to adequately lubricate, guard against contamination, avoid overload, and properly handle and install bearings. In doing so, you can protect these essential industrial components from damage, increase uptime, prolong service life and increase the financial health of your operation.

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