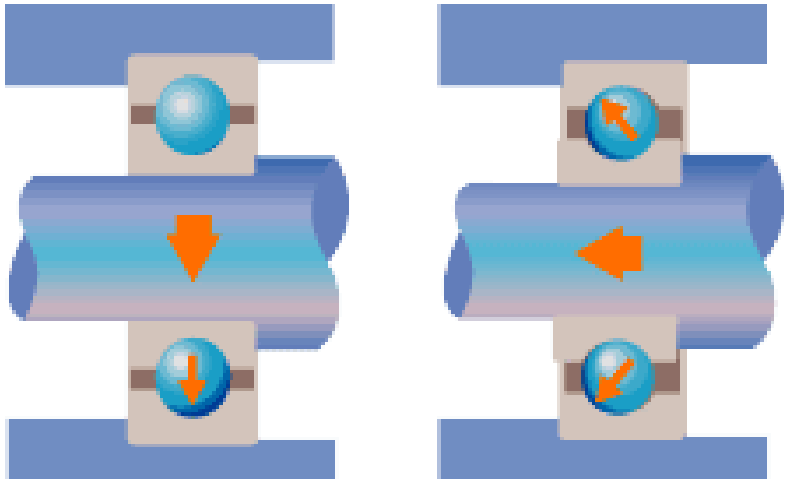
Bearings & Bushes

Part Three Damage and Wear

FAILURE OF ROLLING CONTACT BEARINGS

Bearing Loads

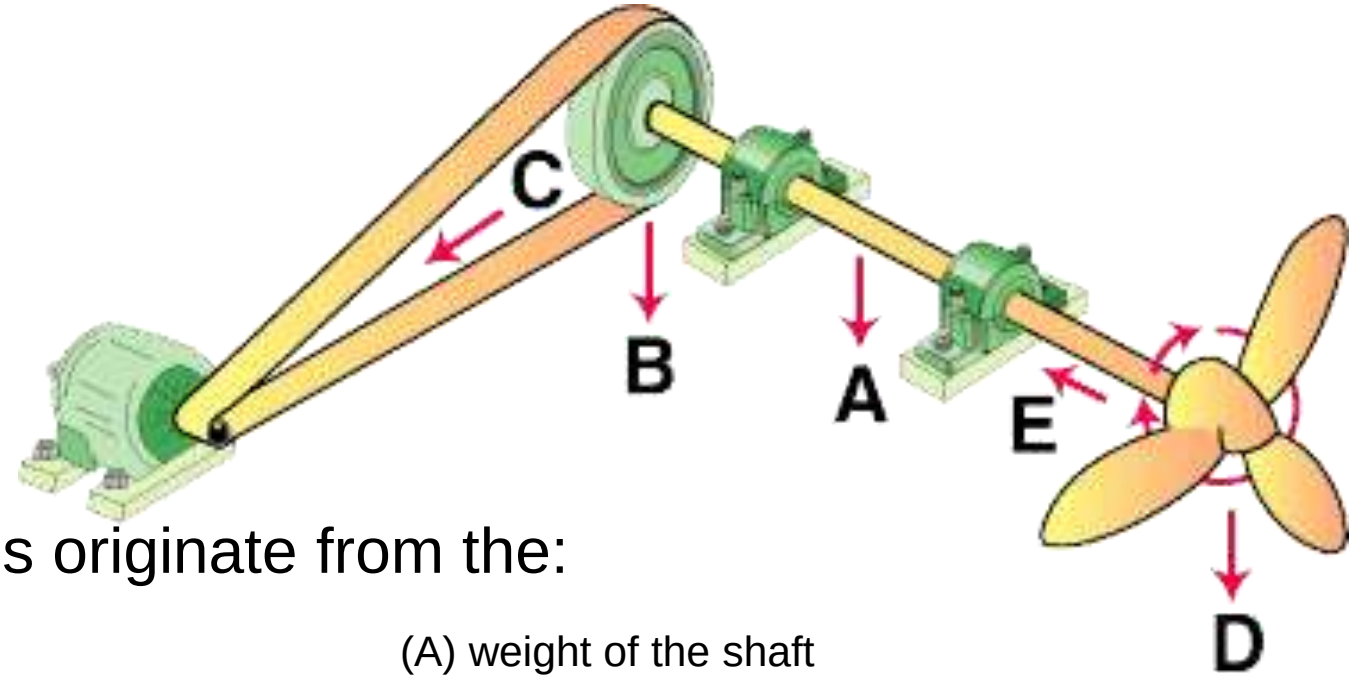
Radial loads are exerted on the bearing on a plane perpendicular *(90°)* to the shaft.



Axial loads, or thrust loads, are exerted on the bearing on a plane parallel to the centre of the shaft.

Combination loads exert both a radial and axial load on the bearing.

The illustration below shows a shaft mounted fan driven by a belt and powered by a motor. Two bearings support the shaft and are subjected to loads as follows:



Radial loads originate from the:

(A) weight of the shaft

(B) weight of the pulley

(C) tension of the belt

(D) weight of the propeller

(E) propeller rotation

Bearing Life

Many factors have a profound affect on the actual life of the bearing.

Some of these factors are:

Temperature
Lubrication
Improper care in mounting resulting in:
- Contamination
- Misalignment
- Deformation

As a result of these factors, an estimated *95%* of all failures are classified as premature bearing failures.

Bearing load ratings are established on the results of laboratory rolling contact fatigue tests.

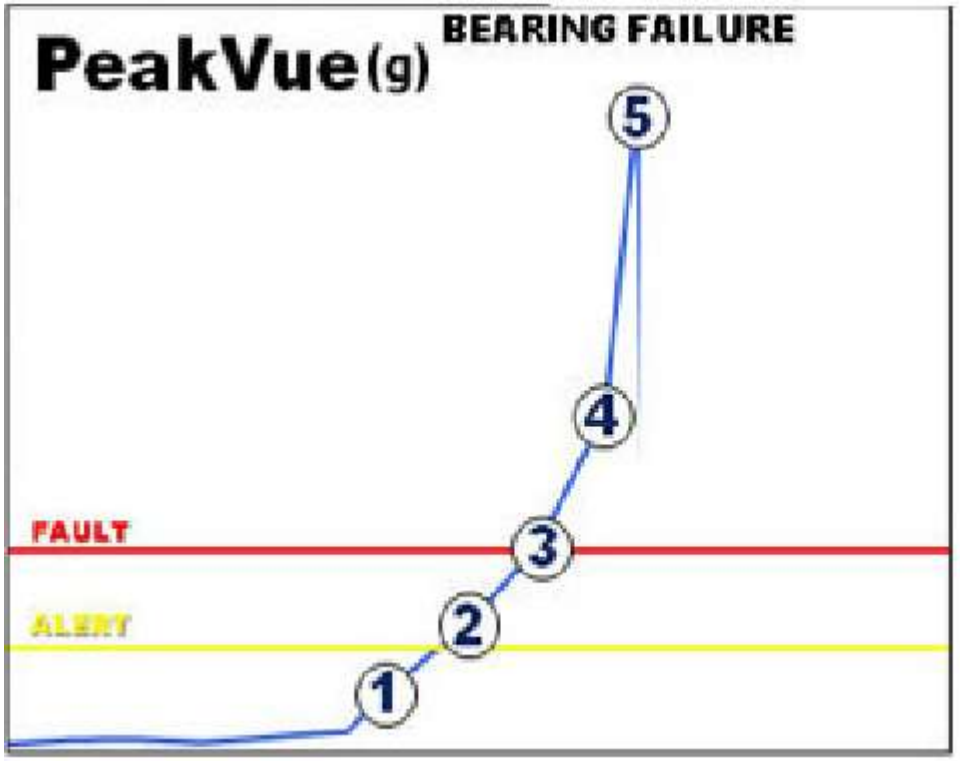
Real world conditions such as misalignment, vibration, shock loading, insufficient or inefficient lubrication, extremes of temperature, or contamination, will decrease the life expectancy of the bearings.

Types of roller bearings:

1. Cylindrical roller bearing.
2. Spherical roller bearing.
3. Taper roller bearing.
4. Needle roller bearing.
5. Needle roller thrust bearing.
6. Spherical roller thrust bearing.

Bearing Failure Graph

Vibration Amplitude



Time

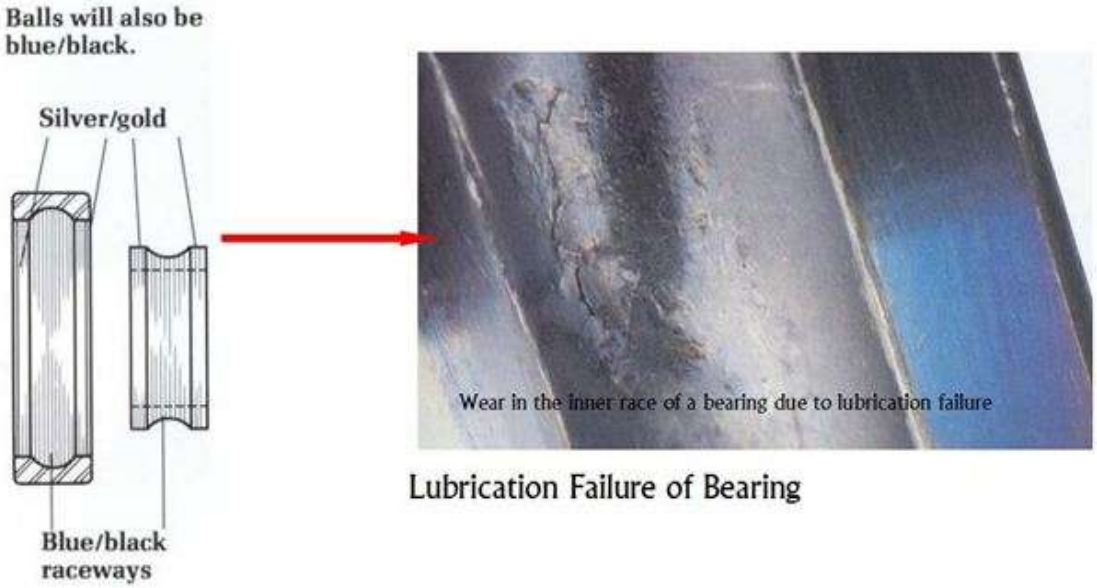
Types of Bearing Failure

Failure by Wear

Failure by Wear can be due to the insufficient lubrication in the roller bearing.

If the lubrication is adequately and correctly applied the bearing should last its design life.

In general wear is caused by the entry of dirt, hard particles, or corrosive fluids that leads to an increase in the running clearances of the bearing, which may lead to noisy operation and early failure of machine.



Lubrication Failure of Bearing

Foreign particles and dirt

Roller bearings are very sensitive to dirt or foreign matter, because of the very high unit pressure between the rollers and raceways.

Due to the rolling action of the balls dirt particles will easily enter in to the bearing.

Foreign material may get in to the bearing during its initial assembly, during repairs or by seepage from the atmosphere in to the bearing housing during operation of the machine.

Dirt, chips, and abrasive grit cause wear by abrasion. This is all so a problem in plain sliding bearings (white metal) as well as rolling element.

One insidious effect of shielded bearings is that foreign particles tend to lodge in the outer race this then may scratch or score the surface severely, which adds move foreign particles to the system.

Dirt Ingress

One very common mechanism for dirt contamination of bearing is over greasing, especially on sealed or shielded bearings.

Figure 8. Shield was pressurized by excessive grease which caused a cage failure.

Figure 7. Over-greasing Failure

Figure 9. Over-greasing caused inside of motor to fill with grease.

Over pressurization of the bearing shields – When grease is added to a grease cavity, grease volume and cavity pressure increase. Damage can occur to the shield on a single- or double-shielded bearing during re-greasing if the grease is added too fast. When the motor is placed into service, the grease will thermally expand.

If the grease cavity is full, thermal expansion can create damaging pressure on the bearing shields.

Failure by hard particles

Usually metallic and can be of any size that will scratch, cut or lap the surface of a bearing.

This failure is also known as third particle abrasive wear. This failure usually occurs on the load carrying surfaces.

Some metallic particles like iron oxide (rust) power will also cause failure on the load surface. since iron oxide is a good lapping compound.

Failure by corrosive fluids

Water, acid, or other corrosive fluids, including those formed by deterioration and breakdown of the lubricant, produce a type of failure that is characterized by a reddish brown coating and very small impression points over the entire exposed surfaces of the raceways.

Usually corrosion will not occur on the ball path because of the rolling action the balls pushes the lubricant

Corrosion

Several products of degradation of oil (alcohols, acids and alkalis) contaminants (such as water), and some anti-wear additives in oil cause corrosion.

A corrosive medium may selectively attack an alloy, removing only one element.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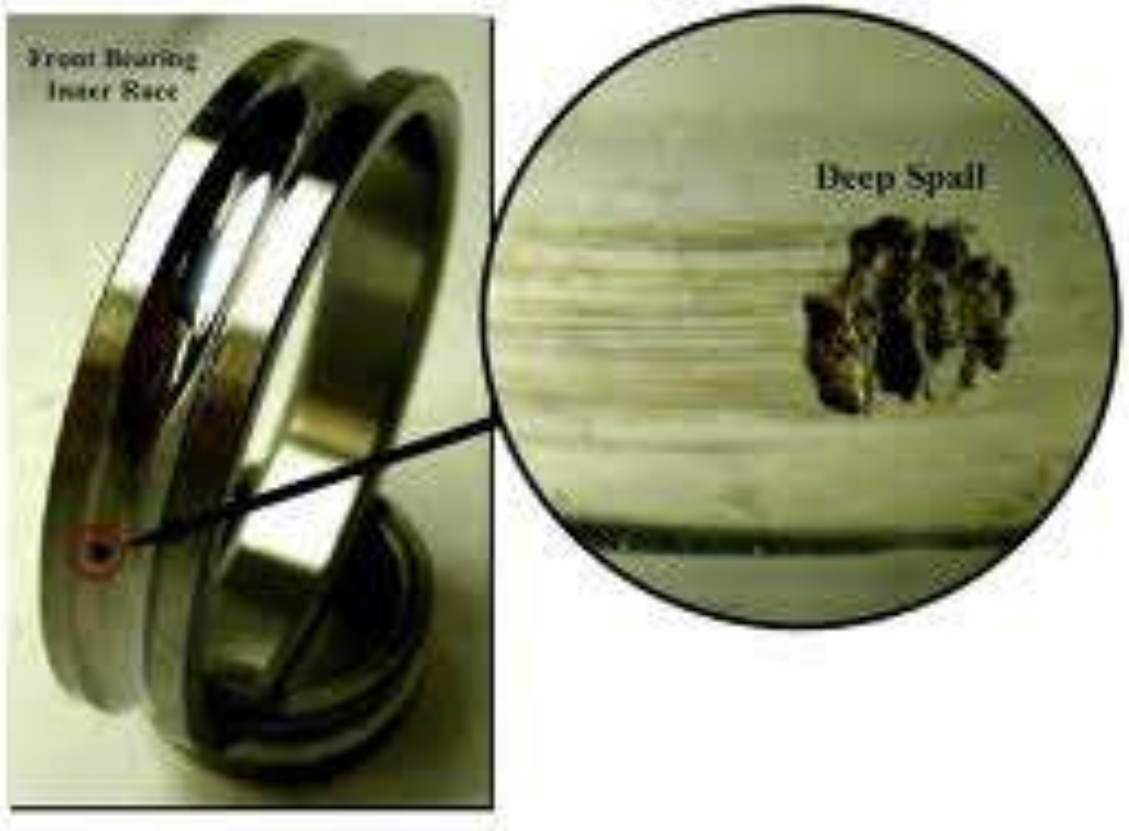
Failure by cumulative material transfer

A type of failure some times called smearing or galling results from considerable sliding between bearing contact surface.

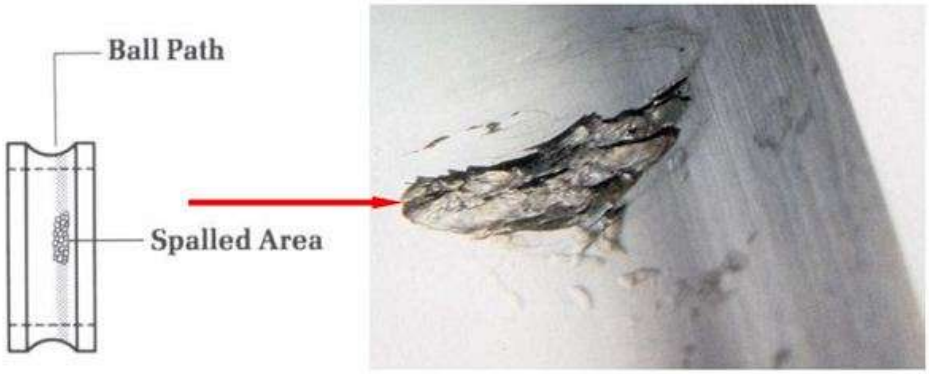
It is characterized by the formation of welded junctions between the contact surfaces.

This welding usually occurs on a localized microscopic scale and results in removable of material from one or both bearing surfaces by tearing action.



Fatigue failure consists of a spalling or pitting of the curved surfaces

Flaking or fatigue Spalling damage



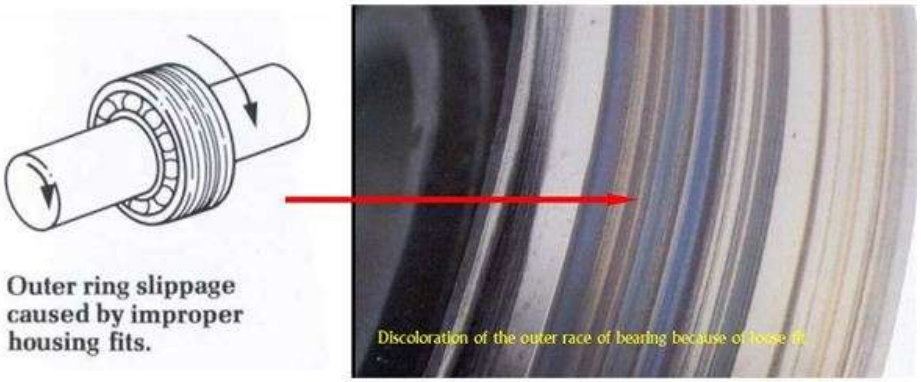
Fatigue Failure

Failure by rotational creep

Rotational creep occurs on inner ring of bearing.

It may result from the ring being initially loose on the shaft as a result of fitting errors or from plastic or elastic deformation due to abnormal loading conditions or severe imbalance.

Rotational creep may also occur in thrust bearings if the shaft against which the ring is not perpendicular to the axis.



Failure due to Loose Fits

Failure by damage

The bulk of damage failures are the result of damage to bearing components outside the contact zone.

Deterioration of the bearing results from one or more cause, inducing overheating, overloading, bulk fatigue fretting, and permanent dimensional changes.

The picture shows flaking due to faulty mounting. The mounting force has passed through the balls and made indentations in the raceway, causing flaking.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Failure by electric pitting

It is produced by passage of electrical current between two surfaces were a possibility of electric current passing through the bearings.

When current is broken at the contact surfaces between raceways and rolling elements, arcing or sparking occurs, producing high temperature and localised damage.

The overall damage is proportional to the number and size of localised points.

Electrical erosion

Some bearings, particularly those in steam turbines, may have an electrical potential applied across them, usually inadvertently.

When the gap spacing in the bearing is small and the applied potential is high enough, sparks will pass through the oil film and cause Erosion. The bearing surfaces will not be reflective, but will appear frosted.

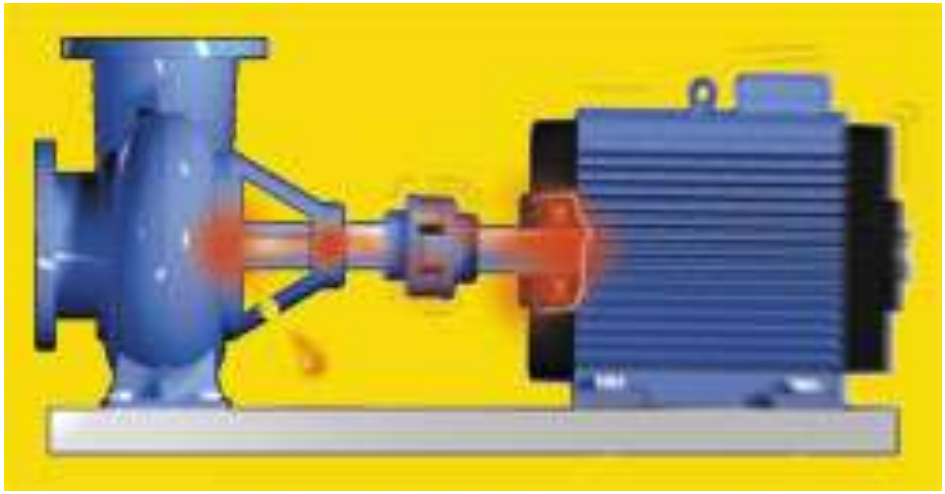
Misalignment

Some bearings are improperly assembled and fracture very early in use.

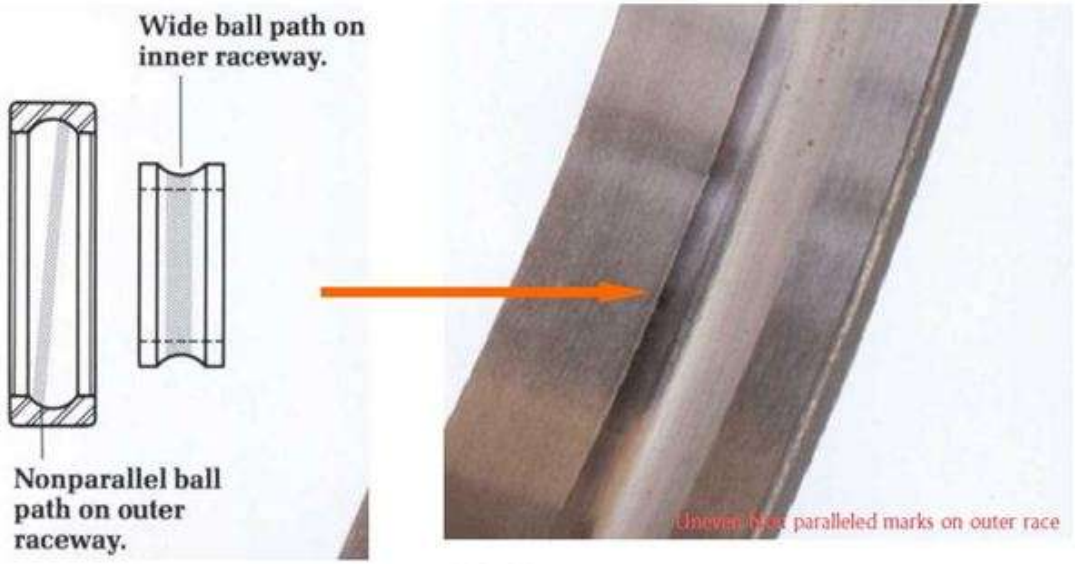
Some bearing-holder systems deflect excessively. The result of misalignment is a distorted wear pattern.

Incorrect installation

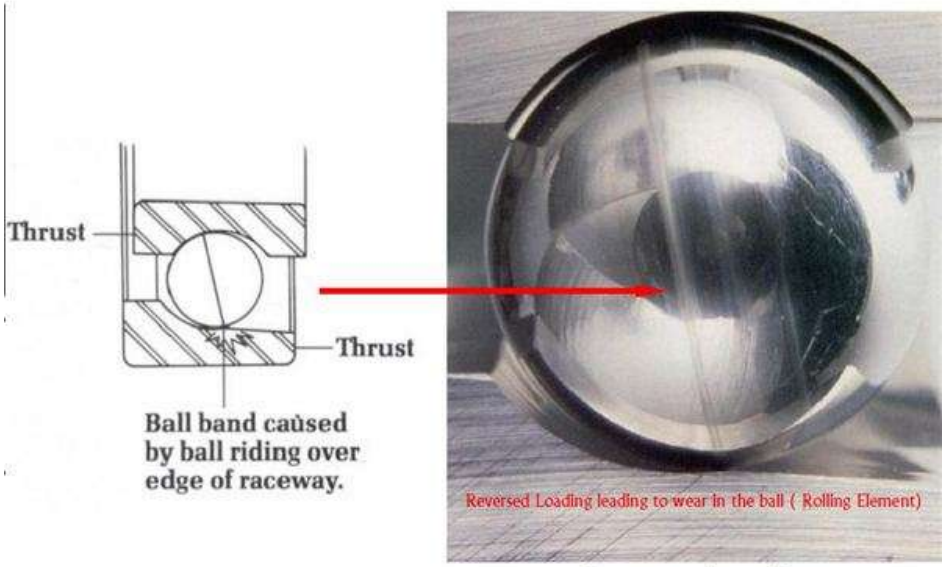
Misalignment



Misalignment of equipment causes :
Vibration
Strain/stress
Overheating
Resulting in bearing breakdown



Misalignment



Reverse Loading

Fretting

When oscillatory sliding occurs with an amplitude of the order of 0.05 m, fretting occurs. This may happen on the outside of the bearing backing, against the housing of the machine

Brinelling

Brinelling is internal surface damage as a result of excessive impact on a stationary bearings. It is a form of permanent deformation of the bearing surfaces where the rollers (or balls) contact the races.

It can be a consequence of background vibration on equipment that is say standby duty and is transmitted through the plinth or connecting pipework to a bearing assembly.

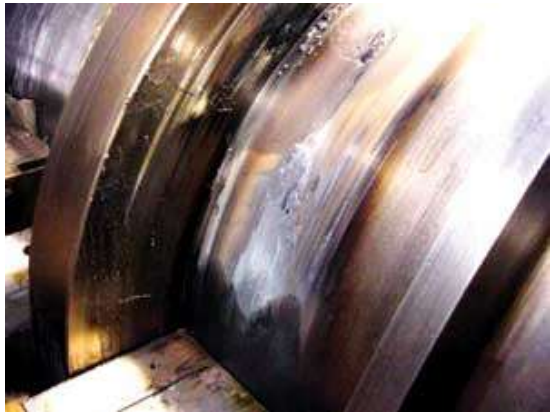
Because of the high frequency vibration over a long duration on a bearing in one position the damage takes place.

This effect can also be seen on bearings that have been stored in an area say on a ship at sea where there is a lot of background vibration.

Plain Bearing Failure Mechanism

In short plain bearings (white metal) do suffer from the same problems as the rolling element bearing but are by fare, much more venerable to overheating, and this is very often as a result of pore lubrication or lubrication failure.

lubrication oil system failure



Preventative Measures and Good Maintenance

For dirt failure

i. Proper maintenance.

ii. Grinding and polishing the journal surfaces if necessary.

iii. Changing the oil and filters at regular intervals.

For fatigue failures

i. Proper lubrication

ii. Maintenance of oil-film thickness at desired level.

For hot shot phenomenon

i. Temperature at contact surface should not be allowed to rise more than the specified level.

ii. Flow of oil, free from dirt should be ensured.

For fretting failure

i. Mating faces of the bearing assembly should be cleared and made burr free while installation.

ii. Attention should be given regarding load carrying capacity.

For excessive interference problems

i. Care should be taken during mounting, specially regarding fit selection.

For corrosion problems

i. Oil suppliers may be consulted.

ii. Investigation may be made for possible coolant leakage into oil.

Finally

The No. 2 engine failed, causing an engine fire, a cabin decompression and damage to the No. 1 engine. This lead to loss of elevator control and damage to the electrical system.

A fire in the cargo hold was not detected because of damage to the electrical fire warning system.

While attempting to return to the airport and attempting a turn to land, the aircraft crashed into a forest, 9 miles short of the runway.

The cause of the engine failure was an overheated bearing

The End
Any Questions ?