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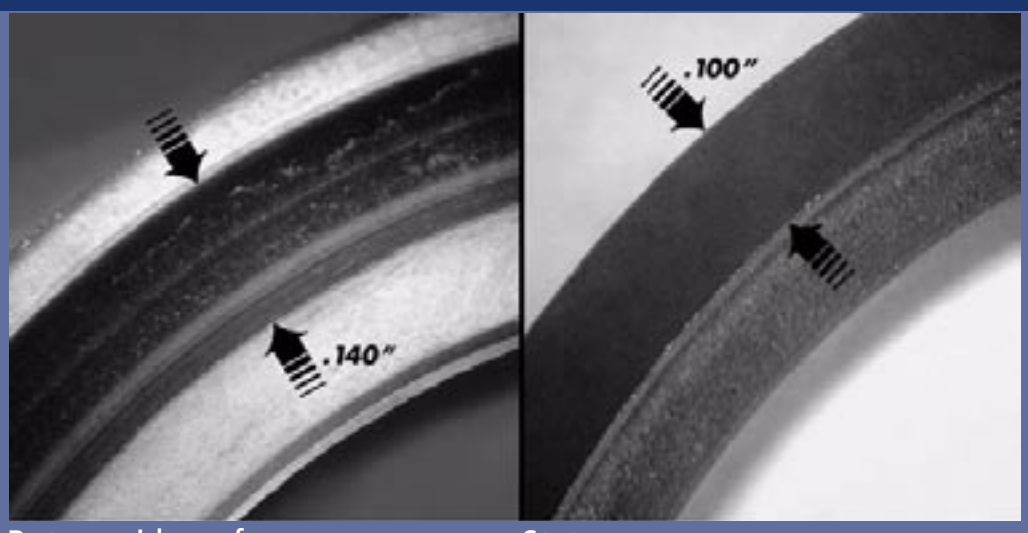
ROTATING MECHANICAL SEAL FAILURE SYMPTOMS

Symptoms of wear marks:

4a10

Wide area of wear

4a11



Rotary wide surface Stator area

- Symptom
  - The wear mark is wider than the narrow sealing surface
- Causes
  - Incorrect centering of the (stationary) seal
  - Radial shaft runout
  - Shaft deflection in operation
- Type of failure
  - Incorrect installation
  - Condition / layout of system
- Solutions
  - Check the bearings for run-out
  - Check installation technologies
  - Improve calculation of the shaft deflection, if necessary!

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BEARING FAILURE SYMPTOMS

4c60 Brinelling due to foreign bodies

Brinelling of rolling elements

Characteristics:

Chatter marks in rolling element interval in the races of bearings that cannot be taken apart. Sometimes, fatigue starting from there, also see "Fatigue as a result of static overloading".
The chatter marks may have also occurred during disassembly. Look out for rollover characteristics (shiny edges), check direction of installation.

Causes:

– Static overloading/thrusts
– Installation or disassembly forces are directed over the rolling elements (incorrect installation sequence, inappropriate tools)

Remedy:

First mount the snug-fitting ring.
Force-fit these together with a disk in case of tight fit of both rings.

Score marks on the shell of rolling elements

Characteristics:

Circumferential notching in the contact areas of rolling elements.

Cause:

Contaminated lubricant; hard particles accumulate in the cage pockets and have an effect there like the particles on a grinding disc.

Remedy:

– Make sure installation is clean
– Improve sealing
– Filter lubricant

Fatigue due to poor lubrication

Characteristics:

Depending on loading, various damage symptoms may occur in case of insufficient lubrication. Minute, very flat nicks occur as a result of relatively low load and presence of shearing strain at the same time. Since they occur in large numbers, they appear as spots on the race, referred to as micropitting, pitting or tetters. In case of high loading with the lubricant diluted, e.g., due to ingress of water, flat pittings occur in shell shape with pressure-sanded races. In case of very high loads and at the same time poor lubricant conditions, it is possible that marked hot zones can occur in the race, which could result in cracks with further rolling.

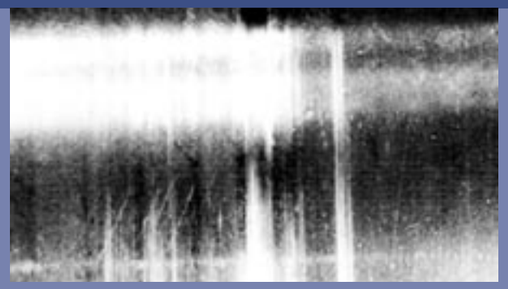
Causes:

– Poor lubrication condition as a result of insufficient lubrication, excessive operating temperature, water ingress, increased friction as a result and material loading on the race surface.
– In part shearing strain as well

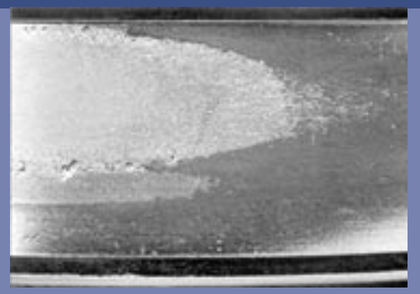
Remedy:

– Increase amount of lubricant
– Use a lubricant with greater viscosity, possibly with proven EP additives.
– Cooling of lubricant and/or bearing metal
– Use softer grease, if necessary
– Prevent ingress of water

Spherical indents in the shoulders of a deep-groove ball bearing. The installation tool was placed on the loose fitting ring and thus the forces are applied via the balls.



Isolated deep score marks on the rollers as a result of foreign bodies in the cage.



Micropittings

Shell-shaped fatigue

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BEARING FAILURE SYMPTOMS

4c61 Fatigue damage

Classic fatigue

Even with very favorable operating conditions, i.e. hydrodynamically separating lubricant film, maximum cleanness of lubricant and moderate temperatures, fatigue damage could appear on parts of rolling-contact bearings depending on the load. With a load index
fs. = C0/Po. > 8 (C0 = static load rating, P0* = equivalent load) it can be assumed to be below the cited conditions of fatigue strength. With greater loads, i.e. small f values, it is probable that fatigue damage will happen after longer operating period to a greater or lesser extent. Such classic fatigue damage, where cracks first develop below the surface, is a relatively rare occurrence in use. Fatigue damage is a much more frequent occurrence in case of unfavorable lubrication or insufficient cleanness of the race surface contact. In case of advance damage, the respective cause can no longer be identified in most cases.

Characteristics:

Cracks forming below the surface of races and rolling elements, material delamination (relatively deep pitting), undamaged race areas show the characteristics of good lubrication in early stages, whereas many indentations of the crushed chippings can be identified to a greater or lesser extent depending on the degree of damage.

Fatigue damage in the race of the outer ring of a tapered roller bearing

Classic fatigue appears in pitting in the race of the inner ring of a deep groove ball bearing. In advance stages, material flakes off the entire race.

Advance fatigue damage on a deep groove ball bearing.

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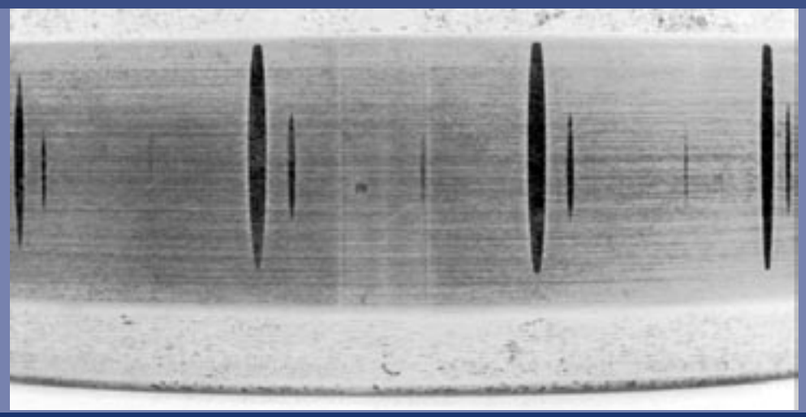
4c62 Standstill marks

Characteristics:
Marks on the race surface at the interval of the rolling elements. Compared to marks caused by incorrect installation (see "Brinelling due to rolling elements") there are no raised edges. Surfaces in depressions frequently show brown discoloring (corrosion) especially severely roughened around the ball bearings (processing structure missing). In case of ball bearings, some score marks can be found running axially. Should the bearing turn some in the meantime, there are usually clusters of adjacent standstill marks.

Causes:
Vibrations in idle machines, which result in micromovements in the contact points of the rolling elements.

Remedy:
– Eliminate/cushion vibrations
– Do not allow machines at risk to be idle, use shipping braces which either relieve or pretension the bearings.
– Use appropriate lubricant (additive).
– Select larger radial play in case of rotating loads.



Standstill marks have formed on the race at the interval of the rolling elements on the inner ring of a cylindrical roller bearing.

Stand still marks on a ball bearing.

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BEARING FAILURE SYMPTOMS

4c63 Craters and grooves

Craters and grooves due to current transfer
Craters

Characteristics:
Craters at the contact points of the rolling elements in the races, sometimes multiple craters in a row or whole strings of pearls on the perimeter. The surface in the craters is formed in part like welding beads.

Causes:
Current transfer, e.g. during welding or due to failure of ground contacts.

Remedy:
In case of electric welding do not allow current to pass through the bearing (ground).

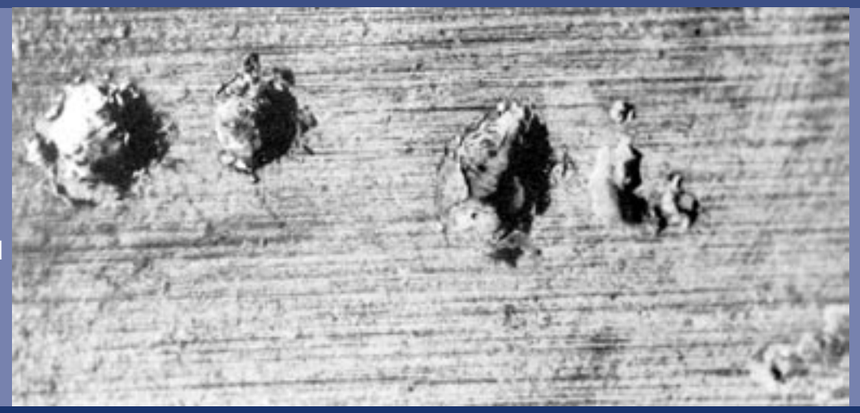
Grooves

Characteristics:
Axially parallel marks of brown discoloration on large parts of the race through to the entire perimeter of the race.

Causes:
Constantly flowing AC or DC power, marks even possible with low current load.

Remedy:
– Do not allow current to pass through the bearing (ground, insulation).
– Use current-insulated bearings.

The groove formation in the race of the outer ring of a deep groove ball bearing was created due to constant current transfer.



Current transfers have resulted in craters forming in the race of a cylindrical roller bearing.

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BEARING FAILURE SYMPTOMS

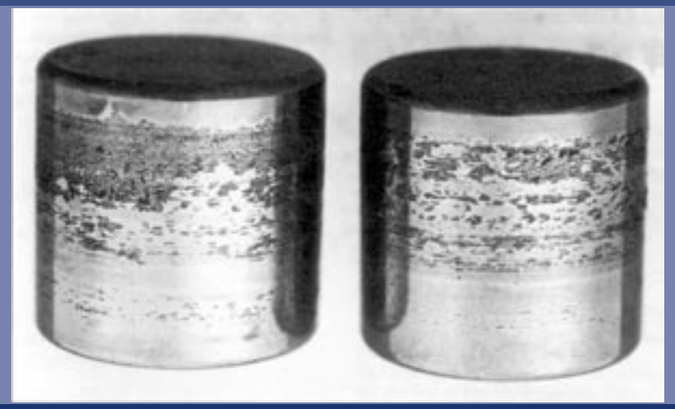
4c64 Slip damage

Slip marks

Characteristics:
Slippage of rolling elements, especially in large, heavy rollers, e.g. in bearings with cylindrical rollers. Roughening of races or rolling elements. Frequently material fracturing and smearing as well. In most case unevenly distributed on the surface, but rather blotchy. Frequently in connection with micropitting, see “Fatigue due to poor lubrication”.

Causes:
– In case of too low loading and insufficient lubrication, slippage of rolling elements on the races. Sometimes load zones are too short, as a result braking of the rolling elements in the off-load zone in the cage pockets and subsequent reacceleration upon entry in the load zone.
– Quick speed changes

Remedy:
– Use bearings with lower bearing capacity
– Pretension bearings, e.g., with springs
– Reduce bearing play
– Ensure sufficient loading even during test runs
– Improving lubrication



Slip marks on cylindrical rollers

Slip damage on the inner ring of a cylindrical roller bearing

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BEARING FAILURE SYMPTOMS

4c65 Brinelling of rolling elements Scrape marks

Scrape marks

Characteristics:
Axially parallel material displacement at the interval of the rolling elements on the races and rolling elements of cylindrical or tapered roller bearings that can be taken apart. Sometimes clusters of such marks, staggered by a couple degrees to each other on the perimeter. Frequently not on the entire perimeter, but rather only on approx. 1/3 of the perimeter.

Causes:
During assembly, the single ring and the ring with the rolling elements are not concentric or are tipped towards one another and then forced together. This is especially critical with large moving masses (heavy shaft is inserted in the outer ring already press-fitted in the housing with bearing inner ring and rolling elements).

Remedy:
– Use appropriate installation tools
– Prevent misalignment
– Assemble parts, if possible while turning slightly at the same time.

Scrape marks in the race of the inner ring of a cylindrical roller bearing occur due to angled insertion into the set of rolling elements

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BEARING FAILURE SYMPTOMS

4c66 Scuff marks

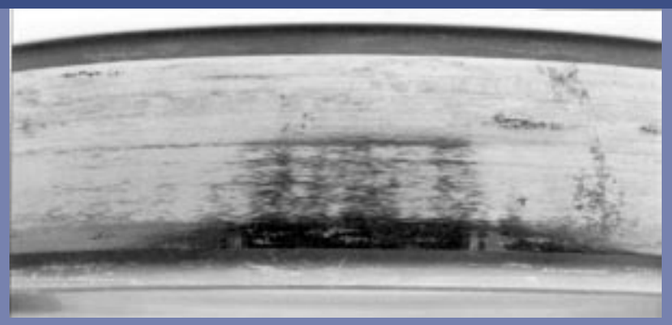
Scuff marks or sliding abrasion

Characteristics:
Cold welds on the mating surfaces (inner ring bore, outer ring shell) and axial contact surfaces or even mirror-like contact surfaces with good surface roughness. Wear of mating surfaces and end faces, possible reduction of pretension or increase in play.

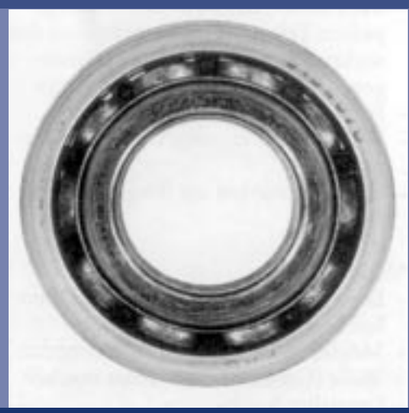
Causes:
– Rotary movements between ring and shaft/housing with loose fit under rotating load, even with static loading while out of balance
– Axial fixing of rings insufficient
– Movable bearing slides stiffly

Remedy:
– Use as snug as possible bearing seat
– Increase axial contact surfaces
– Ensure axial fixing
– Keep mating surfaces dry
– Improve functionality of movable bearing

Scuff marks in the inner ring bore as a result of inner ring rotating on the shaft



Scuff marks on the shell as a result of the outer ring rotating in the housing



Continuous scores and cold welds on the lateral face of the inner ring as a result of the inner ring turning on the shaft

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4c67 Damage due to wear

Fatigue by breakage of case

Characteristics:
Peeling of race in thick plates with case-hardened bearing parts

Causes:
– Break or flaking of case
– Load too high or case thickness at specified load too little, e.g. due to incorrect design loads

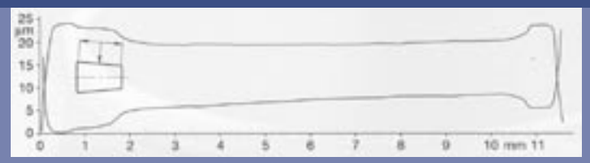
Remedy:
– Adapt thickness of case to the load conditions
– Prevent overloading

Fatigue due to wear

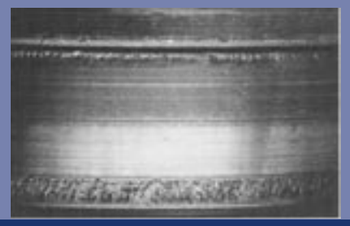
Characteristics:
Local delamination, e.g. on rolling elements of tapered roller bearings, run mark streaky.

Causes:
Change in geometry of rolling elements due to wear in case of contaminated lubricant, e.g. as a result of ingress of foreign matter due to damaged seals. Local overloading in part in connection with insufficient preloading of tapered roller bearings.

Remedy:
– Change lubricant on time
– Filtering of lubricating oil
– Improvement of packing
– Change worn seals in good time
– Special heat treatment for rings and rollers

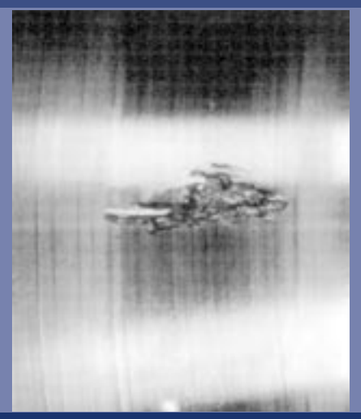


a: Transverse thrust of a roller



b: Race of inner ring and roller with fatigue damage

Wear in certain areas can change the geometry of rolling elements to such extent that it results in fatigue due to local overloading.



Failure mechanism as in this case wear on the edges of the races, transverse thrust of roller

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BEARING FAILURE SYMPTOMS

4c68 Corrosion damage

Corrosion due to moisture (rust)

Characteristics:
Brown discoloration on the race and outer surfaces, in most cased distributed unevenly in the form of individual pits.
In many cases individual rust spots occur with pitting at the interval of the rolling elements (standstill corrosion). Due to capillary action, moisture forms primarily at contact points in case of extended standstill. This later results in wear and premature fatigue, originating from pitting.

Causes:
– Improper storage in warehouse (relative humidity > 60%)
– Considerable temperature changes (formation of condensation)
– Seal failure (increased because lubrication control of dirt)
– Inappropriate lubricant

Remedy:
– Suitable storage according to specifications of the bearing manufacturer
– Improvement of seal (possibly additional cover disks)
– Use of lubricant with anticorrosive additives
– Lubricate more frequently if greased, especially during times of nonuse

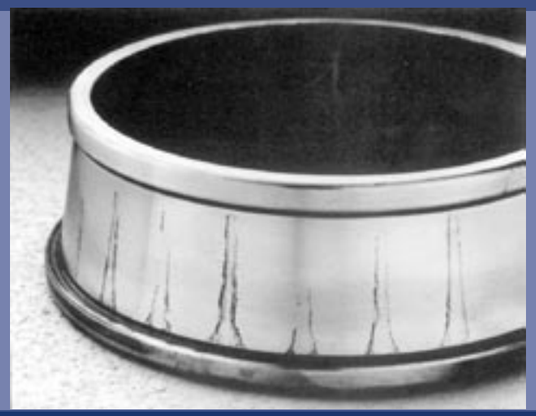
Corrosion due to aggressive media

Characteristics:
Etched pits of black discoloration in most cases

Causes:
– Improper storage in warehouse (storage of aggressive chemicals in the same room)
– Seal failure
– Inappropriate lubricant

Remedy:
– Storage according to specifications of the bearing manufacturer
– Improvement of packing
– Use of lubricant with anticorrosive additives

Rust forming on outer ring of a deep groove ball bearing, which is no longer protected against corrosion due to moisture



Surface damage due to effect of aggressive media. The etched pits have black discoloration in most cases.

Corrosion pits on the race at the interval of the rolling elements

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4c69 Damage due to overheating

Characteristics:
Serious discoloration of bearing parts *) Significant plastic deformation of races and/or rolling elements. Sudden increase in temperature. Frequent jamming of bearing. Hardness far below 58 HRC.

Causes:
The causes cannot be identified in most cases when examining damage resulting from intrinsic heating of overheated bearings.
Possible causes include:
– Bearing clearance too low in operating state, especially in fast-running bearings.
– Insufficient lubrication
– Radial tension due to separate heating
– Excessive lubrication
– Stoppage due to broken cage

Remedy:
– Increase bearing clearance
– In case of external heating, make sure the bearing warms up or cools down slowly to a sufficient extent or the entire bearing warms-up evenly.
– Prevent accumulation of lubricant
– Improve lubrication

***) Note on discoloration:**
Annealing color occurs in connection with damage due to overheating. Depending on the extent of the temperature and its exposure time, it is possible to identify different shades of brown and blue. These are very similar to the oil discolorations which occur more frequently such that it is impossible to conclude that the discoloration is the result of excessive operating temperature. It may be possible to differentiate between annealing color and oil discoloration on the basis of the size of the discoloration. While oil discoloration usually occurs only on rolling elements and directly in the raceway, annealing colors primarily cover a large part of the free bearing surface. Only a hardness test can provide clear proof that extremely high operating temperatures have occurred.

The rollers have left deep indentations in the race during blockage of the overheated cylindrical roller bearing.

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4c70 Fractures

Axial surface cracks or fissures on inner rings

Characteristics:
Ring cracked either completely or in part in axial direction. Fracture edges slightly rounded: Sign that the breakage occurred during operation and was rolled over. In case the cracks have sharp edges, the break occurred during disassembly. The edges of a crack can also be broken in part during extended period of operation.

Causes:
– Slippage of bearing
– Chips in the race
– Rotation of inner ring on shaft
– Insufficient lubrication
– Too snug fit on the shaft
– Shaft keyway
– Out of roundness
– Rubbing of adjacent parts

Remedy:
– Better lubrication (additives, increase amount of oil)
– Find remedy for race damage
– Select suitable fit
– Prevent adjacent parts from rubbing
– Create better seat conditions
– Special heat treatment of rings

Outer ring breakage in peripheral direction

Characteristics:
In most cases the crack runs primarily uniformly in peripheral direction. There are usually multiple fragments.
These breaks normally occur somewhat outside of the middle of the race in case of axial loading. Fatigue damage is often the catalyst. The outer ring shell usually shows an uneven contact pattern.

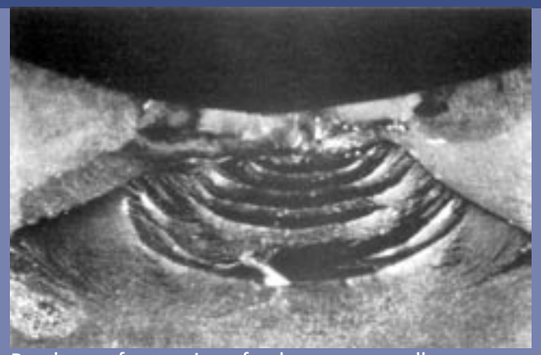
Cause:
Poor support of the ring in the housing.

Remedy:
Improve installation concept.

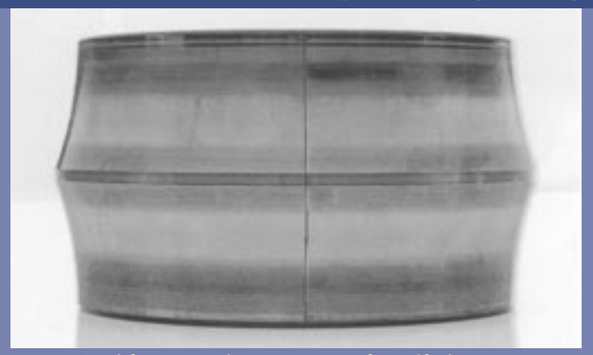
Fatigue failure resulting from race fatigue

Characteristics:
Mostly large-area fatigue damage in the race:
usually stages (lines of rest) in the fractured surface

Causes:
Very advance fatigue damage



Breakage of outer ring of a deep groove roller bearing in axial direction as a result of fatigue



Axial fissure in the inner ring of a self-aligning roller bearing

Outer ring cracked in peripheral direction

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BEARING FAILURE SYMPTOMS

4c71 Frictional corrosion damage

The condition of the seat

Based on the condition of the seat, a wide v Rings mov -
ing against the seats make noise which can be a disturbance. They also result in frictional corrosion and wear. In turn the lubrication may be contaminated by corrosion and/or abrasive particles. Moreover, the ring support may continue to worsen, and the frictional corrosion can make it difficult to take the components apart. Some examples are provided below:

Fretting / frictional corrosion

Characteristics:

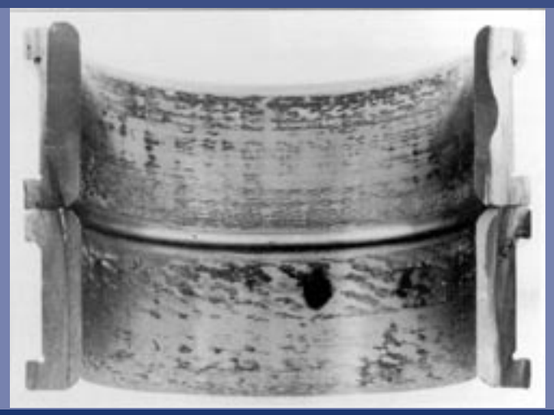
Brown-black spots on the seat, brown abrasion in part close to the bearing or in the lubricant. Wear of the mating surfaces (bore, shell diameter), in case of rotating parts (shaft for the most part) fatigue failure possible, in case of idle parts (primarily housing) possible disturbance of loose bearing function. It is possible to identify such frictional corrosion based on location and size of the load zone and/or a turning of the rings.

Causes:

– Micro-movements between the fitted parts with too loose fit, but no turning rings.
– Disturbances of mating surfaces
– Waves due to laying, deformed housing
– Functionality of movable bearing at the ring with peripheral load

Remedy:

– Ensure functionality of movable bearing at the ring with point load
– Use as snug as possible bearing seat
– Make shaft (housing) more rigid
– Coat bearing seats
– In case of high operating temperatures, use dimensionally stabilized rings (prevents loosening of fit due to ebullition of the rings resulting from structural changes in steel)
– Improve roundness of seats
  Check and, if necessary< improve surface quality of the seats



Frictional corrosion in the borehole of the inner ring of a cylindrical roller bearing with very loose seat

Frictional corrosion makes the size of the load zone apparent on the idle outer ring.