

SHOP MANUAL



GUIDANCE FOR REUSABLE PARTS

BEARINGS



GUIDANCE FOR REUSABLE PARTS
KOMATSU

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INTRODUCTION

This guide shows possible bearing failures and criteria for their reuse. It also explains bearing basics and the causes for bearing failure.

When servicing construction machines, determining whether the existing bearings can be reused is important from the viewpoints of quality and economy. Further, examination of the root causes of failure to avoid their recurrence is also important.

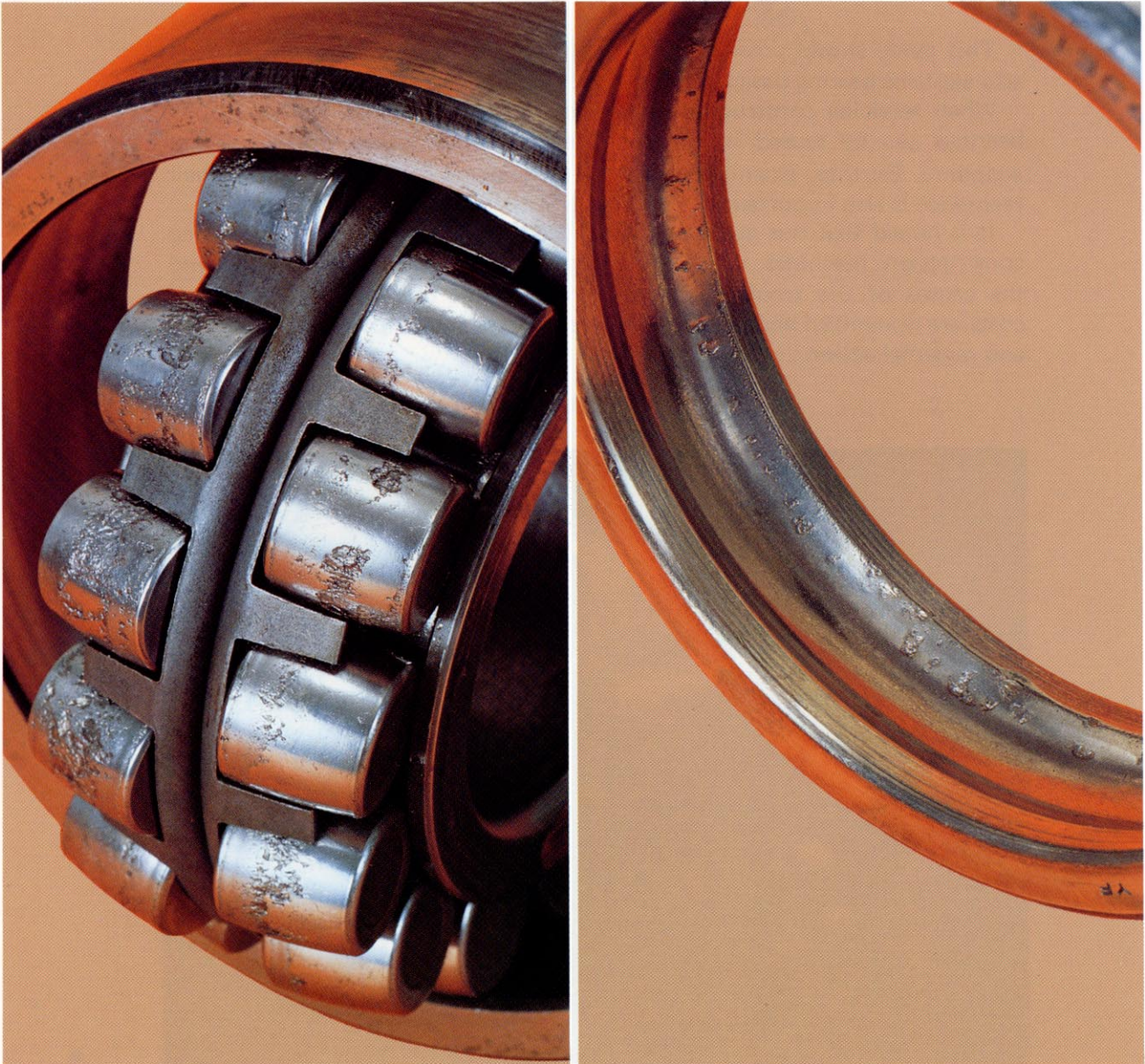
It is hoped that this guide will aid those engaged in servicing or repairing construction machines to diagnose trouble correctly and to understand the causes of the trouble. **Thereby, the machine maintenance and repair costs are minimized and trouble can be prevented by correct troubleshooting and remedial action.**



Note: This publication is intended for guidance only and KOMATSU LTD. hereby expressly denies and excludes any representation, warranty or implied warranty for the reuse of bearings.

REPRESENTATIVE BEARING FAILURES

Flaking



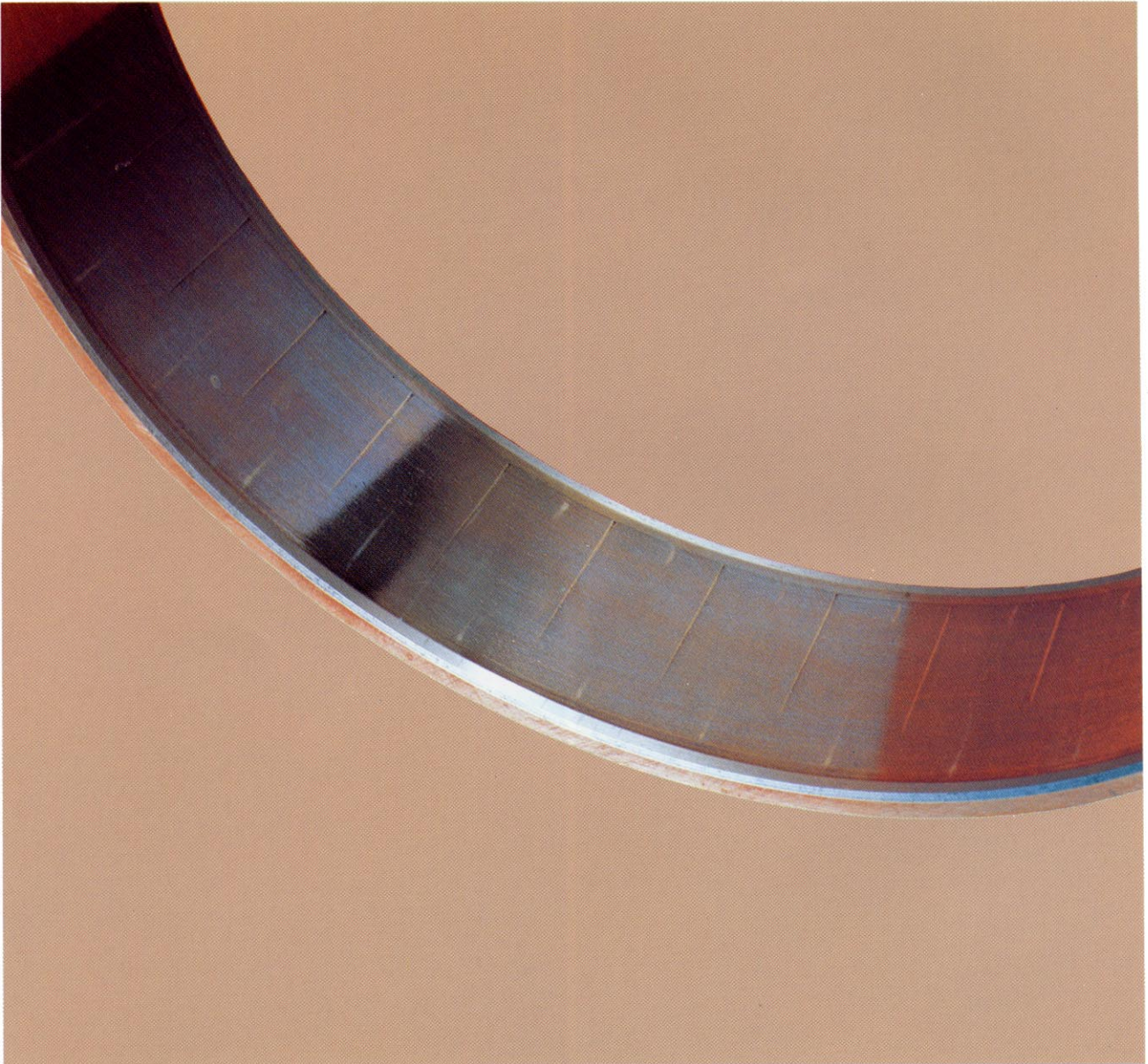
Flaking means the surface of a bearing flaking like the scales on a fish. This happens after running for some time with the rolling surfaces subject to repeated contact loads. This is a fatigue symptom due to rolling movement. When a bearing flakes, it generally indicates the bearing is at the end of its service life.

Seizure



Bearing seizure is where a bearing cannot turn due to severe overheating. Seizing is caused by lack of lubricant, excessive heating, etc. A seized bearing cannot be reused.

Fretting



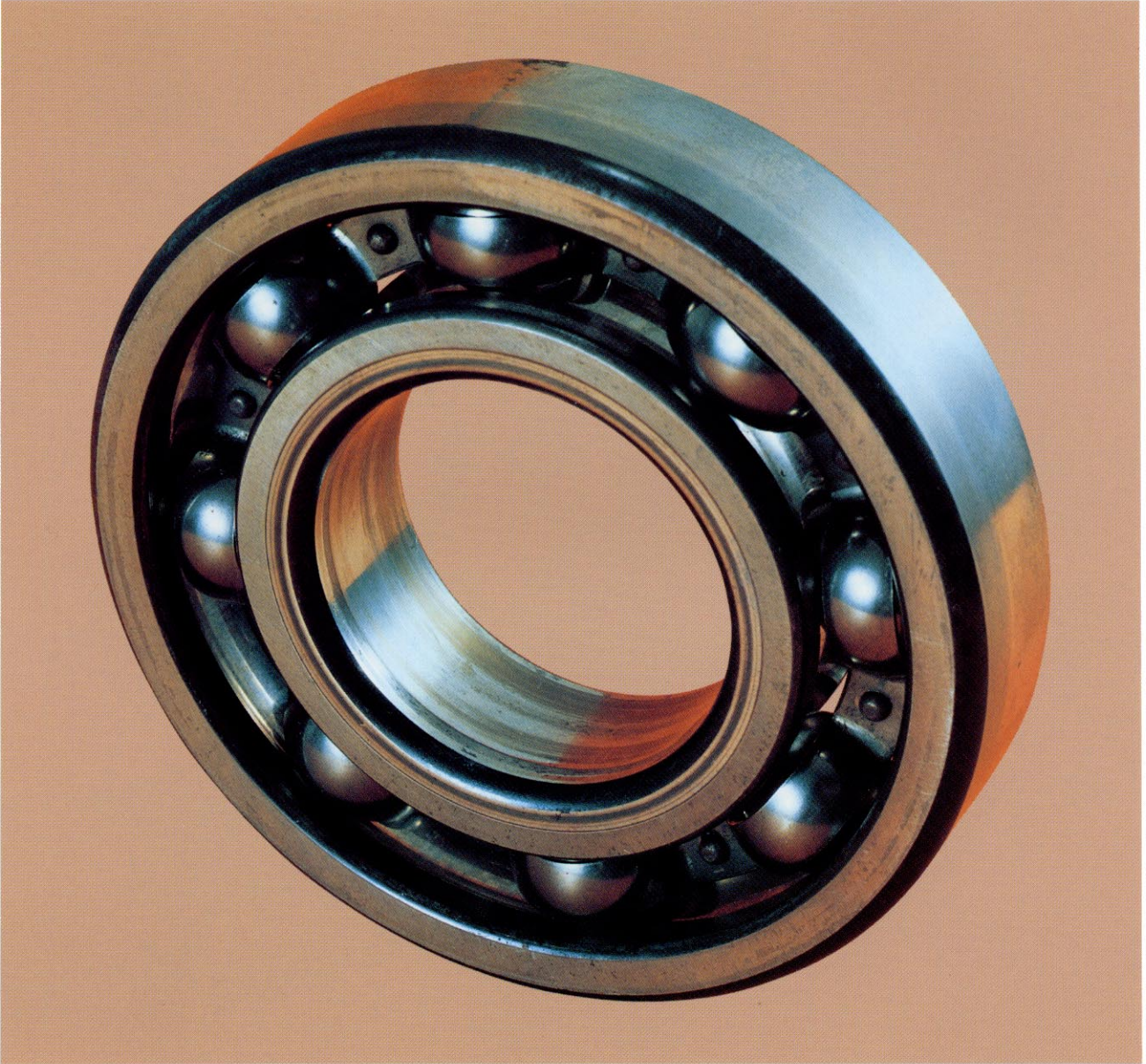
When a bearing is subject to vibration while not running, the bearing wears, giving rust-colored dust on the contacting areas. This is "fretting" which is a defect similar to dents or nicks.

Dent, nick



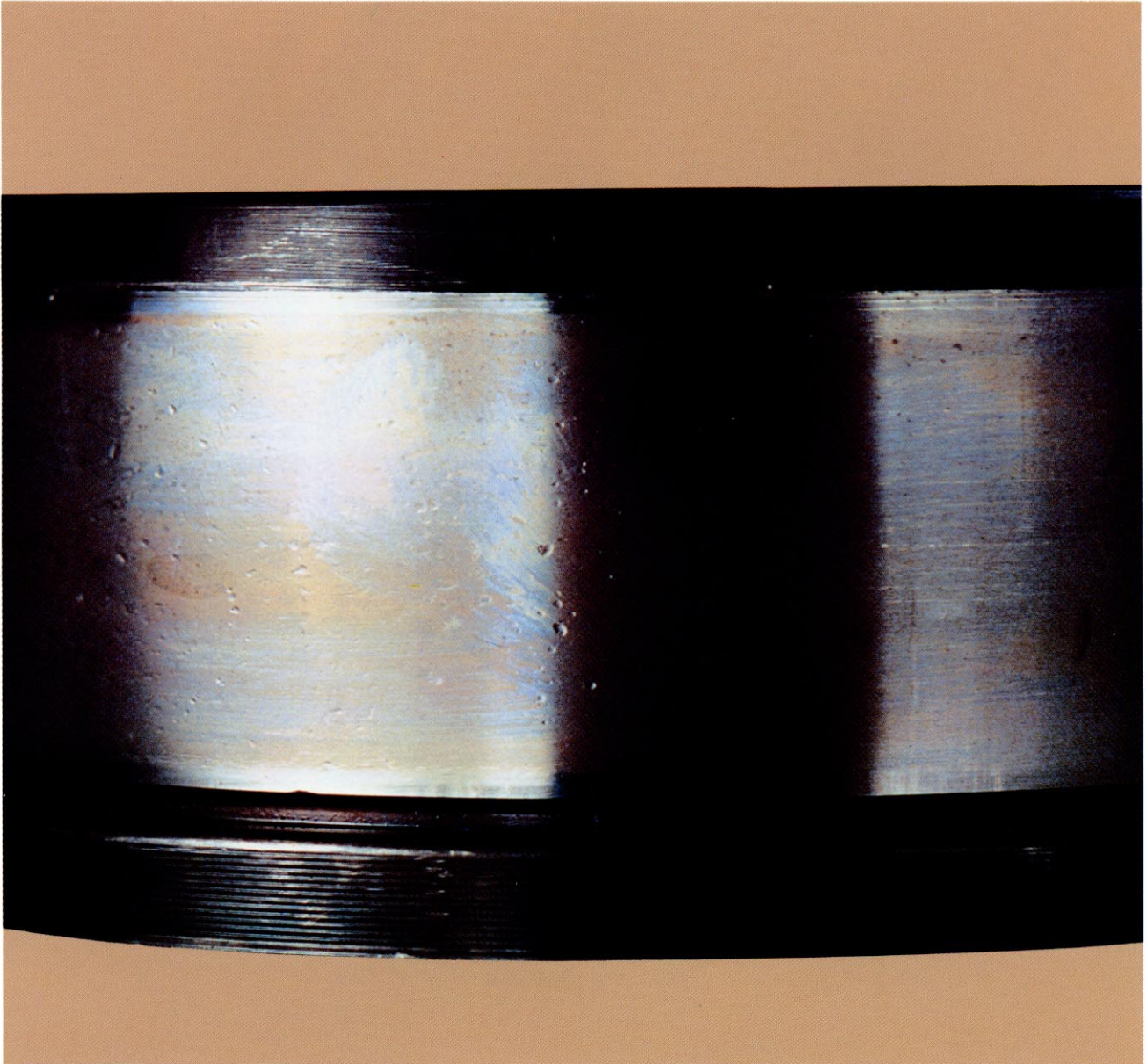
When a bearing runs with solid foreign substances therein, the bearing hits these substances, leaving small dents on the surface. When a bearing is hit with a hammer or the like, nicks are left on the area subjected to the blow or on the contacting surfaces of bearing races.

Creep



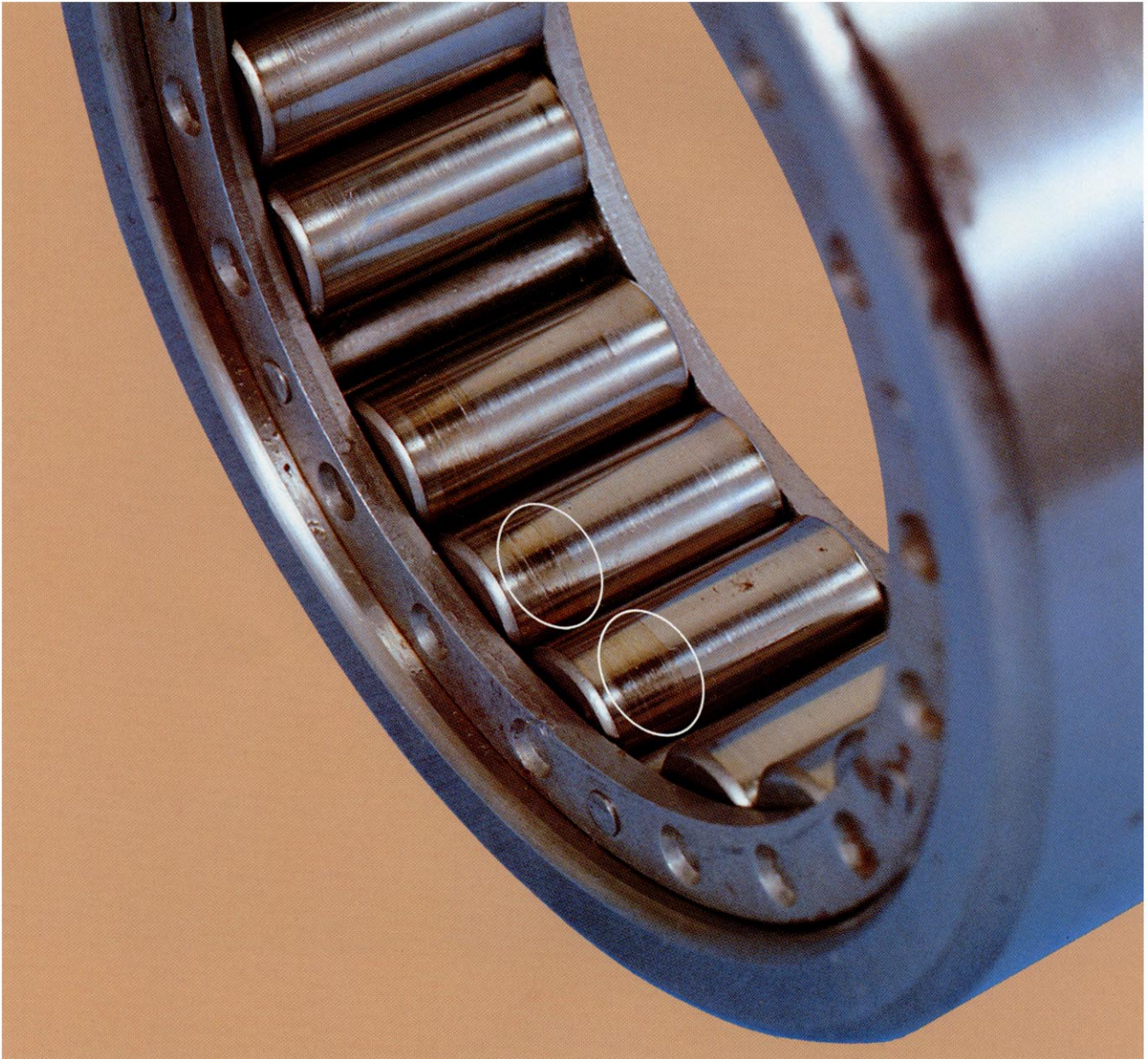
Creep means when bearing outer and inner races roll on and slide over the surface on which they are fit. In the severest cases, the race surfaces are like a mirror surface. This symptom is caused by too loose fitting.

Pitting



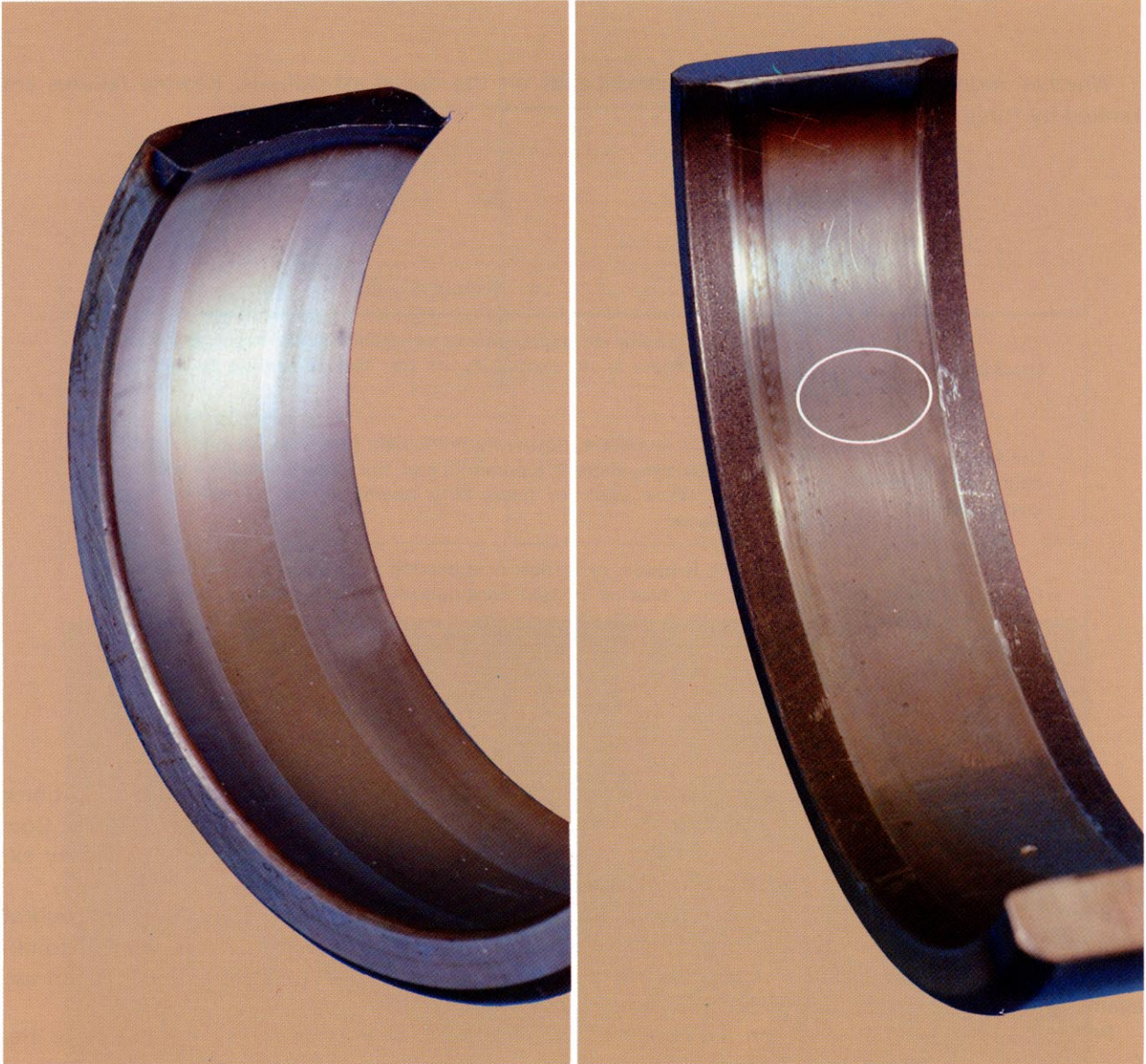
Pitting refers to microscopic size holes formed in the rolling surfaces as a result of rolling fatigue. Pitting frequently develops into flaking.

Smearing



This is a symptom of the bearing rolling surface where clusters of areas which seize slightly are formed locally. Smearing occurs when the balls (or rollers) and the race surfaces rub against each other due to improper lubrication. If these symptoms are slight, the bearing is reusable.

Rough surface (Orange peel)



There are many small dents over all the surface due to foreign substances hitting the surface. If the bearing rolling is not bad despite its rough surface (orange peel), the bearing is reusable.

FAILURE SIGNS AND DIAGNOSIS FOR REUSE

Whether individual bearings are reusable depends on the degree of failures. Bearing failures are ranked by three categories as follows.

Rank	Failure degree
Use again	Failure is minor or slight, posing no problems for machine function. Further, there is no possibility of this failure leading to secondary failures.
Use again only under moderate load condition	Failure is moderate, posing no immediate problems for machine function. However, there is a possibility of this failure causing a secondary failure. When used for heavy-duty operation, such a bearing should be replaced.
Do not use again	Failure is heavy, or critical or a bearing is at the end of its service life. If such a bearing is used continuously, it will cause a serious break down. Thus, such a bearing should be replaced immediately.

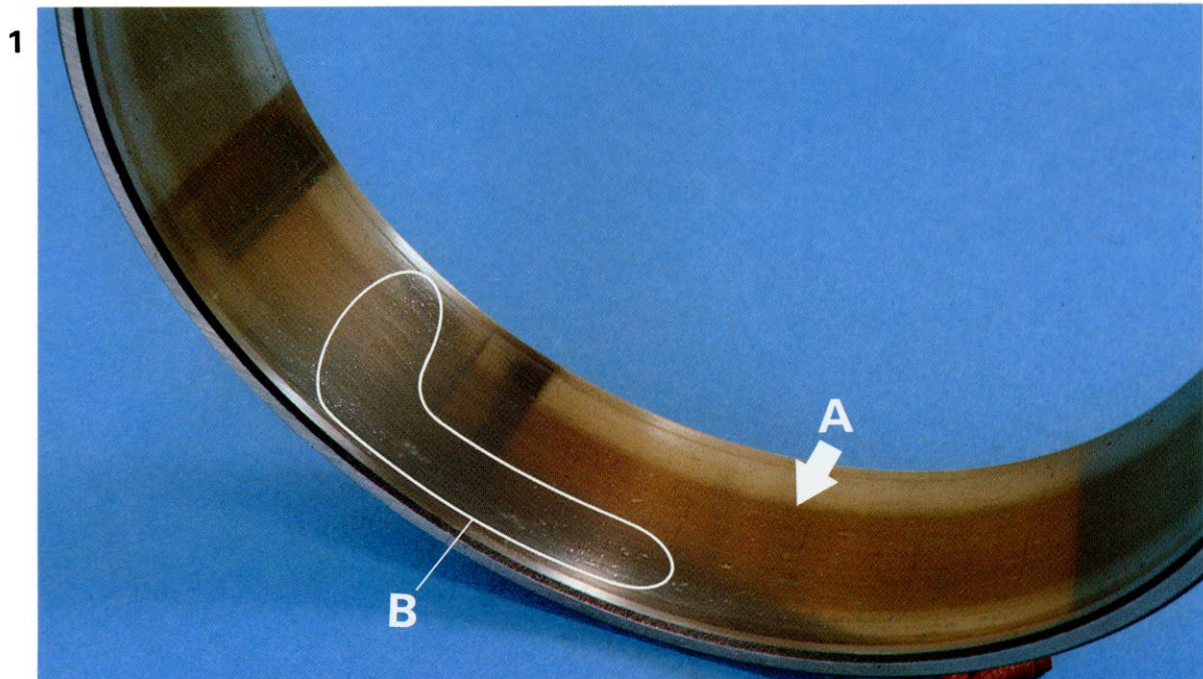
The degree of bearing failures hazard depends on both bearing application and operating conditions; a hazard rank for a certain type of failures may not be the same rank for the other bearings. Consequently, the detrimental effects of a failure, its degree of hazard, etc. must be determined by experience. Refer to the pictures on subsequent pages for ranking bearing failures.

Some failures have two or more symptoms. In such cases, failures should be ranked by the highest degree of hazard. Where a failure is ranked between "Use again only under moderate loading condition" and "Do not use again" according to the reference pictures, its final rank should be "Do not use again" which is the highest degree of anticipated hazard.

Parts usability depends much on the customer's requirement for the remainder of their service life. Consequently, the determination cannot be made unconditionally. It must be considered in context of operating conditions, bearing capability, and length of continued use.

Outer race

Failure sign	Reference picture no.
Discoloring	1 and 2
Dent	1 and 4
Fretting	2 and 3
Nick	5 and 6
Wear	6
Pitting	4 and 7



DO NOT USE AGAIN

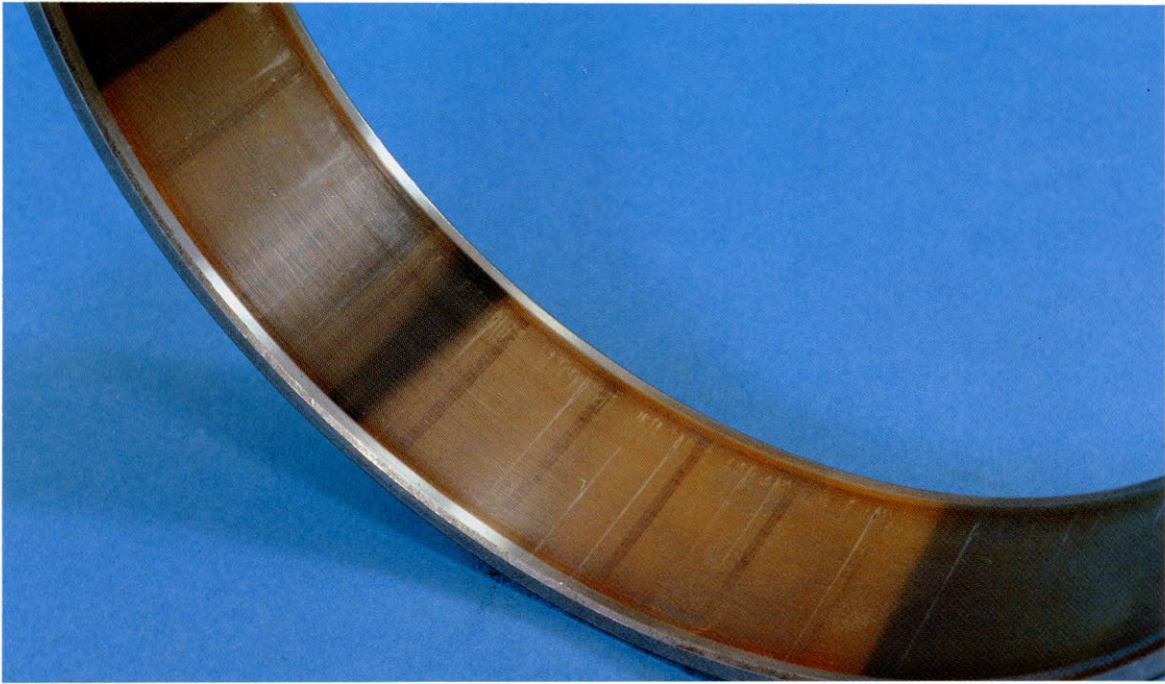
Failure signs

A : Discoloring
B : Dent

Causes

- Deteriorated lube oil
- Contaminated lube oil
- Foreign substances entered into bearing

2



DO NOT USE AGAIN

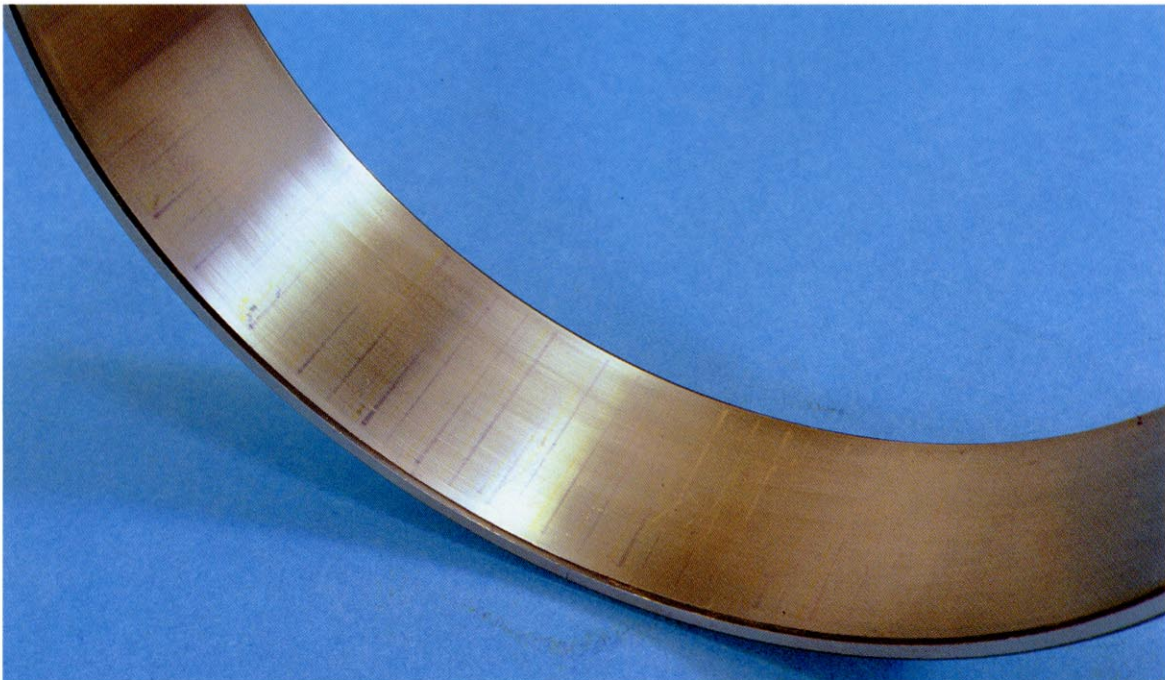
Failure signs

- Discoloring
- Fretting

Causes

- Nicks due to vibration when machine was at a standstill
- Deteriorated lube oil

3



**USE AGAIN ONLY UNDER
MODERATE LOADING CONDITION**

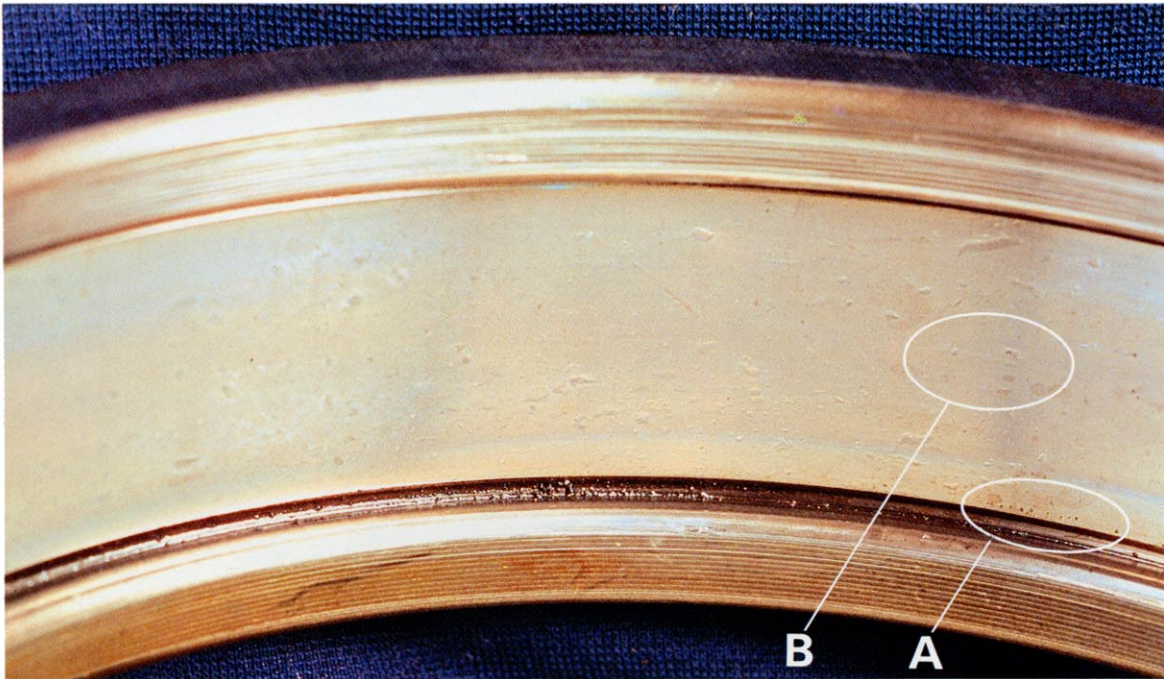
Failure sign

- Fretting

Cause

- Nicks due to vibration when machine was at a standstill

4



DO NOT USE AGAIN

However, criteria for each failure sign are as follows:

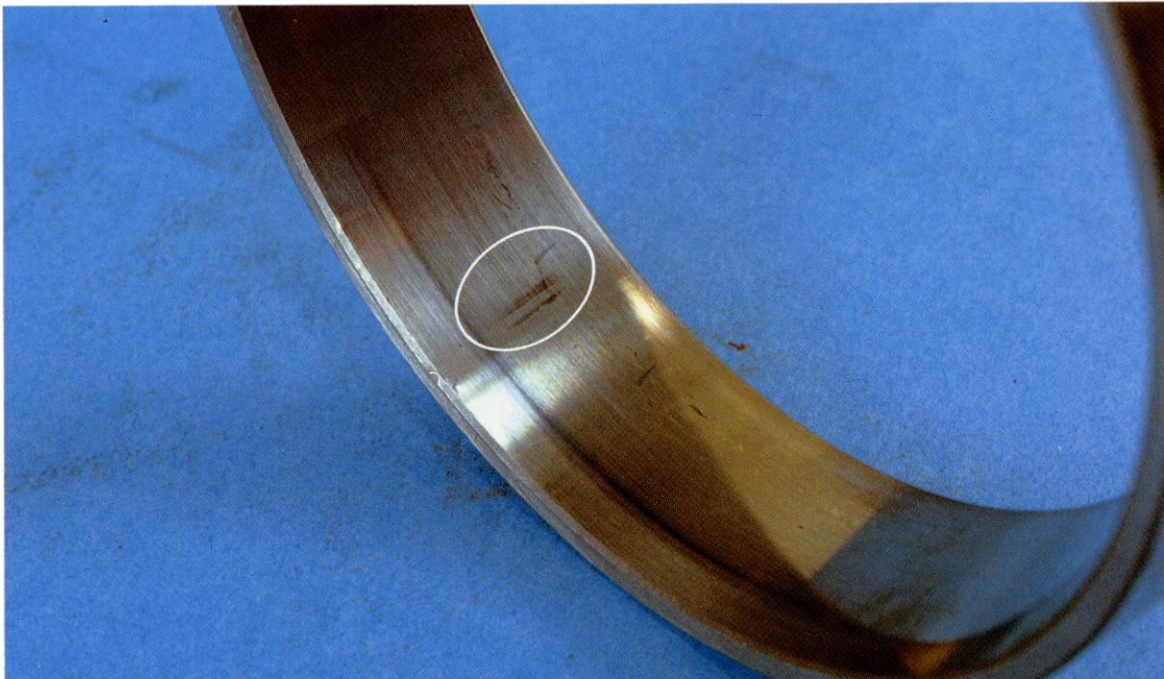
A : Pitting Do not use again

B : Dent Use again only under moderate load condition

Cause

- Fatigue
- Foreign substances entered into bearing.

5



USE AGAIN ONLY UNDER MODERATE LOADING CONDITION

If there are protrusions surrounding the nicks, remove them with an oilstone.

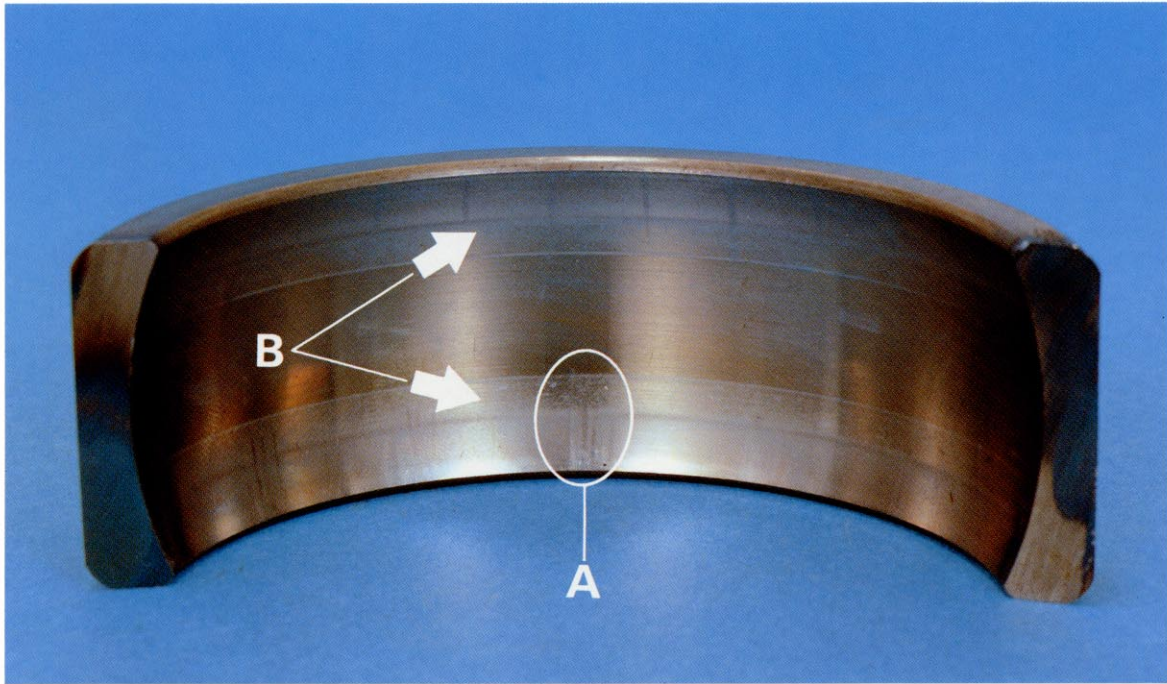
Failure sign

- Nicks

Cause

- Impacts during bearing installation or removal

6



DO NOT USE AGAIN

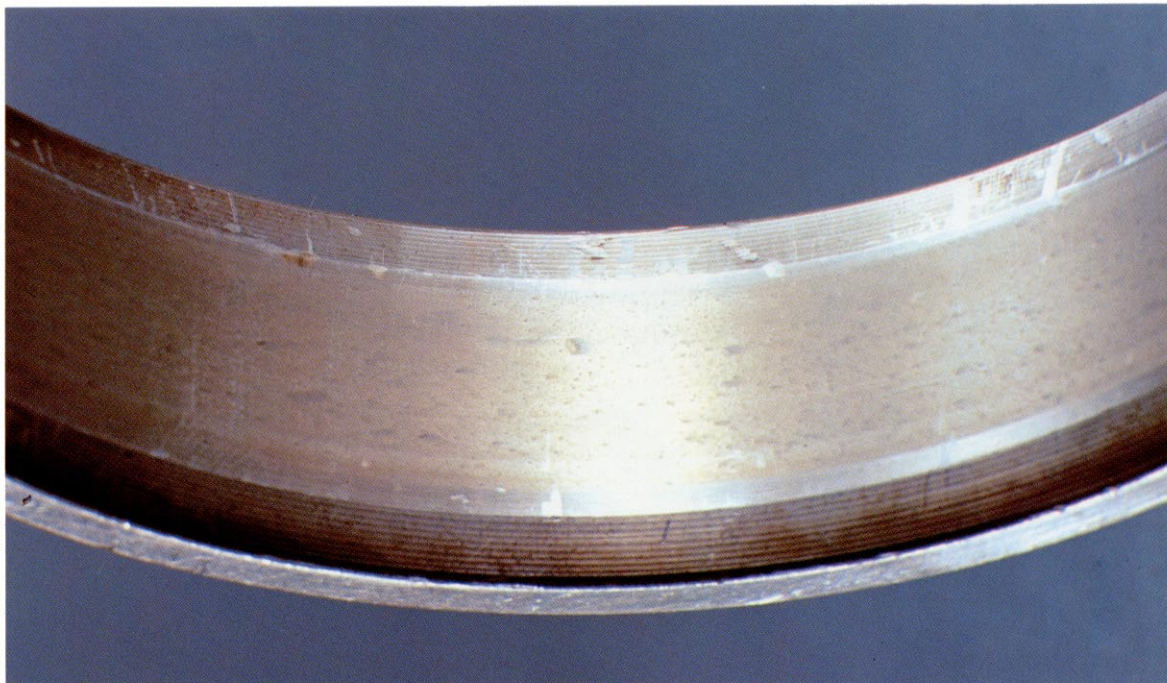
Failure signs

A : Nicks
B : Wear

Cause

- Impacts during bearing installation or removal

7



DO NOT USE AGAIN

Failure sign

- Pitting

Cause

- Fatigue

Inner race

Failure sign	Reference picture no.
Creep	8
Dent	9 and 10
Nick	9
Orange peel	11

8



DO NOT USE AGAIN

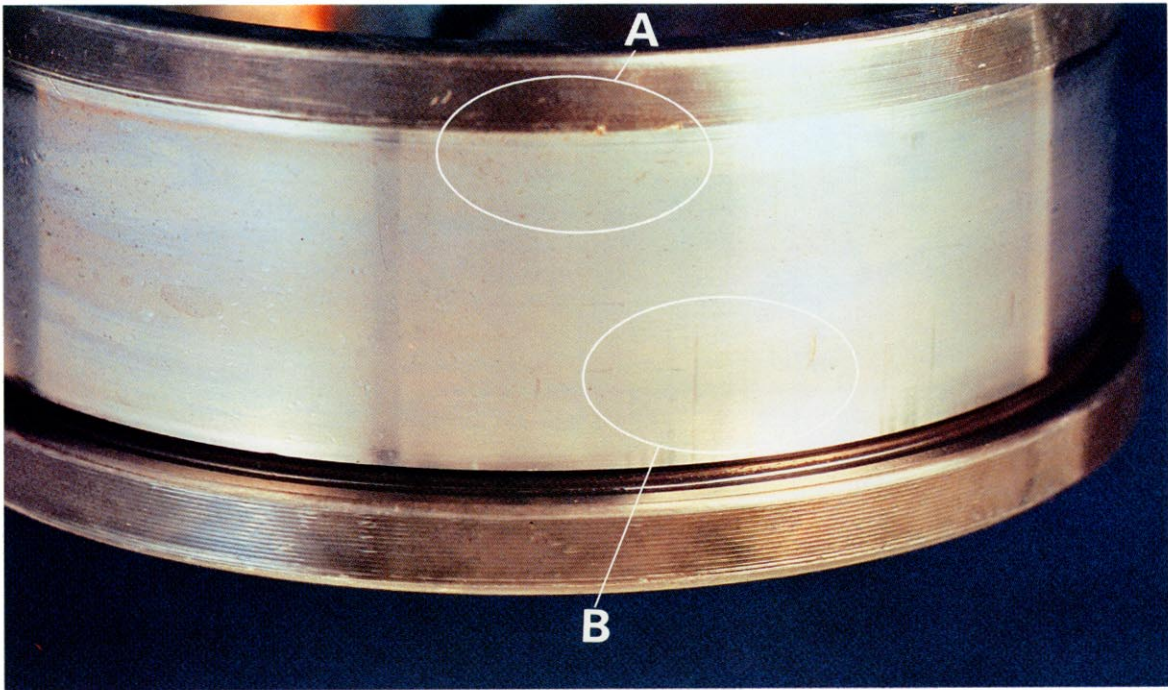
Failure sign

- Creep

Cause

- Improper fitting

9



**USE AGAIN ONLY UNDER
MODERATE LOADING CONDITION**

Failure signs

- A : Nicks
- B : Dents

Causes

- Impacts during bearing installation or removal
- Foreign substances entered into bearing

10



DO NOT USE AGAIN

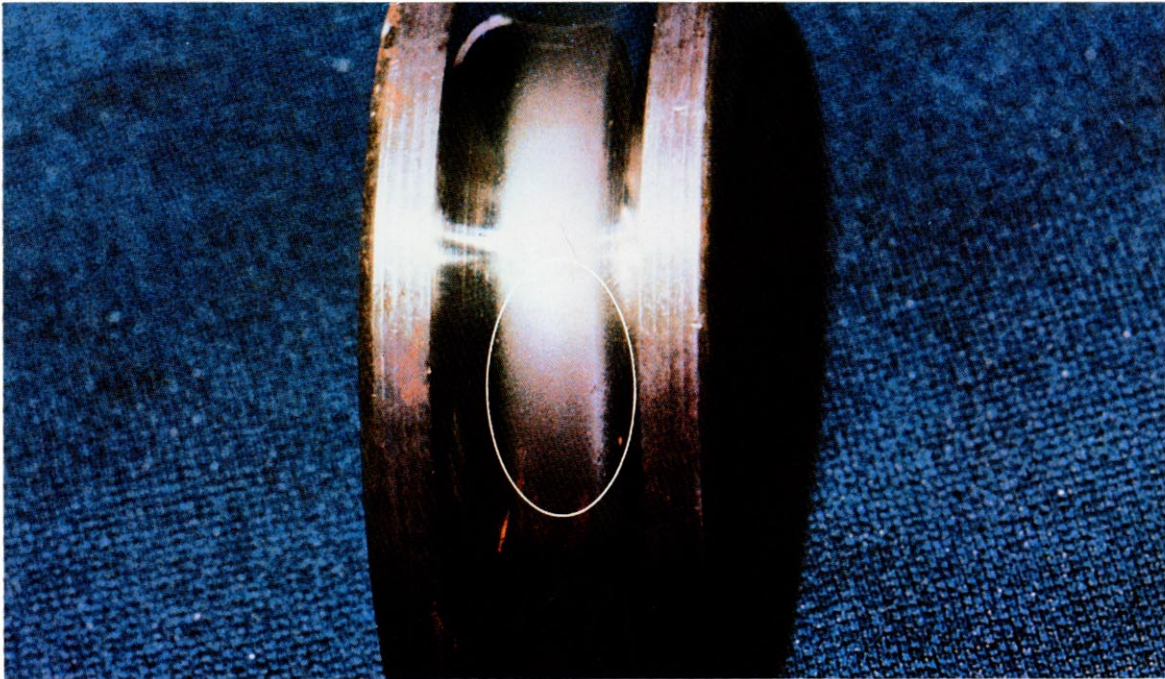
Failure sign

- Dents (brinelling)

Cause

- Dents by overload on balls during bearing installation or removal

11



DO NOT USE AGAIN

Failure sign

- Orange peel

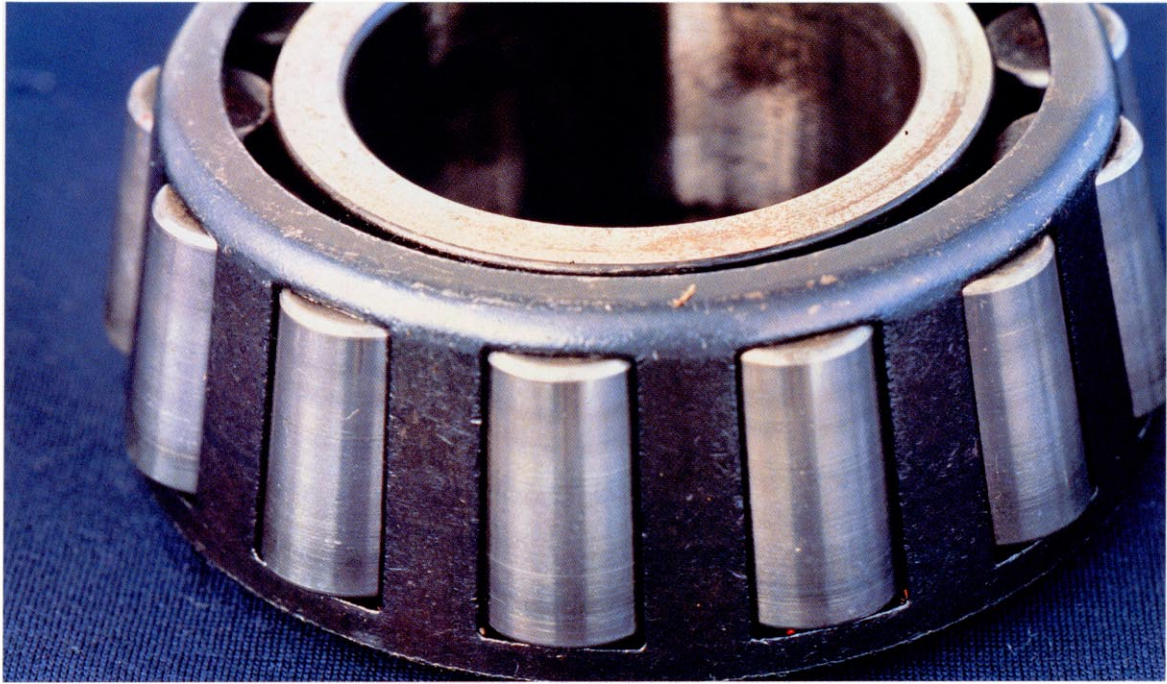
Causes

- Contaminated lube oil
- Foreign substances entered into bearing

Balls (or rollers) and cage

Failure sign	Reference picture no.
Discoloring	12 and 13
Rusting	13
Abrasion flaw	12, 13, 14, 15, 16, 17, 18, 19 and 25
Wear	17, 18, 20, 21, 22, 23 and 24
Dent	24, 25, 26, 27 and 28
Smearing	19, 25, 28 and 29
Corrosion	25
Flaking	31

12



**USE AGAIN ONLY UNDER
MODERATE LOADING CONDITION**

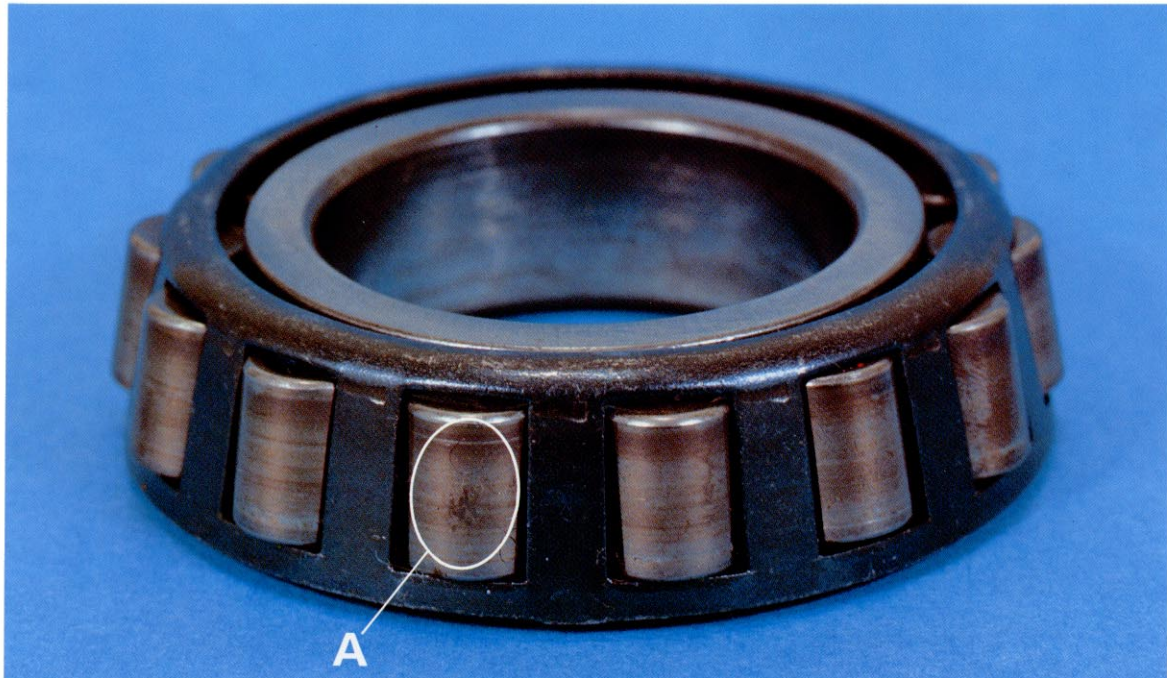
Failure signs

- Discoloring
- Abrasion flow

Causes

- Deteriorated lube oil
- Contaminated lube oil

13

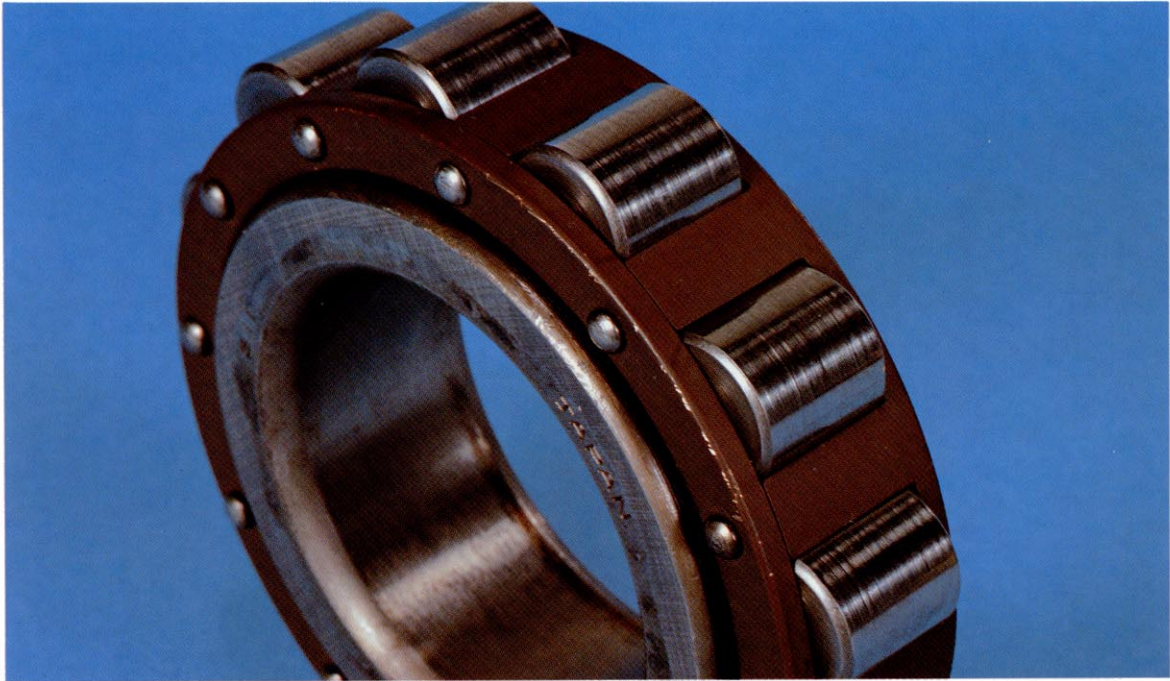


DO NOT USE AGAIN

However, criteria for each failure sign are as follows:

- Discoloring.....
 - Abrasion flaw
- } Use again only under moderate load condition
- A : Rusting Do not use again

14



DO NOT USE AGAIN

Failure sign

- Abrasion flaw

Cause

- Contaminated lube oil

15



DO NOT USE AGAIN

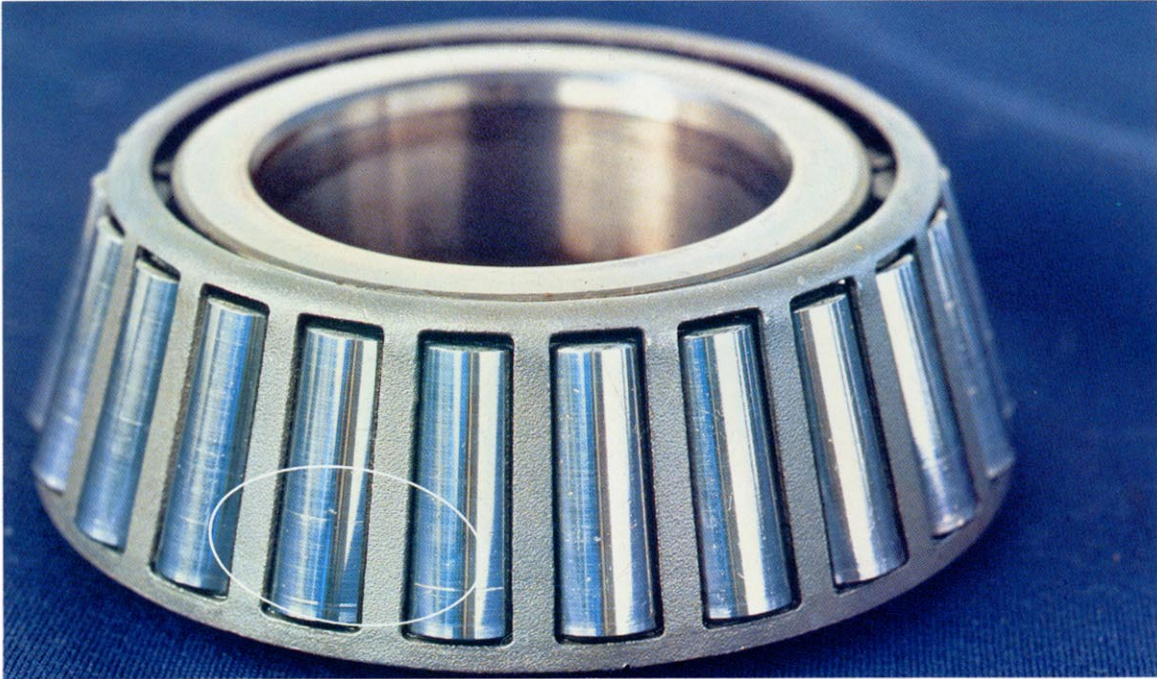
Failure sign

- Abrasion flaw

Cause

- Contaminated lube oil

16



**USE AGAIN ONLY UNDER
MODERATE LOADING CONDITION**

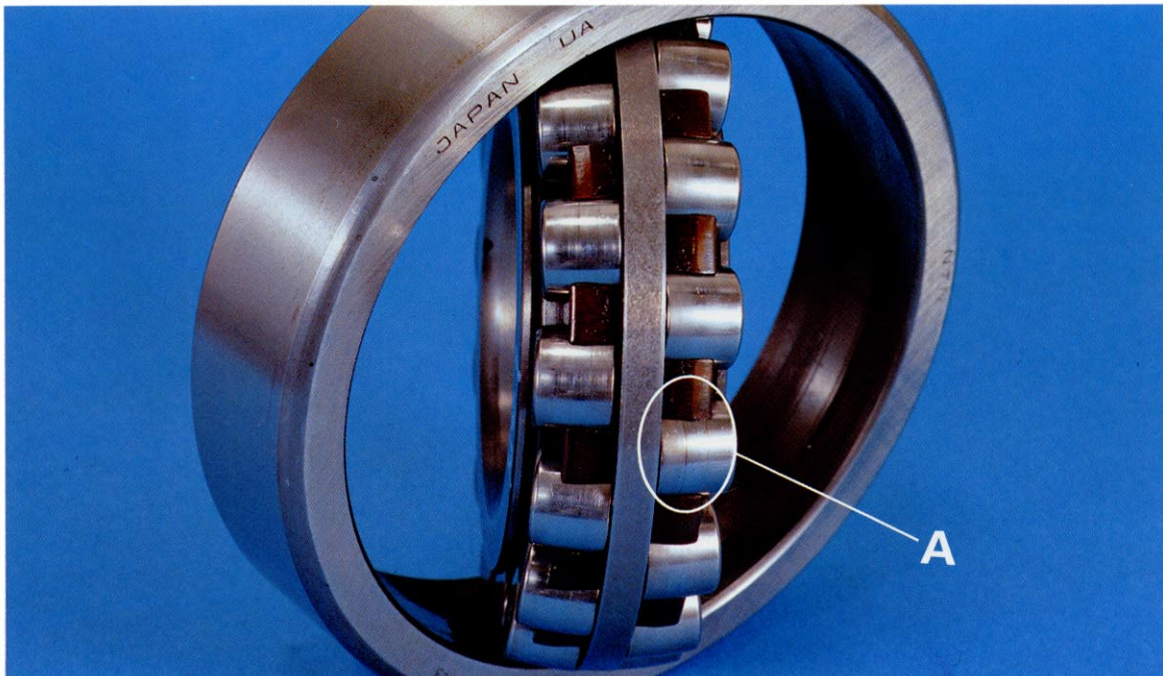
Failure sign

- Abrasion flaw

Cause

- Contaminated lube oil

17



DO NOT USE AGAIN

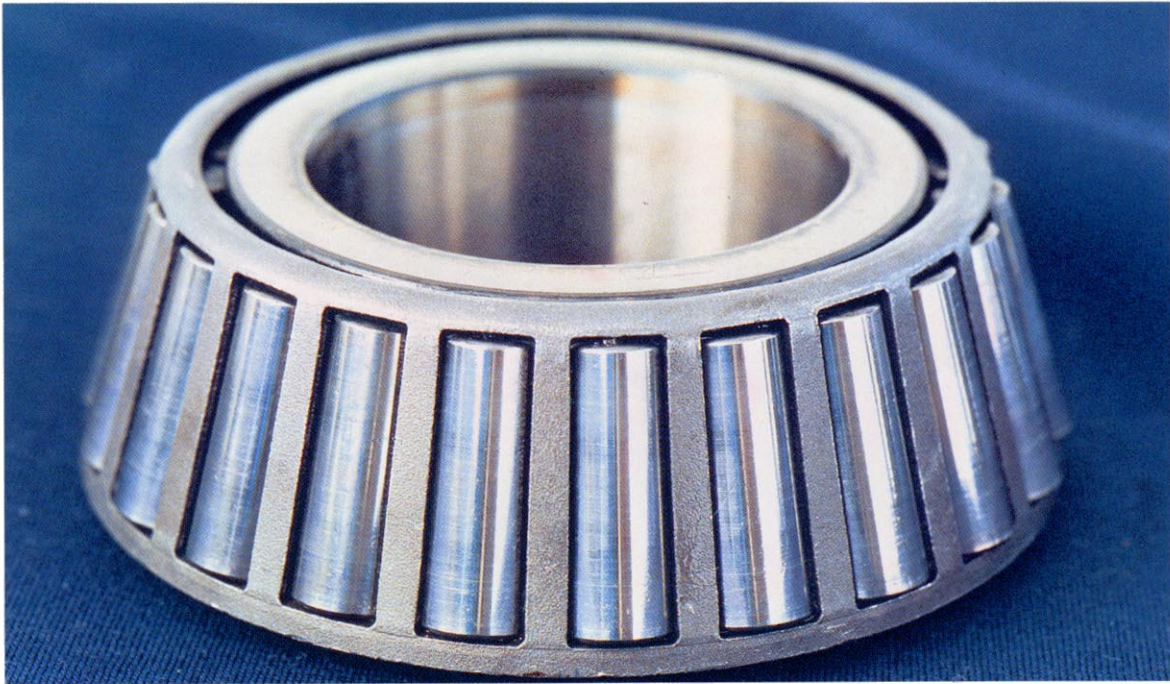
Failure signs

- Wear
- A : Abrasion flaw

Cause

- Contaminated lube oil

18



**USE AGAIN ONLY UNDER
MODERATE LOADING CONDITION**

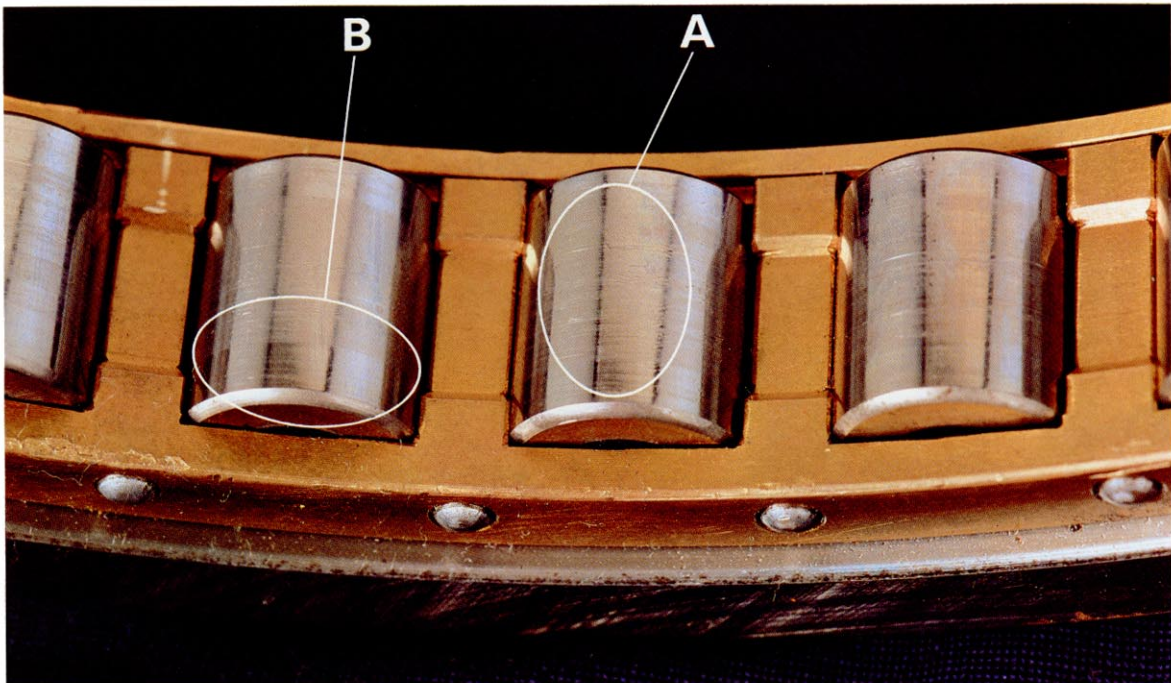
Failure signs

- Wear
- Abrasion flaw

Cause

- Contaminated lube oil

19



DO NOT USE AGAIN

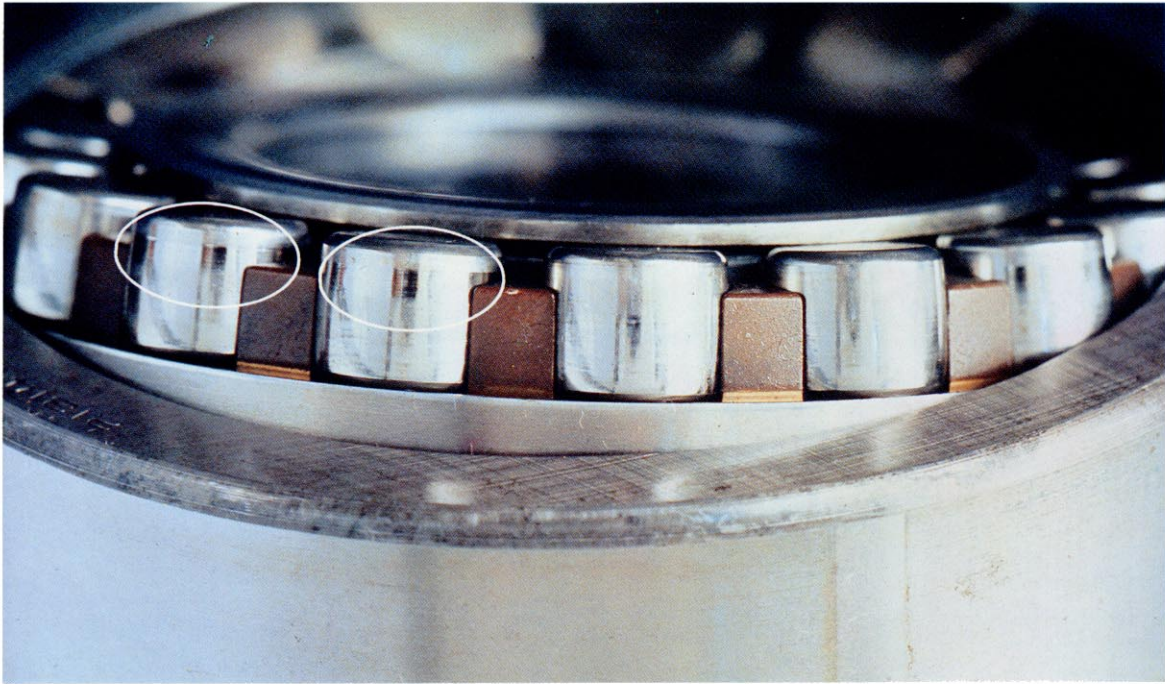
However, criteria for each failure sign are as follows:

- | | |
|------------------------|-------------------------------------------------|
| A: Abrasion flaw | Use again only under moderate loading condition |
| B: Smearing | Do not use again |

Causes

- Contaminated lube oil
- Lack of lube oil

20



DO NOT USE AGAIN

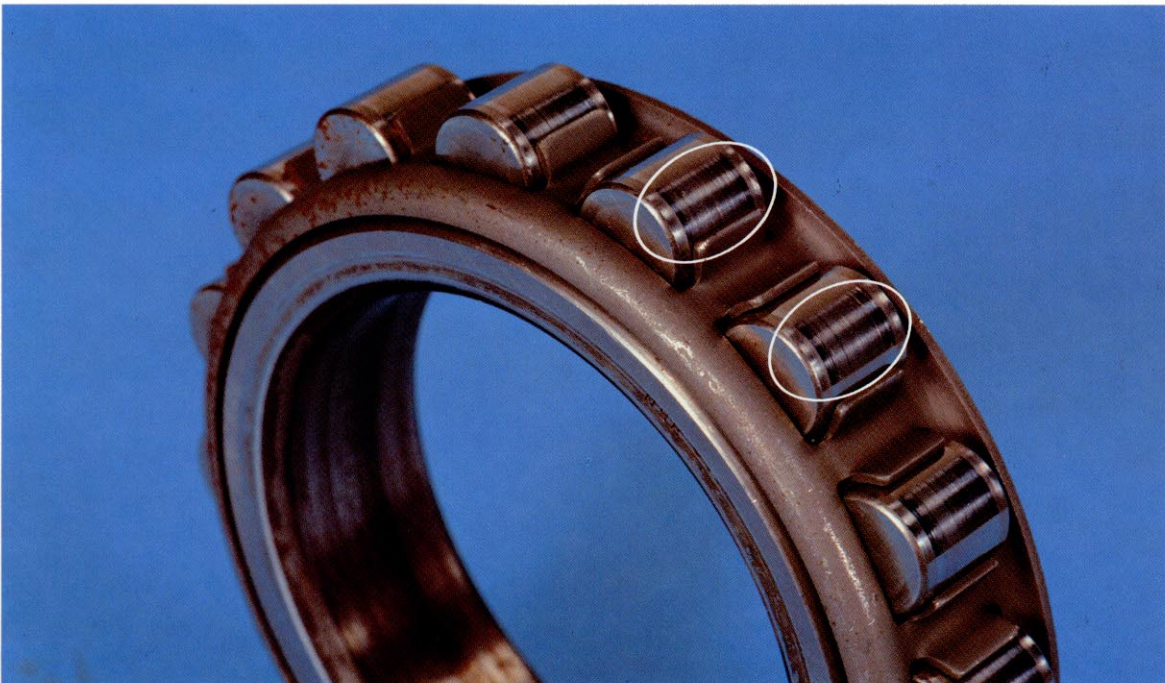
Failure sign

- Wear

Cause

- Contaminated lube oil

21



**USE AGAIN ONLY UNDER
MODERATE LOADING CONDITION**

Failure sign

- Wear

Cause

- Contaminated lube oil

22



**USE AGAIN ONLY UNDER
MODERATE LOADING CONDITION**

Failure sign

- Wear

23



**USE AGAIN ONLY UNDER
MODERATE LOADING CONDITION**

Failure sign

- Wear

24



USE AGAIN ONLY UNDER MODERATE LOADING CONDITION

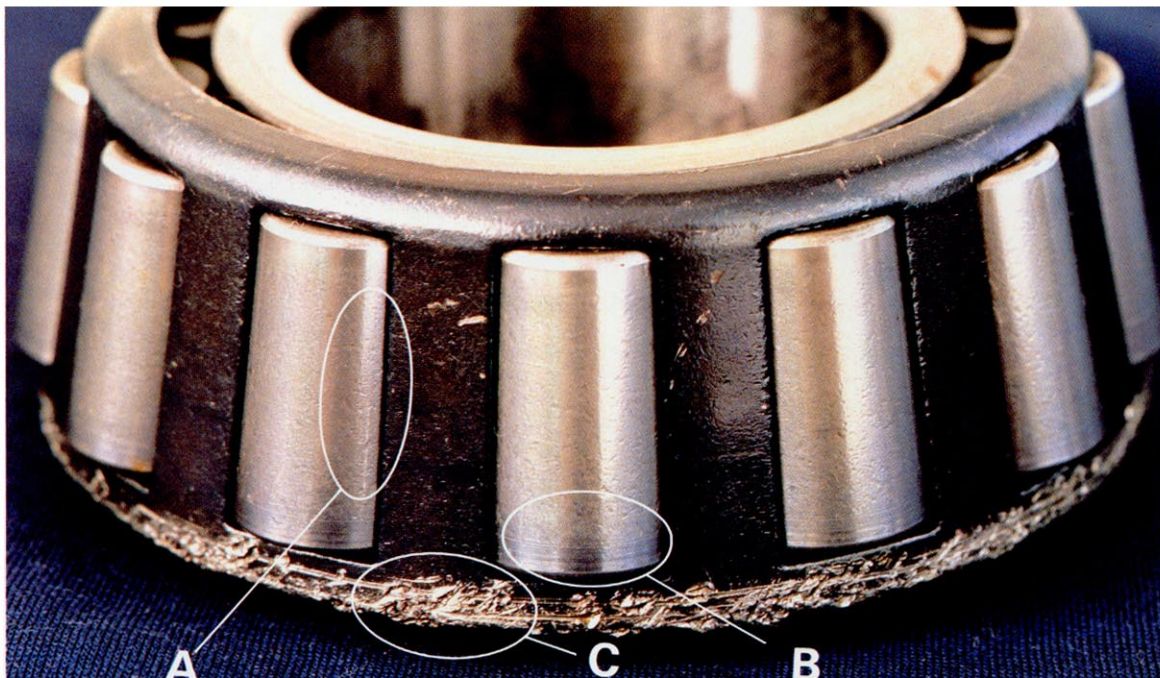
Failure signs

- Wear
- Dent

Causes

- Contaminated lube oil
- Foreign substances entered into bearing

25



DO NOT USE AGAIN

Failure signs

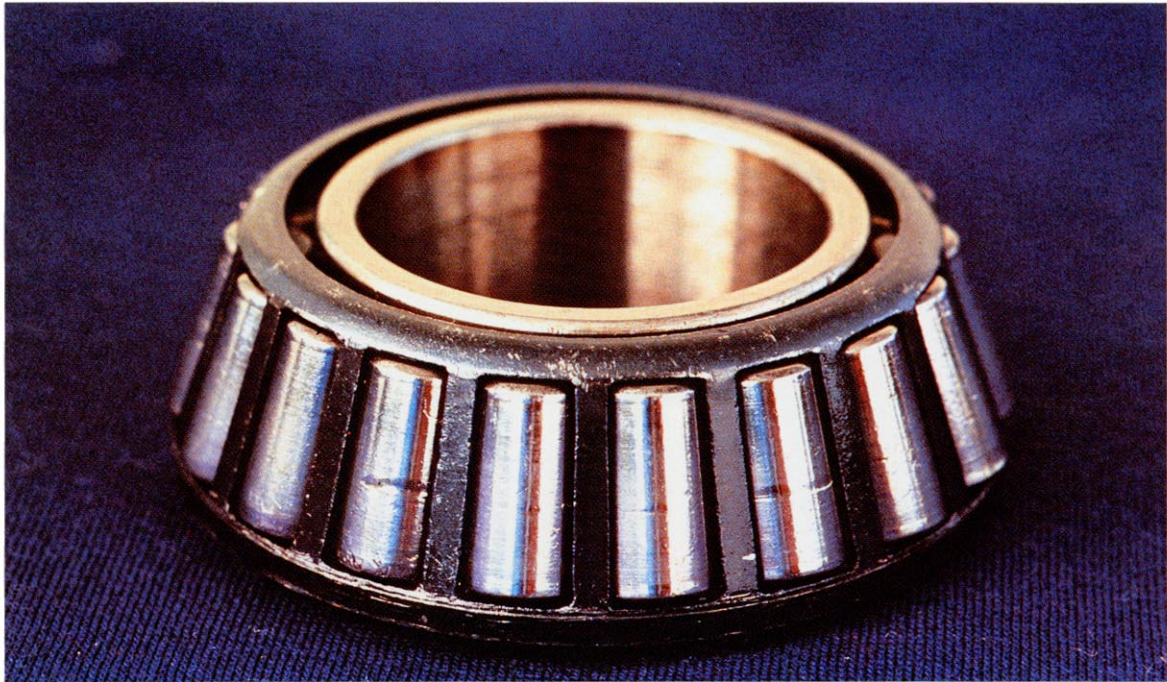
- A : Dent..... Do not use again
- B : Smearing..... } Use again only under
- C : Abrasion flaw ... } moderate load condition

Causes

- Foreign substances entered into bearing
- Lack of lube oil

Note: Abrasion flaw has made by the other parts

26



DO NOT USE AGAIN

Failure sign

- Dent

Cause

- Foreign substances entered into bearing

27



**USE AGAIN ONLY UNDER
MODERATE LOADING CONDITION**

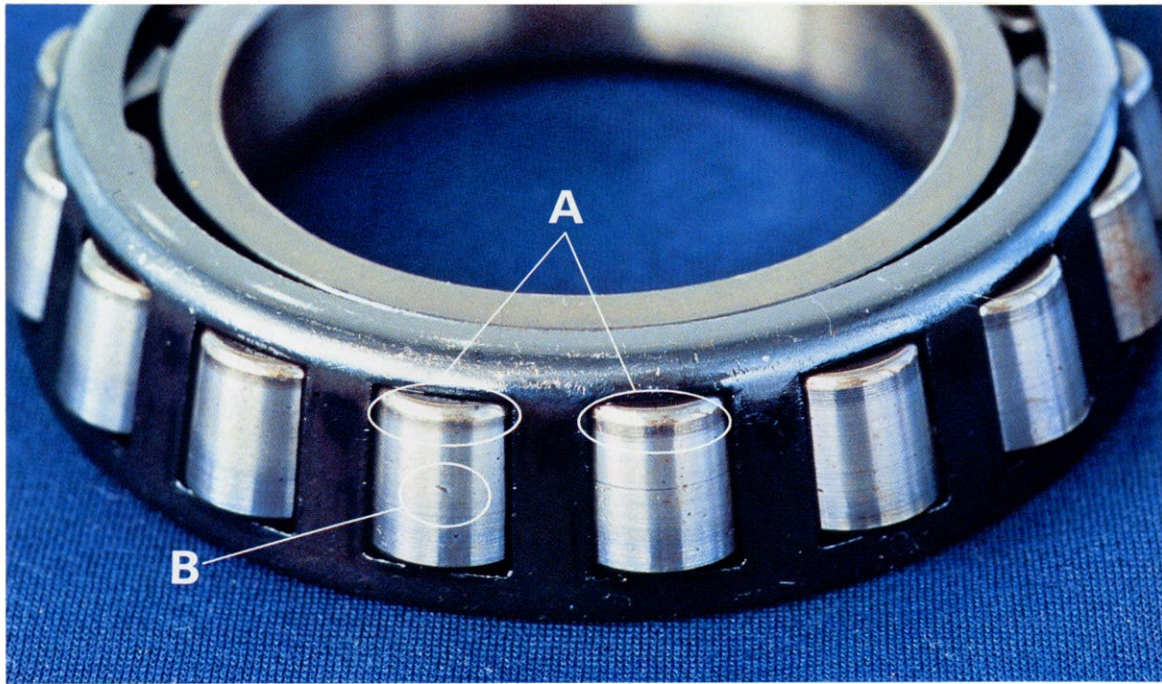
Failure sign

- Dent

Cause

- Foreign substances entered into bearing

28



DO NOT USE AGAIN

Failure signs
A : Dent
B : Smearing

Causes

- Lack of lube oil
- Contaminated lube oil
- Foreign substances entered into bearing

29



DO NOT USE AGAIN

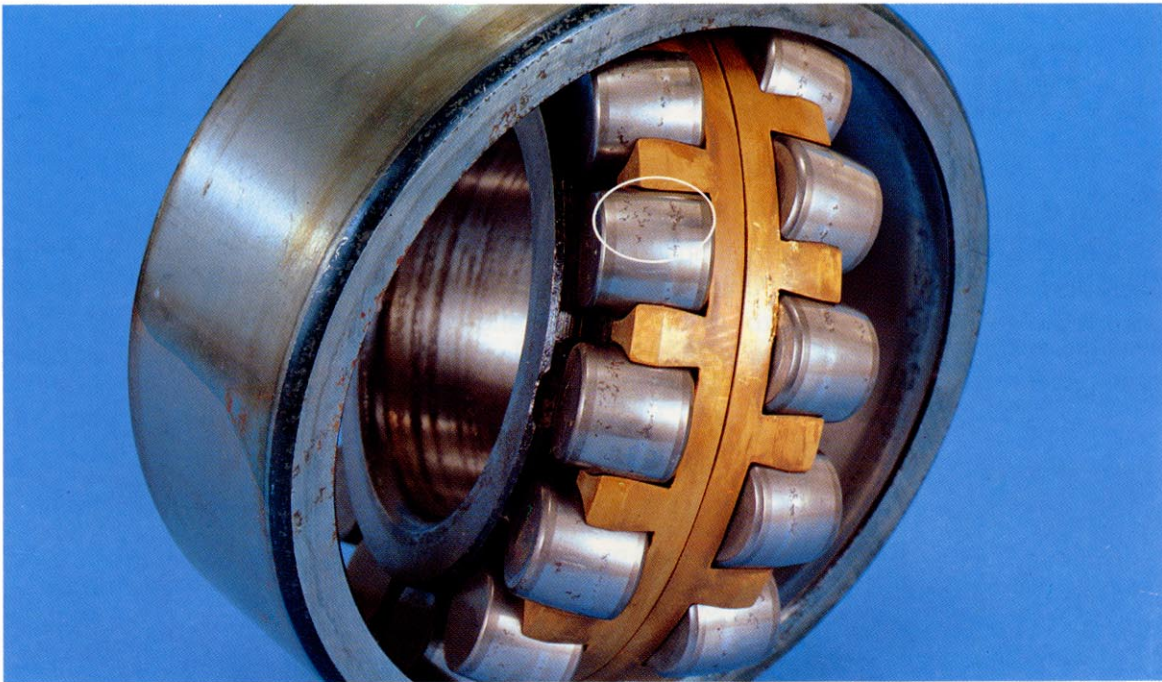
Failure sign

- Smearing

Cause

- Lack of lube oil

30



DO NOT USE AGAIN

Failure sign

- Corrosion

Cause

- Lube oil deteriorated and contaminated with water

31



DO NOT USE AGAIN

Failure sign

- Flaking

Cause

- End of service life

FAILURES AND THEIR CAUSES

Failure times and their causes

A bearing failure may become apparent immediately after starting operation, or during operation, or not be noticed until the machine is overhauled. Knowing when a failure occurred is an important indicator of the cause of failure.

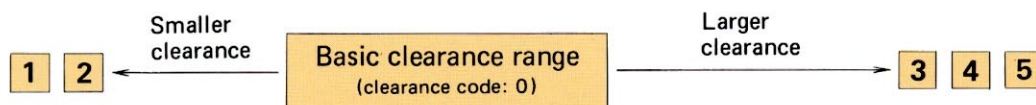
The following table shows the relationship between failure time (or discovery) and cause of failure.

Failure cause \ Failure time	Erroneous bearing selection	Improper handling or installation of bearing	Part failure other than bearing	Failure due to lubricant	Faulty sealing part
Immediately after starting operation	○	○	○	○	
During normal operation		○	○	○	
In overhaul				○	○

Erroneous bearing selection

Improper radial clearance

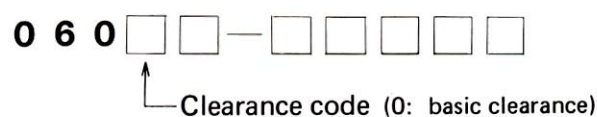
The radial clearance ranges are shown as follows.



When a bearing with smaller than specified radial clearance is used, clearance is eliminated after installation or during operation. This causes overheating, abnormal sounds, seizure, premature flaking, etc.

When a bearing with larger than specified radial clearance is used, vibration increases, which may shorten its service life.

Consequently, a bearing conforming to the specified clearance should be used. In KOMATSU bearing part numbers the fourth figure indicates the clearance.



Unacceptable combination of bearing parts

Outer and inner races for taper roller bearings made by different manufacturers are not mutually interchangeable. Consequently, they must not be used together even if they are of the same type number.

For cylindrical roller bearings, their outer and inner races are interchangeable between some makes. Unless their interchangeability is confirmed, bearing parts must not be interchanged with those of other makes.

Improper handling or installation of bearings

Embedded foreign substances

If dirt, dust or other foreign substances enter a bearing, rotation will be impaired leaving abrasion flaws, dents, orange peel surface or wear on the rolling surface. This will in turn, cause abnormal noise, seizure, or breaking in the worst cases.

For this reason, it is necessary to wash and install bearings in a clean working environment. Shafts and housings should also be kept clean in the same manner. Covers are required to prevent dirt, dust or other foreign substances from sticking to bearings, shafts and housings during storage.

Impacts during handling

Bearings can be nicked, dented or gouged by impacts which can cause premature flaking.

Careless heating

If bearings are heated for their assembly by a bearing heater, care should be taken not to heat them above 120°C (248°F).

If they are heated over 120°C (248°F), the material hardness will be reduced, resulting in shortened life.

Parts failures other than bearings

Insufficient or excessive interference fit

Proper interference fit between inner race and shaft, or outer race and housing is imperative. When a component part has been reconditioned, it should be checked for proper interference fit.

If the interference is too small, the outer or inner race become loose and run out from the housing or shaft, causing fretting or creep.

If the interference is too large, inner clearances of bearing are eliminated, causing abnormal noise, overheating, seizure, premature flaking.

Imperfect cylindricity of fitting surfaces

If a shaft or housing is not within the proper limits of cylindricity, the rollers and races of a roller bearing may partially contact each other, causing abnormal noise, overheating or premature flaking.

Out of roundness of fitting surfaces

The race contour is effected by the fitting surface of shaft or housing, possibly deteriorating the roundness of the race. Particular in an interference fit, the effects of the fitting surface is significant.

If the race face becomes out-of-round, inner clearances of bearing may sometimes be partially eliminated. And, a large internal load will occur at such portions, causing overheating and premature flaking of the bearing.

Fitting surfaces not perpendicular

For a small interference fit or a clearance fit, a bearing should be installed to conform to the shoulders of the fitting surfaces.

If the outer and inner races are inclined relative to each other, the races and balls (or rollers) may partially contact each other, causing premature flaking and the cage to break.

Lack of uniform contact of fitting surfaces

If a keyway or spline groove is extended onto the bearing fitting surface, the races may be deformed by the grooves in the shaft.

If deformation occurs, operating sound level increases or the load will concentrate on the areas having no grooves, causing premature flaking.

Nicks on the fitting surfaces

If the fitting surface is partially raised by nicks, the bearing races will also be raised, and the load will concentrate on such raised portions, causing premature flaking.

Failures due to lubricant

Improper supply of lubricant

Any of the designated lubricants may be used. The amount supplied must be neither too large nor too small. The lubricant must be changed periodically.

If the lubricant is deteriorated, its lubricating performance is reduced, causing bearing overheating, rusting, wear or seizure.

Mixed lubricants

Do not mix different brands of lubricants. If mixed, lubricants sometimes lose their lubricating properties.

Faulty sealing parts

Failures of a labyrinth packing on a shaft or housing, too little grease added or grease solidification will destroy the sealing effect. Wear or damage to oil seals and O-rings make sealing incomplete. In such cases, gear wear dust, dirt, water or other foreign substances infiltrate into bearings.

Bearings are worn, rusted or dented by the foreign substances and this may sometimes cause overheating, seizure or premature flanking.

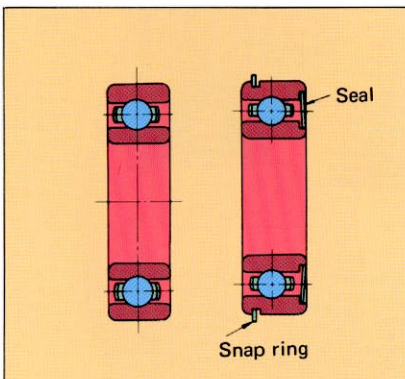
BEARING BASICS

Types of bearings

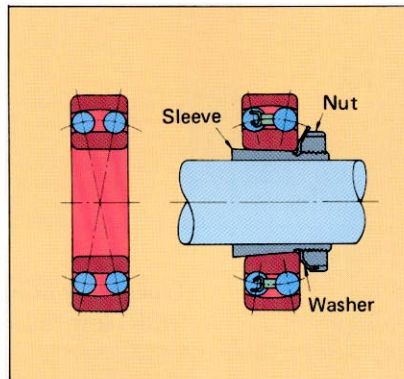
Various types of bearings are shown as follows. Proper bearings are selected depending on operating conditions — the load direction and size, running speed, setting space, lubrication method, etc.

For radial loads

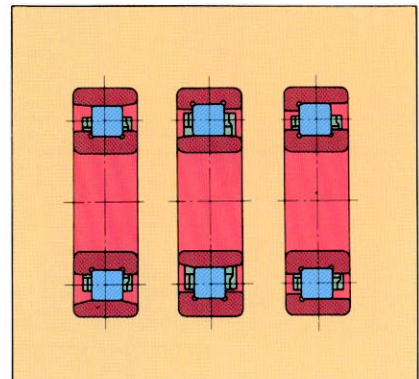
Deep groove radial ball bearings



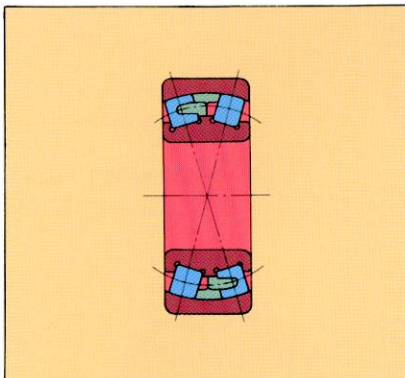
Self-aligning ball bearings



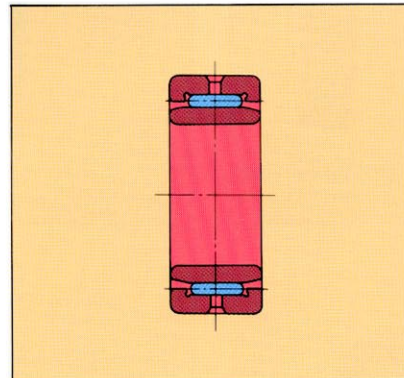
Cylindrical roller bearings



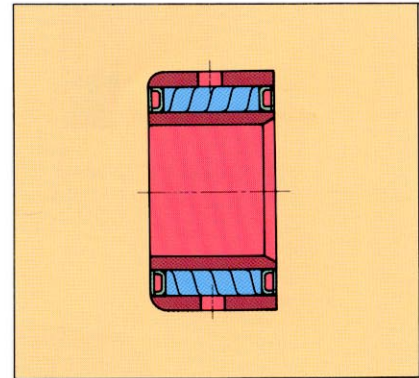
Self-aligning roller bearing
(with spherical rollers)



Needle bearing
(with needles)

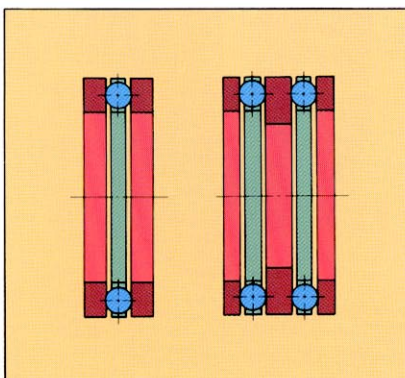


Flexible roller bearing
(with flexible rollers)

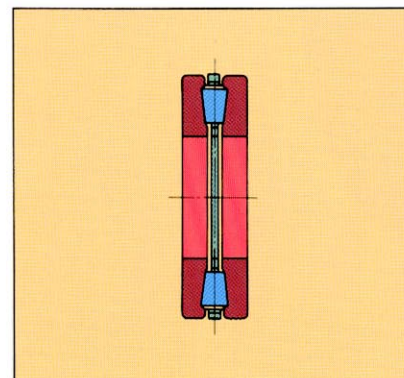


For thrust load

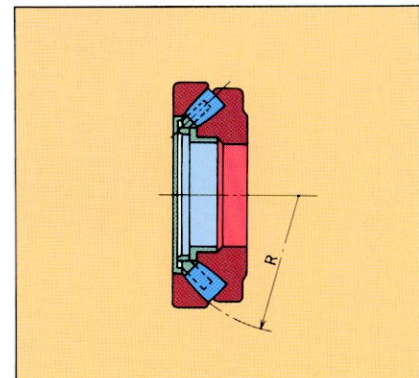
Thrust ball bearings
(with balls)



Thrust taper roller bearing
(with taper rollers)

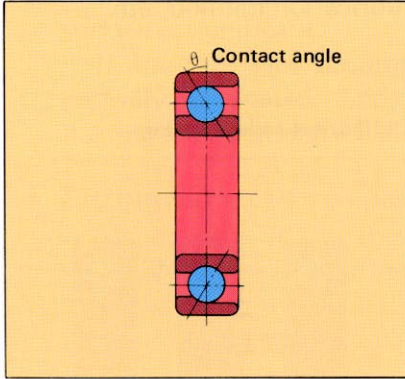


Thrust self-aligning roller bearing
(with spherical rollers)

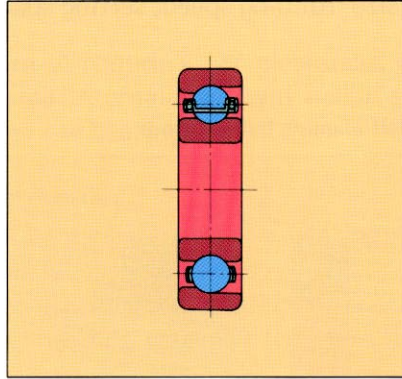


For combined loads

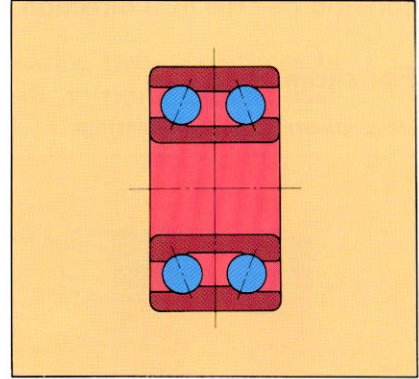
Angular ball bearing



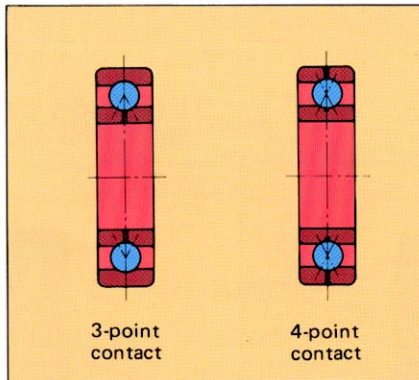
Magnet ball bearing



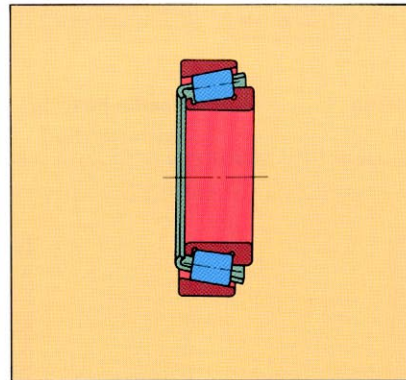
Double-row angular ball bearing



3-point contact ball bearing
4-point contact ball bearing

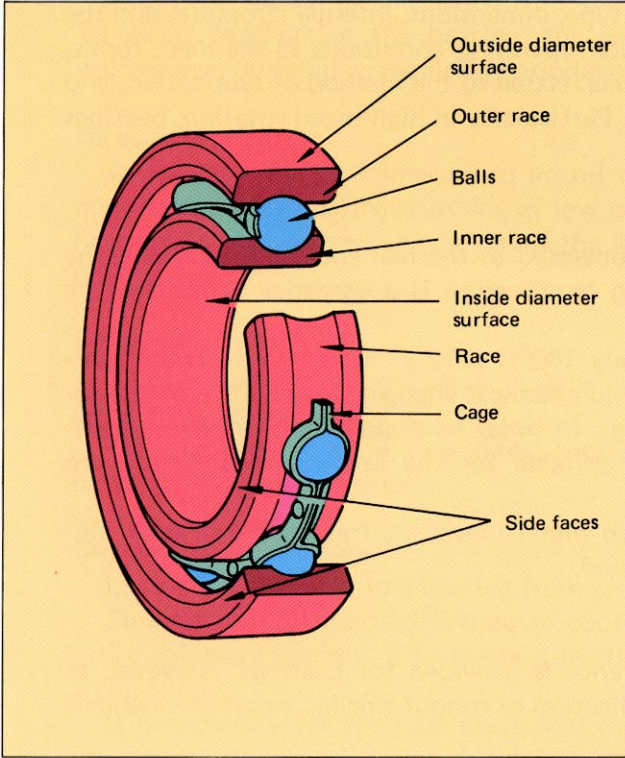


Taper roller bearing
(with taper rollers)

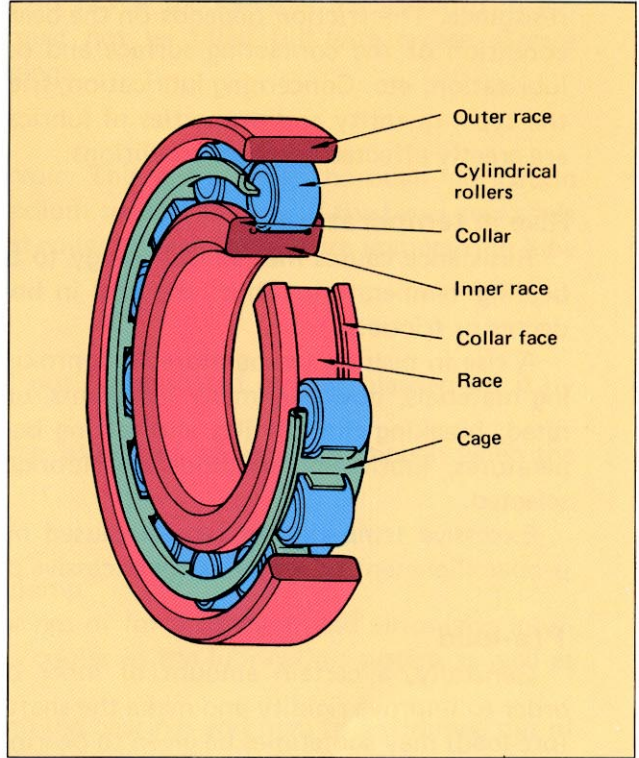


Nomenclature

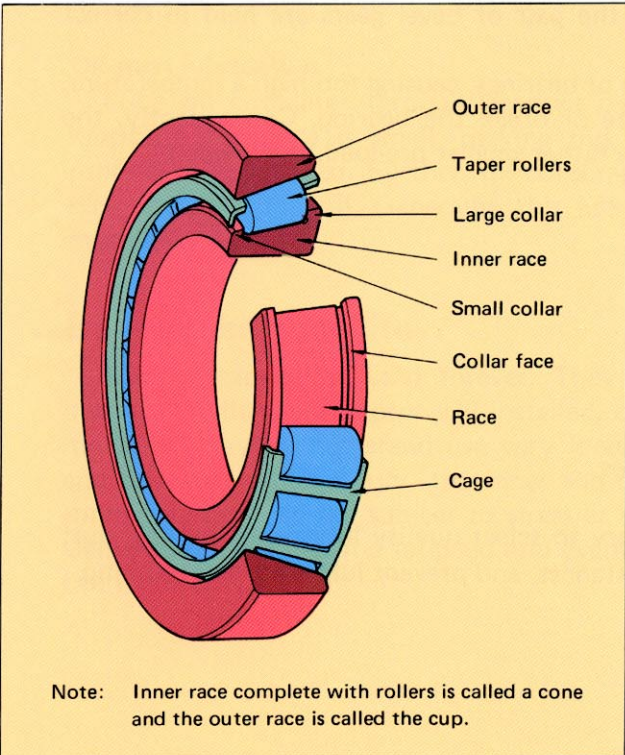
Deep groove radial ball bearing



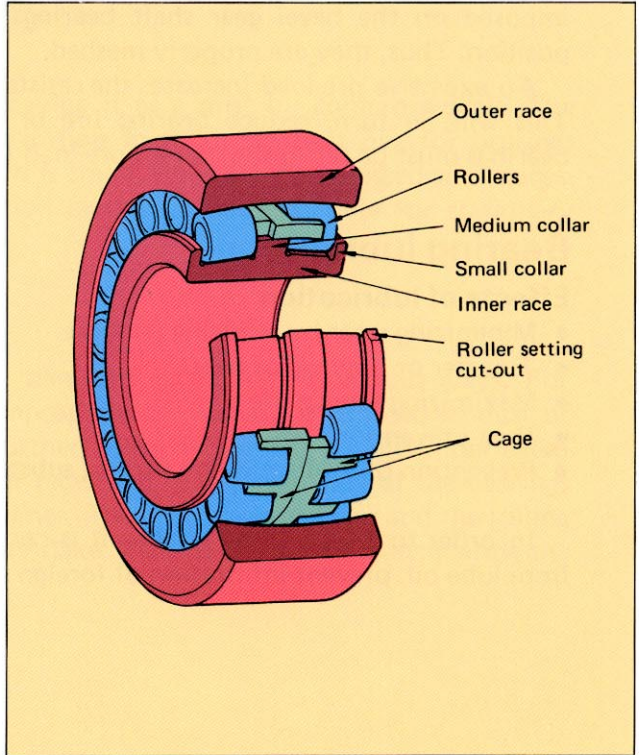
Cylindrical roller bearing



Taper roller bearing



Self-aligning spherical roller bearing



Bearing characteristics

Friction

Ball and roller (anti-friction) bearings generally have a much smaller coefficient of friction than plain (journal) bearings. Particularly, anti-friction bearings have much less starting resistance. The friction depends on the bearing type, dimensions, internal structure, and the condition of the contacting surface and on such operating conditions as the load, rpm's, lubrication, etc. Concerning lubrication, friction is related to the method of lubrication, and the type, quantity and properties of lubricants. Particularly in high-speed rotation, bearings are greatly effected by these conditions.

Rise in temperature

Resistance causes mechanical energy to be converted to thermal energy, thus raising the bearing temperature. Thus, the rise in bearing temperature is a yardstick indicating the degree of friction.

A rise in bearing temperature fo approximately 100°C (212°F) scarcely effects the bearing materials, however, many lubricants, undergo chemical changes. Lube oils are deteriorated, breaking the oil film and seizing bearings. In order to avoid excessive bearing temperatures, lubrication methods and lubricants suitable for the operation conditions are selected.

Excessive temperatures can be caused by too much lubricant, too little lubricant, improper alignment or centering, or excessive pre-load.

Pre-load

Generally, a certain amount of inner clearance is provided for bearings. However, in order to improve rigidity and make the shaft deflection or runout smaller, negative clearance (pre-load) may sometimes be given to bearings.

For example, the movement of a bevel gear shaft in a bulldozer depends on its rigidity to a load applied along its axis. Therefore, a pre-load restricting the shaft movement is imposed on the bevel gear shaft bearings so the pair of bevel gears are held in correct position. Thus, they are properly meshed.

An excessive pre-load increases the resistance of bearings, causing too high a temperature. This will, in turn, reduce bearing life or seize or break the bearing. Consequently, the bearings must be set to the correct pre-load (or a rather smaller pre-load, if allowable).

Bearing lubrication

Effects of lubrication

- Minimizing wear by reducing friction
- Transfer or removal of heat
- Maximizing service life
- Rust prevention
- Prevention of infiltration by foreign substances

In order to ensure these effects, it is necessary to select quality lubricants, remove dust from lube oil, prevent infiltration of foreign substances, and prevent lubricant from leaking.

Lubrication methods

Grease lubrication

A bearing should be lubricated **by filling 1/2 to 1/3 of the space in its case with grease.** To avoid overheating the bearing, the case must not be filled full with grease. Grease decomposes during use, requiring periodic changing.

Oil bath lubrication

A bearing may be immersed in an oil reservoir. This is the most thorough lubrication method used for bearings running at low or medium speeds. In case of the bevel gear shaft bearings in a bulldozer, the center of the lowest roller of each bearing are immersed in lube oil.

Splash lubrication

The bearing is not immersed directly in oil but is lubricated by oil splashed on it by gears or impellers, etc.

The quantity of oil is important, because the supply of oil is rarely enough when the bearing first begins to rotate.

Circulating lubrication

Lube oil is delivered to a bearing from an oil pump.

This lubrication method is used to cool bearings or for a concentrated automatic lubrication of many points. This method features a cooler in the lubrication system as well as an oil filter.

It is necessary for the lube oil to pass through the bearings and then to be drained out of the system periodically. For this reason, oil inlet and outlet ports must not be clogged or closed. When operating a machine, **be careful** not to impose a high load on bearings before the lube oil reaches them.

Oil-mist lubrication

Lube oil circulates through bearings by spraying it as a mist by compressed air. The lubricant resistance is small, making this lubrication method the best one for bearings running at high speed. Further, oil consumption is small. However, compressed air is necessary to spray the oil. Generally, this lubrication method is adopted only for stationary machinery.

Bearing service life

Bearings cannot be used forever. They are damaged or broken in various ways. For instance, if they are improperly installed, or improperly lubricated, or exposed to dust or moisture, they cannot stand use very long. Further, even if they are installed, lubricated and operated satisfactorily, the inner and outer races and rolling elements of the bearings running under load are subject to stress at all times. Thus, the race surfaces and the rolling element surfaces become fatigued and eventually flake. **Flaking is a means of estimating the bearing life.**

PREVENTIVE MAINTENANCE

Operate machines to their full potential by preventing machine troubles. Be careful about the machine conditions at all times, particularly about the oil pressure, oil temperature, oil consumption, unusual sound, and other symptoms.

Most machine troubles and failures can be prevented by carrying out the servicing items positively, referring to the Operation and Maintenance Manuals. Above all, customers should be advised to observe the following matters faithfully in operating and servicing their machines.

- Use the KOMATSU specified lubricating oils and determine their types depending on the varying ambient temperatures. Change oils at the specified intervals.
- Warm up engines thoroughly before operating machines. Abrupt operation under overload, abrupt acceleration and stopping should be avoided wherever possible.
- Frequent abrupt speed changing should be avoided wherever possible.
- Carry out oil level checks, replenishment, oil change, and oil analysis periodically.

