Care and Maintenance of Bearings

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Care and Maintenance of Bearings
(Revised)

We thank you for your interest in **NTN** bearings. This booklet is intended as a guide to bearing maintenance, with the main consideration being on-site bearing maintenance.

Bearings may fail earlier than the expected rolling fatigue life. Early failure is mostly attributable to inadequate handling or maintenance.

We hope this manual assists in preventing early bearing failures or in troubleshooting the causes of bearing failures.

Care and Maintenance of Bearings

Contents

1. Introduction

The rolling-contact bearing is an element of machinery with a very important role, and is critical to the performance of the machine. If one of the bearings breaks or seizes, not only the machine but also the assembly line may stop. If one of the axle bearings of an automobile or a railway car breaks down, a serious accident could occur.

To avoid trouble, every bearing manufacturer should make efforts to assure the highest quality for each bearing, and should emphasize that the user carefully handle and maintain all bearings.

Every bearing becomes unserviceable in the course of time even if it is installed correctly and operated properly. The raceway surfaces and the rolling contact surfaces of the rolling elements are repeatedly subjected to compressive loads, and the surfaces eventually flake.

The life of a rolling-contact bearing is defined as the total number of revolutions (or the number of operating hours at a given constant speed) before flaking occurs.

The bearing may also become unserviceable because of seizing, breakage, wear, false brinelling, corrosion, etc.

These problems are caused by improper selection or handling of the bearing. The problems are avoidable by correct selection, proper handling and maintenance, and are distinguished from the fatigue life of the bearing.

However, breakdowns due to improper application, bearing design, and maintenance are more frequent than flaking due to rolling fatigue in the field.

2. Inspection of Bearings

Inspection of a machine's bearings during operation is important to prevent unnecessary bearing failure. The following methods are generally adopted to inspect the bearing.

(1) Inspection when machine is running
  In order to determine if lubrication replenishment/replacement is needed, bearing temperature and noise/vibration should be checked.

(2) Inspection of bearings after operation
  Bearings should be carefully examined after operation and during periodic inspections in order to note any damage, and measures should be taken to prevent recurrences.

It is important to determine inspection procedures and establish regular inspection intervals based on the importance of the system or machine.

3. Inspection When Machine is Running

3.1 Bearing Temperature

Bearing temperature generally rises with start-up and stabilizes at a temperature slightly lower than at start-up (normally 10 to 40˚C higher than room temperature) in a certain time. The time required for the operating temperature to stabilize depends on the size, type, speed, lubrication, and the heat dissipation condition around the bearing. It ranges from about 20 minutes to as long as several hours.

If bearing temperature does not stabilize but continues to rise, it may be the result of the one of the causes listed in **Table 3.1**. Operation should be stopped and an appropriate corrective action should be taken.

High bearing temperature is not desirable in view of maintaining an adequate service life and preventing lubricant deterioration. A desirable bearing temperature is generally below 100˚C.

Table 3.1 Major causes of high bearing temperature

(1) Extremely insufficient or excessive lubricant
(2) Poor installation of the bearings
(3) Extremely small bearing clearance or extremely heavy load
(4) Extremely high friction between lip and seal groove
(5) Improper lubricant type
(6) Creep between the fitting surfaces

3.2 Operating Sound of Bearing

The following **Table 3.2** lists typical abnormal bearing sounds and their causes. Please note that the descriptions of some of these sounds are rather subjective and thus could vary considerably from person to person.

Table 3.2 Typical Abnormal Bearing Sounds and Their Causes

Sound	Features	Causes
Buzz Roar Howl	Pitch remains constant with changes in speed (dust/contamination). Pitch changes with changes in speed (damage).	• Dust/contamination. • Rough raceway, balls or roller surfaces. • Damaged raceway, balls or roller surfaces.
Hissing	Small bearings.	• Rough raceway, balls or roller surfaces.
Chatter	Generated intermittently at regular intervals.	• Contact with labyrinth or other sections. • Contact between cage and seal.
Screech Howl (grinding sound)	Volume and pitch change with changes in speed. Becomes louder at certain speeds. Sound varies in volume. Occasionally sounds like a siren or whistle.	• Resonance, poor fit (poor shaft shape). • Deformed raceway. • Vibration in raceway, balls or roller surfaces (minor sound considered normal for large bearings).
Crunch Chatter	Felt when bearing is rotated by hand.	• Damaged raceway (felt at regular intervals). • Damaged balls or rollers (felt at irregular intervals). • Dust/contamination, deformed raceway.
Rustle Rattle	·· Large bearings ·· Small bearings Continuous at high speeds.	• Damaged raceway, balls or roller surfaces.
Whir Hum	Disappears as soon as power is switched off.	• Electromagnetic sound of motor.
Tinkle	Generated at irregular intervals (remains constant with changes in speed). Primarily with small bearings.	• Dust/contamination.
Rustle Clatter Patter Clutter	·· Tapered roller bearings ·· Large bearings ·· Small bearings Generated continuously at regular intervals at high speeds.	• Normal if sound generated by cage is clear. • Inadequate grease if generated at low temperatures → use soft grease. • Worn cage pockets, insufficient lubrication, operating with insufficient bearing load.
Fizz Pop Growl	Noticeable at low speeds. Generated continuously at high speeds.	• Clashing sound from inside cage pockets, insufficient lubrication. Eliminated by reducing clearance or applying preload. • Rollers hitting each other in full-roller bearings.
Clang Clatter	Loud metallic clashing sound in thin section type large bearings at low speeds.	• Unstable sound from rolling elements. • Deformed raceway. • Key grating.
Squeak Squeal Growl	Primarily in cylindrical roller bearings, changes with changes in speed, sounds metallic when loud. Eliminated temporarily when refilling grease.	• Too high consistency of lubricant (grease). • Too large radial clearance. • Insufficient lubricant.
Screech Shrill Shriek	Metal-to-metal spalling sound. High pitch.	• Spalling between rollers and ribs of roller bearings. • Too small clearance. • Insufficient lubricant.
Quiet Fizzing/Popping	Generated irregularly on small bearings.	• Bursting sound of bubbles in grease.
Sputter Crackle	Grating sound generated irregularly.	• Fitting flange slipping. • Mounting surface grating. • Key or other grating.
Large overall sound pressure.		• Rough raceway, balls or roller surfaces. • Raceway, rollers, or balls are deformed by wear. • Large clearance due to wear.

3.3 Vibration of Bearing

Damage to the bearing can be detected early by measuring the vibration of the machine. The degree of damage is inferred from quantitative analysis of the amplitude and frequency of the vibration. However, values measured differ depending on the measuring point and the operating condition of the bearing. It is desirable to accumulate measurement data and establish evaluation criteria for each machine.

3.4 Lubricant Selection

The purpose of lubricating the bearing is to cover the rolling contact surfaces and sliding contact surfaces with a thin oil film to avoid direct metal-to-metal contact. Effective lubrication of the rolling-element bearing has the following effects.

(1) Reduces friction and abrasion
(2) Transports heat generated by friction
(3) Prolongs of service life
(4) Prevents rust (corrosion)
(5) Keeps foreign objects (or contamination) away from rolling elements and raceways

For these purposes, a lubricant should be selected by referring to the following criteria.

(1) Grease lubrication

Grease is generally used for lubricating rolling-element bearings because it is easy to handle and simplifies the sealing system.

Carefully examine the type and properties of the base oil, thickener and additives of the grease, then select a grease appropriate for the operating condition of the bearing. The general relation between consistency of grease and the application of the bearing is given in **Table 3.3**. The types and properties of greases are given in the bearing section of the **NTN** general catalog.

Table 3.3 Consistency of Grease

NLGI consistency No.	JIS (ASTM) consistency after 60 workings	Application
0	355 - 385	Centralized lubrication
1	310 - 340	Centralized lubrication
2	265 - 295	General, prelubricated bearing
3	220 - 250	General, high temperature
4	175 - 205	Special applications

(2) Oil lubrication

Oil lubrication is generally suitable for high speed or high temperature operations. It is also suitable for carrying heat away from the bearing.

Oil viscosities required for the operating temperatures of bearings are given in **Table 3.4**.

Carefully study the viscosity, viscosity index, oxidation resistance, corrosion resistance, foaming resistance, etc. to select an oil. **Table 3.5** gives a guide for selecting viscosity.

Fig. 3.1 shows the variation of viscosity with temperature for several lubricating oils. Use **Table 3.5** to select an oil with an adequate viscosity for the operating temperature of the bearing.

Table 3.4 Viscosities Required for Operating Temperature of Bearings

Bearing Type	Kinematic viscosity mm^2/s
Ball, cylindrical roller and needle roller bearings	13
Spherical roller bearings, tapered roller bearings and thrust needle roller bearings	20
Spherical thrust roller bearings	30

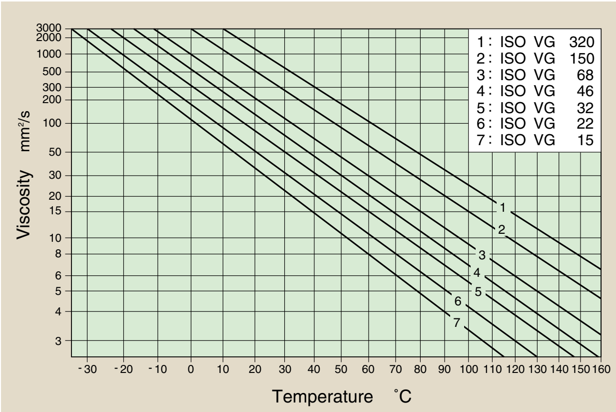


Fig. 3.1 Lubrication oil viscosity-temperature line diagram

3.5 Relubrication

In grease lubrication, the lubricating characteristic of grease deteriorates with operating hours, thus requiring relubrication of the bearing at appropriate intervals. Relubrication intervals of grease depend on the type, dimensions, speed of the bearing, and the type of grease.

A line diagram serving as a rough guide of grease relubrication intervals, is given in the bearing section of the **NTN** general catalog.

For oil lubrication, oil changing intervals depend on the operating condition of the machine and the type of lubrication system. A rough guide to oil changing intervals and for oil analysis intervals is given in **Tables 3.6** and **3.7**.

Table 3.5 Selection Guide For Lubrication Oil Viscosity

Bearing operating temperature ˚C	dn value ❶	ISO viscosity grade of oil (VG)		Applicable bearing types
		Normal load	Heavy or impact load	
-30 ~ 0	Up to allowable speed	22, 32	46	All types
0 ~ 60	~15000	46, 68	100	All types
	15000 ~ 80000	32, 46	68	All types
	80000 ~ 150000	22, 32	32	Except for thrust ball bearings
	150000 ~ 500000	10	22, 32	Single row radial ball bearings Cylindrical roller bearings
60 ~ 100	~15000	150	220	All types
	15000 ~ 80000	100	150	All types
	80000 ~ 150000	68	100, 150	Except for thrust ball bearings
	150000 ~ 500000	32	68	Single row radial ball bearings Cylindrical roller bearings
100 ~ 150	Up to allowable speed	320		All types
0 ~ 60		46, 68		Spherical roller bearings
60 ~ 100		150		

❶ dn value : [$dn = d$ (bearing bore diameter [mm]) × n (operating rotational speed [min^{-1}])
Note 1. The table above is applicable to oil bath lubrication and recirculation lubrication.
2. Consult **NTN** if your operating condition is not shown in the table.

Table 3.6 Lubrication Oil Properties and Serviceable Limits

Property		Serviceable limit		Remarks
		Circulating oil	Gear oil	
Viscosity deterioration $\mathrm{mm^2/s}$		Less than 10%	25% max., 10 to 15% is preferable	Caused by oxidation or mixing with diffrent type of oil.
Water content in volume %		0.2 max.	0.2 max.	May be reusable after water removal
Insoluable matter in weight	Normal Pentane %	0.2 max.	1.0 max.	Oxidation product, carbon, wear particle and dust
	Toluene %	0.1 max.	0.5 max.	Carbon, wear particle and dust
Sedimentation value ml/10ml		0.1 max.		Contaminants such as water and dust, or worn metal particles.
Total acid value KOH mg/g		2 to 3 times that of new oil		Adopt higher value according to additives
Ash %		——	0.2 max.	
Iron content in ash %		——	0.1 max.	

Table 3.7 Frequency of Lubricating Oil Analysis

Lubrication system	Inspection interval	
	Normal operating conditions	Severe operating conditions
Disk lubrication method	One year	6 months
Oil bath or splash lubrication	6 months	3 months
Circulating lubrication	9 months	1 to 3 months

Severe operating conditions refers to:
(1) Severe water condensation or ingress
(2) Excessive ingress of dust, gas, etc.
(3) Operating temperature exceeding 120˚C

4. Check of Bearings after Operation

Bearings after operation and those removed during periodic inspection should be carefully checked visually for symptoms on each component to evaluate whether the bearings' operating conditions are satisfactory.

If any abnormality is detected, find the cause and apply a remedy by checking the abnormality against the failure cases given in Section 5. "Bearing Failures and Solutions."

5. Bearing Failures and Solutions

The bearing is generally usable up to the end of the rolling fatigue life if handled properly. If it fails earlier, it may be due to some fault in the selection, handling, lubrication, and/or mounting of the bearing.

It is sometimes difficult to determine the real cause of bearing failure because many interrelated factors are possible. It is, however, possible to prevent the recurrence of similar problems by considering possible causes according to the situation and condition of the machine on which the bearings failed. Also, installation location, operating conditions, and surrounding structure of the bearings should be taken into consideration.

Bearing failures are classified and illustrated in photos in this section. Use this section as a guide for troubleshooting.

Figures 5.1 to **5.7** show the names of bearing parts referred to in the descriptions of the failure cases.

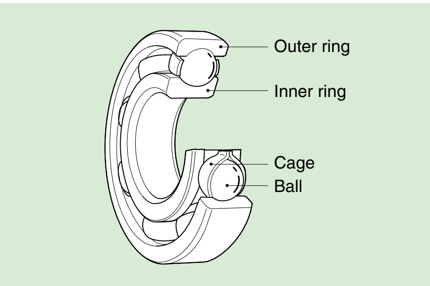


Fig. 5.1 Deep groove ball bearing

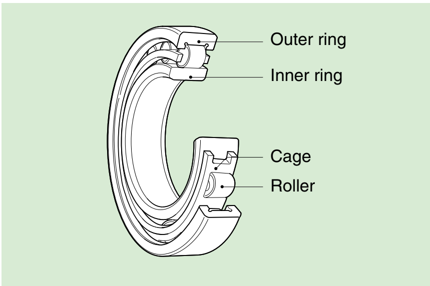


Fig. 5.2 Cylindrical roller bearing

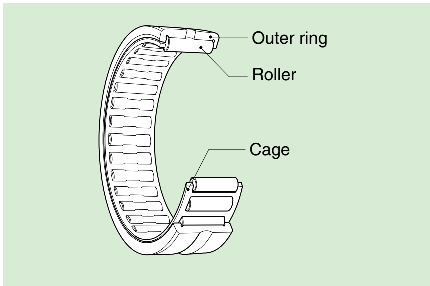


Fig. 5.3 Needle roller bearing

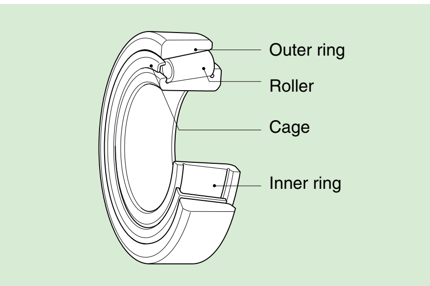


Fig. 5.4 Tapered roller bearing

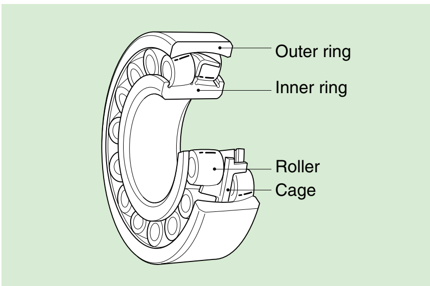


Fig. 5.5 Spherical roller bearing

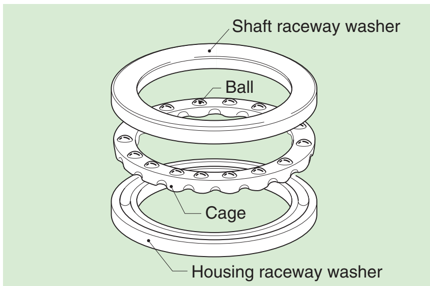


Fig. 5.6 Thrust ball bearing

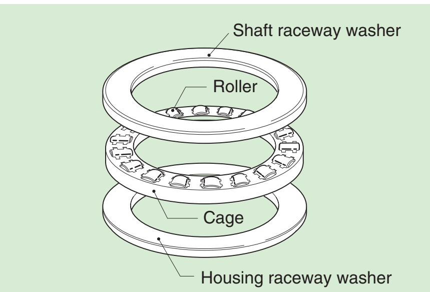


Fig. 5.7 Thrust roller bearing

5.1 Flaking

Condition	Cause	Solution
Raceway surface is flaked. Surface after flaking is very rough.	Rolling fatigue. Flaking may be caused early by overloading, excessive load due to improper handling, poor shaft or housing accuracy, installation error, ingress of foreign objects, rusting, etc.	(1) Find the cause of the heavy load. (2) Check of operating conditions and adopt bearings with larger capacity as necessary. (3) Increase viscosity of oil and improve lubrication system to form an adequate lubricating oil film. (4) Elimination of installation errors.

Photo A-1

- Deep groove ball bearing.
- Inner ring, outer ring, and balls are flaked.
- The cause is excessive load.

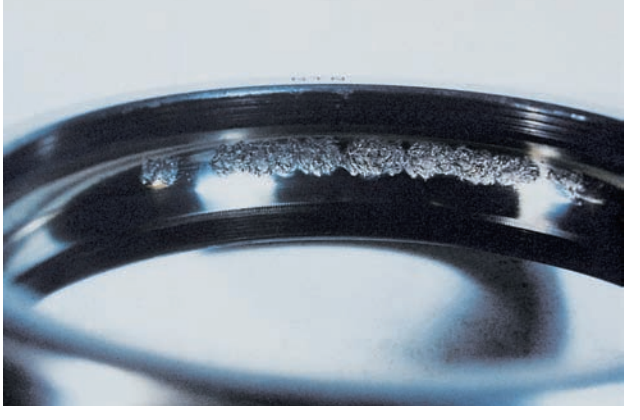


Photo A-2

- Outer ring of angular contact ball bearing.
- Flaking of raceway surface spacing equal to distances between balls.
- The cause is improper handling.

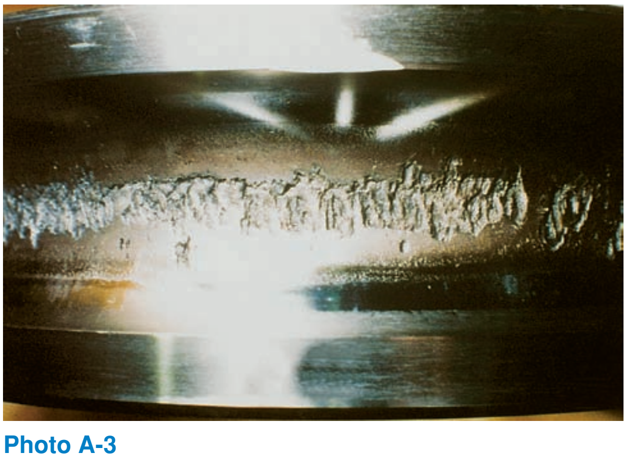


Photo A-3

- Inner ring of deep groove ball bearing.

Photo A-4

- Outer ring raceway of an angular contact ball bearing.

Photo A-5

- Inner ring of deep groove ball bearing.
- Flaking on one side of the raceway surface.
- The cause is an excessive axial load.

Photo A-6

- Inner ring of spherical roller bearing.
- Flaking only on one side of the raceway surface.
- The cause is an excessive axial load.

Photo A-7

- Tapered roller bearing.
- Flaking on 1/4 circumference of inner ring raceway with outer ring and rollers discolored light brown.
- The cause is excessive preload.

Photo A-8

- Outer ring of double row angular contact ball bearing.
- Flaking on 1/4 circumference of outer ring raceway.
- The cause is poor installation.

Photo A-9

- Thrust ball bearing.
- Flaking on inner ring raceway (bearing ring fastened to shaft) and balls.
- The cause is poor lubrication.

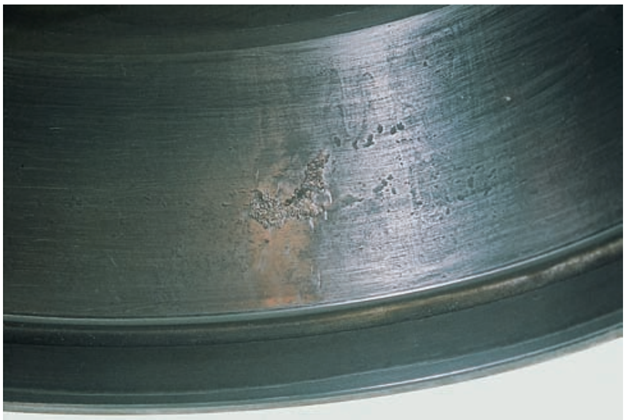


Photo A-10

- Outer ring raceway of double row tapered roller bearing.
- Flaking on the raceway surface.
- Caused by electrical damage (electric current passing thru bearing).

5.2 Peeling

Condition	Cause	Solution
Peeling is a cluster of very small spalls (size about 10μm). Peeling can also include very small cracks which develop into spalls.	Likely to occur in roller bearings. Tends to occur if surface of opposite part is rough or lubrication characteristics are poor. Peeling may develop into flaking.	(1) Control of surface roughness and ingress of foreign objects. (2) Review of lubricant. (3) Proper break-in.

Photo B-1

- Rollers of spherical roller bearing.
- Peeling on rolling contact surfaces.
- The cause is poor lubrication.

Photo B-2

- Tapered roller bearing.
- Peeling turning to flaking on inner ring and rollers.
- The cause is poor lubrication.

5.3 Spalling

Condition	Cause	Solution
Score accompanying seizing. Mounting score in axial direction. Scores on roller end face and guide rib-cycloidal scores. Scratches in spinning direction on raceway surface and rolling contact surfaces.	Poor mounting and removing practice. Oil film discontinuation on the contact surface due to excessive radial load, foreign object trapping, or excessive preload. Slippage or poor lubrication of rolling elements.	(1) Improvement of mounting and removing procedures. (2) Review of operating conditions. (3) Review of preload. (4) Review of lubricant and lubrication method. (5) Improvement of sealing efficiency.

Photo C-1

- Inner ring of cylindrical roller bearing.
- Spalling on rib.
- The cause is excessive load.

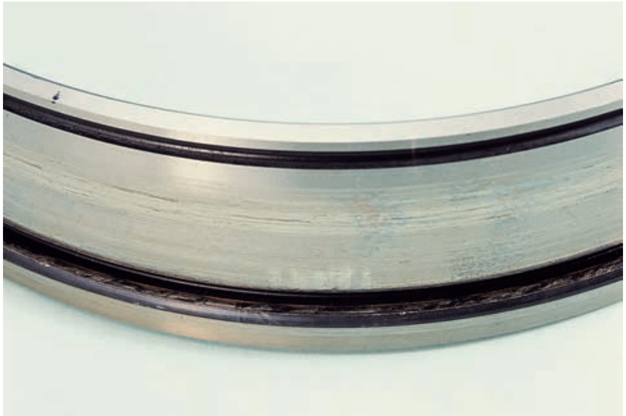


Photo C-2

- Inner ring of tapered roller bearing.
- Spalling on raceway surface and cone back face rib.
- The cause is poor lubrication.

Photo C-3

- Rollers of tapered roller bearing.
- Cycloidal spalling on the end faces (Scuffing).
- The cause is poor lubrication.

Photo C-4

- Roller of cylindrical roller bearing.
- Score in axial direction on rolling contact surface caused during mounting.
- The cause is poor mounting practice.

5.4 Smearing

Condition	Cause	Solution
Surface is roughened and tiny particles adhere.	Rolling elements slip in rolling motion and characteristics of lubricant are too poor to prevent slippage.	(1) Review of optimum lubricant and lubrication method capable of forming sound oil film. (2) Use a lubricant including extreme pressure additive. (3) Take precautions such as a small radial internal clearance and preload to prevent slippage.

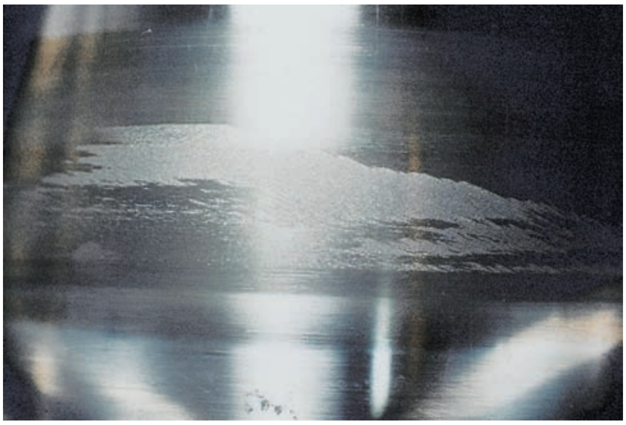


Photo D-1

- Inner ring of cylindrical roller bearing.
- Smearing on raceway surface.
- The cause is slippage of rollers due to foreign objects trapped within.

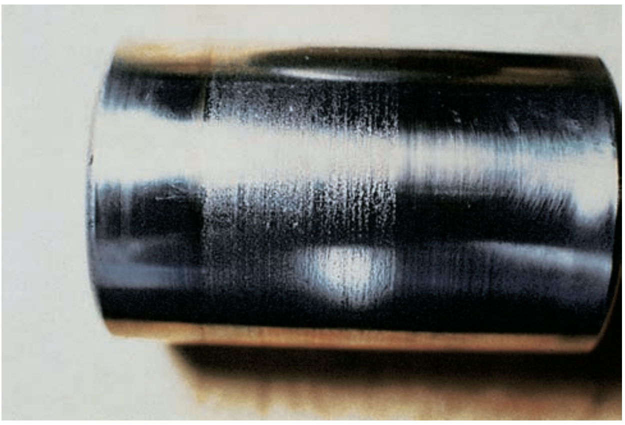


Photo D-2

- Roller of cylindrical roller bearing (corresponding inner ring raceway shown in Photo D-1).
- Smearing on the rolling contact surface.
- The cause is slippage of rollers due to foreign objects trapped within.

Photo D-3

- Rollers of spherical thrust roller bearings.
- Smearing on center of the rolling contact surface.
- The cause is slippage of rollers due to foreign objects trapped within.

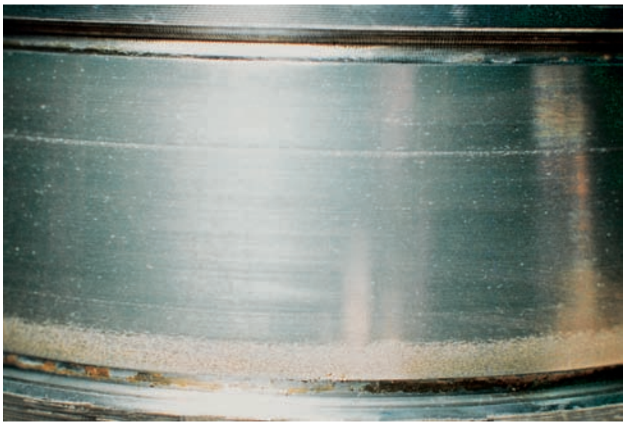


Photo D-4

- Inner ring of double row tapered roller bearing.
- Smearing on the raceway surface.

5.5. Wear

Condition	Cause	Solution
Surface is worn and dimensions are reduced compared with other portions. Surface mostly roughened and scored.	Ingress of solid foreign objects. Dirt and other foreign objects in lubricant. Poor lubrication. Skewing of rollers.	(1) Review of lubricant and lubrication method. (2) Improvement of sealing efficiency. (3) Filtration of lubricating oil. (4) Elimination of misalignment.

Photo E-1

- Outer ring of cylindrical roller bearing.
- Stepped wear on raceway surface.
- The cause is poor lubrication.

Photo E-2

- Inner ring of cylindrical roller bearing (corresponding outer ring shown in Photo E-1).
- Stepped wear along full circumference of raceway surface.
- The cause is poor lubrication.

Photo E-3

- Outer ring of double row angular contact ball bearing.
- Wear on one raceway surface.
- The cause is poor lubrication.

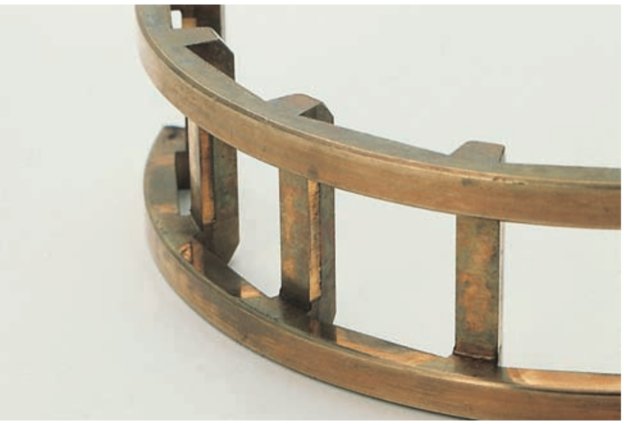


Photo E-4

- Cage of cylindrical roller bearing.
- Wear of pockets of machined high tensile brass casting cage (G1).

5.6 Speckles and Discoloration

Condition	Cause	Solution
Speckles Raceway surface is matted and speckled. Speckles are clusters of tiny dents. **Discoloration** The surface color has changed.	Ingress of foreign objects. Poor lubrication. Temper color by overheating. Deposition of deteriorated oil on surface.	**Speckles** (1) Review of sealing system. (2) Filtration of lubricating oil. (3) Review of lubricant and lubrication method. **Discoloration** (1)Oil deposition is removable by wiping with an organic solvent (oxalic acid). (2) If roughness is not removable by polishing with sandpaper, it is rust or corrosion. If completely removable, it is temper color due to overheating.

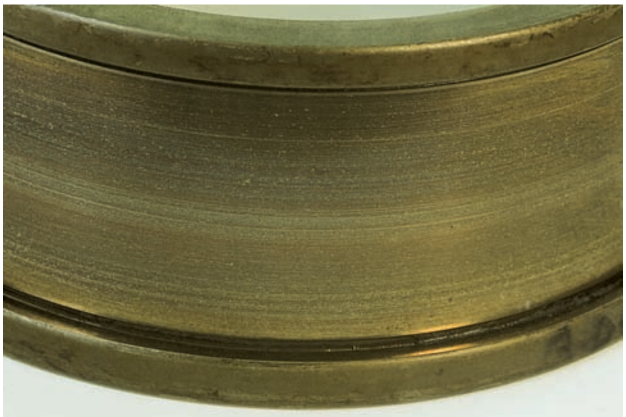


Photo F-1

- Inner ring of double row tapered roller bearing.
- Raceway surface is speckled.
- The cause is electric pitting.

Photo F-2

- Ball of deep groove ball bearing.
- Speckled all over.
- The cause is foreign objects and poor lubrication.

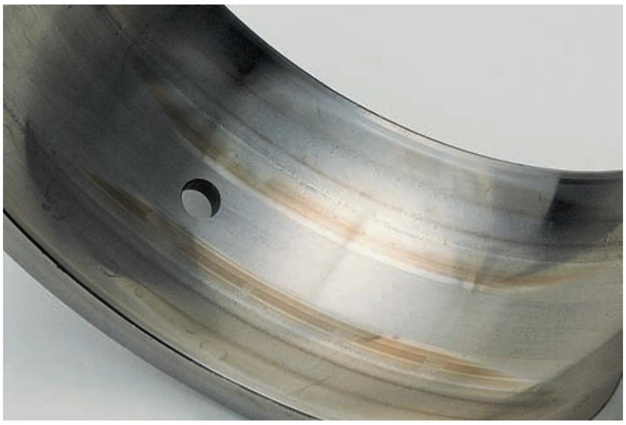


Photo F-3

- Outer ring of spherical roller bearing.
- Discoloration of part of raceway surface.
- The cause is deteriorated oil deposits.

Photo F-4

- Spherical roller bearing.
- Discoloration of inner and outer ring raceway surfaces.
- The cause is deterioration of lubricant.

5.7 Indentations

Condition	Cause	Solution
Hollows in raceway surface produced by solid foreign objects trapped or impacts (False brinelling).	Ingress of solid foreign objects. Trapping of flaked particles. Impacts due to careless handling.	(1) Elimination of ingress of solid foreign objects. (2) Check the bearing and other nearby bearings for flaking if dents are produced by metal particles. (3) Filtration of lubricating oil. (4) Improvement of handling and mounting practices.

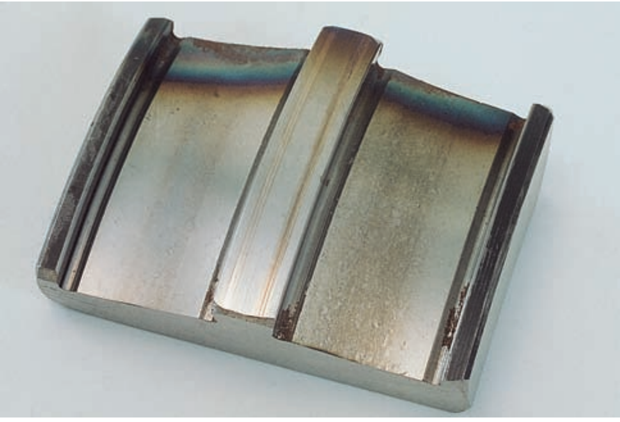


Photo G-1

- Inner ring (cut off piece) of spherical roller bearing.
- Indentation on one raceway surface.
- The cause is trapping of solid foreign objects.

Photo G-2

- Roller of spherical roller bearing.
- Dents on rolling contact surfaces.
- The cause is trapping of solid foreign objects.

Photo G-3

- Rollers of tapered roller bearings.
- Dents on rolling contact surfaces (Temper color at both ends).
- The cause is foreign objects in lubricating oil.

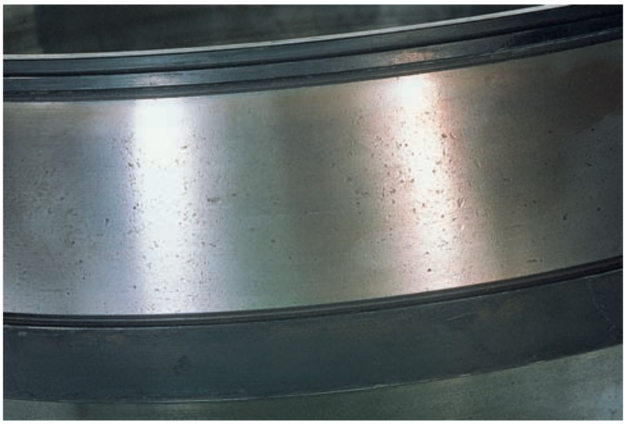


Photo G-4

- Inner ring of tapered roller bearing.
- Dents on raceway surfaces.
- The cause is trapping of solid foreign objects.

5.8 Chipping

Condition	Cause	Solution
Partial chipping of inner ring, outer ring, or rolling elements.	Trapping of large solid foreign objects. Impacts or excessive load. Poor handling.	(1) Troubleshooting and improvements of impacts and excessive load. (2) Improvement of handling practices. (3) Improvement of sealing efficiency.

Photo H-1
- Cylindrical roller bearings.
- Chipping of guide ribs of inner and outer rings.
- The cause is excessive impact load.

Photo H-2
- Inner ring of spherical roller bearing.
- Chipping of ribs.
- The cause is excessive impact load.

Photo H-3
- Inner ring of tapered roller bearing.
- Chipping of cone back face rib.
- The cause is impact due to poor mounting.

Photo H-4
- Inner ring of double row tapered roller bearing.
- Chipping of side face.
- The cause is impact due to improper handling.

5.9 Cracking

Condition	Cause	Solution
Splits, and cracks in bearing rings and rolling elements.	Excessive load. Excessive impacts. Overheating by creeping and rapid cooling. Very loose fit. Large flaking.	(1) Improvement of identification into causes of very large loads. (2) Prevention of creep. (3) Improvement in fit.

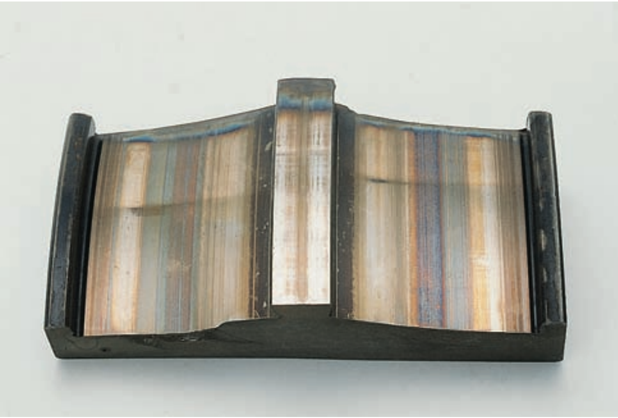


Photo I-1

- Inner ring of spherical roller bearing.
- Split of raceway surface in the axial direction.
- The cause is excessive interference fit.

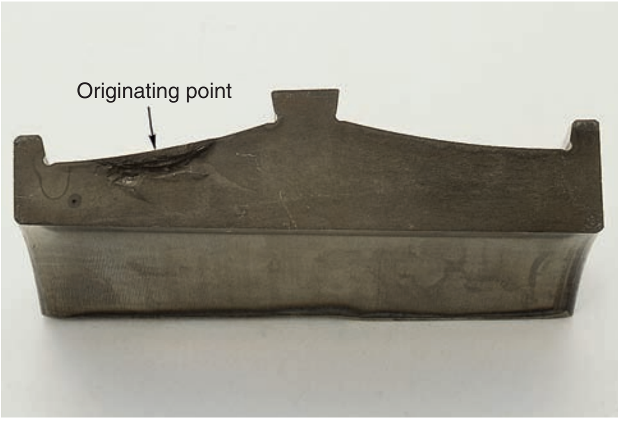


Photo I-2

- Fracture of inner ring shown in Photo I-1.
- Originating point at center of the left raceway surface.

Photo I-3

- Outer ring of four-row cylindrical roller bearing.
- Split of raceway surface in the circumferential direction.
- Originating point is from large flaking.

Photo I-4

- Outer ring of angular contact ball bearing.
- Split of raceway surface in the circumferential direction.
- The cause is slipping of balls due to poor lubrication.

5.10 Rust and Corrosion

Condition	Cause	Solution
Rusting or corrosion of bearing ring and rolling element surfaces. Rust sometimes spaced at equal distances between rolling elements.	Ingress of water or corrosive material (such as acid). Condensation of moisture contained in the air. Poor packaging and storing conditions, and handling with bare hands.	(1) Improvement of sealing efficiency. (2) Periodic inspection of lubricating oil. (3) Improvement of poor bearing handling practices. (4) Measures for rustproofing when not operating for a long period of time.

Photo J-1

- Inner ring of tapered roller bearing.
- Rust on raceway surface spacing equal to distances between rollers.

Photo J-2

- Outer ring of tapered roller bearing.
- Rust on raceway surface spacing equal to distances between rollers.

Photo J-3

- Roller of spherical roller bearing.
- Rust and corrosion of the rolling contact surface.
- The cause is ingress of water.

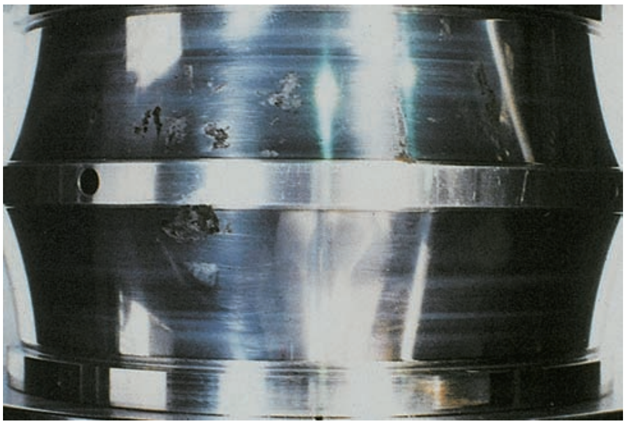


Photo J-4

- Inner ring of spherical roller bearing.
- Rust and corrosion of the raceway surface.
- The cause is ingress of water.

5.11 Seizing

Condition	Cause	Solution
Bearing generates heat and seizes due to heat, preventing spinning. Discoloration, softening, and welding of raceway surface, rolling contact surfaces, and rib surfaces.	Insufficient dissipation of heat generated by bearing. Insufficient lubrication or improper lubricant. Clearance excessively small. Excessive load (or preload). Roller skewing and installation error.	(1) Improvement of heat dissipation from bearing. (2) Review of lubricant and lubrication quantity. (3) Elimination of misalignment. (4) Review of clearance, preload. (5) Review of operating conditions.

Photo K-1

- Inner ring of double row tapered roller bearing.
- Seizing discolors and softens inner ring producing stepped wear at spacing equal to distances between the rollers.
- The cause is poor lubrication.

Photo K-2

- Rollers of double row tapered roller bearing.
- Rollers of same bearing as that of the inner ring shown in Photo K-1. Discoloration, spalling, and adhesion due to seizing can be seen on the rolling contact surfaces and end faces of rollers.

Photo K-3

- Outer ring of spherical roller bearing.
- Stepped wear due to seizing of raceway surface.
- The cause is poor lubrication.

Photo K-4

- Inner ring of tapered roller bearing.
- Seizing of large end of the raceway surface and cone back face rib surfaces.
- The cause is poor lubrication.

5.12 Fretting and Fretting Corrosion

Condition	Cause	Solution
Fretting surfaces wear producing red rust colored particles that form hollows. On the raceway surface, dents called false brinelling are formed at spacing equal to distances corresponding to the rolling elements.	If vibrating loads applied to contacting elements result in small amplitude oscillation, lubricant is driven out from contact areas, and parts become significantly worn. Oscillation angle of the bearing is small. Poor lubrication (no lubrication). Fluctuating load. Vibration during transportation.	(1) Inner ring and outer ring should be packaged separately for transportation. If not separable, bearings should be preloaded. (2) Use oil or high consistency grease when bearings are used for oscillation motion. (3) Review of lubricant. (4) Secure shaft and housing from movement. (5) Improvement in fit.
Called fretting corrosion when forming on fitting surfaces.	Vibration, shaft deflection, installation error, loose fit.	

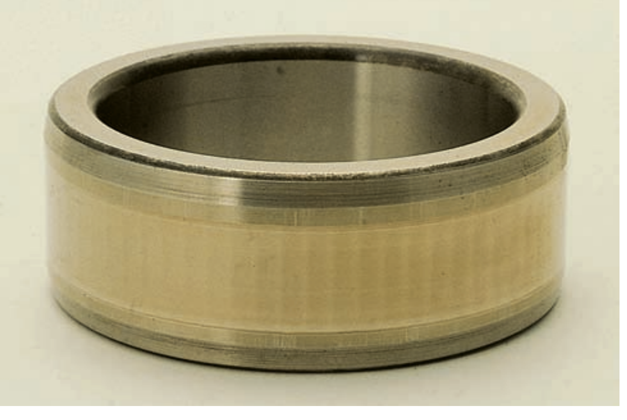


Photo L-1

- Inner ring of cylindrical roller bearing.
- Corrugated fretting along full circumference of raceway.
- The cause is vibration.

Photo L-2

- Inner ring of deep groove ball bearing.
- Fretting along full circumference of raceway.
- The cause is vibration.

Photo L-3

- Outer ring of cylindrical roller bearing.
- Fretting rust on the outside diameter surface.

Photo L-4

- Outer ring of tapered roller bearing.
- Fretting rust on the outside diameter surface.

5.13 Electrical Pitting

Condition	Cause	Solution
Surface is speckled visually and the speckles are clusters of tiny pits (holes) when viewed through a microscope. Further development leads to a corrugated surface.	Electric current passes through bearing, and sparks are generated to fuse the raceway surface.	Avoid flow of electric current by averting current with a slip ring or insulated bearing.

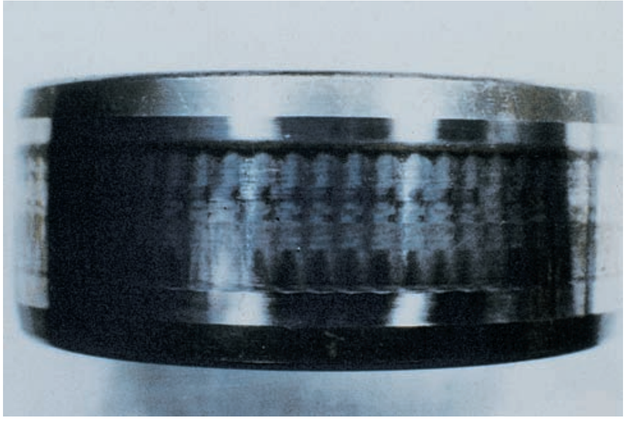


Photo M-1

- Inner ring of cylindrical roller bearing.
- Raceway surface is corrugated by electric pitting.

Photo M-2

- Rollers of tapered roller bearings.
- Electric pitting at center of rolling contact surfaces.

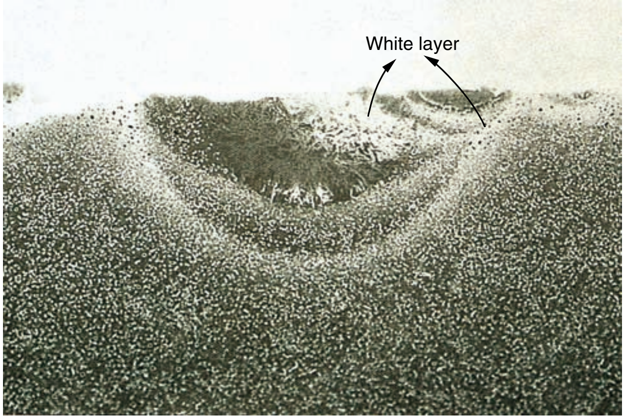
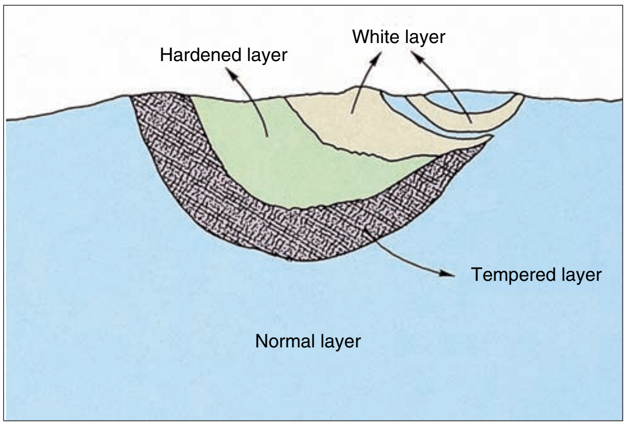


Photo M-3

- Magnified (x400) pitting of roller surface shown in Photo M-2.
- White layer formed on the cross section by nital etchant.



- Explanation of magnified photo M-3.

5.14 Rolling Path Skewing

Condition	Cause	Solution
Rolling element contact path on raceway surface strays or skews.	Deformation or tilt of bearing ring due to poor accuracy of shaft or housing. Poor rigidity of shaft or housing. Deflection of shaft due to excessive clearance.	(1) Improvement of machining accuracy of shaft and housing. (2) Review of rigidity of shaft and housing. (3) Review of clearance.

Photo N-1

- Spherical roller bearing.
- Contacts on inner ring, outer ring, and rollers are not even.
- The cause is poor mounting.

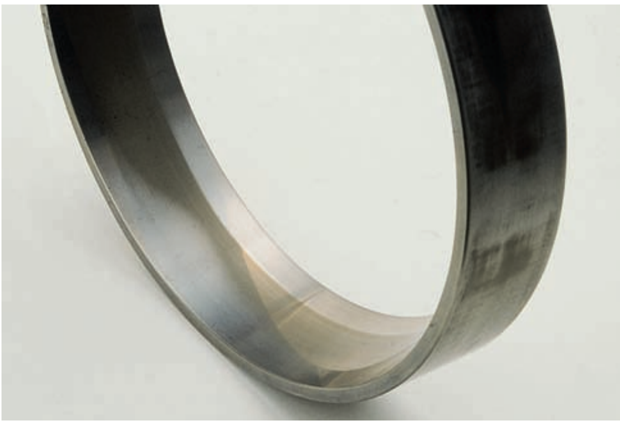


Photo N-2

- Outer ring of tapered roller bearing.
- Contact path on raceway surface strays.
- The cause is poor mounting.

Photo N-3

- Roller of tapered roller bearing (corresponding outer ring is shown in Photo N-2).
- Contact marks on rolling contact surfaces are not even.

5.15 Damage to Cages

Condition	Cause	Solution
Breaking of cage. Wear of pockets or guide. Loosening or breaking of rivets.	Excessive moment load. High speed spinning or large fluctuation of speed. Poor lubrication. Trapping of foreign objects. Heavy vibration. Poor mounting (crooked bearing). Excessive heat (plastic cage in particular).	(1)Review of load conditions. (2) Review of lubricant and lubrication method. (3) Review of cage selection. (4) Improvement of handling practices. (5) Review of rigidity of shaft and housing.

Photo O-1

- Cage of angular contact ball bearing.
- Breakage of machined high tension brass casting cage.
- The cause is poor lubrication.

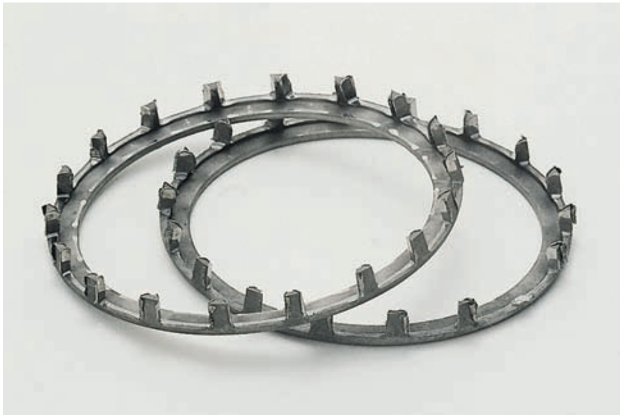


Photo O-2

- Cage of spherical roller bearing.
- Breakage of partitions between pockets of pressed steel cage.

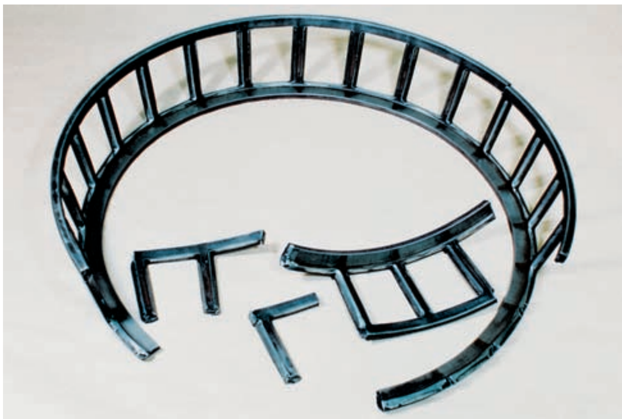


Photo O-3

- Cage of tapered roller bearing.
- Breakage of pockets of pressed steel cage.

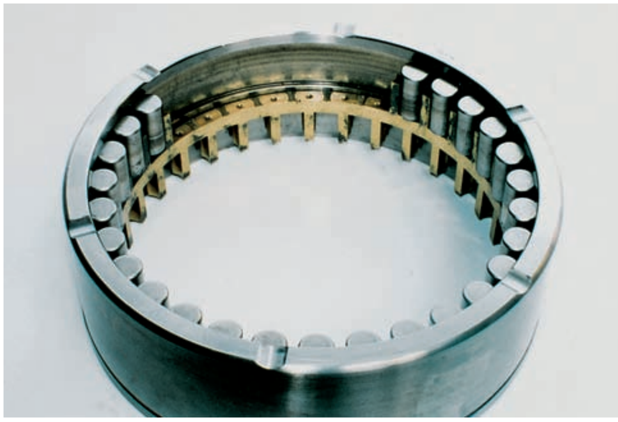


Photo O-4

- Cage of cylindrical roller bearing.
- Breakage of partitions between pockets of machined high tension brass casting cage.

5.16 Creeping

Condition	Cause	Solution
Fitting surfaces become glazed or matted. They can also become spalled.	Insufficient fitting of inner ring under inner ring rotating loads. Insufficient fitting of outer ring under outer ring rotating loads. If the housing is made of a light alloy such as aluminum, fit may be insufficient due to the difference of thermal expansion.	(1) Improvement in fit. (2) Improvement of machining accuracy of shaft and housing.

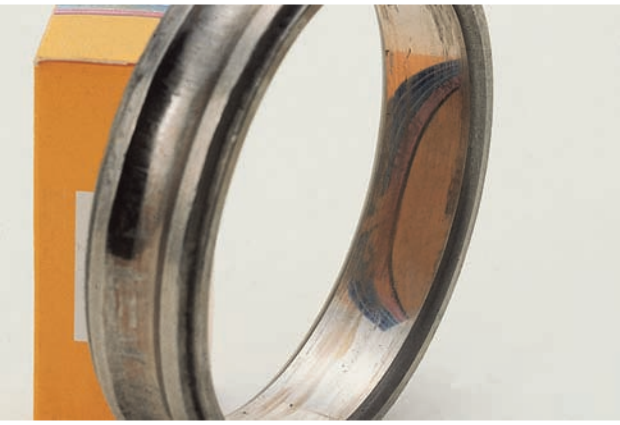


Photo P-1

- Inner ring of deep groove ball bearing.
- Bore wall becomes glazed by creep.

Photo P-2

- Inner ring of tapered roller bearing.
- Spalling due to creep at the center of bore wall.

Photo P-3

- Inner ring of thrust ball bearing.
- Spalling and friction cracking due to creep on bore wall.

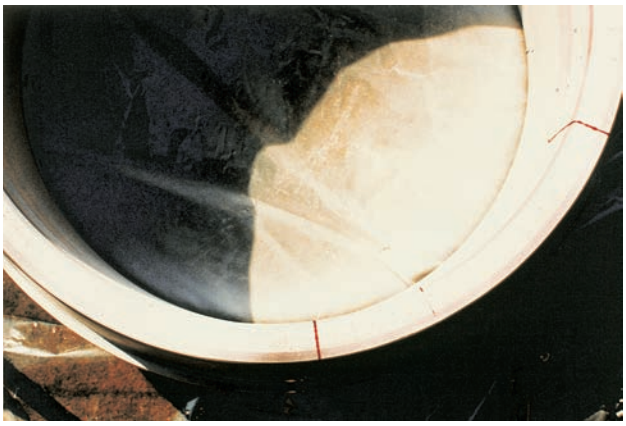


Photo P-4

- Inner ring of tapered roller bearing.
- Spalling and friction cracking on width surface due to creep. The crack developed into a split reaching bore wall.

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