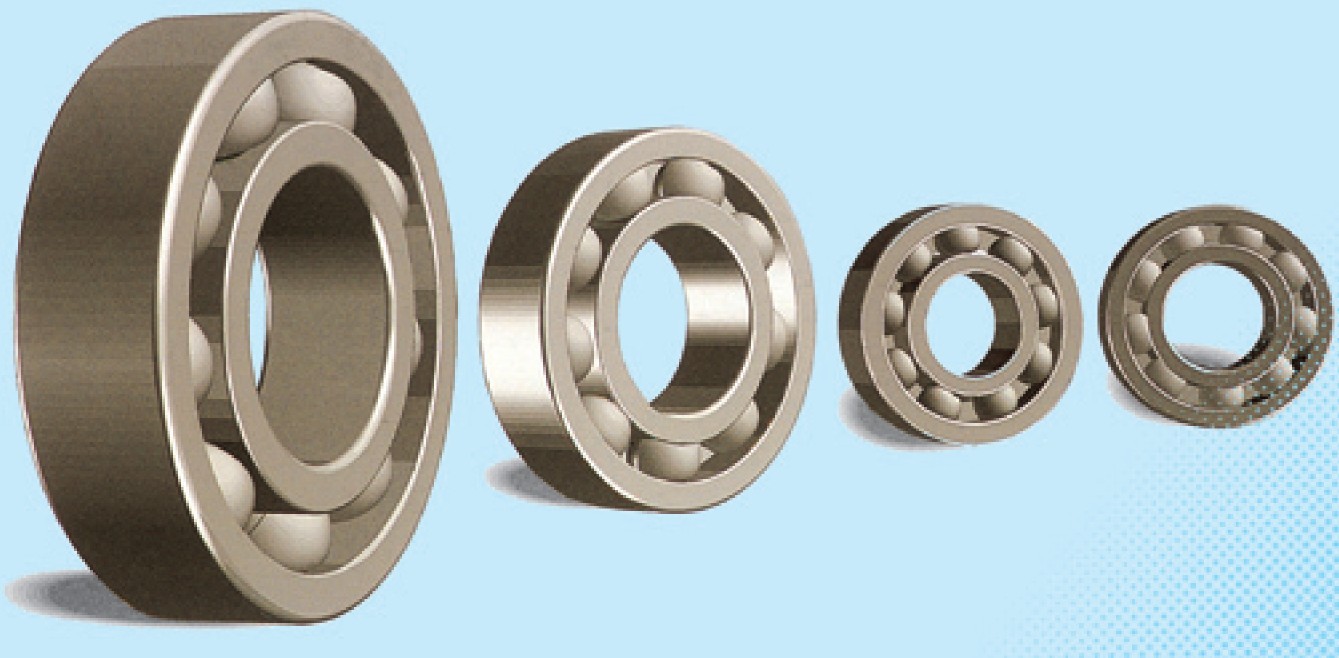
NSK

New Bearing Doctor

Diagnosis of bearing problems. Objective: Smooth & reliable operation.



On the occasion of the “New Bearing Doctor” pamphlet being published, we would like to express our sincere thanks for your continuous patronage of NSK products.

This pamphlet contains explanations about correct bearing handling, mounting, lubrication, and maintenance to prevent premature failure together with color photos of bearing failures. Please be sure to consult the NSK Rolling Bearing Catalog (CAT.No.E1102) for more details regarding handling, maintenance, etc.

Bearings become unserviceable when they suffer premature failure which is due to a lack of attention to proper handling and/or maintenance. Premature failure is completely different from flaking (life) due to rolling fatigue. This pamphlet is useful in determining causes of and measures against premature failure. It’s our pleasure to offer you this pamphlet.

Index of “New Bearing Doctor”

Topic **Page**

1. Introduction 3

2. Bearing Handling 4
   - 2.1 Precautions for Handling 4
   - 2.2 Mounting 4
   - 2.3 Check the Operation 4

3. Bearing Maintenance 5

4. Bearing Performance Factors 5
   - 4.1 Bearing Noise 5
   - 4.2 Bearing Vibration 5
   - 4.3 Bearing Temperature 5
   - 4.4 Effects of Lubrication 5
   - 4.5 Selection of Lubrication 6
   - 4.6 Replenishment and Replacement of Lubricant 7

5. Bearing Inspection 7

6. Running Traces and Applied Loads 8

7. Bearing Damage and Measures 9
   - 7.1 Flaking 10
   - 7.2 Peeling 12
   - 7.3 Scoring 13
   - 7.4 Smearing 15
   - 7.5 Fracture 17
   - 7.6 Cracks 18
   - 7.7 Cage Damage 20
   - 7.8 Denting 22
   - 7.9 Pitting 23
   - 7.10 Wear 24
   - 7.11 Fretting 25
   - 7.12 False Brinelling 26
   - 7.13 Creep 27
   - 7.14 Seizure 28
   - 7.15 Electrical Corrosion 29
   - 7.16 Rust and Corrosion 30
   - 7.17 Mounting Flaws 31
   - 7.18 Discoloration 32

Appendix: Bearing Diagnostic Chart 33

1. Introduction

When a rolling bearing is damaged during machine operation, the entire machine or equipment may seize or malfunction. Since bearings that fail prematurely or unexpectedly cause trouble, it is important to be able to identify and predict failure beforehand, if possible, so that preventive measures can be adopted.

Generally, bearing inspection or housing inspection can identify the cause of the problem. Often the cause is attributable to poor lubrication, improper handling, selecting the wrong bearing, or not enough study of the shaft and housing. Usually the cause can be determined by considering operation of the bearing before the failure, investigating the lubrication conditions and the mounting condition, and carefully observing the damaged bearing itself.

Sometimes bearings are damaged and fail both quickly and unexpectedly. Such premature failure is different from fatigue failure which is due to flaking. Bearing life can be separated and categorized into two types: premature failure and normal rolling contact fatigue.

2. Bearing Handling

2.1 Precautions for Handling

Since rolling bearings are high precision machine parts, they must be handled carefully. Even if high quality bearings are used, their expected life and performance cannot be attained if they are used improperly. The main precautions to be observed are as follows:

(1) Keep the Bearings and Surrounding Area Clean: Dust and dirt, even if invisible to the naked eye, have harmful effects on bearings. It is necessary to prevent the entry of dust and dirt by keeping the bearings and their environment as clean as possible.

(2) Careful Handling: Heavy shocks during handling may scratch or cause other damage to the bearing possibly resulting in bearing failure. Strong impacts may cause brinelling, breaking, or cracking.

(3) Use Proper Tools: Always use the proper tool when handling bearings and avoid general purpose tools.

(4) Prevent Corrosion: Since perspiration on the hands and various other contaminants may cause corrosion, keep your hands clean when handling bearings. Wear gloves if possible.

2.2 Mounting

It is advisable to study the bearing mounting thoroughly since the quality of the bearing mounting influences the bearing's running accuracy, life, and performance. It is recommended that the mounting method include the following steps.

(1) Clean the bearing and surrounding parts.
(2) Check the dimensions and finish conditions of related parts.
(3) Follow mounting procedure.
(4) Check if the bearing is mounted correctly.
(5) Supply with correct kind and quantity of lubricant.

Since most bearings rotate with the shaft, the bearing mounting method is generally an interference (tight) fit for the inner ring and shaft while giving a clearance (loose) fit for the outer ring and housing.

2.3 Check the Operation

After mounting the bearing, it is important to carry out an operating test to confirm that the bearing is mounted properly. Table 2.1 indicates operating test methods. If irregularities are detected, immediately suspend the test and consult Table 2.2 which lists appropriate measures to specific bearing problems.

Table 2.1 Methods to check operation

Machine size	Operating procedure	Bearing condition checks
Small machine	Manual operation. Turn the bearing by hand. If no problems are detected, then proceed to operate the machine.	Stick-slip (Debris, cracks, dents). Uneven rotating torque (Faulty mounting). Excessive torque (Error in mounting or insufficient radial internal clearance).
	Power operation. Initially start at a low speed and without a load. Gradually increase speed and load to reach rating.	Check for irregular noise. Check for bearing temperature rise. Lubricant leakage. Discoloration.
Large machine	Idle operation. Turn ON power and allow machine to rotate slowly. Turn OFF the power and allow the bearing to coast to a stop. If no irregularities are detected by the test, then proceed to the loaded rotation testing.	Vibration. Noise, etc.
	Power operation. Follow the same power operation testing as used for small machine testing.	Follow the same checkpoints as the small machine test.

Table 2.2 Causes and measures for operating irregularities

Irregularities		Possible causes	Measures
Noise	Loud Metallic Sound	Abnormal load	Improve the fit, internal clearance, preload, position of housing shoulder, etc.
		Incorrect mounting	Improve the machining accuracy and alignment of shaft and housing, accuracy of mounting method.
		Insufficient or improper lubricant	Replenish the lubricant or select another lubricant.
		Contact of rotating parts	Modify the labyrinth seal, etc.
	Loud Regular Sound	Flaws, corrosion, or scratches on raceways	Replace or clean the bearing, improve the seals, and use clean lubricant.
		Brinelling	Replace the bearing and use care when handling bearings.
		Flaking on raceway	Replace the bearing.
	Irregular Sound	Excessive clearance	Improve the fit, clearance and preload.
		Penetration of foreign particles	Replace or clean the bearing, improve the seals, and use clean lubricant.
		Flaws or flaking on balls	Replace the bearing.
Abnormal Temperature Rise		Excessive amount of lubricant	Reduce amount of lubricant, select stiffer grease.
		Insufficient or improper lubricant	Replenish lubricant or select a better one.
		Abnormal load	Improve the fit, internal clearance, preload, position of housing shoulder.
		Incorrect mounting	Improve the machining accuracy and alignment of shaft and housing, accuracy of mounting, or mounting method.
		Creep on fitted surface, excessive seal friction	Correct the seals, replace the bearing, correct the fitting or mounting.
Vibration (Axial runout)		Brinelling	Replace the bearing and use care when handling bearings.
		Flaking	Replace the bearing.
		Incorrect mounting	Correct the squareness between the shaft and housing shoulder or side of spacer.
		Penetration of foreign particles	Replace or clean the bearing, improve the seals.
Leakage or Discoloration of Lubricant		Too much lubricant. Penetration by foreign matter or abrasion chips.	Reduce the amount of lubricant, select a stiffer grease. Replace the bearing or lubricant. Clean the housing and adjacent parts.

3. Bearing Maintenance

It is necessary to periodically inspect and maintain the bearing and its operating conditions in order to maximize the bearing life. In general, the following method is adopted.

(1) Inspection under operating conditions

To determine the bearing replacement periods and replenishment intervals for lubricant, investigate the lubricant properties and consider factors such as operating temperature, vibration, and bearing noise. (Refer to Section 4 for more details.)

(2) Inspection of the bearing

Be sure to investigate the bearing thoroughly during times of periodic machine inspection and part replacement. Check the raceway condition. Determine if damage exists. Confirm if the bearing can be reused or should be replaced. (Refer to Section 5 for more details.)

4. Bearing Performance Factors

Key bearing performance factors during operation are bearing noise, vibration, temperature, and lubricant state. Please refer to Table 2.2 if any operation irregularities are detected.

4.1 Bearing Noise

During operation, sound detection instruments (stethoscope, NSK Bearing Monitor, etc.) can be used to investigate the volume and characteristics of the bearing rotation noise. It is possible to distinguish bearing damage such as small flaking by means of its unusual yet characteristic noise.

4.2 Bearing Vibration

Bearing irregularities can be analyzed by measuring the vibrations of an operating machine. A frequency spectrum analyzer is used to measure the magnitude of vibration and the distribution of the frequencies. Test results enable the determination of the likely cause of the bearing irregularity. The measured data varies depending on the operating conditions of the bearing and the location of the vibration pick-up. Therefore, the method requires the determination of evaluation standards for each measured machine.

It is useful to be able to detect irregularities from the bearing vibration pattern during operation. Please refer to the NSK pamphlet CAT. No. E410 (Bearing Monitor) for more information about such a device.

4.3 Bearing Temperature

Generally, the bearing temperature can be estimated from the temperature of the housing outside surface, but a preferable way is to obtain direct measurements from the bearing outer ring by a probe going through an oil hole.

Usually, the bearing temperature gradually increases after the start of operation until reaching a steady state condition about 1 or 2 hours later. The bearing steady state temperature depends on load, rotational speed and heat transfer properties of the machine. Insufficient lubrication or improper mounting might cause the bearing temperature to rise rapidly. In such a case, suspend the machine operation and adopt an appropriate countermeasure.

4.4 Effects of Lubrication

The two main purposes of lubrication are to minimize friction and reduce wear inside bearings that might otherwise fail prematurely. Lubrication provides the following advantages:

(1) Reduction of Friction and Wear

Direct metallic contact between the bearing rings, rolling elements and cage, which are the basic components of a bearing, is prevented by an oil film which reduces the friction and wear in the contact areas.

(2) Extension of Fatigue Life

The rolling fatigue life of bearings depends greatly upon the viscosity and film thickness between the rolling contact surfaces. A heavy film thickness prolongs the fatigue life, but it is shortened if the viscosity of the oil is too low so that the film thickness is insufficient.

(3) Dissipation of Frictional Heat and Cooling

Circulation lubrication may be used to carry away either frictional heat or heat transferred from the outside to prevent the bearing from overheating and the oil from deteriorating.

(4) Sealing and Rust Prevention

Adequate lubrication also helps to prevent foreign material from entering the bearings and guards against corrosion or rusting.

4.5 Selection of Lubrication

Bearing lubrication methods are divided into two main categories: grease lubrication and oil lubrication. A lubrication method is adopted that matches the application conditions and application purpose in order to attain best performance from the bearing. Table 4.1 shows a comparison between grease and oil lubrication.

Table 4.1 Comparison between grease and oil lubrication

Item	Grease lubrication	Oil lubrication
Housing structure and seal method	Simple	May be complex. Careful maintenance required.
Speed	Limiting speed is 65% to 80% of that with oil lubrication	High limiting speed
Cooling effect	Poor	Heat transfer is possible using forced oil circulation
Fluidity	Poor	Good
Lubricant replacement	Sometimes difficult	Easy
Removal of foreign material	Removal of particles from grease is impossible	Easy
External contamination due to leakage	Surroundings seldom contaminated by leakage	Often leaks if proper countermeasures are not taken. Not suitable if external contamination must be avoided.

(1) Grease lubrication

Grease is a lubricant that is made from base oil, thickener, and additives. When selecting a grease, it is necessary to select a grease that is suitable to the bearing application conditions. There are large differences in performance even between different brands of the same type of grease. Therefore special attention must be given to grease selection. Table 4.2 gives examples of applications and grease consistency.

(2) Oil lubrication

There are several different oil lubrication methods: Oil bath, Drip feed, Splash, Circulating, Jet, Oil mist, and Oil air. Oil lubrication methods are more suitable for higher speed and higher temperature applications than are grease lubrication methods. Oil lubrication is especially effective in the case where it is necessary to dissipate heat to the exterior.

Be sure to select a lubricating oil that has suitable viscosity at the bearing operating temperature. Generally, an oil with a low viscosity is used for high speed application while an oil with high viscosity is used for applications with heavy loads. For normal application conditions, Table 4.3 lists the suitable viscosity range for the operating temperature.

For reference when making a selection, Fig. 4.1 shows the relationship between temperature and viscosity for the lubricating oil. Table 4.4 gives examples of how to select the lubrication oil for different bearing application conditions.

Table 4.3 Required viscosity by bearing type

Bearing type	Viscosity at operating temperature
Ball bearings, Cylindrical roller bearings	13 mm^2/s or more
Tapered roller bearings, Spherical roller bearings	20 mm^2/s or more
Spherical thrust roller bearings	32 mm^2/s or more

Remarks: 1 mm^2/s = 1 cSt (Centi-Stokes)

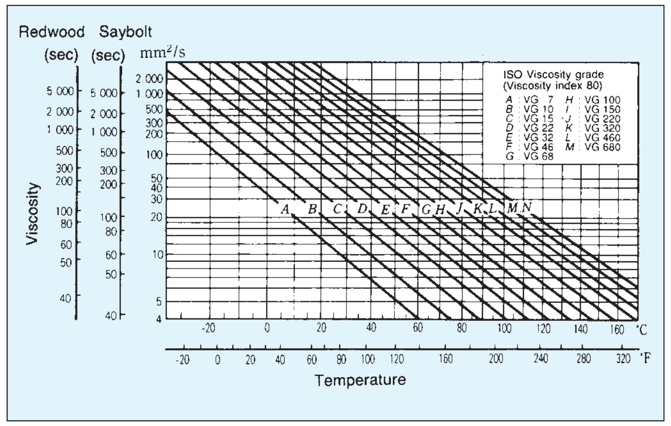


Fig. 4.1 Relation between oil viscosity and temperature

Table 4.2 Examples of applications and grease consistency

Consistency number	# 0	# 1	# 2	# 3	# 4
Consistency (1/10 mm)	355 to 385	310 to 340	265 to 295	220 to 250	175 to 205
Application	Central grease supply	Central grease supply, Low temperature	General grease	General grease, High temperature	High temperature
	Where fretting occurs easily	Where fretting occurs easily	Sealed ball bearings	Sealed ball bearings	Where grease is used as a seal

Table 4.4 Selection of lubricating oils for different bearing applications

Operating temperature	Speed	Light or normal load	Heavy or shock load
–30 to 0°C	Below limiting speed	ISO VG 15, 22, 32 (Refrigerator oil)	—
0 to 50°C	Below 50% of limiting speed	ISO VG 32, 46, 68 (Bearing oil, Turbine oil)	ISO VG 46, 68, 100 (Bearing oil, Turbine oil)
	Between 50% and 100% of limiting speed	ISO VG 15, 22, 32 (Bearing oil, Turbine oil)	ISO VG 22, 32, 46 (Bearing oil, Turbine oil)
	Above limiting speed	ISO VG 10, 15, 22 (Bearing oil)	—
50 to 80°C	Below 50% of limiting speed	ISO VG 100, 150, 220 (Bearing oil)	ISO VG 150, 220, 320 (Bearing oil)
	Between 50% and 100% of limiting speed	ISO VG 46, 68, 100 (Bearing oil, Turbine oil)	ISO VG 68, 100, 150 (Bearing oil, Turbine oil)
	Above limiting speed	ISO VG 32, 46, 68 (Bearing oil, Turbine oil)	—
80 to 110°C	Below 50% of limiting speed	ISO VG 320, 460 (Bearing oil)	ISO VG 460, 680 (Bearing oil, Gear oil)
	Between 50% and 100% of limiting speed	ISO VG 150, 220 (Bearing oil)	ISO VG 220, 320 (Bearing oil)
	Above limiting speed	ISO VG 68, 100 (Bearing oil, Turbine oil)	—

Notes: 1. As for the limiting speed, use the value listed under oil lubrication in the Bearing Dimension Tables of “NSK Rolling Bearings” (No. E1102).
2. Refer to refrigerator oil (JIS K 2211), Bearing oil (JIS K 2239), Turbine oil (JIS K 2213), Gear oil (JIS K 2219).
3. Temperature ranges are shown in the left column in the table above. For operating temperatures that are on the high temperature side, a high viscosity lubrication oil is recommended.

4.6 Replenishment and Replacement of Lubricant

(1) Replenishing Interval

Even if high-quality grease is used, there is deterioration of its properties with time; therefore, periodic replenishment is required. Figs. 4.2 (1) and (2) show the replenishment time intervals for various bearing types running at different speeds. Figs. 4.2 (1) and (2) apply for the condition of high-quality lithium soap-mineral oil grease, bearing temperature of 70°C, and normal load (*P*/*C*=0.1).

• **Temperature**

If the bearing temperature exceeds 70°C, the replenishment time interval must be reduced by half for every 15°C temperature rise of the bearings.

• **Grease**

In case of ball bearings especially, the replenishing time interval can be extended depending on used grease type. (For example, high-quality lithium soap-synthetic oil grease may extend about two times of replenishing time interval shown in Fig. 4.2 (1). If the temperature of the bearings is less than 70℃, the usage of lithium soap-mineral oil grease or lithium soap-syntheticoil grease is appropriate.)

It is advisable to consult NSK.

• **Load**

The replenishing time interval depends on the magnitude of the bearing load.

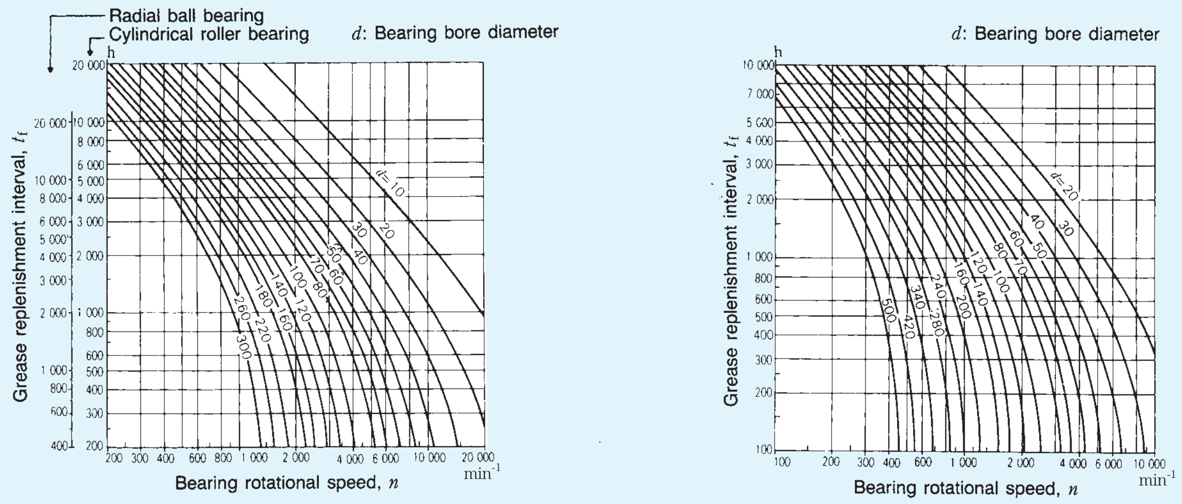
Please refer to Fig. 4.2 (3), and multiply the replenishing time interval by the load factor.

If *P*/*C* exceeds 0.16, it is advisable to consult NSK.

(2) Lubrication oil replacement interval

The oil replacement intervals depend on the operating conditions and the oil quantity. In general, for an operating temperature under 50°C, and in clean environments, the replacement interval is 1 year. If the oil temperature is above 100°C, then the oil should be changed at least once every three months.

Remarks *P* : Equivalent load
C : Basic load rating



(1) Radial ball bearing and cylindrical roller bearing
(2) Tapered roller bearing and spherical roller bearing

P/C	≦ 0.06	0.1	0.13	0.16
Load factor	1.5	1	0.65	0.45

(3) Load factor

Fig. 4.2 Grease replenishment intervals

5. Bearing Inspection

When inspecting a bearing during periodic inspection of equipment, operating inspections, or replacement of adjacent parts, determine the condition of the bearing and if its continued service is advisable.

A record should be kept of the inspection and external appearance of dismounted bearings. After taking a grease sample and measuring the quantity of residual grease, the bearing should be cleaned. Also, determine whether abnormalities and damage exist in the cage, fitting surfaces, rolling element surfaces, and raceway surfaces. Refer to Section 6 regarding the observation of running traces on the raceway surface.

When evaluating whether a bearing can be reused or not, the following points need to be considered: degree of bearing damage, machine performance, critical nature of the application, operating conditions, inspection interval. If the inspection reveals bearing damage or abnormalities, then try to confirm the cause and determine a measure by referring to Section 7 and then carry out the countermeasure.

If your inspection discovers any of the following kinds of damage, which would prevent the bearing from being reused, then the bearing must be replaced with a new one.

(1) Cracks or chipping in the cage, rolling elements, or raceway ring.
(2) Flaking in the rolling elements or raceway ring.
(3) Notable scoring on the rolling elements, rib face (collar), or raceway surface.
(4) Notable wear on the cage or loose rivets.
(5) Flaws or rust on the rolling elements or raceway surface.
(6) Notable dents on the rolling elements or raceway surface.
(7) Notable creep of the outer ring outside surface or inner ring bore.
(8) Discoloration due to heating.
(9) Serious damage on shield or seal of grease packed bearings.

6. Running Traces and Applied Loads

As the bearing rotates, the raceways of the inner ring and outer ring make contact with the rolling elements. This results in a wear path on both the rolling elements and raceways. Running traces are useful, since they indicate the loading conditions, and should be carefully observed when the bearing is disassembled.

If the running traces are clearly defined, it is possible to determine whether the bearing is carrying a radial load, axial load or moment load. Also, the roundness condition of the bearing can be determined. Check whether unexpected bearing loads or large mounting errors occurred. Also, determine the probable cause of the bearing damage.

Fig. 6.1 shows the running traces generated in deep groove bearings under various load conditions. Fig. 6.1 (a) shows the most common running trace generated when the inner ring rotates under a radial load only. Figs. 6.1 (e) through (h) show several different running traces that result in a shortened life due to their adverse effect on the bearings.

Similarly, Fig. 6.2 shows different roller bearing running traces: Fig. 6.2 (i) shows the outer ring running trace when a radial load is properly applied to a cylindrical roller bearing which has a load on a rotating inner ring. Fig. 6.2 (j) shows the running trace in the case of shaft bending or relative inclination between the inner and outer rings. This misalignment leads to the generation of slightly shaded (dull) bands in the width direction. Traces are diagonal at the beginning and end of the loading zone. For double-row tapered roller bearings where a single load is applied to the rotating inner ring, Fig. 6.2 (k) shows the running trace on the outer ring under radial load while Fig. 6.2 (l) shows the running trace on the outer ring under axial load. When misalignment exists between the inner and the outer rings, then the application of a radial load causes running traces to appear on the outer ring as shown in Fig. 6.2 (m).

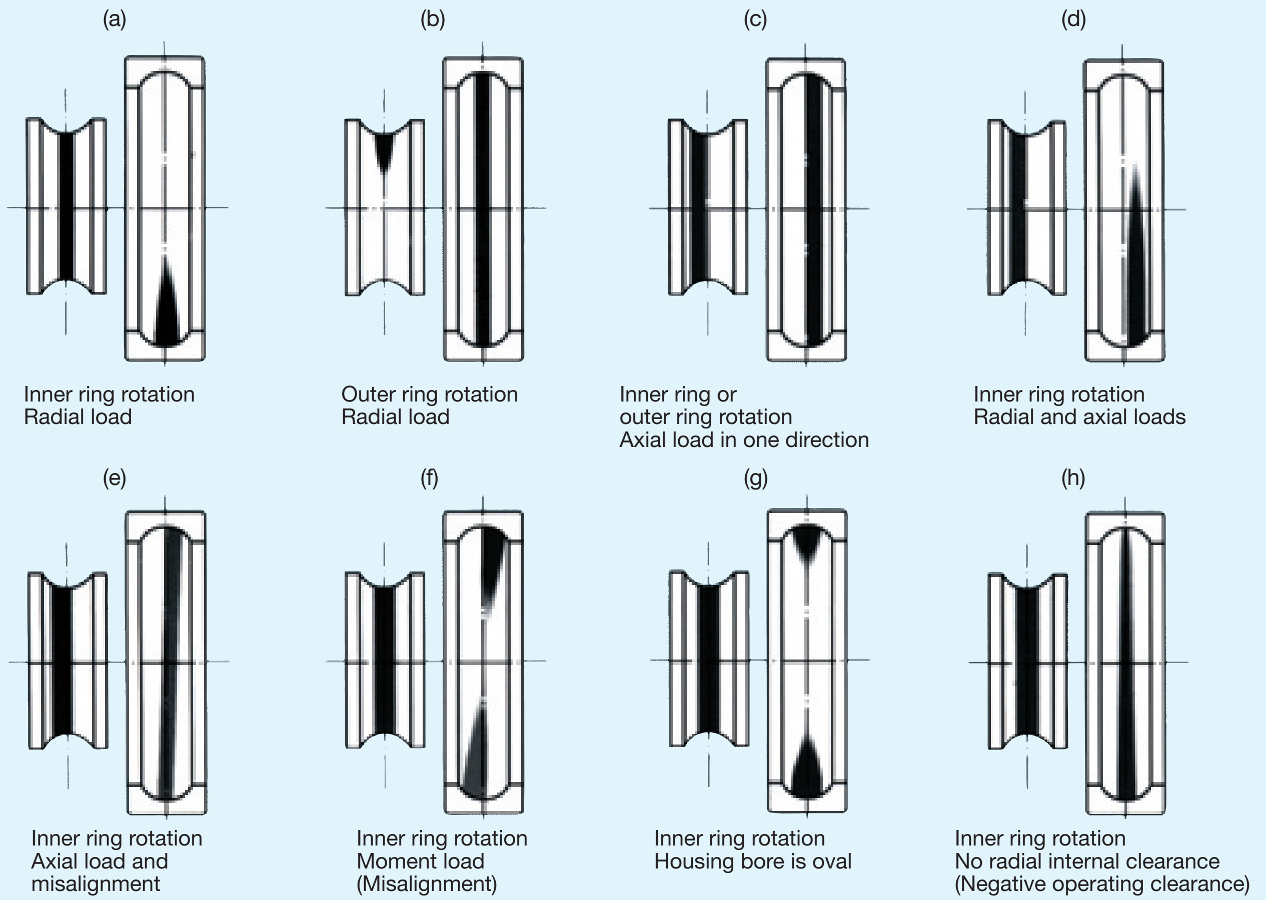


Fig. 6.1 Typical running traces of deep groove ball bearings

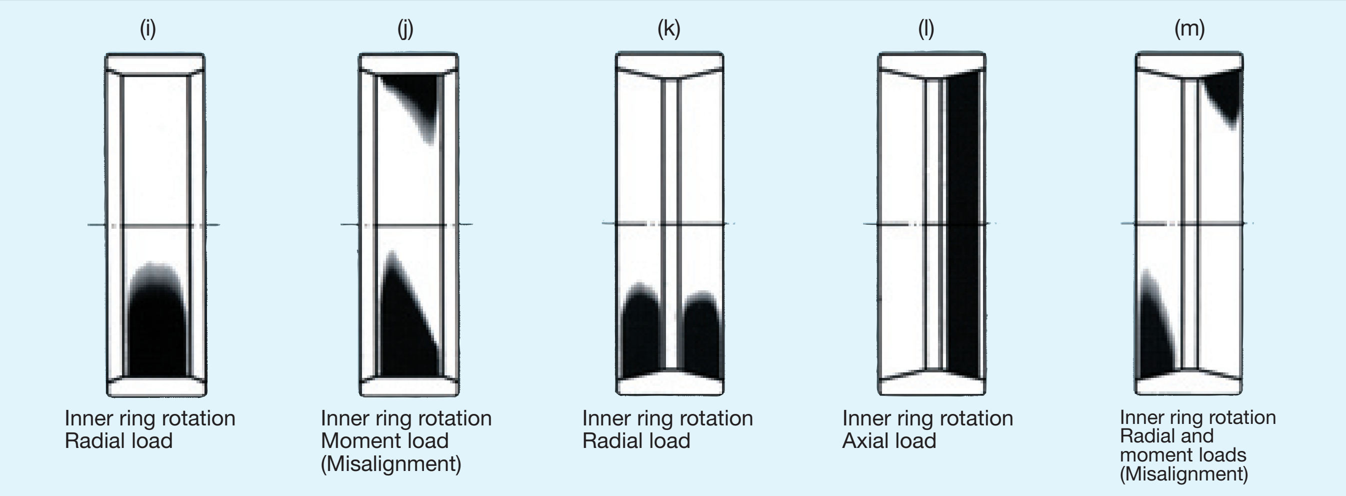


Fig. 6.2 Typical running traces on roller bearings

7. Bearing Damage and Measures

In general, if rolling bearings are used correctly, they will survive to their predicted fatigue life. Bearings, however, often fail prematurely due to avoidable mistakes. In contrast to fatigue life, this premature failure is caused by improper mounting, mishandling, poor lubrication, entry of foreign matter or abnormal heat generation.

For example, one cause of premature failure is rib scoring which is due to insufficient lubrication, use of improper lubricant, faulty lubrication system, entry of foreign matter, bearing mounting error, excessive deflection of the shaft or some combination of these. If all conditions are known for the times both before and after the failure, including the application, the operating conditions, and environment, then a measure can be determined by studying the nature of the failure and its probable causes. A successful measure will reduce similar failures or prevent them from happening again.

Sections 7.1 through 7.18 give various type of bearing damage and measures. Please consult these sections when trying to determine the cause of bearing damage. By the way, the bearing diagnostic chart in the Appendix may be useful as a quick reference guide.

7.1 Flaking

Damage Condition	Possible Cause	Measures
Flaking occurs when small pieces of bearing material are split off from the smooth surface of the raceway or rolling elements due to rolling fatigue, thereby creating regions having rough and coarse texture.	Excessive load Poor mounting (misalignment) Moment load Entry of foreign debris, water penetration Poor lubrication, Improper lubricant Unsuitable bearing clearance Improper precision for shaft or housing, unevenness in housing rigidity, large shaft bending Progression from rust, corrosion pits, smearing, dents (Brinelling)	• Reconfirm the bearing application and check the load conditions • Improve the mounting method • Improve the sealing mechanism, prevent rusting during non-running • Use a lubricant with a proper viscosity, improve the lubrication method • Check the precision of shaft and housing • Check the bearing internal clearance

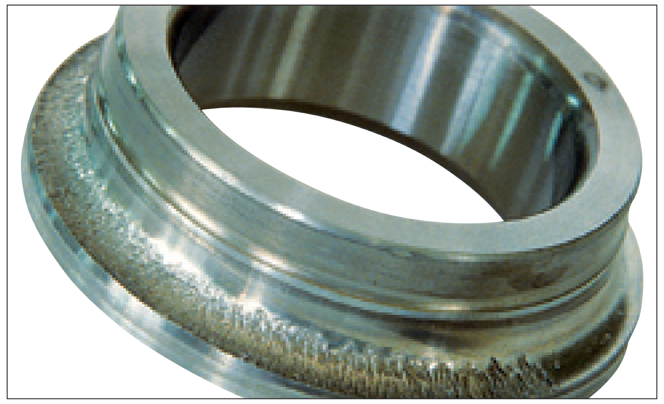


Photo 7-1-1
Part: Inner ring of an angular contact ball bearing
Symptom: Flaking occurs around half of the circumference of the raceway surface
Cause: Poor lubrication due to entry of cutting coolant into bearing

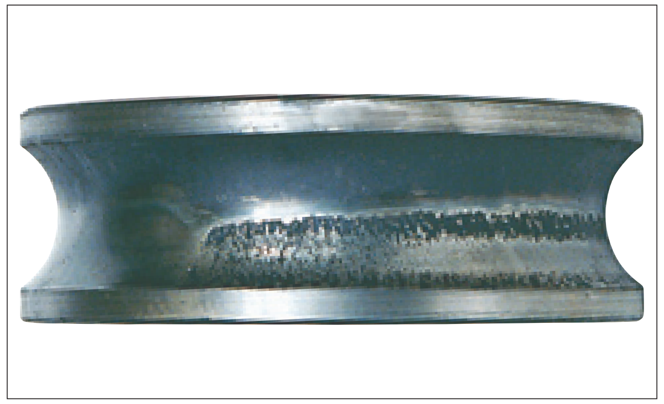


Photo 7-1-2
Part: Inner ring of an angular contact ball bearing
Symptom: Flaking occurs diagonally along raceway
Cause: Poor alignment between shaft and housing during mounting

Photo 7-1-3
Part: Inner ring of deep groove ball bearing
Symptom: Flaking of raceway at ball pitch
Cause: Dents due to shock load during mounting

Photo 7-1-4
Part: Inner ring of an angular contact ball bearing
Symptom: Flaking of raceway at ball pitch
Cause: Dents due to shock load while stationary

Photo 7-1-5
Part: Outer ring of Photo 7-1-4
Symptom: Flaking of raceway surface at ball pitch
Cause: Dents due to shock load while stationary

Photo 7-1-6
Part: Balls of Photo 7-1-4
Symptom: Flaking of ball surface
Cause: Dents due to shock load while stationary

Photo 7-1-7
Part: Inner ring of a spherical roller bearing
Symptom: Flaking of only one raceway over its entire circumference
Cause: Excessive axial load

Photo 7-1-8
Part: Outer ring of Photo 7-1-7
Symptom: Flaking of only one raceway over its entire circumference
Cause: Excessive axial load

Photo 7-1-9
Part: Inner ring of a spherical roller bearing
Symptom: Flaking of only one row of raceway
Cause: Poor lubrication

Photo 7-1-10
Part: Rollers of a cylindrical roller bearing
Symptom: Premature flaking occurs axially on the rolling surfaces
Cause: Scratches caused during improper mounting

7.2 Peeling

Damage Condition	Possible Cause	Measures
Dull or cloudy spots appear on surface along with light wear. From such dull spots, tiny cracks are generated downward to a depth of 5 to 10 μm. Small particles fall off and minor flaking occurs widely.	Unsuitable lubricant Entry of debris into lubricant Rough surface due to poor lubrication Surface roughness of mating rolling part	● Select a proper lubricant ● Improve the sealing mechanism ● Improve the surface finish of the rolling mating parts

Photo 7-2-1
Part: Inner ring of a spherical roller bearing
Symptom: Round shaped peeling pattern occurs on the center of the raceway surface
Cause: Poor lubrication

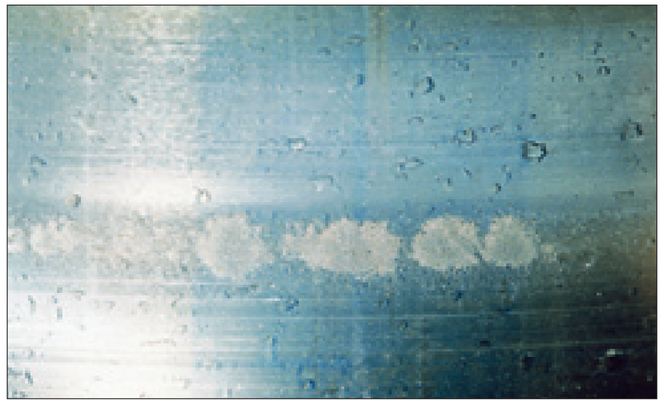


Photo 7-2-2
Part: Enlargement of pattern in Photo 7-2-1

Photo 7-2-3
Part: Convex rollers of Photo 7-2-1
Symptom: Round shaped peeling pattern occurs on the center of the rolling surfaces
Cause: Poor lubrication

Photo 7-2-4
Part: Outer ring of a spherical roller bearing
Symptom: Peeling occurs near the shoulder of the raceway over the entire circumference
Cause: Poor lubrication

7.3 Scoring

Damage Condition	Possible Cause	Measures
Scoring is surface damage due to accumulated small seizures caused by sliding under improper lubrication or under severe operating conditions. Linear damage appears circumferentially on the raceway surface and rolling surface. Cycloidal shaped damage on the roller end. Scoring on rib surface contacting roller end.	Excessive load, excessive preload Poor lubrication Particles are caught in the surface Inclination of inner and outer rings Shaft bending Poor precision of the shaft and housing	● Check the size of the load ● Adjust the preload ● Improve the lubricant and the lubrication method ● Check the precision of the shaft and housing

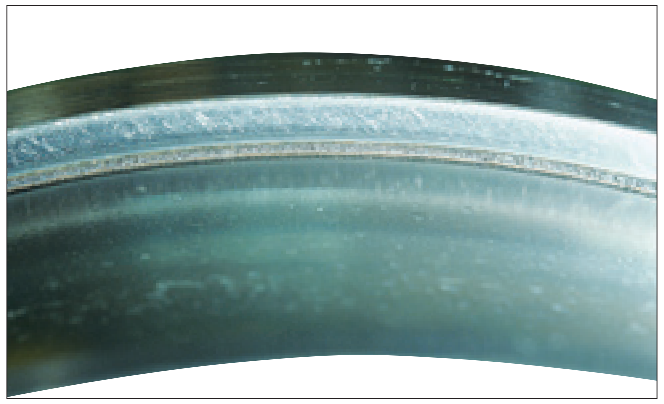


Photo 7-3-1
Part: Inner ring of a spherical roller bearing
Symptom: Scoring on large rib face of inner ring
Cause: Roller slipping due to sudden acceleration and deceleration

Photo 7-3-2
Part: Convex rollers of Photo 7-3-1
Symptom: Scoring on roller end face
Cause: Roller slipping due to sudden acceleration and deceleration

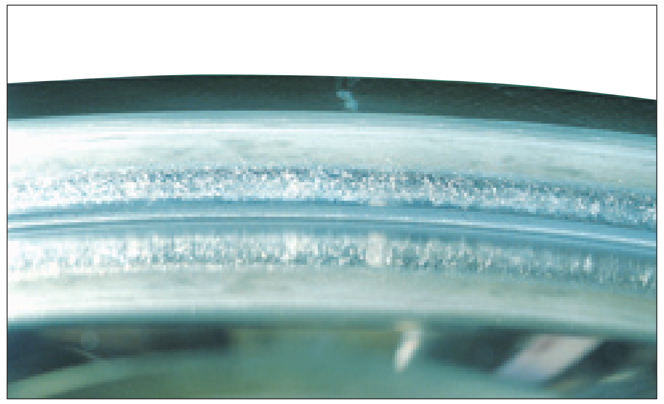


Photo 7-3-3
Part: Inner ring of a tapered roller thrust bearing
Symptom: Scoring on the face of inner ring rib
Cause: Worn particles become mixed with lubricant, and breakdown of oil film occurs due to excessive load

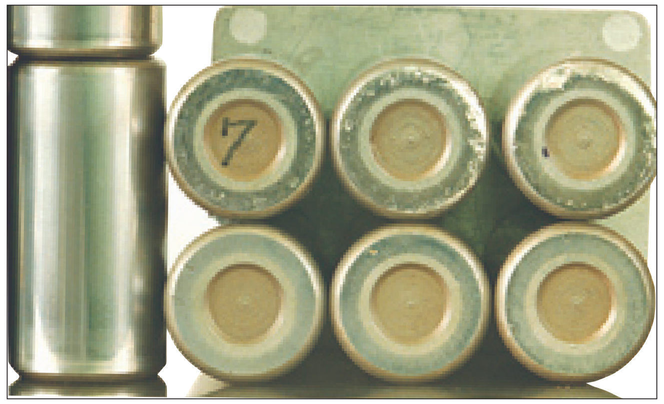


Photo 7-3-4
Part: Rollers of a double-row cylindrical roller bearing
Symptom: Scoring on the roller end face
Cause: Poor lubrication and excessive axial load

Photo 7-3-5
Part: Inner ring of a spherical thrust roller bearing
Symptom: Scoring on the rib face of inner ring
Cause: Debris, which is caught in surface, and excessive axial loading

Photo 7-3-6
Part: Convex rollers of Photo 7-3-5
Symptom: Scoring on the roller end face
Cause: Debris, which is caught in surface, and excessive axial loading

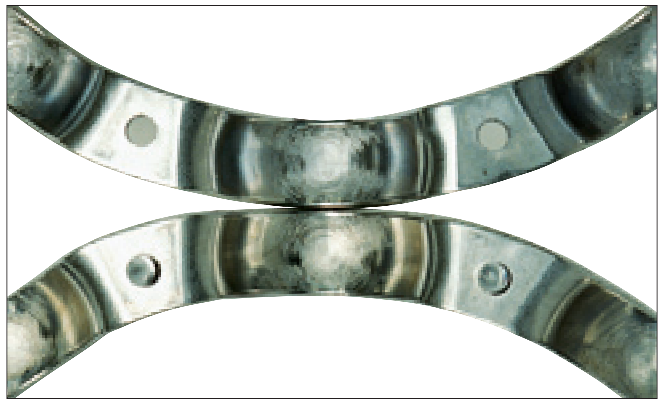


Photo 7-3-7
Part: Cage of a deep groove ball bearing
Symptom: Scoring on the pressed-steel cage pockets
Cause: Entry of debris

7.4 Smearing

Damage Condition	Possible Cause	Measures
Smearing is surface damage which occurs from a collection of small seizures between bearing components caused by oil film rupture and/or sliding. Surface roughening occurs along with melting.	High speed and light load Sudden acceleration/deceleration Improper lubricant Entry of water	● Improve the preload ● Improve the bearing clearance ● Use a lubricant with good oil film formation ability ● Improve the lubrication method ● Improve the sealing mechanism

Photo 7-4-1
Part: Inner ring of a cylindrical roller bearing
Symptom: Smearing occurs circumferentially on raceway surface
Cause: Roller slipping due to excessive grease filling

Photo 7-4-2
Part: Outer ring of Photo 7-4-1
Symptom: Smearing occurs circumferentially on raceway surface
Cause: Roller slipping due to excessive grease filling

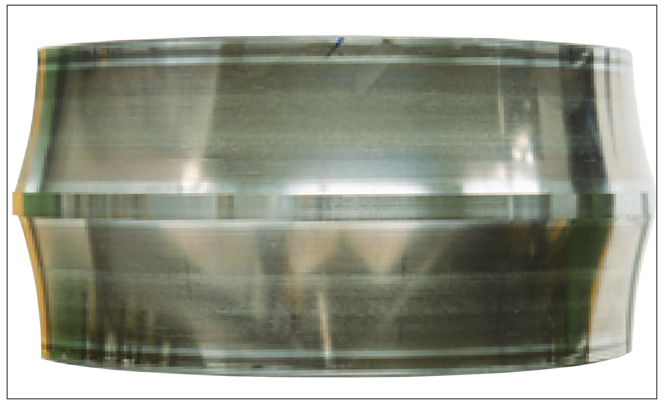


Photo 7-4-3
Part: Inner ring of a spherical roller bearing
Symptom: Smearing occurs circumferentially on raceway surface
Cause: Poor lubrication

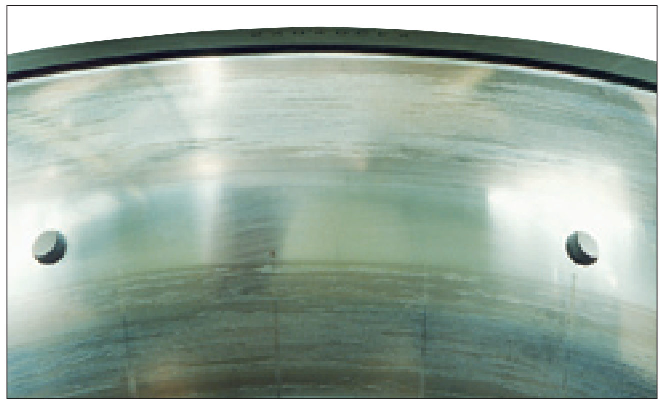


Photo 7-4-4
Part: Outer ring of Photo 7-4-3
Symptom: Smearing occurs circumferentially on raceway surface
Cause: Poor lubrication

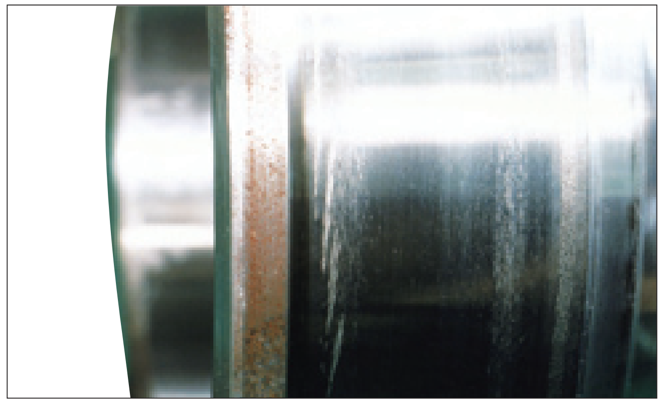


Photo 7-4-5
Part: Inner ring of a spherical roller bearing
Symptom: Partial smearing occurs circumferentially on raceway surface
Cause: Poor lubrication

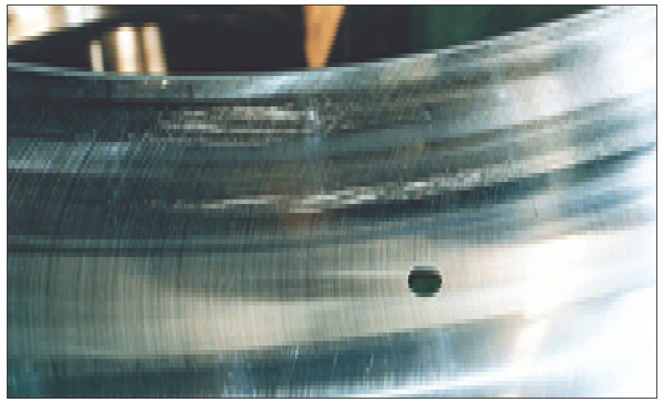


Photo 7-4-6
Part: Outer ring of Photo 7-4-5
Symptom: Partial smearing occurs circumferentially on raceway surface
Cause: Poor lubrication

Photo 7-4-7
Part: Convex rollers of Photo 7-4-5
Symptom: Smearing occurs at the center of the rolling surface
Cause: Poor lubrication

7.5 Fracture

Damage Condition	Possible Cause	Measures
Fracture refers to small pieces which were broken off due to excessive load or shock load acting locally on a part of the roller corner or rib of a raceway ring.	Impact during mounting Excessive load Poor handling such as dropping	● Improve the mounting method (Shrink fit, use of proper tools) ● Reconsider the loading conditions ● Provide enough back-up and support for the bearing rib

Photo 7-5-1
Part: Inner ring of a double-row cylindrical roller bearing
Symptom: Chipping occurs at the center rib
Cause: Excessive load during mounting

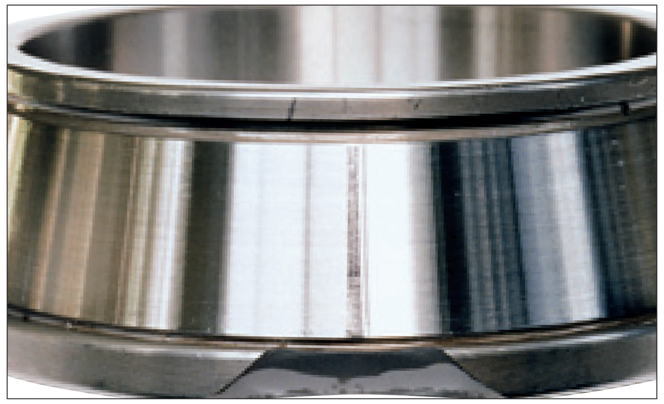


Photo 7-5-2
Part: Inner ring of a tapered roller bearing
Symptom: Fracture occurs at the cone back face rib
Cause: Large shock during mounting

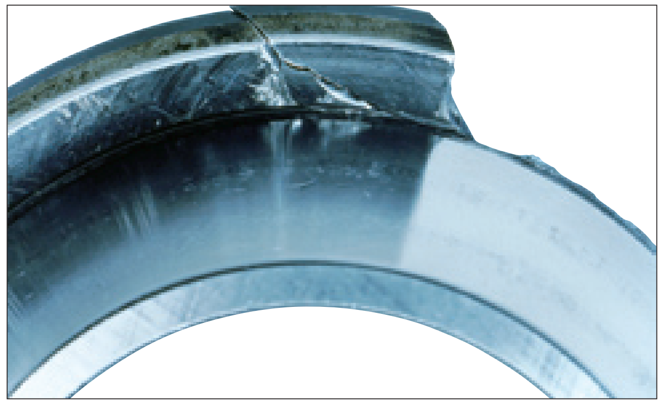


Photo 7-5-3
Part: Inner ring of a spherical thrust roller bearing
Symptom: Fracture occurs at the large rib
Cause: Repeated load

Photo 7-5-4
Part: Outer ring of a solid type needle roller bearing
Symptom: Fracture occurs at the outer ring rib
Cause: Roller inclination due to excessive loading (Needle rollers are long compared to their diameter. Under excessive or uneven loading, rollers become inclined and push against the ribs.)

7.6 Cracks

Damage Condition	Possible Cause	Measures
Cracks in the raceway ring and rolling elements. Continued use under this condition leads to larger cracks or fractures.	Excessive interference Excessive load, shock load Progression of flaking Heat generation and fretting caused by contact between mounting parts and raceway ring Heat generation due to creep Poor taper angle of tapered shaft Poor cylindricality of shaft Interference with bearing chamfer due to a large shaft corner radius	● Correct the interference ● Check the load conditions ● Improve the mounting method ● Use an appropriate shaft shape

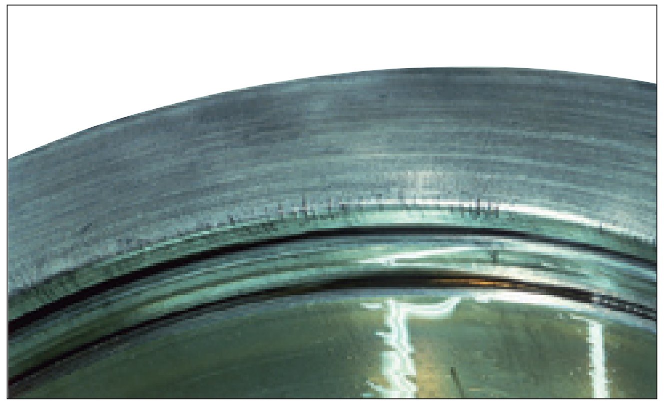


Photo 7-6-1
Part: Outer ring of a double-row cylindrical roller bearing
Symptom: Thermal cracks occur on the outer ring side face
Cause: Abnormal heat generation due to contact sliding between mating part and face of outer ring

Photo 7-6-2
Part: Roller of a tapered roller thrust bearing
Symptom: Thermal cracks occur at large end face of roller
Cause: Heat generation due to sliding with the inner ring rib under poor lubrication

Photo 7-6-3
Part: Outer ring of a double-row cylindrical roller bearing
Symptom: Cracks propageted outward in the axial and circumferential directions from the flaking origin on the raceway surface
Cause: Flaking from a flaw due to shock

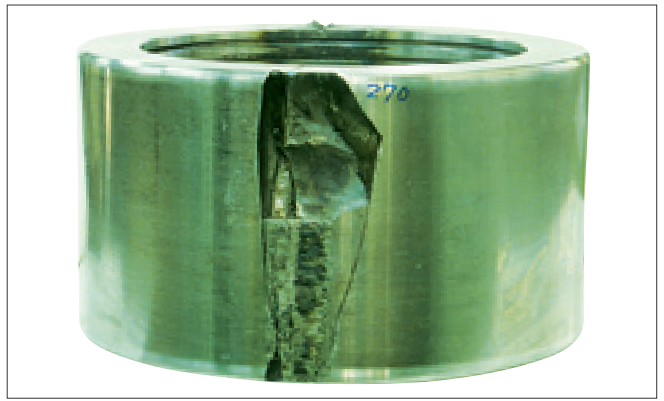


Photo 7-6-4
Part: Outer ring of a double-row cylindrical roller bearing used for outer ring rolling (Outer ring rotation)
Symptom: Cracks occur on outside surface
Cause: Flat wear and heat generation due to non-rotation of the outer ring

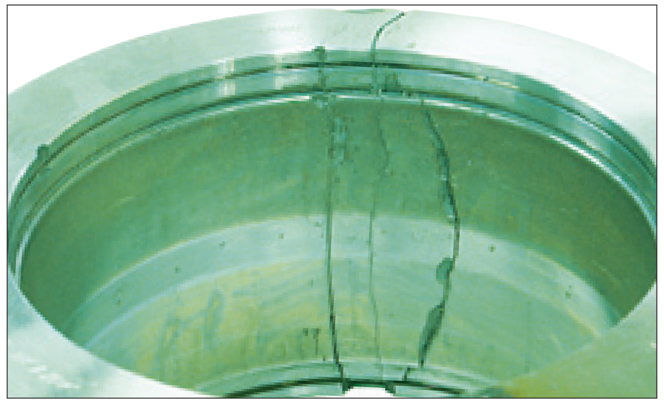


Photo 7-6-5
Part: Raceway surface of outer ring in Photo 7-6-4
Symptom: Outside surface crack developing on the raceway

Photo 7-6-6
Part: Inner ring of a spherical roller bearing
Symptom: Axial cracks occur on raceway surface
Cause: Large fitting stress due to temperature difference between shaft and inner ring.

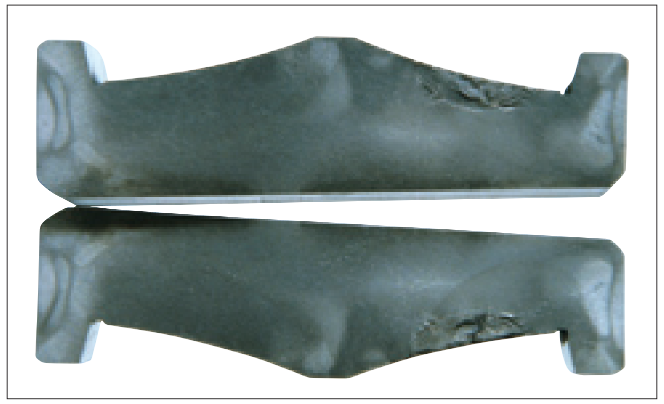


Photo 7-6-7
Part: Cross section of a fractured inner ring in Photo 7-6-6
Symptom: Origin is directly beneath the raceway surface

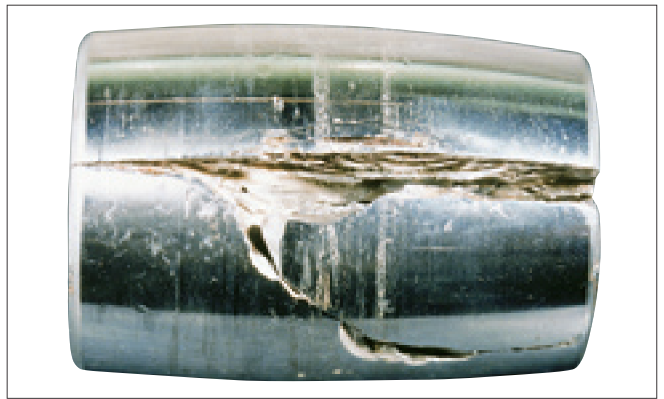


Photo 7-6-8
Part: Roller of a spherical roller bearing
Symptom: Axial cracks occur on rolling surface

7.7 Cage Damage

Damage Condition	Possible Cause	Measures
Cage damage includes cage deformation, fracture, and wear Fracture of cage pillar Deformation of side face Wear of pocket surface Wear of guide surface	Poor mounting (Bearing misalignment) Poor handling Large moment load Shock and large vibration Excessive rotation speed, sudden acceleration and deceleration Poor lubrication Temperature rise	● Check the mounting method ● Check the temperature, rotation, and load conditions ● Reduce the vibration ● Select a cage type ● Select a lubrication method and lubricant

Photo 7-7-1
Part: Cage of a deep groove ball bearing
Symptom: Fracture of pressed-steel cage-pocket

Photo 7-7-2
Part: Cage of an angular contact ball bearing
Symptom: Pocket pillar fractures from a cast iron machined cage
Cause: Abnormal load action on cage due to misaligned mounting between inner and outer rings

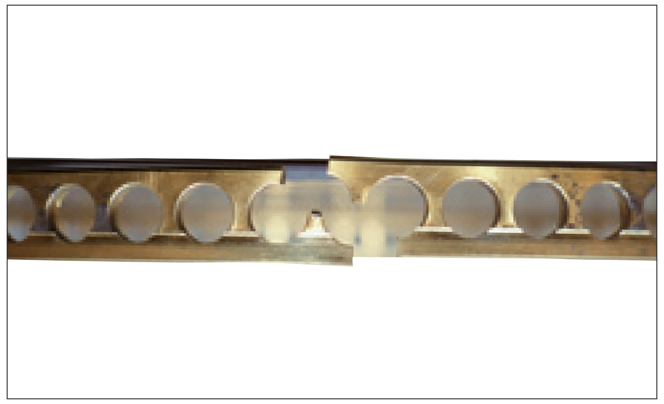


Photo 7-7-3
Part: Cage of an angular contact ball bearing
Symptom: Fracture of machined high-tension brass cage

Photo 7-7-4
Part: Cage of a tapered roller bearing
Symptom: Pillar fractures of pressed-steel cage

Photo 7-7-5
Part: Cage of an angular contact ball bearing
Symptom: Pressed-steel cage deformation
Cause: Shock load due to poor handling

Photo 7-7-6
Part: Cage of a cylindrical roller bearing
Symptom: Deformation of the side face of a machined high-tension brass cage
Cause: Large shock during mounting

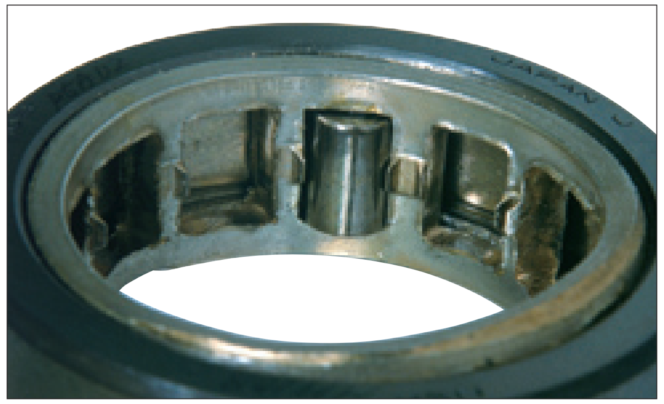


Photo 7-7-7
Part: Cage of a cylindrical roller bearing
Symptom: Deformation and wear of a machined high-tension brass cage

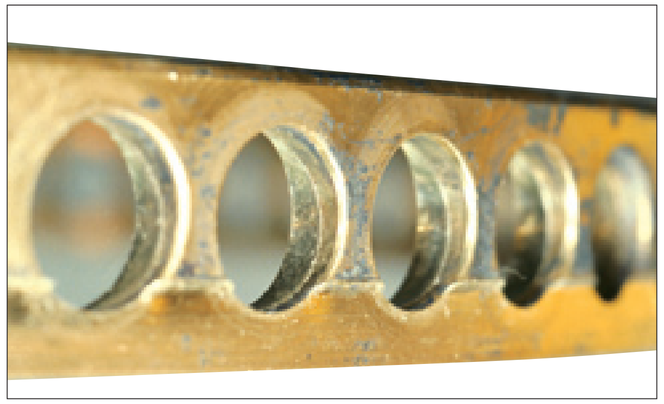


Photo 7-7-8
Part: Cage of an angular contact ball bearing
Symptom: Stepped wear on the outside surface and pocket surface of a machined high-tension brass cage

7.8 Denting

Damage Condition	Possible Cause	Measures
When debris such as small metallic particles are caught in the rolling contact zone, denting occurs on the raceway surface or rolling element surface. Denting can occur at the rolling element pitch interval if there is a shock during the mounting (Brinell dents).	Debris such as metallic particles are caught in the surface Excessive load Shock during transport or mounting	● Wash the housing ● Improve the sealing mechanism ● Filter the lubrication oil ● Improve the mounting and handling methods

Photo 7-8-1
Part: Inner ring of a double-row tapered roller bearing
Symptom: Frosted raceway surface
Cause: Debris caught in the surface

Photo 7-8-2
Part: Outer ring of a double-row tapered roller bearing
Symptom: Indentations on raceway surface
Cause: Debris caught in the surface

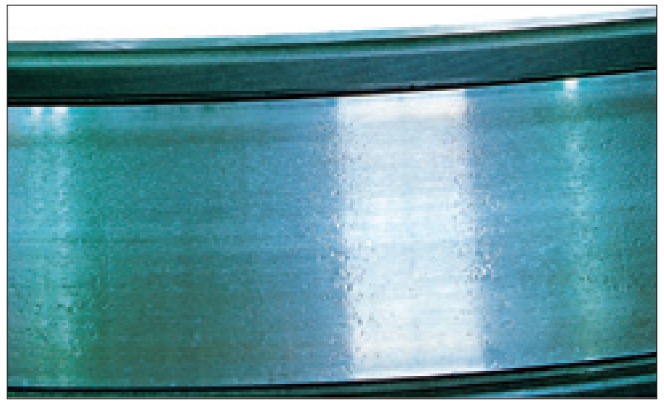


Photo 7-8-3
Part: Inner ring of a tapered roller bearing
Symptom: Small and large indentations occur over entire raceway surface
Cause: Debris caught in the surface

Photo 7-8-4
Part: Tapered rollers of Photo 7-8-3
Symptom: Small and large indentations occur over the rolling surface
Cause: Debris caught in the surface

7.9 Pitting

Damage Condition	Possible Cause	Measures
The pitted surface has a dull luster which appears on the rolling element surface or raceway surface.	Debris becomes caught in the lubricant Exposure to moisture in the atmosphere Poor lubrication	● Improve the sealing mechanism ● Filter the lubrication oil thoroughly ● Use a proper lubricant

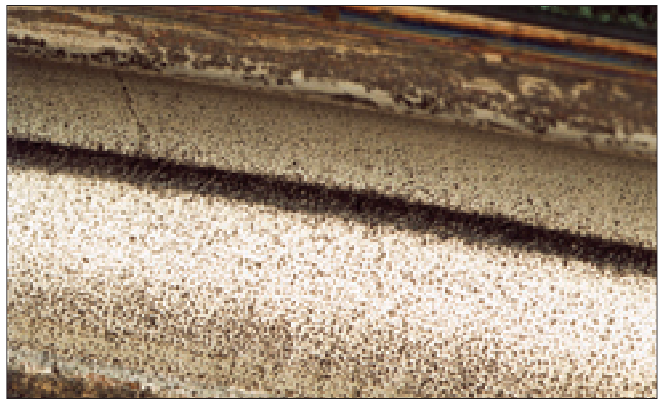


Photo 7-9-1
Part: Outer ring of a slewing bearing
Symptom: Pitting occurs on the raceway surface
Cause: Rust at bottoms of indentations

Photo 7-9-2
Part: Ball of Photo 7-9-1
Symptom: Pitting occurs on the rolling element surface

7.10 Wear

Damage Condition	Possible Cause	Measures
Wear is surface deterioration due to sliding friction at the surface of the raceway, rolling elements, roller end faces, rib face, cage pockets, etc.	Entry of debris Progression from rust and electrical corrosion Poor lubrication Sliding due to irregular motion of rolling elements	● Improve the sealing mechanism ● Clean the housing ● Filter the lubrication oil thoroughly ● Check the lubricant and lubrication method ● Prevent misalignment

Photo 7-10-1
Part: Inner ring of a cylindrical roller bearing
Symptom: Many pits occur due to electrical corrosion and wave-shaped wear on raceway surface
Cause: Electrical corrosion

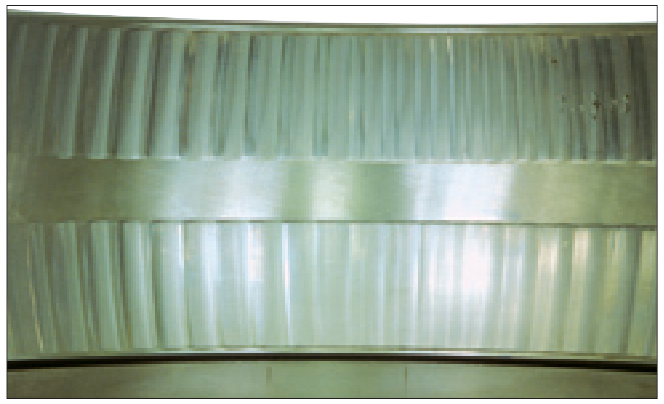


Photo 7-10-2
Part: Outer ring of a spherical roller bearing
Symptom: Wear having a wavy or concave-and-convex texture on loaded side of raceway surface
Cause: Entry of debris under repeated vibration while stationary

Photo 7-10-3
Part: Inner ring of a double-row tapered roller bearing
Symptom: Fretting wear of raceway and stepped wear on the rib face
Cause: Fretting progression due to excessive load while stationary

Photo 7-10-4
Part: Tapered rollers of Photo 7-10-3
Symptom: Stepped wear on the roller head and face
Cause: Fretting progression due to excessive load while stationary

7.11 Fretting

Damage Condition	Possible Cause	Measures
Wear occurs due to repeated sliding between the two surfaces. Fretting occurs at fitting surface and also at contact area between raceway ring and rolling elements. Fretting corrosion is another term used to describe the reddish brown or black worn particles.	Poor lubrication Vibration with a small amplitude Insufficient interference	● Use a proper lubricant ● Apply a preload ● Check the interference fit ● Apply a film of lubricant to the fitting surface

Photo 7-11-1
Part: Inner ring of a deep groove ball bearing
Symptom: Fretting occurs on the bore surface
Cause: Vibration

Photo 7-11-2
Part: Inner ring of an angular contact ball bearing
Symptom: Notable fretting occurs over entire circumference of bore surface
Cause: Insufficient interference fit

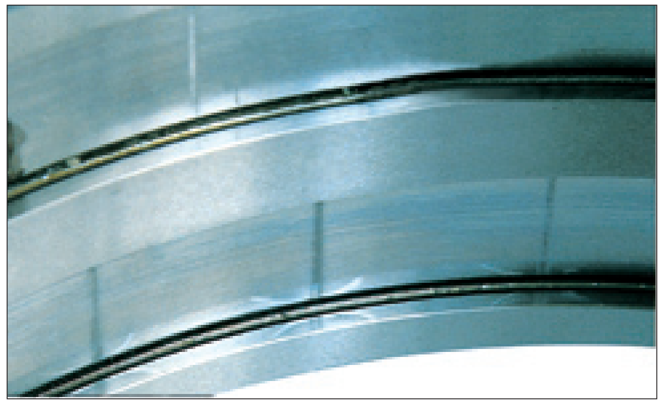


Photo 7-11-3
Part: Outer ring of a double-row cylindrical roller bearing
Symptom: Fretting occurs on the raceway surface at roller pitch intervals

7.12 False Brinelling

Damage Condition	Possible Cause	Measures
Among the different types of fretting, false brinelling is the occurrence of hollow spots that resemble brinell dents, and are due to wear caused by vibration and swaying at the contact points between the rolling elements and raceway.	Oscillation and vibration of a stationary bearing during such times as transporting Oscillating motion with a small amplitude Poor lubrication	● Secure the shaft and housing during transporting ● Transport with the inner and outer rings packed separately ● Reduce the vibration by preloading ● Use a proper lubricant

Photo 7-12-1
Part: Inner ring of a deep groove ball bearing
Symptom: False brinelling occurs on the raceway
Cause: Vibration from an external source while stationary

Photo 7-12-2
Part: Outer ring of Photo 7-12-1
Symptom: False brinelling occurs on the raceway
Cause: Vibration from an external source while stationary

Photo 7-12-3
Part: Outer ring of a thrust ball bearing
Symptom: False brinelling of raceway surface at ball pitch
Cause: Repeated vibration with a small oscillating angle

Photo 7-12-4
Part: Rollers of a cylindrical roller bearing
Symptom: False brinelling occurs on rolling surface
Cause: Vibration from an external source while stationary

7.13 Creep

Damage Condition	Possible Cause	Measures
Creep is the phenomenon in bearings where relative slipping occurs at the fitting surfaces and thereby creates a clearance at the fitting surface. Creep causes a shiny appearance, occasionally with scoring or wear.	Insufficient interference or loose fit Insufficient sleeve tightening	● Check the interference, and prevent rotation ● Correct the sleeve tightening ● Study the shaft and housing precision ● Preload in the axial direction ● Tighten the raceway ring side face ● Apply adhesive to the fitting surface ● Apply a film of lubricant to the fitting surafce

Photo 7-13-1
Part: Inner ring of a spherical roller bearing
Symptom: Creep accompanied by scoring of bore surface
Cause: Insufficient interference

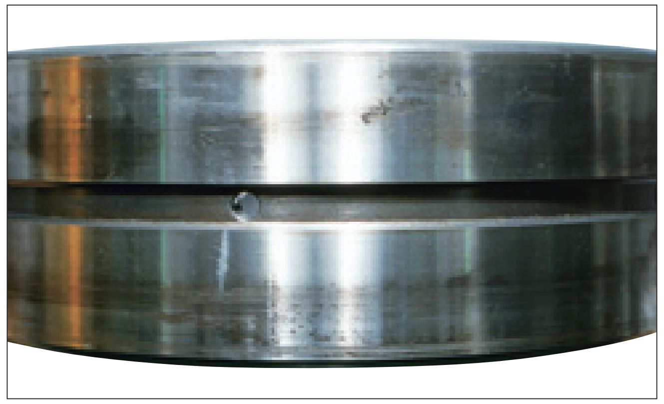


Photo 7-13-2
Part: Outer ring of a spherical roller bearing
Symptom: Creep occurs over entire circumference of outside surface
Cause: Loose fit between outer ring and housing

7.14 Seizure

Damage Condition	Possible Cause	Measures
When sudden overheating occurs during rotation, the bearing becomes discolored. Next, raceway rings, rolling elements, and cage will soften, melt and deform as damage accumulates.	Poor lubrication Excessive load (Excessive preload) Excessive rotational speed Excessively small internal clearance Entry of water and debris Poor precision of shaft and housing, excessive shaft bending	● Study the lubricant and lubrication method ● Reinvestigate the suitability of the bearing type selected ● Study the preload, bearing clearance, and fitting ● Improve the sealing mechanism ● Check the precision of the shaft and housing ● Improve the mounting method

Photo 7-14-1
Part: Inner ring of a spherical roller bearing
Symptom: Raceway is discolored and melted. Worn particles from the cage were rolled and attached to the raceway
Cause: Insufficient lubrication

Photo 7-14-2
Part: Convex rollers of Photo 7-14-1
Symptom: Discoloration and melting of roller rolling surface, adhesion of worn particles from cage
Cause: Insufficient lubrication

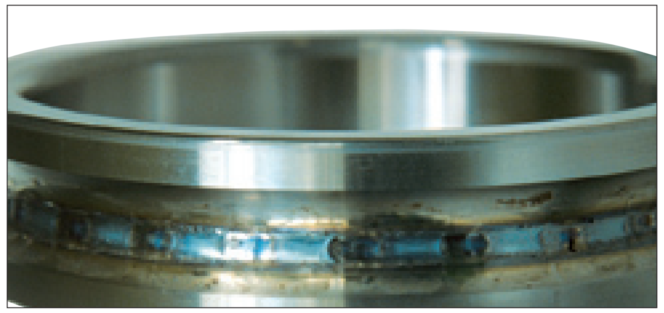


Photo 7-14-3
Part: Inner ring of an angular contact ball bearing
Symptom: Raceway discoloration, melting occurs at ball pitch intervals
Cause: Excessive preload

Photo 7-14-4
Part: Outer ring in Photo 7-14-3
Symptom: Raceway discoloration, melting occurs at ball pitch intervals
Cause: Excessive preload

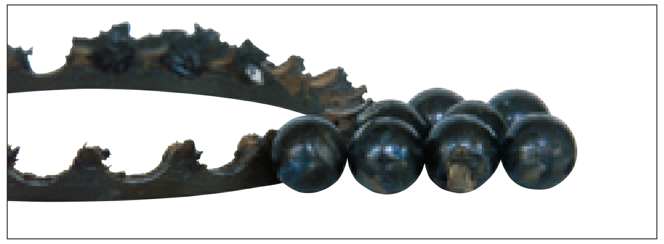


Photo 7-14-5
Part: Balls and cage of Photo 7-14-3
Symptom: Cage is damaged by melting, balls become discolored and melted
Cause: Excessive preload

7.15 Electrical Corrosion

Damage Condition	Possible Cause	Measures
When electric current passes through a bearing, arcing and burning occur through the thin oil film at points of contact between the race and rolling elements. The points of contact are melted locally to form "fluting" or groove-like corrugations which are seen by the naked eye. The magnification of these grooves will reveal crater-like depressions which indicate melting by arcing.	Electrical potential difference between inner and outer rings Electrical potential difference of a high frequency that is generated by instruments or substrates when used near a bearing.	• Design electric circuits which prevent current flow through the bearings • Insulation of the bearing

Photo 7-15-1
Part: Inner ring of a tapered roller bearing
Symptom: Striped pattern of corrosion occurs on the raceway surface

Photo 7-15-2
Part: Tapered rollers in Photo 7-15-1
Symptom: Striped pattern of corrosion occurs on the rolling surface

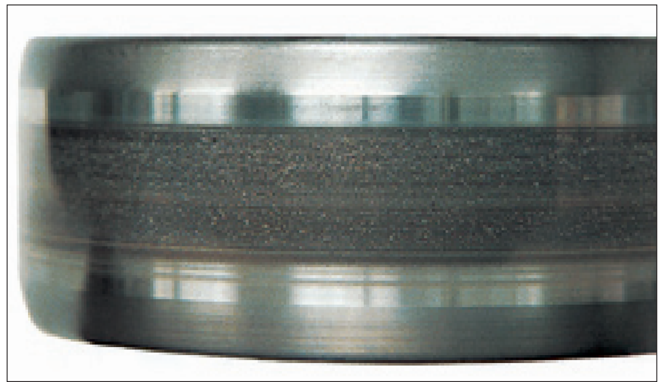
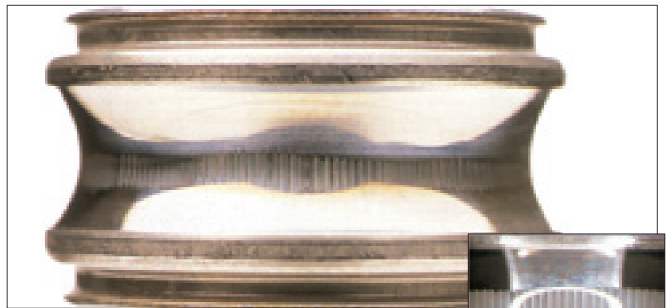
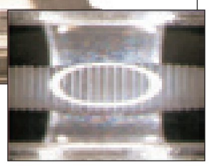


Photo 7-15-3
Part: Inner ring of a cylindrical roller bearing
Symptom: Belt pattern of electrical corrosion accompanied by pits on the raceway surface

Photo 7-15-4
Part: Balls of a groove ball bearing
Symptom: Electrical corrosion has a dark color that covers the entire ball surface





Enlargement

Photo 7-15-5
Part: Inner ring of a deep groove ball bearing
Symptom: Fluting occurs on the raceway surface (High frequency)

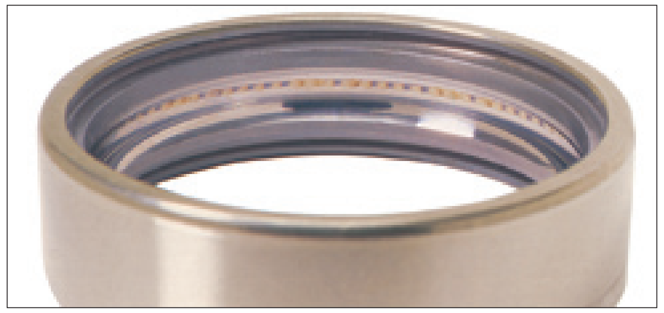


Photo 7-15-6
Part: Outer ring of a deep groove ball bearing
Symptom: Fluting occurs on the raceway surface (High frequency)

7.16 Rust and Corrosion

Damage Condition	Possible Cause	Measures
Bearing rust and corrosion are pits on the surface of rings and rolling elements and may occur at the rolling element pitch on the rings or over the entire bearing surfaces.	Entry of corrosive gas or water Improper lubricant Formation of water droplets due to condensation of moisture High temperature and high humidity while stationary Poor rust preventive treatment during transporting Improper storage conditions Improper handling	• Improve the sealing mechanism • Study the lubrication method • Anti-rust treatment for periods of non-running • Improve the storage methods • Improve the handling metheod

Photo 7-16-1
Part: Outer ring of a cylindrical roller bearing
Symptom: Rust on the rib face and raceway surface
Cause: Poor lubrication due to water entry

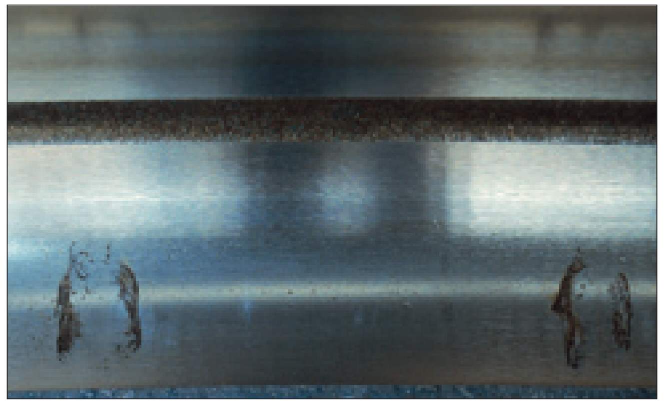


Photo 7-16-2
Part: Outer ring of a slewing ring
Symptom: Rust on raceway surface at ball pitch
Cause: Moisture condensation during stationary periods

Photo 7-16-3
Part: Inner ring of a spherical roller bearing
Symptom: Rust on raceway surface at roller pitch
Cause: Entry of water into lubricant

Photo 7-16-4
Part: Rollers of a spherical roller bearing
Symptom: Pit-shaped rust on rolling contact surface. Corroded portions.
Cause: Moisture condensation during storage

7.17 Mounting Flaws

Damage Condition	Possible Cause	Measures
Straight line scratches on surface of raceways or rolling elements caused during mounting or dismounting of bearing.	Inclination of inner and outer rings during mounting or dismounting. Shock load during mounting or dismounting.	● Use appropriate jig and tool ● Avoid a shock load by use of a press machine ● Center the relative mating parts during mounting

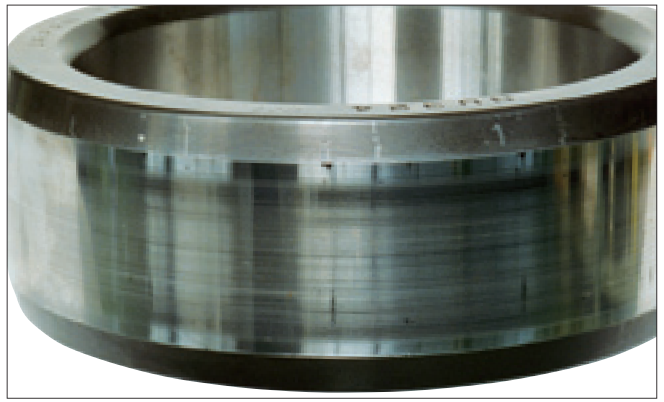


Photo 7-17-1
Part: Inner ring of a cylindrical roller bearing
Symptom: Axial scratches on raceway surface
Cause: Inclination of inner and outer rings during mounting

Photo 7-17-2
Part: Outer ring of a double-row cylindrical roller bearing
Symptom: Axial scratches at roller pitch intervals on raceway surface
Cause: Inclination of inner and outer rings during mounting

Photo 7-17-3
Part: Rollers of a cylindrical roller bearing
Symptom: Axial scratches on rolling surface
Cause: Inclination of inner and outer rings during mounting

7.18 Discoloration

Damage Condition	Possible Cause	Measure
Discoloration of cage, rolling elements, and raceway ring occurs due to a reaction with lubricant and high temperature.	Poor lubrication Oil stain due to a reaction with lubricant High temperature	● Improve the lubrication method

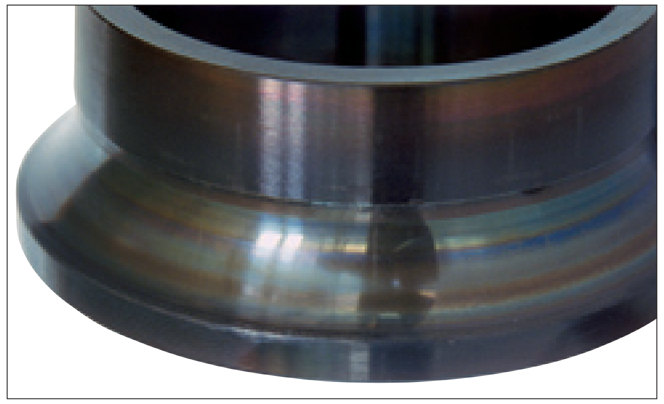


Photo 7-18-1
Part: Inner ring of an angular contact ball bearing
Symptom: Bluish or purplish discoloration on raceway surface
Cause: Heat generation due to poor lubrication

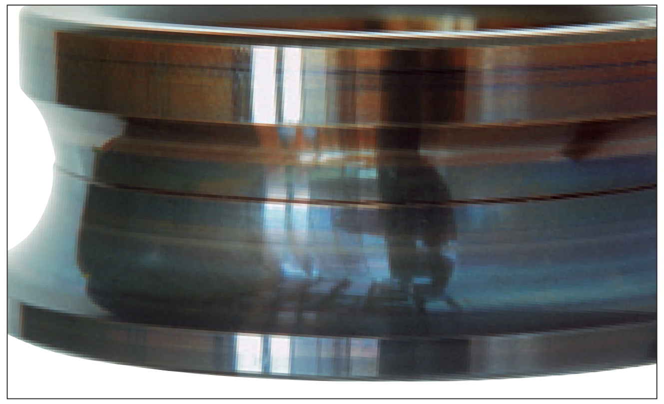


Photo 7-18-2
Part: Inner ring of a 4-point contact ball bearing
Symptom: Bluish or purplish discoloration on raceway surface
Cause: Heat generation due to poor lubrication

Appendix Bearing Diagnostic Chart

Damage name	Location (Phenomenon)	Cause													Remarks
		Handling		Bearing surrounding			Lubri-cation		Load			Speed			
		Stock·Shipping	Mounting	Shaft Housing	Sealed device Water·Debris	Temperature	Lubricant	Lubrication method	Excessive load Impact load	Moment	Ultra small load	High speed, High acceleration & deceleration	Shaking·Vibration Stationary	Bearing Selection	
1. Flaking	Raceway, Rolling surface		○	○	○		○	○	○	○				○	
2. Peeling	Raceway, Rolling surface				○		○	○			○	○			
	Bearing outside surface (Rolling contact)			○*	○		○	○							* Mating rolling part
3. Scoring	Roller end face surface, Rib surface		○	○	○		○	○	○	○		○			
	Cage guide surface, Pocket surface		○		○		○	○							
4. Smearing	Raceway, Rolling surface				○		○	○			○	○			
5. Fracture	Raceway collar, Rollers	○	○	○					○	○					
6. Cracks	Raceway rings, Rolling elements		○	○		○			○	○					
	Rib surface, Roller end face, Cage guide surface (Thermal crack)			○				○	○	○					
7. Cage damage	(Deformation), (Fracture)		○	○					○	○					
	(Wear)		○		○		○	○	○	○		○			
8. Denting	Raceway, Rolling surface, (Innumerable small dents)				○			○							
	Raceway (Debris on the rolling element pitch)	○	○						○				○		
9. Pitting	Raceway, Rolling surface				○		○	○							
10. Wear	Raceway, Rolling surface, Rib surface, Roller end face		○		○		○	○							
11. Fretting	Raceway, Rolling surface	○	○	○			○	○	○			○	○		
	Bearing outside & bore, side surface (Contact with housing and shaft)		○	○					○						
12. False brinelling	Raceway, Rolling surface	○					○	○					○		
13. Creep	Fitting surface		○	○		○	○*	○*	○			○			* Clearance fit
14. Seizure	Raceway ring, Rolling element, Cage		○	○	○		○	○	○	○		○		○	
15. Electrical corrosion	Raceway, Rolling surface		○*	○*											* Electricity passing through the rolling element
16. Rust and corrosion	Raceway ring, Rolling element, Cage	○	○		○	○	○	○							
17. Mounting flaws	Raceway, Rolling surface		○	○											
18. Discoloration	Raceway ring, Rolling element, Cage					○	○	○							

Remark: This chart is not comprehensive. It lists only the more commonly occurring damages, causes, and locations.

NSK LTD.-HEADQUARTERS, TOKYO, JAPAN
www.nsk.com

Nissei Bldg., 1-6-3 Ohsaki, Shinagawa-ku, Tokyo 141-8560, Japan
INDUSTRIAL MACHINERY BUSINESS DIVISION-HEADQUARTERS
P: 03-3779-7227 F: 03-3779-7644 C: 81
GLOBAL AFTERMARKET DEPARTMENT
P: 03-3779-7253 F: 03-3779-7644 C: 81
PRECISION MACHINERY DEPARTMENT
P: 03-3779-7163 F: 03-3779-7644 C: 81
MECHATRONICS BUSINESS DEPARTMENT
P: 0466-21-3027 F: 0466-21-3206 C: 81
AUTOMOTIVE BUSINESS DIVISION-HEADQUARTERS
P: 03-3779-7189 F: 03-3779-7917 C: 81

●Africa
South Africa:
NSK SOUTH AFRICA (PTY) LTD.
JOHANNESBURG 25 Galaxy Avenue, Linbro Business Park, Sandton, Gauteng, P.O. Box 1157, Kelvin, 2054, South Africa
P: 011-458-3600 F: 011-458-3608 C: 27

●Asia and Oceania
Australia:
NSK AUSTRALIA PTY. LTD. www.au.nsk.com
MELBOURNE 11 Dalmore Drive, Scoresby, Victoria 3179, Australia
P: 03-9764-8302 F: 03-9764-8304 C: 61
SYDNEY 24-28 River Road West, Parramatta, New South Wales 2150, Australia
P: 02-8843-8100 F: 02-9893-8406 C: 61
BRISBANE 1/69 Selhurst Street, Coopers Plains, Queensland 4108, Australia
P: 07-3347-2600 F: 07-3345-5376 C: 61
PERTH Unit 1, 71 Tacoma Circuit, Canning Vale, Western Australia 6155, Australia
P: 08-9256-5000 F: 08-9256-1044 C: 61

China:
NSK HONG KONG LTD.
HONG KONG Suite 814, World Commerce Centre, Harbour City, T.S.T, KLN, Hong Kong, China
P: 02739-9933 F: 02739-9323 C: 852
SHENZHEN Room 8B08-09, Jueshi Tower, Jiabing Road, Luohu, Shenzhen, Guangdong, China (518001)
P: 0755-25904886 F: 0755-25904883 C: 86
KUNSHAN NSK CO., LTD.
OFFICE/PLANT 258 South Huang Pu Jiang Rd., Kunshan Economic & Technical Development Zone, Jiang Su, China (215335)
P: 0512-5771-5654 F: 0512-5771-5689 C: 86
CHANGSHU NSK NEEDLE BEARING CO., LTD.
OFFICE/PLANT No. 66 Dongnan Road, Changshu Southeast Economic Development Zone, Changshu City, Jiangsu, China (215500)
P: 0512-5230-1111 F: 0512-5230-6011 C: 86
NSK STEERING SYSTEMS DONGGUAN CO., LTD.
OFFICE/PLANT High-tech Park, Shilong Road, Guanlong Section, Dongguan, Guangdong, China (523119)
P: 0769-2262-0960 F: 0769-2316-2867 C: 86
ZHANGJIAGANG NSK PRECISION MACHINERY CO., LTD.
OFFICE/PLANT No. 34 Zhenxing Road, Zhangjiagang Economic Development Zone, Zhangjiagang City, Jiangsu, China (215600)
P: 0512-5867-6496 F: 0512-5818-0970 C: 86
SUZHOU NSK BEARINGS CO., LTD.
OFFICE/PLANT No. 22 Taishan Road, Suzhou New District, Jiangsu, China (215129)
P: 0512-6665-5666 F: 0512-6665-9138 C: 86
NSK (CHINA) RESEARCH & DEVELOPMENT CO., LTD.
JIANGSU No.8 NSK Rd., Huaqiao Economic Development Zone, Kunshan, Jiangsu, China (215332)
P: 0512-5796-3000 F: 0512-5796-3300 C: 86
NSK (SHANGHAI) TRADING CO., LTD.
JIANGSU No.8 NSK Rd., Huaqiao Economic Development Zone, Kunshan, Jiangsu, China (215332)
P: 0512-5796-3000 F: 0512-5796-3300 C: 86
NSK (CHINA) INVESTMENT CO., LTD. www.nsk.com.cn
HEAD OFFICE No.8 NSK Rd., Huaqiao Economic Development Zone, Kunshan, Jiangsu, China (215332)
P: 0512-5796-3000 F: 0512-5796-3300 C: 86
BEIJING Room 2116, Beijing Fortune Bldg., 5 Dong San Huan Bei Lu, Chao Yang District, Beijing, China (100004)
P: 010-6590-8161 F: 010-6590-8166 C: 86
GUANGZHOU Room 3101/3102/3106A, Guangdong Telecom Plaza, 18 Zhongshan Er Road, Guangzhou, Guangdong, China (510080)
P: 020-3786-4833 F: 020-3786-4501 C: 86
CHENGDU Room1117, Lippo Tower, No.62 North Kehua Road, Chengdu, Sichuan, China (610041)
P: 028-8528-3680 F: 028-8528-3690 C: 86
SHENYANG Room 3805~3806, Tower A, Royal Wanxin International Mansion, No.390 Qingnian Street, Heping District, Shenyang, Liaoning, China (110003)
P: 024-2334-2868 F: 024-2334-2058 C: 86
DALIAN Room 1805 Xiwang Tower, No.136 Zhongshan Road, Zhongshan District, Dalian, Liaoning, China (116001)
P: 0411-8800-8168 F: 0411-8800-8160 C: 86
NSK CHINA SALES CO., LTD.
HEAD OFFICE No.8 NSK Rd., Huaqiao Economic Development Zone, Kunshan, Jiangsu, China (215332)
P: 0512-5796-3000 F: 0512-5796-3300 C: 86
CHANGCHUN Room 1001, Building A, Zhongyin Building, 727 Xi'an Road, Changchun, Jilin, China (130061)
P: 0431-8898-8682 F: 0431-8898-8670 C: 86
TIAN JIN Room 06, 09F The Exchange Tower 2, No. 189 NanJing Road, Heping District, Tianjin, China (300050)
P: 022-8319-5030 F: 022-8319-5033 C: 86
NANJING A1 22F, Golden Eagle International Plaza, No.89 Hanzhong Road, Nanjing, Jiangsu, China (210029)
P:025-8472-6671 F:025-8472-6687 C:86
CHONGQING Room 2306, Unit B, No.137, Keyuan 2nd Road, Jiulongpo District, Chonqing, China (400039)
P:023-6806-5310 F:023-6806-5292 C:86
NSK-WARNER (SHANGHAI) CO., LTD.
OFFICE/PLANT No. 2518 Huancheng Road (West) Fengxian District, Shanghai,China (201401)
P: 021-3365-5757 F: 021-3365-5262 C: 86
AKS PRECISION BALL (HANGZHOU) CO., LTD.
PLANT No. 189 Hongda Road, Xiaoshan Area of Economic & Technological Development Zone, Hangzhou, Zhejiang, China (311231)
P: 0571-2280-1288 F: 0571-2280-1268 C: 86
NSK-YAGI PRECISION FORGING (ZHANGJIAGANG) CO., LTD.
PLANT No. 34 Zhenxing Road, Zhangjiagang Economic Development Zone, Zhangjiagang City, Jiangsu, China (215600)
P:0512-5867-6496 F:0512-5818-0970 C:86
NSK-WANDA ELECTRIC POWER ASSISTED STEERING SYSTEMS CO.,LTD.
OFFICE/PLANT 1833 Yatai Road, Wenyan Town, Xiaoshan, Hangzhou, Zhejiang, China (311258)
P:0571-8231-4818 F:0571-8248-6656 C:86
SHENYANG NSK PRECISION CO., LTD.
OFFICE/PLANT No. 7, 15 Street, Shenyang Economic & Technological Development Area, Shenyang, Liaoning, China (110141)
P: 024-2532-6080 F: 024-2532-6081 C: 86

India:
RANE NSK STEERING SYSTEMS LTD.
CHENNAI 14, Rajagopalan Salai, Vallancherry, Guduvancherry, Tamil Nadu-603 202, India
P:044-474-06017 F:044-274-66001 C:91
BAWAL Plot No.28A, Sector 6, HSIIDC Growth Centre Bawal, District Rewari, Haryana -123 501, India
P:01284-264281 F:01284-264280 C:91
NSK INDIA SALES CO.PVT.LTD.
CHENNAI New No.7, Old No.5, Boat Club Road, Chennai-600 028, India
P:044-2433-1161 F:044-2433-1160 C:91
GURGAON 107, Park Centra, Sector-30, Opposite 32nd Milestone, NH-8, Gurgaon, Haryana-122 001, India
P:0124-4104-530 F:0124-4104-532 C:91
KOLKATA 502, Trinity Towers, 83, Topsia Road, Kolkata-700 046, India
P:033-4001-2062 F:033-4001-2064 C:91
MUMBAI 321, A Wing, Ahura Centre, 82, Mahakali Caves Road, Andheri East, Mumbai -400 093, India
P:022-2838-7787 F:022-2838-5191 C:91
NSK-ABC BEARINGS LTD.
OFFICE/PLANT Plot No.A2, SIPCOT Growth Centre, Oragadam, Mathur Village, Sriperumbudur Taluk, Kancheepuram District, Tamil Nadu-602 105, India
P:044-2714-3000 F:044-2714-3099 C:91

Indonesia:
PT. NSK BEARINGS MANUFACTURING INDONESIA
JAKARTA PLANT Blok M4, Kawasan Berikat MM2100 Industrial Town Cikarang Barat, Bekasi 17520, Indonesia
P: 021-898-0155 F: 021-898-0156 C: 62
PT. NSK INDONESIA www.id.nsk.com
JAKARTA Summitmas II, 6th Floor, Jl. Jend Sudirman Kav. 61-62, Jakarta 12190, Indonesia
P: 021-252-3458 F: 021-252-3223 C: 62
PT. NSK-WARNER INDONESIA
BEKASI MM2100 Industrial Town, Cikarang Barat, Bekasi 17520, Indonesia
P: 021-8998-3216 F: 021-8998-3218 C: 62

Korea:
NSK KOREA CO., LTD. www.kr.nsk.com
SEOUL Posco Center (West Wing) 9F, 892, Daechi-4Dong, Kangnam-Ku, Seoul, 135-777, Korea
P: 02-3287-0300 F: 02-3287-0345 C: 82
CHANGWON PLANT 60, Seongsan-Dong, Changwon, Kyungsangnam-Do, 642-315, Korea
P: 055-287-6001 F: 055-285-9982 C: 82

Malaysia:
NSK BEARINGS (MALAYSIA) SDN. BHD. www.my.nsk.com
HEAD OFFICE No. 2, Jalan Pemaju, U1/15, Seksyen U1, Hicom Glenmarie Industrial Park, 40150 Shah Alam, Selangor, Malaysia
P: 03-7803-8859 F: 03-7806-5982 C: 60
PRAI No.36, Jalan kikik, Taman Inderawasih, 13600 Prai, Penang, Malaysia
P: 04-3902275 F: 04-3991830 C: 60
JOHOR BAHRU 88 Jalan Ros Merah 2/17, Taman Johor Jaya, 81100 Johor Bahru, Johor, Malaysia
P: 07-3546290 F: 07-3546291 C: 60
KOTA KINABALU No. 8 Lot 3B, Block C, Lorong Waja 2, Taman Waja, Jalan Pintas, Kepayan Ridge, 88300 Kota Kinabalu, Sabah, Malaysia
P: 088-413798 F: 088-413798 C: 60
IPOH Gr. Floor, 89 Jalan Bendahara, 31650 Ipoh, Perak, Malaysia
P: 05-2555000 F: 05-2553373 C: 60
NSK MICRO PRECISION (M) SDN. BHD. www.my.nsk.com
MALAYSIA PLANT No.43 Jalan Taming Dua,Taman Taming Jaya 43300 Balakong, Selangor Darul Ehsan, Malaysia
P: 03-8961-3960 F: 03-8961-3968 C: 60

New Zealand:
NSK NEW ZEALAND LTD. www.nsk-rhp.co.nz
AUCKLAND 3 Te Apunga Place, Mt. Wellington, Auckland, New Zealand
P: 09-276-4992 F: 09-276-4082 C: 64

Philippines:
NSK REPRESENTATIVE OFFICE
MANILA 8th Floor The Salcedo Towers 169 H.V. dela Costa St., Salcedo Village Makati City, Philippines 1227
P: 02-893-9543 F: 02-893-9173 C: 63

Singapore:
NSK INTERNATIONAL (SINGAPORE) PTE LTD.
SINGAPORE 238A, Thomson Road, #24-01/05, Novena Square Tower A, Singapore 307684
P: 6496-8000 F: 6250-5845 C: 65
NSK SINGAPORE (PRIVATE) LTD. www.nsk-singapore.com.sg
SINGAPORE 238A, Thomson Road, #24-01/05, Novena Square Tower A, Singapore 307684
P: 6496-8000 F: 6250-5845 C: 65

Taiwan:
TAIWAN NSK PRECISION CO., LTD.
TAIPEI 11F., No.87, Song Jiang Rd., Jhongshan District, Taipei City 104, Taiwan R.O.C.
P: 02-2509-3305 F: 02-2509-1393 C: 886
TAICHUNG 107-7, Sec. 3, Wen Xing Rd., Taichung City 407, Taiwan R.O.C.
P: 04-2311-7978 F: 04-2311-2627 C: 886
TAINAN No.8 Daye 1st Rd., Southern Taiwan Science Park, Tainan County 741, Taiwan R.O.C.
P: 06-505-5861 F: 06-505-5061 C: 886

Worldwide Sales Offices and Manufacturing Plants

P: Phone F: Fax C: Country Code Printed in Japan

TAIWAN NSK TECHNOLOGY CO., LTD.
TAIPEI 11F., No. 87, Songjiang Rd., Jhongshan District, Taipei City 104, Taiwan R.O.C.
P: 02-2509-3305 F: 02-2509-1393 C: 886

Thailand:
NSK BEARINGS (THAILAND) CO.,LTD.
BANGKOK 26 Soi On-Nuch 55/1 Pravet District, Bangkok 10250, Thailand
P: 02320-2555 F: 02320-2826 C: 66

NSK BEARINGS MANUFACTURING (THAILAND) CO., LTD.
OFFICE/PLANT 700/430 Moo 7, Amata Nakorn Industrial Estate, T.Donhualor, A.Muangchonburi, Chonburi 20000, Thailand
P: 038-454-010 F: 038-454-017 C: 66

SIAM NSK STEERING SYSTEMS CO., LTD.
OFFICE/PLANT 90 Moo 9, Wellgrow Industrial Estate, Km.36 Bangna-Trad Rd., Bangwao, Bangpakong, Chachoengsao 24180, Thailand
P: 038-522-343 F: 038-522-351 C: 66

NSK ASIA PACIFIC TECHNOLOGY CENTRE (THAILAND) CO., LTD.
CHONBURI 700/430 Moo 7, Amata Nakorn Industrial Estate, T.Donhualor, A.Muangchonburi, Chonburi 20000, Thailand
P: 038-454-631 F: 038-454-634 C: 66

Vietnam:
NSK VIETNAM CO., LTD.
HEAD OFFICE Techno Center, Room 204-205, Thang Long Industrial Park, Dong Anh District, Hanoi, Vietnam
P: 04-3955-0159 F: 04-3955-0158 C: 84

NSK REPRESENTATIVE OFFICE
HO CHI MINH CITY Suite 307, Metropolitan Building, 235 Dong Khoi Street, District 1,HCMC, Vietnam
P: 08-3822-7907 F: 08-3822-7910 C: 84

●Europe

NSK EUROPE LTD. (EUROPEAN HEADQUARTERS) www.eu.nsk.com
MAIDENHEAD Belmont Place, Belmont Road, Maidenhead, Berkshire SL6 6TB, U.K.
P: 01628-509-800 F: 01628-509-808 C: 44

France:
NSK FRANCE S.A.S.
PARIS Quartier de l'Europe, 2 Rue Georges Guynemer, 78283 Guyancourt, France
P: 01-30-57-39-39 F: 01-30-57-00-01 C: 33

Germany:
NSK DEUTSCHLAND GMBH
HEAD OFFICE Harkortstrasse 15, D-40880 Ratingen, Germany
P: 02102-4810 F: 02102-4812-290 C: 49
STUTTGART Liebknechtstrasse 33, D-70565 Stuttgart-Vaihingen, Germany
P: 0711-79082-0 F: 0711-79082-289 C: 49
WOLFSBURG Heinrich-Nordhoff-Strasse 101, D-38440 Wolfsburg, Germany
P: 05361-27647-10 F: 05361-27647-70 C: 49

NSK PRECISION EUROPE GMBH
DÜSELDORF Harkortstrasse 15, D-40880 Ratingen, Germany
P: 02102-4810 F: 02102-4812-290 C: 49

NEUWEG FERTIGUNG GMBH
OFFICE/PLANT Ehinger Strasse 5, D-89597 Munderkingen, Germany
P: 07393-540 F: 07393-5414 C: 49

Italy:
NSK ITALIA S.P.A.
MILANO Via Garibaldi 215, Garbagnate Milanese (Milano) 20024, Italy
P: 0299-5191 F: 0299-025778 C: 39

INDUSTRIA CUSCINETTI S.P.A.
TORINO PLANT Via Giotto 4, I-10080, S. Benigno C. se (Torino), Italy
P: 011-982-4811 F: 011-988-0284 C: 39

Netherlands:
NSK EUROPEAN DISTRIBUTION CENTRE B.V.
De Kroonstraat 38, 5048 AP Tilburg, Netherlands
P: 013-4647647 F: 013-4647648 C: 31

Poland:
NSK EUROPE LTD. REPRESENTATIVE OFFICE
WARSAW Ul. Migdalowa 4/73, 02-796, Warsaw, Poland
P: 022-645-1525 F: 022-645-1529 C: 48

NSK BEARINGS POLSKA S.A.
OFFICE/PLANT Ul. Jagiellonska 109, 25-734 Kielce, Poland
P: 041-366-5001 F: 041-367-0500 C: 48

NSK EUROPEAN TECHNOLOGY CENTER, POLAND OFFICE
Ul. Jagiellonska 109, 25-734 Kielce, Poland
P: 041-367-0940 F: 041-367-0930 C: 48

NSK STEERING SYSTEMS EUROPE (POLSKA) SP.ZO.O.
CORPORATE Ul. Mariana Jachimowicza 17, 58-306 Walbrzych, Poland
OFFICE/PLANT P: 074-664-4101 F: 074-664-4104 C: 48

NSK NEEDLE BEARING POLAND SP.ZO.O.
OFFICE/PLANT UL. Jagiellonska 109, 25-734 Kielce, Poland
P: 041-345-2469 F: 041-345-0361 C: 48

NSK POLSKA SP.ZO.O.
KIELCE Ul. Karczowkowska 41, 25-711 Kielce, Poland
P: 041-347-5110 F: 041-347-5101 C: 48

Spain:
NSK SPAIN S.A.
BARCELONA C/Tarragona 161, 2a Planta, 08014, Barcelona, Spain
P: 093-433-5775 F: 093-433-5776 C: 34

Turkey:
NSK RULMANLARI ORTA DOGU TIC. LTD. STI.
ISTANBUL 19 Mayis Mah. Ataturk Cad. Ulya Engin Is Merkezi No. 68 Kat. 6, Kozyatagi 34734, Istanbul, Turkey
P: 0216-355-0398 F: 0216-355-0399 C: 90

United Kingdom:
NSK BEARINGS EUROPE LTD.
PETERLEE 3 Brindley Road, South West Industrial Estate, Peterlee, Co. Durham SR8 2JD, U.K.
PLANT P: 0191-586-6111 F: 0191-586-3482 C: 44
NEWARK Northern Road, Newark, Nottinghamshire NG24 2JF, U.K.
PLANT P: 01636-605-123 F: 01636-605-000 C: 44

NSK EUROPEAN TECHNOLOGY CENTRE
NEWARK Northern Road, Newark, Nottinghamshire NG24 2JF, U.K.
P: 01636-605-123 F: 01636-643-241 C: 44

NSK UK LTD.
NEWARK Northern Road, Newark, Nottinghamshire NG24 2JF, U.K.
P: 01636-605-123 F: 01636-605-000 C: 44

NSK PRECISION UK LTD.
PLANT Northern Road, Newark, Nottinghamshire NG24 2JF, U.K.
P: 01636-605-123 F: 01636-605-000 C: 44

NSK STEERING SYSTEMS EUROPE LTD.
HEAD OFFICE Belmont Place, Belmont Road, Maidenhead, Berkshire SL6 6TB, U.K.
P: 01628-509-800 F: 01628-509-808 C: 44
PETERLEE 6/7 Doxford Drive, South West Industrial Estate, Peterlee, Co. Durham SR8 2PP, U.K.
PLANT P: 0191-518-6400 F: 0191-518-6421 C: 44

●North and South America

NSK AMERICAS, INC. (AMERICAN HEADQUARTERS)
ANN ARBOR 4200 Goss Road, Ann Arbor, Michigan 48105, U.S.A.
P: 734-913-7500 F: 734-913-7511 C: 1

Argentina:
NSK ARGENTINA SRL
BUENOS AIRES Garcia del Rio 2477 Piso 7 Oficina "A" (1429) Buenos Aires-Argentina
P: 11-4704-5100 F: 11-4704-0033 C: 54

Brazil:
NSK BRASIL LTDA. www.br.nsk.com
HEAD OFFICE Rua 13 de Maio, 1633-14th Andar-Bela Vista-CEP 01327-905 São Paulo, SP, Brazil
P: 011-3269-4786 F: 011-3269-4720 C: 55
SUZANO PLANT Av. Vereador Joao Batista Fitipaldi, 66, CEP 08685-000, Vila Maluf, Suzano, SP, Brazil
P: 011-4744-2527 F: 011-4744-2529 C: 55
BELO HORIZONTE Rua Ceara 1431-4th andar-sala 405-Funcionarios Belo Horizonte-MG, Brazil 30150-311
P: 031-3274-2591 F: 031-3273-4408 C: 55
JOINVILLE Rua Blumenau, 178-sala 910-Centro Joinville-SC, Brazil 89204-250
P: 047-3422-5445 F: 047-3422-2817 C: 55
PORTO ALEGRE Av. Cristovão Colombo, 1694-sala 202-Floresta Porto Alegre-RS, Brazil 90560 001
P: 051-3222-1324 F: 051-3222-2599 C: 55
RECIFE Av. Conselheiro Aguiar, 2738-6th andar-conj. 604-Boa Viagem Recife-PE, Brazil 51020-020
P: 081-3326-3781 F: 081-3326-5047 C: 55

Peru:
NSK PERU S.A.C.
SANTIAGO Av. Caminos del Inca 670, Ofic : # 402, Santiago del Surco, Lima, Perú
P: 01-652-3372 F: 01-638-0555 C: 51

Canada:
NSK CANADA INC. www.ca.nsk.com
HEAD OFFICE 5585 McAdam Road, Mississauga, Ontario, Canada L4Z 1N4
P: 905-890-0740 F: 800-800-2788 C: 1
TORONTO 5585 McAdam Road, Mississauga, Ontario, Canada L4Z 1N4
P: 877-994-6675 F: 800-800-2788 C: 1
MONTREAL 2150-32E Avenue Lachine, Quebec, Canada H8T 3H7
P: 514-633-1220 F: 800-800-2788 C: 1
VANCOUVER 3353 Wayburne Drive, Burnaby, British Columbia, Canada V5G 4L4
P: 877-994-6675 F: 800-800-2788 C: 1

Mexico:
NSK RODAMIENTOS MEXICANA, S.A. DE C.V. www.mx.nsk.com
MEXICO CITY Av. Presidente Juarez No.2007 Lote 5, Col. San Jeronimo Tepetlacalco, Tlalnepantla, Estado de Mexico, Mexico, C.P.54090
P: 55-3682-2900 F: 55-3682-2937 C: 52
MONTERREY Av. Ricardo Margain 575. Torre C. IOS Campestre, San Pedro Garcia, Nuevo Leon, Mexico, C.P.66267
P: 81-8000-7300 F: 81-8000-7095 C: 52

United States of America:
NSK CORPORATION www.us.nsk.com
HEAD OFFICE 4200 Goss Road, Ann Arbor, Michigan 48105, U.S.A.
P: 734-913-7500 F: 734-913-7511 C: 1
NSK AMERICAN 4200 Goss Road, Ann Arbor, Michigan 48105, U.S.A.
TECHNOLOGY CENTER P: 734-913-7500 F: 734-913-7511 C: 1
CLARINDA PLANT 1100 N. First Street, Clarinda, Iowa 51632, U.S.A.
P: 712-542-5121 F: 712-542-4905 C: 1
FRANKLIN PLANT 3400 Bearing Drive, Franklin, Indiana 46131, U.S.A.
P: 317-738-5000 F: 317-738-5064 C: 1
LIBERTY PLANT 1112 East Kitchel Road, Liberty, Indiana 47353, U.S.A.
P: 765-458-5000 F: 765-458-7832 C: 1

NSK PRECISION AMERICA, INC. www.npa.nsk.com
OFFICE/PLANT 3450 Bearing Drive, Franklin, Indiana 46131, U.S.A.
P: 317-738-5000 F: 317-738-5050 C: 1
SAN JOSE 780 Montague Expressway, Suite 508, San Jose, California 95131, U.S.A.
P: 408-944-9400 F: 408-944-9405 C: 1

NSK STEERING SYSTEMS AMERICA, INC. www.nssa.nsk.com
OFFICE/PLANT 110 Shields Drive, Bennington, Vermont 05201, U.S.A.
P: 802-442-5448 F: 802-442-2253 C: 1
DYERSBURG PLANT 2962 Fort Hudson Road, Dyersburg, TN 38204, U.S.A.
P: 731-288-3000 F: 731-288-3001 C: 1
ANN ARBOR 4200 Goss Road, Ann Arbor, Michigan 48105, U.S.A.
P: 734-913-7500 F: 734-913-7102 C: 1

NSK-WARNER U.S.A., INC.
TROY 3001 West Big Beaver Road, Suite 701, Troy, Michigan 48084, U.S.A.
P: 248-822-8888 F: 248-822-1111 C: 1

NSK LATIN AMERICA, INC. www.la.nsk.com
MIAMI 2500 NW 107th Avenue, Suite 300, Miami, Florida 33172, U.S.A.
P: 305-477-0605 F: 305-477-0377 C: 1

<As of November 2010>
For the latest information, please refer to the NSK website.

NSK used environmentally friendly paper and printing methods for this publication.

CAT. No. E7005b 2010 C-12 Printed in Japan