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.
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</table>
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 (light) 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>
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<tr>
<th>Irregularities</th>
<th>Possible causes</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal load</td>
<td>Improve the fit, internal clearance, preload, position of housing shoulder, etc.</td>
<td></td>
</tr>
<tr>
<td>Incorrect mounting</td>
<td>Improve the machining accuracy and alignment of shaft and housing, accuracy of mounting method</td>
<td></td>
</tr>
<tr>
<td>Insufficient or improper lubricant</td>
<td>Replenish the lubricant or select another lubricant</td>
<td></td>
</tr>
<tr>
<td>Contact of rotating parts</td>
<td>Modify the labyrinth seal, etc</td>
<td></td>
</tr>
<tr>
<td>Flaws, corrosion, or scratches on raceways</td>
<td>Replace or clean the bearing, improve the seals, and use clean lubricant</td>
<td></td>
</tr>
<tr>
<td>Brinelling</td>
<td>Replace the bearing and use care when handling bearings</td>
<td></td>
</tr>
<tr>
<td>Flaking on raceway</td>
<td>Replace the bearing</td>
<td></td>
</tr>
<tr>
<td>Excessive clearance</td>
<td>Improve the fit, clearance and preload</td>
<td></td>
</tr>
<tr>
<td>Penetration of foreign particles</td>
<td>Replace or clean the bearing, improve the seals, and use clean lubricant</td>
<td></td>
</tr>
<tr>
<td>Flaws or flaking on balls</td>
<td>Replace the bearing</td>
<td></td>
</tr>
<tr>
<td>Abnormal Temperature Rise</td>
<td>Reducing the amount of lubricant, select a stiffer grease</td>
<td></td>
</tr>
<tr>
<td>Excessive amount of lubricant</td>
<td>Replace lubricant or select a better one</td>
<td></td>
</tr>
<tr>
<td>Abnormal load</td>
<td>Improve the fit, internal clearance, preload, position of housing shoulder</td>
<td></td>
</tr>
<tr>
<td>Incorrect mounting</td>
<td>Improve the machining accuracy and alignment of shaft and housing, accuracy of mounting, or mounting method</td>
<td></td>
</tr>
<tr>
<td>Creep on fitted surface, excessive seal friction</td>
<td>Correct the seals, replace the bearing, correct the fitting or mounting</td>
<td></td>
</tr>
<tr>
<td>Vibration (Axial runout)</td>
<td>Brinelling</td>
<td>Replace the bearing and use care when handling bearings</td>
</tr>
<tr>
<td></td>
<td>Flaking</td>
<td>Replace the bearing</td>
</tr>
<tr>
<td></td>
<td>Incorrect mounting</td>
<td>Correct the clearance between the shaft and housing shoulder or side of spacer</td>
</tr>
<tr>
<td></td>
<td>Penetration of foreign particles</td>
<td>Replace or clean the bearing, improve the seals</td>
</tr>
<tr>
<td>Leaking or Discoloration of Lubricant</td>
<td>Too much lubricant, penetration by foreign matter or abrasion chips</td>
<td>Reduce the amount of lubricant, select a stiffer grease</td>
</tr>
</tbody>
</table>
### 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 inspect the bearing thoroughly during times of periodic machine inspection and part replacement. Check the racetrack 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 measurement 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 among 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

<table>
<thead>
<tr>
<th>Item</th>
<th>Grease lubrication</th>
<th>Oil lubrication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing structure and seal</td>
<td>Simple</td>
<td>Simple</td>
</tr>
<tr>
<td>Lubricant replacement</td>
<td>Sometimes difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>Internal contamination due</td>
<td>Sumbplings seldom</td>
<td>Sumbplings</td>
</tr>
<tr>
<td>to leakage</td>
<td>contaminated by</td>
<td>contaminated by</td>
</tr>
<tr>
<td>Viscosity range for the operating temperature</td>
<td>Suitable for high-speed machines.</td>
<td>Suitable for high-speed machines.</td>
</tr>
</tbody>
</table>

#### Table 4.2 Examples of applications and grease consistency

<table>
<thead>
<tr>
<th>Consistency number</th>
<th># 0</th>
<th># 1</th>
<th># 2</th>
<th># 3</th>
<th># 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistency (1/10 mm)</td>
<td>350 to 385</td>
<td>310 to 340</td>
<td>250 to 295</td>
<td>220 to 250</td>
<td>175 to 205</td>
</tr>
</tbody>
</table>

#### Table 4.3 Required viscosity by bearing type

<table>
<thead>
<tr>
<th>Bearing type</th>
<th>Viscosity at operating temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball bearings</td>
<td>15 mm²/s or more</td>
</tr>
<tr>
<td>Cylindrical roller bearings</td>
<td>20 mm²/s or more</td>
</tr>
<tr>
<td>Tapered roller bearings, Spherical roller bearings</td>
<td>32 mm²/s or more</td>
</tr>
</tbody>
</table>

#### Notes:
1. As for the limiting speed, use the values listed under oil lubrication in the Bearing Dimension Tables of "NSK Rolllings Bearings" (No. E1102).
2. Refer to the table under oil lubrication in "NSK Rolllings Bearings" (No. E1102).
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°C, the usage of lithium soap-mineral oil grease or lithium soap-synthetic grease is appropriate.)

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 0°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

P/C ≤ 0.05 0.1 0.13 0.16

Load factor 1.5 1 0.65 0.45

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, rolling 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.
(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 and outer 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.
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

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>Excessive load</td>
<td>Reconfirm the bearing application and check the load conditions</td>
</tr>
<tr>
<td></td>
<td>Poor mounting (misalignment)</td>
<td>Improve the mounting method</td>
</tr>
<tr>
<td></td>
<td>Moment load</td>
<td>Improve the sealing mechanism, prevent rusting during non-running</td>
</tr>
<tr>
<td></td>
<td>Entry of foreign debris, water penetration</td>
<td>Use a lubricant with a proper viscosity, improve the lubrication method</td>
</tr>
<tr>
<td></td>
<td>Poor lubrication, Improper lubricant</td>
<td>Improve the sealing mechanism, prevent rusting during non-running</td>
</tr>
<tr>
<td></td>
<td>Unsuitable bearing clearance</td>
<td>Improve the sealing mechanism, prevent rusting during non-running</td>
</tr>
<tr>
<td></td>
<td>Improper precision for shaft or housing, unevenness in housing rigidity, large shaft bending</td>
<td>Improve the sealing mechanism, prevent rusting during non-running</td>
</tr>
<tr>
<td></td>
<td>Progression from rust, corrosion pits, smearing, dents (Brinelling)</td>
<td>Check the precision of shaft and housing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check the bearing internal clearance</td>
</tr>
</tbody>
</table>

---

**Fig. 6.2** Typical running traces on roller bearings
7.2 Peeling

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dull or cloudy spots appear on surface along with light wear.</td>
<td>Unsuitable lubricant</td>
<td>Select a proper lubricant</td>
</tr>
<tr>
<td>From such dull spots, tiny cracks are generated downward to a depth of</td>
<td>Entry of debris into lubricant</td>
<td>Improve the sealing mechanism</td>
</tr>
<tr>
<td>5 to 10 μm. Small particles fall off and minor flaking occurs widely.</td>
<td>Rough surface due to poor lubrication</td>
<td>Improve the surface finish of the rolling parts</td>
</tr>
<tr>
<td></td>
<td>Surface roughness of mating rolling part</td>
<td></td>
</tr>
<tr>
<td>Round shaped peeling pattern occurs on the center of the raceway surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor lubrication</td>
<td></td>
</tr>
</tbody>
</table>

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

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

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

- **Photo 7-2-1**: Inner ring of a spherical roller bearing
  - 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**: Enlargement of pattern in Photo 7-2-1

- **Photo 7-2-3**: Convex rollers of Photo 7-2-1
  - 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**: Outer ring of a spherical roller bearing
  - Part: Outer ring of a spherical roller bearing
  - Symptom: Peeling occurs near the shoulder of the raceway over the entire circumference
  - Cause: Poor lubrication

- **Photo 7-2-5**: Outer ring of Photo 7-1-4

- **Photo 7-2-6**: Balls of Photo 7-1-4

- **Photo 7-2-7**: Inner ring of a spherical roller bearing

- **Photo 7-2-8**: Outer ring of Photo 7-1-7

- **Photo 7-2-9**: Rollers of a cylindrical roller bearing

- **Photo 7-2-10**: Convex rollers of Photo 7-2-1

- **Photo 7-2-11**: Outer ring of a spherical roller bearing

- **Photo 7-2-12**: Inner ring of a spherical roller bearing

- **Photo 7-2-13**: Convex rollers of Photo 7-2-1

- **Photo 7-2-14**: Outer ring of a spherical roller bearing

- **Photo 7-2-15**: Inner ring of a spherical roller bearing

- **Photo 7-2-16**: Convex rollers of Photo 7-2-1

- **Photo 7-2-17**: Outer ring of a spherical roller bearing

- **Photo 7-2-18**: Inner ring of a spherical roller bearing

- **Photo 7-2-19**: Convex rollers of Photo 7-2-1

- **Photo 7-2-20**: Outer ring of a spherical roller bearing

- **Photo 7-2-21**: Inner ring of a spherical roller bearing

- **Photo 7-2-22**: Convex rollers of Photo 7-2-1

- **Photo 7-2-23**: Outer ring of a spherical roller bearing

- **Photo 7-2-24**: Inner ring of a spherical roller bearing

- **Photo 7-2-25**: Convex rollers of Photo 7-2-1

- **Photo 7-2-26**: Outer ring of a spherical roller bearing

- **Photo 7-2-27**: Inner ring of a spherical roller bearing

- **Photo 7-2-28**: Convex rollers of Photo 7-2-1

- **Photo 7-2-29**: Outer ring of a spherical roller bearing

- **Photo 7-2-30**: Inner ring of a spherical roller bearing

- **Photo 7-2-31**: Convex rollers of Photo 7-2-1

- **Photo 7-2-32**: Outer ring of a spherical roller bearing

- **Photo 7-2-33**: Inner ring of a spherical roller bearing

- **Photo 7-2-34**: Convex rollers of Photo 7-2-1

- **Photo 7-2-35**: Outer ring of a spherical roller bearing

- **Photo 7-2-36**: Inner ring of a spherical roller bearing

- **Photo 7-2-37**: Convex rollers of Photo 7-2-1

- **Photo 7-2-38**: Outer ring of a spherical roller bearing

- **Photo 7-2-39**: Inner ring of a spherical roller bearing

- **Photo 7-2-40**: Convex rollers of Photo 7-2-1

- **Photo 7-2-41**: Outer ring of a spherical roller bearing

- **Photo 7-2-42**: Inner ring of a spherical roller bearing

- **Photo 7-2-43**: Convex rollers of Photo 7-2-1

- **Photo 7-2-44**: Outer ring of a spherical roller bearing

- **Photo 7-2-45**: Inner ring of a spherical roller bearing

- **Photo 7-2-46**: Convex rollers of Photo 7-2-1

- **Photo 7-2-47**: Outer ring of a spherical roller bearing

- **Photo 7-2-48**: Inner ring of a spherical roller bearing

- **Photo 7-2-49**: Convex rollers of Photo 7-2-1

- **Photo 7-2-50**: Outer ring of a spherical roller bearing

- **Photo 7-2-51**: Inner ring of a spherical roller bearing

- **Photo 7-2-52**: Convex rollers of Photo 7-2-1

- **Photo 7-2-53**: Outer ring of a spherical roller bearing

- **Photo 7-2-54**: Inner ring of a spherical roller bearing

- **Photo 7-2-55**: Convex rollers of Photo 7-2-1

- **Photo 7-2-56**: Outer ring of a spherical roller bearing

- **Photo 7-2-57**: Inner ring of a spherical roller bearing

- **Photo 7-2-58**: Convex rollers of Photo 7-2-1

- **Photo 7-2-59**: Outer ring of a spherical roller bearing

- **Photo 7-2-60**: Inner ring of a spherical roller bearing

- **Photo 7-2-61**: Convex rollers of Photo 7-2-1

- **Photo 7-2-62**: Outer ring of a spherical roller bearing

- **Photo 7-2-63**: Inner ring of a spherical roller bearing

- **Photo 7-2-64**: Convex rollers of Photo 7-2-1
7.3 Scoring

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>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</td>
<td>• Check the size of the load  • Adjust the preload  • Improve the lubricant and the lubrication method  • Check the precision of the shaft and housing</td>
</tr>
</tbody>
</table>

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
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

7.3 Scoring

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 7.4 Smearing

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
</table>
| 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

---

<table>
<thead>
<tr>
<th>Photo 7-4-5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part:</strong> Inner ring of a spherical roller bearing</td>
</tr>
<tr>
<td><strong>Symptom:</strong> Partial smearing occurs circumferentially on raceway surface</td>
</tr>
<tr>
<td><strong>Cause:</strong> Poor lubrication</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Photo 7-4-6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part:</strong> Outer ring of Photo 7-4-5</td>
</tr>
<tr>
<td><strong>Symptom:</strong> Partial smearing occurs circumferentially on raceway surface</td>
</tr>
<tr>
<td><strong>Cause:</strong> Poor lubrication</td>
</tr>
</tbody>
</table>

---

**7.4 Smearing**
- **Damage Condition:** 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.
- **Possible Cause:**
  - High speed and light load
  - Sudden acceleration/deceleration
  - Improper lubricant
  - Entry of water
- **Measures:**
  - 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

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>Impact during mounting&lt;br&gt;Excessive load&lt;br&gt;Poor handling such as dropping</td>
<td>• Improve the mounting method (Shrink fit, use of proper tools)&lt;br&gt;• Reconsider the loading conditions&lt;br&gt;• Provide enough back-up and support for the bearing rib</td>
</tr>
</tbody>
</table>

#### 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

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracks in the raceway ring and rolling elements. Continued use under this condition leads to larger cracks or fractures.</td>
<td>Excessive interference&lt;br&gt;Excessive load, shock load&lt;br&gt;Progression of flaking&lt;br&gt;Heat generation and fretting caused by contact between mating parts and raceway ring&lt;br&gt;Heat generation due to creep&lt;br&gt;Poor taper angle of tapered shaft&lt;br&gt;Poor cylindricality of shaft&lt;br&gt;Interference with bearing chamfer due to a large shaft corner radius</td>
<td>• Correct the interference&lt;br&gt;• Check the load conditions&lt;br&gt;• Improve the mounting method&lt;br&gt;• Use an appropriate shaft shape</td>
</tr>
</tbody>
</table>

| Photo 7-6-1 | **Part:** Outer ring of a double-row cylindrical roller bearing<br>**Symptom:** Thermal cracks occur on the outer ring side face<br>**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<br>**Symptom:** Thermal cracks occur at large end face of roller<br>**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<br>**Symptom:** Cracks propagated outward in the axial and circumferential directions from the flaking origin on the raceway surface<br>**Cause:** Flaking from a flaw due to shock |
### 7.7 Cage Damage

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

**Possible Cause**

- Poor mounting (Bearing misalignment)
- Poor handling
- Large moment load
- Shock and large vibration
- Excessive rotation speed, sudden acceleration and deceleration
- Poor lubrication
- Temperature rise

**Measures**

- Check the mounting method
- Check the temperature, rotation, and load conditions
- Reduce the vibration
- Select a cage type
- Select a lubrication method and lubricant
7.8 Denting

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

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 7-7-5
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

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

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

7.10 Wear

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

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

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

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear occurs due to repeated sliding between the two surfaces.</td>
<td>Poor lubrication</td>
<td>Use a proper lubricant</td>
</tr>
<tr>
<td>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.</td>
<td>Vibration</td>
<td>Apply a preload</td>
</tr>
<tr>
<td></td>
<td>Insufficient interference</td>
<td>Check the interference fit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Apply a film of lubricant to the fitting surface</td>
</tr>
</tbody>
</table>

### 7.12 False Brinelling

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>Oscillation and vibration of a stationary bearing during such times as transporting.</td>
<td>Secure the shaft and housing during transporting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transport with the inner and outer rings packed separately</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduce the vibration by preloading</td>
</tr>
<tr>
<td></td>
<td>Poor lubrication</td>
<td>Use a proper lubricant</td>
</tr>
</tbody>
</table>

---

**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

**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

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
</table>
| 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 | - Check the interference, and prevent rotation  
- Correct the sleeve tightening  
- Study the shaft and housing precision  
- Apply adhesive to the fitting surface  
- Apply a film of lubricant to the fitting surface |

### 7.14 Seizure

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
</table>
| 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, 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 |
7.15 Electrical Corrosion

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>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 &quot;fluting&quot; 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.</td>
<td>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.</td>
<td>• Design electric circuits which prevent current flow through the bearings • Insulation of the bearing</td>
</tr>
</tbody>
</table>

7.16 Rust and Corrosion

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>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.</td>
<td>• Improve the sealing mechanism • Study the lubrication method • Anti-rust treatment for periods of non-running • Improve the storage methods • Improve the handling method</td>
</tr>
</tbody>
</table>
### 7.17 Mounting Flaws

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

### 7.18 Discoloration

<table>
<thead>
<tr>
<th>Damage Condition</th>
<th>Possible Cause</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discoloration of cage, rolling elements, and raceway ring occurs due to a reaction with lubricant and high temperature.</td>
<td>Poor lubrication  Oil stain due to a reaction with lubricant  High temperature</td>
<td>Improve the lubrication method</td>
</tr>
</tbody>
</table>

---

**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

**Photo 7-18-1**
Part: Inner ring of an angular contact ball bearing  
Symptom: Blush 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: Blush or purplish discoloration on raceway surface  
Cause: Heat generation due to poor lubrication
# Appendix Bearing Diagnostic Chart

<table>
<thead>
<tr>
<th>Damage name</th>
<th>Location (Phenomenon)</th>
<th>Cause</th>
<th>Handling</th>
<th>Bearing surrounding</th>
<th>Lubrication</th>
<th>Load</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Flaking</td>
<td>Raceway, Rolling surface</td>
<td>○</td>
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<tr>
<td>2. Peeling</td>
<td>Raceway, Rolling surface</td>
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<td></td>
<td>Bearing outside surface (Rolling contact)</td>
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<tr>
<td>3. Scoring</td>
<td>Roller end face surface, Rib surface</td>
<td>○</td>
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<td>○</td>
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<tr>
<td></td>
<td>Cage guide surface, Pocket surface</td>
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<tr>
<td>4. Smearing</td>
<td>Raceway, Rolling surface</td>
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<tr>
<td>5. Fracture</td>
<td>Raceway collar, Rollers</td>
<td>○</td>
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<tr>
<td>6. Cracks</td>
<td>Raceway rings, Rolling elements</td>
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<tr>
<td></td>
<td>Rib surface, Roller end face, Cage guide surface (Thermal crack)</td>
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<tr>
<td>7. Cage damage (Deformation), (Fracture) (Wear)</td>
<td>Raceway, Rolling surface</td>
<td>○</td>
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<tr>
<td>8. Denting</td>
<td>Raceway, Rolling surface, (Innumerable small dents)</td>
<td>○</td>
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<td></td>
<td>Raceway (Debris on the rolling element pitch)</td>
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<td>9. Pitting</td>
<td>Raceway, Rolling surface</td>
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<tr>
<td>10. Wear</td>
<td>Raceway, Rolling surface, Rib surface, Roller end face</td>
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<td>○</td>
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<td>11. Fretting</td>
<td>Raceway, Rolling surface</td>
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<td></td>
<td>Bearing outside &amp; bore, side surface (Contact with housing and shaft)</td>
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<tr>
<td>12. False brinelling</td>
<td>Raceway, Rolling surface</td>
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<tr>
<td>13. Creep</td>
<td>Fitting surface</td>
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<tr>
<td>14. Seizure</td>
<td>Raceway ring, Rolling element, Cage</td>
<td>○</td>
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<td>15. Electrical corrosion</td>
<td>Raceway, Rolling surface</td>
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<td>16. Rust and corrosion</td>
<td>Raceway ring, Rolling element, Cage</td>
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<td>17. Mounting flaws</td>
<td>Raceway, Rolling surface</td>
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<td>18. Discoloration</td>
<td>Raceway ring, Rolling element, Cage</td>
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</tbody>
</table>

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