## 16. Bearing damage and corrective measures

### 16.1 Bearing damage, main causes of bearing damage, and remedies for correcting the problem

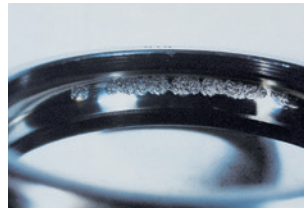
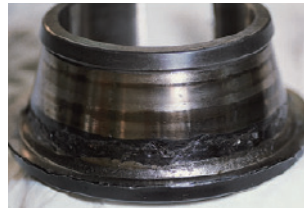
If handled correctly, bearings can generally be used for a long time before reaching their fatigue life. If damage occurs prematurely, the problem could stem from improper bearing selection, handling, or lubrication. If this occurs, take note of the application, operating conditions, and environment. By investigating several possible causes surmised from the type of damage and condition at the time the damage occurred, it is possible to prevent the same kind of damage from reoccurring.
**Table 16.1** gives the main causes of bearing damage and remedies for correcting the problem.

For details, see the special catalog "**Care and Maintenance of Bearings (CAT. No. 3017/E)**".





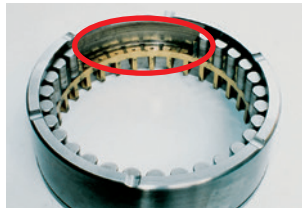
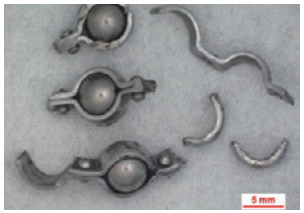
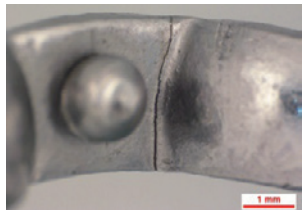
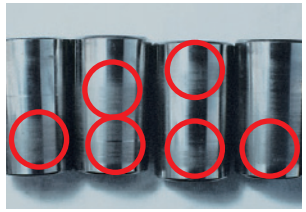
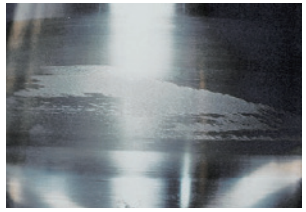
Table 16.1 Bearing damage, main causes of bearing damage and remedies for correcting the problem

| Phenomenon | | |
|---|---|---|
| **Spalling (Flaking)** | The surface of the raceway and rolling elements peel away in flakes leaving a highly irregular and very poor surface. | **Causes**<br>● Excessive load, normal fatigue life, improper handling<br>● Improper installation<br>● Insufficient accuracy of shaft or housing<br>● Insufficient clearance<br>● Contamination<br>● Rust<br>● Insufficient lubrication<br>● Reduction in hardness due to abnormal temperature rise |
|  <br>● Inner ring of spherical roller bearing<br>● Spalling on one row of the raceway surface in this case.<br>● An excessive axial load is the cause. |  <br>● Outer ring of angular contact ball bearing<br>● Spalling on the raceway surface with spacing equal to the distance between balls.<br>● Improper handling is the cause. | **Correction**<br>● Select a different type or size of bearing.<br>● Reevaluate the clearance.<br>● Improve the precision of the shaft and housing.<br>● Improve assembly method and handling.<br>● Reevaluate the layout (design) of the area around the bearing.<br>● Review lubricant type and lubrication methods. |
| **Seizure** | Extreme thermal conditions eventually resulting in seizure of the bearing. | **Causes**<br>● Insufficient clearance (including clearances reduced by local deformation)<br>● Insufficient lubrication or improper lubricant<br>● Excessive loads (including excessive preload)<br>● Roller skewing due to a misaligned bearing<br>● Reduction in hardness due to abnormal temperature rise<br>● High speed or large fluctuating load |
|  <br>● Inner ring of double-row tapered roller bearing<br>● Seizure causes discoloration and softening, producing stepped abrasion on the raceway surface with spacing equal to the distance between the rollers.<br>● Insufficient lubrication is the cause. |  <br>● Inner ring of tapered roller bearing<br>● Evidence of seizure on the large diameter side of raceway surface and large rib surface<br>● Insufficient lubrication is one possible cause. | **Correction**<br>● Review lubricant type and quantity.<br>● Check for proper clearance. (Increase clearances.)<br>● Take steps to prevent misalignment.<br>● Improve assembly method and handling. |
| **Cracks/chips** | Localized spalling occurs. Little cracks or notches appear. | **Causes**<br>● Excessive shock loads<br>● Improper handling (use of steel hammer, damage from large particle contamination)<br>● Formation of decomposed surface layer due to improper lubrication<br>● Excessive interference<br>● Spalling<br>● Friction cracking<br>● Imprecise mating component (oversized fillet radius) |
|  <br>● Inner ring of tapered roller bearing<br>● Chipped large rib.<br>● Impact due to improper preloading is the cause. |  <br>● Outer ring of four-row cylindrical roller bearing<br>● Cracks in the circumferential direction of raceway surface<br>● These cracks were initiated by spalling. | **Correction**<br>● Review lubricant (friction crack prevention).<br>● Select proper interference and review materials.<br>● Improve assembly method and handling. |

# Bearing Damage and Corrective Measures



Table 16.1 (continued)

| Phenomenon | | |
|---|---|---|
| **Cage damage** Rivets break or become loose resulting in cage damage. Fracture of riveted steel cage at the corner radius. | Causes | ● Excessive load or moment loading<br>● High speed or excessive speed fluctuations<br>● Insufficient lubrication<br>● Impact with foreign objects<br>● Excessive vibration<br>● Improper mounting (mounted misaligned) |
|  <br>● Cage of angular contact ball bearing<br>● Breakage of high strength, machined brass cage<br>● Insufficient lubrication is the cause. | | |
|  <br>● Cage of cylindrical roller bearing<br>● Breakage of partitions between pockets of high strength, machined brass cage | | |
|  <br>● Cage of deep groove ball bearing<br>● Breakage of riveted steel cage | Correction | ● Review lubricant type and lubrication methods.<br>● Review cage type selection.<br>● Investigate shaft and housing rigidity.<br>● Improve assembly method and handling. |
|  <br>● Cage of deep groove ball bearing<br>● Breakage at corner of riveted steel cage | | |
| **Rolling path skewing** Abrasion or an irregular, rolling path skewing due to rolling elements along raceway surfaces. | Causes | ● Insufficient accuracy of shaft or housing<br>● Improper installation<br>● Insufficient shaft or housing rigidity<br>● Shaft whirling caused by excessive internal bearing clearances |
|  <br>● Spherical roller bearing<br>● Uneven contact on inner ring, outer ring, and roller<br>● Improper installation is the cause. | | |
|  <br>● Roller of tapered roller bearing<br>● Evidence of uneven contact on rolling element surface | Correction | ● Reevaluate the clearance.<br>● Improve the precision of the shaft and housing.<br>● Review rigidity of shaft and housing. |
| **Smearing, Scuffing** The surface becomes rough and some small deposits form. Scuffing generally refers to roughness on the race rib face and the ends of the rollers. | Causes | ● Insufficient lubrication<br>● Contamination ingress<br>● Roller skewing due to a misaligned bearing<br>● Bare spots in the collar oil film due to large axial loading<br>● Excessive slippage of the rolling elements |
|  <br>● Inner ring of cylindrical roller bearing<br>● Scuffing on the rib surface. | | |
|  <br>● Inner ring of cylindrical roller bearing<br>● Smearing on the raceway surface.<br>● The cause is slippage of rollers due to contaminants. | Correction | ● Review lubricant type and lubrication methods.<br>● Improve sealing performance.<br>● Review preload.<br>● Improve assembly method and handling. |



Commentary

# Bearing Damage and Corrective Measures

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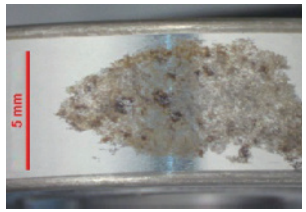
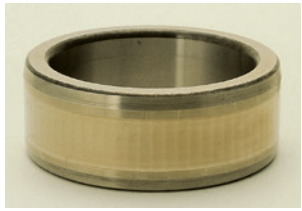
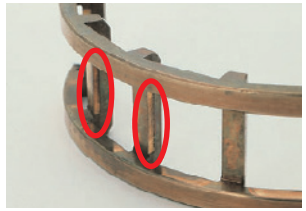
Table 16.1 (continued)

| Phenomenon | | |
|---|---|---|
| **Rust/ corrosion** The surface becomes either partially or fully rusted, and occasionally rust occurs spaced at equal distances between rolling elements. | Causes | ● Poor storage conditions<br>● Poor packaging<br>● Insufficient rust inhibitor<br>● Penetration by water, acid, etc.<br>● Handling with bare hands |
|  <br>● Inner ring of tapered roller bearing<br>● Rust at equal distances between rolling elements on raceway surface. | | |
|  <br>● Outer ring of deep groove ball bearing<br>● Rust on the outside diameter surface. | Correction | ● Take measures to prevent rusting while in storage.<br>● Periodically inspect the lubricating oil.<br>● Improve sealing performance.<br>● Improve assembly method and handling. |
| **Fretting** There are two types of fretting. In one, a rusty wear powder forms on the mating surfaces. In the other, brinelling indentations form on the raceway corresponding to rolling element spacing. | Causes | ● Insufficient interference<br>● Small bearing oscillation angle<br>● Insufficient lubrication<br>● Fluctuating loads<br>● Vibration during transport, or while stopped |
|  <br>● Inner ring of cylindrical roller bearing<br>● Ripple-like fretting on the entire circumference of the raceway surface.<br>● Vibration is the cause. | | |
|  <br>● Inner ring of deep groove ball bearing<br>● Fretting on the entire circumference of the raceway surface.<br>● Vibration is the cause. | Correction | ● Review lubricant type and lubrication methods.<br>● Review the interference fit and apply a coat of lubricant to fitting surface.<br>● Pack the inner and outer rings separately for transport. |
| **Wear** The surfaces wear and dimensional deformation results. Wear is often accompanied by roughness and scratches. | Causes | ● Entrapment of foreign particles in the lubricant<br>● Inadequate lubrication<br>● Roller skewing due to a misaligned bearing |
|  <br>● Inner ring of cylindrical roller bearing<br>● Stepped wear on the entire circumference of the raceway surface.<br>● Insufficient lubrication is the cause. | | |
|  <br>● Cage of cylindrical roller bearing<br>● Wear of pocket part of high strength, machined brass cage | Correction | ● Review lubricant type and lubrication methods.<br>● Improve sealing performance.<br>● Take steps to prevent misalignment.<br>● Improve assembly method and handling. |
| **Electrolytic corrosion** Pits form on the raceway. The pits gradually grow into ripples. | Causes | ● Electric current flowing through the rollers |
|  <br>● Inner ring of deep groove ball bearing<br>● Ripple-like electrolytic corrosion on the raceway surface. | | |
|  <br>● The cross section of the electrolytic corrosion on the roller rolling element surface is enlarged (×400).<br>● The white layer shows up by nital etching of the cross section. | Correction | ● Create a bypass circuit for the current.<br>● Insulate the bearing. |

# Bearing Damage and Corrective Measures

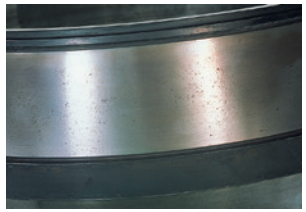


Table 16.1 (continued)

**Phenomenon**

**Scratching and Denting** — Scoring during assembly, gouges due to hard foreign objects, and surface denting due to mechanical shock.

- Roller of cylindrical roller bearing
- Axial direction scratches on the rolling element surface at the time of preloading
- Improper preloading is the cause.



- Inner ring of tapered roller bearing
- Dents on the entire raceway surface
- Impact with hard foreign objects is the cause.

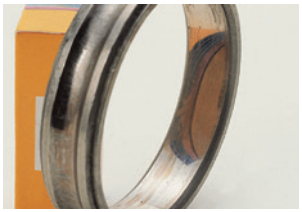
**Causes**

- Entrapment of hard foreign matter
- Dropping or other mechanical shocks due to careless handling
- Assembled misaligned
- Excessive load or moment loading

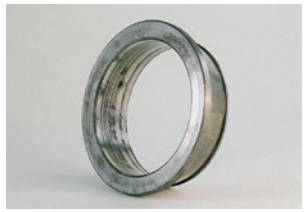
**Correction**

- Improve assembly method and handling.
- Improve sealing performance (to prevent infiltration of foreign matter).
- Check area surrounding bearing (when caused by metal fragments).

**Creeping** — Surface becomes mirrored due to bore and outside diameter bearing surfaces spinning against the mating shaft or housing surface during operation. May be accompanied by discoloration or scoring.



- Inner ring of deep groove ball bearing
- Mirrored bore surface due to creeping on the shaft.



- Inner ring of tapered roller bearing
- Scuffing on bore surface due to creeping on the shaft.

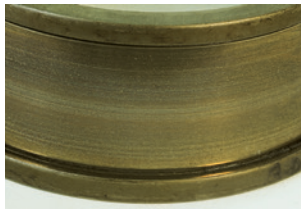
**Causes**

- Insufficient interference with mating component
- Sleeve not fastened down properly
- Abnormal temperature rise
- Excessive loads
- High speed/rapid acceleration or deceleration

**Correction**

- Reevaluate the interference fit.
- Review operating conditions.
- Improve the precision of the shaft and housing.
- Fix of the faces of inner/outer ring

**Speckles and discoloration** — Luster of raceway surfaces is gone; surface is matted, rough, and / or evenly dimpled. Surface covered with minute dents.



- Inner ring of double-row tapered roller bearing
- Speckles and discoloration on the raceway surface.
- Electrolytic corrosion is the cause.

- Ball of deep groove ball bearing
- Large speckles and discoloration
- Impact with hard foreign objects and insufficient lubrication are the cause.

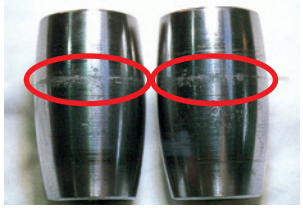
**Causes**

- Infiltration of bearing by foreign matter
- Insufficient lubrication

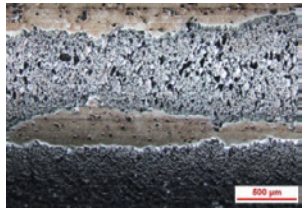
**Correction**

- Review lubricant type and lubrication methods.
- Review sealing mechanisms.
- Examine lubrication oil purity (filter may be excessively dirty, etc.).

**Peeling** — Patches of minute spalling or peeling (size, approx. 10 μm). Innumerable hair-line cracks visible though not yet peeling. (This type of damage is frequently seen on roller bearings.)



- Spherical rollers
- Linear peeling on the rolling element surface.
- Insufficient lubrication is the cause.



- Outer ring of deep groove ball bearing
- Peeling on the load zone of the raceway surface.

**Causes**

- Infiltration of bearing by foreign matter
- Insufficient lubrication

**Correction**

- Review lubricant type and lubrication methods.
- Improve sealing performance (to prevent infiltration of foreign matter).
- Perform run-in.







**Table 16.2** gives the main causes of bearing damage. In the table, factors that are likely to be the cause of each damage are marked by ○; however, factors without ○ may be the cause of the damage in special circumstances.

Table 16.2 Bearing damage and causes

| Bearing damage | Damaged parts | Causes | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Handling | | Bearing periphery | | | Lubrication | | Load | | | Speed | | | Bearing selection | |
| | | Poor storage condition/ vibration during transportation | Improper handling/ installation | Insufficient accuracy of shaft/housing | Infiltration of bearing by foreign matter (insufficient sealing performance) | Temperature (heat effect) | Lubricant (insufficient/ improper quality) | Lubrication method (insufficient) | Excessively large impact load/preload | Excessively large moment | Excessively small load | High speed/ rapid acceleration and deceleration | Large vibration | Swinging/vibration/standstill | Excessively large/ small clearance | Excessively large/ small interference |
| Spalling (Flaking) | Raceway surface/ rolling element surface | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | | | ○ | |
| Seizure | Raceway/ rolling element/cage | | ○ | | | ○ | ○ | ○ | ○ | ○ | | ○ | | | ○ | |
| Cracks/chips | Raceway/rolling element | | ○ | ○ | | | ○ | | ○ | ○ | | | | | | ○ |
| Cage damage | Rivets break or become loose | | ○ | | ○ | | ○ | ○ | ○ | ○ | | ○ | ○ | | | |
| Rolling path skewing | Raceway surface | | ○ | ○ | | | | | | | | | | | ○ | |
| Smearing/ scuffing | Raceway surface/ rolling element surface/ rib surface/ roller end surface | | ○ | | ○ | | ○ | ○ | ○ | | ○ | | | | | |
| Rust/ corrosion | Rust on a part of or the entire surface of the rolling element pitch | ○ | ○ | | ○ | | ○ | ○ | | | | | | | | |
| Fretting | Red rust on fitting surface | | ○ | | | | | | ○ | | | | ○ | | | |
| | Brinelling indentations form on the raceway of the rolling element pitch | ○ | | | | | ○ | ○ | | | | | | ○ | | ○ |
| Wear | Raceway surface/ rolling element surface/ rib surface/ roller end surface | | ○ | | ○ | | ○ | ○ | | | | | | | | |
| Electrolytic corrosion | Pits form on the raceway. The pits gradually grow into ripples. | | ○ | | | | | | | | | | | | | |
| Scratching and Denting | Raceway surface/ rolling element surface | | ○ | | ○ | | | | ○ | ○ | | | | | | |
| Creeping | Fitting surface | | ○ | ○ | | ○ | | | ○ | | | | | | | ○ |
| Speckles and discoloration | Raceway surface/ rolling element surface | | | | ○ | | ○ | ○ | | | | | | | | |
| Peeling | Raceway surface/ rolling element surface | | | | ○ | | ○ | ○ | | | | | | | | |

## 16.2 Rolling paths and how load is applied

When a bearing rotates in response to a load, the raceway surfaces of the inner and outer rings develop a hazy rolling path due to rolling contact with the rolling element. The rolling path on the raceway surface is normal. Evaluation of the rolling path of a used bearing can provide the engineer with useful information regarding the conditions the bearing had been exposed to.

Rolling path observation clarifies if a radial load was applied, an axial load was applied, or a moment load was applied. It can also shows if the bearing experienced a large load or a mounting error. These observations provide extremely important references when determining the cause of bearing damage.

**Fig. 16.1** shows rolling paths of point and linear contacts caused under various load conditions.

(1) is a general rolling path generated when a radial load is applied to a bearing with inner ring rotation. The width of the rolling path becomes small at the entrance of the load zone of the outer ring, which is the fixed side. On the other hand, (2) shows a rolling path pattern opposite to (1) when a radial load is applied during outer ring rotation. (3) is a rolling path generated when an axial load in one direction is applied to a bearing, and an example of linear contact on a spherical roller bearing. When a combined load is applied during inner ring rotation, a rolling path pattern such as (4) is caused. As shown in (5), when a radial load is applied to a bearing with significant misalignment due to a moment load, rolling paths are generated at two positions separated by 180 degrees in the load zone of the outer ring, which is the fixed side. (6) shows the case where the housing bore diameter is an ellipse. Rolling paths are left on the fixed side outer ring at two positions but are not misaligned. (5) and (6) indicate improper bearing use, and the bearing life may be shorter because of the adverse effect.





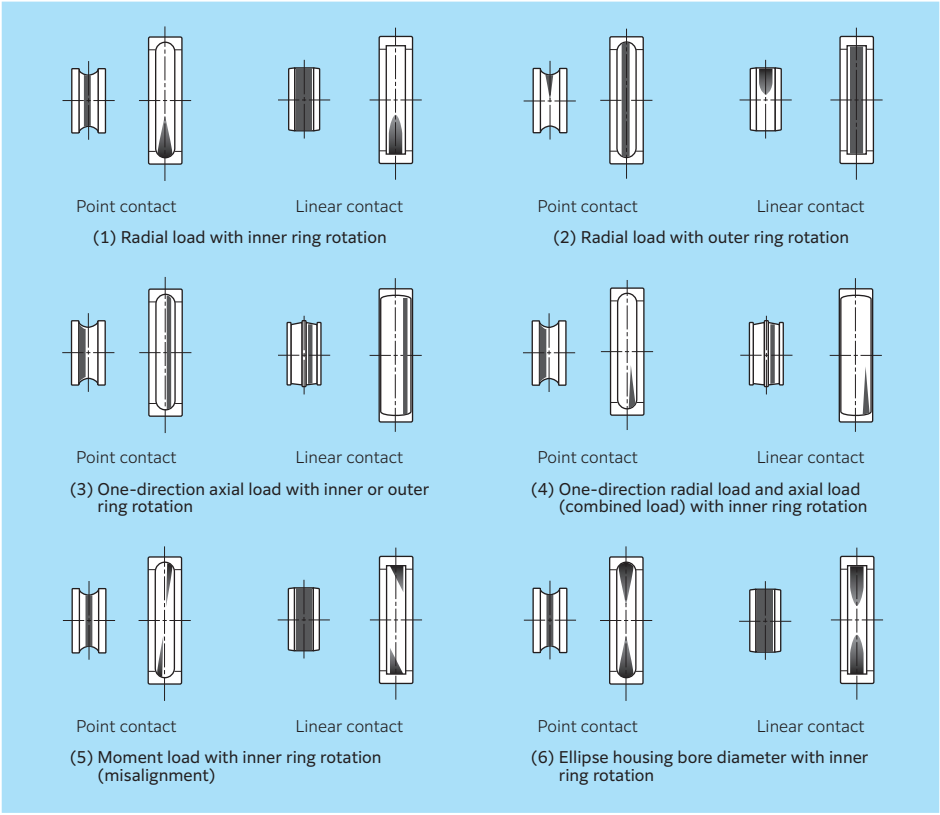



Fig. 16.1 Rolling paths and how load is applied