
SKF
TOOL
RELEASE

Troubleshooting

Introduction

Why bearings fail

Only a small fraction of all bearings in use fail (→ **diagram 1**). Most of them (some 90%) outlive the equipment to which they are fitted. A number of bearings (9,5%) are replaced prior to failure for security (preventive) reasons. Approximately 0,5% of bearings are replaced because they are damaged or failed.

There are several reasons why bearings can be damaged or fail, including:

- fatigue
- ineffective seals
- inadequate lubrication
- heavier loading than anticipated
- wrong or inadequate fits
- incorrect installation

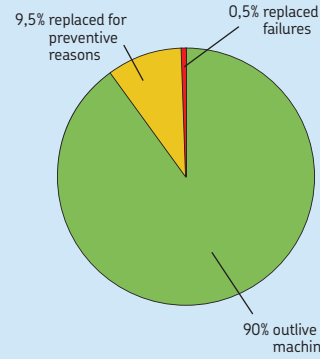
Each of these events produces its own particular damage to the bearing and leaves an imprint, called a pattern (→ *Path patterns*, starting on **page 291**). Consequently, by examining a damaged bearing carefully, it is possible, in the majority of cases, to find the root cause of damage. Based on the findings, corrective actions can be taken to prevent a recurrence of the problem.

Of the bearings that do fail, generally speaking:

- 1/3 fail due to fatigue
- 1/3 fail due to lubrication problems
- 1/6 fail due to contamination

Diagram 1

Bearing life and failure



For additional information about SKF condition monitoring instruments and SKF maintenance products, visit www.skf.com/cm and www.mapro.skf.com.

SKF offers a broad range of mechanical maintenance services (→ *Mechanical maintenance services*, **page 330**) and the SKF Reliability Maintenance Institute (RMI) offers a comprehensive range of training courses (→ *Training*, starting on **page 326**). Contact your local SKF representative for additional information, or visit www.skf.com/services.

- 1/6 fail for other reasons (such as improper handling and mounting)

The figures vary, depending on the industrial segment. In the Pulp and Paper industry, for example, a major cause of bearing failure is contamination and inadequate lubrication, not fatigue.

Factors influencing bearing service life

Generally speaking, bearings in an application have a calculated life (→ *Bearing life*, starting on **page 27**). Whether or not bearings reach or exceed that calculated life depends on a number of factors:

- **Bearing quality**
  Only bearings manufactured to the highest quality standards can provide long service life.

- **Storage**
  Stocking bearings correctly is an important aspect of proper storage. Avoid overstocking and using the “first in, first out” approach will help make sure that “fresh” bearings are on the shelf. This is particularly important for bearings containing seals or shields, as they are lubricated at the factory and the grease has a limited shelf life. Also keep in mind that with rapid changes in manufacturing technology, bearings made today have a much longer built-in life than bearings made 10 or 15 years ago. For additional information about storing bearings, refer to the section *Storage*

of bearings, seals and lubricants, starting on **page 41**.

- **Application**
  The application utilizes the appropriate bearings.

- **Mounting**
  Bearings will only function properly if mounted correctly (→ *Mounting rolling bearings*, starting on **page 44**). Improper mounting techniques can easily damage bearings, causing premature failure.

- **Lubrication**
  Different operating conditions require different lubricants and relubrication intervals. Therefore, it is important to not only apply the right lubricant, but to also apply the right amount, at the right time, using the right method (→ *Lubrication*, starting on **page 178**).

- **Sealing solution**
  The purpose of a seal is to keep lubricants in and contaminants out of the bearing. Premature bearing failure could result if the application is not sealed adequately.

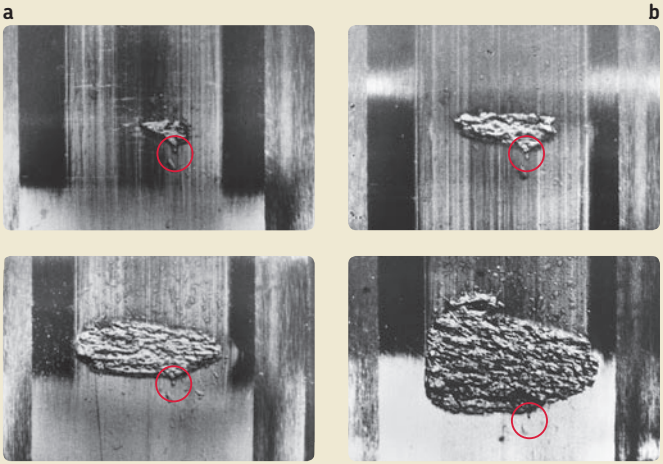
If any one of these factors is weak, bearing service life can be compromised. If they are all strong, long bearing service life can be expected.

For example, take an application with inadequate sealing. When contaminants in the form of particles get into the bearing through the seal, they can be over-rolled by the rolling elements. The over-rolling creates dents in the raceways (→ **fig. 1**). Hard particles may cause dents with sharp corners. When the area around the dents is stressed, surface fatigue is initiated and metal will start to break away from the raceway. This is called spalling. Once spalling has occurred, damage will progress until the bearing becomes unserviceable.

The amount of time from the first (initial) damage until the bearing becomes unserviceable can vary considerably. At higher speeds, it can take a matter of seconds. In large, slow rotating machines, it can take months. The question, "When should I replace the bearing?" is best answered by monitoring the condition of the bearing (→ *Inspection*, starting on **page 216**).

If a damaged bearing goes undiagnosed, and is not replaced before it fails catastrophically, secondary damage to the machine and its components can result. Also, when a bearing fails catastrophically, it can be difficult, even impossible, to determine the root cause of the failure.

Fig. 1



Damage progression
A hard contaminant was over-rolled and made a dent in the raceway (**a**). The material fatigue started just behind the dent. Over a period of time, spalling becomes more and more important (**b**, **c**). If the machine is not stopped in time, secondary damage to machine components might occur. Also, the root cause of the damage might have (completely) disappeared (**d**).

Troubleshooting

Bearings that are not operating properly usually exhibit identifiable symptoms. The best way to identify these symptoms, and take corrective action at an early stage, is to establish a plant-wide condition monitoring programme (→ *Inspection*, starting on **page 216**).

In cases where condition monitoring equipment is not available or practical, the following section presents some useful hints to help identify the most common symptoms, their causes, and whenever possible, some practical solutions. Depending on the degree of bearing damage, some symptoms may be misleading and, in many cases, are the result of secondary damage. To effectively troubleshoot bearing problems, it is necessary to analyze the symptoms according to those first observed in the application. This is dealt with in more detail in the chapter *Bearing damage and their causes*, starting on **page 288**.

Common symptoms of bearing trouble

Symptoms of bearing trouble can usually be reduced to a few common ones that are listed here. Each symptom is broken down into categories of conditions that can lead to those symptoms (→ **table 1**). Each condition has a numerical code that references practical solutions for that specific condition (→ **table 2**, starting on **page 236**).

NOTE: Troubleshooting information presented in this chapter should be used as a guideline only.

Table 1

Common symptoms of bearing trouble

A	Excessive heat → **table 1a**
B	Excessive noise levels → **table 1b**
C	Excessive vibration levels → **table 1c**, **page 234**
D	Excessive shaft movement → **table 1d**, **page 234**
E	Excessive frictional moment to rotate the shaft → **table 1e**, **page 235**

Table 1a

Symptom: A. Excessive heat

Solution code	Possible cause
	Lubrication problem
1	Insufficient lubricant – too little grease, or too low oil level
2	Excessive lubricant – too much grease without the ability to purge or oil level too high
3	Wrong type of lubricant – wrong consistency, wrong viscosity, wrong additives
4	Wrong lubrication system
	Sealing conditions
5	Housing seals too tight, or other components foul the seals
6	Multiple seals in a bearing (housing) arrangement
7	Misalignment of the external (housing) seals
8	Operating speed too high for the contact seals in a bearing
9	Seals not properly lubricated
10	Seals oriented in the wrong direction
	Insufficient clearance in operation
11	Wrong choice of initial bearing internal clearance
12	Shaft material expanding more than bearing steel (e.g. stainless steel)
13	Large temperature difference between the shaft and housing (housing much cooler than the shaft)
14	Excessive drive-up on a tapered seat
15	Excessive out-of-round condition of the shaft or housing – bearing pinched in an oval housing
16	Excessive shaft interference fit or oversized shaft seat diameter
17	Excessive housing interference fit or undersized housing seat diameter
	Improper bearing loading
18	Too heavily loaded bearings as a result of changing application parameters
19	Offset misalignment of two units
20	Angular misalignment of two units
21	Bearing installed backwards
22	Unbalanced or out-of-balance condition
23	Wrong bearing located
24	Excessive thrust loads induced
25	Insufficient load
26	Excessive preload

Table 1b

Symptom: B. Excessive noise levels

Solution code	Possible cause
	Metal-to-metal contact
1	Insufficient lubricant
3	Oil film too thin for the operating conditions
25	Rolling elements sliding (skidding)
	Contamination
27	Dents in raceways and/or rolling elements due to ingress and over-rolling of solid contaminants
28	Solid particles left in the housing from manufacturing or previous bearing failures
29	Liquid contaminants reducing the lubricant viscosity
	Too loose fits
30	Inner ring creeping (turning) on the shaft
31	Outer ring creeping (turning) in the housing
32	Bearing lock nut loose on the shaft or on the bearing sleeve
33	Bearing not clamped securely against mating components
34	Excessive radial/axial internal clearance in the bearing
	Surface damage
1, 2, 3, 4	Wear from ineffective lubrication
25	Smearing damage due to sliding rolling elements
27	Dents in raceways and/or rolling elements due to over-rolling of solid contaminants
35	Dents in raceways and/or rolling elements from impact or shock loading
36	False brinelling marks on raceways and/or rolling elements due to static vibration
37	Spalls in raceways and/or rolling elements due to material fatigue
38	Spalls in raceways and/or rolling elements due to surface initiated damage
39	Static etching on raceways and/or rolling elements due to chemical/liquid contaminants
40	(Micro) Spalls on raceways and/or rolling elements due to moisture or damaging electric current
41	Fluting in raceways and/or rolling elements due to passage of damaging electric current
	Rubbing
7	Housing seals installed incorrectly
32	Adapter or withdrawal sleeve not properly clamped
33	Spacer rings not properly clamped
42	Lock washer tabs bent

Table 1c

Symptom: C. Excessive vibration levels

Solution code	Possible cause
	Metal-to-metal contact
25	Rolling elements sliding (skidding)
	Contamination
27	Dented raceways and/or rolling elements due to ingress and over-rolling of solid contaminants
28	Solid particles left in the housing from manufacturing or previous bearing failures
	Too loose fits
30	Inner ring creeping (turning) on the shaft
31	Outer ring creeping (turning) in the housing
	Surface damage
1, 2, 3, 4	Wear from ineffective lubrication
25	Smearing damage due to sliding rolling elements
27	Dents in raceways and/or rolling elements due to over-rolling of solid contaminants
35	Dents in raceways and/or rolling elements from impact or shock loading
36	False brinelling marks on raceways and/or rolling elements due to static vibration
37	Spalls in raceways and/or rolling elements due to material fatigue
38	Spalls in raceways and/or rolling elements due to surface initiated damage
39	Static etching on raceways and/or rolling elements due to chemical/liquid contaminants
40	(Micro) Spalls on raceways and/or rolling elements due to moisture or damaging electric current
41	Fluting in raceways and/or rolling elements due to passage of damaging electric current

Table 1d

Symptom: D. Excessive shaft movement

Solution code	Possible cause
	Looseness
30	Inner ring loose on the shaft
31	Outer ring excessively loose in the housing
33	Bearing not properly clamped on the shaft or in the housing
	Surface damage
1, 2, 3, 4	Wear from ineffective lubrication
37	Spalls in raceways and/or rolling elements due to fatigue
38	Spalls in raceways and/or rolling elements due to surface initiated damage
	Incorrect internal bearing clearance
11	Bearing with wrong clearance installed
33	Bearing not properly clamped on the shaft or in the housing, excessive endplay

Table 1e

Symptom: E. Excessive frictional moment to rotate the shaft

Solution code	Possible cause
	Preloaded bearing
11	Wrong clearance selected for the replacement bearing
12	Shaft material expanding more than bearing steel (e.g. stainless steel)
13	Large temperature difference between the shaft and housing
14	Excessive drive-up on a tapered seat
15	Excessive out-of-round condition of the shaft or housing – pinched bearing
16, 17	Excessive shaft and/or housing interference fits
26	Excessive preload – incorrect assembly (preload)
	Sealing drag
5	Housing seals too tight, or other components foul the seals
6	Multiple seals in a bearing (housing) arrangement
7	Misalignment of external (housing) seals
9	Seals not properly lubricated
	Surface damage
37	Spalls in raceways and/or rolling elements due to fatigue
38	Spalls in raceways and/or rolling elements due to surface initiated damage
41	Fluting in raceways and/or rolling elements due to passage of damaging electric current
	Design
43	Shaft and/or housing shoulders out-of-square with the bearing seat
44	Shaft shoulder is too large, fouling the seals/shields

Trouble conditions and their solutions

Practical solutions to common symptoms of bearing trouble are provided in **Table 2**, starting on **page 236**.

WARNING
To minimize the chance of serious injuries, prior to starting any work, perform required lockout/tagout procedures.

CAUTION: Direct contact with petroleum products may cause allergic reactions! Read the material safety data sheets before handling lubricants and use protective gloves at all times.

Table 2

Trouble conditions and their solutions

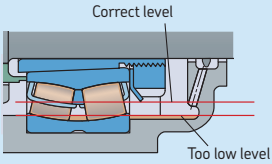
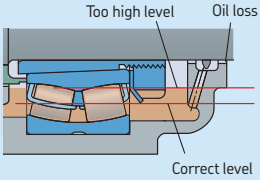
Solution code	Condition / Practical solutions
1	**Insufficient lubricant** Grease lubrication Considerations during first-fill or start-up: • The grease should fill 100% of the bearing, and up to the bottom of the shaft in the housing (1/3 to 1/2). • If the housing cavity alongside the bearing is small, the grease quantity may need to be reduced slightly to avoid overheating from churning. • → *Lubrication*, starting on **page 178**. Actions during operation: • Check for worn or damaged seals or improper seals. (Check for grease leakage.) • Leakage from incompatibility of greases. (Check for grease leakage.) Actions during relubrication: • Make sure the relubrication interval is correct (not too long). • Make sure the grease reaches the bearing. • Make sure fresh grease gets into the bearing.  Oil bath lubrication Consideration during first fill, refill or standstill: • The oil bath level should be at the middle of the lowest rolling element in a static condition. Actions during operation: • Make sure the housing is vented properly to avoid back pressure, which can cause a malfunction of automatic lubricators. • Check the seals for wear, damage and leaks. • Check the housing split for leaks and apply a thin layer of gasket cement if necessary.
2	**Excessive lubricant** Too much lubricant can cause excessive churning and elevated temperatures. Grease lubrication Considerations during first fill or start-up: • The grease should fill 100% of the bearing, and up to the bottom of the shaft in the housing (1/3 to 1/2). • If the housing cavity alongside the bearing is small, the grease quantity may need to be reduced slightly to avoid overheating from churning. • → *Lubrication*, starting on **page 178**. Actions during operation: • Check if grease purging is possible, either through the seals or a drain plug. A grease escape valve might avoid applying excessive grease. • Check the seals for proper orientation, which will enable excess lubricant to purge while keeping contaminants out. • Make sure the relubrication interval is not too short. • Make sure to apply the right quantity when relubricating.  Oil bath lubrication Actions: • Make sure the oil bath level is set to the middle of the lowest rolling element in a static condition. • Inspect oil return holes for blockages. • Installing a sight glass on all housings is a quick, easy way to check whether the oil level in the housings is correct.

Table 2 cont.

Trouble conditions and their solutions

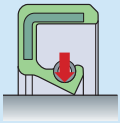
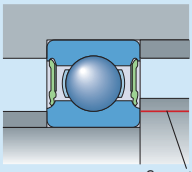
Solution code	Condition / Practical solutions
3	 **The wrong lubricant** Actions: • Review the application to determine the correct base oil viscosity (grease, oil) and consistency (grease) required for the specific operating conditions (→ *Lubrication*, starting on **page 178**). • Metal-to-metal contact can lead to excessive heat and premature wear, ultimately leading to higher noise levels. • Check the miscibility if the grease or oil has been changed from one type to another. • Check the grease consistency. • Check the operating viscosity.
4	**The wrong lubrication system** Actions: • Review the operational speed and measure the operating temperature. • Determine if a suitable lubricant and lubrication system is used. • Switching from grease to oil can be a simple solution. • Switching from oil bath lubrication to circulating oil can be a solution. • Adding an auxiliary cooler to an existing oil lubrication system can also avoid many heat related problems. • Consult with SKF or the equipment manufacturer for specific requirements. • Reference the speed rating values provided in the manufacturer's product guide. SKF values for reference and limiting speeds can be found in the *SKF Interactive Engineering Catalogue* available online at www.skf.com.
5	  **Housing seals are too tight** Actions: • Check the shaft diameter to make sure it is the correct size for the specific spring-type seal being used to avoid excessive friction or replace the seal with a seal that has the right spring tension. • Make sure the seals are lubricated properly. • Check seal lips for wear. • Felt seals should be soaked in hot oil prior to installation. **Other components foul the bearing seals** Action: • Check components adjacent to the seals: – abutment heights (→ *SKF Interactive Engineering Catalogue* available online at www.skf.com) – possibility to accommodate axial displacement if shaft elongation occurs

Table 2 cont.

Trouble conditions and their solutions

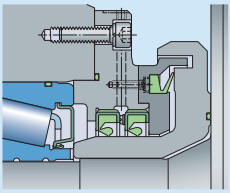
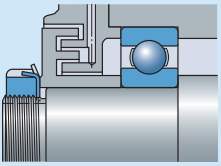
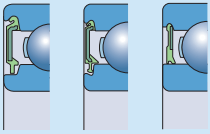
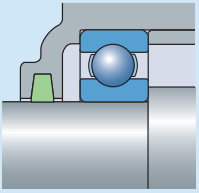
Solution code		Condition / Practical solutions
6		**Multiple seals in a bearing (housing) arrangement** Considerations: • If multiple contact seals are used to help keep contaminants out, friction and heat will increase. • Before adding additional seals to an application, consider the thermal effects on the bearing and lubricant. • In addition, consider the extra power required to rotate the equipment.
7		**Misalignment of external (housing) seals** Considerations during assembling: • Any misalignment of the shaft relative to the housing can cause a non-contact or gap type seal to rub. This condition can elevate temperatures, increase noise levels and accelerate wear during the initial running-in period. It also compromises sealing integrity. Actions: • Check the alignment and correct accordingly. • If misalignment cannot be avoided, there might be a need to increase the clearance or gaps between the external seals.
8	 Contact seals	**Operating speed too high for contact seals in the bearing** Considerations: • Seal lips have a limiting speed. If operating speeds exceed these limits, seal lip damage and grease leakage will result. • If the operating speed has been increased or if a bearing with a different seal is used, check that the bearing seal can accommodate the speed. • Contact seals will generate more heat than low-friction seals, shields or open bearings.
9		**Seals not properly lubricated** Considerations: • Dry running contact seals can add significant amounts of heat to the system. Action during assembly: • Make sure that seals are properly lubricated at start-up of new or rebuilt equipment. (Felt seals should be soaked in hot oil, prior to installation.) Actions during operation: • Normally the lubricant in the housing will get thrown outward towards the seals and automatically lubricate them. • Properly lubricated seals will run cooler and will create an effective seal since any gaps between the contacts will be filled with a lubricant barrier. • Proper lubrication will also reduce premature seal wear. • Check seals for wear or damage.

Table 2 cont.

Trouble conditions and their solutions

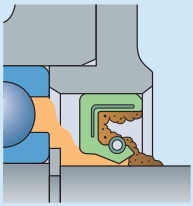
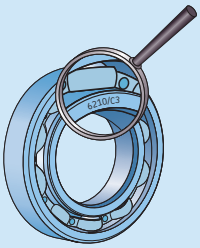
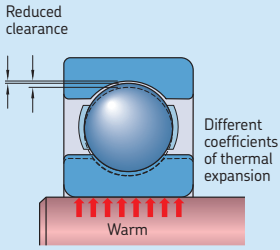
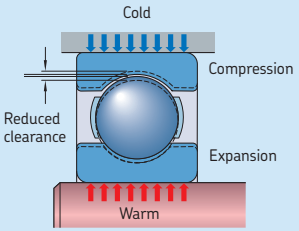
Solution code	Condition / Practical solutions
10	 **Seals oriented in the wrong direction and not allowing grease purge** Consideration during assembly: • Depending on the application, contact seals may need to be oriented in a specific direction to either allow the lubricant to purge or to prevent oil leakage. Action: • Check the application drawings, or contact the equipment manufacturer to determine the proper orientation of the seals for the equipment. Consideration during operation: • Seal lips that face outward will usually allow purging of excess lubricant and prevent the ingress of contaminants. Action: • Seals must be oriented correctly to keep grease in and contaminants out of the bearing.
11	 Wrong choice of initial bearing internal clearance Action: • Check the package to make sure that the internal clearance of the new bearing is in accordance with the original design specification. • If a bearing is overheating after it has been replaced, and if larger clearance is required for the application, contact the SKF application engineering service for the effects of additional clearance on the equipment, as well as the bearing. • Check all dimensions, as component wear can influence bearing clearance.
12	 **Shaft (and housing) material expands more than bearing steel** Considerations during redesign or remanufacturing: • In some cases, shaft and housing materials might be changed, e.g. stainless steel shaft to comply with food regulations, or, an aluminium housing to reduce equipment weight. • When the shaft material has a higher coefficient of thermal expansion than bearing steel, the radial internal clearance is further reduced. Therefore, for certain stainless steel shaft materials (300 series), either a slightly looser shaft fit is required or a bearing with increased radial internal clearance is required, e.g. CN to C3, C3 to C4, etc. • If a housing made from a material with a higher coefficient of thermal expansion than bearing steel, e.g. aluminium, is used, a slightly tighter fit may be required to prevent the outer ring from turning in the housing seat. Action: • In both cases it might be necessary to calculate the effect of the new shaft or housing material on internal bearing clearance and replace the bearing accordingly.

Table 2 cont.

Trouble conditions and their solutions

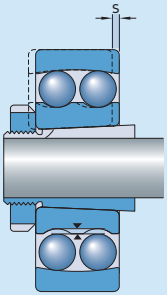
Solution code	Condition / Practical solutions
13	**Large temperature difference between the shaft and housing**
14	**Excessive drive-up on a tapered seat**



Considerations during design:
- Due to their design, bearing arrangements often have an inner ring temperature that is higher than the outer ring temperature. For example, the shaft in an electric motor is relatively warm, causing the inner ring to expand. The motor covers that contain the bearing outer rings have a rather large surface area that promotes heat dissipation, making the temperature difference quite substantial.

Considerations during operation:
- A large temperature difference between the shaft and housing reduces bearing internal clearance, which can result in too little clearance or even preload, causing high operating temperatures.

Actions:
- Check the shaft and housing temperatures closest to the bearing.
- If justified, select a bearing with increased internal clearance to prevent preloading, e.g. CN to C3, C3 to C4, etc.



Considerations during mounting:
- Mounting a bearing with a tapered bore on a tapered seat (shaft or sleeve) reduces the radial internal clearance within the bearing.

Considerations during operation:
- Too much drive-up "s" may result in too little internal clearance or even preload. This causes higher operating temperatures.
- Excessive drive-up "s" may result in too high hoop stresses in the bearing, resulting in inner ring cracking.

Actions:
- Small self-aligning ball bearings: After mounting on the shaft, check whether the outer ring can be swivelled easily. If not, dismount the bearing, and start the mounting procedure from the beginning.
- Large self-aligning ball bearings, spherical roller and CARB toroidal roller bearings: Compare the resulting clearance after mounting with the initial bearing clearance. Refer to **Appendix F**, starting on **page 402** for maximum values for clearance reduction. If there is insufficient clearance, dismount the bearing and start the mounting procedure from the beginning.
- For appropriate mounting, use the SKF Drive-up method or tightening angle method for self-aligning ball bearings, the SKF Drive-up method or clearance reduction method for spherical roller and CARB toroidal roller bearings. The well-proven SKF Drive-up method (→ **page 57**) is an easy way to achieve the correct running clearance without using feeler gauges. Use the SENSORMOUNT method (→ **page 67**) for very large bearings.

Table 2 cont.

Trouble conditions and their solutions

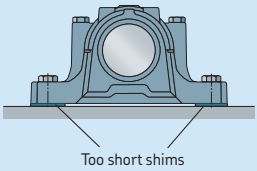
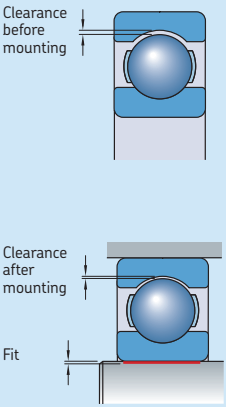
Solution code		Condition / Practical solutions
15		**Bearing is mounted on/in an out-of-round component** Considerations during operation: • A bearing outer ring in an out-of-round or distorted housing (oval clamping/pinching) leads to reduced clearance or preload and an increase in operating temperature. • This is often characterized by two load zones in the outer ring that are 180° apart. • Oval clamping (pinching) can also restrict axial movement of the non-locating bearing and induce heavy axial loads. Actions: • Check that the support surface is flat to avoid soft foot. Any shims should cover the entire area of the housing base. • Make sure the housing support surface is rigid enough to avoid flexing. • Check the shaft and housing seats for roundness (ovality) (→ **Appendix D-1**, **page 386**). • Re-machine if necessary.
16		**Excessive shaft interference fit or oversized shaft seat diameter** Considerations during design: • An interference fit between the bearing inner ring and shaft seat will expand the inner ring and reduce the bearing internal clearance. • If the fit is too tight, it may result in too little operating clearance in the bearing, or even preload. This will lead to a hot running bearing. Actions: • Check that the installed bearing has the correct internal clearance. • If the shaft is new or refurbished, carefully check the bearing seat dimensions for both dimensional and form accuracy (→ **Appendix D-1**, **page 386**). • Prior to taking any corrective action, check the dimensions of the housing bore. • If all dimensions are to specification, a bearing with a larger internal clearance might be required. • Note that an interference fit on the shaft and in the housing will probably result in too little operating clearance (→ *Radial location of bearings*, starting on **page 31**).

Table 2 cont.

Trouble conditions and their solutions

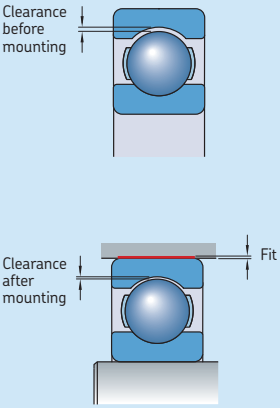
Solution code		Condition / Practical solutions
17		**Excessive housing interference fit or undersized housing seat diameter** Considerations during design: • An interference fit between the bearing outer ring and housing seat will compress the outer ring and reduce the bearing internal clearance. • If the fit is too tight, it may result in too little operating clearance in the bearing or even preload. This will lead to a hot running bearing. Actions: • Check that the installed bearing has the correct internal clearance. • If the housing is new or refurbished, carefully check the bearing seat dimensions for both dimensional and form accuracy (→ **Appendix D-1**, **page 386**). Regrind the housing seat to the appropriate fit. If this is not possible, use a bearing with a larger internal clearance. • Note that an interference fit on the shaft and in the housing will probably result in too little operating clearance (→ *Radial location of bearings*, starting on **page 31**). • Note that for a rotating inner ring load, an interference fit in the housing will cause the "floating" bearing to become fixed, inducing an axial load and excessive heat.
18		**Too heavily loaded bearings as a result of changing application parameters** Considerations during redesign or remanufacturing: • Increasing the external loads on a bearing will generate more heat within the bearing. • Heavier loads will reduce bearing service life. • Therefore, if a design change is made, review the loads to make sure they have not increased. Examples: • Going from a coupling to a belt drive. • Going from a coupling to a sheave. • Increasing the speed of a piece of equipment. Action: • Changes in the performance of a piece of equipment should be reviewed with the original equipment manufacturer.

Table 2 cont.

Trouble conditions and their solutions

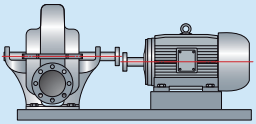
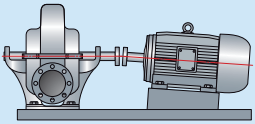
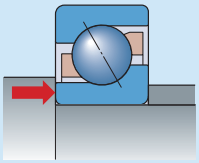
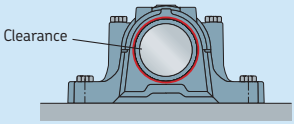
Solution code		Condition / Practical solutions
19		**Offset misalignment of two units** Considerations during assembly: • The two housings are not in a straight line (vertically or horizontally). • This induces additional loads on the bearings and seals, which increase friction and temperature and reduce service life of the bearings, seals and lubricant. Action: • Align the housings using the appropriate equipment using shims to realign vertically (→ *Alignment*, starting on **page 158**).
20		**Angular misalignment of two units** Considerations during assembly: • The two support surfaces are not aligned: one is angled relative to the other. • This induces additional loads on the bearings and seals, which increase friction and temperature and reduce service life of the bearings, seals and lubricant. Action: • Align the housings using the appropriate equipment and shims (→ *Alignment*, starting on **page 158**).
21		**Bearing installed backwards causing unloading of angular contact ball bearings** Considerations during assembly: • Directional bearings must be installed in the right direction to function properly. • For example: Single row angular contact ball bearings can only accommodate axial loads in one direction. If installed backwards, the axial load will be taken on the low shoulder of the inner ring, which damages the bearing, increases heat generated by the bearing and leads to premature bearing failure. Action: • During mounting/assembly, make sure the axial load is accommodated by the "high" shoulder.
22		**Unbalanced or out-of-balance condition** Considerations during operation: • An unbalanced load can generate a rotating outer ring load that will significantly increase the heat generated by the bearing while increasing the load on the bearing. Actions: • Inspect the rotor for a build-up of dirt/contaminants. • Rebalance the equipment. • Note that too large a housing seat will also cause vibration and outer ring creeping (turning).

Table 2 cont.

Trouble conditions and their solutions

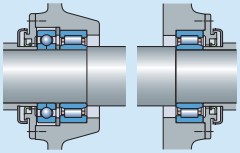
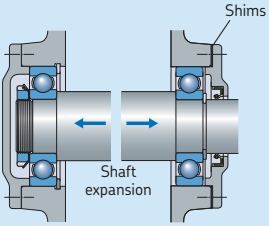
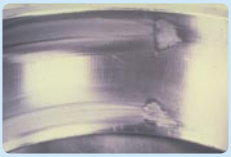
Solution code		Condition / Practical solutions
23		**The wrong bearing is (radially) located** Considerations during design or assembly: • In some applications, the bearing arrangement for the locating position consists of a radial bearing and a thrust bearing. • If the radial bearing is fixed axially, it will be subjected to axial loads, resulting in too heavy combined loads. This can lead to excessive temperatures and possibly premature bearing failure. • If the axial bearing is fixed radially, it will be subjected to radial loads, resulting in (too) heavy combined loads. This can lead to excessive temperatures and possibly premature bearing failure. Action: • Make sure that the radial bearing is axially relieved, and the thrust bearing radially relieved. To prevent the outer ring of the thrust bearing from turning, a stop should be provided, e.g. a four-point contact ball bearing generally has locating slots in the outer ring.
24		**Bearings are cross-located and the shaft can no longer expand** Considerations during design or assembly: • When bearings are cross-located and shaft expansion is too restricted, internal axial loads will be induced in both bearings. • The induced loads can cause excessive operating temperatures and an increased frictional moment. • The induced loads can be heavy and lead to premature fatigue spalling. Actions: • Insert shims between the housing and cover to obtain adequate clearance between the cover and the outer ring side face to avoid axial preloading of the bearings. • If possible, apply an axial spring load on the outer ring to reduce axial clearance in the bearing system. • Determining the expected shaft elongation should help establish how much clearance is required between the bearing outer ring side face and the housing cover.
25		**Smearing caused when insufficiently loaded rolling elements slide (skid)** Considerations during design: • In order to provide satisfactory operation and avoid smearing, all ball and roller bearings must always be subjected to a given minimum load (→ *SKF Interactive Engineering Catalogue*, available online at www.skf.com). • If the minimum load requirements are not met, sliding (skidding) can occur. This generates excessive heat and noise. Extremely stiff greases can contribute to this condition, especially in very cold environments. Actions: • Additional external loads must be applied, or external spring type devices are required. • Alternatively, a bearing with different internal clearance or a different bearing type might be required. • Downsizing the bearing might also be a solution.

Table 2 cont.

Trouble conditions and their solutions

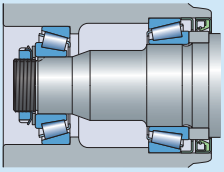
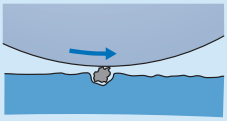
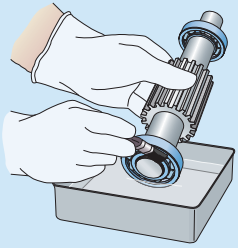
Solution code		Condition / Practical solutions
26		**Bearing adjustment results in excessive preload** Considerations during mounting or assembly: • When adjusting the axial clearance or preload in a bearing arrangement, over-tightening the adjustment device (lock nut) can result in excessive preload and excessive operating temperatures. • Excessive preload will also increase the frictional moment in the bearings. Example: tapered roller bearings or angular contact ball bearings with one bearing on each end of the shaft. Actions: • Check with the equipment manufacturer for the proper mounting procedures to set the endplay (axial clearance) or preload in the equipment. • Use a dial indicator to measure the axial shaft movement (during and) after adjustment.
27		**Solid contaminants enter the bearing and dent the rolling surfaces** Consideration during operation: • Contaminants can damage the bearing contact surfaces, increasing noise and vibration levels. In some cases, temperatures may also increase. Actions: • Check the sealing arrangement for the following: – The correct seal was used. – The seal was installed correctly. – There is no seal wear, seal damage or lubricant leakage. • The relubrication interval may need to be shortened. Supplying smaller quantities of fresh grease more frequently can help purge contaminated grease from the bearing/housing cavity (→ *Relubrication*, starting on **page 192**). • Consider replacing open bearings with sealed bearings.
28		**Solids from manufacturing or previous bearing failures in the housing** Considerations during cleaning or assembly and about lubricant cleanliness: • Denting of the bearing contact surfaces can occur when solid contaminants are left in the bearing housing from a previous failure, from wear of other components such as gears, or from contaminated lubricant. • This can increase temperature, noise and vibration levels. Actions: • Remove any burrs and make sure that all machined surfaces are smooth. • Thoroughly clean the housing and all components within the housing before fitting a new bearing. • Make sure the applied lubricant is clean and does not contain any contaminants. (Grease containers should be closed and stored properly.)

Table 2 cont.

Trouble conditions and their solutions

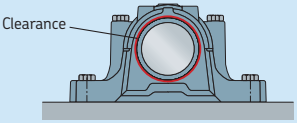
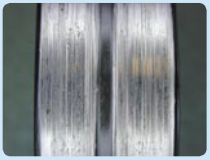
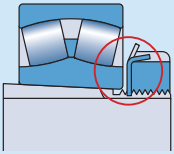
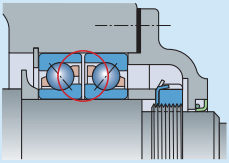
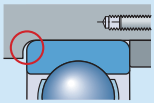
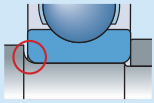
Solution code		Condition / Practical solutions
29		**Liquid contaminants reduce the lubricant viscosity** Considerations during assembly or lubrication and about sealing: • Liquid contaminants will reduce the lubricant viscosity, which can lead to metal-to-metal contact. • In addition, it can cause rust to form on the bearing contact surfaces. • These conditions lead to increased temperature, wear, and noise levels. Actions: • Check the housing seals to make sure they can adequately prevent the ingress of liquid contaminants. • The relubrication interval may need to be shortened. Supplying smaller quantities of fresh grease more frequently can help purge contaminated grease from the bearing/housing cavity (→ *Relubrication*, starting on **page 192**).
30		**Inner ring creeps (turns) on the shaft seat** Considerations about fits or creep: • Most applications have a rotating shaft where the load is uni-directional. This is considered a rotating inner ring load and requires a tight fit on the shaft to prevent relative movement. Proper performance of bearings is highly dependent on correct fits. • However, an inner ring can creep or turn on its shaft seat if the seat is undersized or worn. • This leads to increased noise and vibration levels as well as wear. Action: • Metalize and regrind the shaft seat to the appropriate size (→ *Radial location of bearings*, starting on **page 31**).
31	 	**Outer ring creeps (turns) in the housing seat** Worn or oversized seat Considerations about fits or creep: • Most applications have a stationary housing where the load is uni-directional. This is considered a stationary outer ring load and, under most conditions, the outer ring can be held in place with a loose fit. • However, an outer ring can creep or turn in its housing seat if the seat is oversized or worn. • This leads to increased noise and vibration levels as well as wear. Actions: • Metalize and regrind the housing seat to the appropriate size (→ *Radial location of bearings*, starting on **page 31**). • For large housings, machining the seat to a larger diameter and using a cartridge sleeve might be a solution. Unbalanced load Considerations about fits or creep: • Loads resulting from an unbalanced shaft can cause outer ring creep, even if the fits are correct. Actions: • Eliminate the source of the unbalance. • Rebalance the machine.

Table 2 cont.

Trouble conditions and their solutions

Solution code		Condition / Practical solutions
32		**The bearing lock nut is loose on the shaft or adapter sleeve** Considerations during mounting or assembly: • A loose lock nut or lock washer on the shaft or adapter sleeve can cause the bearing to come loose on its seat. • This can cause the inner ring to creep (turn) on its shaft seat. • This condition can increase noise levels and heat generated by the bearing, but also leads to poor positioning of the bearing. Actions: • Tighten the lock nut to obtain the appropriate position of the inner ring (bearing internal clearance) (→ *Mounting rolling bearings*, starting on **page 44**). • Make sure the lock nut is properly locked, with a lock washer tab for example, when mounting is completed.
33		**The bearing is not clamped securely against mating components** Considerations during mounting or assembly: • A bearing that is not properly clamped against an adjacent component might not attain the necessary internal clearance or preload. • This condition can increase noise levels and have a negative impact on bearing performance. Examples: • A pair of matchable angular contact ball bearings that are not properly clamped. • This can increase axial clearance in the bearing pair, which can lead to ball sliding damage (smearing), increased noise levels, and lubrication problems. • Not properly clamping the bearing will also affect positioning of the shaft. Action: • Make sure that the locking device positions both bearings against their shaft shoulder or spacer.
	 	**Fillet (corner radius) too large** Considerations during mounting or assembly: • If the fillet of an adjacent component is too large, the bearing will not be supported properly. • This condition can distort the bearing rings. • The bearing will not achieve the proper internal clearance (preload). Action: • Machine the fillet to obtain the proper support.

9

Table 2 cont.

Trouble conditions and their solutions

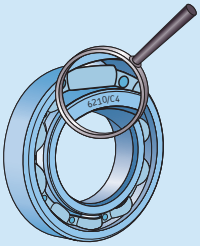
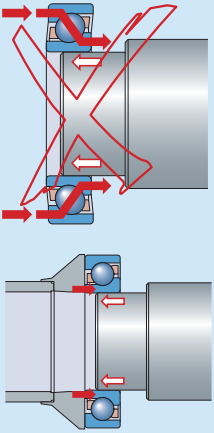
Solution code		Condition / Practical solutions
34		**Too large radial or axial internal clearance in a bearing** Considerations during operation: • Excessive radial or axial internal clearance can increase noise levels because the rolling elements are able to move freely outside the load zone. • In addition, too much clearance can also have a detrimental effect on bearing performance because of sliding of the rolling elements. Actions: • The use of springs or wave washers can provide an adequate axial load to keep the rolling elements loaded at all times (mainly in applications with ball bearings). • Review the needed initial clearance in the bearing; adjust the clearance selection where appropriate.
35		**Rolling surfaces are dented from impact or shock loading (incorrect mounting method)** Considerations during design: • Most bearings are mounted with an interference fit either on the shaft or in the housing. Considerations during mounting: • When mounting the bearing ring with an interference fit, always apply force to that ring. Never allow the mounting force to be transmitted through the rolling elements as this can easily dent the raceways and rolling elements. • The resulting damage can increase noise and vibration levels, and temperature. • The bearing will probably fail prematurely. Actions: • Replace the bearing. • Never hammer any part of a bearing directly when mounting. Always use a mounting sleeve. • Review the mounting procedures making sure that no mounting forces are applied through the rolling elements (→ *Cold mounting*, starting on **page 53**). • Use a bearing fitting tool. (The SKF Bearing fitting tool kit is an excellent tool for smaller bearings.)
36		**Rolling surfaces are false-brinelled due to vibration** Considerations during operation: • Vibrations from other machines while a piece of equipment is not rotating can lead to false-brinelling on the raceways. This damage typically occurs in the loaded zone, and is characterized by dents that match the distance between the rolling elements. • This common problem leads to noise in equipment that sits idle for longer periods of time next to other equipment that is operating, i.e. standby equipment. Actions: • Periodically rotate the shaft of standby equipment to help minimize the effects of the vibration. • Isolating the equipment from the vibration would be the real solution but isn't always practical. • → *Bearing damage and their causes*, starting on **page 288**.

Table 2 cont.

Trouble conditions and their solutions

Solution code		Condition / Practical solutions
37		**Rolling surfaces are spalled due to material fatigue** Considerations during operation: • Pure material fatigue in a high quality rolling bearing is becoming rare. • Fatigue spalling is the result of an abnormal operating condition that leads to higher stress in the bearing, such as misalignment, oval clamping (pinching) or the result of material defects such as inclusions or poor quality steel. Actions: • Only use high quality bearings. • Check damaged bearings for misalignment. Realign where necessary. • Check damaged bearings for possible oval clamping (pinching). Repair and machine seats where necessary. • → *Bearing damage and their causes*, starting on **page 288**.
38		**Rolling surfaces are spalled due to surface initiated fatigue** Considerations during operation: • Inadequate lubrication leads to metal-to-metal contact between the rolling surfaces. • Causes include but are not limited to: viscosity too low at operating temperature, wear particles and ingress of contaminants. Actions: • Review operating viscosity of the lubricant, taking real operating conditions into consideration. • To discharge wear particles, consider more frequent relubrication. • Check the condition of the sealing arrangement. • → *Bearing damage and their causes*, starting on **page 288**.
		**Rolling surfaces are spalled, initiated from surface damage** Considerations during mounting or operation: • Surface initiated damage includes conditions such as brinelling from impact, false brinelling from vibration, water etching, particle denting, passage of electric current, etc. Actions: • Identify the source of the damage and take appropriate action, e.g. eliminate impact through the rolling elements during mounting, replace seals to prevent ingress of contaminants, ground equipment properly, etc. • → *Bearing damage and their causes*, starting on **page 288**.

Table 2 cont.

Trouble conditions and their solutions

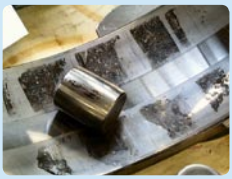
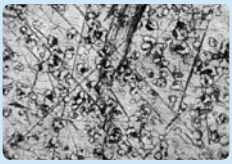
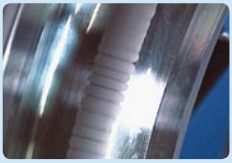
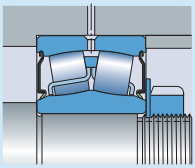
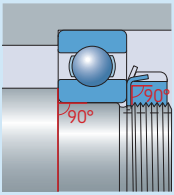
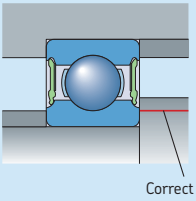
Solution code		Condition / Practical solutions
39		**Etching of rolling surfaces from chemical/liquid contaminants (water, acids, gasses, or other corrosives)** During standstill: • Etching (corrosion) occurs when the equipment is idle and is most common in grease lubricated bearings. • Damage from static etching usually occurs at rolling element distance. Actions: • Check the sealing system. • Upgrade the sealing arrangement by installing a protective shield and/or flinger. • Supplying smaller quantities of fresh grease more frequently can help purge contaminated grease from the bearing/housing cavity (→ *Relubrication*, starting on **page 192**). • Periodically rotate the shaft to minimize the damaging effects of static etching. • → *Bearing damage and their causes*, starting on **page 288**.
40		**Raceways and/or rolling elements have (micro) spalls** During operation: • Micro spalls of the rolling surfaces, sometimes called pitting, is the result of either corrosive contaminants or current leakage (electric erosion). • Whatever the cause, increased noise and vibration levels will result. Actions: • → Solution codes **39** and **41**. • → *Bearing damage and their causes*, starting on **page 288**.
41		**Raceways and/or rolling elements have (micro) spalls** During operation: • Current leakage (electric erosion) – current passing through the bearing – might result in craters at the surface. As they are very small, they can hardly be observed with the naked eye. The SKF Electrical discharge detector pen is a non-contact instrument that can help in establishing the presence of electrical discharge currents. Actions: • Magnify area from 500 × to 1 000 × to confirm the presence of craters. • → *Bearing damage and their causes*, starting on **page 288**.
		**Fluting of rolling surfaces** During operation: • Fluting of the raceways is secondary damage most commonly attributed to the passage of damaging electric current across the bearing. • In some rare cases, a washboard appearance can be the result of vibration during operation. • Current through the bearing can originate from grounding problems, frequency inverters, cabling, motor design and driven machinery. Actions: • Check that the equipment is grounded properly. • If proper grounding does not correct the problem, alternative solutions include INSOCOAT bearings (with an insulation coating), hybrid bearings (with ceramic rolling elements) or using an insulating sleeve in the housing bore. • → *Bearing damage and their causes*, starting on **page 288**.

Table 2 cont.

Trouble conditions and their solutions

Solution code		Condition / Practical solutions
42		**Lock washer tabs are bent, fouling the cage or bearing seals** Considerations during mounting or assembly: • Some lock washers have bent tabs that can foul the bearing cage or seals, generate noise and accelerate wear and damage. • Used lock washers can also have a damaged locking tab or anti-rotation tab that isn't apparent and may shear off later. Actions: • Never reuse washers (and nuts). • Note that KMFE lock nuts have a built-in spacer to avoid this kind of damage; alternatively, an intermediate ring can be positioned between the bearing and the lock nut.
43		**Shaft and/or housing shoulders are out-of-square with the bearing seat** Considerations about machined shoulders during mounting or assembly: • Out-of-square shaft/housing shoulders can distort the bearing rings, which will increase the frictional moment in the bearing and generate heat. • → Solution codes **19** and **20**. Action: • Machine parts to achieve correct perpendicularity.
44		**Shaft shoulder is too high and is fouling the seals/shields** Considerations about machined shoulders during assembly or operation: • If the shoulder is too high, it can foul the seals/shields. Actions: • Check that the shoulder diameter is in accordance with recommendations in the *SKF Interactive Engineering Catalogue*, available online at www.skf.com. • Machine the shaft shoulder to clear the seals/shields.