SKF
NJ 315 ECJ
100–16

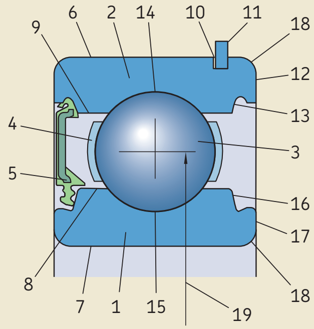
Basics

Terminology

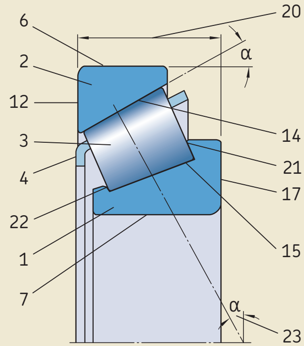
Bearings (→ fig. 1)

1 Inner ring
2 Outer ring
3 Rolling element: ball, cylindrical roller, needle roller, tapered roller, spherical roller, toroidal roller
4 Cage
5 Sealing device
Seal – made of elastomer, contact (shown in figure) or non-contact
Shield – made of sheet steel, non-contact
6 Outer ring outside diameter
7 Inner ring bore
8 Inner ring shoulder diameter
9 Outer ring shoulder diameter
10 Snap ring groove
11 Snap ring
12 Outer ring side face
13 Seal anchorage groove
14 Outer ring raceway
15 Inner ring raceway
16 Seal groove
17 Inner ring side face
18 Chamfer
19 Bearing mean diameter
20 Total bearing width
21 Guiding flange
22 Retaining flange
23 Contact angle
24 Shaft washer
25 Rolling element and cage assembly
26 Housing washer
27 Housing washer with sphered seat surface
28 Seat washer

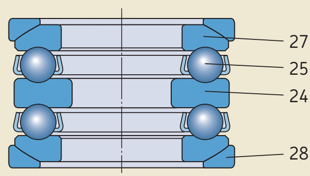
Fig. 1



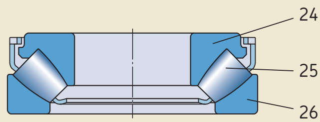
Deep groove ball bearing



Tapered roller bearing



Double direction thrust ball bearing



Spherical roller thrust bearing

Bearing arrangements (→ fig. 2)

1 Cylindrical roller bearing
2 Four-point contact ball bearing
3 Housing
4 Shaft
5 Shaft abutment shoulder
6 Shaft diameter
7 Locking plate
8 Radial shaft seal
9 Distance ring
10 Housing bore
11 Housing cover
12 Snap ring

Housings (→ fig. 3)

1 Housing cap
2 Housing base
3 Housing foot
4 Attachment bolt
5 Cap bolt
6 Dimple
7 Grease fitting
8 Hole for eye bolt

Seals (→ fig. 4)

1 Rubber shell
2 Sheet steel reinforcement
3 Seal lip
4 Auxiliary seal lip
5 Garter spring
6 Seal counterface

Fig. 2

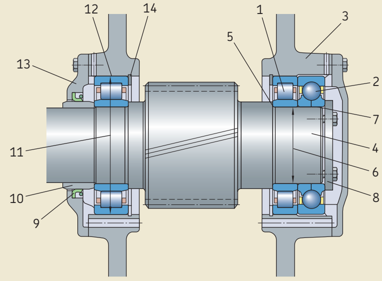
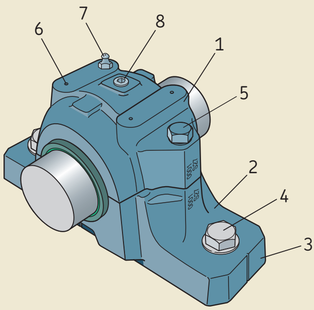
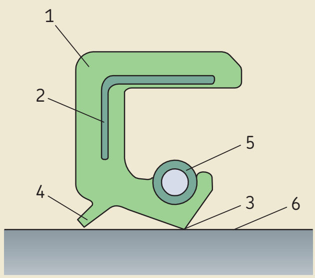


Fig. 3



SNL plummer (pillow) block housing

Fig. 4

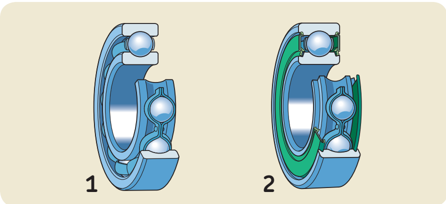


Radial shaft seal

Rolling bearing types and designs

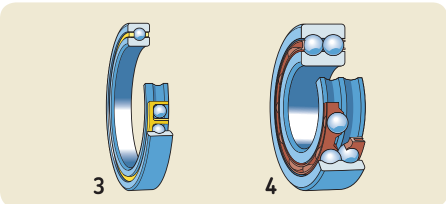
This section gives a summary of the different standard bearing types and designs. Most are illustrated.

Radial bearings



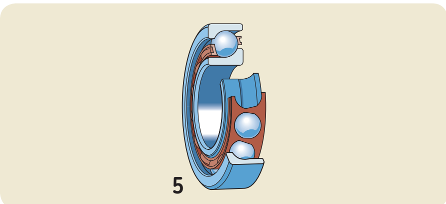
Deep groove ball bearings

single row, with or without filling slots
- open basic design (**1**)
- with shields
- with contact seals (**2**)
- with a snap ring groove, with or without a snap ring



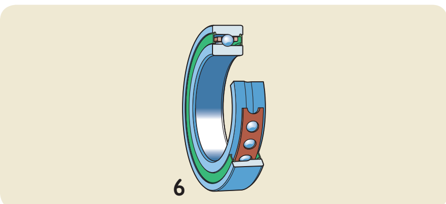
single row with a fixed section
- open basic design (**3**)
- with contact seals

double row (**4**)

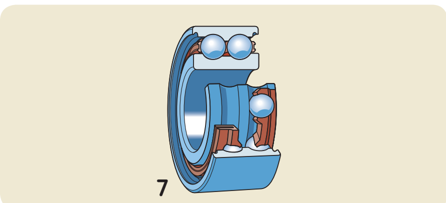


Angular contact ball bearings

single row
- basic design for single mounting
- design for universal matching (**5**)

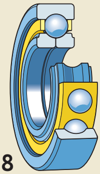


single row high- and super-precision
- open basic design
- with contact seals
- open high-speed design
- with contact seals (**6**)
- open high-capacity design
- with contact seals



double row
- with a one-piece inner ring (**7**)
  - open basic design
  - with shields
  - with contact seals
- with a two-piece inner ring

Radial bearings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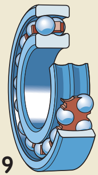
Four-point contact ball bearings (**8**)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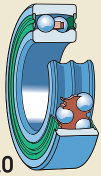
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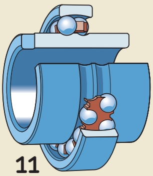
Self-aligning ball bearings

with a cylindrical or tapered bore
- open basic design (**9**)
- with contact seals (**10**)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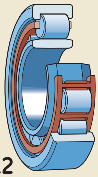
with an extended inner ring (**11**)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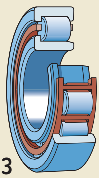
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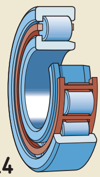
Cylindrical roller bearings

single row
- NU design (**12**)
  - with angle ring
- N design (**13**)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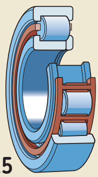
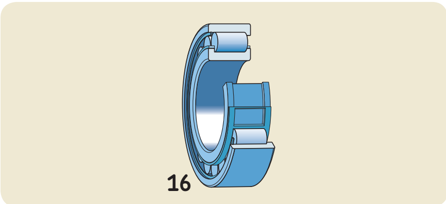

15

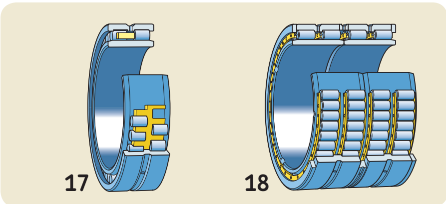
single row
- NJ design (**14**)
  - with angle ring
- NUP design (**15**)

Radial bearings

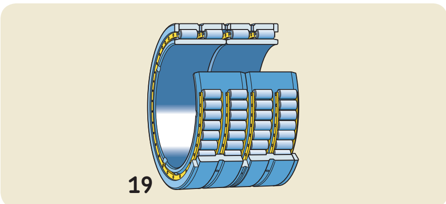


Cylindrical roller bearings

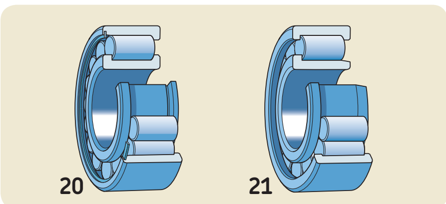
single row
- high-capacity NCF design (**16**)



double row
- with a cylindrical or tapered bore
  - NNU design (**17**)
  - NN design (**18**)
  - NNUP design

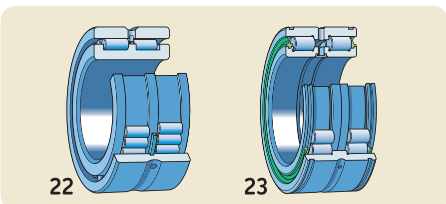


four-row
- with a cylindrical or tapered bore
  - open design (**19**)
  - with contact seals



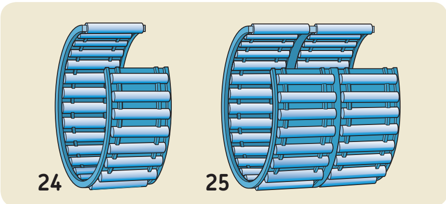
Full complement cylindrical roller bearings

single row
- NCF design (**20**)
- NJG design (**21**)



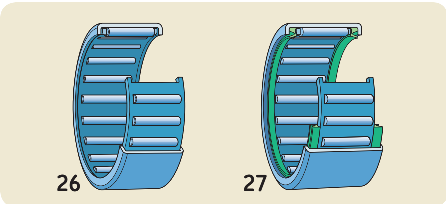
double row
- with integral flanges on the inner ring (**22**)
- with integral flanges on the inner and outer rings
- with contact seals (**23**)

Radial bearings



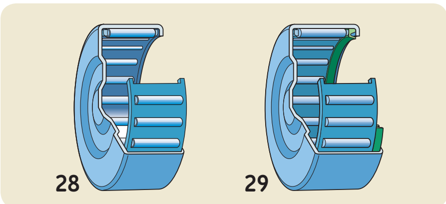
Needle roller and cage assemblies

single row (**24**)
double row (**25**)



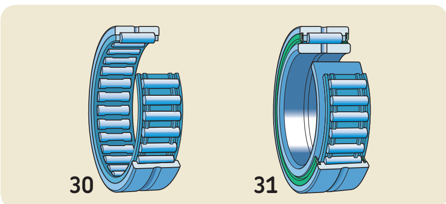
Drawn cup needle roller bearings, open ends

single and double row
- open basic design (**26**)
- with contact seals (**27**)



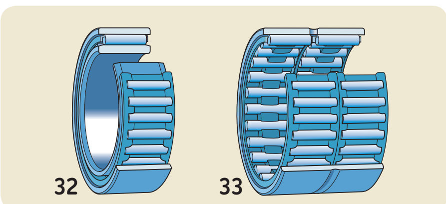
Drawn cup needle roller bearings, closed end

single and double row
- open basic design (**28**)
- with a contact seal (**29**)



Needle roller bearings with flanges

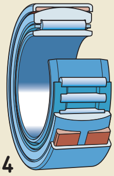
single and double row
- without an inner ring (**30**)
- with an inner ring
  - open basic design
  - with contact seals (**31**)



Needle roller bearings without flanges

single and double row
- with an inner ring (**32**)
- without an inner ring (**33**)

Radial bearings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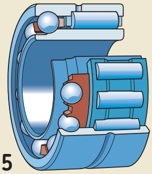
Alignment needle roller bearings

without an inner ring
with an inner ring (**34**)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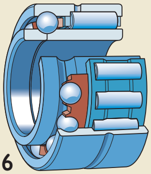
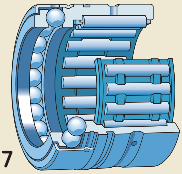

36

Combined needle roller bearings

Needle roller / angular contact ball bearings
single direction (**35**)
double direction (**36**)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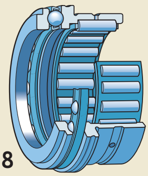
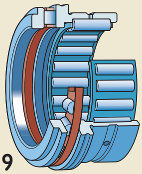

38

Needle roller / thrust ball bearings
with a full complement thrust ball bearing (**37**)
with a cage-guided ball set
with or without (**38**) a cover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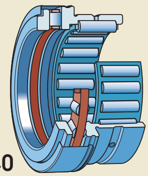
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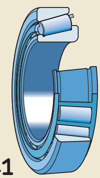
Needle roller / cylindrical roller thrust bearings
without a cover (**39**)
with a cover (**40**)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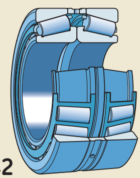
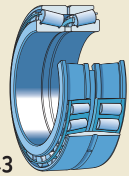

42

Tapered roller bearings

single row
single bearings (**41**)
matched bearing sets
face-to-face (**42**)
back-to-back
tandem

Radial bearings



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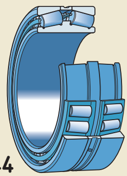
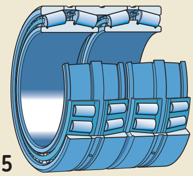


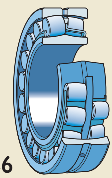
44

double row
- TDO configuration (back-to-back) (**43**)
- TDI configuration (face-to-face) (**44**)



45

four-row
- open design
- with contact seals
  - TQO configuration (**45**)
  - TQI configuration



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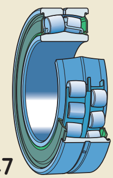
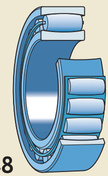


47

Spherical roller bearings

with a cylindrical or tapered bore
- open basic designs (**46**)
- with contact seals (**47**)



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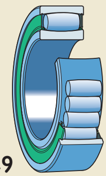

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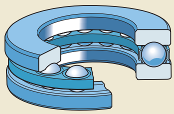
CARB toroidal roller bearings

with a cylindrical or tapered bore
- open basic designs
  - with a cage-guided roller set (**48**)
  - with a full complement roller set
    - with contact seals (**49**)

Thrust bearings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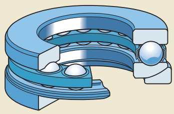
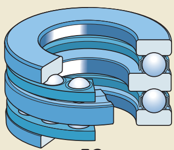

51

Thrust ball bearings

single direction
- with a flat housing washer (**50**)
- with a sphered housing washer
  - with (**51**) or without a seat washer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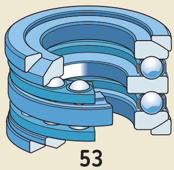
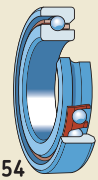

53

double direction
- with flat housing washers (**52**)
- with sphered housing washers
  - with (**53**) or without seat washers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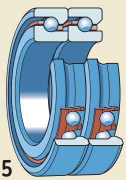
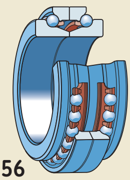

55

Angular contact thrust ball bearings

high- and super-precision bearings
- single direction
  - basic design for single mounting (**54**)
  - design for universal matching
  - matched bearing sets (**55**)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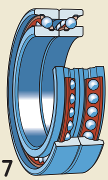
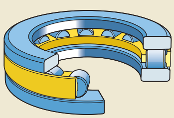

57

- double direction
  - basic design (**56**)
  - high-speed design (**57**)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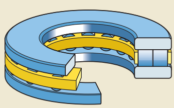
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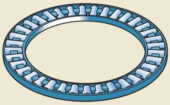
Cylindrical roller thrust bearings

single direction
- single row (**58**)
- double row (**59**)

components
- cylindrical roller and cage thrust assemblies
- shaft and housing washers

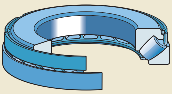
Thrust bearings



60

Needle roller thrust bearings

single direction
- needle roller and cage thrust assemblies (**60**)
- raceway washers
- thrust washers



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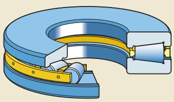
Spherical roller thrust bearings

single direction (**61**)



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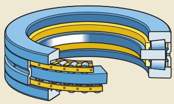


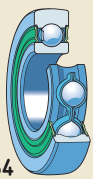
63

Tapered roller thrust bearings

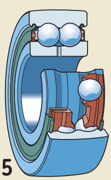
single direction
- with or without (**62**) a cover
- screw down bearings

double direction (**63**)

Track runner bearings



64

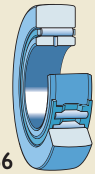


65

Cam rollers

single row ball bearing cam roller (**64**)
double row ball bearing cam roller (**65**)

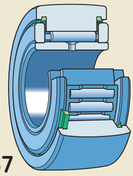
Track runner bearings



66

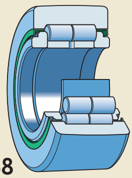
Support rollers

with a needle roller and cage assembly, without axial guidance
- with or without contact seals
  - without an inner ring
  - with an inner ring (**66**)

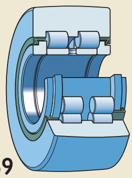


67

with needle rollers, with thrust washers for axial guidance
- with or without contact seals
  - with a needle roller and cage assembly (**67**)
  - with a full complement of needle rollers

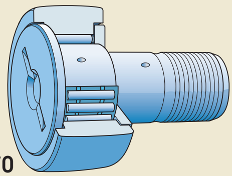


68



69

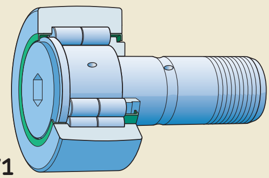
with a full complement of cylindrical rollers, axially guided by flanges
- with labyrinth seals (**68**)
- with contact seals (**69**)
- with lamellar seals



70

Cam followers

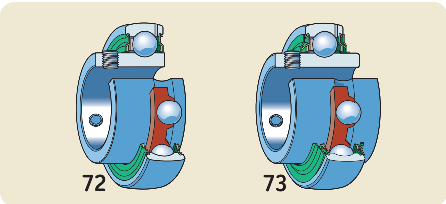
with needle rollers, axially guided by the stud, thrust plate and roller flanges
- with or without contact seals
  - with a concentric seat (**70**)
  - with an eccentric seat collar
  - with a needle roller and cage assembly (**70**)
  - with a full complement of needle rollers



71

with a full complement of cylindrical rollers, axially guided by the stud, flange ring and roller flanges
- with labyrinth seals (**71**)
- with contact seals
- with a concentric seat (**71**)
- with an eccentric seat collar

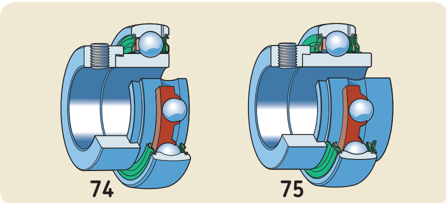
Y-bearings



72 73

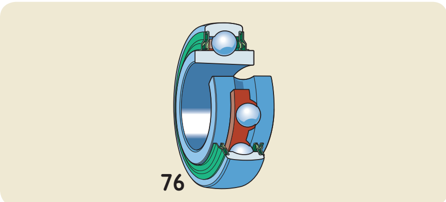
Y-bearings (insert bearings)

with grub (set) screws
- inner ring extended on one side (**72**)
- inner ring extended on both sides (**73**)



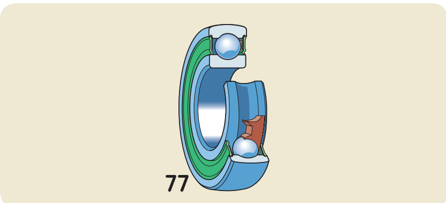
74 75

with an eccentric locking collar
- inner ring extended on one side (**74**)
- inner ring extended on both sides (**75**)



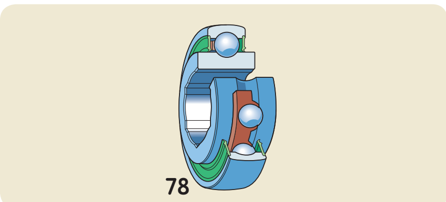
76

with a tapered bore
- inner ring extended on both sides (**76**)
- for adapter sleeve mounting



77

with a standard inner ring
- located on the shaft with an interference fit (**77**)



78

with a hexagonal bore (**78**)

Designation system for rolling bearings

Basic designations

All SKF standard bearings have a characteristic basic designation, which generally consists of three, four or five figures or a combination of letters and figures. The design of the system used for almost all standard ball and roller bearing types is shown schematically in **diagram 1**. The figures and combinations of letters and figures have the following meaning:

- The first figure or the first letter or combination of letters identifies the bearing type and eventually a basic variant.
- The following two figures identify the ISO dimension series; the first figure indicates the width or height series (dimensions B, T or H) and the second the diameter series (dimension D).
- The last two figures of the basic designation give the size code of the bearing; when multiplied by 5, the bore diameter in millimetres is obtained.

The most important exceptions to the basic bearing designation system are listed here.

1 In a few cases, the figure for the bearing type or the first figure of the dimension series identification is omitted. These figures are shown in brackets in **diagram 1**.

2 Bearings with bore diameters of 10, 12, 15 or 17 mm have the following size code identifications:
00 = 10 mm
01 = 12 mm
02 = 15 mm
03 = 17 mm

3 For bearings having a bore diameter smaller than 10 mm, or 500 mm and larger, the bore diameter is generally given in millimetres and is not coded. The size identification is separated from the rest of the bearing designation by an oblique stroke, e.g. 618/8 (d = 8 mm) or 511/530 (d = 530 mm). This is also true of standard bearings in accordance with ISO 15:1998 that have bore diameters of 22, 28 or 32 mm, e.g. 62/22 (d = 22 mm).

4 For some small bearings having a bore diameter smaller than 10 mm, such as deep groove, self-aligning and angular contact ball bearings, the bore diameter is also given in millimetres (uncoded) but is not separated from the series designation by an oblique stroke, e.g. 629, 129 or 709 (d = 9 mm).

5 Bore diameters that deviate from standard bore diameters are uncoded and given in millimetres up to three decimal places. This bore diameter identification is part of the basic designation and is separated from the basic designation by an oblique stroke, e.g. 6202/15.875 (6202 bearing with a special bore d = 15,875 mm = 5/8 in.).

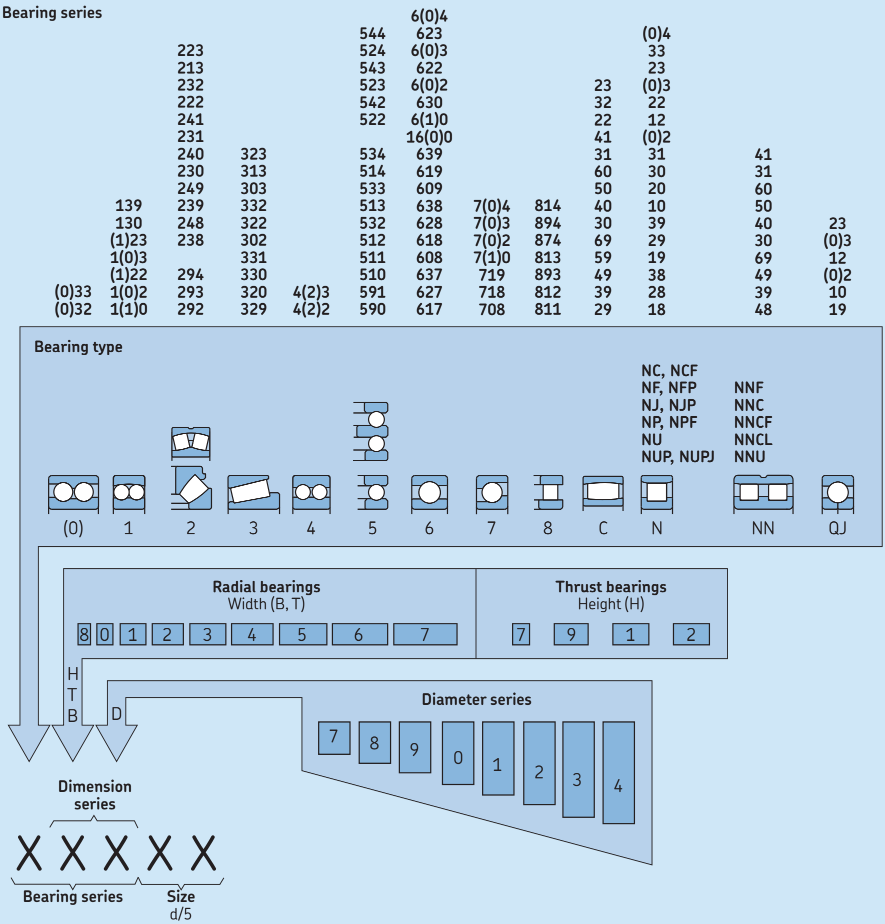
Series designations

Each standard bearing belongs to a given bearing series, which is identified by the basic designation without the size identification. Series designations often include a suffix A, B, C, D or E or a combination of these letters, e.g. CA. These are used to identify differences in internal design, e.g. contact angle.

The most common bearing series designations are shown in **diagram 1**, above the bearing sketches. The figures in brackets are omitted in the series designation.

Diagram 2

Designation system for SKF standard metric ball and roller bearings



Code	Bearing type
0	Double row angular contact ball bearing
1	Self-aligning ball bearing
2	Spherical roller bearings, spherical roller thrust bearing
3	Tapered roller bearing
4	Double row deep groove ball bearing
5	Thrust ball bearing
6	Single row deep groove ball bearing

Code	Bearing type
7	Single row angular contact ball bearing
8	Cylindrical roller thrust bearing
C	CARB toroidal roller bearing
N	Cylindrical roller bearing. Two or more letters are used to identify the number of the rows or the configuration of the flanges, e.g. NJ, NU, NUP, NN, NNU, NNCF etc.

Code	Bearing type
QJ	Four-point contact ball bearing
T	Tapered roller bearing in accordance with ISO 355-2007

Designation suffixes

Designation suffixes are used to identify designs, variants or features that differ from the original or current standard bearing. Some of the most commonly used designation suffixes are listed here.

CN Normal internal clearance, normally only used together with an additional letter that identifies a reduced or displaced clearance range
CS Sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR) on one side of the bearing
2CS CS contact seal on both sides of the bearing
CS2 Sheet steel reinforced contact seal of fluoro rubber (FKM) on one side of the bearing
2CS2 CS2 contact seal on both sides of the bearing
CS5 Sheet steel reinforced contact seal of hydrogenated acrylonitrile-butadiene rubber (HNBR) on one side of the bearing
2CS5 CS5 contact seal on both sides of the bearing
C1 Bearing internal clearance smaller than C2
C2 Bearing internal clearance smaller than Normal (CN)
C3 Bearing internal clearance greater than Normal (CN)
C4 Bearing internal clearance greater than C3
C5 Bearing internal clearance greater than C4
F Machined steel or special cast iron cage, rolling element centred
FA Machined steel or special cast iron cage, outer ring centred
FB Machined steel or special cast iron cage, inner ring centred
G.. Grease fill. A second letter indicates the temperature range of the grease and a third letter identifies the actual grease. A figure following the three-letter grease code indicates that the filling degree deviates from the standard: Figures 1, 2 and 3 indicate a smaller fill than standard, 4 up to 9 a larger fill.
H Pressed snap-type steel cage, hardened
HT Grease fill for high temperatures. HT or a two-digit number following HT identifies the actual grease. Filling degrees other than standard are identified by a letter or letter/figure combination following HTxx.
J Pressed steel cage, rolling element centred, unhardened
K Tapered bore, taper 1:12
K30 Tapered bore, taper 1:30
LHT Grease fill for low and high temperatures. LHT or a two-digit number following LHT identifies the actual grease. Filling degrees other than standard are identified by a letter or letter/figure combination following LHTxx.
LS Contact seal of acrylonitrile-butadiene rubber (NBR) or polyurethane (AU) with or without sheet steel reinforcement, on one side of the bearing
2LS LS contact seal on both sides of the bearing
LT Grease fill for low temperatures. LT or a two-digit number following LT identifies the actual grease. Filling degrees other than standard are identified by a letter or letter/figure combination following LTxx.
M Machined brass cage, rolling element centred
MA Machined brass cage, outer ring centred
MB Machined brass cage, inner ring centred
ML Machined one-piece window-type brass cage, inner or outer ring centred
MT Grease fill for medium temperatures. MT or a two-digit number following MT identifies the actual grease. Filling degrees other than standard are identified by a letter or letter/figure combination following MTxx.
N Snap ring groove in the outer ring
NR Snap ring groove in the outer ring with the appropriate snap ring
P Injection moulded cage of glass fibre reinforced polyamide 66, rolling element centred
PHA Injection moulded cage of glass fibre reinforced polyetheretherketone (PEEK), outer ring centred
RS Contact seal of acrylonitrile-butadiene rubber (NBR) with or without sheet steel reinforcement on one side of the bearing

2RS RS contact seal on both sides of the bearing
RSH Sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR) on one side of the bearing
2RSH RSH contact seal on both sides of the bearing
RSL Sheet steel reinforced low-friction contact seal of acrylonitrile-butadiene rubber (NBR) on one side of the bearing
2RSL RSL low-friction contact seal on both sides of the bearing
RS1 Sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR) on one side of the bearing
2RS1 RS1 contact seal on both sides of the bearing
RS1Z Sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR) on one side and one shield on the other side of the bearing
RS2 Sheet steel reinforced contact seal of fluoro rubber (FKM) on one side of the bearing
2RS2 RS2 contact seal on both sides of the bearing
RZ Sheet steel reinforced non-contact seal of acrylonitrile-butadiene rubber (NBR) on one side of the bearing
2RZ RZ non-contact seal on both sides of the bearing
TN Injection moulded cage of polyamide 66, rolling element centred
TNH Injection moulded cage of glass fibre reinforced polyetheretherketone (PEEK), rolling element centred
TN9 Injection moulded cage of glass fibre reinforced polyamide 66, rolling element centred
V Full complement bearing (without cage)
WT Grease fill for low as well as high temperatures. WT or a two-digit number following WT identifies the actual grease. Filling degrees other than standard are identified by a letter or letter/figure combination following WTxx.
W64 Solid Oil filling
Y Pressed brass cage, rolling element centred
Z Shield of pressed sheet steel on one side of the bearing
2Z Z shield on both sides of the bearing

Identifying SKF products

Bearing identification

NOTE: To be sure you are buying a genuine SKF bearing, purchase only from SKF or SKF Authorized Distributors.

Almost all SKF bearings are marked with the following identifiers on the inner or outer ring side faces (→ **fig. 5**):

1 SKF trademark
2 Complete bearing designation
3 Date of manufacture, coded
4 Country of manufacture

The type of bearing and its features can be identified from its designation. Other identifiers, depending on the bearing type, may also be present on the bearing.

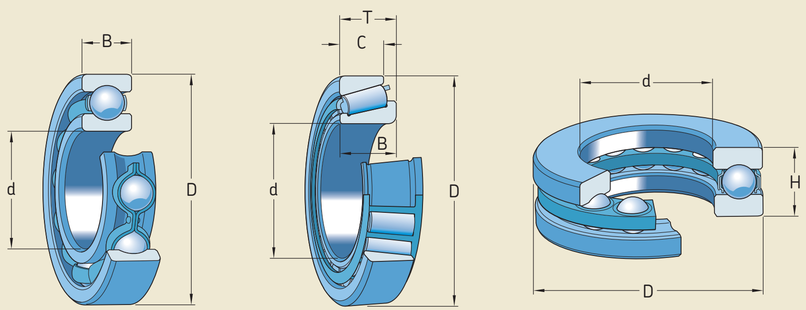
NOTE: Sometimes, only part of the information is found on one ring. For example, the outer ring of a cylindrical roller bearing with roller and cage assembly might have the identification 3NU20. This identifies an outer ring of diameter series 3 for a 100 mm bore (20 × 5). This outer ring can be matched with a NU, NJ or NUP inner ring to form a complete bearing. In this case, the complete bearing designation should be found on the inner ring, e.g. NJ 320 ECP/C3. The complete designation is always printed on the package and is most often obtainable from machine drawings and equipment specifications.

Fig. 5

If the designation marked on the bearing is no longer legible, the basic bearing designation can generally be identified by measuring the boundary dimensions (→ **fig. 6**) and using the *SKF Interactive Engineering Catalogue*, available online at www.skf.com.

1 Identify the bearing type (→ *Rolling bearing types and designs*, **page 12**).
2 Measure the bore d of the bearing.
3 Measure the outside diameter D of the bearing.
4 Measure the widths B, C, T or height H of the bearing.

Fig. 6



Radial ball bearing

Radial roller bearing

Thrust ball bearing

5 Using the Detailed search functionality of the *SKF Interactive Engineering Catalogue*, enter the boundary dimensions, to identify the possible basic bearing designation.

NOTE: To determine the complete bearing designation, identify the cage type and material, the design of the seal, and any other visible features. For additional support, contact your SKF Authorized Distributor or the SKF Application engineering service.

Split housing and bearing unit identification

All SNL, SONL and SAF split plummer (pillow) block housings have their designations cast into the housing cap (→ **fig. 7**). The cap and base of each housing are marked with a unique serial number to prevent mixing components when mounting several housings in one session.

For bearing units, identify the bearing and housing (and other components where applicable) separately.

Replacement seals

Replacement seals should correspond in design and material to the original. Seals made of a different material than the original should only be used if absolutely necessary.

CAUTION: When replacing a seal, check the old seal's part number carefully. A simple error, like using a standard nitrile rubber seal to replace an identical, more resistant fluoro rubber seal, can result in sudden "mysterious" seal failure.

Bearing life

Basic rating life

The life of a rolling bearing is defined as the number of revolutions or the number of operating hours at a given speed that the bearing can endure before the first sign of fatigue occurs on one of its rings or rolling elements. This life can be calculated as a function of the bearing type, load and speed, using the basic rating life equation

Fig. 7

$$L_{10} = \left(\frac{C}{P}\right)^p$$

or, if the speed is constant

$$L_{10h} = \frac{10^6}{60\,n}\,L_{10}$$

where

L_{10} = basic rating life (at 90% reliability [millions of revolutions]

L_{10h} = basic rating life (at 90% reliability [operating hours]

C = basic dynamic load rating [kN]

P = equivalent dynamic bearing load [kN]

n = rotational speed [r/min]

p = exponent of the life equation
= 3 for ball bearings
= $10/3$ for roller bearings

SKF rating life

For modern high quality bearings, the basic rating life can deviate significantly from the actual service life in a given application. Therefore, ISO 281: 2007 contains a modified life equation to supplement the basic rating life.

The equation for SKF rating life is

$$L_{nm} = a_1\, a_{SKF}\, L_{10} = a_1\, a_{SKF} \left(\frac{C}{P}\right)^p$$

or, if the speed is constant

$$L_{nmh} = \frac{10^6}{60\, n} L_{nm}$$

where
L_{nm} = SKF rating life (at 100 – n[1] % reliability) [millions of revolutions]
L_{nmh} = SKF rating life (at 100 – n[1] % reliability) [operating hours]
L_{10} = basic rating life (at 90% reliability) [millions of revolutions]
a_1 = life adjustment factor for reliability
a_{SKF} = SKF life modification factor
C = basic dynamic load rating [kN]
P = equivalent dynamic bearing load [kN]
n = rotational speed [r/min]
p = exponent of the life equation
= 3 for ball bearings
= $^{10}/_3$ for roller bearings

For additional information about how to calculate SKF rating life, refer to the *SKF Interactive Engineering Catalogue*, available online at www.skf.com.

Service life

Bearing service life

When calculating basic bearing life, the result can deviate significantly from the service life in a given application. Service life, which is the actual life of a bearing under real operating conditions until it fails (becomes unserviceable), depends on a variety of influencing factors including lubrication, the level of contamination within the bearing environment, misalignment, proper installation, and operating conditions such as loads, speed, temperature, and vibration levels. To take these influencing factors into account, SKF strongly recommends calculating the SKF rating life, and not just the basic rating life.

Seal service life

Seals are used to keep lubricant in and contaminants out of the bearing. In doing so, seals also protect the lubricant from contaminants, which ultimately helps the bearing achieve maximum service life.

Unlike bearings, seal life cannot be calculated. Seal service life is even harder to predict because it is almost entirely dependent on the operating conditions, as well as the level of contamination within the environment, shaft alignment, installation procedures and exposure to harsh chemicals like cleaning agents.

Lubricant service life

In virtually every application, the lubricant has a significant impact on bearing service life. Therefore, all lubricants should be matched to the operating conditions of the application. Whether a bearing in an arrangement is lubricated with grease or oil, the effectiveness of the lubricant will deteriorate over time due to mechanical working, ageing, and the build-up of contaminants resulting from component wear and/or ingress of contaminants. As a result, the actual service life of a lubricant is difficult to predict. However, SKF provides guidelines for relubrication intervals and maintenance procedures later in this publication.

Cleanliness

Contamination can adversely affect bearing and seal service life. It also can have a negative influence on the service life of the lubricant. Therefore, it is important that rolling bearings are lubricated with clean grease or oil and that the lubricant is fully protected from contaminants by an effective sealing system.

Cleanliness should be observed during all maintenance activities from mounting and relubrication to inspection and dismounting. Detailed recommendations regarding cleanliness are provided later in the relevant chapters, but some general guidelines are provided here:

[1] The factor n represents the failure probability, i.e. the difference between the requisite reliability and 100%.

- Keep bearings in their original package, where they are well protected, until immediately before mounting.
- Mount bearings in an area that is free from dirt, dust and moisture.
- Use professional tools for all maintenance activities.
- Clean up grease and oil spills immediately.
- Clean grease fittings prior to relubrication and close them properly with a suitable grease fitting cap.
- Use properly identified and clean containers to transport and supply lubricant. The use of a separate container for each type of lubricant is a good practice and strongly advised.
- For routine washdowns, direct the hose away from the seals.

NOTE: It is better to prevent bearings from becoming dirty than to clean them. Many bearing types cannot be separated and are therefore difficult to clean.

Bearing internal clearance

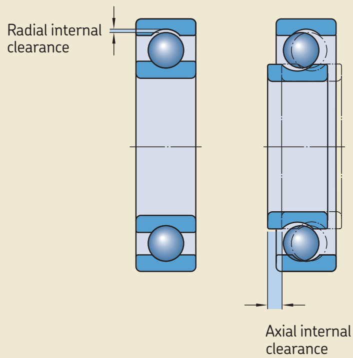
Bearing internal clearance is defined as the total distance through which one bearing ring can be moved relative to the other (→ **fig. 8**):

- in the radial direction (radial internal clearance)
- in the axial direction (axial internal clearance)

It is necessary to distinguish between the internal clearance of a bearing before mounting (→ **Appendix E**, starting on **page 388**) and the internal clearance in a mounted bearing that has reached its operating temperature (operational clearance). The initial internal clearance (before mounting) is greater than the operational clearance because different degrees of interference in the fits and differences in thermal expansion of the bearing rings and the associated components cause the rings to be expanded or compressed.

The radial internal clearance of a bearing is of considerable importance to achieve satisfactory operation. As a general rule:

Fig. 8



- Ball bearings should always have an operational clearance that is virtually zero, or there may be a slight preload.
- Cylindrical, spherical and CARB toroidal roller bearings should always have some residual clearance during operation.
- Tapered roller bearings should always have some residual clearance, except in bearing arrangements where stiffness is desired, such as pinon bearing arrangements where the bearings are mounted with a certain amount of preload.

NOTE: Where operating and mounting conditions differ from the normal, e.g. where interference fits are used for both bearing rings or unusual temperatures prevail, bearings with greater or smaller internal clearance than Normal may be required. In these cases, SKF recommends checking residual clearance in the bearing after it has been mounted.

Bearing arrangements

Generally, two bearings are required to support a rotating machine component, with the typical arrangement comprising one locating and one non-locating bearing position. In some applications, both bearings share the responsibility to locate the shaft axially. These are called adjusted or cross-located bearing arrangements.

Types of bearing arrangements

Locating and non-locating bearing arrangements

Arrangements with a locating and non-locating bearing are most common (→ **fig. 9**).

The bearing in the locating position, which is typically positioned at the drive end of a machine, supports the shaft radially and locates it axially in both directions. It must, therefore, be fixed in position both on the shaft and in the housing. Suitable bearing types for the locating position include:

- deep groove ball bearings (→ **fig. 9**)
- self-aligning ball bearings
- spherical roller bearings (→ **fig. 10**, left)
- double row or paired single row angular contact ball bearings
- matched tapered roller bearings
- cylindrical roller bearings (NJ and HJ, and NUP design bearings)

Combinations of a radial bearing that can accommodate a purely radial load and a bearing that takes the thrust load can also be used, e.g. an NU design cylindrical roller bearing and a four-point contact ball bearing (→ **fig. 11**).

The bearing in the non-locating position provides radial support and if needed, accommodates axial displacement of the shaft, relative to the housing, as a result of thermal expansion. Some bearings can take axial displacement within the bearing. Typical bearing types with this capability include:

- CARB toroidal roller bearings
- cylindrical roller bearings with flanges on one ring only, i.e. N and NU design bearings

For other bearings in the non-locating position, axial displacement takes place between one of

Fig. 9

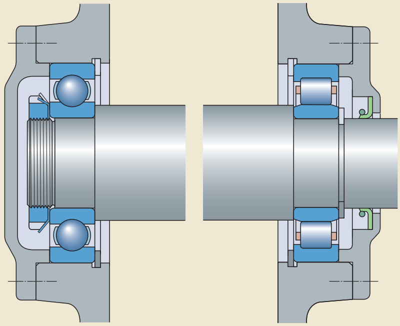


Fig. 10

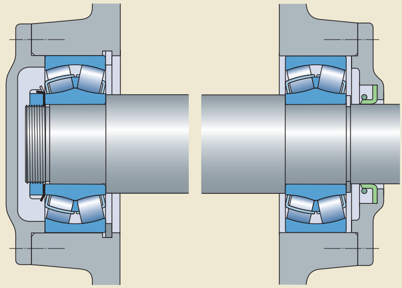
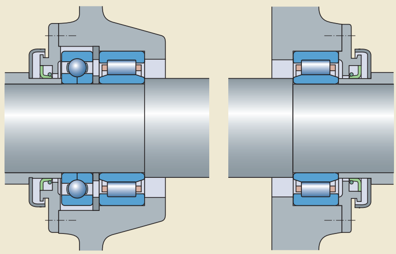


Fig. 11



the bearing rings and its seat, typically between the outer ring and the housing bore. Suitable bearing types for the non-locating position include:

- deep groove ball bearings
- self-aligning ball bearings
- spherical roller bearings (→ **fig. 10**, right)

Adjusted bearing arrangements

In an adjusted bearing arrangement, the shaft is located axially in one direction by one bearing and in the opposite direction by the other bearing. This arrangement, also referred to as cross-locating, is generally used for short shafts. All kinds of radial ball and roller bearings that accommodate axial loads in at least one direction are suitable for cross-locating bearing arrangements, including:

- deep groove ball bearings
- angular contact ball bearings (→ **fig. 12**)
- tapered roller bearings

Fig. 12

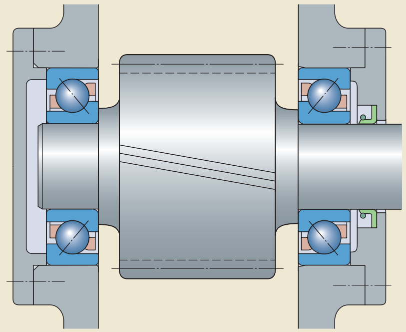
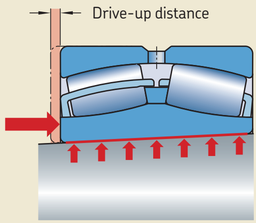


Fig. 13



Methods of bearing location

Radial location of bearings

If the load carrying ability of a bearing is to be fully utilized, its rings or washers must be fully supported around their complete circumference and across the entire width of the raceway.

Generally, satisfactory radial location and adequate support can only be obtained when the rings are mounted with an appropriate degree of interference. Inadequately or incorrectly secured bearing rings generally cause damage to the bearings and associated components. In cases where an interference fit cannot be used and a loose fit is to be applied, special precautions are necessary to limit bearing creep, otherwise a worn bearing seat on the shaft or in the housing may result.

NOTE: Creep is the relative movement between a bearing ring and its seat, and typically occurs when there is an insufficient interference fit for the load conditions or when an interference fit cannot be applied.

Selection of fit

Bearings with a cylindrical bore

When selecting fits for bearings with a cylindrical bore, the first thing to consider is the conditions of rotation (→ **table 1**). Essentially, there are three different conditions:

- Rotating load refers to a bearing ring that rotates while the direction of the applied load is stationary. (A rotating load can also refer to a bearing ring that is stationary, and the direction of the applied load rotates.)
- Stationary load refers to a bearing ring that is stationary while the direction of the applied load is also stationary. (A stationary load can also refer to a bearing ring that rotates at the same speed as the load.)
- Direction of load indeterminate refers to variable external loads, shock loads, vibrations and unbalance loads in high-speed machines.

Other factors to be taken into consideration when selecting fits are listed in **table 2**, on **pages 33** and **34**.

Bearings with a tapered bore

Bearings with a tapered bore are mounted either directly on a tapered shaft seat, or with an adapter or withdrawal sleeve on a cylindrical shaft seat. The inner ring fit is determined by how far the ring is driven up on the shaft seat or sleeve (→ **fig. 13**, **page 31**).

Table 1

Conditions of rotation and loading

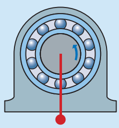
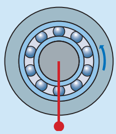
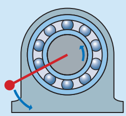
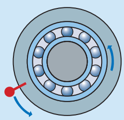
Operating conditions	Schematic illustration	Load condition	Example	Recommended fits
Rotating inner ring Stationary outer ring Constant load direction		Rotating load on inner ring Stationary load on outer ring	Belt-driven shafts	Interference fit for inner ring Loose fit for outer ring
Stationary inner ring Rotating outer ring Constant load direction		Stationary load on inner ring Rotating load on outer ring	Conveyor idlers Car wheel hub bearings	Loose fit for inner ring Interference fit for outer ring
Rotating inner ring Stationary outer ring Load rotates with inner ring		Stationary load on inner ring Rotating load on outer ring	Vibratory applications Vibrating screens or motors	Interference fit for outer ring Loose fit for inner ring
Stationary inner ring Rotating outer ring Load rotates with outer ring		Rotating load on inner ring Stationary load on outer ring	Gyratory crusher (Merry-go-round drives)	Interference fit for inner ring Loose fit for outer ring

Table 2

Factors to consider when selecting fits

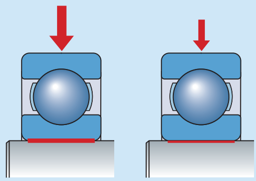
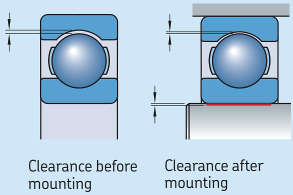
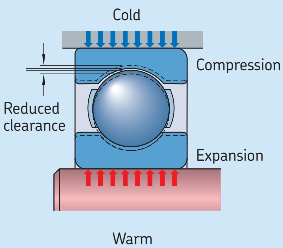
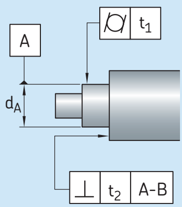
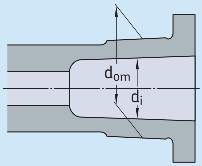
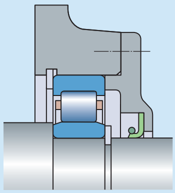
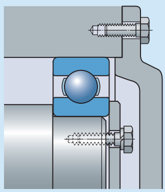
Factors		Situation	Guideline rules
Magnitude of load		Bearings subjected to heavy loads tend to creep more than those subjected to light loads.	To prevent creep, select greater interference fits for bearings subjected to heavier loads. Shock loads should also be considered. Magnitude of load is defined as: • $P \leq 0,05\ C$ – light load • $0,05\ C < P \leq 0,1\ C$ – normal load • $0,1\ C < P \leq 0,15\ C$ – heavy load • $P > 0,15\ C$ – very heavy load
Bearing internal clearance		The tighter the interference fit, the bigger the reduction in the initial bearing internal clearance after mounting.	When tight fits are applied, bearings with radial internal clearance greater than Normal may be required.
Temperature differences		The outer ring often has a lower temperature than the inner ring during operation, resulting in reduced internal clearance.	Depending on the (expected) operating temperatures of the components, bearings with radial internal clearance greater than Normal may be required.
Running accuracy requirements		Bearings with clearance fits are susceptible to vibration when high demands are placed on running accuracy.	When high demands are placed on running accuracy, select fits corresponding to at least tolerance grade IT5 for the shaft and at least tolerance grade IT6 for the housing. To reduce runout and vibration, select interference fits.

Table 2 cont.

Factors to consider when selecting fits

Factors		Situation	Guideline rules
Design and material of shaft and housing		Fits might be less effective for hollow shafts or thin-walled housings. Poor contact on the bearing seat, e.g. in split housings, can distort the bearing ring, causing it to become out-of round. The material of the bearing seat, if not made from bearing steel, will affect the fit selection, due to the different coefficients of thermal expansion.	Select heavier than normal interference fits for bearings mounted in thin-walled or light-alloy housings, or on hollow shafts. Split housings are not suitable for heavy interference fits. For these housings, SKF recommends tolerance group G or H (or at most, K).
Ease of mounting and dismounting		Mounting and dismounting is easier for bearings with a clearance fit than for bearings with an interference fit.	If an interference fit is needed and easy mounting and dismounting is essential, select separable bearings or bearings with a tapered bore. Bearings with a tapered bore can be mounted either directly on a tapered shaft seat or on an adapter or withdrawal sleeve on a cylindrical shaft seat.
Displacement of the bearing in the non-locating position		Some bearings can accommodate axial displacement within the bearing, such as cylindrical roller bearings having one ring without flanges, needle roller bearings or CARB toroidal roller bearings.	Bearings that cannot accommodate axial displacement within the bearing should have one ring free, i.e. select a clearance fit for the ring carrying the stationary load.

Recommended fits and tolerances

The tolerances for the bore and outside diameter of rolling bearings are internationally standardized. To achieve a suitable fit, only a limited number of ISO tolerance classes need to be considered for the shaft and housing seats for rolling bearing applications. The location of the most commonly used tolerance classes relative to the bearing bore and outside diameter tolerances are illustrated in **fig. 14**.

NOTE: A letter and figure designate each ISO tolerance class. The letter (lower case for shaft diameters and upper case for housing bores) locates the tolerance zone relative to the nominal dimension. The figure provides the size of the tolerance zone.

Recommendations for bearing fits for solid steel shafts and for cast iron and steel housings are provided in **Appendix A**, starting on **page 334**. The appropriate values for the tolerances for rolling bearing seats on shafts and in housings are provided in **Appendix B**, starting on **page 338**.

If bearings are to be mounted with an interference fit on a hollow shaft, it is generally necessary to use a heavier interference fit than would be used for a solid shaft, in order to achieve the same surface pressure between the inner ring and shaft seat. For additional information, refer to the *SKF Interactive Engineering Catalogue*, available online at www.skf.com.

Dimensional, form and running accuracy requirements

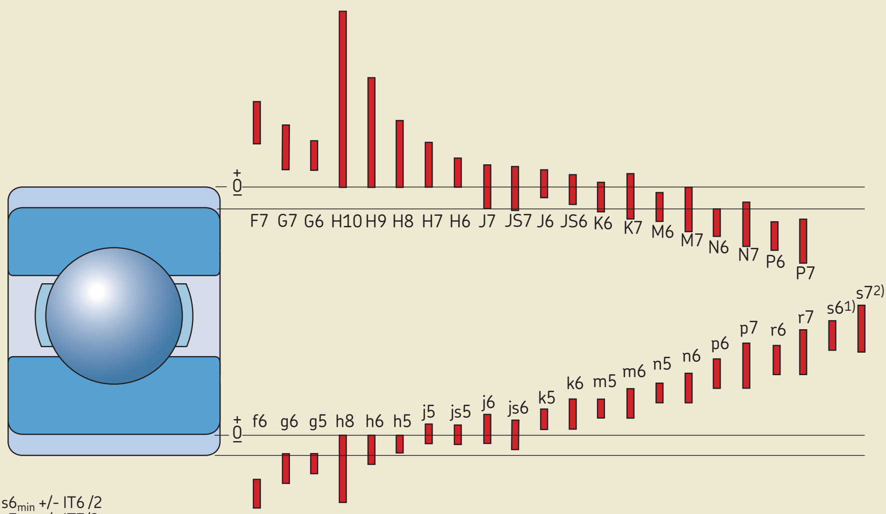
The accuracy of cylindrical bearing seats on shafts and in housing bores should correspond to the accuracy of the bearings used. SKF recommends the following guidelines for form and running accuracy when machining seats and abutments.

Dimensional accuracy

For bearings made to Normal tolerances, the dimensional accuracy of cylindrical seats on the shaft should be at least tolerance grade IT6. The dimensional accuracy of the housing should be at least tolerance grade IT7. Where adapter or withdrawal sleeves are used, a wider diameter tolerance (tolerance grade IT9) can be permitted than for bearing seats (→ **Appendix B-7**, **page 384**). The numerical values of standard tolerance grades IT are provided in **Appendix C**, on **page 385**.

For bearings with higher accuracy, correspondingly better grades should be used.

Fig. 14



1) $s6_{min}$ +/- IT6/2
2) $s7_{min}$ +/- IT7/2

Tolerances for cylindrical form

The cylindricity tolerance t_1 of a bearing seat should be one to two IT tolerance grades better than the prescribed dimensional tolerance, depending on the requirements. For example, if a bearing seat on a shaft has been machined to tolerance class m6, then the accuracy of form should be tolerance grade IT5 or IT4. The tolerance value t_1 for cylindricity is obtained for an assumed shaft diameter of 150 mm from t_1 = IT5/2 = 18/2 = 9 µm. However, the tolerance t_1 is for a radius, therefore 2 × t_1 applies for the shaft diameter.

Guideline values for the cylindrical form tolerance t_1 (and the total runout tolerance t_3) for bearing seats are provided in **Appendix D-1**, on **page 386**.

When bearings are to be mounted on adapter or withdrawal sleeves, the cylindricity of the sleeve seat be tolerance grade IT5/2 (for tolerance class h9) (→ **Appendix B-7**, **page 384**).

Tolerance for perpendicularity

Abutments for bearing rings should have a perpendicularity tolerance that is better by at least one IT tolerance grade than the diameter tolerance of the associated cylindrical seat. For thrust bearing washer seats, the perpendicularity tolerance should not exceed tolerance grade IT5.

Guideline values for the perpendicularity tolerance t_2 (and for the total axial runout t_4) are provided in **Appendix D-1**, on **page 386**.

Surface roughness of bearing seats

The roughness of bearing seat surfaces does not have the same degree of influence on bearing performance as the dimensional, form and running accuracies. However, the smoothness of the mating surfaces will have a direct effect on the accuracy of the interference fit. For bearing arrangements where a high level of accuracy is required, guideline values for the mean surface roughness R_a are provided in **Appendix D-2**, on **page 387**. These guideline values apply to ground seats.

NOTE: For fine turned seats, the roughness should be one or two grades higher than those of ground seats. For non-critical bearing arrangements, relatively high surface roughness is permissible.

Axial location of bearings

An interference fit alone is inadequate to axially locate a bearing ring. As a rule, a suitable means of axially securing the ring is needed.

For locating bearings, both bearing rings should be secured axially on both sides (→ **fig. 15**).

For non-locating bearings, axial location depends on the bearing design as follows:

- For non-separable bearings, the ring having the tighter fit (usually the inner ring) should be secured axially; the outer ring being free to move axially on its seat (→ **fig. 16**).
- For separable bearings, e.g. cylindrical roller bearings, both rings should be secured axially (→ **fig. 17**).
- For CARB toroidal roller bearings, both rings should be secured axially.

For adjusted (cross-located) bearing arrangements, each bearing ring needs only be secured axially on one side (→ **fig. 18**, **page 38**).

Fig. 15

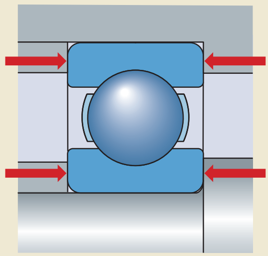


Fig. 16

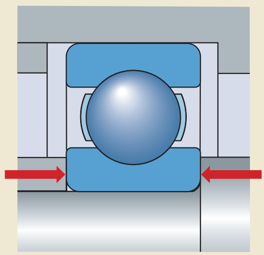
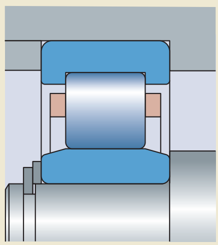


Fig. 17



Abutment and fillet dimensions

The dimensions of shaft and housing shoulders, spacer sleeves and covers must be able to support the bearing rings adequately, without any contact between rotating parts of the bearing and a stationary component.

The transition between the bearing seat and shaft or housing shoulder, may either take the form of a simple fillet, or be relieved in the form of an undercut. Suitable dimensions for the fillets are provided in **Appendix D-3**, on **page 387**. The greater the fillet radius (for the smooth form curve), the more favourable is the stress distribution in the shaft fillet area.

For heavily loaded shafts, therefore, a large radius is generally required. In such cases a spacing collar should be provided between the inner ring and shaft shoulder to provide a sufficiently large support surface for the bearing ring. The side of the collar facing the shaft shoulder should be relieved so that it does not contact the shaft fillet (→ **fig. 19**).

CARB toroidal roller bearings

CARB toroidal roller bearings can accommodate axial expansion of the shaft within the bearing. To be sure that these axial displacements of the shaft with respect to the housing can take place, it is necessary to provide adequate space on both sides of the bearing (→ **fig. 20**).

To calculate the required abutment width, refer to the *SKF Interactive Engineering Catalogue*, available online at www.skf.com.

Fig. 18

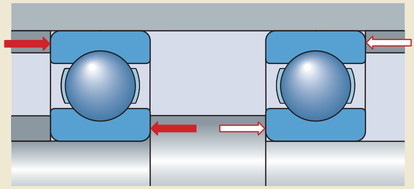


Fig. 19

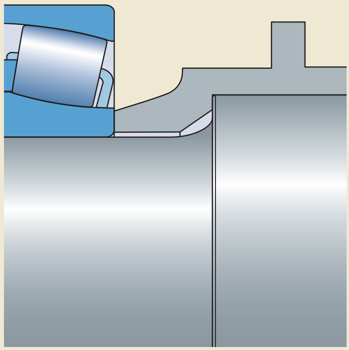
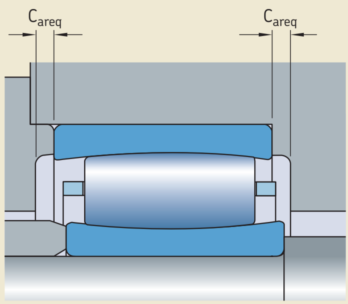


Fig. 20



Sealing arrangements

The performance of a sealing arrangement is vital to the cleanliness of the lubricant and the service life of the bearings. Where seals for rolling bearings are concerned, a distinction is made between seals that are integral to the bearing and those that are positioned outside the bearing.

External seals

There are two broad categories of external seals:

- contact seals
- non-contact seals

Seals in contact with stationary surfaces are known as static seals and their effectiveness depends on the radial or axial deformation of their cross section when installed. Typical examples include gaskets and O-rings. Seals in contact with sliding surfaces are called dynamic seals and are used to seal passages between a stationary component, e.g. a housing, and a rotating component, normally the shaft. Their function is to keep lubricant in and contaminants out of the bearing arrangement (→ **fig. 21**).

The most common contact seal is the radial shaft seal. Other types include V-ring seals and felt seals.

NOTE: When the primary function of a radial shaft seal is to retain the lubricant, it should be installed with the seal lip facing the grease, i.e. facing inward. When the primary function is to exclude contaminants, the seal lip should be facing the contaminants, i.e. facing outward.

Non-contact radial shaft seals function by virtue of the sealing effect of a narrow, relatively long gap that can be arranged axially, radially or in combination. Non-contact seals, which range from simple gap-type seals to multi-stage labyrinth seals (→ **fig. 22**), do not generate friction and do not wear.

NOTE: Non-contact seals are suitable for high-speed and/or high temperature applications.

Fig. 21

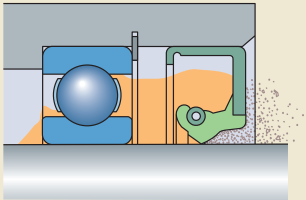


Fig. 22

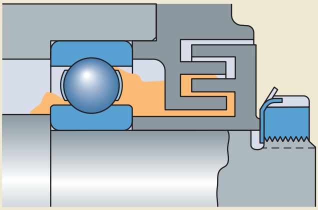
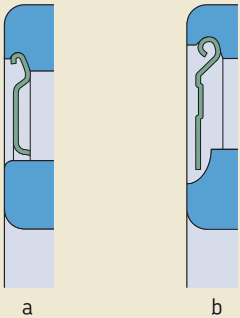


Fig. 23



Integral bearing sealing solutions

There are two categories of integral bearing sealing solutions:

- shields
- seals

Shields

Shields, produced from sheet steel, are non-contacting and are used in applications where contamination is limited. They are also used in applications where, due to speed or operating temperatures, low friction is important. The bearings are lubricated for life and should not be relubricated.

Shields form (→ **fig. 23**, **page 39**):

- a narrow gap with the inner ring shoulder (**a**)
- an efficient labyrinth seal with a recess in the inner ring shoulder (**b**)

Seals

Seals integrated in SKF bearings are generally made of elastomer materials and reinforced by sheet steel.

Bearings with contact seals are preferred for arrangements where resistance to contamination is needed, where the presence of moisture or water spray cannot be ruled out, or where a long service life with minimal maintenance is required.

How a seal contacts a bearing ring depends on the bearing type and design of the seal. Seals can make contact in any one of the following ways (→ **fig. 24**):

- with the inner ring shoulder (**a**) or against a recess in the inner ring shoulder (**b**, **c**, **d**)
- with the lead-in at the sides of the inner ring raceway (**e**, **f**) or the outer ring (**g**)

For deep groove ball bearings, SKF has also developed non-contact integral seals, which form an extremely small gap with the inner ring (→ **fig. 25a** and **b**) and low-friction integral seals, which practically do not contact the inner ring (→ **fig. 25c**). Both fulfil high demands on sealing and low-friction operation of the bearing. As a result, bearings fitted with these seals can be operated at the same speeds as bearings with shields, but with improved seal performance. They are lubricated for life and should not be relubricated.

Fig. 24

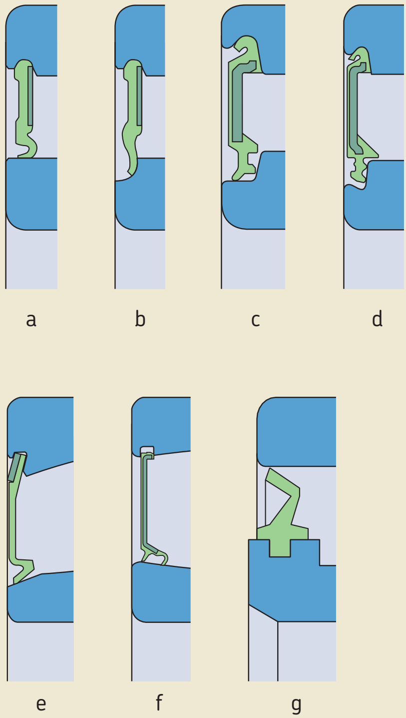
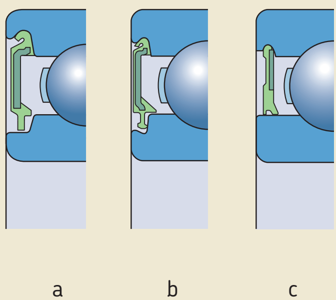


Fig. 25



Storage of bearings, seals and lubricants

The conditions under which bearings, seals and lubricants are stored can have an adverse effect on their performance. Inventory control can also play an important role in performance, particularly if seals and lubricants are involved. Therefore, SKF recommends a “first in, first out” inventory policy.

Storage of bearings, bearing units and housings

Storage conditions

To maximize the service life of bearings, SKF recommends the following basic housekeeping practices:

- Store bearings flat, in a vibration-free, dry area with a cool, steady temperature. There should not be a draft in the stocking area.
- Control and limit the relative humidity of the storage area as follows:
  - 75% at 20 °C *(70 °F)*
  - 60% at 22 °C *(72 °F)*
  - 50% at 25 °C *(75 °F)*
- Keep bearings in their original unopened packages until just before mounting, to prevent dust and moisture contamination as well as corrosion of the bearing components.

NOTE: Machines on standby should be rotated or run as frequently as possible to redistribute the grease within the bearings and change the position of the rolling elements relative to the raceways.

Bearing units and housings should be stored under similar conditions as bearings, i.e. in a cool, dust-free, moderately ventilated room, where the relative humidity is controlled.

Shelf life of open bearings

SKF bearings are coated with a rust-inhibiting compound and suitably packaged before distribution. For open bearings, the preservative provides protection against corrosion for approximately five years, provided the storage conditions are appropriate. After five years, SKF recommends following these guidelines:

1. Remove the bearing from the package, without damaging the package if possible.
2. Clean the bearing using a suitable solvent.
3. Carefully dry the bearing.
4. Visually inspect the bearing for signs of corrosion or damage. If the bearing is in a satisfactory condition, apply a fresh coating of an appropriate rust-inhibiting compound and repack the bearing in its original package.

NOTE: Bearing inspection and repackaging is a service that can be provided by SKF. Contact your local SKF sales representative or SKF Authorized Distributor.

Shelf life of sealed bearings

The maximum storage interval for SKF sealed bearings is dictated by the lubricant inside the bearings. Lubricant deteriorates over time as a result of ageing, condensation, and separation of the oil and thickener. Therefore, sealed bearings should not be stored for more than three years.

NOTE: For small bearings, it is impractical to remove the seals, clean the bearing, re-grease it and then re-fit the seals. But more importantly, by doing this, the seals could be damaged and contaminants could be introduced into the bearings in the process.

Some larger bearings have seals retained in the outer ring by a circlip. Where necessary, the seals can be removed and replaced.

Storage of elastomer seals

Storage conditions

To maximize the service life of elastomer seals, SKF recommends the following basic housekeeping practices:

- Store elastomer seals flat, in a cool, moderately ventilated area, at temperatures between 15 and 25 °C (*60* and *75 °F*).
- Control and limit the relative humidity of the storage area to 65% maximum.
- Protect seals from direct sunlight or light with a high proportion of UV radiation.
- Keep seals in their original packages until just before mounting to prevent degradation of the material when subjected to the environment. If the original packages are not available, store them in airtight containers.
- Store seals separately from solvents, fuels, lubricants and other chemicals that produce fumes and vapours.
- Store seals made of different materials separately.

CAUTION: Seals should never be hung from pegs or nails during storage. If stored like this, under stress or load, seals are subject to permanent deformations and cracks.

Shelf life

Natural and synthetic rubber changes its physical properties over time and is affected by air, heat, light, moisture, solvents and certain metals, especially copper and manganese. As a result, rubber seals may become unusable due to hardening or softening, peeling, cracks or other surface damage.

Storage of lubricants

Storage conditions

Lubricants are affected by temperature, light, water, moisture and oxygen. Incidental exposure to these elements is normally not harmful. However, any exposure hastens the onset of ageing.

To maximize lubricant shelf life, SKF recommends the following:

- Store lubricants in a vibration-free, dry area where the temperature is below 40 °C *(105 °F)*. This is particularly important for containers that have been opened, as humidity causes lubricant degradation and accelerates oxidation.
- Store lubricants indoors on proper storage racks. Indoor storage also protects any labelling on the container.
- Store oil drums on their sides to keep contaminants from collecting on the top of the drums.
- Keep container lids closed to prevent the entry of contaminants.
- Label all containers clearly. Identification problems may arise if labels are worn or damaged. Colour coding is also recommended.
- Keep lubricants in their original containers.
- Do not store dispensed lubricant in open cans.

Shelf life

The shelf life of a lubricant is the period from the fill date to an estimated expiration date, provided the lubricant is stored properly. Production dates are normally coded on the containers and should be monitored regularly. In general, the production date on SKF bearing grease cans and automatic lubricators, for example, is indicated by a four-digit code such as 0710, which indicates the grease was produced in 2007, week 10.

Most lubricants will deteriorate over time. Guidelines for the shelf life of various lubricants are provided in **table 3**.

If a lubricant has exceeded its shelf life, it may not be as effective. Therefore, SKF strongly recommends using only those lubricants that are well within their estimated expiration date.

NOTE: Consider the cost implications of a machine breakdown as a result of expired lubricant, compared to the cost of replacing the lubricant.

Lubricant disposal

Improper disposal of lubricants can be hazardous to the community and the environment. Dispose of all lubricants in accordance with national and local laws and regulations and good environmental safety practices.

Table 3

Lubricant shelf life at 20 °C *(70 °F)*

Lubricant	Maximum shelf life
Lubricating oils	10 years[1)]
SKF aftermarket greases (except the food grade grease LGFP 2)	5 years
SKF food grade grease LGFP 2	2 years
Grease in sealed SKF deep groove ball bearings, e.g. MT47 or MT33	3 years
Lubricant in SKF SYSTEM 24 lubricators in the LAGD series	2 years
Lubricant in SKF SYSTEM 24 lubricators in the LAGE series (except when filled with LGFP 2 or oil)	3 years
Lubricant in SKF SYSTEM 24 lubricators in the LAGE series filled with LGFP 2 or oil	2 years

1) Shelf lives may be reduced due to certain additive packages in the lubricant. Check with the lubricant manufacturer.