High-precision bearings

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Contents

SKF

The SKF brand now stands for more than ever before, and means more to you as a valued customer.

While SKF maintains its leadership as the hallmark of quality bearings throughout the world, new dimensions in technical advances, product support and services have evolved SKF into a truly solutions-oriented supplier, creating greater value for customers.

These solutions encompass ways to bring greater productivity to customers, not only with breakthrough application-specific products, but also through leading-edge design simulation tools and consultancy services, plant asset efficiency maintenance programmes, and the industry's most advanced supply management techniques.

The SKF brand still stands for the very best in rolling bearings, but it now stands for much more.

SKF – the knowledge engineering company

Foreword

Machine tools and other precision applications require superior bearing performance. Extended speed capability, high accuracy, good contribution to system rigidity, low heat generation and low noise levels are some of the challenges.

Rolling bearings for general industrial applications can only partly fulfil these requirements. Therefore, SKF manufactures special high-precision bearings designed to comply with the demanding requirements of machine tools and other precision applications.

This catalogue presents the current assortment of SKF high-precision bearings and related products.

Structure of the catalogue

This catalogue is divided into nine main chapters, marked with numbered blue tabs in the right margin:

- Chapter 1 provides design and application recommendations.
- Chapters 2 to 5 describe the various bearing types. Each chapter contains descriptions of the products, and product tables listing data for selecting a bearing and designing the bearing arrangement.
- Chapter 6 contains information about components to lock a bearing on a shaft.
- Chapter 7 presents special gauges.
- Chapter 8 is an overview about other SKF products and services related to machine tools and other precision applications.
- In chapter 9 all products presented in this catalogue are listed in alpha-numeric order.

About the data in this catalogue

The data in this catalogue relate to SKF's state-of-the-art technology and production capabilities as of mid 2007. The data may differ from that presented in earlier catalogues because of redesign, technological developments, or revised methods of calculation. This catalogue supersedes all previous SKF catalogues about high-precision bearings.

SKF reserves the right to make continuing improvements to SKF products regarding materials, design and manufacturing methods, as well as changes necessitated by technological developments.

The units used in this catalogue are in accordance with ISO (International Organization for Standardization) standard 1000:1992, and SI (Système International d'Unités). A table for unit conversions can be found on **page 7**.

Basic load ratings for bearings have been calculated in accordance with ISO 281:2007 and ISO 76:2006.

Other SKF catalogues

The total SKF product portfolio is much broader than only high-precision bearings. Product information is available via the SKF website at www.skf.com. The Interactive Engineering Catalogue provides not only product information, but also online calculation tools, CAD drawings in various formats and search and selection functions.

The main printed SKF catalogues are:

- General Catalogue
- Needle roller bearings
- Y-bearings and Y-bearing units
- Bearing housings

- Linear motion standard range
- Spherical plain bearings and rod ends
- Maintenance and lubrication products
- VOGEL centralized lubrication systems
- Industrial shaft seals
- Power transmission products
- Asset Management Services

Contact your local SKF representative for more information about SKF products and services.

More advantages

SKF aims to deliver industry-leading, high value products, services and knowledge-engineered solutions. Many capabilities contribute to the overall value customers receive in making SKF their supplier of choice, such as

- simplified bearing selection
- short delivery times
- worldwide availability
- commitment to product innovation
- state-of-the-art application solutions
- extensive engineering and technology knowledge in virtually every industry.

Unit conversions

Quantity	Unit	Conversion			
Length	inch	1 mm	0,03937 in	1 in	25,40 mm
	foot	1 m	3,281 ft	1 ft	0,3048 m
	yard	1 m	1,094 yd	1 yd	0,9144 m
	mile	1 km	0,6214 mile	1 mile	1,609 km
Area	square inch	1 mm^2	0,00155 sq.in	1 sq.in	645,16 mm^2
	square foot	1 m^2	10,76 sq.ft	1 sq.ft	0,0929 m^2
Volume	cubic inch	1 cm^3	0,061 cub.in	1 cub.in	16,387 cm^3
	cubic foot	1 m^3	35 cub.ft	1 cub.ft	0,02832 m^3
	imperial gallon	1 l	0,22 gallon	1 gallon	4,5461 l
	U.S. gallon	1 l	0,2642 U.S. gallon	1 U.S. gallon	3,7854 l
Velocity, speed	foot per second	1 m/s	3,28 ft/s	1 ft/s	0,30480 m/s
	mile per hour	1 km/h	0,6214 mile/h (mph)	1 mile/h (mph)	1,609 km/h
Mass	ounce	1 g	0,03527 oz	1 oz	28,350 g
	pound	1 kg	2,205 lb	1 lb	0,45359 kg
	short ton	1 tonne	1,1023 short ton	1 short ton	0,90719 tonne
	long ton	1 tonne	0,9842 long ton	1 long ton	1,0161 tonne
Density	pound per cubic inch	1 g/cm^3	0,0361 lb/cub.in	1 lb/cub.in	27,680 g/cm^3
Force	pound-force	1 N	0,225 lbf	1 lbf	4,4482 N
Pressure, stress	pounds per square inch	1 MPa	145 psi	1 psi	$6{,}8948 \times 10^3$ Pa
Moment	inch pound-force	1 Nm	8,85 in.lbf	1 in.lbf	0,113 Nm
Power	foot-pound per second	1 W	0,7376 ft lbf/s	1 ft lbf/s	1,3558 W
	horsepower	1 kW	1,36 HP	1 HP	0,736 kW
Temperature	degree	Celsius	$t_C = 0{,}555\,(t_F - 32)$	Fahrenheit	$t_F = 1{,}8\,t_C + 32$

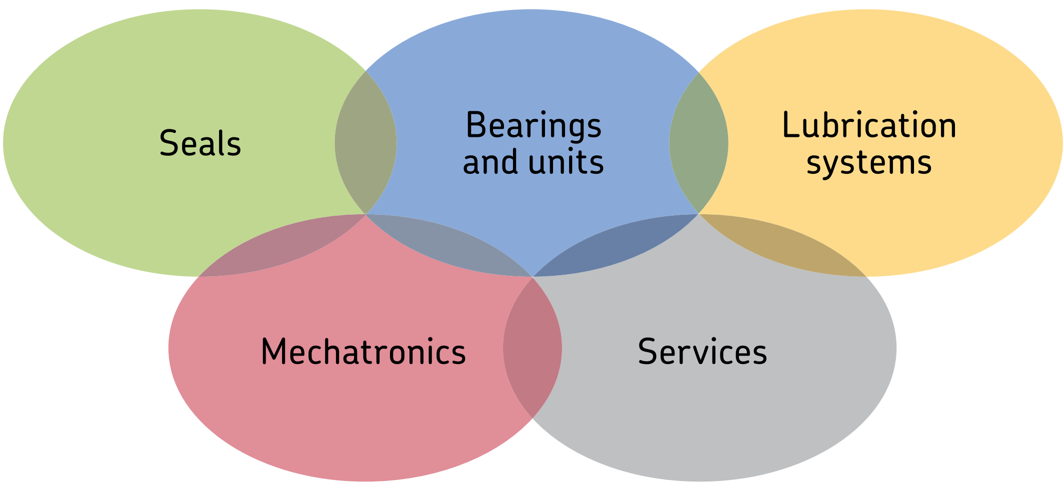
SKF – the knowledge engineering company

From the company that invented the self-aligning ball bearing more than 100 years ago, SKF has evolved into a knowledge engineering company that is able to draw on five technology platforms to create unique solutions for its customers. These platforms include bearings, bearing units and seals, of course, but extend to other areas including: lubricants and lubrication systems, critical for long bearing life in many applications; mechatronics that combine mechanical and electronics knowledge into systems for more effective linear motion and sensorized solutions; and a full range of services, from design and logistics support to conditioning monitoring and reliability systems.

Though the scope has broadened, SKF continues to maintain the world's leadership in the design, manufacture and marketing of rolling bearings, as well as complementary products such as radial seals. SKF also holds an increasingly important position in the market for linear motion products, high-precision aerospace bearings, machine tool spindles and plant maintenance services.

The SKF Group is globally certified to ISO 14001, the international standard for environmental management, as well as OHSAS 18001, the health and safety management standard. Individual divisions have been approved for quality certification in accordance with either ISO 9000 or QS 9000.

With some 100 manufacturing sites worldwide and sales companies in 70 countries, SKF is a truly international corporation. In addition, our distributors and dealers in some 15 000 locations around the world, an e-business marketplace and a global distribution system put SKF close to customers for the supply of both products and services. In essence, SKF solutions are available wherever and whenever customers need them. Overall, the SKF brand and the corporation are stronger than ever. As the knowledge engineering company, we stand ready to serve you with world-class product competencies, intellectual resources, and the vision to help you succeed.



Evolving by-wire technology

SKF has a unique expertise in fast-growing by-wire technology, from fly-by-wire, to drive-by-wire, to work-by-wire. SKF pioneered practical fly-by-wire technology and is a close working partner with all aerospace industry leaders. As an example, virtually all aircraft of the Airbus design use SKF by-wire systems for cockpit flight control.

SKF is also a leader in automotive by-wire technology, and has partnered with automotive engineers to develop two concept cars, which employ SKF mechatronics for steering and braking. Further by-wire development has led SKF to produce an all-electric forklift truck, which uses mechatronics rather than hydraulics for all controls.

Harnessing wind power

The growing industry of wind-generated electric power provides a source of clean, green electricity. SKF is working closely with global industry leaders to develop efficient and trouble-free turbines, providing a wide range of large, highly specialized bearings and condition monitoring systems to extend equipment life of wind farms located in even the most remote and inhospitable environments.

Working in extreme environments

In frigid winters, especially in northern countries, extreme sub-zero temperatures can cause bearings in railway axleboxes to seize due to lubrication starvation. SKF created a new family of synthetic lubricants formulated to retain their lubrication viscosity even at these extreme temperatures. SKF knowledge enables manufacturers and end user customers to overcome the performance issues resulting from extreme temperatures, whether hot or cold. For example, SKF products are at work in diverse environments such as baking ovens and instant freezing in food processing plants

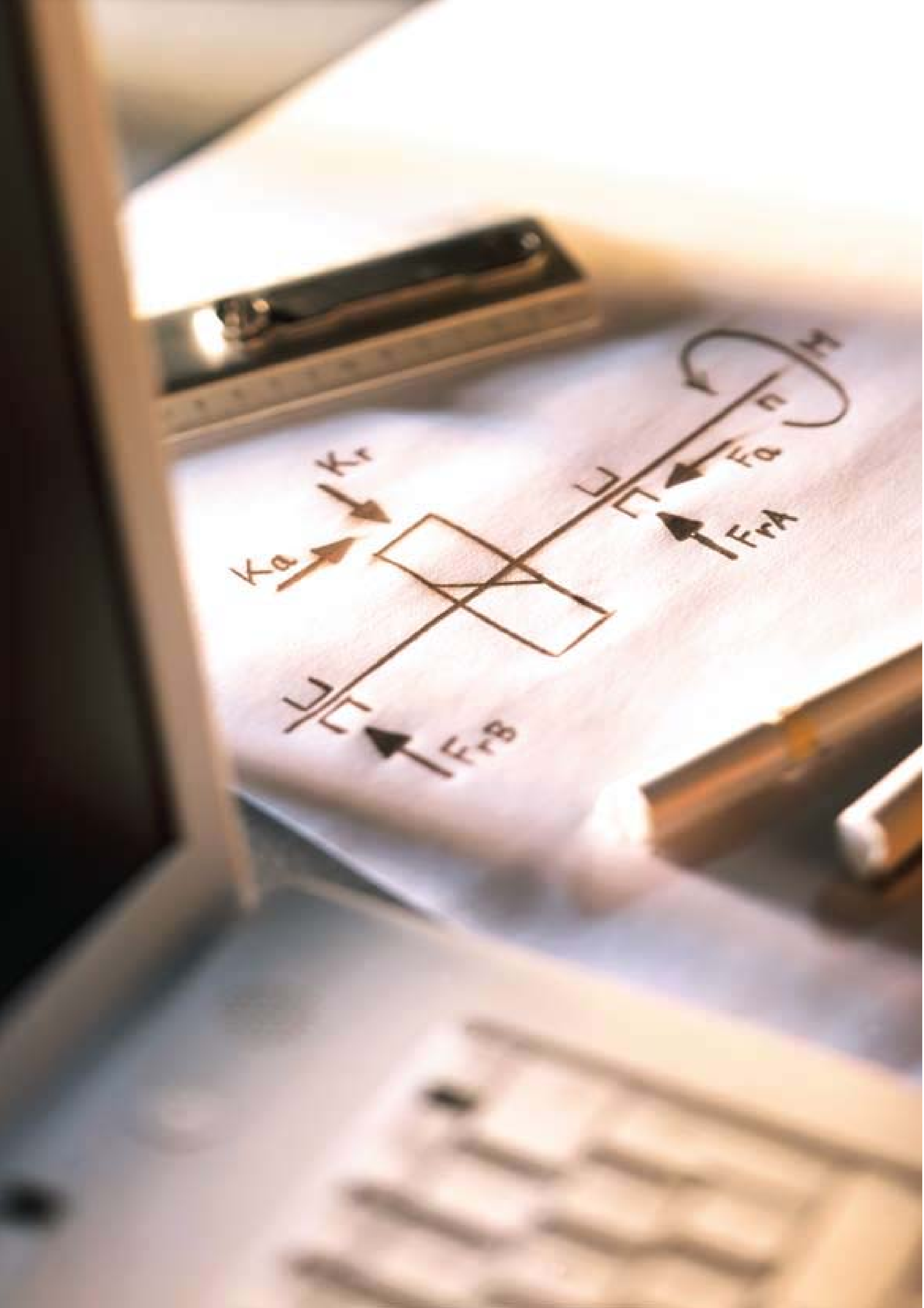
Developing a cleaner cleaner

The electric motor and its bearings are the heart of many household appliances. SKF works closely with appliance manufacturers to improve their products' performance, cut costs, reduce weight, and reduce energy consumption. A recent example of this cooperation is a new generation of vacuum cleaners with substantially more suction. SKF knowledge in the area of small bearing technology is also applied to manufacturers of power tools and office equipment.

Maintaining a 350 km/h R&D lab
In addition to SKF's renowned research and development facilities in Europe and the United States, Formula One car racing provides a unique environment for SKF to push the limits of bearing technology. For over 50 years, SKF products, engineering and knowledge have helped make Scuderia Ferrari a formidable force in F1 racing. (The average racing Ferrari utilizes more than 150 SKF components.) Lessons learned here are applied to the products we provide to automakers and the aftermarket worldwide.

Delivering Asset Efficiency Optimization
Through SKF Reliability Systems, SKF provides a comprehensive range of asset efficiency products and services, from condition monitoring hardware and software to maintenance strategies, engineering assistance and machine reliability programmes. To optimize efficiency and boost productivity, some industrial facilities opt for an Integrated Maintenance Solution, in which SKF delivers all services under one fixed-fee, performance-based contract.

Planning for sustainable growth
By their very nature, bearings make a positive contribution to the natural environment, enabling machinery to operate more efficiently, consume less power, and require less lubrication. By raising the performance bar for our own products, SKF is enabling a new generation of high-efficiency products and equipment. With an eye to the future and the world we will leave to our children, the SKF Group policy on environment, health and safety, as well as the manufacturing techniques, are planned and implemented to help protect and preserve the earth's limited natural resources. We remain committed to sustainable, environmentally responsible growth.

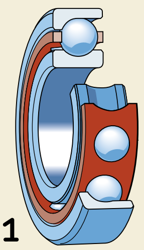

M
n
Kr
Fa
Ka
FrA
FrB

Principles of high-precision bearing selection and application

Selection of bearing type

Bearing types

SKF's comprehensive assortment of high-precision bearings is designed for machine tool spindles and other applications that require a high level of running accuracy at high to extremely high speeds. Each bearing type incorporates unique features to make it suitable for specific operating conditions. For details about the different bearing types, refer to the relevant product sections.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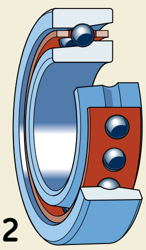
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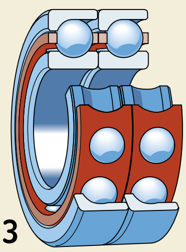
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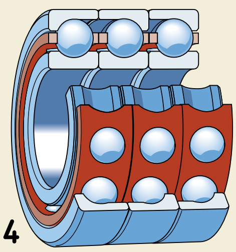
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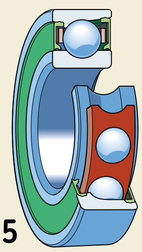
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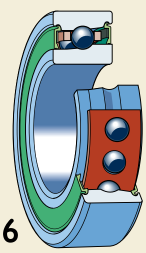
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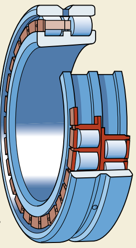
Angular contact ball bearings
(product chapter 2, starting on **page 95**)

Open (unsealed) angular contact ball bearings
- all-steel bearings (**1**)
- hybrid bearings
- all-steel high-speed bearings
- hybrid high-speed bearings (**2**)
- all types in different designs:
  - basic design for single mounting
  - design for universal matching (**3**)
  - universally matchable bearing sets
  - matched bearing sets (**4**)

Sealed angular contact ball bearings
- all-steel bearings (**5**)
- hybrid bearings
- all-steel high-speed bearings
- hybrid high-speed bearings (**6**)
- all types in different designs:
  - basic design for single mounting
  - design for universal matching
  - universally matchable bearing sets
  - matched bearing sets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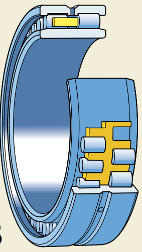
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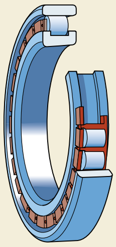
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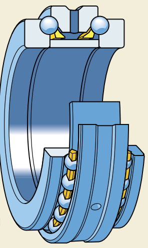
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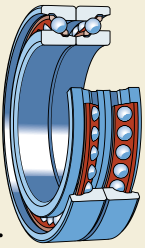
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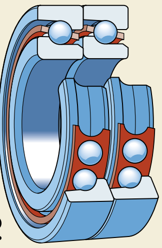
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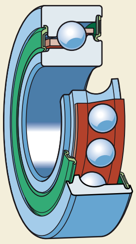
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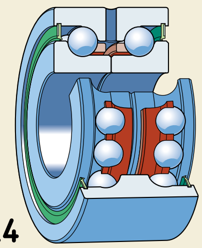
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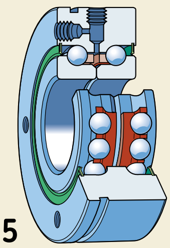
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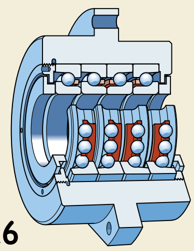

16

Cylindrical roller bearings
(product chapter 3, starting on **page 197**)

Double row cylindrical roller bearings, NN design
- all-steel bearings (**7**)
- hybrid bearings

Double row cylindrical roller bearings, NNU design (**8**)

Single row cylindrical roller bearings, N design
- basic design bearings (**9**)
- high-speed design bearings
- hybrid bearings

Double direction angular contact thrust ball bearings
(product chapter 4, starting on **page 227**)

Basic design bearings, 2344(00) series
- all-steel bearings (**10**)
- hybrid bearings

High-speed design bearings, BTM series
- all-steel bearings (**11**)
- hybrid bearings

Angular contact thrust ball bearings for screw drives
(product chapter 5, starting on **page 243**)

Single direction bearings
- universally matchable bearings for mounting as sets (**12**)
- matched bearing sets
- sealed bearings (**13**)

Double direction bearings
- basic design bearings, BEAS series (**14**)
- bearings for bolt mounting (**15**)

Cartridge units with a flanged housing (**16**)

Basic selection criteria

Bearing selection is paramount when dealing with machine tool spindles and other applications that require a high degree of accuracy at high speeds. The SKF high-precision bearing assortment comprises different bearing types, each with features designed to meet specific application requirements.

When designing a high-precision bearing arrangement, various factors should be considered. These include

- precision
- rigidity
- available space
- speed
- load
- axial displacement
- integral seals.

The importance of these factors varies, depending on the requirements of the application.

Because each application has a different set of influencing factors, bearing selection must be done on a case by case basis, making it impossible to set general rules for the selection of a bearing series or type. The following sections provide descriptions of the above-mentioned factors that influence bearing selection in high-precision applications. More detailed information about these influencing factors can be found in special sections within this chapter.

The information in this catalogue is intended to facilitate the design of high-precision bearing arrangements with typical requirements. Where demands on precision and productivity are exceptionally high, it may be necessary to contact the SKF application engineering service. For highly demanding applications, SKF offers special solutions such as hybrid bearings, nitro-alloy high-performance bearings, or coated bearings.

Table 1

Comparison of tolerance classes

SKF tolerance class	Standard tolerance classes for running accuracy acc. to			dimensional accuracy acc. to		
	ISO[1]	ANSI/ ABMA[2]	DIN[3]	ISO[1]	ANSI/ ABMA[2]	DIN[3]
P4A	2	ABEC 9[4]	P2	4	ABEC 7	P4
P4C	4	ABEC 7	P4	4	ABEC 7	P4
P5	5	ABEC 5	P5	5	ABEC 5	P5
P7	2	ABEC 9[4]	P2	4	ABEC 7	P4
P9	2	ABEC 9	P2	2	ABEC 9	P2
PA9A	2	ABEC 9	P2	2	ABEC 9	P2
SP	4	ABEC 7	P4	5	ABEC 5	P5
UP	2	ABEC 9	P2	4	ABEC 7	P4

1) ISO 492:2002 or ISO 199:2005
2) ANSI/ABMA Std. 20-1996
3) DIN 620-2:1988 or DIN 620-3:1982
4) Valid for bearings up to 120 mm bore, larger bearings acc. to ABEC 7 or better

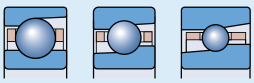
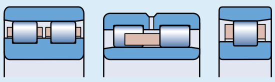
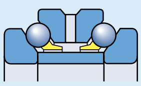
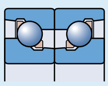
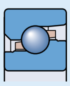
Precision

When dealing with rolling bearings, precision is described by tolerance classes for running accuracy and dimensional accuracy. **Table 1** shows a comparison of the tolerance classes used by SKF and different standards.

Most SKF high-precision bearings are manufactured to P4A, P4C, P7 or SP tolerance classes. Standard and optional tolerance classes for SKF high-precision bearings are listed in **table 2**.

Table 2

Standard and optional tolerance classes for SKF high-precision bearings

Bearing type		**Standard tolerance class**	**Optional tolerance class**
Angular contact ball bearings		P4A or P7	PA9A or P9
Cylindrical roller bearings		SP	UP
Double direction angular contact thrust ball bearings in the 2344(00) series		SP	UP
Double direction angular contact thrust ball bearings in the BTM series		P4C	–
Angular contact thrust ball bearings for screw drives		P4A	–

Running accuracy

The running accuracy of a bearing arrangement depends on the accuracy of all the components within the arrangement. Running accuracy of a bearing is mainly affected by the accuracy of the form and position of the raceways on the bearing rings.

When selecting the appropriate tolerance class for a particular bearing, the maximum radial or axial runout (depending on the bearing type) of the inner ring is usually the determining factor for most applications.

Diagram 1 compares relative values of the maximum radial runout of the inner ring for different tolerance classes.

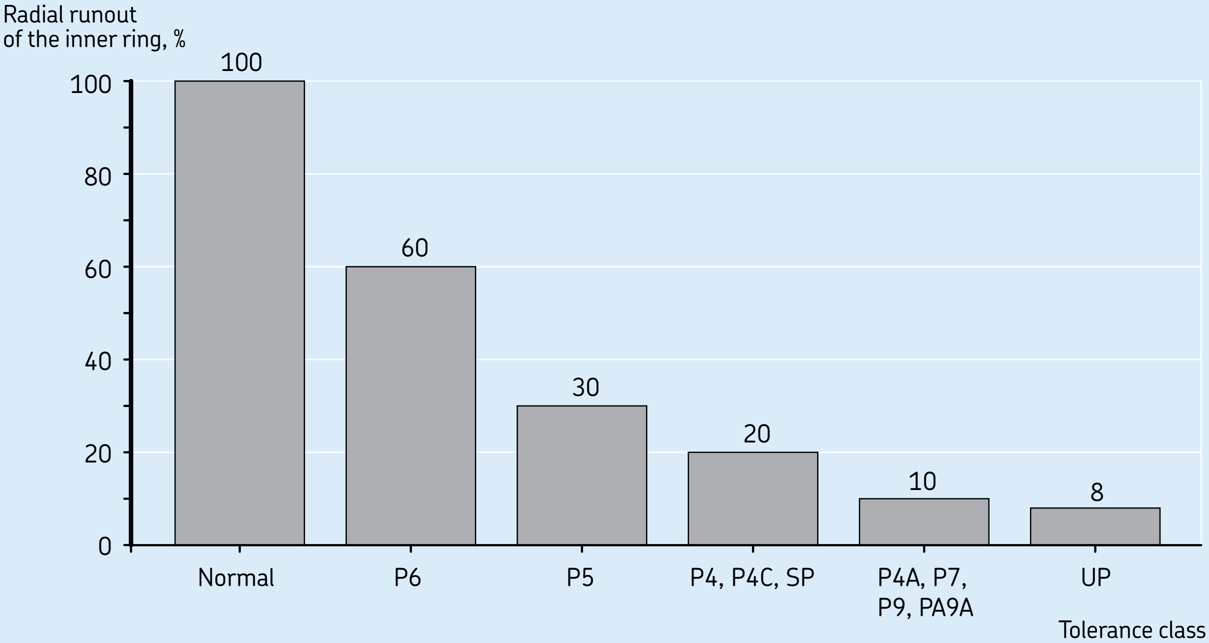
Dimensional accuracy

The dimensional accuracy of a bearing is important, relative to the fit between the bearing inner ring and shaft or the outer ring and housing. Because the fit influences the clearance or preload of mounted bearings, the tolerances of the bearing and its seats should be kept within close limits.

Cylindrical roller bearings with a tapered bore have slightly larger permissible dimensional deviations than other types of high-precision bearings. That is because the clearance or preload is determined during mounting by driving the inner ring up on its tapered seat.

Diagram 1

Relative radial runout limits for different tolerance classes



Rigidity

In machine tool applications the rigidity of the spindle is extremely important as the magnitude of elastic deformation under load determines the productivity and accuracy of the tool. Although bearing stiffness contributes to system rigidity, there are other influencing factors including tool overhang as well as the number and position of the bearings.

Factors that determine bearing stiffness include:

- The rolling element type: Roller bearings are stiffer than ball bearings. Ceramic rolling elements are stiffer than those made of steel.
- The number and size of the rolling elements: A large number of small rolling elements makes bearings stiffer.
- The contact angle: A contact angle close to the load angle results in a higher degree of stiffness.

In applications requiring a high degree of radial rigidity, cylindrical roller bearings are typically the best option. However angular contact ball bearings with a minimal contact angle can also be used.

In applications where a high degree of axial rigidity is required, angular contact thrust ball bearings with a large contact angle are preferred. The rigidity can be increased by preload, but this can limit the permissible speed.

For more information about system rigidity and bearing stiffness, refer to the section "System rigidity", starting on **page 38**.

Available space

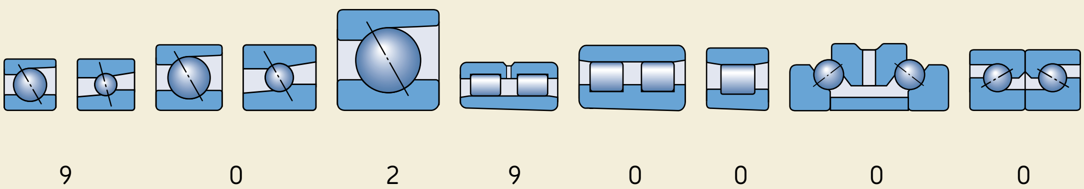
High-precision applications generally call for bearings with a low cross section, due to limited space and high requirements for rigidity and running accuracy. Bearings with a low cross section are able to accommodate relatively large diameter shafts to provide the necessary rigidity within a relatively small bearing envelope.

Angular contact ball bearings, cylindrical roller bearings and angular contact thrust ball bearings commonly used in machine tool applications are almost exclusively bearings in the ISO 9 and 0 Diameter Series (→ **fig. 1**). Angular contact ball bearings in the 2 Diameter Series are rarely used in new designs, but are still common in existing applications. By selecting bearings in the 9 or 0 Diameter Series, it is possible to achieve an optimal bearing arrangement for a particular application within the same radial space.

Angular contact ball bearings for screw drives have larger cross sections, because limited space is not typically a major concern. Diameter Series 2 or 3 is common for these bearings. In addition to the other general requirements for high-precision bearings, load carrying capacity is extremely important for bearings used in screw drives.

Fig. 1

Diameter Series for high-precision bearings used in spindle applications



Speed

The attainable speeds for high-precision bearings are primarily dependent on bearing type, design and material, type and magnitude of load as well as lubricant and lubrication method. For the permissible speed, operating temperature is an additional limit.

High-precision bearing arrangements that operate at high speeds require bearings that generate low levels of friction and heat; high-precision angular contact ball bearings and cylindrical roller bearings are best suited for these applications. For extremely high speeds hybrid bearings (bearings with ceramic rolling elements) may be necessary.

When compared to other precision bearing types, angular contact ball bearings enable the highest speeds. **Diagram 2** compares the relative speed capability of SKF angular contact ball bearings in the different series. For details about the bearing series, refer to "Designation system" in the chapter "Angular contact ball bearings" (→ **page 128**).

High-precision cylindrical roller bearings are able to attain approximately the same speeds as angular contact ball bearings in the 70 CD series (→ **diagram 2**).

Thrust bearings are unable to attain the same high speeds as radial bearings.

It is a general rule, that to attain higher speeds, a certain loss of rigidity must be tolerated.

For more information about attainable speeds, refer to the section "Speed" (→ **page 28**).

Loads

In high-speed precision applications, the load carrying capacity of a bearing is typically less important than in general engineering applications. Other criteria such as stiffness, size of the required bore in the hollow spindle, machining speed and accuracy are the decisive factors. When selecting the bearing type, the magnitude and direction of the load play an important role.

Bearings and bearing arrangements for combined loads

A combined load occurs when radial and axial loads act simultaneously on a bearing. A very effective way to accommodate combined loads is by using bearings with raceways in the inner and outer rings that are displaced relative to each other in the direction of the bearing axis (→ **fig. 2**). High-precision bearings with these characteristics include

- angular contact ball bearings in the 719, 70 and 72 series
- single direction angular contact thrust ball bearings in the BSA and BSD series
- double direction angular contact thrust ball bearings in the BEAS and BEAM series.

The ability of a bearing to accommodate axial load is determined by the contact angle α; the greater the angle, the higher the axial load carrying capacity of the bearing. Speed capability however, is inversely proportional to the contact angle, meaning that as the contact angle increases, speed capability decreases.

In applications where there are combined loads, and very heavy axial loads, the radial and axial loads can be supported by separate bearings.

Bearings for purely radial loads

Cylindrical roller bearings (bearings in the NN 30, NNU 49 and N 10 series) accommodate only radial loads. Because they enable axial displacement between the inner ring and the outer ring, these bearings are unable to accommodate any axial load. They can, however, accommodate heavier radial loads than ball bearings, within the same boundary dimensions.

Fig. 2

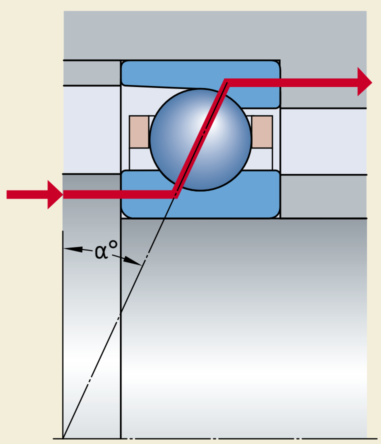
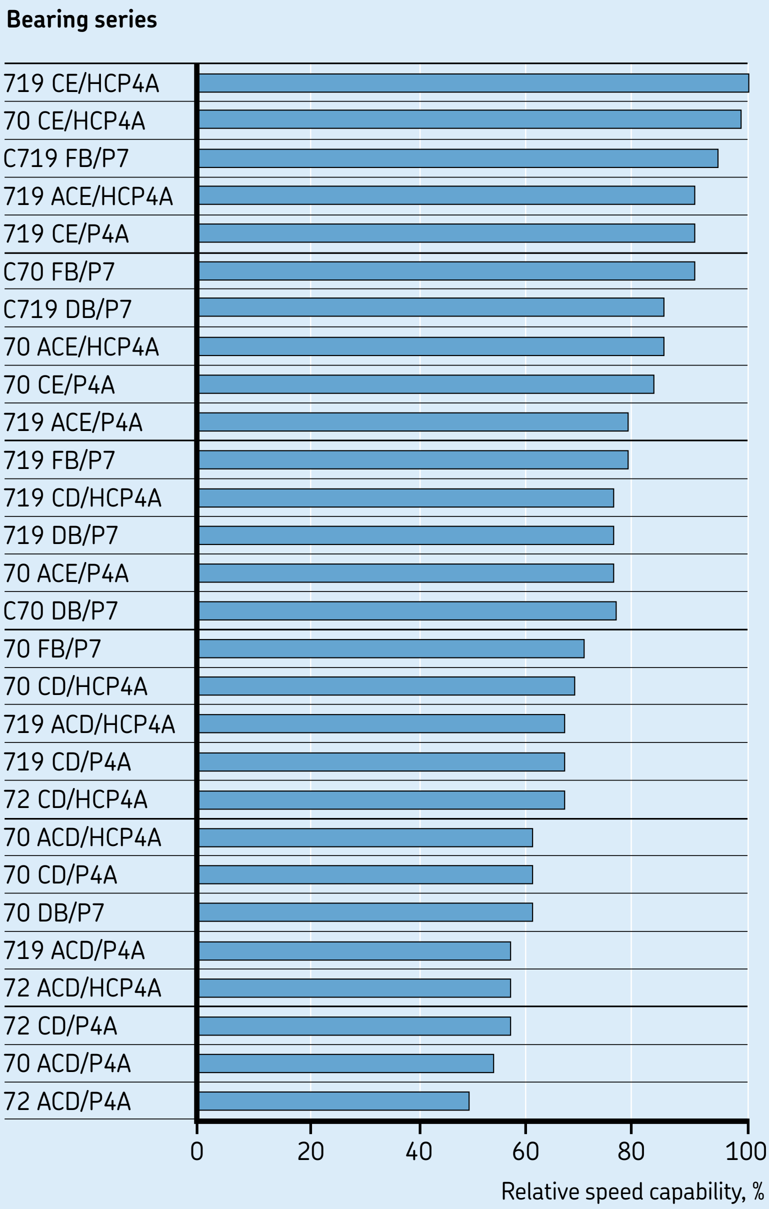


Diagram 2

Relative speed capability of angular contact ball bearings



Bearings for purely axial loads

Double direction angular contact thrust ball bearings (bearings in the 2344(00) and BTM series) are designed to support purely axial loads acting in both directions. However, sets of angular contact ball bearings are also a viable solution, particularly in high-speed applications.

For large size bearing arrangements or those subjected to very heavy axial loads, special single direction thrust ball bearings or cylindrical roller thrust bearings are recommended. For more information about these special bearings, contact the SKF application engineering service.

To make sure that the axial bearing is only subjected to axial load, the bearing outer ring should be mounted with radial clearance.

Axial displacement

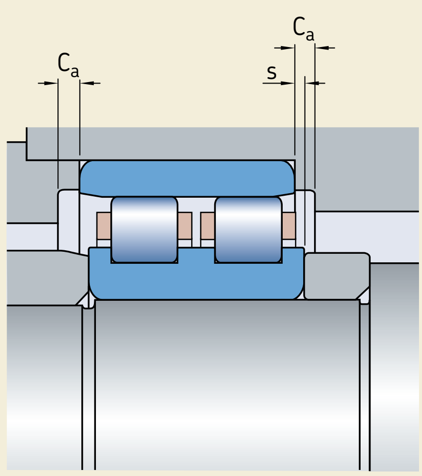
Traditional bearing arrangements typically consist of a locating bearing and a non-locating bearing.

The locating bearing does not accommodate axial displacement; however, it does provide axial location of the shaft in both directions. In machine tool applications pairs of angular contact ball bearings or angular contact thrust ball bearings are suitable for use as locating bearings.

The non-locating bearing accommodates axial displacement e.g. from thermal expansion of the shaft. Cylindrical roller bearings are well suited for use in the non-locating position due to their ability to accommodate axial movement of the shaft relative to the housing, within the bearing (→ **fig. 3**); this enables the bearing to be mounted with an interference fit for both the inner ring and outer ring.

If paired angular contact ball bearings are used in the non-locating position, the inner or outer bearing rings must have a loose fit. However, a loose fit has a negative effect on the system rigidity.

Fig. 3



Integral seals

To achieve optimum bearing performance, it is extremely important that the bearing arrangement is sealed properly. Seals typically fall into one of two categories: external or integral. External seals are positioned outside the bearing. Integral seals are built into the bearing. Integral seals are particularly useful for bearings that are lubricated with small quantities of grease.

SKF high-precision angular contact ball bearings are available with integral low friction seals (→ **fig. 4**). These seals enable high speeds and provide good sealing efficiency. The bearings are filled with an appropriate grease and grease quantity. The integral seals retain the grease in the bearing and keep contaminants out.

Among angular contact thrust ball bearings for screw drives, double direction bearings are available with non-contact shields or with contact seals (→ **fig. 5**). Cartridge units are sealed as standard with labyrinth seals.

Fig. 4

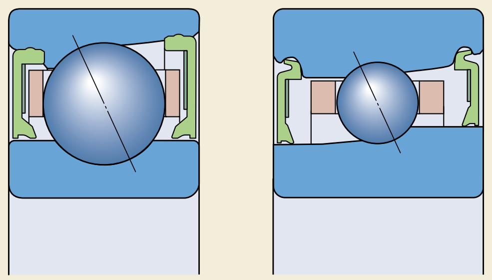
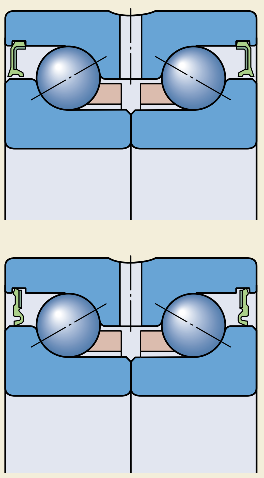


Fig. 5



Loads and bearing life

In industrial applications, bearing size is usually determined by its load carrying capacity in relation to the load, required life and required reliability of the application. For machine tool applications, bearing size is almost always determined by other factors such as system rigidity or fixed dimensions of the spindle diameter as well as the speed and feed parameters of the application.

For high-precision bearing arrangements, determining the actual load is particularly complex as it involves many influencing factors. SKF has developed special computer programs to analyse static indeterminate spindle bearing arrangements. For more information, contact the SKF application engineering service or take advantage of the SKF Engineering Consultancy Services.

This catalogue explains the basics concerning load carrying ability and calculating the life of high-precision bearings. It enables manual calculation of load limits and bearing life together with the formulae in the SKF General Catalogue. Calculations described here can be easily performed online using the SKF Interactive Engineering Catalogue, available at www.skf.com.

Permissible static loads

When a machine is not operational, static loads or vibration produced from other machines in the vicinity can cause permanent deformation to the contacts between the rolling elements and raceways. Shock loads at low speeds can also cause permanent deformations. In the case of high-precision bearing arrangements, permanent deformation must not occur. To make sure that static loads do not lead to permanent deformation, the basic static load rating of the bearing and equivalent static bearing load can be compared to determine if a bearing is at risk for permanent deformation.

Basic static load rating

The basic static load rating C_0 is defined in ISO 76:2006. It corresponds to a calculated contact stress at the centre of the most heavily loaded rolling element/raceway contact that produces a permanent deformation of the rolling element and raceway that is approximately 0,0001 of the rolling element diameter. The loads are purely radial for radial bearings and axial and centrically acting for thrust bearings.

The basic static load rating C_0 is listed in the product tables.

Equivalent static bearing load

To compare actual loads with the basic static load rating, the actual loads must be converted into an equivalent load P_0. This is defined as that hypothetical load (radial for radial bearings and axial for thrust bearings) which, if applied would cause the same maximum rolling element load in the bearing as the actual loads to which the bearing is subjected.

Information and data necessary to calculate the equivalent static bearing load are provided in the introductory text to each product chapter.

Checking the static load carrying capacity

A sufficient safety factor to protect the bearing from permanent deformation can be obtained when

$$P_0 \leq \frac{C_0}{s_0}$$

where
P_0 = equivalent static bearing load, kN
C_0 = basic static load rating, kN
s_0 = static safety factor
= 3 for all-steel high-precision angular contact ball bearings (including thrust ball bearings)
= 5 for all-steel high-precision cylindrical roller bearings

For hybrid bearings, the static safety factor should be increased by 10 %.

For angular contact thrust ball bearings for screw drives, a static safety factor of 3 is a guideline value, but safety factors down to $s_0 = 1$ can be used.

Dynamic bearing loads and life

The general information about bearing life calculation and basic load ratings provided in the SKF General Catalogue is also valid for high-precision bearings. It should be noted that all life calculations based on ISO 281:2007 are valid for a "normal" speed range. For applications where the speed factor A ≥ 500 000, additional influencing factors should be considered. The speed factor is

$$A = n\, d_m$$

where
A = speed factor, mm/min
n = rotational speed, r/min
d_m = bearing mean diameter
= 0,5 (d + D), mm

Contact the SKF application engineering service for additional information.

Bearing life can be calculated for fatigue conditions based on statistical assumptions. For detailed information, refer to the SKF General Catalogue or the SKF Interactive Engineering Catalogue available at www.skf.com.

A simple way to calculate bearing life is the classic ISO formula for basic rating life. However, SKF recommends using the SKF rating life, which makes predicting bearing life more precise. Both calculation methods use the basic dynamic load rating and the equivalent dynamic bearing load as their basis.

Basic dynamic load rating

The basic dynamic load rating C is defined in ISO 281:2007. It expresses the bearing load that will provide a basic rating life of 1 000 000 revolutions. It is assumed that the load is constant in magnitude and direction and is radial for radial bearings or axial and centrically acting for thrust bearings.

The basic dynamic load rating C is listed in the product tables.

Equivalent dynamic bearing load

To calculate bearing life with basic dynamic load ratings, it is necessary to convert the actual dynamic loads into an equivalent dynamic bearing load. The equivalent dynamic bearing load P is defined as a hypothetical load, constant in magnitude and direction, acting radially for radial bearings or axially and centrically on thrust bearings. The hypothetical load P is used to represent the effect that the actual load would have on bearing life.

Information, necessary to calculate the equivalent dynamic bearing load, is provided in the introductory text to each product chapter.

Basic rating life

A rough method for estimating bearing life is to use the basic rating life equation in accordance with ISO 281:2007

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

where
L_{10} = basic rating life at 90 % reliability, millions of revolutions
C = basic dynamic load rating, kN
P = equivalent dynamic bearing load, kN
p = exponent of the life equation
= 3 for ball bearings
= 10/3 for roller bearings

SKF rating life

For high-precision bearings, the basic rating life can deviate significantly from the actual service life in a given application. Service life in a particular application depends on a variety of influencing factors. The SKF rating life uses a life modification factor that takes the lubricant, contamination and the fatigue load limit P_u of the material into account. The SKF rating life is a life calculation method that is in accordance with ISO 281:2007.

The fatigue load limit P_u is listed in the product tables. For more information about the calculation method, refer to the SKF General Catalogue (section "Selection of bearing size" in "Principles of bearing selection and application"). The SKF Interactive Engineering Catalogue at www.skf.com provides easy to use calculation functions.

Rating life for hybrid bearings

When calculating the rating life for hybrid bearings, the same life values can be used as for all-steel bearings. The ceramic rolling elements in hybrid bearings are much harder and stiffer than the steel rolling elements found in all-steel bearings. Although this increased level of hardness and stiffness creates a higher degree of contact stresses between the ceramic rolling elements and the steel raceway, field experience and laboratory tests show that the same rating lives can be used for both bearing types.

Extensive experience and testing shows that in typical machine tool applications, the service life of a hybrid bearing is significantly longer than the service life of an all-steel bearing. The extended service life of hybrid bearings is due to their hardness, low density and surface finish. The hardness of ceramic rolling elements makes them less susceptible to wear, while their low density minimizes centrifugal and inertia forces; their surface finish enables the bearing to maximize the effects of the lubricant.

Requisite minimum load

In bearings that operate at high speeds or are subjected to fast accelerations or rapid changes in the direction of load, the inertia forces of the rolling elements and the friction in the lubricant can have a detrimental effect on the rolling conditions in the bearing arrangement and may cause damaging sliding movements to occur between the rolling elements and raceways. To provide satisfactory operation, rolling bearings should always be subjected to a given minimum load.

A general "rule of thumb" indicates that minimum loads corresponding to 0,01 C should be imposed on ball bearings and 0,02 C on roller bearings.

Friction

Friction in a bearing can be described as the total resistance to rotation. It dictates the amount of heat generated within a bearing and consequently determines the bearing's operating temperature. The amount of friction within a bearing depends on the load, including preload, and several other factors including bearing type, size, operating speed and the properties and quantity of the lubricant.

Friction in a bearing is produced in the contact areas. These are the areas where the rolling elements make contact with the raceways, cage(s) and lubricant. If the bearing is sealed, the contact area also includes the area where the seals contact the bearing ring.

For detailed information about friction in high-precision bearings, contact the SKF application engineering service.

Effects of clearance and preload on friction

High operating temperatures or high speeds can reduce the internal clearance or increase the preload in a bearing. Either of these changes can result in an increase in friction. This is particularly important for high-precision bearing arrangements because they are typically preloaded and are extremely sensitive to changes in preload. For specific application conditions sensitive to changes in clearance or preload, contact the SKF engineering application service.

Effects of grease fill on friction

During initial start-up, or after relubrication, the frictional moment of a grease lubricated bearing can be exceptionally high during the first few hours or days of operation. This high initial frictional moment is caused by the distribution of grease within the free space of the bearing. After this "running-in" period, the frictional moment will decrease until it reaches values similar to those of an oil lubricated bearing. An excessive amount of grease will result in a higher frictional moment in the bearing.

Frictional behaviour of hybrid bearings

Because ceramic rolling elements have higher values for the modulus of elasticity than steel rolling elements, hybrid bearings have smaller contact areas than all-steel bearings. The smaller contact area reduces the amount of friction produced by the rolling and sliding components of the bearing.

Speed

The speed at which a rolling bearing can operate is largely determined by the temperature of the bearing during operation. High-precision bearings that generate low levels of friction are best suited for high-speed applications due to their corresponding low operating temperatures. In general, ball bearings are preferred over roller bearings due to the reduced contact area. However, hybrid bearings provide additional benefits for all types of bearings. **Diagram 1** compares the temperature rise in existing grease lubricated spindles for different bearing types. The curves for the bearings can be considered representative for the whole bearing series.

Diagrams 2 and **3** provide guideline values for the speeds attainable by bearings in different series. For details about the bearing series, refer to the section "Designation system" in the relevant product chapters. **Diagram 2** is valid for oil-air lubrication, **diagram 3** (→ **page 30**) for grease lubrication. The diagrams are based on the speed factor A. The speed factor is

$$A = n\, d_m$$

where

A = speed factor, mm/min

n = rotational speed, r/min

d_m = bearing mean diameter = 0,5 (d + D), mm

It should be noted that bearings with a lower cross section can principally attain higher speeds because of the smaller value for d_m.

Diagram 1

Temperature rise in grease lubricated spindle bearings

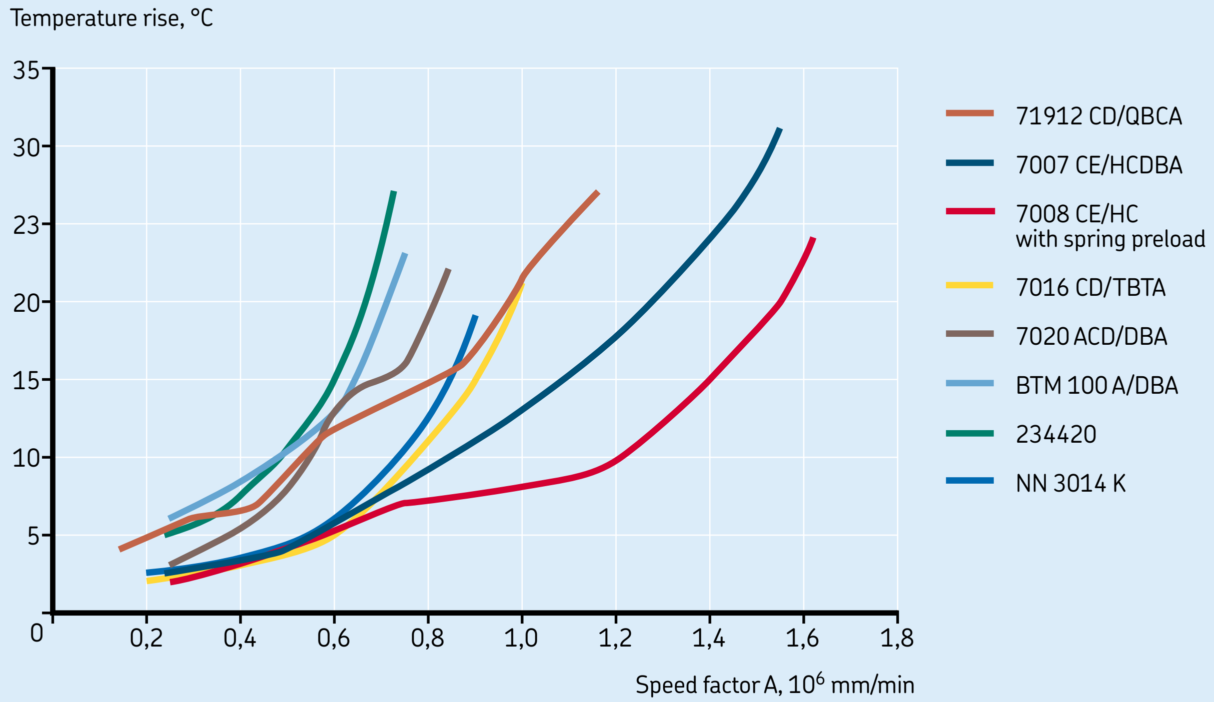


Diagram 2

Guideline values for attainable speeds – oil-air lubrication

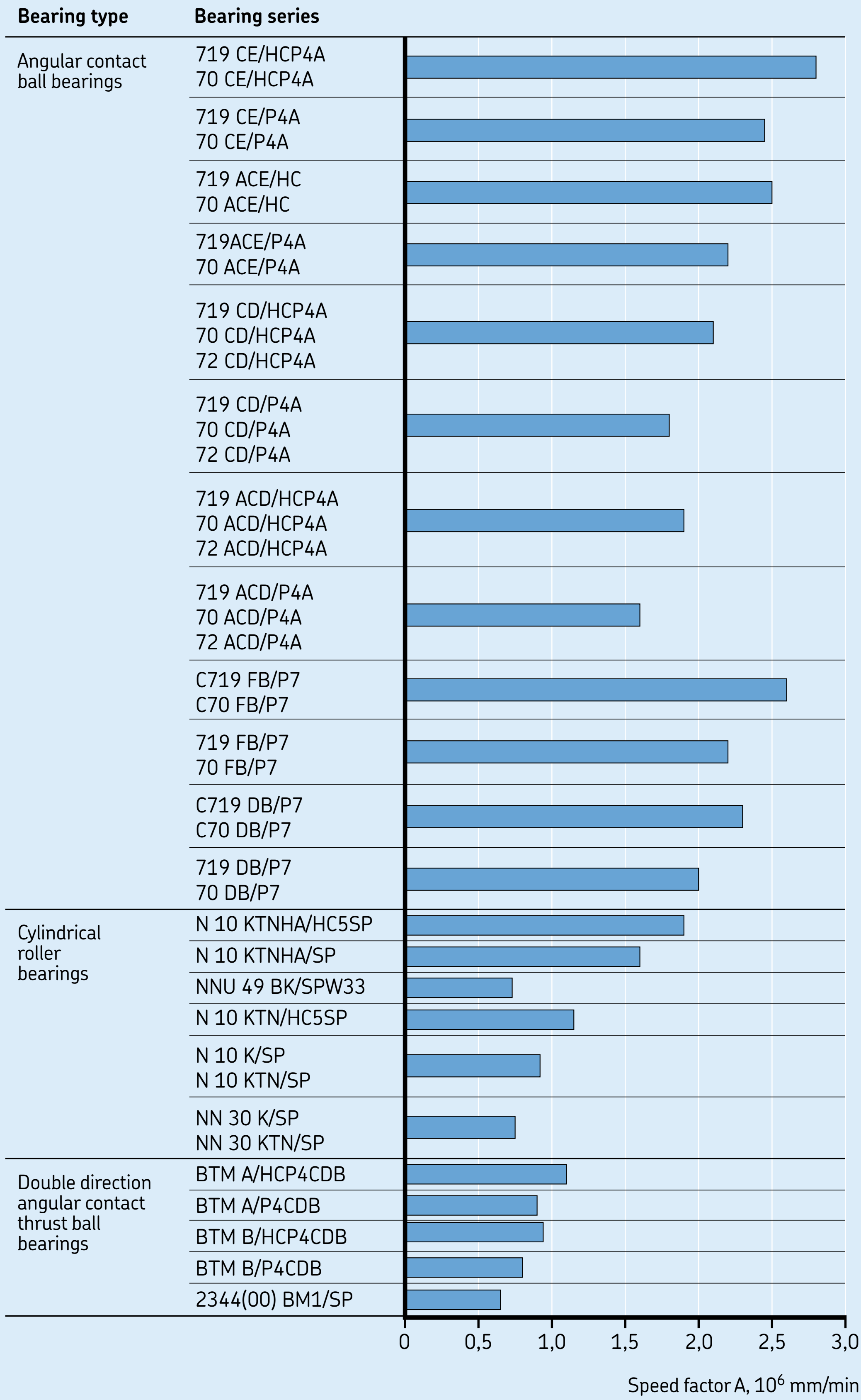
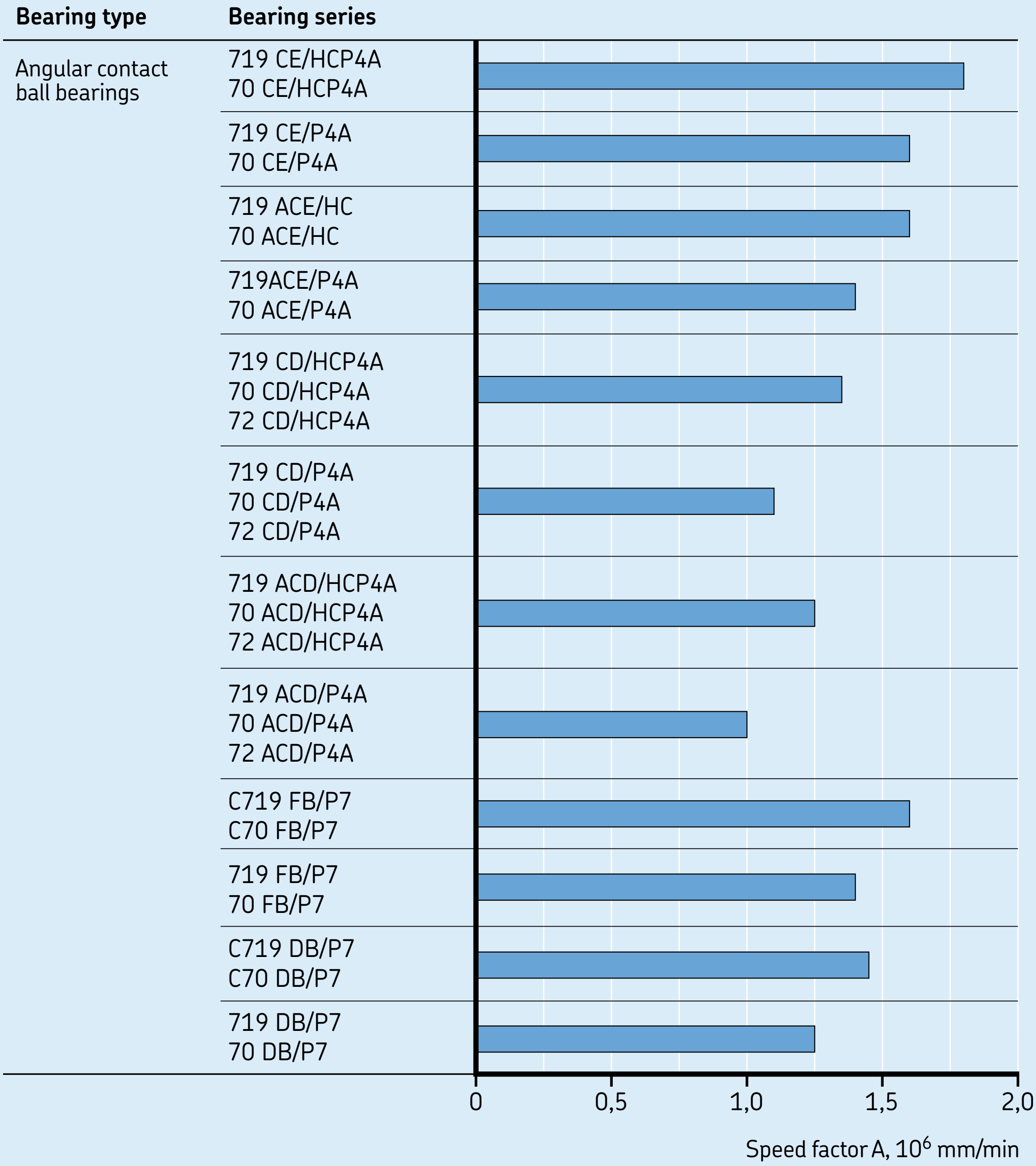


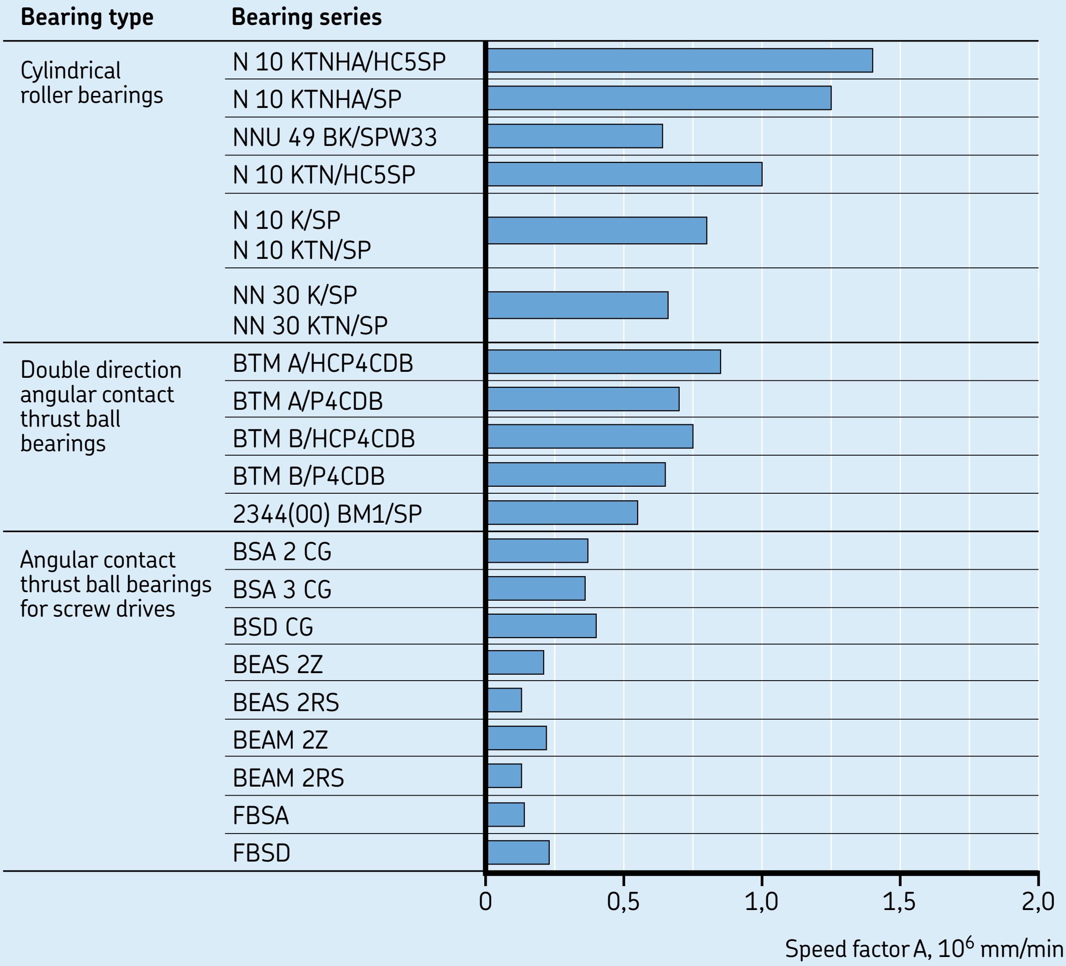
Diagram 3

Guideline values for attainable speeds – grease lubrication



cont. diagram 3

Guideline values for attainable speeds – grease lubrication



Permissible speeds

The permissible speed of a bearing is typically determined by the operating temperature of the application and its ability to dissipate heat. Heat in this case is not just generated by friction in the bearings, but also includes heat generated by motors, power losses and work procedures.

In applications where heat dissipation is not adequate, either because of design considerations or high ambient temperatures, additional cooling methods might be needed in order to keep bearing temperatures within a permissible range.

Cooling can be accomplished through different lubrication methods. In a circulating oil system, for example, the oil is filtered and typically cooled before returning to the bearings. With the oil-air method, the minimum quantity of oil enables bearings to operate with lowest friction. The oil jet lubrication method, which moves heat away from the bearings, is another way to reduce operating temperatures.

Because the permissible speed is influenced by factors other than the bearing itself, the product tables in this catalogue list “attainable speeds” and not speed limits.

Attainable speeds

The attainable speeds listed in the product tables are guideline values and are valid under the following conditions

- lightly loaded bearings ($P \leq 0,05\ C$)
- good heat dissipation, away from the bearings
- light spring preload when angular contact ball bearings are incorporated
- suitably lubricated bearings.

Maximum speeds

The values listed in the product tables for oil-air lubrication can be considered maximum values. Only oil jet lubrication can enable higher speeds. In this case, oil type, supply and drain rates, oil inlet temperature etc. should be considered. Contact the SKF application engineering service for additional information.

Speeds for other oil lubrication methods

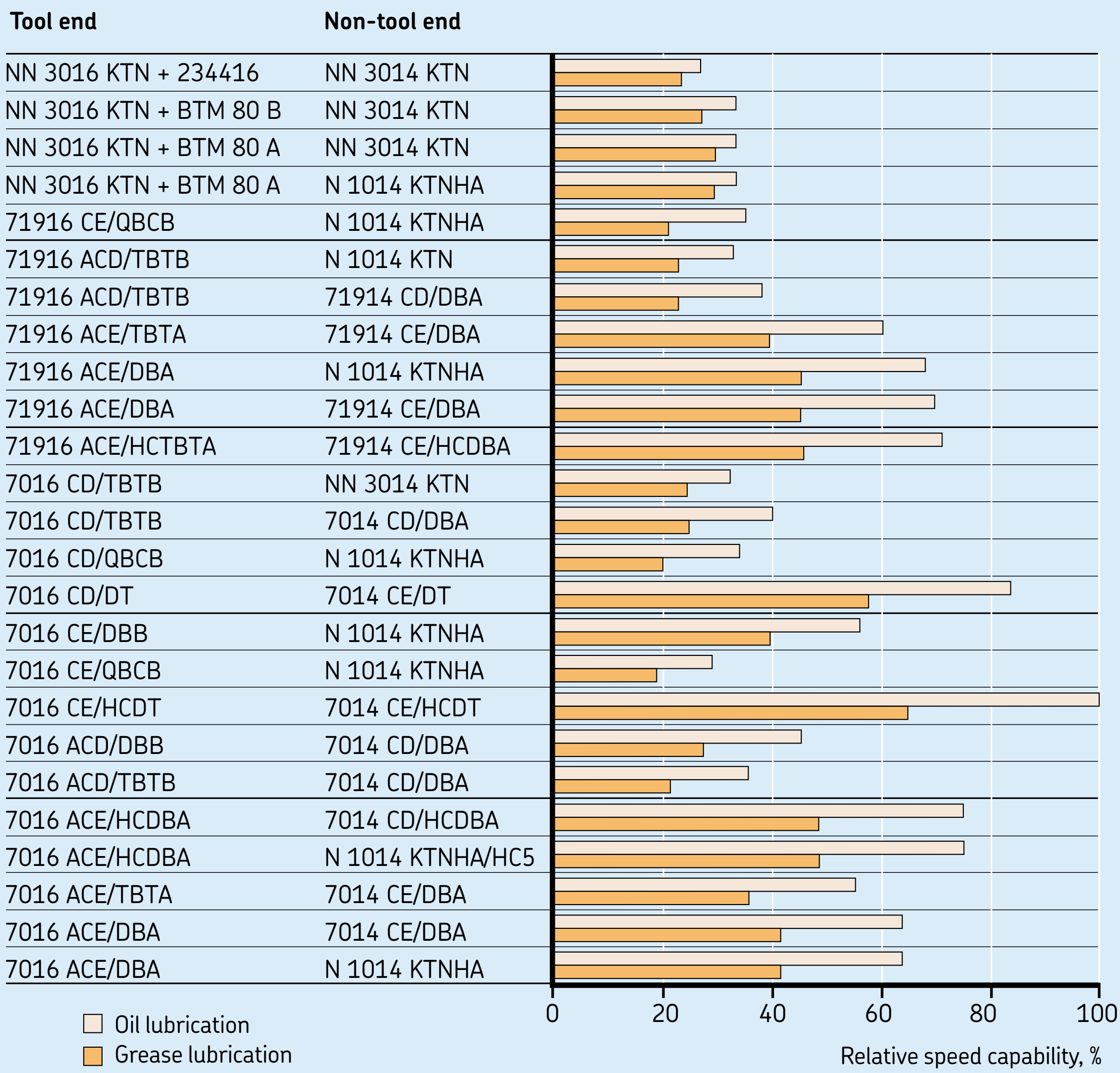
The attainable speeds for oil-air lubrication can be used to estimate attainable speeds for other oil lubrication methods. For oil bath lubrication, a reduction factor of 0,3 to 0,4 should be considered. For oil mist lubrication, a reduction factor of 0,95 is adequate.

Speeds of bearing arrangements

A typical spindle bearing arrangement, which can contain various bearing types, comprises a bearing set on the tool end and another set on the non-tool end. The set on the tool end is usually the critical one. It typically uses larger diameter bearings, forcing a higher speed factor A. **Diagram 4** provides a comparison of possible bearing arrangements and their relative speed capability. The comparison is based on bearings with an 80 mm bore on the tool end and 70 mm bore on the non-tool end. For details about the bearing series, refer to the section “Designation system” in the relevant product chapter.

Diagram 4

Relative speed capability of typical spindle bearing arrangements



Preload

Preload is a force acting between the rolling elements and bearing rings that is not caused by external load. Preload can be regarded as negative internal clearance. Reasons to apply preload include

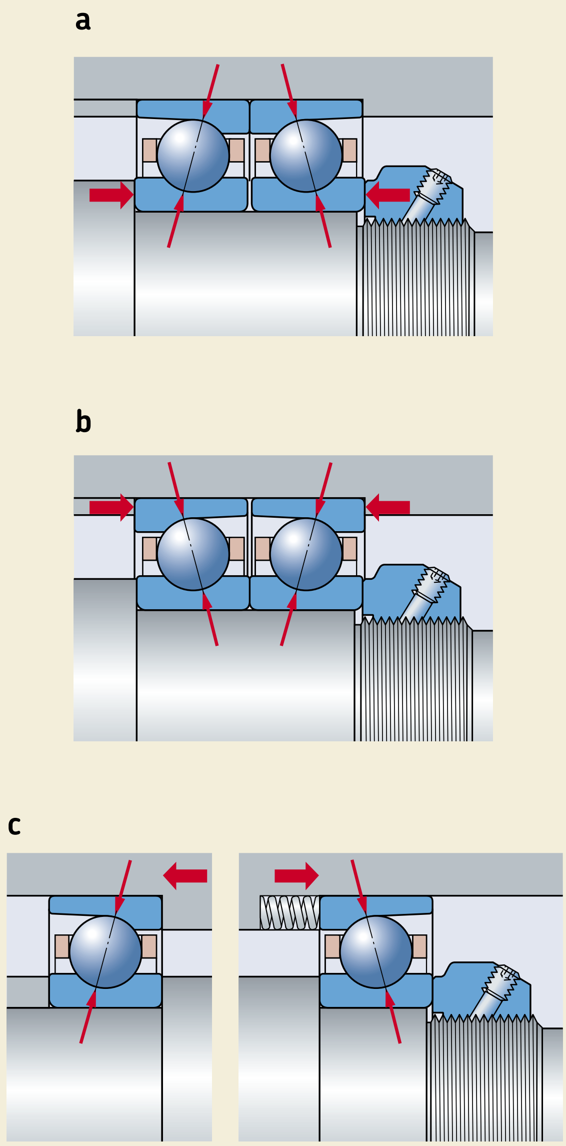
- enhanced stiffness
- enhanced accuracy of shaft guidance
- reduced noise level
- longer service life.

In the majority of high-precision applications preload is needed to enhance system rigidity or to increase running accuracy. Preload is also recommended in applications where bearings operate without load or under very light load and at high speeds. In these applications, the preload provides a minimum load on the bearing and prevents skidding, that otherwise could damage the bearing.

Preloading different bearing types

Depending on the bearing type, preload may be either radial or axial. Single row angular contact ball bearings are generally used in conjunction with a second bearing of the same type, mounted in a back-to-back or face-to-face arrangement (→ **fig. 1**). These bearings are typically subjected to axial preload. Cylindrical roller bearings can only be radially preloaded (→ **fig. 2**) and angular contact thrust ball bearings can only be axially preloaded (→ **fig. 3**).

Fig. 1



Angular contact ball bearings

Axial preload in single row angular contact ball bearings is produced by displacing one bearing ring axially in relation to the other (→ **fig. 1a** and **b**) by an amount corresponding to the desired preload force or by springs (→ **fig. 1c**).

Matched bearing sets and universally matchable bearings have a "built-in" preload. When mounted immediately adjacent to each other, a given preload will be obtained without further adjustment. This built-in preload can be influenced by mounting and operating conditions. For additional information, refer to the section "Preload in mounted bearing sets" (→ **page 119**).

If it is necessary to change the built-in preload, spacers between the bearing rings can be used. For additional information, refer to the section "Individual adjustment of preload" (→ **page 124**).

Fig. 2

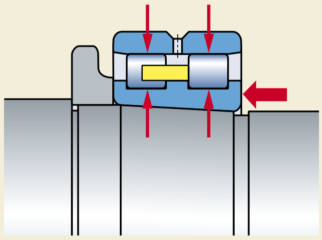
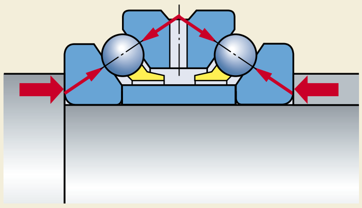


Fig. 3



Influence of an external load on preloaded bearing sets

The influence of an external axial load on a preloaded bearing set is shown in **diagram 1**. The curves represent the spring characteristics of two bearings in a set. The red curve represents bearing A, which is subjected to an external axial load K_a. The blue curve represents bearing B, which becomes unloaded by the axial load.

The two bearings are preloaded by an axial displacement δ_0 of one bearing ring in relation to the other, resulting in a preload force F_0 acting on both bearings. When bearing A is subjected to an external axial load K_a, the force in the bearing will increase to F_{aA} while bearing B is unloaded to the residual force F_{aB}. Axial displacement of the bearing rings will follow the spring curves. The axial displacement δ_{Ka} of the preloaded bearing is less than for a bearing set that has not been preloaded but is subjected to the same axial load (δ'_{Ka}).

When the external axial load reaches the level where bearing B is completely unloaded, this load is called the “lifting force” (K_{a1}). This may occur e.g. when a spindle is subjected to heavy axial forces. In this case, the bearing is rotating at a relatively low speed and if the spindle is not subjected to strong acceleration, there is normally no resulting damage to the bearing. There is, however, a risk that the unloaded balls will stop rolling and start skidding, which can result in premature bearing damage.

The lifting force varies depending on the preload. For bearing sets where only one bearing accommodates the axial load, it can be estimated from

$$K_{a1} = 2{,}8\ F_0$$

For bearing sets where two bearings accommodate the axial load use

$$K_{a1} = 4{,}2\ F_0$$

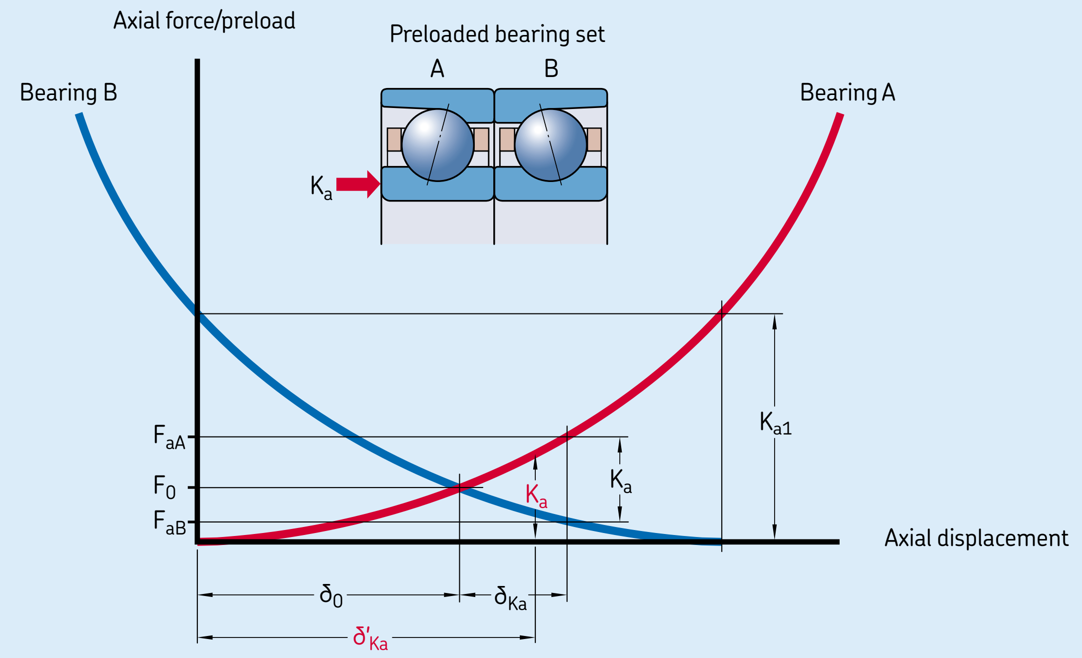
To avoid the lifting force phenomena, it is possible to increase the preload, or to use bearing sets with different contact angles. For additional information, contact the SKF application engineering service.

Preloading with springs

Using springs to apply preload to angular contact ball bearings is common, especially in high-speed grinding spindles. To preload with springs, it must be possible for a spring located on one side of the arrangement to displace the outer rings of both bearings in the axial direction.

Diagram 1

External axial loads on preloaded bearing sets



When using springs, the preload force remains practically constant under all operating conditions. For additional information concerning preloading with springs and values for preload force, refer to the section “Preload with constant force” (→ **page 122**).

Preloading with springs is not suitable for bearing applications where a high degree of stiffness is required, where the direction of load changes, or where undefined shock loads can occur.

Cylindrical roller bearings

Cylindrical roller bearings with a tapered bore are preloaded by driving the inner ring up onto its tapered seat. The resulting interference fit causes the inner ring to expand and to obtain the necessary preload. To accurately set preload, internal clearance gauges should be used. For additional information, refer to the sections ”Additional mounting recommendations for cylindrical roller bearings” (→ **page 86**) or “Adjusting for clearance or preload” (→ **page 208**).

Angular contact thrust ball bearings

Angular contact thrust ball bearings have a built-in preload so that when mounted correctly, a certain preload force exists. This preload force depends on the interference fit and may be influenced by operating conditions. For additional information, refer to the section “Effect of an interference fit on the preload” (→ **page 233**).

Under load, angular contact thrust ball bearings exhibit similar characteristics to angular contact ball bearings, therefore the information provided for angular contact ball bearings is valid. The lifting force for single direction angular contact thrust ball bearings for screw drives (bearings in the BSA and BSD series) is the same as for angular contact ball bearings. For double direction angular contact thrust ball bearings (bearings in the 2344(00) and BTM series), the lifting force can be estimated from

$$K_{a1} = 2{,}85\ F_0$$

System rigidity

System rigidity in machine tool applications is extremely important because the magnitude of deflection under load determines machining accuracy. Bearing stiffness is only one factor that influences system rigidity, others include

- shaft diameter
- tool overhang
- housing stiffness
- number and position of bearings and influence of fits.

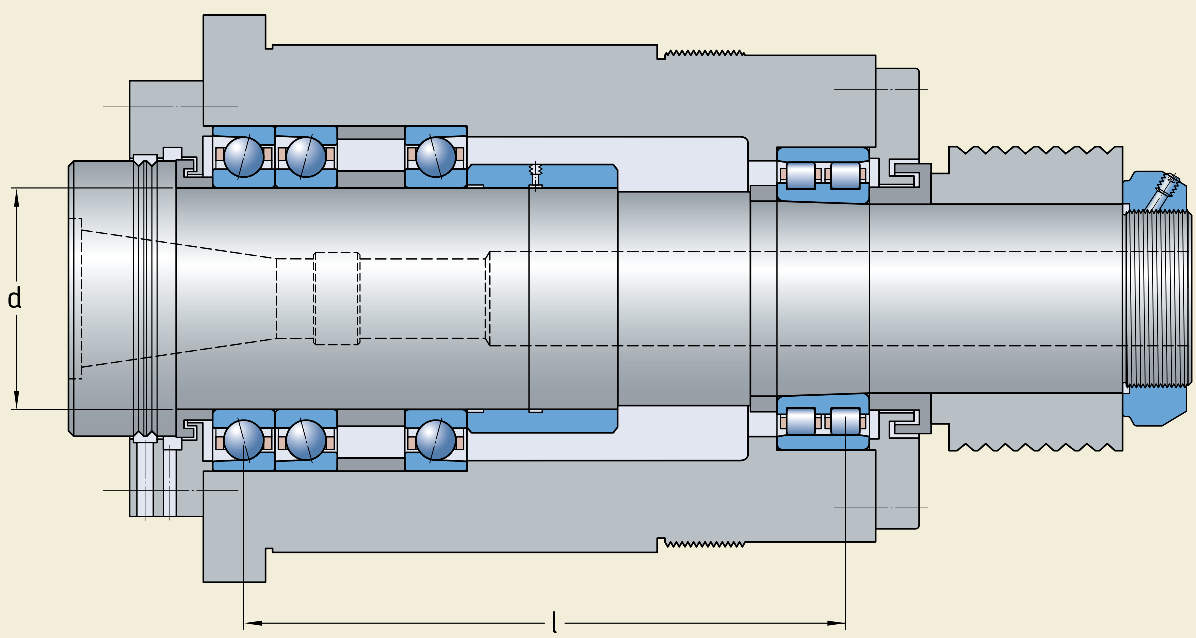
Some general guidelines for designing high-speed precision applications include:

- Select the largest possible shaft diameter.
- Minimize the distance between the tool end support position and the spindle nose.
- Keep the distance between the two bearing sets short (→ **fig. 1**). A guideline for the spacing is

$l \approx 3 \ldots 3{,}5\ d$

where
l = distance between the first tool end bearing row and the rearmost non-tool end bearing row
d = bore diameter of the tool end bearing

Fig. 1

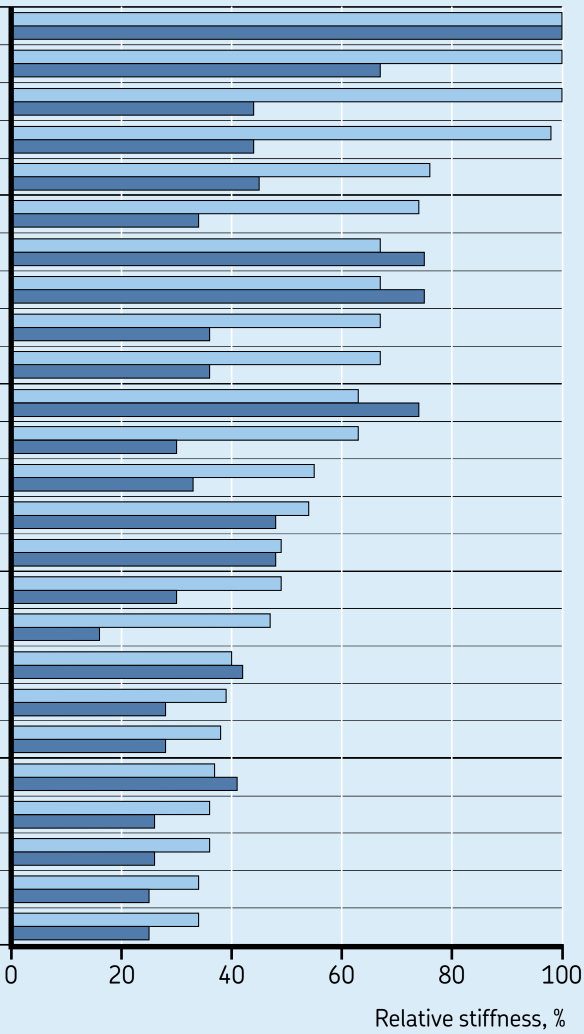


- Select a suitable bearing arrangement. **Diagram 1** provides an overview about the relative stiffness of different bearing arrangements. For details about the bearing series, refer to the section “Designation system” in the relevant product chapters. The comparison is based on preloaded bearings with 100 mm bore on the tool end and 90 mm bore on the non-tool end. These guideline values cannot be taken as tools for precise calculations of system rigidity. Contact the SKF application engineering service for advanced system analysis.

Diagram 1

Relative stiffness of typical spindle bearing arrangements

Tool end	Non-tool end
NN 3020 KTN + 234420	NN 3018 KTN
NN 3020 KTN + BTM 100 B	NN 3018 KTN
NN 3020 KTN + BTM 100 A	NN 3018 KTN
NN 3020 KTN + BTM 100 A	N 1018 KTN
7020 CD/QBCB	N 1018 KTN
71920 CE/QBCB	N 1018 KTNHA
71920 ACD/TBTB	NN 3018 KTN
71920 ACD/TBTB	71918 CD/DBA
7020 CD/TBTB	NN 3018 KTN
7020 CD/TBTB	7018 CD/DBA
7020 ACD/TBTB	7018 CD/DBA
7020 CE/QBCB	N 1018 KTNHA
7020 CE/HCDT	7018 CE/HCDT
7020 ACD/DBB	7018 CD/DBA
71920 ACE/HCTBTA	71918 CE/HCDBA
7020 CD/DT	7018 CE/DT
7020 CE/DBB	N 1018 KTNHA
71920 ACE/TBTA	71918 CE/DBA
7020 ACE/HCDBA	7018 CD/HCDBA
7020 ACE/HCDBA	N 1018 KTNHA/HC5
7020 ACE/TBTA	7018 CE/DBA
71920 ACE/DBA	N 1018 KTNHA
71920 ACE/DBA	71918 CE/DBA
7020 ACE/DBA	7018 CE/DBA
7020 ACE/DBA	N 1018 KTNHA



Radial stiffness
Axial stiffness

Bearing stiffness

The stiffness of a bearing depends on its type and size. The most important parameters are

- type of rolling elements (balls or rollers)
- number and size of rolling elements
- contact angle.

To enhance bearing stiffness, bearings can be preloaded. Preloading bearings is standard practice in machine tool applications.

A loose fit can have a negative influence on the total stiffness of a bearing arrangement; however, a loose housing fit may be necessary for bearing arrangements using angular contact ball bearings in the non-locating position. Typically the non-locating bearing position is on the non-tool end of a spindle. Therefore, the influence on system rigidity for the tool end is limited. If a high degree of stiffness is also desired for the non-tool end, a cylindrical roller bearing with a tapered bore should be used. It accommodates axial displacement within the bearing and enables an interference fit for both the inner ring and outer ring.

Bearing data – general

SKF high-precision bearings are manufactured to several general specifications. These specifications concerning dimensions, tolerances, preload or clearance, and materials are described in the following sections. Additional details are provided in the introductory text of the individual product chapters.

Boundary dimensions

Manufacturers and users of rolling bearings are, for reasons of price, quality and ease of replacement, only interested in a limited number of bearing sizes. Boundary dimensions of SKF high-precision bearings follow the ISO General Plans or conform to standard industry dimensions. General Plans valid for SKF high-precision bearings are in accordance with ISO 15:1998. Additional information is provided under the heading "Dimensions" in the introductory text of the individual product chapters.

Dimension Series

The ISO General Plans for boundary dimensions of radial bearings contain a progressive series of standardized outside diameters for every standard bore diameter, arranged in a Diameter Series. Within each Diameter Series different Width Series have been established. By combining a Width Series with a Diameter Series, a Dimension Series is derived.

For high-precision bearings, only a limited number of dimension series are used; mainly those in the 9 and 0 Diameter Series. **Table 1**, **page 42**, lists Diameter and Width Series used for SKF high-precision bearings.

Chamfer dimensions

Minimum values for the chamfer dimensions (→ **fig. 1**) in the radial direction (r_1, r_3) and the axial direction (r_2, r_4) are provided in the product tables. Minimum chamfer dimensions are in accordance with ISO 15:1998, ISO 12043:2007 or ISO 12044:1995.

The appropriate maximum chamfer limits, which are important when dimensioning fillet radii, are listed in **table 2**, **page 43**. The values are in accordance with ISO 582:1995.

Fig. 1

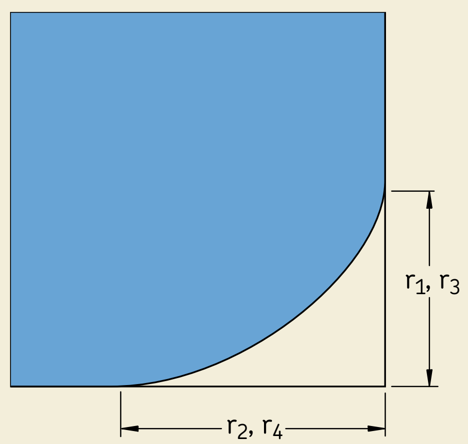


Table 1

Diameter and Width Series for SKF high-precision bearings

ISO General Plan Diameter Series	Width Series	SKF bearing series Designation	Bearing type
9	1	719 ACD	Angular contact ball bearing
	1	719 ACE	Angular contact ball bearing
	1	719 CD	Angular contact ball bearing
	1	719 CE	Angular contact ball bearing
	1	S719 ACD	Sealed angular contact ball bearing
	1	S719 CD	Sealed angular contact ball bearing
	1	S719 DB	Sealed angular contact ball bearing
	1	S719 FB	Sealed angular contact ball bearing
	4	NNU 49 B	Double row cylindrical roller bearing
	4	NNU 49 BK	Double row cylindrical roller bearing
0	1	70 ACD	Angular contact ball bearing
	1	70 ACE	Angular contact ball bearing
	1	70 CD	Angular contact ball bearing
	1	70 CE	Angular contact ball bearing
	1	S70 ACD	Sealed angular contact ball bearing
	1	S70 CD	Sealed angular contact ball bearing
	1	S70 DB	Sealed angular contact ball bearing
	1	S70 FB	Sealed angular contact ball bearing
	1	N 10 K	Single row cylindrical roller bearing
	3	NN 30	Double row cylindrical roller bearing
	3	NN 30 K	Double row cylindrical roller bearing
	–	2344(00)	Double direction angular contact thrust ball bearing
	–	BTM B	Double direction angular contact thrust ball bearing
	–	BTM A	Double direction angular contact thrust ball bearing
2	0	72 ACD	Angular contact ball bearing
	0	72 CD	Angular contact ball bearing
	–	BSA 2 CG	Angular contact thrust ball bearing for screw drives
3	–	BSA 3 CG	Angular contact thrust ball bearing for screw drives

Table 2

Maximum chamfer limits

Minimum single chamfer dimension r_s min	Nominal bearing bore diameter d		Maximum chamfer dimensions Radial bearings		Thrust bearings
	over	incl.	$r_{1,3}$ max	$r_{2,4}$ max	$r_{1,2,3,4}$ max
mm	mm		mm		
0,2	–	–	0,5	0,8	0,5
0,3	–	40	0,6	1	0,8
	40	–	0,8	1	0,8
0,6	–	40	1	2	1,5
	40	–	1,3	2	1,5
1	–	50	1,5	3	2,2
	50	–	1,9	3	2,2
1,1	–	120	2	3,5	2,7
	120	–	2,5	4	2,7
1,5	–	120	2,3	4	3,5
	120	–	3	5	3,5
2	–	80	3	4,5	4
	80	220	3,5	5	4
	220	–	3,8	6	4
2,1	–	280	4	6,5	4,5
	280	–	4,5	7	4,5
2,5	–	100	3,8	6	–
	100	280	4,5	6	–
	280	–	5	7	–
3	–	280	5	8	5,5
	280	–	5,5	8	5,5
4	–	–	6,5	9	6,5
5	–	–	8	10	8
6	–	–	10	13	10
7,5	–	–	12,5	17	12,5

Table 3

Tolerance symbols

Tolerance symbol	Definition
	Bore diameter
d	Nominal bore diameter
d_s	Single bore diameter
d_{mp}	Mean bore diameter; arithmetical mean of the largest and smallest single bore diameters in one plane
Δ_{ds}	Deviation of a single bore diameter from the nominal ($\Delta_{ds} = d_s - d$)
Δ_{dmp}	Deviation of the mean bore diameter from the nominal ($\Delta d_{mp} = d_{mp} - d$)
Δ_{d2mp}	Deviation of the mean bore diameter at the small end of a tapered bore from the nominal; arithmetical mean of the largest and smallest single bore diameters, measured in one plane in a defined distance from the bearing side face
Δ_{d3mp}	Deviation of the mean bore diameter at the large end of a tapered bore from the nominal; arithmetical mean of the largest and smallest single bore diameters, measured in one plane in a defined distance from the bearing side face
V_{dp}	Bore diameter variation; difference between the largest and smallest single bore diameters in one plane
V_{dmp}	Mean bore diameter variation; difference between the largest and smallest mean bore diameter
	Outside diameter
D	Nominal outside diameter
D_s	Single outside diameter
D_{mp}	Mean outside diameter; arithmetical mean of the largest and smallest single outside diameters in one plane
ΔD_s	Deviation of a single outside diameter from the nominal ($\Delta D_s = D_s - D$)
ΔD_{mp}	Deviation of the mean outside diameter from the nominal ($\Delta D_{mp} = D_{mp} - D$)
VD_p	Outside diameter variation; difference between the largest and smallest single outside diameters in one plane
VD_{mp}	Mean outside diameter variation; difference between the largest and smallest mean outside diameter
	Width or height
B, C	Nominal width of inner ring and outer ring, respectively
B_s, C_s	Single width of inner ring and outer ring, respectively
B_{1s}, C_{1s}	Single width of inner ring and outer ring, respectively, of a bearing belonging to a matched set
Δ_{Bs}, Δ_{Cs}	Deviation of single inner ring width or single outer ring width from the nominal ($\Delta B_s = B_s - B$; $\Delta C_s = C_s - C$)
Δ_{B1s}, Δ_{C1s}	Deviation of single inner ring width or single outer ring width of a bearing belonging to a matched set from the nominal (not valid for universally matchable bearings) ($\Delta B_{1s} = B_{1s} - B_1$; $\Delta C_{1s} = C_{1s} - C_1$)
V_{Bs}, V_{Cs}	Ring width variation; difference between the largest and smallest single widths of inner ring and of outer ring, respectively
T	Nominal height of a thrust bearing (H)
T_s	Single height
ΔT_s	Deviation of height of single direction thrust bearing from the nominal
ΔT_{2s}	Deviation of height of double direction thrust bearing from the nominal

cont. table 3

Tolerance symbols	
Tolerance symbol	**Definition**
	Running accuracy
K_{ia}, K_{ea}	Radial runout of inner ring and outer ring, respectively, of assembled bearing
S_d	Side face runout with reference to bore (of inner ring)
S_D	Outside inclination variation; variation in inclination of outside cylindrical surface to outer ring side face
S_{ia}, S_{ea}	Axial runout of inner ring and outer ring, respectively, of assembled bearing
S_i, S_e	Thickness variation, measured from middle of raceway to back (seat) face of shaft washer and of housing washer, respectively (axial runout)

Tolerances

SKF high-precision bearings are manufactured to tolerance classes similar to internationally standardized tolerance classes. Standards for rolling bearing tolerances are:

- ISO 199:2005
  Rolling bearings – Thrust bearings – Tolerances.
- ISO 492:2002
  Rolling bearings – Radial bearings – Tolerances.

For an overview about available bearing types and tolerance classes, refer to the section "Precision" under "Basic selection criteria" (→ **page 17**).

Actual tolerance values are provided under the heading "Tolerances" in the introductory text of the individual product chapters. The tolerance symbols used there are listed together with their definitions in **table 3**.

Preload and internal clearance

Preload in angular contact ball bearings and angular contact thrust ball bearings

SKF high-precision angular contact ball bearings for mounting in sets and angular contact thrust ball bearings are manufactured with a built-in preload. Preload is the axial force required to press the bearing rings of a bearing set or the inner ring parts of a double direction thrust ball bearing together to a zero distance.

It is necessary to distinguish between the preload in an unmounted bearing set and a mounted bearing set in operation. 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 and change the actual preload.

Details about the preload in unmounted bearings and ways to estimate the preload in operation are provided in the introductory texts of the individual product chapters.

Internal clearance or preload in cylindrical roller bearings

SKF high-precision cylindrical roller bearings are manufactured with radial internal clearance. Radial internal clearance is defined as the total distance through which one bearing ring can be moved relative to the other in the radial direction. It is necessary to distinguish between the radial internal clearance before mounting and the condition in a mounted bearing that has reached its operating temperature. Internal clearance in the bearing prior to mounting will be reduced after the bearing has been mounted. Factors that affect internal clearance include the degree of the interference fit and thermal expansion of the bearing rings and associated components. In some cases, these factors can reduce clearance enough to create a preload in the bearing.

Details about the internal clearance in unmounted bearings and recommendations about clearance or preload in operation are provided in the introductory text of the relevant product chapter.

Cages

Bearing cages can greatly influence the suitability of a rolling bearing for a particular application. The primary purpose of a bearing cage is to

- separate the rolling elements and keep them spaced evenly for uniform load distribution
- reduce the noise level
- guide the rolling elements in the unloaded zone to improve rolling conditions and prevent damaging sliding movements
- retain the rolling elements when mounting separable bearings.

Cages are stressed by friction, inertia forces and heat. Depending on the material, cages can also be affected by certain lubricants, lubricant additives or by-products when ageing, organic solvents or coolants. Therefore cage design and material are of paramount importance for the performance and the operational reliability of the bearing.

In the introductory text of each product chapter information is provided about standard cages fitted to the bearings and alternatives, if available. Standard cages are those considered most suitable for the majority of typical applications.

Materials

The material from which a bearing component is made determines to a large extent the performance and reliability of that bearing. For the bearing rings and rolling elements typical considerations include hardness for load carrying capacity, fatigue resistance under rolling contact conditions, under clean or contaminated lubrication conditions, and the dimensional stability of the bearing components. For the cage, considerations include friction, strain, heat, inertia forces, and in some cases, the chemical action of certain lubricants, solvents, coolants and refrigerants. Seals integrated in rolling bearings can also have a considerable impact on the performance and reliability of the bearings. The material of the seals must withstand oxidation and offer excellent thermal or chemical resistance.

Because SKF has the competence and facilities to provide a variety of materials, processes and coatings, SKF application engineers can assist in selecting those bearings that can provide superior performance for a particular application.

Materials for bearing rings and rolling elements

Standard steel for high-precision bearings

The standard steel used to produce SKF high-precision bearings is a through-hardening carbon chromium steel, containing approximately 1 % carbon and 1,5 % chromium, in accordance with ISO 683-17:1999. The composition of this rolling bearing steel provides an optimum balance between manufacturing and application performance. Bearing rings and rolling elements are subjected to a martensitic heat treatment that provides sufficient resistance to subsurface rolling contact fatigue, sufficient static carrying capacity and structural strength combined with adequate dimensional stability.

SKF high-precision bearings are dimensionally stabilized up to 150 °C. But other factors like cage material, seal material or lubricant might limit the permissible operating temperature.

For information about material properties, refer to **table 4**.

Nitrogen steel

To improve corrosion resistance, the use of nitrogen as an alloying element has been introduced to bearing steel development. Nitrogen leads to the precipitation of chromium nitrides rather than chromium carbides, enabling a much higher content of chromium to be dissolved in the steel matrix. The result is a steel that better resists oxidation and provides longer bearing service life.

Nitrogen steel is used for Nitroalloy high-performance bearings. Contact the SKF application engineering service, prior to selecting Nitroalloy bearings.

Ceramics for rolling elements

The common ceramic used for rolling elements in SKF high-precision bearings is a bearing grade silicon nitride material. It consists of fine elongated grains of beta-silicon nitride in a glassy phase matrix. It provides a combination of favourable properties especially for high-speed bearings

- high hardness
- high modulus of elasticity
- low density
- low coefficient of thermal expansion.

For information about material properties, refer to **table 4**.

Cage materials

Fabric reinforced phenolic resin

Fabric reinforced phenolic resin is used as standard for cages in high-precision angular contact ball bearings. The lightweight material is strong and minimizes centrifugal and inertia forces. It supports lubricant retention in the bearing. Fabric reinforced phenolic resin can be used for operating temperatures up to 120 °C.

Polyamide 66

Polyamide 66, with or without glass fibre reinforcement, is used for cages in many high-precision cylindrical roller bearings and angular contact thrust ball bearings. Polyamide 66 is characterized by a favourable combination of strength and elasticity. Due to its excellent sliding properties on lubricated steel surfaces and the superior finish of the contact surfaces, polyamide 66 cages promote low friction, low heat generation and low wear. Polyamide 66 can be used for operating temperatures up to 120 °C, provided it does not come in contact with agressive lubricants. Aggressive lubricants (e.g. oils with EP-additives or some synthetic oils) may promote ageing effects that can be compensated for by reducing the normal operating temperature. For additional information about polyamide 66, refer to the SKF General Catalogue.

Polyetheretherketone (PEEK)

Glass fibre reinforced PEEK is used as standard for cages in some high-precision angular contact ball bearings and can be used for other bearings, mainly to attain higher speeds. The exceptional properties of PEEK provide a superior combination of strength and flexibility. It can also accommodate higher operating temperatures while providing high chemical and wear resistance. The material does not show signs of ageing from temperature or oil additives up to 200 °C. However, the maximum temperature for high-speed use is limited to 150 °C as this is the softening temperature of the polymer.

Table 4

Material properties of bearing grade silicon nitride and bearing steel

Material properties	**Bearing grade silicon nitride**	**Bearing steel**
Mechanical properties		
Density (g/cm^3)	3,2	7,9
Hardness	1 600 HV10	700 HV10
Modulus of elasticity (kN/mm^2)	310	210
Coefficient of thermal expansion (10^{-6}/K)	3	12
Electrical properties (at 1 MHz)		
Electrical resistivity (Ωm)	1012 (insulator)	$0{,}4 \times 10^{-6}$ (conductor)
Dielectric strength (kV/mm)	15	–
Relative dielectric constant	8	–

Brass

Machined brass cages are used for a number of high-precision double row cylindrical roller bearings and double direction angular contact thrust ball bearings. They are unaffected by most common bearing lubricants, including synthetic oils and greases. Brass cages can be used at temperatures up to 250 °C.

Other cage materials

In addition to the materials described above, SKF high-precision bearings for special applications may be fitted with cages made of other engineered polymers, light alloys or silver-plated steel. For information about cages made from alternative materials, contact the SKF application engineering service.

Seal materials

Seals integrated in SKF high-precision bearings are typically made from elastomers that are reinforced with sheet steel. The elastomer materials generally used are described below.

Acrylonitrile-butadiene rubber

Acrylonitrile-butadiene rubber (NBR) is the "universal" seal material. This copolymer, produced from acrylonitrile and butadiene, shows good resistance to the following media

- most mineral oils and greases with a mineral oil base
- normal fuels: petrol, diesel and light heating oils
- animal and vegetable oils and fats
- hot water.

NBR also tolerates short-term dry running of the sealing lip. The permissible operating temperature range is –40 to +100 °C; for brief periods temperatures of up to 120 °C can be tolerated. At higher temperatures the material hardens.

Fluoro rubber

Fluoro rubbers (FKM) are characterized by their high thermal and chemical resistance. Their resistance to ageing and ozone is very good and their gas permeability is very slight. They have exceptionally good wear characteristics even under harsh environmental conditions and can withstand operating temperatures up to 200 °C. Seals made from this material can tolerate dry running of the lip for short periods. Fluoro rubbers are also resistant to oils and hydraulic fluids, fuels and lubricants, mineral acids and aliphatic as well as aromatic hydrocarbons, which would cause seals made from other materials to fail. In the presence of esters, ethers, ketones, certain amines and hot anhydrous hydrofluorides, fluoro rubbers should not be used.

At temperatures above 300 °C, fluoro rubber gives off dangerous fumes. As handling seals made of fluoro rubber constitutes a potential safety risk, the safety precautions mentioned hereafter must always be considered.

WARNING!

Safety precautions for fluoro rubber
Fluoro rubber is very stable and harmless in normal operating conditions up to 200 °C. However, if exposed to extreme temperatures above 300 °C, e.g. fire or the flame of a cutting torch, fluoro rubber seals give off hazardous fumes. These fumes can be harmful if inhaled, as well as to the eyes. In addition, once the seals have been heated to such temperatures, they are dangerous to handle even after they have cooled and should not be in contact with the skin.

If it is necessary to handle bearings with seals that have been subjected to high temperatures, such as when dismounting the bearing, the following safety precautions should be observed:

- Always wear protective goggles, gloves and appropriate breathing apparatus.
- Place the remains of the seals in an airtight plastic container marked with a symbol for “material will etch”.
- Follow the safety precautions in the appropriate material safety data sheet (MSDS).

If contact is made with the seals or if fumes have been inhaled, wash hands thoroughly; flush eyes with plenty of water and consult a doctor immediately.

The user is responsible for the correct use of the product during its service life and its proper disposal. SKF takes no responsibility for the improper handling of fluoro rubber seals or for any injury resulting from their use.

Application of bearings

Bearing arrangements

The majority of high-precision bearings are used in machine tool spindles. Depending on the type of machine tool and its intended purpose, spindles may have different requirements regarding bearing arrangements.

Bearing arrangements for heavy loads

Lathe spindles are typically used to cut metals at relatively low speeds. Depth of cut and feed rates are usually pushed to the limit and depend on the required surface finish. In a lathe, power is normally transmitted through a pulley or toothed gears, resulting in heavy radial loads at the non-tool end of the shaft. On the tool end of the shaft, where there are heavy combined loads, a high degree of rigidity and high load carrying capacity are important operational requirements.

In a lathe spindle it is common to have a double row cylindrical roller bearing at the non-tool end and a double row cylindrical roller bearing in combination with a double row angular contact thrust ball bearing at the tool end (→ **fig. 1**, **page 52**). The outside diameter of the thrust bearing housing washer is manufactured to a special tolerance, enabling the bearing to be radially free when mounted in the housing. This prevents the bearing from carrying any radial load. This bearing arrangement provides a long calculated life and a high degree of rigidity and stability so that good quality work pieces can be produced.

A good rule of thumb is to have the distance between the tool end and non-tool end bearing centres in the range 3–3,5 times the bore diameter of the bearing at the tool end. This rule applies in general where heavy loads are involved.

Additional arrangements for CNC lathes and conventional milling machines (→ **fig. 2**, **page 52** and **fig. 3**, **page 53**) and live centres (→ **fig. 4**, **page 53**) are provided.

Bearing arrangements for greater rigidity and higher speeds

When higher speeds are required, as is the case for high-speed machining centres ($A > 1\,200\,000$ mm/min), there is typically a compromise between rigidity and load carrying capacity. In these applications, the spindle is usually driven directly by a motor (motorized spindles), or through a coupling. Therefore, there are no radial loads on the non-tool end as is the case with a belt driven spindle. Consequently, single row angular contact ball bearings paired in sets and single row cylindrical roller bearings are frequently used (→ **fig. 5**, **page 54**).

In this bearing system, the tool end bearing set is axially located, while the cylindrical roller bearing on the non-tool end enables axial displacement within the bearing, due to spindle elongation. Another arrangement example for high-speed machining centres, turning centres and milling operations is shown in **fig. 6**, **page 54**.

If enhanced performance is required, SKF recommends using hybrid bearings equipped with silicon nitride rolling elements.

Maximum speed bearing arrangements

When exceptionally high speeds (A > 2 000 000 mm/min) are involved, i.e. internal grinding applications, it is quite common to see angular contact ball bearings preloaded by springs on both ends of the spindle (→ **figs. 7** and **8**, **page 55**). This is done to control preload and the amount of heat generated by the bearings. When sets of angular contact ball bearings are preloaded by a constant axial load, preload and the resulting heat increases with speed.

However, when springs are used to apply an axial preload, preload remains constant with speed, thereby improving the kinematic behaviour and reducing the amount of heat generated by the bearings. An even better solution than springs is to preload angular contact ball bearings with a hydraulic system. Using hydraulics, the amount of preload can be adjusted according to the speed of the spindle, therefore obtaining the best possible combination of rigidity, heat generation and bearing service life.

Fig. 1

Tool end: NN 30 K + 2344(00); non-tool end: NN 30 K

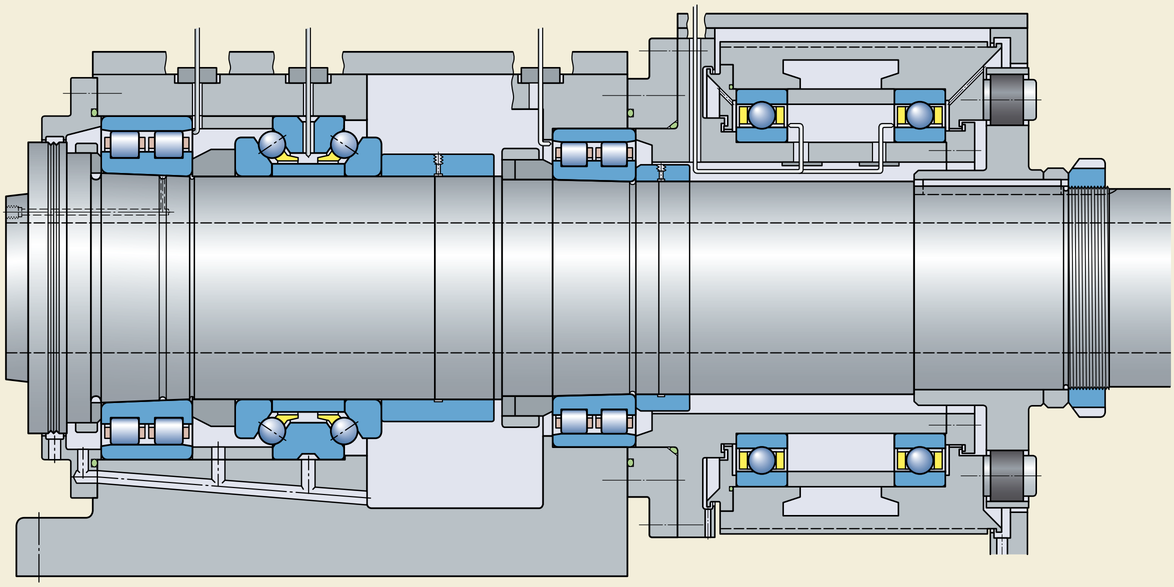


Fig. 2

Tool end: 70 ACD/P4ATBT; non-tool end: NN 30 K

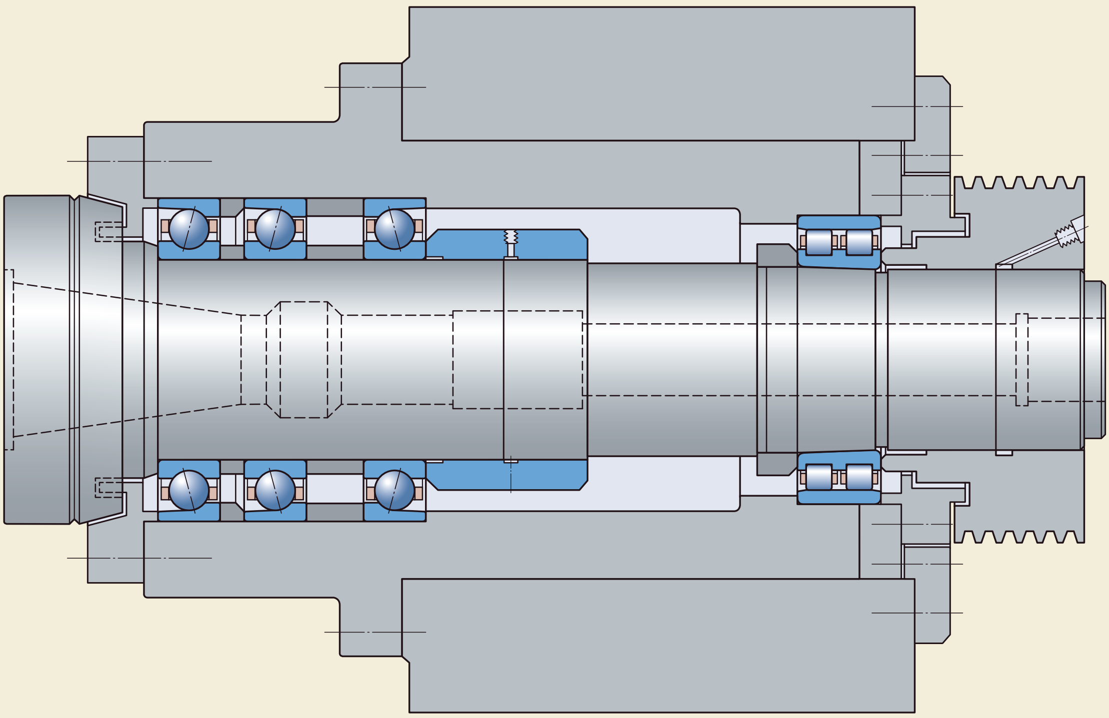


Fig. 3

Tool end: N 10 KTN + BTM-A/HC; non-tool end: N 10 KTN

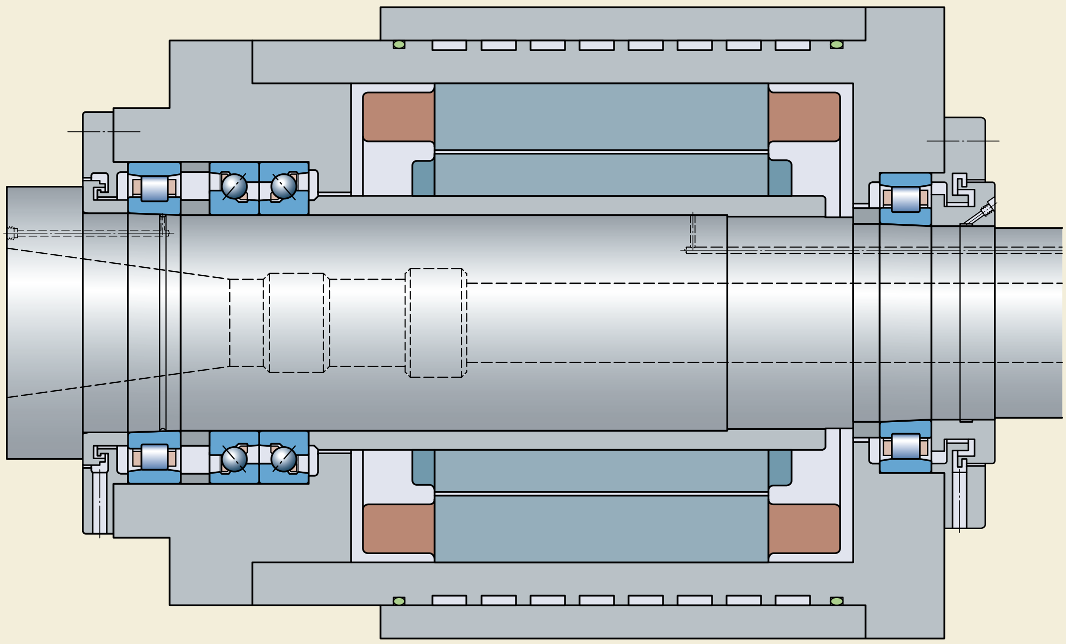


Fig. 4

Tool end: NN 30 K; non-tool end: 72 ACD/P4AQBT

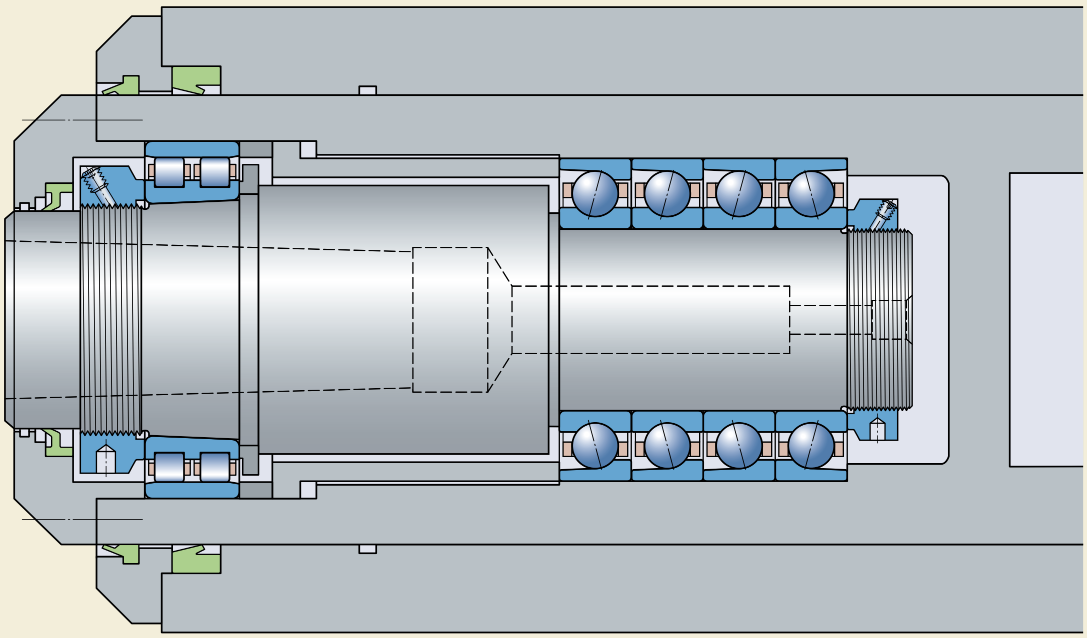


Fig. 5

Tool end: 70 CE/HCP4ADB; non-tool end: N 10 KTN
or
tool end: 70 CD/P4ADB; non-tool end: N 10 KTN

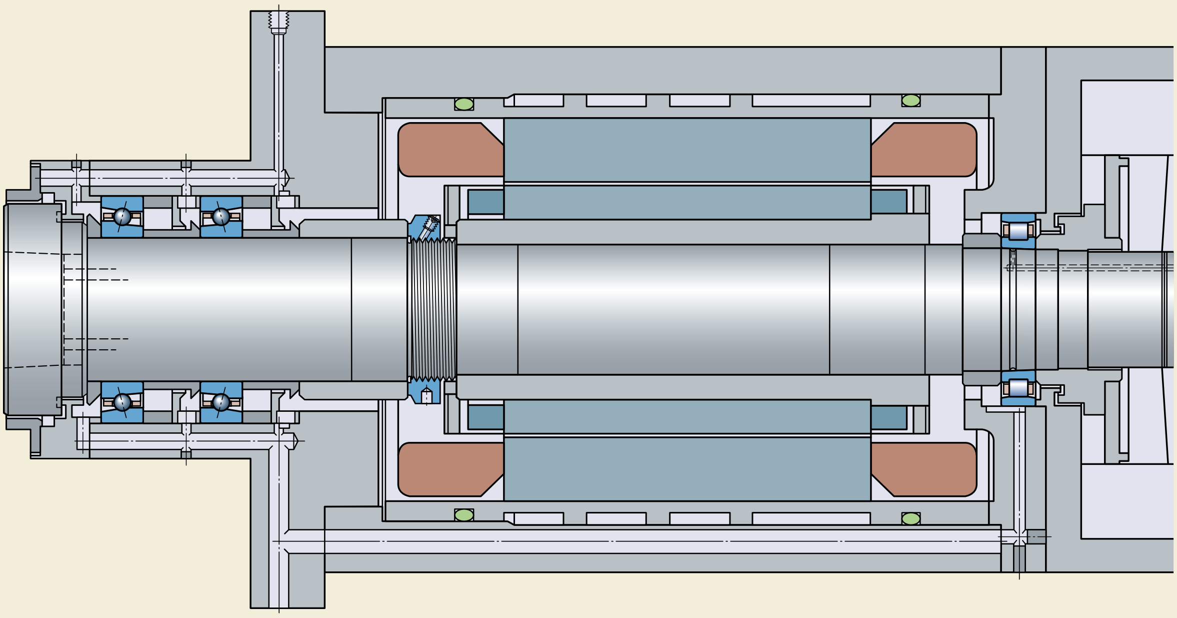


Fig. 6

Tool end: 70 CD/P4AQBC; non-tool end: 70 CD/P4A
or
tool end: 70 CE/HCP4AQBC; non-tool end: 70 CE/HCP4A

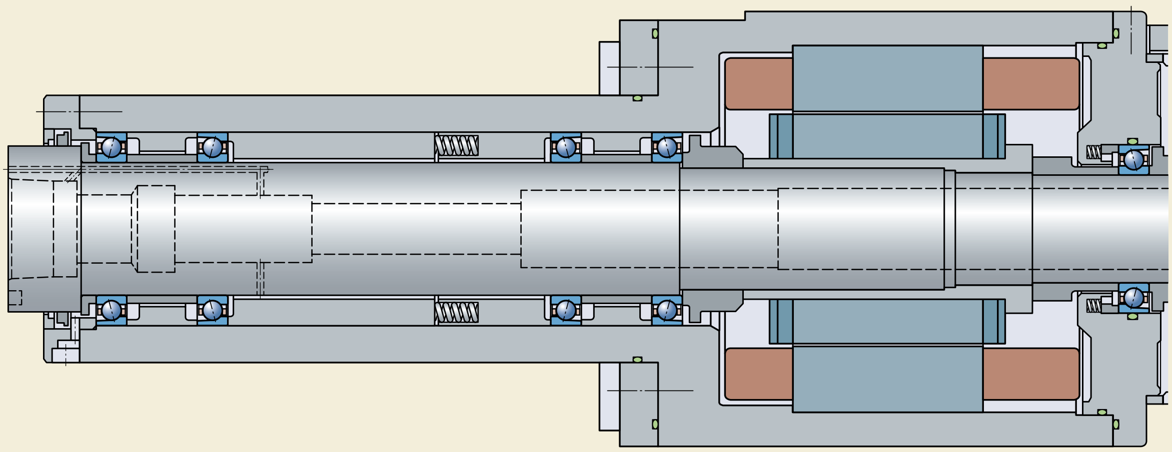


Fig. 7

Tool end: 70 CE/HCP4A; non-tool end: 70 CE/HCP4A

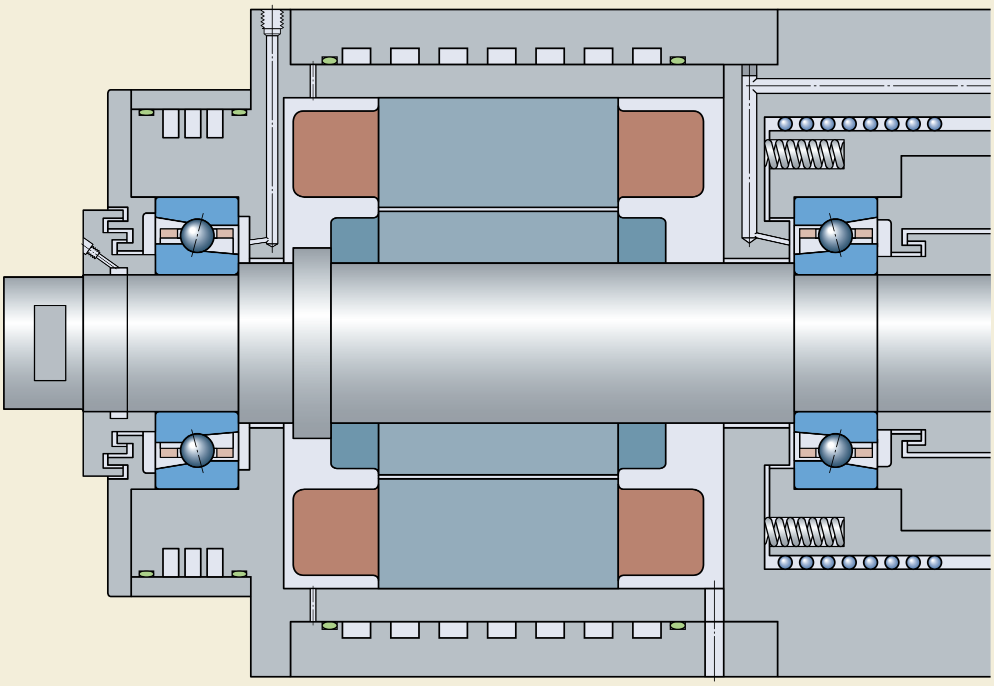
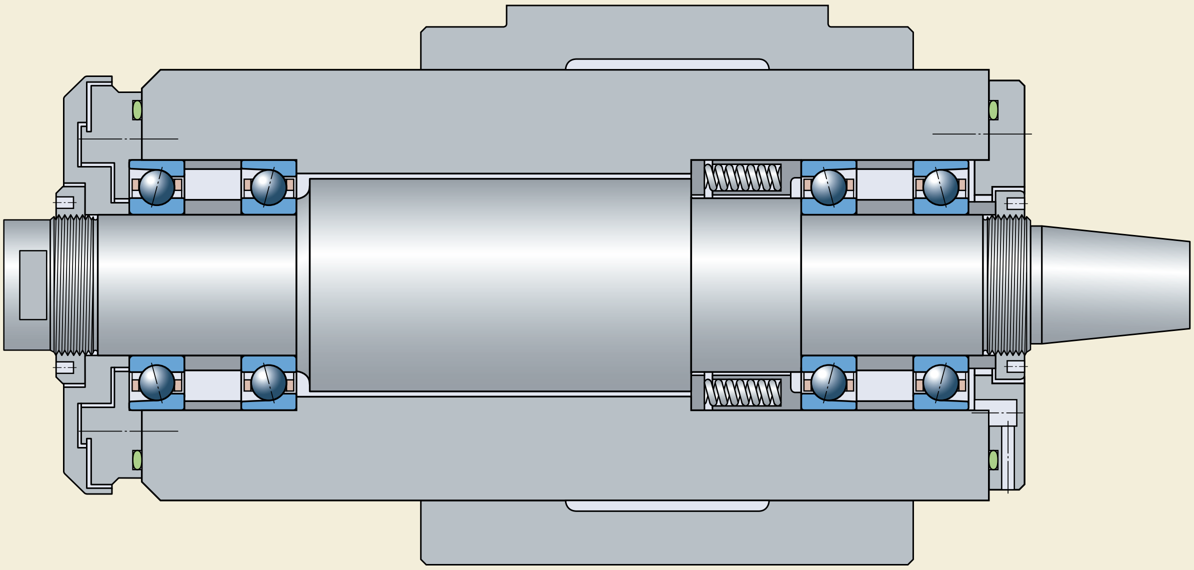


Fig. 8

Tool end: 70 CD/HCP4ADT; non-tool end: 70 CD/HCP4ADT



Radial location of bearings

If the load carrying ability of a bearing is to be fully utilized, its rings or washers must be supported around their complete circumference and across the entire width of the raceway. The support, which must be firm and even, can be provided by a cylindrical or tapered seat or for thrust bearing washers, by a flat (plane) support surface. This means that bearing seats must be made with adequate accuracy and their surfaces should not be interrupted by grooves, holes or other features, unless the seat is prepared to apply the oil injection method. This is particularly important for high-precision bearings that have relatively thin rings, which tend to reproduce the shape of the shaft or housing seat. In addition, the bearing rings must be reliably secured to prevent them from turning on, or in their seats under load.

In general, 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 usually cause damage to the bearings and associated components. However, when easy mounting and dismounting are desirable, or when axial displacement is required with a non-separable bearing, an interference fit cannot always be used. In certain cases where a loose fit is employed, it is necessary to take special precautions to limit the inevitable wear from creep by, for example, surface hardening the bearing seat and abutments.

Recommended shaft and housing fits

Appropriate shaft and housing tolerances for high-precision bearings are provided in **tables 1** and **2**. The shaft tolerances are also applicable for hollow spindles unless the speed is very high (A > 1 200 000 mm/min). In these special cases, contact the SKF application engineering service.

The table of housing tolerance recommendations also provides information as to whether or not the outer ring of an angular contact ball bearing can be axially displaced in the housing bore. For double direction angular contact thrust ball bearings, the outside diameter of the housing washer is made to tolerances such that sufficient radial clearance in the housing bore seat is obtained. Therefore, for bearings in the 2344(00) and BTM series mounted adjacent to an appropriate cylindrical roller bearing in the same housing bore seat, tolerances tighter than those recommended in **table 2** should not be used. For detailed information, refer to the chapter “Double direction angular contact thrust ball bearings” (**→ page 227**).

In the case of angular contact ball and cylindrical roller bearings operating under normal conditions i.e. moderate loads and speeds, it is preferable to work with the particular interference/clearance values shown in **tables 3** and **4**. For extreme conditions, such as very high speeds or heavy loading, contact the SKF application engineering service.

Specific recommendations for angular contact thrust ball bearings for screw drives are provided in the relevant product chapter (**→ page 243**).

Table 3

Preferred shaft fits

Bearing type	**Bearing bore** over	incl.	**Interference**
–	mm		µm
Angular contact ball bearings	–	50	0–2
	50	80	1–3
	80	120	1–4
	120	150	2–5
	150	200	2–6

Table 1

Fits for steel shafts

Bearing type	Shaft diameter		Tolerance for bearings to tolerance class	
	over	incl.	P4A, P7, SP, P4C	PA9A, P9, UP
–	mm		–	
Angular contact ball bearings				
with rotating outer ring load	–	240	h4	h3
with rotating inner ring load	–	240	js4	js3
Cylindrical roller bearings				
with cylindrical bore	–	40	js4	–
	40	140	k4	–
	140	200	m5	–
	200	500	n5	–
Double direction angular contact thrust ball bearings	–	200	h4	h3

Table 2

Fits for cast iron and steel housings

Bearing type	Conditions	Tolerance for bearings to tolerance class	
		P4A, P7, SP, P4C	PA9A, P9, UP
Angular contact ball bearings	Non-locating bearings, displacement of outer ring desired	H5[1)]	H4[1)]
	Locating bearings, displacement of outer ring not required	JS5	JS4
	Rotating outer ring load	M5	M4
Cylindrical roller bearings	Normal and light loads	K5	K4
	Heavy loads, rotating outer ring loads	M5	M4
Double direction angular contact thrust ball bearings	–	K5	K4

1) Use upper half of tolerance range when heavy belt and gear loads are acting at the non-tool end

Table 4

Preferred housing fits

Bearing type	Outside diameter		Clearance		Interference
	over	incl.	locating	non-locating	
–	mm		µm		µm
Angular contact ball bearings	–	50	0–2	5–8	–
	50	120	0–3	6–10	–
	120	150	0–4	8–12	–
	150	250	0–5	10–15	–
Cylindrical roller bearings	–	460	–	–	0–2

Tolerance tables

Appropriate ISO shaft and housing tolerance limits for high-precision bearings are provided in **tables 5** and **6**. The position of the tolerance grades relative to the bearing bore and outside diameter tolerances are illustrated in **diagram 1**.

Table 5

ISO tolerance limits for shafts

Shaft diameter Nominal over	incl.	**Tolerance** h4 Limits high	h4 low	h3 high	h3 low	js3 high	js3 low	js4 high	js4 low	js5 high	js5 low
mm		µm									
6	**10**	0	–4	0	–2,5	+1,25	–1,25	+2	–2	+3	–3
10	**18**	0	–5	0	–3	+1,5	–1,5	+2,5	–2,5	+4	–4
18	**30**	0	–6	0	–4	+2	–2	+3	–3	+4,5	–4,5
30	**50**	0	–7	0	–4	+2	–2	+3,5	–3,5	+5,5	–5,5
50	**80**	0	–8	0	–5	+2,5	–2,5	+4	–4	+6,5	–6,5
80	**120**	0	–10	0	–6	+3	–3	+5	–5	+7,5	–7,5
120	**180**	0	–12	0	–8	+4	–4	+6	–6	+9	–9
180	**250**	0	–14	0	–10	+5	–5	+7	–7	+10	–10
250	**315**	0	–16	0	–12	+6	–6	+8	–8	+11,5	–11,5

Shaft diameter Nominal over	incl.	**Tolerance** js6 Limits high	js6 low	k4 high	k4 low	k5 high	k5 low	m5 high	m5 low	n5 high	n5 low
mm		µm									
6	**10**	+4,5	–4,5	+5	+1	+7	+1	+12	+6	+16	+10
10	**18**	+5,5	–5,5	+6	+1	+9	+1	+15	+7	+20	+12
18	**30**	+6,5	–6,5	+8	+2	+11	+2	+17	+8	+24	+15
30	**50**	+8	–8	+9	+2	+13	+2	+20	+9	+28	+17
50	**80**	+9,5	–9,5	+10	+2	+15	+2	+24	+11	+33	+20
80	**120**	+11	–11	+13	+3	+18	+3	+28	+13	+38	+23
120	**180**	+12,5	–12,5	+15	+3	+21	+3	+33	+15	+45	+27
180	**250**	+14,5	–14,5	+18	+4	+24	+4	+37	+17	+51	+31
250	**315**	+16	–16	+20	+4	+27	+4	+43	+20	+57	+34

Diagram 1

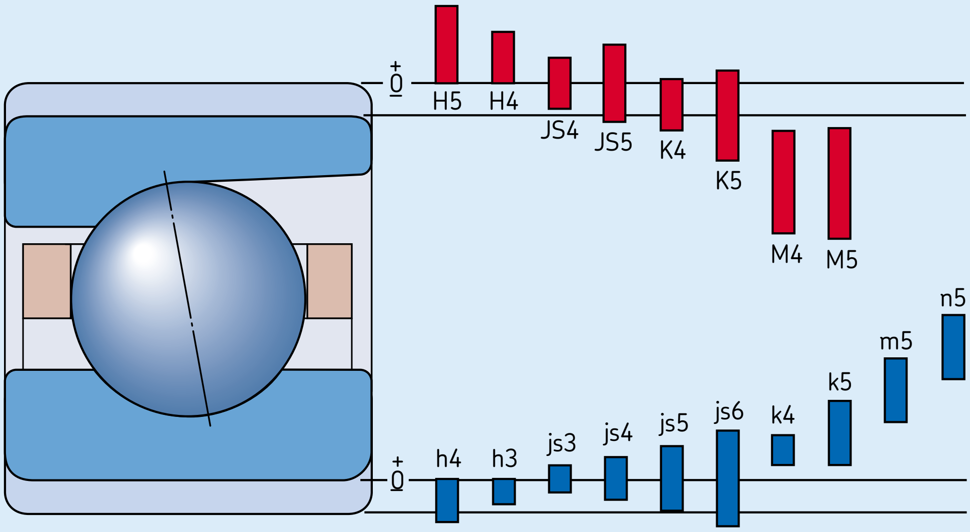


Table 6

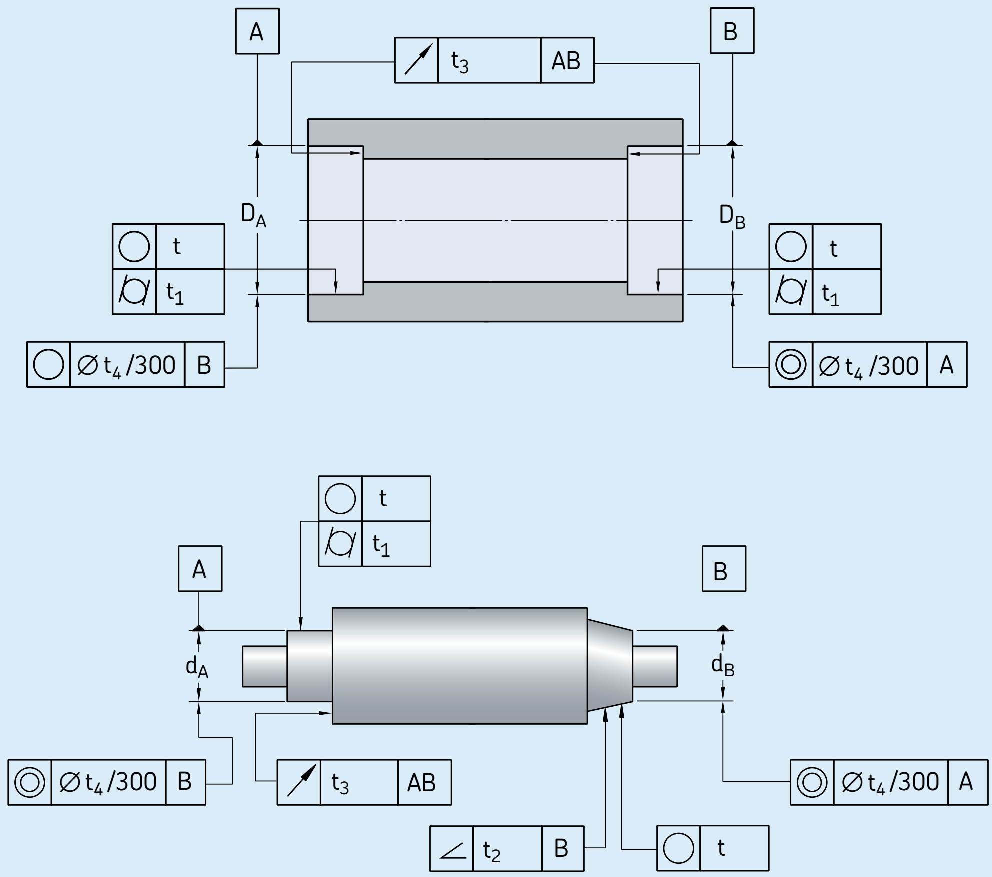
ISO tolerance limits for housings

Housing bore diameter Nominal over	incl.	Tolerance H5 Limits high	low	H4 high	low	JS4 high	low	JS5 high	low
mm		µm							
18	**30**	+9	0	+6	0	+3	–3	+4,5	–4,5
30	**50**	+11	0	+7	0	+3,5	–3,5	+5,5	–5,5
50	**80**	+13	0	+8	0	+4	–4	+6,5	–6,5
80	**120**	+15	0	+10	0	+5	–5	+7,5	–7,5
120	**180**	+18	0	+12	0	+6	–6	+9	–9
180	**250**	+20	0	+14	0	+7	–7	+10	–10
250	**315**	+23	0	+16	0	+8	–8	+11,5	–11,5
315	**400**	+25	0	+18	0	+9	–9	+12,5	–12,5
400	**500**	+27	0	+20	0	+10	–10	+13,5	–13,5

Housing bore diameter Nominal over	incl.	Tolerance K4 Limits high	low	K5 high	low	M4 high	low	M5 high	low
mm		µm							
18	**30**	0	–6	+1	–8	–6	–12	–5	–14
30	**50**	+1	–6	+2	–9	–6	–13	–5	–16
50	**80**	+1	–7	+3	–10	–8	–16	–6	–19
80	**120**	+1	–9	+2	–13	–9	–19	–8	–23
120	**180**	+1	–11	+3	–15	–11	–23	–9	–27
180	**250**	0	–14	+2	–18	–13	–27	–11	–31
250	**315**	0	–16	+3	–20	–16	–32	–13	–36
315	**400**	+1	–17	+3	–22	–16	–34	–14	–39
400	**500**	0	–20	+2	–25	–18	–38	–16	–43

Table 7

Accuracy of form and position for bearing seats on shafts and in housings



Characteristic	Symbol	Tolerance zone	Permissible deviations for bearings to tolerance class P4A, P7, SP, P4C	PA9A, P9, UP
Roundness	○	t	IT2/2	IT1/2
Cylindricity	⌭	t_1	IT2/2	IT1/2
Angularity	∠	t_2	IT3/2	IT2/2
Circular axial runout	↗	t_3	IT1	IT0
Coaxiality	◎	t_4	IT4	IT3

Accuracy of seats and abutments

Form and running accuracy

Maximum running accuracy, high speeds and low operating temperatures can only be achieved, even with high-precision bearings, if the mating parts and other associated components are made with equal precision as the bearings. Deviations from geometric form of associated seats and abutments must therefore be kept to a minimum when machining mating parts. Form and position recommendations in accordance with ISO 1101:2004 are provided in **table 7**.

Thin-walled bearing rings adapt themselves to the form of their seat. Any errors of form in the shaft or housing bore seat can therefore affect the bearing raceways and bearing performance e.g. angular misalignment of one bearing ring relative to the other, can cause high operating temperatures, particularly at high speeds.

The numerical values of applicable ISO tolerance grades IT are provided in **table 8**.

Surface roughness

The surface roughness of a bearing seat influences, to some extent, the dimensional accuracy. For bearing arrangements where demands for accuracy are high, guideline values for the surface roughness R_a to DIN 7184 are provided in **table 9**. The roughness class N values conform to ISO 1302:2002.

Table 8

ISO tolerance grades

Nominal dimension over	incl.	Tolerance grades IT0 max	IT1	IT2	IT3	IT4	IT5
mm		µm					
6	**10**	0,6	1	1,5	2,5	4	6
10	**18**	0,8	1,2	2	3	5	8
18	**30**	1	1,5	2,5	4	6	9
30	**50**	1	1,5	2,5	4	7	11
50	**80**	1,2	2	3	5	8	13
80	**120**	1,5	2,5	4	6	10	15
120	**180**	2	3,5	5	8	12	18
180	**250**	3	4,5	7	10	14	20
250	**315**	4	6	8	12	16	23
315	**400**	5	7	9	13	18	25
400	**500**	6	8	10	15	20	27

Table 9

Guideline values for surface roughness of bearing seats

Seat diameter d, D Nominal over	incl.	**Surface roughness R_a (roughness class N)** Shaft for bearings to tolerance class P4A, P7, SP, P4C	PA9A, P9, UP	Housing P4A, P7, SP, P4C	PA9A, P9, UP
mm		µm			
–	**80**	0,2 (N4)	0,1 (N3)	0,4 (N5)	0,2 (N4)
80	**250**	0,4 (N5)	0,2 (N4)	0,8 (N6)	0,4 (N5)
250	**500**	0,8 (N6)	0,4 (N5)	1,6 (N7)	0,8 (N6)

Axial location of bearings

An interference fit alone is inadequate to locate a bearing ring axially. As a rule, a suitable means of axially securing the ring is needed. Both rings of a locating bearing should be axially secured on both sides.

For non-locating bearings of non-separable design, e.g. angular contact ball bearings, the ring having the tighter fit – usually the inner ring – should be axially secured; the other ring must be free to move axially relative to its seat. For non-locating bearings of separable design, e.g. cylindrical roller bearings, both rings should be axially secured.

In machine tool applications, the tool end bearings generally locate the shaft by transmitting the axial load from the shaft to the housing. In general, then, tool end bearings are located axially, while non-tool end bearings are axially free.

Locating methods

Lock nuts

Bearing inner rings having an interference fit are generally mounted so that the inner ring abuts a shoulder on the shaft on one side. On the opposite side, they are typically secured with a lock nut in the KMT or KTMA series (→ **fig. 9**).

Bearings with a tapered bore, mounted directly on tapered journals, are generally secured on the shaft by lock nuts. For detailed information about lock nuts, refer to the chapter "Locking devices" (→ **page 275**).

Spacer sleeves

Instead of integral shaft or housing shoulders, it is often more convenient to use spacer sleeves or collars between the bearing rings or between a bearing ring and an adjacent component, (→ **fig. 10**). In these cases, the dimensional and form tolerances for abutments apply.

Stepped sleeves

Another way to locate a bearing axially is to use stepped sleeves (→ **fig. 11**). These sleeves are particularly suitable for high-precision bearing arrangements, as they have very small runout and provide superior accuracy compared to threaded lock nuts. Stepped sleeves are therefore generally used in very high-speed spindles where the accuracy provided by conventional locking devices may not be adequate.

For detailed information about stepped sleeves, refer to the chapter "Locking devices" (→ **page 275**).

Housing covers

Bearing outer rings having an interference fit are generally mounted so that the ring abuts a shoulder in the housing on one side. On the opposite side, the outer ring is usually retained by a housing cover.

Housing covers and their securing screws can, in some cases, have a negative impact on bearing form and performance. If the wall thickness between the bearing seat and the screw holes is too small, and/or the screws are tightened too much, the outer ring raceway may deform. Bearings in the lightest ISO Dimension

Fig. 9

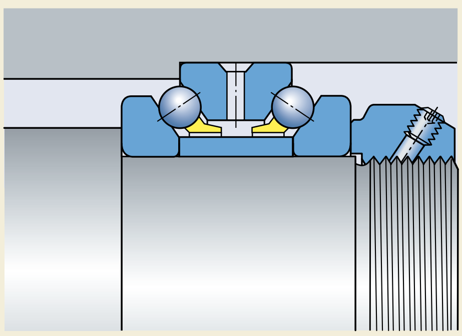
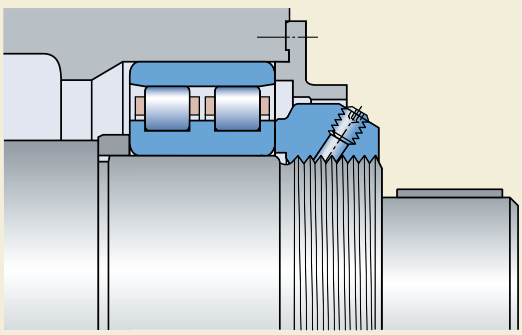


Fig. 10



19 series are more susceptible to this type of damage than those in the ISO Dimension 10 series or above.

It is advantageous to use a greater number of small diameter screws. Using only three or four screws should be avoided as such a small number of tightening points may produce lobes in the housing bore. This can result in changeable frictional moment, noise and unstable preload (when angular contact ball bearings are used). For complex spindle design where space is restricted, only thin-section bearings and a limited number of screws are possible. In these cases, an FEM (finite element method) analysis is recommended to accurately monitor deformation.

In addition, the axial clearance between the housing side face and the flange of the cover should be checked. A guideline value is 10–15 µm per 100 mm housing bore diameter (→ **fig. 12**).

Fig. 11

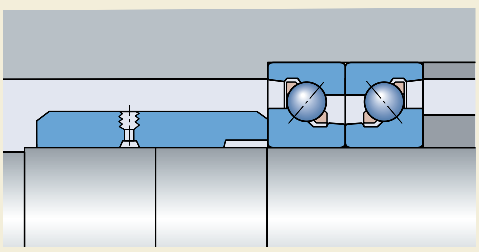
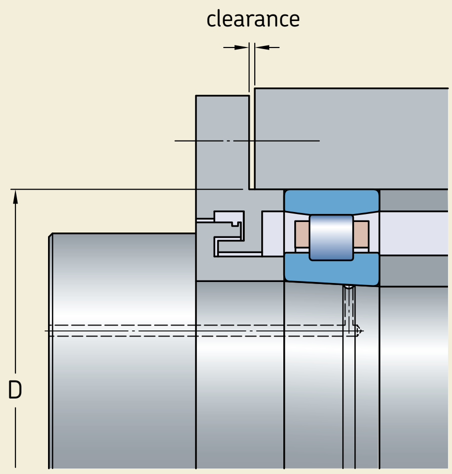


Fig. 12



Provision for mounting and dismounting

It is often necessary to make provisions during the design phase to facilitate mounting and dismounting of a bearing. For example, slots or recesses machined in the shaft or housing shoulder enable a withdrawal tool to be used (→ **fig. 13**) or threaded holes in a housing shoulder enable the use of screws to push a bearing from its housing seat (→ **fig. 14**).

Provision for the oil injection method

The oil injection method for mounting and dismounting bearings has been widely used with excellent results for bearings mounted on cylindrical or tapered seats. The distribution of oil between mating surfaces is accomplished by a circumferential oil distribution groove that communicates with a supply duct in the shaft (→ **fig. 15**).

The oil distribution groove should be located on the bearing seat, about one third of the way in, on the side that the bearing will be mounted or dismounted. The groove should be quite narrow since there is no significant edge pressure with narrow grooves. This facilitates the drainage of oil after mounting. For that same reason, the edges of the groove should be rounded. **Table 10** provides recommended dimensions for the distribution grooves and supply ducts. Recommendations for connection hole designs and associated ducts are also provided (→ **table 11**).

Fig. 13

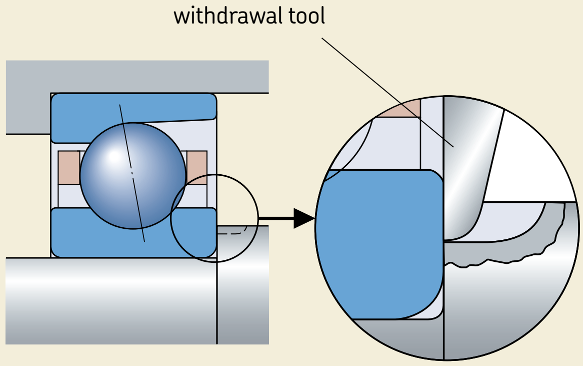


Fig. 14

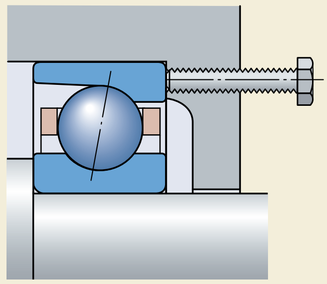


Fig. 15

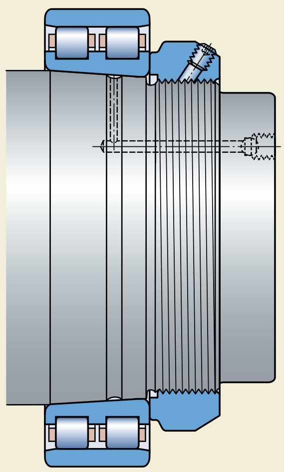
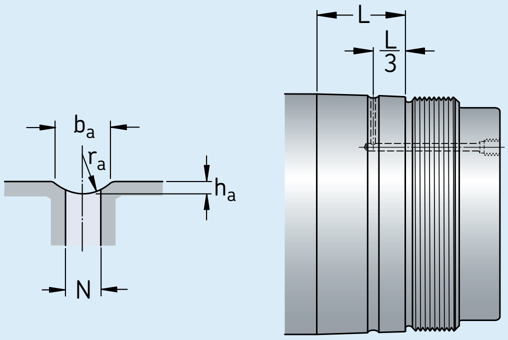


Table 10

Recommended dimensions for oil supply ducts and distribution grooves

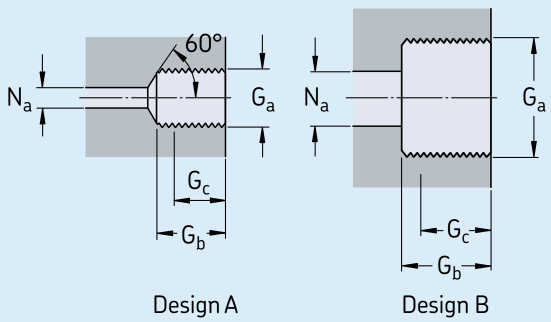


Seat diameter over	incl.	Dimensions b_a	h_a	r_a	N
mm		mm			
–	**50**	2,5	0,5	2	2
50	**100**	3	0,5	2,5	2,5
100	**150**	4	0,8	3	3
150	**200**	4	0,8	3	3
200	**250**	5	1	4	4
250	**300**	5	1	4	4
300	**400**	6	1,25	4,5	5
400	**500**	7	1,5	5	5
500	**650**	8	1,5	6	6
650	**800**	10	2	7	7

L = width of bearing seat

Table 11

Recommended design and dimensions of connection holes and associated ducts



Thread G_a	Design	Dimensions G_b	G_c[1]	N_a max
–	–	mm		
M 4×0,5	A	5	4	2
M 6	A	10	8	3
G 1/8	A	12	10	3
G 1/4	A	15	12	5
G 3/8	B	15	12	8
G 1/2	B	18	14	8
G 3/4	B	20	16	8

[1] Effective threaded length

Seals

Contaminants and moisture can negatively affect bearing service life and performance; particularly in machine tool applications where coolant and swarf are an integral part of the operating environment. Therefore, an effective sealing arrangement is essential if the spindle is to operate reliably. To protect the bearings, SKF offers a wide assortment of seals. They can be external or integral to the bearing: contact and non-contact.

External sealing arrangements

An effective external seal keeps lubricant in and contaminants out of the bearing arrangement. There are two types of external seals available: contact (→ **fig. 16**) and non-contact (→ **fig. 17**). The type chosen depends on the application and the operating conditions.

Contact seals

The effectiveness of a contact seal (→ **fig. 16**) depends on its ability to maintain a minimum pressure against a counterface, usually located on the shaft. These seals are generally very reliable, provided the counterface has the appropriate surface finish and the sealing lip is sufficiently lubricated.

Unfortunately, the friction and heat resulting from the seal-counterface contact at higher speeds ($A \geq 200\,000$ mm/min) means that contact seals can only be used in lower speed spindles and/or in applications where the additional heat will not significantly affect spindle performance. As a result, non-contact seals are almost always used for high-speed precision applications.

Non-contact seals

Non-contact seals function by virtue of the sealing effect of a very narrow gap. These seals, which do not generate any friction, do not limit speeds, making them an excellent solution for machine tool applications.

Seal variants range from simple gap-type seals to multi-stage labyrinth seals (→ **fig. 17**). Compared to gap-type seals, multi-stage labyrinth seals are considerably more effective as their series of axially and radially arranged gaps make it more difficult for contaminants and cutting fluid to reach the bearing.

Fig. 16

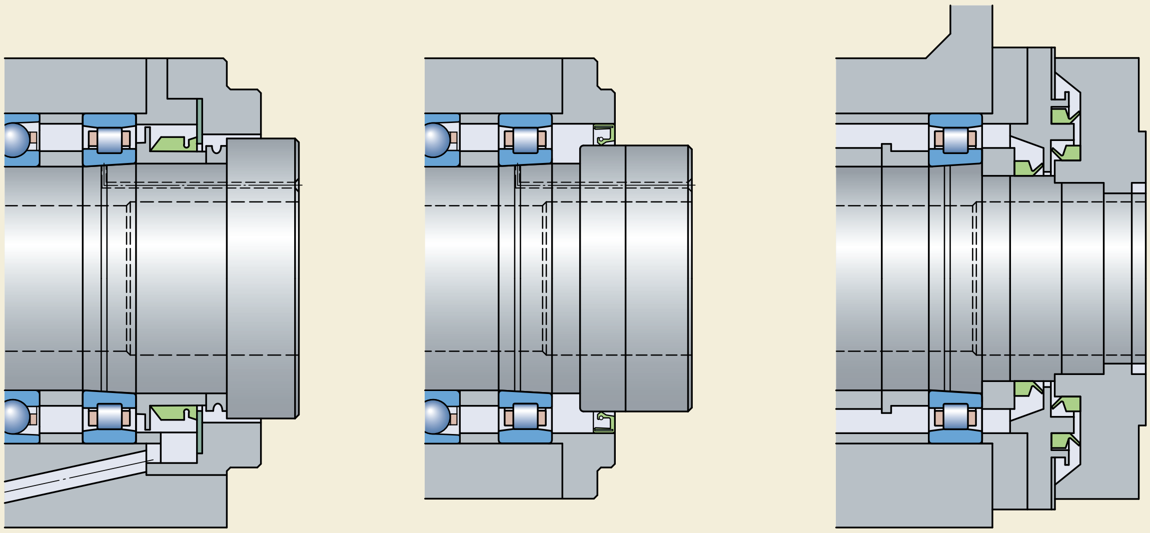
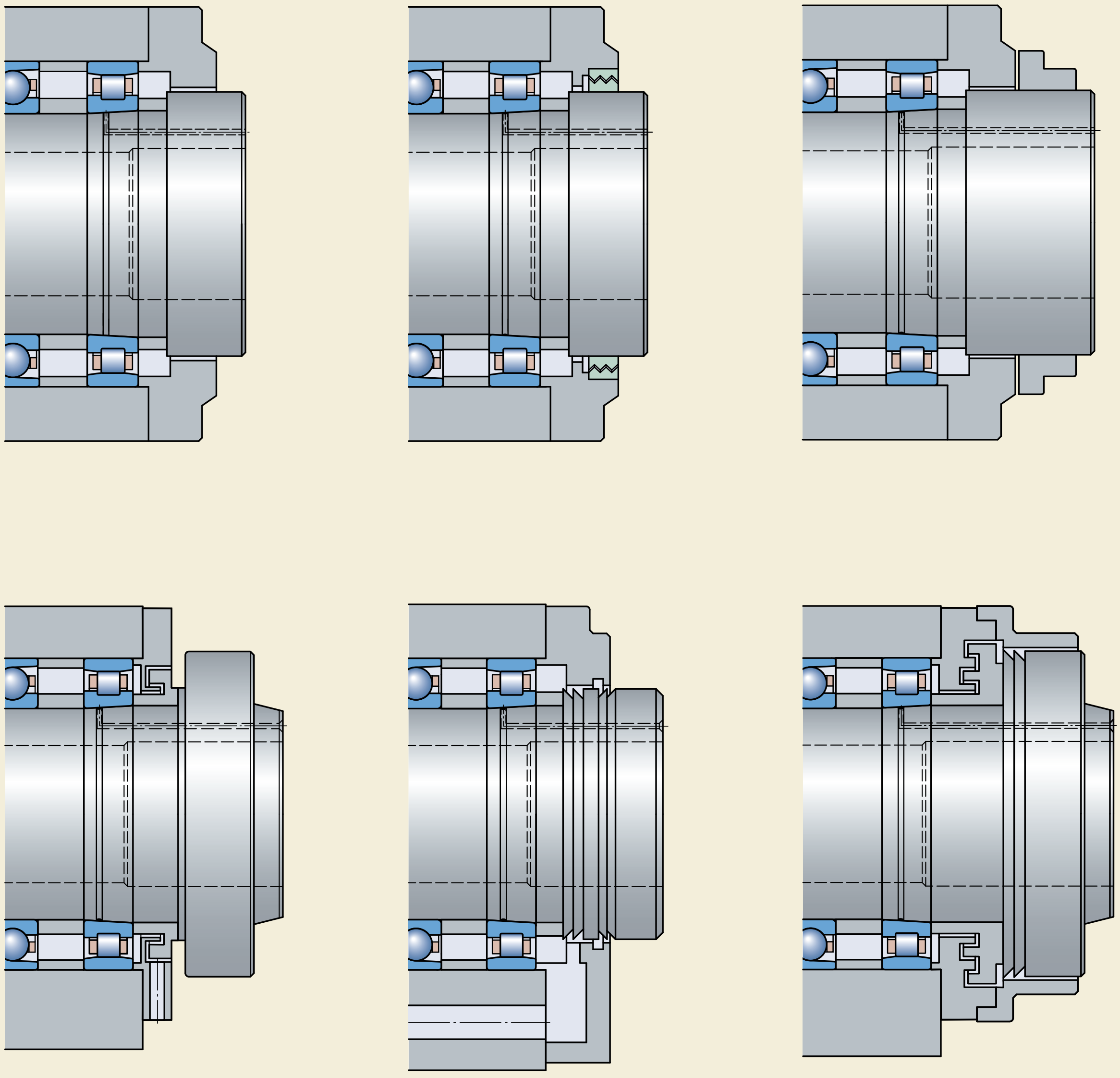


Fig. 17



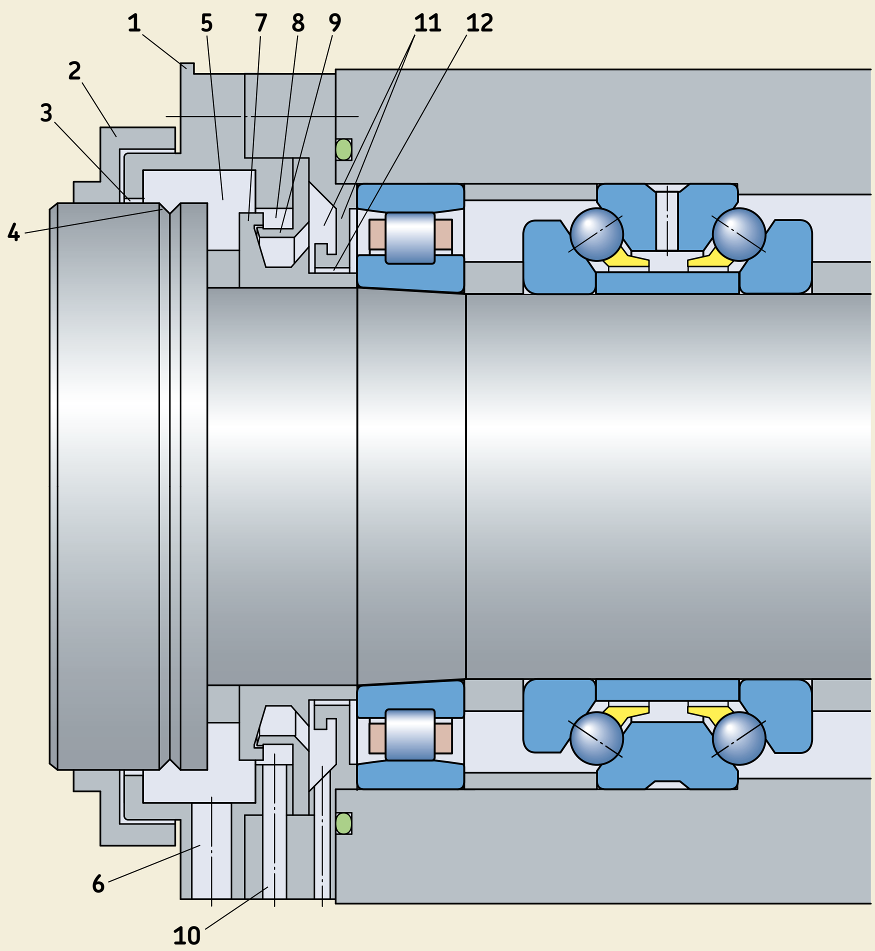
In highly contaminated environments where contact seals cannot be used, a complex labyrinth seal design is often required. Labyrinth type seals can have three or more stages to keep lubricant in, and contaminants out of the bearing arrangement. The principle of a highly efficient labyrinth seal is outlined in **fig. 18**. It consists of three preventative stages: primary, secondary and final. The design with the drainage chambers and the collecting provisions is derived from studies made by Dr. Wankel and the Technical University of Stuttgart, Germany.

The primary stage comprises a housing cover (**1**), a splash guard (**2**) and the shaft, designed together to form the first labyrinth. The housing cover prevents contaminants from entering the labyrinth directly, while the splashguard, using centrifugal force, redirects contaminants away from the cover. A radial gap (**3**) between the housing cover labyrinth and the shaft should be between 0,1 and 0,2 mm.

The secondary stage is designed to reduce the velocity of any fluid manages to pass the primary barrier and drain it away. Starting with annular grooves on the shaft (**4**), the main design features of this stage include a large drainage chamber (**5**) and an outlet hole (**6**). Annular grooves assist in directing the fluid away under non-rotating conditions, while the drainage chamber serves to reduce fluid velocity arising from the rotation of the shaft. Drainage using a large outlet area (approximately 250 mm^2) limits the collection of fluid inside.

Features used in the previous stages are again incorporated in the final stage. This section consists of labyrinth rings (**7**) with radial gaps measuring between 0,2 and 0,3 mm, a fluid retardation chamber (**8**), a collector (**9**) to guide the fluid toward the drainage area and an outlet hole (**10**) with a drainage area of approximately 150 mm^2. Space allowing, an additional chamber, collector and drainage hole of approximately 50 mm^2 (**11**) can be incorporated, with the final radial gap (**12**) being approximately 1 mm to avoid capillary action.

Fig. 18



When designing these types of sealing arrangements, the following should be taken into consideration:

- In order to avoid inward pumping effects, the labyrinth components should progressively decrease in diameter from the outside.
- Machining spirals that can direct the fluid toward the bearing should be avoided, especially if the spindle is designed to rotate in both the clockwise and anti-clockwise directions.
- Under severe operating conditions, an air barrier can be created by applying air between the labyrinth gaps. It is important that the flow is balanced so that the dominant flow is outward. An air barrier can provide a reasonably efficient sealing effect even with a simple labyrinth design. Additional protection is achieved by creating high pressure inside the spindle. This is the case when oil-air or oil mist lubrication systems are used.
- A sealing system that takes up considerable axial space is favourable, as this enables large drainage areas and collectors to be incorporated into the system. In these cases however, the spindle will be less rigid as a result of the long overhang from the front bearings (and cutting force position).

Integral bearing seals

Sealed bearings are generally used for arrangements where a sufficiently effective external seal cannot be provided due to cost implications or because there is inadequate space.

The most common SKF high-precision angular contact ball bearings are also available with a low-friction integral seal fitted on both sides. Details can be found in the section “Sealed bearings” (→ **page 100**).

Lubrication

The choice of the lubricant and lubrication method for a particular application depends primarily on the operating conditions e.g. permissible temperature or speed, but may also be dictated by the lubrication of adjacent components e.g. gear wheels.

For an adequate lubricant film to be formed between the rolling elements and raceways, only a very small amount of lubricant is required. Therefore, grease lubrication for spindle bearing arrangements is becoming increasingly popular. With grease lubrication, the hydrodynamic friction losses are small and operating temperatures can be kept to a minimum. However, where speeds are very high, the bearings should be lubricated with oil as the service life of grease is too short under such conditions and oil provides the added benefit of cooling.

Grease lubrication

Grease lubricated bearing arrangements are suitable for a wide range of speeds. Lubricating high-precision bearings with suitable quantities of good quality grease permits relatively high-speed operation without an excessive rise in temperature.

The use of grease also means that the design of a bearing arrangement can be relatively simple because grease is more easily retained in the bearing than oil. Grease also protects the bearing by contributing to sealing against solid contaminants and moisture.

Grease selection

In most spindle applications with high-precision bearings, grease with a mineral base oil and lithium thickener is suitable. These greases adhere well to the bearing surfaces and can be used in applications where temperatures range from –30 to +110 °C. For applications with high speeds and high temperatures and where long service life is required, the use of bearing grease based on synthetic oil, e.g. the SKF diester oil based grease LGLT 2, has proved effective.

For angular contact thrust ball bearings in screw drive applications under most operating conditions, grease with an ester or mineral base oil and calcium complex thickener can be used. For additional information refer to the chapter "Angular contact thrust ball bearings for screw drives", starting on **page 243**.

Alternative greases may be required if any of the following conditions exist

- operating temperatures are below +50 °C or above +100 °C
- bearing speed is very high or very low
- bearings are subjected to heavy or shock loads
- water resistance is important.

Accurate grease selection comprises four steps.

1. Select the consistency grade

Greases are divided into various consistency grades according to the National Lubricating Grease Institute (NLGI) scale. Greases with a high consistency, i.e. stiff greases, are assigned high NLGI grades, while those with low consistency, i.e. soft greases, are given low NLGI grades. In rolling bearing applications, three consistency grades are recommended from the scale. Here are some guidelines:

- The most common greases, used in normal bearing applications, have an NLGI grade of 2.
- Low consistency grade rolling bearing greases, i.e. those classified as NLGI 1 greases, are preferred for low ambient temperatures and oscillating applications.

- NLGI 3 greases are recommended for large bearings, bearing arrangements with a vertical shaft, high ambient temperatures or the presence of vibration.

2. Determine the required base oil viscosity
For detailed information about calculating the required base oil viscosity, refer to the section "Lubrication" in the SKF General Catalogue. The graphs in this catalogue are based on the elasto-hydrodynamic theory of lubrication (EHL) with full film conditions. Calculations can also be made online with the formulae provided in the SKF Interactive Engineering Catalogue at www.skf.com.

In most grease lubricated bearings there is only a minute amount of lubricant in the contact area between the rolling elements and raceways. Therefore, a thinner oil film than predicted by EHL theories will result.

When using the graphs to determine the required base oil viscosity for grease lubricated high-precision bearings, corrections for very low and very high viscosities are necessary. From practical experience, adjust the required viscosity ν at 40 °C as follows:

- For $\nu < 20$ mm²/s, multiply the viscosity by a factor of 1–2. In this low range, the viscosity of the oil is too thin to form a sufficiently thick oil film.
- For 20 mm²/s $< \nu <$ 250 mm²/s, no correction factor is used.
- For $\nu > 250$ mm²/s, contact the SKF application engineering service.

3. Verify the presence of EP additives
Grease with EP additives may be used if high-precision bearings are subjected to very heavy loads i.e. $P > 0{,}15\ C$, shock loads or if frequent start-up and shut down occurs during the working cycle. Lubricants with EP additives should only be used if necessary, as some additives may have a detrimental effect on bearings e.g. certain EP additives are not always compatible with the bearing materials. For additional information, contact the SKF application engineering service.

4. Check additional requirements
If certain operating conditions of high importance to the application exist, the properties of the grease should complement these conditions accordingly. The following recommendations are provided as guidelines:

- For superior water resistance, consider a grease with a calcium thickener over a lithium thickener.
- For good rust protection, select an appropriate additive.
- If there is a high vibration level, choose a grease with a high mechanical stability.

The Internet based SKF grease selection program LubeSelect can be used to select an appropriate grease.

Initial grease fill

High-precision bearings operating at high speed should be lubricated with small quantities of grease. Freshly greased bearings should be operated at low speeds during the running-in phase (→ **page 76**). This enables the grease to be evenly distributed within the bearing. If this running-in phase is neglected, risk of temperature peaking can lead to premature bearing failure.

In machine tool applications that mostly run at high speeds, less than 40 % of the free space in the bearings should be filled with grease. The amount of grease will vary, depending on the application. However, keep in mind that the larger the grease fill, the longer the running-in phase. From experience in the field, the most common grease fill is about 10 % of the free space in the bearing.

Suggested grease fills for SKF high-precision angular contact ball bearings, thrust bearings and cylindrical roller bearings are provided in **table 1**. The values are based on a filling grade of 10–15 %. Information about the initial grease fill for angular contact thrust ball bearings for screw drives is provided in the relevant product chapter (→ **page 259**).

Sealed angular contact ball bearings are supplied with a standard grease type and fill (→ **page 100**). On request, these bearings can be delivered with alternative grease types and filling grades. For additional information, contact the SKF application engineering service.

Table 1

Initial grease fills

Bearing Bore diameter d	 Size	**Initial grease fill** Bearing series 719 CD 719 ACD	 719 CE 719 ACE	 719 DB 719 FB	 70 CD 70 ACD	 70 CE 70 ACE	 70 DB 70 FB	 72 CD 72 ACD	 N 10	 NN 30	 NNU 49	 2344(00)	 BTM-A BTM-B
mm	–	cm^3											
8	**8**	–	–	–	0,05	–	–	–	–	–	–	–	–
9	**9**	–	–	–	0,06	–	–	–	–	–	–	–	–
10	**00**	0,04	–	–	0,08	–	–	0,12	–	–	–	–	–
12	**01**	0,04	–	–	0,09	–	–	0,15	–	–	–	–	–
15	**02**	0,07	–	–	0,13	–	–	0,22	–	–	–	–	–
17	**03**	0,08	–	–	0,18	–	–	0,3	–	–	–	–	–
20	**04**	0,15	0,16	–	0,3	0,34	–	0,46	–	–	–	–	–
25	**05**	0,18	0,18	–	0,34	0,4	–	0,57	–	0,9	–	–	–
30	**06**	0,21	0,21	0,24	0,53	0,57	0,47	0,83	–	1,1	–	1,9	–
35	**07**	0,31	0,32	0,31	0,66	0,71	0,61	1,2	–	1,4	–	2,3	–
40	**08**	0,48	0,49	0,46	0,8	0,86	0,74	1,5	1,2	1,7	–	2,7	–
45	**09**	0,54	0,55	0,58	1,1	1,1	0,98	1,8	1,3	1,9	–	3,2	–
50	**10**	0,58	0,59	0,63	1,2	1,2	1,04	2,1	1,5	2,1	–	3,5	–
55	**11**	0,83	0,85	0,86	1,7	1,55	1,56	2,6	1,8	2,6	–	4,5	–
60	**12**	0,9	0,92	0,92	1,8	1,65	1,68	3,3	2	2,8	–	4,8	3,2
65	**13**	0,95	0,98	0,98	1,9	1,75	1,84	4,1	2,1	3	–	5,1	3,3
70	**14**	1,5	1,6	1,55	2,7	2,5	2,45	4,6	2,6	3,8	–	6	4,4
75	**15**	1,7	1,7	1,63	2,8	2,7	2,59	5	2,8	4	–	6,4	–
80	**16**	1,7	1,8	1,80	3,7	3,6	3,48	6	3,4	4,9	–	7,7	6,4
85	**17**	2,4	2,5	2,40	3,9	3,8	3,64	7,2	3,5	5,1	–	8,1	6,7
90	**18**	2,5	2,6	2,50	5	5	4,69	9	4,1	5,9	–	9,6	8,9
95	**19**	2,6	2,7	2,60	5,2	5,2	4,87	11	4,3	6,2	–	10	–
100	**20**	3,5	3,6	3,68	5,4	5,5	5,08	13	4,5	6,5	4,5	11	9,6
105	**21**	3,7	3,8	–	6,8	–	–	16	5,3	7,6	7	12	–
110	**22**	3,8	3,9	3,95	8,5	–	7,37	18	6,1	8,8	7,3	14	12
120	**24**	5,1	5,3	5,24	9	–	7,84	22	6,7	9,6	9	15	17
130	**26**	6,8	–	–	14	–	–	–	–	12	11	19	26
140	**28**	7,2	–	–	15	–	–	–	–	17	15	27	–
150	**30**	11	–	–	18	–	–	–	–	20	19	31	–
160	**32**	11	–	–	22	–	–	–	–	22	21	36	–
170	**34**	12	–	–	28	–	–	–	–	29	24	43	–
180	**36**	18	–	–	37	–	–	–	–	34	30	51	–
190	**38**	19	–	–	38	–	–	–	–	36	31	53	–
200	**40**	27	–	–	51	–	–	–	–	42	39	57	–
220	**44**	28	–	–	67	–	–	–	–	76	62	–	–
240	**48**	31	–	–	72	–	–	–	–	83	68	–	–
260	**52**	50	–	–	–	–	–	–	–	140	122	–	–
280	**56**	53	–	–	–	–	–	–	–	155	128	–	–
300	**60**	90	–	–	–	–	–	–	–	225	140	–	–
320	**64**	82	–	–	–	–	–	–	–	245	142	–	–

Grease service life and relubrication intervals

There are several important factors influencing grease service life, some of which are difficult to estimate. As it is extremely complex to calculate precisely how long the grease can survive in a given application, it is better to talk of estimated grease service life. The estimated service life of the grease drives the relubrication interval calculation. Various methods can be used to calculate the relubrication interval for grease lubricated bearings and the following data can assist in making the best estimate.

Diagram 1 shows the theoretical relubrication interval t_f for high-precision bearings in various executions. The basic conditions for which the diagram is valid are

- an all-steel bearing
- a bearing mounted on a horizontal shaft
- a bearing operating temperature that does not exceed 70 °C
- a good quality grease with a lithium thickener
- a relubrication interval at the end of which 90 % of the bearings are still reliably lubricated (L_{10} life).

If necessary, the relubrication interval taken from the diagram should be adjusted using correction factors relating to the bearing type, variant and operating conditions.

The relubrication interval becomes

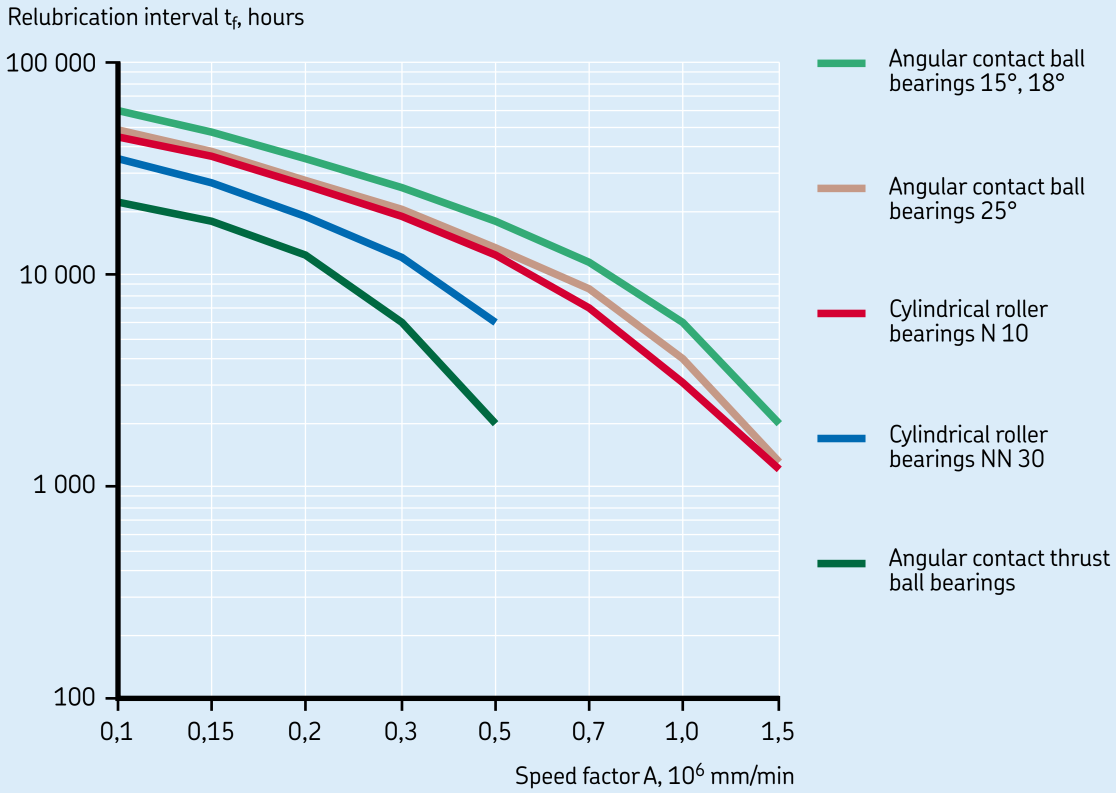
$$T_{relub} = t_f \; C_1 \; C_2 \; ... \; C_i$$

The angular contact ball and thrust ball bearing curves refer to single bearings only and therefore values for matched sets should be reduced accordingly (→ **table 2**). The table also provides information for adjustment according to the preload class. When sets comprising more than four bearings are used, contact the SKF application engineering service.

For hybrid bearings the estimated grease service life can be revised by multiplying the

Diagram 1

Grease relubrication interval guidelines



calculated value for the all-steel bearing by the applicable correction factor (→ **table 3**).

Depending on the application details, the relubrication interval should be multiplied by the relevant correction factors (→ **table 4**).

Other conditions such as the presence of water, cutting fluids and vibration (not included here) may also affect grease service life.

Machine tool spindles often operate under variable working conditions. If the speed spectrum is known and the relubrication interval for each speed is estimated, a total relubrication interval can be calculated from

$$t_{f\,tot} = 100 / \Sigma\,(a_i/t_{fi})$$

where

$t_{f\,tot}$ = total relubrication interval, hours
a_i = part of the total cycle time at speed n_i, %
t_f = relubrication interval at speed n_i, hours

Table 2

Correction factor for bearing sets and preload

Bearing type Arrangement	**Correction factor C_1** Preload class light	 moderate	 heavy
Angular contact ball bearings			
Set of 2	0,8	0,7	0,55
Set of 3	0,7	0,55	0,35
Set of 4	0,65	0,45	0,25
Double direction angular contact thrust ball bearings			
2344(00) series	1	–	–
BTM series	1	–	0,5
Angular contact thrust ball bearings for screw drives			
Set of 2	0,8	0,7	0,55
Set of 3	0,7	0,55	0,35
Set of 4	0,65	0,45	0,25

Table 3

Correction factor for hybrid bearings

Bearing type	**Correction factor C_2** Speed factor $n\,d_m \times 10^6$, mm/min 0,5	 0,7	 1	 1,5
Angular contact ball bearings	3	3,5	3	2,8
Double direction angular contact thrust ball bearings	3	–	–	–
Cylindrical roller bearings	3	3	3	2,5

Table 4

Correction factors for operating conditions

Operating condition	**Correction factor**	
Shaft position		
Vertical	C_3	0,5
Horizontal		1
Bearing load		
C/P > 20	C_4	1
C/P > 10		0,7
C/P > 8		0,5
C/P > 5		0,3
C/P > 2		0,2
C/P > 1		0,1
Reliability		
L_1	C_5	0,37
L_{10}		1
L_{50}		2
Air flow-through		
Low	C_6	1
Moderate		0,3
Strong		0,1
Moisture and dust		
Low	C_7	1
Moderate		0,5
High		0,3
Very high		0,1
Operating temperature		
40 °C	C_8	2
55 °C		2
70 °C		1
85 °C		0,5
100 °C		0,25

Miscibility

Where an alternative grease is considered for an application, its compatibility with the current grease relative to the base oil type (→ **table 5**) and thickener type (→ **table 6**) should be checked. This practice is based on grease composition and is only an indication; individual testing may be required. Notwithstanding, the suitability of the new grease for the application should first be verified.

Before applying new grease, as much as possible of the old lubricant should be removed from the bearing arrangement. If the new grease is incompatible with the existing grease, or if PTFE thickener or silicon based greases are present, the bearings should first be thoroughly washed using appropriate solvents. When restarting, close monitoring of the bearings is necessary to make sure the grease functions well.

Running-in of grease lubricated high-precision bearings

A grease lubricated high-precision bearing will initially run with a higher frictional moment. If the bearing is run at high speed without a running-in period, the temperature rise can be considerable. The high frictional moment is due to the churning of the grease and it takes time for the excess grease to work its way out of the contact zone. This period can be minimized by applying a small quantity of grease distributed evenly on both sides of the bearing during the assembly stage. Spacers between two adjacent bearings are also beneficial.

The time required to stabilize the operating temperature depends on a number of factors – the type of grease, the grease fill, how the grease is applied to the bearings, the bearing type and internal design, and the running-in procedure.

Bearings typically work with minimal lubricant when properly run-in, enabling the lowest frictional moment and temperature to be achieved. The grease that collects at the sides of the bearing will act as a reservoir and the oil will bleed into the raceways to provide efficient lubrication for a long time.

Running-in can be done in several ways. Wherever possible and regardless of the procedure chosen, running-in should involve operating the bearing in both a clockwise and anticlockwise direction.

Standard running-in procedure

This is the most common running-in procedure and can be summarized as follows:

1. Select a low starting speed and a relatively small speed increment interval.

2. Decide on an absolute temperature limit, usually 60 to 65 °C. It is advisable to set the machine with limit switches that will stop the spindle if the temperature rise exceeds the limits set.

3. Start operation at the chosen initial speed.

4. Monitor the temperature by taking measurements at the bearing outer ring position avoiding peaks, and wait for it to stabilize. If the temperature reaches the limit, stop operation and allow the bearing to cool. Start again at the same speed and wait for the temperature to stabilize.

5. Increase the speed by one interval and repeat step 4.

6. Continue increasing the speed in intervals, allowing the temperature to stabilize below the limit at each stage. Proceed until this is achieved for one speed interval greater than the operating speed of the system. This results in a lower temperature rise during normal operation. The bearing is now properly run-in.

This standard running-in procedure is time-consuming. For a medium to high speed spindle, each stage can take anywhere from 30 minutes to two hours before the temperature stabilizes. The total time for the running-in process could be 8–10 hours.

Table 5

Compatibility of base oil types

	Mineral oil	Ester oil	Polyglycol	Silicone-methyl	Silicone-phenyl	Polyphenylether
Mineral oil	+	+	–	–	+	o
Ester oil	+	+	+	–	+	o
Polyglycol	–	+	+	–	–	–
Silicone-methyl	–	–	–	+	+	–
Silicone-phenyl	+	+	–	+	+	+
Polyphenylether	o	o	–	–	+	+

\+ compatible
– incompatible
o individual testing required

Table 6

Compatibility of thickener types

	Lithium soap	Calcium soap	Sodium soap	Lithium complex soap	Calcium complex soap	Sodium complex soap	Barium complex soap	Aluminium complex soap	Clay	Polyurea
Lithium soap	+	o	–	+	–	o	o	–	o	o
Calcium soap	o	+	o	+	–	o	o	–	o	o
Sodium soap	–	o	+	o	o	+	+	–	o	o
Lithium complex soap	+	+	o	+	+	o	o	+	–	–
Calcium complex soap	–	–	o	+	+	o	–	o	o	+
Sodium complex soap	o	o	+	o	o	+	+	–	–	o
Barium complex soap	o	o	+	o	–	+	+	+	o	o
Aluminium complex soap	–	–	–	+	o	–	+	+	–	o
Clay	o	o	o	–	o	–	o	–	+	o
Polyurea	o	o	o	–	+	o	o	o	o	+

\+ compatible
\- incompatible
o individual testing required

Short running-in procedure

An alternative solution to the one mentioned earlier, reduces the number of stages and shortens the overall running-in time. The main steps can be summarized as follows:

1. Select a starting speed approximately 20–25 % of the attainable speed for grease lubrication (→ product tables) and choose a relatively large speed increment interval.

2. Decide on an absolute temperature limit, usually 60 to 65 °C. It is advisable to set the machine with limit switches that will stop the spindle if the temperature rise exceeds the limits set.

3. Start operation at the chosen initial speed.

4. Monitor the temperature by taking measurements at the bearing outer ring position until the temperature reaches the limit. Care should be taken as the temperature increase may be very rapid.

5. Stop operation and let the outer ring of the bearing cool down by 5 to 10 °C.

6. Start operation at the same speed a second time and monitor the temperature until the limit is reached again.

7. Repeat steps 5 and 6 until the temperature stabilizes below the limit. When the temperature peak is lower than the alarm limit, the bearing is run-in at that particular speed.

8. Increase the speed by one interval and repeat steps 4 to 7.

9. Proceed until the bearing is running at one speed interval greater than the operating speed of the system. This results in a lower temperature rise during normal operation. The bearing is now properly run-in.

Although each stage may have to be repeated several times, each cycle is just a few minutes long. The total time for this running-in process is substantially less than with the standard procedure.

Oil lubrication

Oil lubrication is recommended for many applications, as the method of supply can be adapted to suit the operating conditions and machine design. When selecting the most appropriate oil lubrication method, the following factors should be considered

- quantity and viscosity of the oil
- speed and hydrodynamic friction losses (a function of the speed)
- permissible bearing temperature.

The relationship between oil quantity, friction losses and bearing temperature is shown in **diagram 2**. The diagram illustrates the conditions in different regions:

- Region A
  Because of insufficient oil quantity, complete separation of rolling elements and raceways cannot be achieved. Metal-to-metal contact leads to increased friction and temperature and finally bearing wear.
- Region B
  A greater quantity of oil is available and a cohesive, load-carrying oil film can be formed. Here, the condition is reached where friction, and consequently temperature, are at a minimum.
- Region C
  A further increase in oil quantity will increase friction and temperature.
- Region D
  The quantity is such that equilibrium between heat generation and heat removal by the oil flow is achieved.
- Region E
  With even larger oil quantities the cooling effect predominates and the temperature falls.

For spindle bearing arrangements, the high operating speeds and requisite low operating temperatures generally require an oil-air lubrication system or a circulating oil lubrication system with oil cooling capabilities. The conditions obtained with these two methods correspond to those of regions B or E respectively.

Oil lubrication methods

Oil bath

Using an oil bath is the simplest method of oil lubrication. Oil, which is picked up by the rotating components of the bearing, is distributed within the bearing and then flows back to a sump. Oil bath lubrication is particularly suitable for low speeds and enables the design of relatively simple and economic bearing arrangements. At high speeds however, the bearings are supplied with too much oil, increasing friction within the bearing, and causing the operating temperature to rise.

Circulating oil

With circulating oil lubrication, oil is pumped to a position above the bearing, and runs down through the bearing and settles in a reservoir. The oil is filtered and, if required, cooled before being returned to the bearing. This method is suitable for high-precision bearings that rotate at high speed, provided there is an effective system for cooling the oil and the oil leaving the bearing can be removed from the arrangement by suitable drainage ducts.

Additional cooling of the oil enables the operating temperature of the bearing to remain low. The lower inlet temperature and high oil volume enable more heat to be removed from the system even though this large quantity of oil generates greater friction. In addition to requiring powerful pumps and cooling devices, this method is very demanding in terms of sealing and is therefore more expensive than an oil bath system.

Guideline values for oil flow rates are provided in **table 7**. For a more accurate analysis, contact the SKF application engineering service.

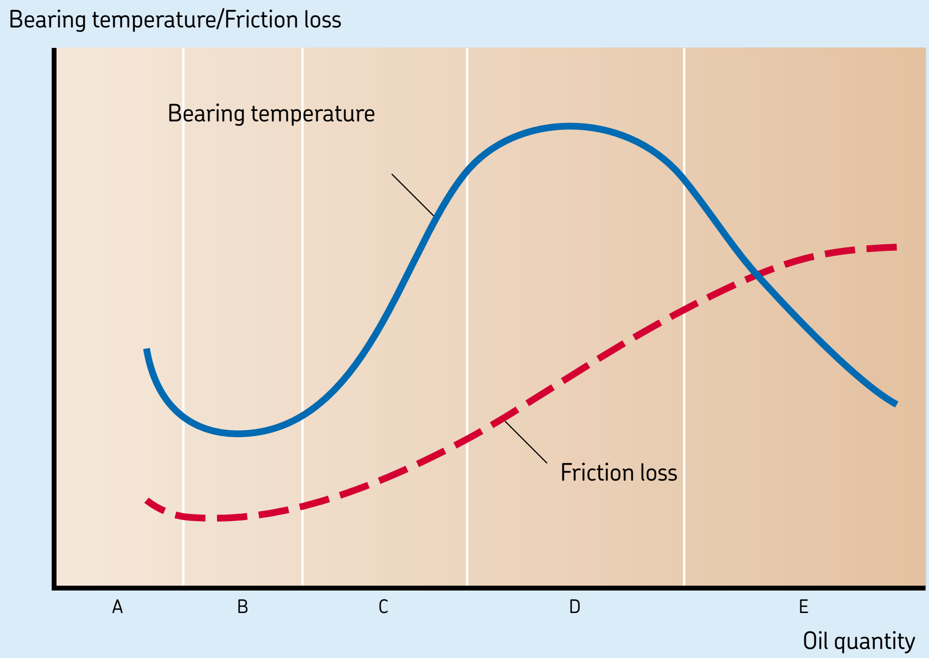
Table 7

Oil flow rate guidelines

Bore diameter d		**Oil flow rate Q**	
over	incl.	low	high
mm		l/min	
–	**50**	0,3	1,0
50	**120**	0,8	3,6
120	**400**	1,8	6,0

Diagram 2

Bearing temperature and friction losses as a function of oil quantity



Oil drop

With the oil drop method, an accurately metered quantity of oil is supplied to the bearing at given intervals. The delivered quantity may be relatively small, keeping friction losses at high speeds to a minimum. However, it is difficult to ascertain whether the oil is able to penetrate the bearing at high speeds and therefore, individual testing is always recommended. Where possible, the oil-air method should be chosen in preference to the oil drop method.

Oil jet

For very high-speed operation a sufficient but not excessive amount of oil should be supplied to the bearing to provide adequate lubrication, without increasing the operating temperature unnecessarily. One particularly efficient method of achieving this is the oil jet method, where a jet of oil under high pressure is directed at the side of the bearing. The velocity of the oil jet should be sufficiently high (at least 15 m/s) to penetrate the turbulence surrounding the rotating bearing. It is important that the oil leaving the bearing can be removed from the arrangement by adequately dimensioned ducts.

Oil mist

Oil mist lubrication is fairly costly and is not recommended due to possible negative environmental effects. In this method, finely divided oil droplets are supplied to the bearing in a stream of compressed air. The air passing through the bearing assists with cooling and enhances the sealing by producing a slight excess pressure. Minimum quantities of oil are required; in practice it is difficult to supply the bearing reliably with such small amounts.

Oil-air

With the oil-air method – also called the oil-spot method – accurately metered quantities of oil are directed at each individual bearing by compressed air. These minimum quantities enable bearings to operate with lowest friction, and most often at lower temperatures or at higher speeds than with other lubrication methods. Oil is supplied to the feed lines at given intervals by a metering unit. The oil, transported by compressed air, coats the inside surface of the feed lines and "creeps" toward the nozzles, where it is delivered to the bearing. The compressed air produces an excess pressure in the bearing arrangement to prevent contaminants from entering.

Guideline values for the quantity of oil to be supplied to a bearing can be obtained from

$$Q = \frac{q\,d\,B}{100}$$

where

Q = oil flow rate, mm^3/h
d = bearing bore diameter, mm
B = bearing width, mm
q = factor
- q = 1–2 for cylindrical roller bearings
- q = 2–5 for angular contact ball and thrust ball bearings
- q = 10–20 for angular contact ball bearings in high speed applications (due to the pumping effect of the bearings)

Individual testing is however always recommended in order to optimize the conditions.

Different bearing designs show varying sensitivity to oil quantity change, e.g. roller bearings are very sensitive; for ball bearings, the quantity can be changed substantially without any major rise in bearing temperature.

A factor influencing temperature rise and reliability of oil-air lubrication is the lubrication interval i.e. the time in between two measures from the oil-air lubricator. Generally the lubrication interval is determined by the oil flow rate generated by each injector and the oil quantity supplied per hour. The interval can vary from one minute to one hour, with the most common interval being 15–20 minutes.

Feed lines from the lubricator should be long enough; normally 1–5 m in length depending on the lubrication interval. The air pressure should be 0,2–0,3 MPa, but should be increased for longer runs to compensate for the pressure drop along the pipe's length.

To keep the rise in temperature at the lowest possible level, make sure that the oil leaving the bearing can be removed from the arrangement by adequately dimensioned drainage ducts.

With horizontal spindles it is relatively easy to arrange drainage ducts on each side of the bearings. Where bearings with lubrication grooves are used, a drainage duct for the annular groove is recommended. For vertical shafts, the oil passing the upper bearing(s) should be prevented from reaching the lower bearings, which otherwise will receive too much lubricant. Drainage, together with a sealing device, should be incorporated beneath each bearing. An efficient seal should also be provided at the spindle nose to prevent lubricant from reaching the work piece.

The oil nozzles should be positioned correctly, to make sure that the oil can be introduced into the contact area between the rolling elements and raceways and to avoid interference with the cage. **Table 8** on **page 83** provides values for the diameters (measured on the bearing) where oil injection should take place for the most common bearing types and variants. The data shown in the table refers to bearings equipped with standard cages. For bearings fitted with alternative cages or bearing types not shown, contact the SKF application engineering service.

Note: The speed ratings listed in the product tables for oil lubrication refer specifically to oil-air lubrication.

Lubricating oils

To lubricate high-precision bearings, high quality lubricating oils without EP additives are generally recommended. The requisite viscosity of the oil can be determined following the recommendations in the section "Lubrication" in the SKF General Catalogue or Interactive Engineering Catalogue at www.skf.com and is essentially a function of bearing size, speed and operating temperature. The Internet based SKF program LubeSelect can also be used to select oil type and viscosity.

With oil-air lubrication systems many oil types are suitable. Oils with a viscosity of 40–100 mm^2/s at 40 °C are typically used as are oils with EP additives, which are preferable especially for roller bearings.

The intervals at which the oil should be changed when using the oil bath, circulating oil and oil jet methods, depend mainly on the operating conditions and the quantity of oil involved. Additional information can be found in the SKF Interactive Engineering Catalogue at www.skf.com or obtained from the oil supplier.

When oil drop, oil mist or oil-air lubrication is used, the lubricant is "lost" and is therefore supplied to the bearings only once.

Lubricant storage

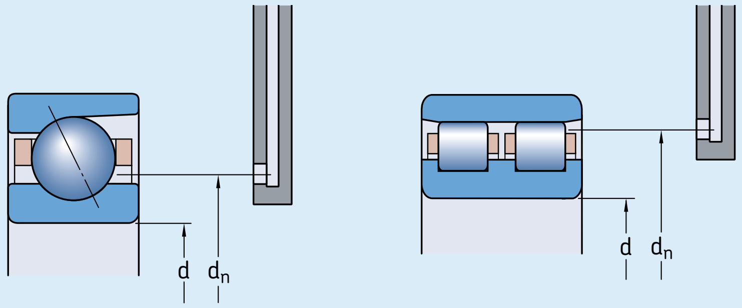
Most materials including oils and greases deteriorate over time. The art of good storage practice is to have items readily available when required and to ensure stock turnover so that lubricants are used before any significant performance loss has occurred. Lubricant properties may vary considerably during storage due to exposure to air/oxygen, temperature, light, water and moisture, oil separation and the presence of particles. Therefore, lubricants should be stored in a cool, dry, indoor area and should never be exposed to direct sunlight. The lubricants should be stored in their original container, which should be kept closed until needed. After use, the container should be immediately sealed again.

The recommended maximum storage time is two years for greases and ten years for lubricating oils, assuming reasonable stock keeping practices and protection from excessive heat and cold.

Grease or oil in excess of the recommended shelf life is not necessarily unsuitable for service. It is advisable to check if the lubricant still meets the product requirements and specifications.

Table 8

Oil nozzle positions for various bearings



Bearing Bore diameter d	Size	**Oil nozzle position d_n** Bearing series 719 CD 719 ACD	719 CE 719 ACE	719 DB 719 FB	70 CD 70 ACD	70 CE 70 ACE	70 DB 70 FB	72 CD 72 ACD	N 10[1)] NN 30	NNU 49
mm	–	mm								
8	**8**	–	–	–	13,6	–	–	–	–	–
9	**9**	–	–	–	15,1	–	–	–	–	–
10	**00**	14,8	–	–	16,3	–	–	18,2	–	–
12	**01**	16,8	–	–	18,3	–	–	20	–	–
15	**02**	20,1	–	–	21,8	–	–	23	–	–
17	**03**	22,1	–	–	24	–	–	25,9	–	–
20	**04**	26,8	26,8	–	28,7	28,8	–	31,1	–	–
25	**05**	31,8	31,8	–	33,7	33,8	–	36,1	40,5	–
30	**06**	36,8	36,8	36,6	39,7	40	40	42,7	47,6	–
35	**07**	43	43	43,1	45,7	46	46,1	49,7	54	–
40	**08**	48,7	48,7	49	51,2	51,5	51,6	55,6	60	–
45	**09**	54,2	54,2	54,1	56,7	57,2	57,2	60,6	66,4	–
50	**10**	58,7	58,7	58,6	61,7	62,2	61,8	65,6	71,4	–
55	**11**	64,7	64,7	64,7	68,7	69,7	69,2	72,6	79,8	–
60	**12**	69,7	69,7	69,7	73,6	74,7	74,2	79,5	85	–
65	**13**	74,7	74,7	74,7	78,6	79,7	79	86,5	89,7	–
70	**14**	81,7	81,7	81,9	85,6	86,7	86,1	91,5	98,5	–
75	**15**	86,7	86,7	86,9	90,6	91,7	91,1	96,5	103,5	–
80	**16**	91,7	91,7	91,6	97,6	98,7	98	103,5	111,4	–
85	**17**	98,6	98,6	98,9	102,6	103,7	103	111,5	116,5	–
90	**18**	103,3	103,6	103,9	109,5	110,6	110	117,5	125,4	–
95	**19**	108,6	108,6	108,9	114,5	115,6	115	124,4	130,3	–
100	**20**	115,6	115,6	115,7	119,5	120,6	120	131,4	135,3	113,8
105	**21**	120,6	120,6	–	126,5	–	–	138,4	144,1	119
110	**22**	125,6	125,6	125,6	133,5	–	134,6	145,9	153	124
120	**24**	137,6	137,6	137,7	143,5	–	144,6	158,2	162,9	136,8
130	**26**	149,5	–	–	157,5	–	–	–	179,6	147
140	**28**	159,5	–	–	167,4	–	–	–	188	157
150	**30**	173,5	–	–	179,4	–	–	–	201,7	169,9
160	**32**	183,5	–	–	191	–	–	–	214,4	179,8
170	**34**	193,5	–	–	205,8	–	–	–	230,8	189,8
180	**36**	207,4	–	–	219,7	–	–	–	248,9	203,5
190	**38**	217,4	–	–	229,7	–	–	–	258,9	213
200	**40**	231,4	–	–	243,2	–	–	–	275,3	227
220	**44**	251,4	–	–	267,1	–	–	–	302,4	247
240	**48**	271,4	–	–	287	–	–	–	322,4	267
260	**52**	299,7	–	–	–	–	–	–	355,2	294,5
280	**56**	319,7	–	–	–	–	–	–	375,3	313,5
300	**60**	347	–	–	–	–	–	–	408,4	362
320	**64**	362,1	–	–	–	–	–	–	428	382

[1)] For bearings in the N 10 series equipped with TNHA cages, contact the SKF application engineering service

Mounting and dismounting

When mounting or dismounting high-precision bearings, all recommendations and guidelines valid for rolling bearings should be considered. Recommendations and guidelines can be found in the SKF General Catalogue, the SKF Interactive Engineering Catalogue (available online at www.skf.com) and the SKF Bearing Maintenance Handbook. The detailed mounting instructions for other rolling bearings, available at www.skf.com/mount, may also be helpful.

Appropriate methods and tools

For high-precision bearings, it is very important to choose the appropriate method of mounting and to use the correct tools. SKF offers a comprehensive assortment of maintenance products including mechanical and hydraulic tools and heating equipment as well as other products for mounting and maintenance (→ the catalogue "SKF Maintenance and Lubrication Products" or online at www.mapro.skf.com).

To be sure that bearings are mounted and maintained properly, SKF offers seminars and hands-on training courses as part of the SKF Reliability Systems concept. Installation and maintenance assistance may also be available from your local SKF company.

SKF spindle service

Machine tool spindles often require special tools and skills for maintenance and repair. SKF supports customers with a worldwide network of spindle service centres. The services offered include spindle reconditioning, from bearing replacement to shaft and nose restorations, performance upgrades and analysis. SKF can also provide complete monitoring services as well as preventative maintenance services for machine tool spindles.

Special mounting recommendations for high-precision bearings

Compared to other rolling bearings, mounting high-precision bearings requires more accuracy, more caution and higher skills.

Cleanliness

Bearings should be mounted in a dry and dust-free room. Most SKF high-precision bearings are manufactured under clean room conditions. To exploit their full performance potential, contaminants should not enter the bearings during mounting.

Fig. 1

Bearings with thin rings

High-precision bearings often have thin rings relative to their size. For these bearings only limited mounting forces should be applied. Therefore, SKF recommends using hot mounting methods for all high-precision bearings with thin rings. However, for bearings in the NNU 49 series with a tapered bore, the SKF oil injection method is recommended.

Temperatures for hot mounting

High-precision bearings are typically mounted with a low degree of interference. That means, a relatively small difference in temperature between the bearing ring and its mating part is required. The following temperature differences are often sufficient

- 20 to 30 °C between the inner ring and shaft
- 10 to 30 °C between the housing bore and outer ring.

To heat bearings evenly, to avoid contamination and to reliably control the temperature, SKF electric induction heaters (→ **fig. 1**) are recommended.

Compared with bearings, stepped sleeves require a greater difference in temperature between the mating parts during mounting. Stepped sleeves are used to lock bearings on the shaft. They are mounted with a high degree of interference. Temperature differences for mounting are provided in the dimension tables for stepped sleeves, starting on **page 288**.

Additional mounting recommendations for angular contact ball bearings

Compressing bearing sets after hot mounting

High-precision angular contact ball bearings are typically used in sets. When the bearings are heated, their bore diameter becomes larger and their width also expands. The larger bore diameter facilitates mounting.

When cooling, their bore diameter contracts to obtain the necessary (interference) fit; their width also contracts and a small gap between the bearings can result. This gap can negatively impact the preload in the bearing set. To avoid this, the bearings should be pressed against each other when cooling (→ **fig. 2**) with an axial force that is slightly greater than the dismounting force (→ **page 89**).

Using package markings to select bearings for a set

When selecting universally matchable angular contact ball bearings to make a set from existing stock, the package provides helpful information. The mean outside and the mean bore diameter deviation from the nominal diameters is noted on the package (→ **fig. 3**). Bearings with similar deviations should be used together in a set.

Fig. 2

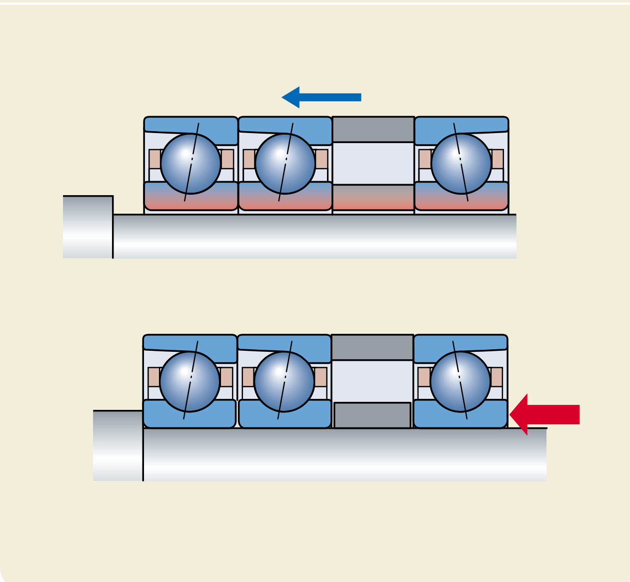


Fig. 3

Additional mounting recommendations for cylindrical roller bearings

When mounting high-precision cylindrical roller bearings with a tapered bore, the radial internal clearance or preload should be adjusted accurately. This is done by driving the inner ring up on its seat (→ **fig. 4**). The expansion of the ring determines the clearance or preload of the mounted bearing. For proper mounting, the inside or outside envelope diameter of the roller set must be accurately measured. SKF internal clearance gauges in the GB 30 (→ **fig. 5**) or GB 49 series (→ **fig. 6**) enable simple and accurate measuring. For more information about internal clearance gauges, refer to the chapter "Gauges", starting on **page 293**.

Mounting a cylindrical roller bearing in the NN 30 K series using a gauge in the GB 30 series is described in the following section. A similar procedure can be applied when mounting cylindrical roller bearings in the NNU 49 K series using a gauge in the GB 49 series.

When mounting without the assistance of an internal clearance gauge, be sure that the accuracy of the readings is sufficient for the application.

Mounting a bearing in the NN 30 K series using a GB 30 series gauge

For mounting a bearing in the NN 30 K series, an internal clearance gauge of the appropriate size in the GB 30 series is required. SKF recommends using hydraulic tools to drive the bearing up on its seat. Provisions for oil injection are useful for dismounting (→ **page 64**). The typical mounting procedure comprises the following steps:

1. Mounting the outer ring
   - Heat the housing to the appropriate temperature and slide the outer ring in position.

Fig. 4

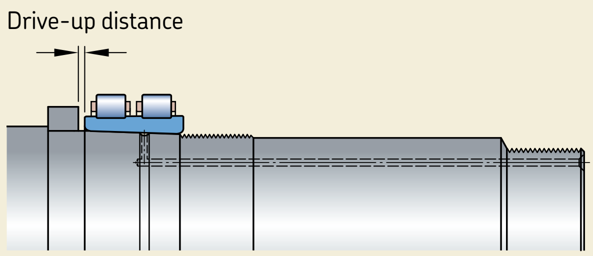


Fig. 5

Fig. 6

2. Preparing the gauge
   - Let the housing and the outer ring cool to ambient temperature. Then measure and record the outer ring raceway diameter with a bore gauge. Place the gauge inside the outer ring and set the dial indicator to zero (→ **fig. 7**).
   - Place the bore gauge in the centre of the gauging zone of the GB 30 gauge (→ **fig. 8**). Adjust the GB 30 gauge, using the adjustment screw until the bore gauge indicates zero minus a correction value provided in the GB 30 instructions for use.
   - Reduce the inside diameter of the GB 30 gauge by the value of the desired preload or increase the inside diameter by the value of the desired clearance, using the adjustment screw. Then set the indicator of the gauge to zero and keep the indicator setting un-changed during the mounting process.

3. Mounting the inner ring (trial)
   - Lightly coat the tapered seat with a thin oil and mount the inner ring with roller and cage assembly. The inner ring should make good contact with its seat.

Fig. 7

Fig. 8

Fig. 9

Fig. 10

- Expand the GB 30 gauge with the adjustment screw, place it over the roller set and release the adjustment screw so that the gauge makes contact with the roller set (→ **fig. 9** on **page 87**).
- Drive the inner ring with roller and cage assembly together with the gauge further on its seat until the indicator on the gauge reads zero. The inner ring is now in the correct position for the desired preload or clearance.
- Expand the gauge using the adjustment screw and remove it from the roller and cage assembly.

4. Mounting the inner ring (final)
   - Measure the distance between the bearing side face and the shaft abutment using gauge blocks (→ **fig. 10** on **page 87**). Take measurements at different diametrical positions to check accuracy and misalignment. The difference between the single measurements should not exceed 3 to 4 µm.
   - Grind the pre-machined spacer ring to the measured width.
   - Remove the inner ring, mount the spacer ring and drive-up the inner ring again until it firmly abuts the spacer ring.
   - Place the GB 30 gauge over the roller set as described earlier. Don't forget to release the adjustment screw. If the indicator shows zero again, the inner ring is properly mounted. Remove the gauge and locate the inner ring, using a suitable locking device.

Mounting bearings with a tapered bore through measuring radial clearance prior to mounting

When exact preload adjustment is not critical for an application, mounting can be done without using an accurate internal clearance gauge. The principle of this method is to measure the clearance on the outer ring raceway of the assembled bearing and calculate the required axial drive-up distance. Common practice is to measure the internal clearance with the outer ring. This method does not take into account that the outer ring is compressed when mounted with an interference fit in the housing. To compensate for this, it can be assumed that the outer ring raceway diameter will decrease by 80 % of the diametric interference fit.

The procedure comprises the following steps:

1. Mounting the inner ring (trial)
   - Lightly coat the tapered seat with a thin oil and position the inner ring on the shaft. It should make good contact with its seat, but should not be driven-up too far.
   - There should still be clearance when the outer ring is put in place. Bear in mind that small bearings may have only 15 µm internal clearance before mounting. An axial drive-up of 0,1 mm causes a clearance reduction of about 8 µm.

2. Measuring the internal clearance prior to mounting
   - With the inner ring in place on the shaft, position the outer ring over the rollers.
   - To measure the radial clearance, the outer ring should be moved perpendicular to the shaft. To facilitate this, a perpendicular disc should be used. The disc should be placed between the bearing and the drive-up device. If it is placed on the other side, provisions e.g. slots, are required to enable measuring the distance between the bearing and the abutment.
   - Move the outer ring up and down and measure the total displacement using a dial indicator (→ **fig. 11**). This measured displacement is the radial internal clearance of the bearing, prior to mounting.
   - Do not apply excessive force to the outer ring. Elastic deformation may cause measurement errors.

3. Determining the spacer ring width
   - Measure the distance L between the bearing side face and the shaft abutment (→ **fig. 11**). Take measurements at different diametrical positions to check accuracy and alignment. The difference between the single measurements should not exceed 3 to 4 µm.
   - Calculate the required width of the spacer ring

$$B = L - B_a$$

where

B = required width of the spacer ring

L = measured distance from the bearing inner ring to the abutment

B_a = the required axial drive-up distance to achieve the desired clearance reduction or preload (→ **page 208**)

4. Mounting the bearing (final)
   - Grind the pre-machined spacer ring to the measured width.
   - Remove the inner ring, mount the spacer ring and drive-up the inner ring again, until it firmly abuts the spacer ring.
   - Locate the inner ring, using a suitable locking device.
   - Heat the housing to the required temperature and mount the outer ring.

Dismounting recommendations

All dismounting recommendations and guidelines valid for other rolling bearings should also be considered for high-precision bearings. Recommendations and guidelines can be found in the SKF General Catalogue, the SKF Interactive Engineering Catalogue (available online at www.skf.com), at www.skf.com/mount and the SKF Bearing Maintenance Handbook.

Because of the typically lower degree of interference for high-precision bearings, lower forces are needed to dismount compared to other rolling bearings.

Dismounting forces

For bearings in spindle applications, the dismounting forces can be estimated as follows:

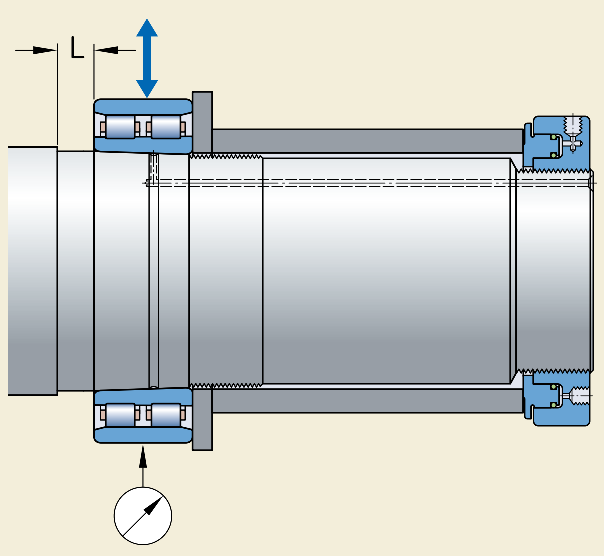
- For dismounting a set of three angular contact ball bearings from the housing

  $F \approx 0{,}02\ D$

- For dismounting a set of three angular contact ball bearings from the shaft

  $F \approx 0{,}07\ d$

Fig. 11



- For dismounting a cylindrical roller bearing from its tapered seat

  $F \approx 0{,}3\ d$

where

F = dismounting force, kN

D = bearing outside diameter, mm

d = bearing bore diameter, mm

Reusing bearings

To determine if a bearing can be reused, it must be inspected carefully. A detailed inspection requires disassembling the bearing. Angular contact ball bearings cannot be disassembled without damage unless special tools are used. Cylindrical roller bearings can only be partly disassembled.

SKF does not recommend reusing high-precision bearings. The risk for unplanned downtime or unsatisfactory performance outweighs, in most cases, the cost of new bearings.

Bearings should be dismounted carefully, regardless of whether they will be reused again, because careless dismounting could damage associated components. Also, if the bearing is dismounted carefully, it can be used for damage analysis if required.

Test runs

New or modified high-precision bearing arrangement designs should be tested before being put into operation. SKF recommends a test run of the complete assembly so that noise and bearing temperature, among other factors, can be checked. The test run should be carried out under partial load and – where there is a wide speed range – at slow or moderate speed.

Note: A rolling bearing should never be allowed to start up unloaded and accelerate to high speed, as damaging sliding movements could occur between the rolling elements and the raceways, or the cage could be subjected to inadmissible stresses.

An increase in bearing temperature immediately after start up is normal. For example, in the case of grease lubrication, the temperature will not drop until the grease has been evenly distributed in the bearing arrangement, after which an equilibrium temperature will be reached. More information about running-in of grease lubricated bearings can be found on **page 76**.

Unusually high temperatures may indicate that the preload is too heavy, there is too much lubricant in the bearing arrangement or that the bearing is radially or axially distorted. Other possibilities could be an associated component that was not manufactured properly.

Bearing storage

Bearings can be stored in their original packaging for many years, provided that the relative humidity in the storeroom does not exceed 60 % and there are no great fluctuations in temperature. The storeroom should be clean and free of vibration. Bearings that are not stored in their original packaging should be well protected against corrosion and contamination.

If sealed bearings are stored for a long period of time, the lubricating properties of the grease may deteriorate.

Large rolling bearings should only be stored lying down, preferably with the entire side face of the rings supported. If kept in a standing position, the weight of the rings and rolling elements can give rise to permanent deformation because the rings are relatively thin-walled.

Product data


THRUST

Angular contact ball bearings

Designs

SKF offers a wide selection of high-precision angular contact ball bearings; not only with regard to the number of types and designs, but also the number of sizes. It covers shaft diameters from 8 to 320 mm, to include virtually every machine-tool application and other precision bearing arrangement where high-precision angular contact ball bearings can be used.

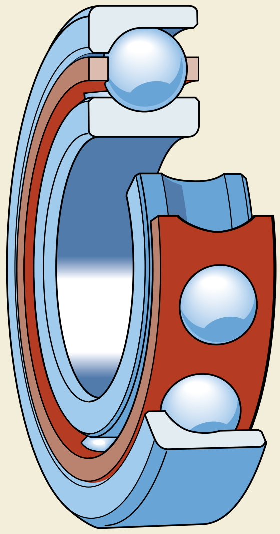
Single row SKF high-precision angular contact ball bearings (→ **fig. 1**) are non-separable and – like all angular contact ball bearings – have raceways in the inner and outer rings that are displaced relative to each other in the direction of the bearing axis. This means that, in addition to radial loads, these bearings can also accommodate axial loads in one direction. Radial loads produce axial forces in these bearings that need to be balanced by counterforces. Angular contact ball bearings are therefore always adjusted against a second bearing or used in sets.

SKF high-precision angular contact ball bearings can accommodate a variety of operating requirements relative to

- load carrying capacity
- running accuracy
- speed capability
- rigidity
- vibration behaviour
- available space.

They are therefore available in three bearing series and these in turn are available in many designs with different characteristics.

Fig. 1



Bearing series

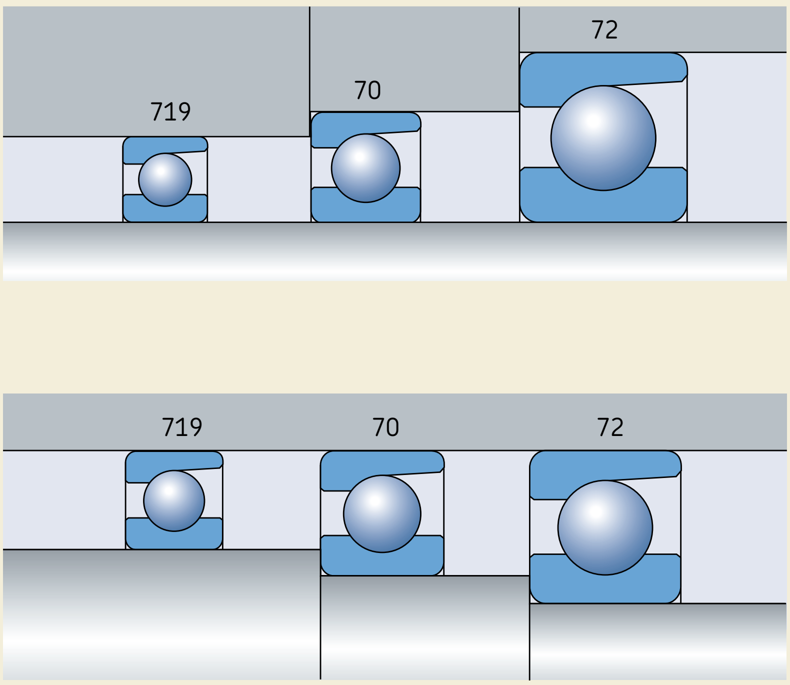
The SKF assortment of high-precision angular contact ball bearings incorporates bearings in three series

- the extremely light 719 series
- the light 70 series
- the robust 72 series.

The cross-sections of the three bearing series illustrated in **fig. 2** show their differences, which vary depending on the bore and outside diameter of the bearing. Each bearing series has characteristic features that make it particularly suitable for certain bearing applications. For higher speeds or tight radial mounting space, bearings in the 719 or 70 series should be selected. For heavy loads at relatively low speeds, bearings in the 72 series are suitable.

If a high degree of stiffness is required, bearings in the 719 series are typically used, as they can contain the greatest number of balls, relative to their bore size. They can also accommodate the largest shaft diameter, relative to their outside diameter. Both characteristics are particularly important for system rigidity, as the rigidity of a spindle increases with its shaft diameter, and the rigidity of a bearing arrangement increases with the number of balls.

Fig. 2



Design features

To match the features of SKF high-precision angular contact ball bearings to the operating requirements described above, the following variants within each series can be supplied

- three different contact angles (→ **fig. 3**)
- normal number of large balls or a larger number of smaller balls (→ **fig. 4**)
- steel or ceramic balls (→ **fig. 5**)
- open bearings or bearings with low-friction seals (→ **fig. 6**, **page 100**).

For all variants within each of the three series, the ring shoulders can have a different height on one or both bearing rings. Every bearing has the largest possible number of balls that are guided through a light, one-piece cage made of fabric reinforced phenolic resin or glass fibre reinforced polyetheretherketone (PEEK).

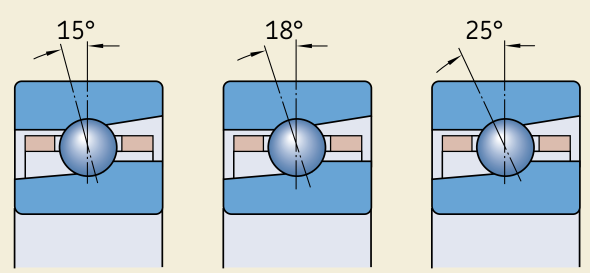
Contact angles

SKF high-precision angular contact ball bearings are produced as standard with (→ **fig. 3**)

- a 15° contact angle, designation suffix CD or CE
- a 18° contact angle, designation suffix FB
- a 25° contact angle, designation suffix ACD, ACE or DB.

The different contact angles offer a unique variety of combinations in terms of load carrying capacity, speed capability and rigidity. Bearings with a 25° contact angle are used primarily in applications requiring high axial rigidity or high axial load carrying capacity.

Fig. 3



Ball sizes

SKF high-precision angular contact ball bearings with a CD or ACD designation suffix contain a maximum number of balls to provide the highest possible load carrying capacity. To complement these, SKF also produces so-called high-speed bearings, identified by the ACE, CE, DB or FB designation suffix. These bearings do not have the same high load carrying capacity but can accommodate higher speeds.

High-speed bearings are equipped with a larger number of smaller balls than the CD or ACD designs (→ **fig. 4**). The smaller balls are lighter and reduce the centrifugal forces acting on the outer ring raceway, thereby reducing stress on the rolling contact surfaces. As smaller balls require less space, the bearing rings have a larger cross section, making them less susceptible to deformation resulting from irregularities of the bearing seat, either on the shaft or in the housing.

Ball materials

The most common high-precision angular contact ball bearings are available as standard as (→ **fig. 5**)

- all-steel bearings
- hybrid bearings with ceramic (silicon nitride) balls.

As silicon nitride balls are considerably lighter and harder than steel balls, hybrid bearings can provide a higher degree of rigidity and run considerably faster than a comparable all-steel bearing.

The lower weight of the ceramic balls reduces the centrifugal forces within the bearing and the heat generated in the bearing, thereby significantly prolonging service life of the lubricant and markedly extending the maintenance intervals. In addition, hybrid bearings are considerably less sensitive to damage caused by rapid acceleration and deceleration. For detailed information about silicon nitride, refer to the section "Materials", starting on **page 46**.

SKF hybrid angular contact ball bearings are identified by either

- the designation suffix HC, e.g. 7000 CD/HCP4A or
- the prefix C, e.g. C7012 FB/P7.

Fig. 4

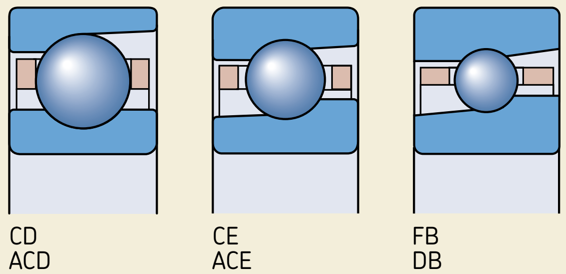
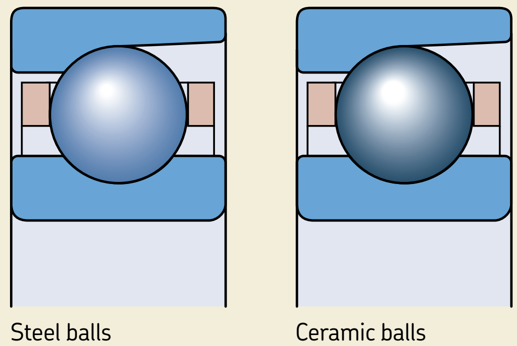


Fig. 5



Sealed bearings

The most common SKF high-precision angular contact ball bearings are also available with seals. These bearings are fitted on both sides with a low-friction seal, which forms an extremely narrow gap with the cylindrical surface of the inner ring shoulder and is practically non-contacting (→ **fig. 6**). The seals are made of an oil- and wear-resistant acrylonitrile-butadiene rubber (NBR) and are reinforced with sheet steel. The operating temperature range of these seals is between –25 and +100 °C.

When sealed, the bearings are filled as standard with a high-grade, low-viscosity grease that has a lithium soap thickener and a synthetic ester base oil. The quantity of grease fills some 25 to 35 % of the free space in the bearing. The temperature range for the grease is between –55 and +110 °C.

Sealed bearings are lubricated for life and are maintenance-free under normal operating conditions. They should not be washed or heated to temperatures above 80 °C. Heat should only be applied with an induction heater, that rapidly heats the bearing rings, while all non-metallic components remain cool.

Other bearings

In addition to the bearings listed in the product tables starting on **page 130**, the assortment of SKF high-precision angular contact ball bearings also includes other standard bearings and special bearings. These bearings provide optimal solutions for applications that place particularly high demands on relubrication or wear-resistance.

Bearings with an annular groove and lubrication holes

Bearings with an annular groove and two lubrication holes in the outer ring are available for applications that need a minimal amount of lubricant to be supplied directly and safely through the outer ring. To prevent oil from leaking between the bearing outside diameter and the housing bore, the cylindrical surface of the outer ring has two additional annular grooves to accommodate O-rings (→ **fig. 7**). These bearing designs are identified by the designation suffix L, e.g. 7010 CE/HCP4AL.

Nitroalloy high-performance bearings

Nitroalloy high-performance bearings are designed for extreme, high-speed applications where resistance to wear is a key requirement. The rings of these bearings are made from exceptionally corrosion-resistant steel with high fatigue strength and elevated-temperature hardness. The balls are made of silicon nitride. These two factors together markedly increase bearing efficiency, enabling it to run several times longer than a comparable hybrid bearing.

For additional information about these bearings, contact the SKF application engineering service.

Fig. 6

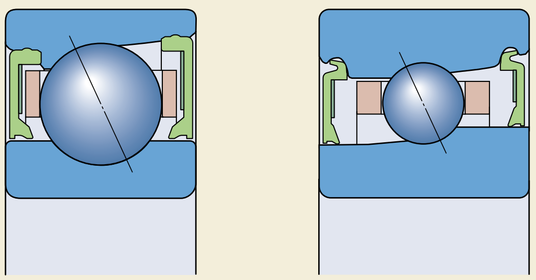
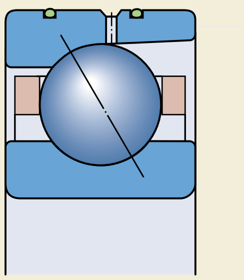


Fig. 7



Single bearing arrangements with standard bearings

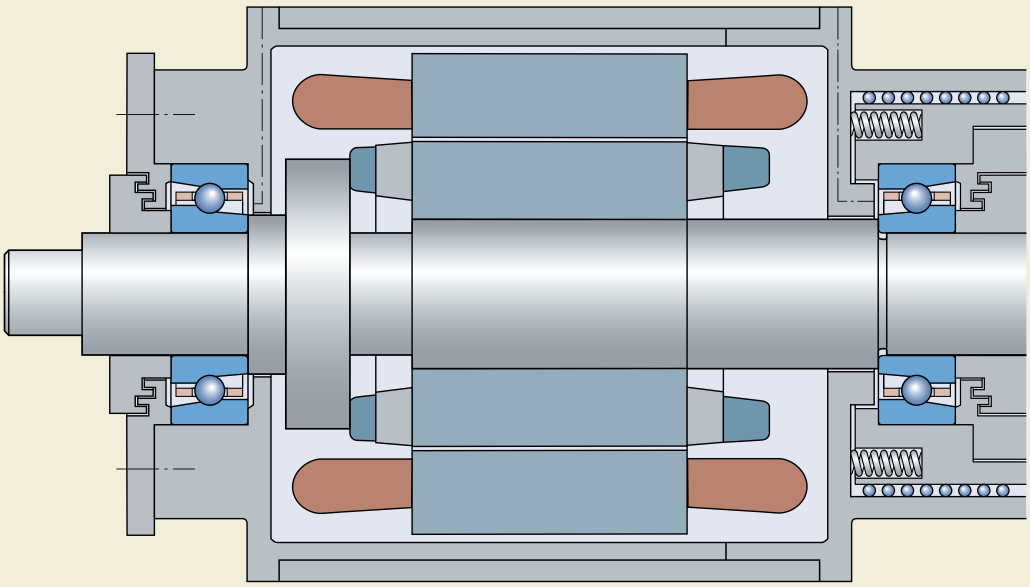
Standard SKF high-precision angular contact ball bearings are intended for arrangements where only one bearing is used in each bearing position (→ **fig. 8**). Like all high-precision angular contact ball bearings, they are made to the P4A tolerance class as standard. Although the width of the bearing rings is to tight tolerances, these bearings are not suitable for mounting immediately adjacent to each other. For single bearing arrangements, any of the following SKF high-precision angular contact ball bearing designs can be used

- CD or ACD design angular contact ball bearings
- CE or ACE as well as FB or DB design high-speed angular contact ball bearings
- CD/HC or ACD/HC design hybrid angular contact ball bearings
- CE/HC or ACE/HC as well as C.FB or C.DB design hybrid high-speed angular contact ball bearings
- S.CD or S.ACD design sealed angular contact ball bearings
- S.FB or S.DB design sealed high-speed angular contact ball bearings
- S.CD/HC or S.ACD/HC design sealed hybrid angular contact ball bearings
- SC.FB or SC.DB design sealed hybrid high-speed angular contact ball bearings.

Open bearings are listed in the product tables starting on **page 130**, sealed bearings starting on **page 176**.

2

Fig. 8



Universally matchable bearings

These SKF high-precision angular contact ball bearings are specifically manufactured so that when mounted in random order, but immediately adjacent to each other, a given preload and/or an even load distribution is obtained, without the use of shims or similar devices. Universally matchable bearings can be used in any arrangement (back-to-back, face-to-face or tandem, → **fig. 9**) in sets with up to four bearings. For advice about the arrangements and their suitability, refer to the section "Matched bearing sets" on **page 104**.

Universally matchable bearings are identified by the designation suffix G, followed by A, B or C, to specify the preload class, e.g. 7014 CDGA/P4A. When ordering universally matchable bearings, the number of bearings in the set should be specified, e.g. three of item 7014 CDGA/P4A in order to be able to form a bearing set 7014 CD/P4ATBTA.

Universally matchable bearing sets

Universally matchable bearing sets are also available. The bore and outside diameter of the bearings in a set are matched to within a maximum of one-third of the applicable permitted diameter tolerance, enabling an even better load distribution compared to a pair of universally matchable bearings. The bearings in these sets can be deployed either in pairs or individually, to form any desired bearing arrangement.

Bearing sets consisting of two bearings have DGA, DGB or DGC designation suffix, depending on the preload class, e.g. 7020 ACD/P4ADGA. When ordering, indicate the number of bearing sets and not the number of single bearings required.

Reducing inventories

To decrease inventories and improve parts availability, SKF recommends using universally matchable bearings. With universally matchable bearings, a multitude of different matched bearing sets can be obtained. The kind of potential savings that can be realized with an initial inventory is shown in **table 1**.

Table 1

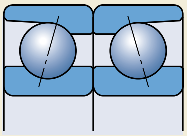
Alternative replacement bearings for matched bearing sets[1)]

Original matched bearing sets		**Equivalent replacement bearings when using universally matchable bearings**	
Designation	Quantity	Designation	Quantity
7010 CD/P4ATBTA	2	**7010 CDGA/P4A**	6
7010 CD/P4AQBCA	2	**7010 CDGA/P4A**	8
7010 CD/P4ADT	5	**7010 CDGA/P4A**	10
7010 CD/P4ADBA	15	**7010 CDGA/P4A**	30
7010 CD/P4ADFA	4	**7010 CDGA/P4A**	8

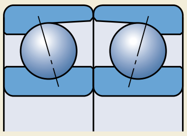
1) In this case, instead of 5 different matched bearing sets, only some single universal bearings 7010 CDGA/P4A need to be stocked

Fig. 9

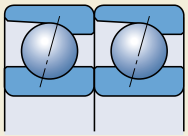
Bearing sets with 2 bearings



Back-to-back arrangement (DB[1])

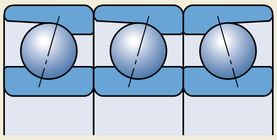


Face-to-face arrangement (DF[1])

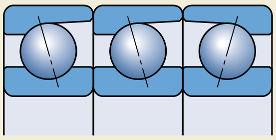


Tandem arrangement (DT[1])

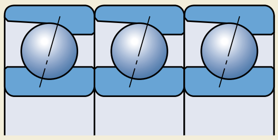
Bearing sets with 3 bearings



Tandem and back-to back arrangement (TBT[1])

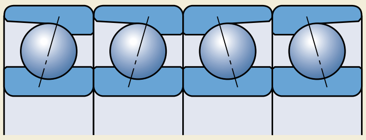


Tandem and face-to-face arrangement (TFT[1])

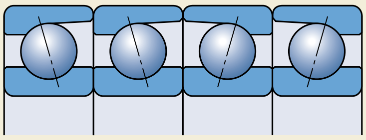


Tandem arrangement (TT[1])

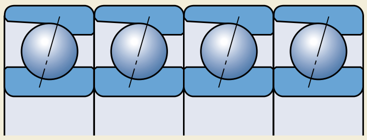
Bearing sets with 4 bearings



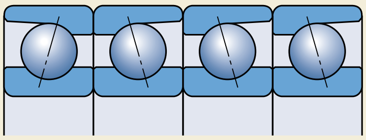
Back-to-back arrangement (QBC[1])



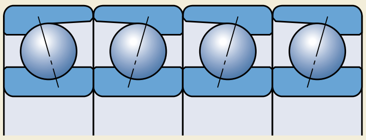
Face-to-face arrangement (QFC[1])



Tandem arrangement (QT[1])



Back-to-back and tandem arrangement (QBT[1])



Face-to-face and tandem arrangement (QFT[1])

[1] Designation suffix for matched bearing sets

Matched bearing sets

SKF high-precision angular contact ball bearings can also be supplied as complete bearing sets, made up of two, three or four bearings. Matched bearing sets are matched to each other during production in such a way that when mounting the bearings immediately adjacent to each other, the predetermined value for preload is obtained with even load distribution. The bore and outside diameters are matched to within a maximum of one-third of the diameter tolerance. For bearings in tolerance class PA9A, the diameter tolerances are even closer.

The possible bearing arrangements using bearing sets with two, three or four bearings are shown in **fig. 9** on **page 103**.

Back-to-back bearing arrangements

In back-to-back arrangements (→ **fig. 10a**), the load lines diverge towards the bearing axis. Axial loads acting in both directions can be accommodated, but only by one bearing or bearing set in each direction. Bearings mounted back-to-back provide a relatively stiff bearing arrangement that can also accommodate tilting moments.

Face-to-face bearing arrangements

In face-to-face arrangements (→ **fig. 10b**), the load lines converge towards the bearing axis. Axial loads acting in both directions can be accommodated, but only by one bearing or bearing set in each direction. Face-to-face bearing arrangements are not as stiff as back-to-back arrangements and are less suitable to accommodate tilting moments.

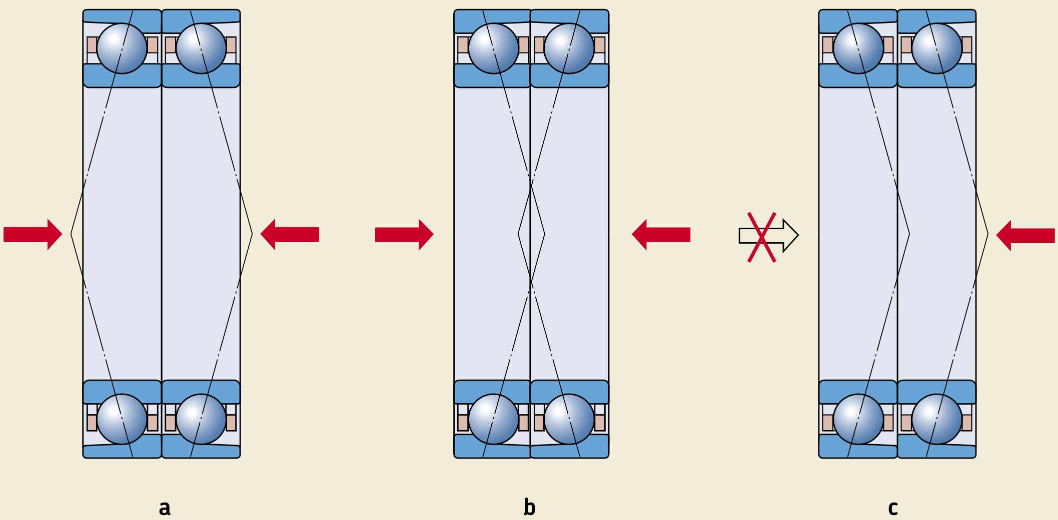
Tandem bearing arrangements

In a tandem arrangement (→ **fig. 10c**), the load lines are parallel so that radial and axial loads are shared equally by the bearings. The bearing set can only accommodate axial loads acting in one direction. If axial loads act in the opposite direction, or if combined loads are present, another bearing adjusted against the tandem arrangement should be added.

Other bearing arrangements

Other bearing arrangements with three or four bearings can combine tandem arrangements with back-to-back or face-to-face arrangements. This enables the design engineer to adapt the bearing arrangement to the application's requirements for rigidity and load carrying capacity, e.g. to different load levels in the axial direction.

Fig. 10



Marking of bearings and bearing sets

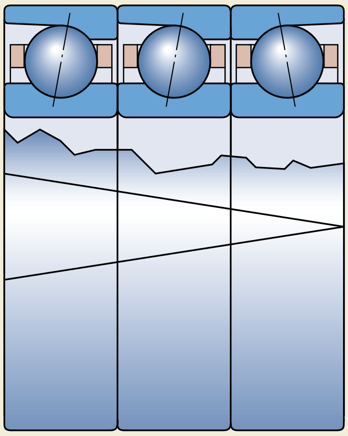
Each high-precision angular contact ball bearing is marked with various identifiers (→ **fig. 11**) on the outside surface of the outer ring and on one side face of the inner ring and outer ring:

1 Complete designation of the bearing or bearing set
2 Country of origin
3 Mean outside diameter deviation from the nominal diameter. An asterisk (*) on the outer ring marks the position of the maximum eccentricity
4 A "V-shaped" marking (for matched bearing sets)
5 Manufacturing date, coded
6 Serial number, for matched bearing sets only.
7 Mean bore diameter deviation from the nominal diameter. An asterisk (*) on the inner ring marks the position of the maximum eccentricity
8 SKF trademark

Fig. 11

A “V-shaped” marking on the outside surface of the outer rings of matched bearing sets (→ **fig. 12**) indicates how the bearings should be mounted to obtain the proper preload in the set. The marking also indicates how the bearing set should be mounted in relation to the axial load. The “V” should point in the direction in which the axial load will act on the inner ring. In applications where there are axial loads in both directions, the “V” should point toward the greater of the two loads.

Fig. 12



Bearing data – general

Cages

SKF high-precision angular contact ball bearings have an outer ring shoulder guided cage (→ **fig. 13**), made either of fabric reinforced phenolic or glass fibre reinforced polyetheretherketone (PEEK). These lightweight cages keep centrifugal forces low, and are designed to enable good lubricant supply to the ball/raceway contact areas. Standard cages are not identified by a suffix in the bearing designation. Bearings that have a PEEK cage are marked in the product tables by a footnote.

Dimensions

The boundary dimensions of SKF high-precision angular contact ball bearings in the Dimension Series 19, 10 and 02 are in accordance with ISO 15:1998.

Fig. 13

Tolerances

SKF high-precision angular contact ball bearings are made to P4A or P7 tolerance class as standard. On request, bearings can be supplied to the higher precision PA9A or P9 tolerance class.

The tolerance values are listed as follows

- P4A and P7 tolerance classes in **table 2** on **page 108**
- PA9A and P9 tolerance classes in **table 3** on **page 109**.

The symbols used in the tolerance tables are listed in **table 3** on **pages 44** and **45**, together with their definitions.

Table 2

Classes P4A and P7 tolerances for radial angular contact ball bearings

Inner ring

d		Δ_{dmp}		Δ_{ds}		V_{dp}	V_{dmp}	Δ_{Bs}		Δ_{B1s}		V_{Bs}	K_{ia}	S_d	S_{ia}
over	incl.	high	low	high	low	max	max	high	low	high	low	max	max	max	max
mm		µm		µm		µm	µm	µm		µm		µm	µm	µm	µm
2,5	**10**	0	–4	0	–4	1,3	1	0	–40	0	–250	1,3	1,3	1,3	1,3
10	**18**	0	–4	0	–4	1,3	1	0	–80	0	–250	1,3	1,3	1,3	1,3
18	**30**	0	–5	0	–5	1,3	1	0	–120	0	–250	1,3	2,5	1,3	2,5
30	**50**	0	–6	0	–6	1,3	1	0	–120	0	–250	1,3	2,5	1,3	2,5
50	**80**	0	–7	0	–7	2	1,3	0	–150	0	–250	1,3	2,5	1,3	2,5
80	**120**	0	–8	0	–8	2,5	1,5	0	–200	0	–250	2,5	2,5	2,5	2,5
120	**150**	0	–10	0	–10	6	3	0	–250	0	–380	4	4	4	4
150	**180**	0	–10	0	–10	6	3	0	–250	0	–380	4	6	5	6
180	**250**	0	–12	0	–12	7	4	0	–300	0	–500	5	7	6	7
250	**315**	0	–13	0	–13	8	5	0	–350	0	–550	6	8	7	7
315	**400**	0	–16	0	–16	10	6	0	–400	0	–600	6	9	8	8

Outer ring

D		Δ_{Dmp}		Δ_{Ds}		V_{Dp}	V_{Dmp}	Δ_{Cs}, Δ_{C1s}	V_{Cs}	K_{ea}	S_D	S_{ea}
over	incl.	high	low	high	low	max	max		max	max	max	max
mm		µm		µm		µm	µm		µm	µm	µm	µm
18	**30**	0	–5	0	–5	2	1,3	Values are identical to those for the inner ring of the same bearing (Δ_{Bs}, Δ_{B1s})	1,3	2,5	1,3	2,5
30	**50**	0	–6	0	–6	2	1,3		1,3	2,5	1,3	2,5
50	**80**	0	–7	0	–7	2	1,3		1,3	3,8	1,3	3,8
80	**120**	0	–8	0	–8	2,5	1,3		2,5	5	2,5	5
120	**150**	0	–9	0	–9	2,5	1,5		2,5	5	2,5	5
150	**180**	0	–10	0	–10	6	3		4	6	4	6
180	**250**	0	–11	0	–11	6	4		5	8	5	8
250	**315**	0	–13	0	–13	8	5		5	9	6	8
315	**400**	0	–15	0	–15	9	6		7	10	8	10
400	**500**	0	–20	0	–20	12	8		8	13	10	13

Table 3

Classes PA9A and P9 tolerances for radial angular contact ball bearings

Inner ring

d		Δ_{ds}		V_{dp}	V_{dmp}	Δ_{Bs}		Δ_{B1s}		V_{Bs}	K_{ia}	S_d	S_{ia}
over	incl.	high	low	max	max	high	low	high	low	max	max	max	max
mm		µm		µm	µm	µm		µm		µm	µm	µm	µm
2,5	**10**	0	–2,5	1,3	1	0	–25	0	–250	1,3	1,3	1,3	1,3
10	**18**	0	–2,5	1,3	1	0	–80	0	–250	1,3	1,3	1,3	1,3
18	**30**	0	–2,5	1,3	1	0	–120	0	–250	1,3	2,5	1,3	2,5
30	**50**	0	–2,5	1,3	1	0	–120	0	–250	1,3	2,5	1,3	2,5
50	**80**	0	–3,8	2	1,3	0	–150	0	–250	1,3	2,5	1,3	2,5
80	**120**	0	–5	2,5	1,5	0	–200	0	–380	2,5	2,5	2,5	2,5
120	**150**	0	–6,5	3	2	0	–250	0	–380	2,5	2,5	2,5	2,5
150	**180**	0	–6,5	3	2	0	–300	0	–500	3,8	5	3,8	5
180	**250**	0	–7,5	4	2,5	0	–350	0	–500	3,8	5	3,8	5

Outer ring

D		Δ_{Ds}		V_{Dp}	V_{Dmp}	Δ_{Cs}, Δ_{C1s}	V_{Cs}	K_{ea}	S_D	S_{ea}
over	incl.	high	low	max	max		max	max	max	max
mm		µm		µm	µm		µm	µm	µm	µm
18	**30**	0	–3,8	2	1,3	Values are identical to those for the inner ring of the same bearing (Δ_{Bs}, Δ_{B1s})	1,3	2,5	1,3	2,5
30	**50**	0	–3,8	2	1,3		1,3	2,5	1,3	2,5
50	**80**	0	–3,8	2	1,3		1,3	3,8	1,3	3,8
80	**120**	0	–5	2,5	1,3		2,5	5	2,5	5
120	**150**	0	–5	2,5	1,5		2,5	5	2,5	5
150	**180**	0	–6,5	3	2		2,5	5	2,5	5
180	**250**	0	–7,5	4	2,5		3,8	6,5	3,8	6,5
250	**315**	0	–7,5	4	3,5		3,8	6,5	3,8	6,5
315	**400**	0	–10	5	5		6,5	7,5	6,5	7,5

Preload in bearings prior to mounting

Standard high-precision angular contact ball bearings for single bearing arrangements do not have any preload. Preload can only be obtained by mounting and adjusting one bearing against another bearing, which provides location in the opposite direction.

Universally matchable bearings and matched bearing sets are produced in three different preload classes to meet the varying requirements regarding rotational speed, rigidity and heat generation

- class A, light preload
- class B, moderate preload
- class C, heavy preload.

The preload level depends on the bearing series, the contact angle, the inner geometry and the size of the bearing and applies to bearing sets in back-to-back or face-to-face arrangements. Preload values are not standardized. They are listed in the following tables

- open bearings in the 719 series in **table 4** on **page 111**
- sealed bearings in the 719 series in **table 5** on **page 112**
- open bearings in the 70 series in **table 6** on **page 113**
- sealed bearings in the 70 series in **table 7** on **page 114**
- open bearings in the 72 series in **table 8** on **page 115**.

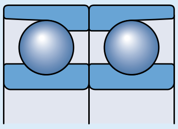
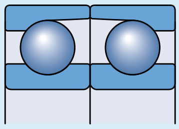
Matched bearing sets with a different preload can be supplied on request. Matched bearing sets, consisting of three or four bearings, have a heavier preload than sets with two bearings. The preload for these bearing sets is obtained by multiplying the values listed in **tables 4** to **8** by a factor of

- 1,35 for TBT and TFT sets
- 1,6 for QBT and QFT sets
- 2 for QBC and QFC sets.

Matched hybrid bearing sets (HC designation suffix or C or SC prefix) are available as standard only in preload classes A and B. Preload class C is typically not recommended in applications using hybrid bearings.

Similarly, for high-speed bearings (ACE, CE, DB or FB designation suffix), typically only preload classes A and B are appropriate. In cases where extreme speed and rigidity are requirements, bearing sets with a different preload may be necessary. In these cases, contact the SKF application engineering service.

Open bearings in the 719 series: Preload of unmounted universally matchable single row angular contact ball bearings or universally matchable bearing sets, arranged back-to-back or face-to-face

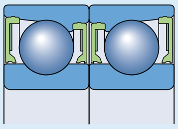



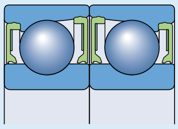
Bearing		Axial preload of bearings in the series[1]									
Bore diameter	Size	719 ACD 719 ACD/HC Preload class			719 CD 719 CD/HC Preload class			719 ACE 719 ACE/HC Preload class		719 CE 719 CE/HC Preload class	
		A	B	C[2]	A	B	C[2]	A	B	A	B
mm	–	N									
10	**00**	15	30	60	10	20	40	–	–	–	–
12	**01**	15	30	60	10	20	40	–	–	–	–
15	**02**	25	50	100	15	30	60	–	–	–	–
17	**03**	25	50	100	15	30	60	–	–	–	–
20	**04**	35	70	140	25	50	100	35	105	20	60
25	**05**	40	80	160	25	50	100	40	120	25	75
30	**06**	40	80	160	25	50	100	40	120	25	75
35	**07**	60	120	240	35	70	140	55	165	35	105
40	**08**	70	140	280	45	90	180	75	225	45	135
45	**09**	80	160	320	50	100	200	80	240	50	150
50	**10**	80	160	320	50	100	200	80	240	50	150
55	**11**	120	240	480	70	140	280	120	360	75	225
60	**12**	120	240	480	70	140	280	120	360	75	225
65	**13**	120	240	480	80	160	320	130	390	80	240
70	**14**	200	400	800	130	260	520	170	510	105	315
75	**15**	210	420	840	130	260	520	180	540	110	330
80	**16**	220	440	880	140	280	560	180	540	110	330
85	**17**	270	540	1 080	170	340	680	230	690	140	420
90	**18**	280	560	1 120	180	360	720	230	690	140	420
95	**19**	290	580	1 160	190	380	760	245	735	150	450
100	**20**	360	720	1 440	230	460	920	295	885	180	540
105	**21**	360	720	1 440	230	460	920	300	900	185	555
110	**22**	370	740	1 480	230	460	920	310	930	190	570
120	**24**	450	900	1 800	290	580	1 160	385	1 155	235	705
130	**26**	540	1 080	2 160	350	700	1 400	–	–	–	–
140	**28**	560	1 120	2 240	360	720	1 440	–	–	–	–
150	**30**	740	1 480	2 960	470	940	1 880	–	–	–	–
160	**32**	800	1 600	3 200	490	980	1 960	–	–	–	–
170	**34**	800	1 600	3 200	500	1 000	2 000	–	–	–	–
180	**36**	1 000	2 000	4 000	630	1 260	2 520	–	–	–	–
190	**38**	1 000	2 000	4 000	640	1 280	2 560	–	–	–	–
200	**40**	1 250	2 500	5 000	800	1 600	3 200	–	–	–	–
220	**44**	1 300	2 600	5 200	850	1 700	3 400	–	–	–	–
240	**48**	1 430	2 860	5720	860	1 720	3 440	–	–	–	–
260	**52**	1 730	3 510	7 020	1 050	2 110	4 220	–	–	–	–
280	**56**	1 820	3 640	7 280	1 090	2 180	4 360	–	–	–	–
300	**60**	2 200	4 400	8 800	1 400	2 800	5 600	–	–	–	–
320	**64**	2 200	4 400	8 800	1 400	2 800	5 600	–	–	–	–

[1] The values for the axial preload of open bearings in the 719 series to FB or DB design are in accordance with those for the sealed bearings (prefix S or SC) and are listed in **table 5** on **page 112**
[2] Only valid for all-steel bearings

Table 5

Sealed bearings in the 719 series: Preload of unmounted universally matchable single row angular contact ball bearings or universally matchable bearing sets, arranged back-to-back or face-to-face



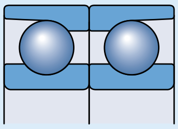


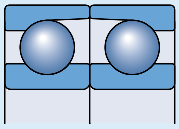
Bearing Bore diameter	 Size	Axial preload of bearings in the series **S719 ACD** **S719 ACD/HC** Preload class A	 B	 C[1]	 **S719 CD** **S719 CD/HC** Preload class A	 B	 C[1]	 **S719 DB** **SC719 DB** Preload class A	 B	 C[1]	 **S719 FB** **SC719 FB** Preload class A	 B	 C[1]
mm	–	N											
30	**06**	40	80	160	25	50	100	29	58	115	18	36	72
35	**07**	60	120	240	35	70	140	30	60	120	19	38	76
40	**08**	70	140	280	45	90	180	32	64	125	20	40	80
45	**09**	80	160	320	50	100	200	44	88	175	28	56	110
50	**10**	80	160	320	50	100	200	46	92	185	29	58	115
55	**11**	120	240	480	70	140	280	58	115	230	37	74	150
60	**12**	120	240	480	70	140	280	60	120	240	38	76	150
65	**13**	120	240	480	80	160	320	63	125	250	40	80	160
70	**14**	200	400	800	130	260	520	80	160	320	50	100	200
75	**15**	210	420	840	130	260	520	83	165	330	52	105	210
80	**16**	220	440	880	140	280	560	93	185	370	60	120	240
85	**17**	270	540	1 080	170	340	680	100	200	400	63	125	250
90	**18**	280	560	1 120	180	360	720	105	210	420	65	130	260
95	**19**	290	580	1 160	190	380	760	110	220	440	70	140	280
100	**20**	360	720	1 440	230	460	920	140	280	560	90	180	360
110	**22**	370	740	1 480	230	460	920	150	300	600	95	190	380
120	**24**	450	900	1 800	290	580	1 160	170	340	680	105	210	420
130	**26**	540	1 080	2 160	350	700	1 400	–	–	–	–	–	–
140	**28**	560	1 120	2 240	360	720	1 440	–	–	–	–	–	–
150	**30**	740	1 480	2 960	470	940	1 880	–	–	–	–	–	–

[1] Only valid for all-steel bearings

Table 6

Open bearings in the 70 series: Preload of unmounted universally matchable single row angular contact ball bearings or universally matchable bearing sets, arranged back-to-back or face-to-face





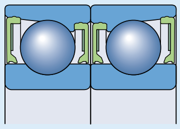
Bearing Bore diameter	Size	Axial preload of bearings in the series[1] 70 ACD 70 ACD/HC Preload class			70 CD 70 CD/HC Preload class			70 ACE 70 ACE/HC Preload class		70 CE 70 CE/HC Preload class	
		A	B	C[2]	A	B	C[2]	A	B	A	B
mm	–	N									
8	**8**	20	40	80	10	20	40	–	–	–	–
9	**9**	20	40	80	10	20	40	–	–	–	–
10	**00**	25	50	100	15	30	60	–	–	–	–
12	**01**	25	50	100	15	30	60	–	–	–	–
15	**02**	30	60	120	20	40	80	–	–	–	–
17	**03**	40	80	160	25	50	100	–	–	–	–
20	**04**	50	100	200	35	70	140	55	165	35	105
25	**05**	60	120	240	35	70	140	55	165	35	105
30	**06**	90	180	360	50	100	200	80	240	50	150
35	**07**	90	180	360	60	120	240	80	240	50	150
40	**08**	100	200	400	60	120	240	90	270	55	165
45	**09**	170	340	680	110	220	440	105	315	65	195
50	**10**	180	360	720	110	220	440	115	345	70	210
55	**11**	230	460	920	150	300	600	120	360	75	225
60	**12**	240	480	960	150	300	600	130	390	80	240
65	**13**	240	480	960	160	320	640	130	390	80	240
70	**14**	300	600	1 200	200	400	800	180	540	110	330
75	**15**	310	620	1 240	200	400	800	180	540	110	330
80	**16**	390	780	1 560	240	480	960	230	690	140	420
85	**17**	400	800	1 600	250	500	1 000	230	690	140	420
90	**18**	460	920	1 840	300	600	1 200	295	885	180	540
95	**19**	480	960	1 920	310	620	1 240	295	885	180	540
100	**20**	500	1 000	2 000	310	620	1 240	300	900	185	555
105	**21**	560	1 180	2 360	360	720	1 440	–	–	–	–
110	**22**	650	1 300	2 600	420	840	1 680	–	–	–	–
120	**24**	690	1 380	2 760	430	860	1 720	–	–	–	–
130	**26**	900	1 800	3 600	560	1 120	2 240	–	–	–	–
140	**28**	900	1 800	3 600	570	1 140	2 280	–	–	–	–
150	**30**	1 000	2 000	4 000	650	1 300	2 600	–	–	–	–
160	**32**	1 150	2 300	4 600	730	1 460	2 920	–	–	–	–
170	**34**	1 250	2 500	5 000	800	1 600	3 200	–	–	–	–
180	**36**	1 450	2 900	5 800	900	1 800	3 600	–	–	–	–
190	**38**	1 450	2 900	5 800	950	1 900	3 800	–	–	–	–
200	**40**	1 750	3 500	7 000	1 100	2 200	4 400	–	–	–	–
220	**44**	2 000	4 000	8 000	1 250	2 500	5 000	–	–	–	–
240	**48**	2 050	4 100	8 200	1 300	2 600	5 200	–	–	–	–

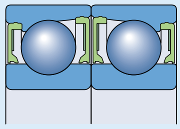
[1] The values for the axial preload of open bearings in the 70 series to FB or DB design are in accordance with those for the sealed bearings (prefix S or SC) and are listed in **table 7** on **page 114**

[2] Only valid for all-steel bearings

Table 7

Sealed bearings in the 70 series: Preload of unmounted universally matchable single row angular contact ball bearings or universally matchable bearing sets, arranged back-to-back or face-to-face



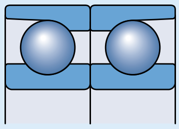


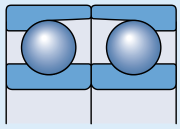
Bearing		**Axial preload of bearings in the series**											
Bore diameter	Size	**S70 ACD** **S70 ACD/HC** Preload class			**S70 CD** **S70 CD/HC** Preload class			**S70 DB** **SC70 DB** Preload class			**S70 FB** **SC70 FB** Preload class		
		A	B	C[1)]	A	B	C[1)]	A	B	C[1)]	A	B	C[1)]
mm	–	N											
30	**06**	90	180	360	50	100	200	38	76	155	24	48	96
35	**07**	90	180	360	60	120	240	40	80	160	26	52	105
40	**08**	100	200	400	60	120	240	43	85	170	28	56	110
45	**09**	170	340	680	110	220	440	57	115	230	35	70	140
50	**10**	180	360	720	110	220	440	60	120	240	37	74	145
55	**11**	230	460	920	150	300	600	83	165	330	52	105	210
60	**12**	240	480	960	150	300	600	85	170	340	54	110	220
65	**13**	240	480	960	160	320	640	92	185	370	57	115	230
70	**14**	300	600	1 200	200	400	800	115	230	460	70	140	280
75	**15**	310	620	1 240	200	400	800	120	240	480	75	150	300
80	**16**	390	780	1 560	240	480	960	160	320	640	98	195	390
85	**17**	400	800	1 600	250	500	1 000	160	320	640	100	200	400
90	**18**	460	920	1 840	300	600	1 200	170	340	680	105	210	420
95	**19**	480	960	1 920	310	620	1 240	175	345	690	110	220	440
100	**20**	500	1 000	2 000	310	620	1 240	175	350	700	110	220	440
110	**22**	650	1 300	2 600	420	840	1 680	220	440	880	135	270	540
120	**24**	690	1 380	2 760	430	860	1 720	230	460	920	140	280	560
130	**26**	900	1 800	3 600	560	1 120	2 240	–	–	–	–	–	–
140	**28**	900	1 800	3 600	570	1 140	2 280	–	–	–	–	–	–
150	**30**	1 000	2 000	4 000	650	1 300	2 600	–	–	–	–	–	–

1) Only valid for all-steel bearings

Table 8

Open bearings in the 72 series: Preload of unmounted universally matchable single row angular contact ball bearings or universally matchable bearing sets, arranged back-to-back or face-to-face





Bearing Bore diam-eter	Size	**Axial preload of bearings in the series** **72 ACD** **72 ACD/HC** Preload class A	B	C[1]	**72 CD** **72 CD/HC** Preload class A	B	C[1]
mm	–	N					
10	**00**	35	70	140	20	40	80
12	**01**	35	70	140	20	40	80
15	**02**	45	90	180	30	60	120
17	**03**	60	120	240	35	70	140
20	**04**	70	140	280	45	90	180
25	**05**	80	160	320	50	100	200
30	**06**	150	300	600	90	180	360
35	**07**	190	380	760	120	240	480
40	**08**	240	480	960	150	300	600
45	**09**	260	520	1 040	160	320	640
50	**10**	260	520	1 040	170	340	680
55	**11**	330	660	1 320	210	420	840
60	**12**	400	800	1 600	250	500	1 000
65	**13**	450	900	1 800	290	580	1 160
70	**14**	480	960	1 920	300	600	1 200
75	**15**	500	1 000	2 000	310	620	1 240
80	**16**	580	1 160	2 320	370	740	1 480
85	**17**	600	1 200	2 400	370	740	1 480
90	**18**	750	1 500	3 000	480	960	1 920
95	**19**	850	1 700	3 400	520	1 040	2 080
100	**20**	950	1 900	3 800	590	1 180	2 360
105	**21**	1 000	2 000	4 000	650	1 300	2 600
110	**22**	1 050	2 100	4 200	670	1 340	2 680
120	**24**	1 200	2 400	4 800	750	1 500	3 000

[1] Only valid for all-steel bearings

Attainable speeds

The attainable rotational speeds provided in the product tables should be regarded as guideline values. They are valid for single bearings under light load (P ≤ 0,05 C) that are lightly preloaded using springs. In addition, good heat dissipation from the bearing arrangement is a prerequisite.

The values provided are for oil-air lubrication and should be reduced if other oil lubrication methods are used. The values provided for grease lubrication are maximum values that can be attained with a good lubricating grease that has a low consistency and low viscosity. For additional information contact the SKF application engineering service.

If single bearings are adjusted against each other with heavier preload, e.g. in order to increase spindle rigidity, or if bearing sets with two, three or four bearings mounted directly adjacent to each other are used, the attainable rotational speeds provided in the product tables need to be reduced. Values for the maximum rotational speeds in these cases can be obtained by multiplying the guideline value provided in the product tables by a reduction factor (dependent on the bearing design, the preload and the bearing arrangement) as listed in **table 9.**

If the rotational speed obtained is not sufficient for the application, spacer rings in the bearing set (→ **fig. 14**) can be used to significantly increase the speed capability.

Fig. 14

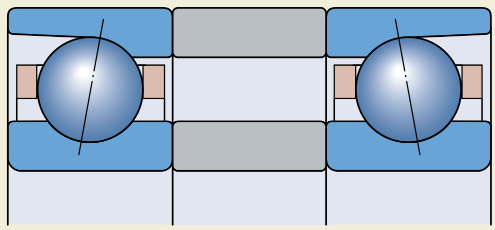


Table 9

Speed reduction factors for bearing sets

Bearing arrangement	**Speed reduction factors for bearing designs** ACD, CD, FB, DB ACE, CE with d ≤ 50 mm Preload class A	B	C	ACE, CE with d > 50 mm Preload class A	B
Two bearings arranged in tandem	0,9	0,8	0,65	0,9	0,7
Two bearings arranged back-to-back or face-to-face	0,8	0,7	0,55	0,75	0,6
bearing sets with 3 bearings	0,7	0,55	0,35	0,65	0,4
bearing sets with 4 bearings	0,65	0,45	0,25	0,55	0,3

Load carrying capacity of bearing sets

The values listed in the product tables for the basic dynamic load rating (C) and the basic static load rating (C_0) as well as for the fatigue load limit (P_u) apply to single bearings. For bearing sets, the corresponding values for single bearings should be multiplied by the following factors

- for bearing sets with two bearings
  $C = 1,62 \times C_{\text{single bearing}}$
  $C_0 = 2 \times C_{0 \text{ single bearing}}$
  $P_u = 2 \times P_{u \text{ single bearing}}$
- for bearing sets with three bearings
  $C = 2,16 \times C_{\text{single bearing}}$
  $C_0 = 3 \times C_{0 \text{ single bearing}}$
  $P_u = 3 \times P_{u \text{ single bearing}}$
- for bearing sets with four bearings
  $C = 2,64 \times C_{\text{single bearing}}$
  $C_0 = 4 \times C_{0 \text{ single bearing}}$
  $P_u = 4 \times P_{u \text{ single bearing}}$.

Equivalent bearing loads

When determining the equivalent bearing load for preloaded angular contact ball bearings, the preload must be taken into account. Depending on the operating conditions, the requisite axial component of the bearing load F_a for a bearing pair, arranged back-to-back or face to face, can be determined approximately from the following equations.

For bearing pairs under radial load and mounted with an interference fit

$$F_a = G_m$$

For bearing pairs under radial load and preloaded by springs

$$F_a = G_{A,B,C}$$

For bearing pairs under axial load and mounted with an interference fit

$$F_a = G_m + 0.67\ K_a \qquad \text{for } K_a \leq 3\ G_m$$
$$F_a = K_a \qquad \text{for } K_a > 3\ G_m$$

For bearing pairs under axial load and preloaded by springs

$$F_a = G_{A,B,C} + K_a$$

where

F_a = axial component of the bearing load, N
$G_{A,B,C}$ = preload of a bearing pair, N
G_m = preload in the mounted bearing pair, N (→ section "Preload in mounted bearing sets", starting on **page 119**)
K_a = external axial force acting on a single bearing, N

Equivalent dynamic bearing load

For single bearings and bearings paired in tandem

$P = F_r$ for $F_a/F_r \leq e$
$P = XF_r + YF_a$ for $F_a/F_r > e$

For bearings mounted in pairs, arranged back-to-back or face-to-face

$P = F_r + Y_1F_a$ for $F_a/F_r \leq e$
$P = XF_r + Y_2F_a$ for $F_a/F_r > e$

For bearing sets, P is the equivalent dynamic load of the bearing set, while F_r and F_a are the radial and axial components of the load respectively, acting on the bearing set.

The values for the factors e, X and Y depend on the bearing contact angle and are listed in **tables 10** and **11**. For bearings with a 15° or 18° contact angle, the factors e, X and Y depend on the relationship $f_0 F_a/C_0$, where f_0 is a calculation factor (→ product tables), F_a the axial component of the load and C_0 the basic static load rating.

Equivalent static bearing load

For single bearings and bearing sets in tandem arrangements

$P_0 = 0,5 F_r + Y_0F_a$

For bearings mounted in pairs, arranged back-to-back or face-to-face

$P_0 = F_r + Y_0F_a$

If $P_0 < F_r$, $P_0 = F_r$ should be used. For bearing sets, P_0 is the equivalent static load of the bearing set, while F_r and F_a are the radial and axial components of the load respectively, acting on the bearing set.

The values for the factor Y_0 depend on the bearing contact angle and are listed in **tables 10** and **11**.

Table 10

Factors for single bearings and bearings arranged in tandem

$f_0 F_a/C_0$	e	X	Y	Y_0
Contact angle 15° (Designation suffix CD or CE)				
≤ 0,178	0,38	0,44	1,47	0,46
0,357	0,40	0,44	1,40	0,46
0,714	0,43	0,44	1,30	0,46
1,07	0,46	0,44	1,23	0,46
1,43	0,47	0,44	1,19	0,46
2,14	0,50	0,44	1,12	0,46
3,57	0,55	0,44	1,02	0,46
≥ 5,35	0,56	0,44	1,00	0,46
Contact angle 18° (Designation suffix FB)				
–	0,57	0,43	1	0,42
Contact angle 25° (Designation suffix ACD, ACE or DB)				
–	0,68	0,41	0,87	0,38

Table 11

Factors for bearings paired back-to-back or face-to-face

$2 f_0 F_a/C_0$	e	X	Y_1	Y_2	Y_0
Contact angle 15° (Designation suffix CD or CE)					
≤ 0,178	0,38	0,72	1,65	2,39	0,92
0,357	0,40	0,72	1,57	2,28	0,92
0,714	0,43	0,72	1,46	2,11	0,92
1,07	0,46	0,72	1,38	2,00	0,92
1,43	0,47	0,72	1,34	1,93	0,92
2,14	0,50	0,72	1,26	1,82	0,92
3,57	0,55	0,72	1,14	1,66	0,92
≥ 5,35	0,56	0,72	1,12	1,63	0,92
Contact angle 18° (Designation suffix FB)					
–	0,57	0,7	1,09	1,63	0,84
Contact angle 25° (Designation suffix ACD, ACE or DB)					
–	0,68	0,67	0,92	1,41	0,76

Preload in mounted bearing sets

Matched bearing sets have a heavier preload when mounted than when unmounted. The increase depends mainly on

- the actual tolerances for the bearing seats on the spindle and in the housing bore. As a result of an interference fit, the rings are deformed elastically and either expanded or compressed.
- the rotational speed of the spindle, if the bearings are pressed against each other.

The increase in preload can, among other things, also be caused by

- temperature differences between the inner ring, the outer ring and the balls
- different coefficient of thermal expansion for the spindle and housing materials
- deviations from the geometrical form in the associated components, e.g. in terms of cylindricity, perpendicularity or concentricity of the bearing seats.

If the bearings are mounted with the usual fits (shaft tolerance js4 and housing bore tolerance JS5) on a steel shaft and in a thick-walled steel or cast iron housing, bearing preload can be determined with sufficient accuracy from

$$G_m = f\, f_1\, f_2\, f_{HC}\, G_{A,B,C}$$

where

G_m = preload in the mounted bearing set, N

$G_{A,B,C}$ = preload in the unmounted bearing set (→ **tables 4**, **5**, **6**, **7** or **8** on **pages 111** to **115**), N

f = a bearing factor depending on bearing series and size (→ **table 12** on **page 120**)

f_1 = a correction factor depending on the contact angle (→ **table 13** on **page 121**)

f_2 = a correction factor depending on the preload class (→ **table 13** on **page 121**)

f_{HC} = a correction factor for hybrid bearings (→ **table 13** on **page 121**)

Considerably tighter fits may be necessary, for example for very fast running spindles, where the centrifugal forces can loosen the inner ring from its seat on the shaft. These bearing arrangements must be carefully evaluated and calculated. In these cases, contact the SKF application engineering service.

Calculation example

What preload is to be expected in a matched bearing set 71924 CD/P4ADBC after mounting?

The preload for the unmounted set is obtained from **table 4** on **page 111** for bearings in the 719 CD series, preload class C, size 24 with G_C = 1 160 N.

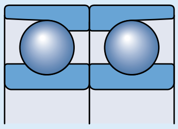
With the bearing factor f = 2,19 from **table 12** on **page 120** and correction factors f_1 = 1 and f_2 = 1,19 from **table 13** on **page 121**, the preload of the mounted bearing set results

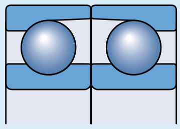
$$G_m = f\, f_1\, f_2\, G_C$$

$$= 2{,}19 \times 1 \times 1{,}19 \times 1\,160 \approx 3\,020 \text{ N}$$

Table 12

Bearing factor f





Bearing		Bearing factor for bearing series and design						
Bore diam-eter	Size	719			70			72
		CD ACD	CE ACE	DB FB	CD ACD	CE ACE	DB FB	CD ACD
mm	–	–						
8	**8**	–	–	–	1,2	–	–	–
9	**9**	–	–	–	1,2	–	–	–
10	**00**	1,26	–	–	1,2	–	–	1,15
12	**01**	1,29	–	–	1,22	–	–	1,17
15	**02**	1,33	–	–	1,24	–	–	1,19
17	**03**	1,35	–	–	1,26	–	–	1,2
20	**04**	1,39	1,27	–	1,29	1,24	–	1,22
25	**05**	1,45	1,35	–	1,33	1,26	–	1,25
30	**06**	1,51	1,43	1,33	1,37	1,28	1,21	1,27
35	**07**	1,57	1,5	1,36	1,4	1,31	1,23	1,3
40	**08**	1,62	1,57	1,39	1,44	1,33	1,25	1,32
45	**09**	1,68	1,64	1,41	1,47	1,35	1,27	1,35
50	**10**	1,72	1,7	1,44	1,5	1,36	1,28	1,37
55	**11**	1,77	1,76	1,46	1,53	1,38	1,3	1,39
60	**12**	1,82	1,81	1,48	1,56	1,4	1,31	1,4
65	**13**	1,86	1,86	1,50	1,59	1,41	1,32	1,42
70	**14**	1,9	1,9	1,52	1,61	1,43	1,33	1,43
75	**15**	1,94	1,94	1,53	1,63	1,44	1,34	1,45
80	**16**	1,97	1,98	1,54	1,65	1,45	1,34	1,46
85	**17**	2,01	2,01	1,55	1,67	1,46	1,35	1,47
90	**18**	2,04	2,04	1,56	1,69	1,47	1,35	1,47
95	**19**	2,07	2,06	1,57	1,7	1,48	1,36	1,48
100	**20**	2,1	2,08	1,57	1,72	–	1,36	1,49
105	**21**	2,12	2,09	–	1,73	–	–	1,49
110	**22**	2,15	2,1	1,57	1,74	–	1,36	1,49
120	**24**	2,19	2,11	1,57	1,78	–	1,36	1,49
130	**26**	2,23	–	–	1,77	–	–	1,48
140	**28**	2,26	–	–	1,78	–	–	–
150	**30**	2,28	–	–	1,79	–	–	–
160	**32**	2,3	–	–	1,79	–	–	–
170	**34**	2,31	–	–	1,79	–	–	–
180	**36**	2,32	–	–	1,78	–	–	–
190	**38**	2,32	–	–	1,77	–	–	–
200	**40**	2,31	–	–	1,76	–	–	–
220	**44**	2,3	–	–	1,74	–	–	–
240	**48**	2,27	–	–	1,72	–	–	–
260	**52**	2,23	–	–	–	–	–	–
280	**56**	2,19	–	–	–	–	–	–
300	**60**	2,15	–	–	–	–	–	–
320	**64**	2,15	–	–	–	–	–	–

Correction factors for preload calculation

Bearing series	Correction factors f_1	f_2 Preload class A	B	C	f_{HC}
(S)719 CD	1	1	1,09	1,19	1
(S)719 ACD	0,92	1	1,09	1,18	1
719 CE	1	1	1,14	–	1
719 ACE	0,92	1	1,14	–	1
(S)719 FB	1	1	1,06	1,14	1
(S)719 DB	0,98	1	1,05	1,12	1
(S)719 CD/HC	1	1	1,12	–	1,04
(S)719 ACD/HC	0,92	1	1,12	–	1,04
719 CE/HC	1	1	1,14	–	1,04
719 ACE/HC	0,92	1	1,14	–	1,04
(S)C719 FB	1	1	1,06	–	1,04
(S)C719 DB	0,98	1	1,05	–	1,03
(S)70 C	1	1	1,06	1,2	1
(S)70 ACD	0,92	1	1,06	1,18	1
70 CE	1	1	1,08	–	1
70 ACE	0,96	1	1,08	–	1
(S)70 FB	1	1	1,03	1,08	1
(S)70 DB	0,98	1	1,04	1,07	1
(S)70 CD/HC	1	1	1,05	–	1,02
(S)70 ACD/HC	0,92	1	1,04	–	1,03
70 CE/HC	1	1	1,1	–	1,02
70 ACE/HC	0,96	1	1,07	–	1,02
(S)C70 FB	1	1	1,04	–	1,02
(S)C70 DB	0,98	1	1,04	–	1,02
72 CD	1	1	1,04	1,1	1
72 ACD	0,96	1	1,05	1,09	1
72 CD/HC	1	1	1,03	–	1,02
72 ACD/HC	0,96	1	1,03	–	1,02

Preload with constant force

In precision, high-speed applications, a constant, uniform preload is important. To maintain the proper preload, calibrated linear springs are typically used between the bearing outer ring and housing shoulder (→ **fig. 15**). With springs, the kinematic behaviour of the bearing will not influence preload under normal operating conditions. Note however, that a spring loaded bearing arrangement has a lower degree of stiffness than an arrangement using axial displacement to set the preload. The spring preload method is practically standard for spindles used on internal grinders.

Guideline values for the most common spring loaded bearing arrangements are listed in **table 14**. The values apply to single bearings in the CD design. For bearings in tandem arrangements, the table values should be multiplied by a factor, equal to the number of bearings preloaded with the spring force. The spring preload forces specified are a compromise between minimal difference in contact angle at the inner and outer ring raceways and axial rigidity at high rotational speeds. Heavier preloads lead to higher operating temperatures. For additional information, contact the SKF application engineering service.

Fig. 15

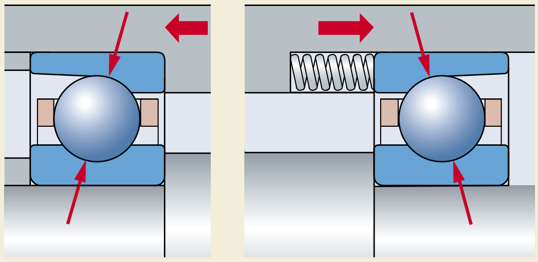


Table 14

Speed-depending guideline values for spring preload forces

Bearing Basic designation	**Speed factor n $d_m \times 10^6$** 2,25	2	1,75	1,5	1,25
	Preload[1)]				
–	N				
7000 CD	150	150	150	125	100
7001 CD	150	150	150	125	100
7002 CD	160	160	160	125	100
7003 CD	175	175	160	125	100
7004 CD	250	250	200	150	150
7005 CD	280	280	250	200	175
7006 CD	350	350	300	200	175
7007 CD	400	400	350	300	200
7008 CD	400	400	350	300	200
7009 CD	750	750	650	500	400
7010 CD	750	750	650	500	400
7011 CD	1 000	1 000	900	800	600
7012 CD	1 000	1 000	900	800	600

1) Valid for single bearings in the CD design. For bearings in tandem arrangements, the table values should be multiplied by a factor, equal to the number of bearings

Preload by axial displacement

For machining centres, milling machines, lathes and drills, rigidity and precise axial guidance are critical parameters, especially when alternating axial forces occur. For these applications, the preload in the bearings is usually obtained by adjusting the bearing rings relative to each other in the axial direction. This preload method offers significant advantages in terms of system rigidity. However, depending on the bearing type and ball material, preload increases considerably with rotational speed (→ **diagram 1**).

Universally matchable bearings or matched bearing sets are manufactured to exacting specifications so that when mounted properly, they will attain their predetermined axial displacement and will consequently attain the proper preload (→ **fig. 16**). With standard bearings, precision matched spacer rings must be used.

Fig. 16

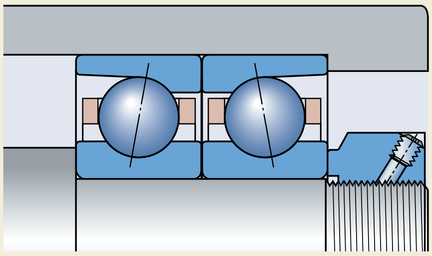
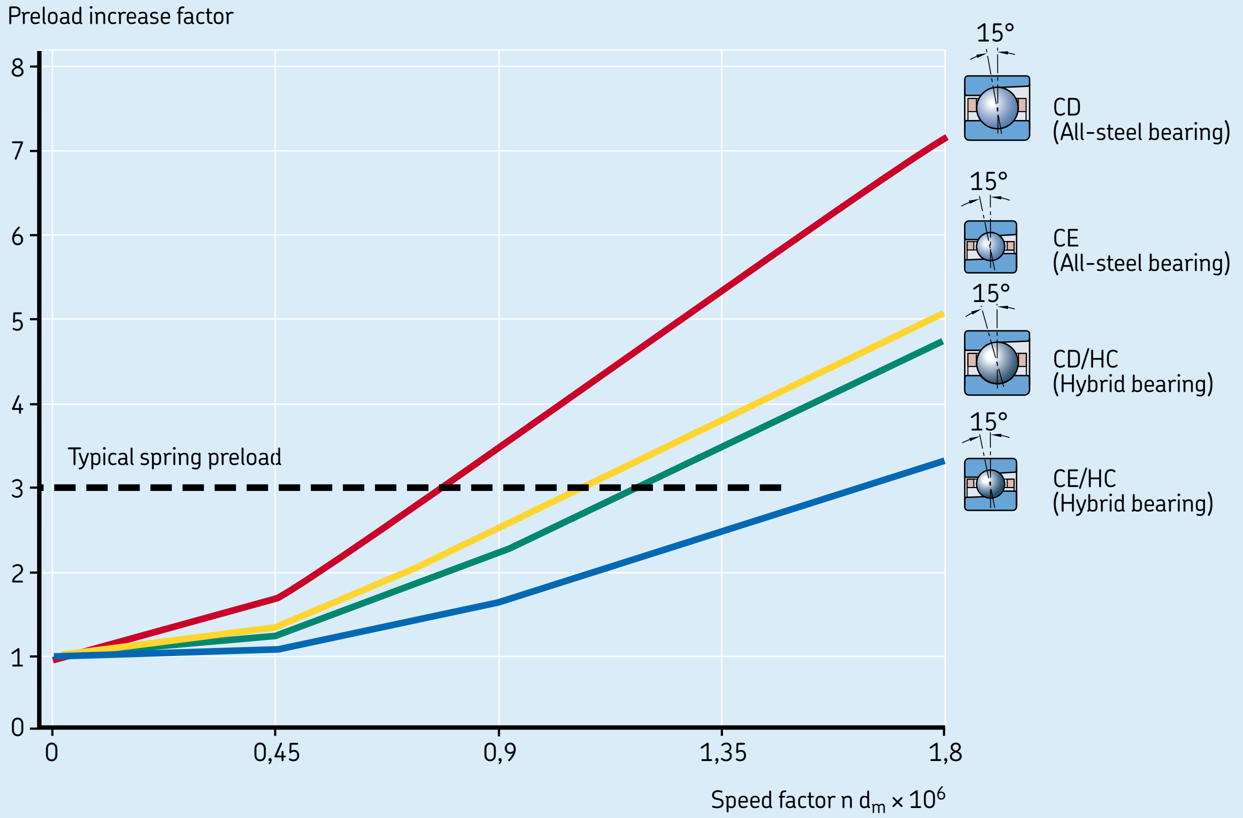


Diagram 1

Speed-depending preload increase
Reference bearing type 7014



Individual adjustment of preload

In cases where universally matchable bearings or matched bearing sets are used, preload is determined at the factory during production. In some cases, however, it may be necessary to optimize the preload to accommodate operating conditions. In these cases, the bearings should not be modified, as this requires special tools, and knowledge, and the bearings could be damaged irreparably. Bearing modification should be entrusted exclusively to SKF Spindle Service Centres. It is possible, however, to increase or decrease preload by using spacer rings between the bearings (→ **fig. 17**). By grinding the side face of the inner or outer spacer the preload in the bearing set can be changed.

Table 15 provides information about which of the equal-width spacer ring side faces must be ground and what effect it will have. **Tables 16** and **17** on **pages 126** and **127** contain the necessary dimensional deviation for the overall width of the spacer rings.

Spacer rings

As a rule, the use of spacer rings in angular contact ball bearing sets is advantageous when

- preload in the bearing set needs to be changed
- system rigidity should be increased
- nozzles for oil lubrication must be as close as possible to the bearing raceways
- sufficiently large space is needed for surplus grease in order to reduce heat generated by the bearings.

To achieve maximum bearing performance, the spacer rings must not deform under load, because form deviations influence the preload in the bearing set. Here, the guidelines for the shaft and housing tolerances should be used.

The spacer rings should be made of high-grade steel that can be hardened to between 45 and 60 HRC, depending on the application. Particular importance must be given to the plane parallelism of the face surfaces, where the permissible shape deviation must not exceed 1 to 2 µm. The overall width of the inner and outer spacer rings should be identical.

The most accurate way to do this is to process the width of the concentric inner and outer spacer rings in one operation.

Fig. 17

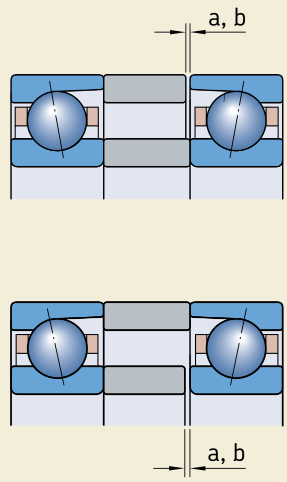


Table 15

Necessary spacer ring width reduction

Preload change	**Width reduction** Value	Spacer ring between bearings arranged back-to-back	face-to-face
Increasing the preload			
A to B	a	inside	outside
B to C	b	inside	outside
A to C	a + b	inside	outside
Decreasing the preload			
B to A	a	outside	inside
C to B	b	outside	inside
C to A	a + b	outside	inside

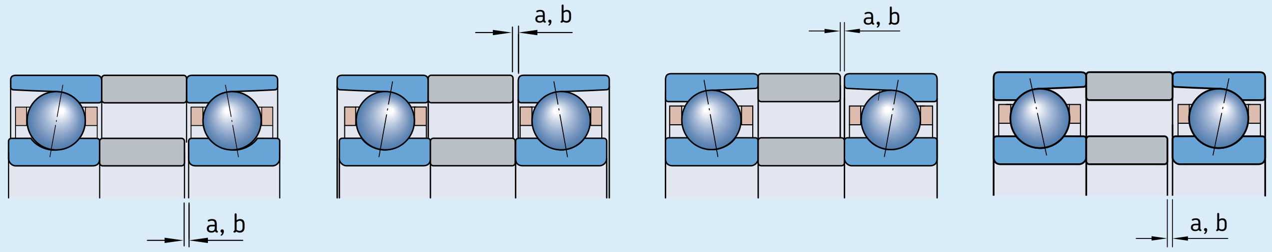
Effect of rotational speed on preload

Using strain gauges, SKF has determined that preload changes with rotational speed and that there is a marked increase in preload at very high speeds. This is mainly attributable to the heavy centrifugal forces on the balls causing them to change their position within the bearing. When compared to an all-steel bearing, hybrid bearings, i.e. bearings with ceramic balls, due to the lower mass of the balls, can attain much higher rotational speeds without significantly increasing preload (→ **diagram 1**, **page 123**). When the speed factor $n\ d_m$ exceeds the value 10^6 to $1,2 \times 10^6$ and the bearings are clamped, contact the SKF application engineering service.

2

Table 16

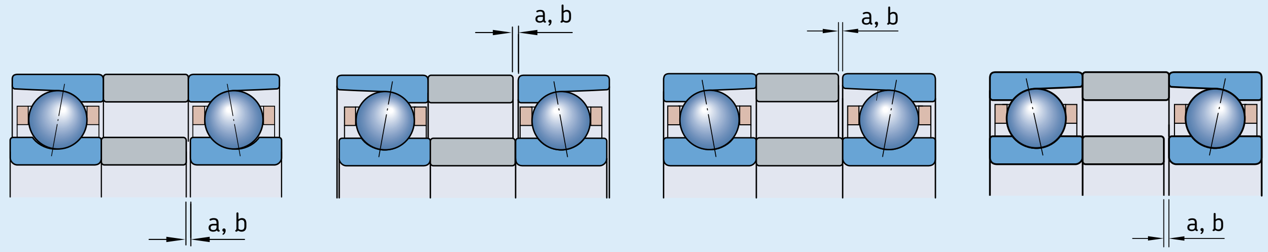
Guideline values to reduce spacer width for bearings in the CD, CE or FB design



Bearing Bore diameter	Size	Requisite spacer width reduction for bearings in the series 719 CD S719 CD a	b	70 CD S70 CD a	b	72 CD a	b	719 CE S(C)719 FB a	70 CE S(C)70 FB a
mm	–	µm							
8	**8**	–	–	4	6	–	–	–	–
9	**9**	–	–	4	6	–	–	–	–
10	**00**	4	6	5	7	6	9	–	–
12	**01**	4	6	5	7	6	9	–	–
15	**02**	5	7	5	8	7	11	–	–
17	**03**	5	7	6	9	8	11	–	–
20	**04**	5	8	7	10	8	12	10	14
25	**05**	5	8	7	10	8	12	11	13
30	**06**	5	8	8	13	11	15	11	16
35	**07**	6	10	8	13	12	17	13	15
40	**08**	7	11	8	13	13	21	14	15
45	**09**	7	11	12	17	14	21	15	16
50	**10**	7	12	12	17	14	21	15	17
55	**11**	10	15	14	19	16	24	21	15
60	**12**	10	15	14	19	18	26	21	16
65	**13**	10	18	14	20	20	29	22	16
70	**14**	13	19	15	23	20	29	25	19
75	**15**	13	19	15	23	20	29	25	19
80	**16**	13	20	17	25	20	32	26	22
85	**17**	15	22	17	25	20	32	29	22
90	**18**	15	23	18	29	25	36	29	26
95	**19**	16	23	19	29	25	39	30	26
100	**20**	17	26	19	29	27	41	33	26
105	**21**	17	26	21	32	28	42	34	–
110	**22**	17	26	23	34	28	42	35	–
120	**24**	19	29	23	35	30	46	38	–
130	**26**	21	31	26	39	–	–	–	–
140	**28**	21	33	26	39	–	–	–	–
150	**30**	25	38	27	43	–	–	–	–
160	**32**	26	39	29	45	–	–	–	–
170	**34**	26	40	29	45	–	–	–	–
180	**36**	28	44	30	47	–	–	–	–
190	**38**	29	44	31	49	–	–	–	–
200	**40**	31	49	34	54	–	–	–	–
220	**44**	33	51	37	56	–	–	–	–
240	**48**	33	51	38	59	–	–	–	–
260	**52**	33	51	–	–	–	–	–	–
280	**56**	35	53	–	–	–	–	–	–
300	**60**	40	62	–	–	–	–	–	–
320	**64**	40	63	–	–	–	–	–	–

Table 17

Guideline values to reduce spacer width for bearings in the ACD, ACE and DB design



Bearing Bore diameter	Size	Requisite spacer width reduction for bearings in the series 719 ACD S719 ACD a	b	70 ACD S70 ACD a	b	72 ACD a	b	719 ACE S(C)719 DB a	70 ACE S(C)70 DB a
mm	–	mm							
8	**8**	–	–	3	4	–	–	–	–
9	**9**	–	–	3	4	–	–	–	–
10	**00**	2	4	3	5	3	6	–	–
12	**01**	2	4	3	5	3	6	–	–
15	**02**	3	5	3	5	5	7	–	–
17	**03**	3	5	4	6	5	8	–	–
20	**04**	4	5	4	7	5	8	7	9
25	**05**	4	5	5	7	5	8	7	8
30	**06**	4	5	6	9	7	11	7	10
35	**07**	5	6	6	9	9	12	8	9
40	**08**	5	7	6	9	10	14	9	9
45	**09**	5	7	7	12	10	14	9	10
50	**10**	5	7	8	12	10	14	9	10
55	**11**	6	10	8	14	11	17	13	10
60	**12**	6	10	8	14	12	18	13	10
65	**13**	6	10	8	14	13	20	14	10
70	**14**	8	13	10	15	13	21	15	12
75	**15**	9	13	10	15	13	21	15	12
80	**16**	9	13	12	18	13	22	15	14
85	**17**	10	15	12	18	13	22	17	14
90	**18**	10	16	12	19	16	25	18	16
95	**19**	10	16	12	20	17	27	18	16
100	**20**	11	18	13	21	18	29	20	16
105	**21**	11	18	13	22	18	30	20	–
110	**22**	11	18	15	23	18	30	21	–
120	**24**	12	21	15	24	20	32	23	–
130	**26**	14	22	17	27	–	–	–	–
140	**28**	14	23	17	27	–	–	–	–
150	**30**	16	26	18	28	–	–	–	–
160	**32**	17	27	18	30	–	–	–	–
170	**34**	17	27	18	30	–	–	–	–
180	**36**	18	30	19	33	–	–	–	–
190	**38**	18	30	19	33	–	–	–	–
200	**40**	20	33	22	37	–	–	–	–
220	**44**	21	34	24	38	–	–	–	–
240	**48**	21	35	24	39	–	–	–	–
260	**52**	22	36	–	–	–	–	–	–
280	**56**	23	38	–	–	–	–	–	–
300	**60**	25	41	–	–	–	–	–	–
320	**64**	25	42	–	–	–	–	–	–

Designation system

The complete designation for a single high-precision angular contact ball bearing consists of a combination of letters and figures to identify each of the following

- bearing series
- bearing size
- contact angle
- internal design
- ball material
- tolerance class.

The designation of matched bearing sets also includes suffixes identifying the number of bearings in the set, their arrangement and preload.

The designation system for SKF high-precision angular contact ball bearings is shown in **table 18** together with their definitions.

Table 18

Designation system for SKF high-precision angular contact ball bearings

Examples: 71910 ACE/HCP4AQBCA — 719 | 10 | ACE | / | HC | P4A | Q | BC | A

SC7008 FBGA/P7 — SC | 70 | 08 | FBGA | / | P7

Prefix

C	Hybrid bearing (if not specified by suffix)
S	Sealed bearing
SC	Sealed hybrid bearing

Bearing series

719	ISO Dimension Series 19
70	ISO Dimension Series 10
72	ISO Dimension Series 02

Bearing size

8	8 mm bore diameter
9	9 mm bore diameter
00	10 mm bore diameter
01	12 mm bore diameter
02	15 mm bore diameter
03	17 mm bore diameter
04	(×5) 20 mm bore diameter
	up to
64	(×5) 320 mm bore diameter

Contact angle and internal design

ACD	25° contact angle
ACE	25° contact angle, high-speed design
CD	15° contact angle
CE	15° contact angle, high-speed design
DB	25° contact angle, high-speed design
FB	18° contact angle, high-speed design
GA	Universally matchable bearing, preload class A
GB	Universally matchable bearing, preload class B
GC	Universally matchable bearing, preload class C

Cage design and ball material

–	Window-type cage of fabric reinforced phenolic resin or glass fibre reinforced PEEK, outer ring centred (no suffix)
–	Balls made of carbon chromium steel (no suffix)
HC	Balls made of silicon nitride (hybrid bearings)

Tolerances

P4A	Dimensional accuracy to ISO tolerance class 4, running accuracy better than ISO class 4
P7	Dimensional accuracy to ISO tolerance class 4, running accuracy better than ISO class 4
PA9A	Dimensional and running accuracy to ABMA tolerance class ABEC 9
P9	Dimensional and running accuracy to ABMA tolerance class ABEC 9

Number of bearings per set

D	2 bearings
T	3 bearings
Q	4 bearings

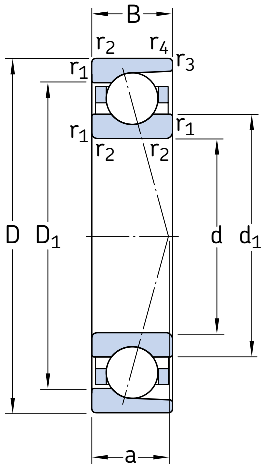
Bearing arrangement in matched sets

B	Back-to-back
F	Face-to-face
T	Tandem
BT	Back-to-back tandem
FT	Face-to-face tandem
BC	Back-to-back of pairs in tandem
FC	Face-to-face of pairs in tandem

Preload

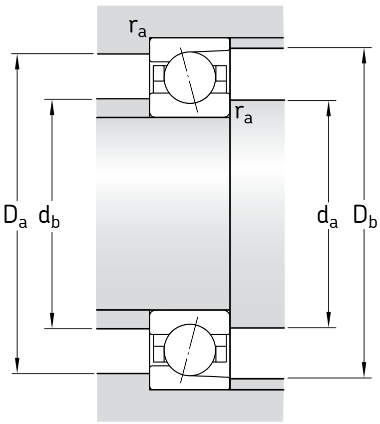
A	Light preload
B	Medium preload
C	Heavy preload
G..	Special preload, value in daN, e.g. G240

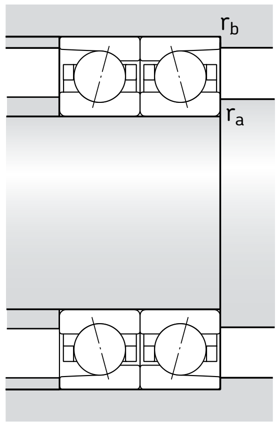
Angular contact ball bearings
d **8 – 12** mm



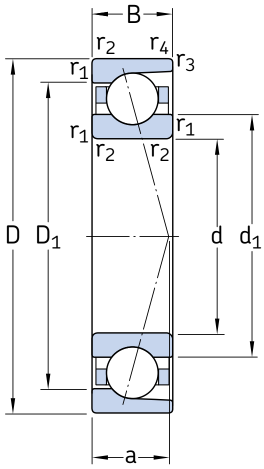
CD, ACD

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
8	22	7	2,96	1,16	0,048	8,4	70 000	110 000	0,011	**708 CD/P4A**
	22	7	2,96	1,16	0,048	8,4	75 000	120 000	0,010	**708 CD/HCP4A**
	22	7	2,91	1,12	0,048	–	67 000	100 000	0,011	**708 ACD/P4A**
	22	7	2,91	1,12	0,048	–	70 000	110 000	0,010	**708 ACD/HCP4A**
9	24	7	3,25	1,34	0,057	8,8	70 000	110 000	0,014	**709 CD/P4A**
	24	7	3,25	1,34	0,057	8,8	75 000	120 000	0,012	**709 CD/HCP4A**
	24	7	3,12	1,29	0,054	–	63 000	95 000	0,014	**709 ACD/P4A**
	24	7	3,12	1,29	0,054	–	70 000	110 000	0,012	**709 ACD/HCP4A**
10	22	6	2,51	1,1	0,048	9,5	70 000	110 000	0,009	**71900 CD/P4A**
	22	6	2,51	1,1	0,048	9,5	80 000	120 000	0,008	**71900 CD/HCP4A**
	22	6	2,42	1,06	0,045	–	63 000	95 000	0,009	**71900 ACD/P4A**
	22	6	2,42	1,06	0,045	–	70 000	110 000	0,008	**71900 ACD/HCP4A**
	26	8	4,1	1,66	0,071	8,3	67 000	100 000	0,018	**7000 CD/P4A**
	26	8	4,10	1,66	0,071	8,3	70 000	110 000	0,016	**7000 CD/HCP4A**
	26	8	3,97	1,6	0,067	–	56 000	85 000	0,018	**7000 ACD/P4A**
	26	8	3,97	1,6	0,067	–	67 000	100 000	0,016	**7000 ACD/HCP4A**
	30	9	5,4	2,6	0,093	8,2	60 000	90 000	0,029	**7200 CD/P4A**
	30	9	5,4	2,6	0,093	8,2	70 000	100 000	0,025	**7200 CD/HCP4A**
	30	9	5,2	2,45	0,09	–	53 000	80 000	0,029	**7200 ACD/P4A**
	30	9	5,2	2,45	0,09	–	63 000	95 000	0,025	**7200 ACD/HCP4A**
12	24	6	2,65	1,25	0,053	9,8	63 000	95 000	0,010	**71901 CD/P4A**
	24	6	2,65	1,25	0,053	9,8	75 000	110 000	0,009	**71901 CD/HCP4A**
	24	6	2,55	1,18	0,05	–	56 000	85 000	0,010	**71901 ACD/P4A**
	24	6	2,55	1,18	0,05	–	67 000	100 000	0,009	**71901 ACD/HCP4A**
	28	8	4,49	1,9	0,08	8,7	60 000	90 000	0,020	**7001 CD/P4A**
	28	8	4,49	1,90	0,08	8,7	67 000	100 000	0,017	**7001 CD/HCP4A**
	28	8	4,36	1,83	0,078	–	53 000	80 000	0,020	**7001 ACD/P4A**
	28	8	4,36	1,83	0,078	–	63 000	95 000	0,017	**7001 ACD/HCP4A**
	32	10	5,85	2,9	0,108	8,5	53 000	80 000	0,036	**7201 CD/P4A**
	32	10	5,85	2,9	0,108	8,5	67 000	95 000	0,032	**7201 CD/HCP4A**
	32	10	5,72	2,75	0,104	–	48 000	70 000	0,036	**7201 ACD/P4A**
	32	10	5,72	2,75	0,104	–	56 000	85 000	0,032	**7201 ACD/HCP4A**



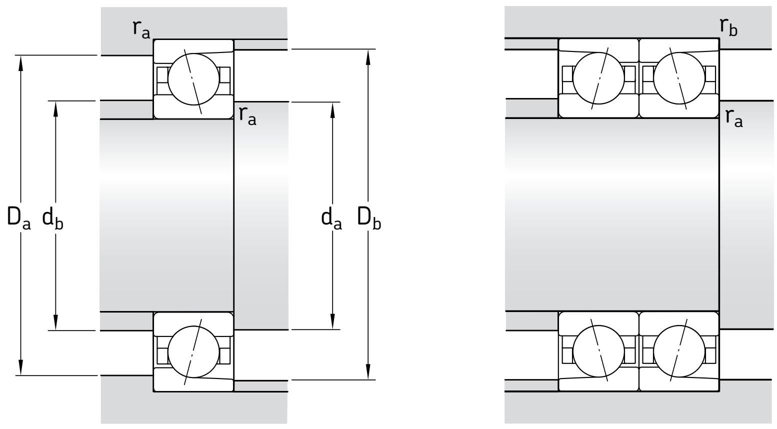


Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
8	12,6	17,4	0,3	0,2	6	10	10	20	20,6	0,3	0,2
	12,6	17,4	0,3	0,2	6	10	10	20	20,6	0,3	0,2
	12,6	17,4	0,3	0,2	7	10	10	20	20,6	0,3	0,2
	12,6	17,4	0,3	0,2	7	10	10	20	20,6	0,3	0,2
9	14,1	18,9	0,3	0,2	6	11	11	22	22,6	0,3	0,2
	14,1	18,9	0,3	0,2	6	11	11	22	22,6	0,3	0,2
	14,1	18,9	0,3	0,2	7	11	11	22	22,6	0,3	0,2
	14,1	18,9	0,3	0,2	7	11	11	22	22,6	0,3	0,2
10	14	18	0,3	0,2	5	12	12	20	20,6	0,3	0,2
	14	18	0,3	0,2	5	12	12	20	20,6	0,3	0,2
	14	18	0,3	0,2	7	12	12	20	20,6	0,3	0,2
	14	18	0,3	0,2	7	12	12	20	20,6	0,3	0,2
	15,1	20,9	0,3	0,2	6	12	12	24	24,6	0,3	0,2
	15,1	20,9	0,3	0,2	6	12	12	24	24,6	0,3	0,2
	15,1	20,9	0,3	0,2	8	12	12	24	24,6	0,3	0,2
	15,1	20,9	0,3	0,2	8	12	12	24	24,6	0,3	0,2
	16,8	23,6	0,6	0,3	7	14,2	14,2	25,8	27,6	0,6	0,3
	16,8	23,6	0,6	0,3	7	14,2	14,2	25,8	27,6	0,6	0,3
	16,8	23,6	0,6	0,3	9	14,2	14,2	25,8	27,6	0,6	0,3
	16,8	23,6	0,6	0,3	9	14,2	14,2	25,8	27,6	0,6	0,3
12	16	20	0,3	0,2	5	14	14	22	22,6	0,3	0,2
	16	20	0,3	0,2	5	14	14	22	22,6	0,3	0,2
	16	20	0,3	0,2	7	14	14	22	22,6	0,3	0,2
	16	20	0,3	0,2	7	14	14	22	22,6	0,3	0,2
	17,1	22,9	0,3	0,2	7	14	14	26	26,6	0,3	0,2
	17,1	22,9	0,3	0,2	7	14	14	26	26,6	0,3	0,2
	17,1	22,9	0,3	0,2	9	14	14	26	26,6	0,3	0,2
	17,1	22,9	0,3	0,2	9	14	14	26	26,6	0,3	0,2
	18,6	25,4	0,6	0,3	8	16,2	16,2	27,8	29,6	0,6	0,3
	18,6	25,4	0,6	0,3	8	16,2	16,2	27,8	29,6	0,6	0,3
	18,6	25,4	0,6	0,3	10	16,2	16,2	27,8	29,6	0,6	0,3
	18,6	25,4	0,6	0,3	10	16,2	16,2	27,8	29,6	0,6	0,3



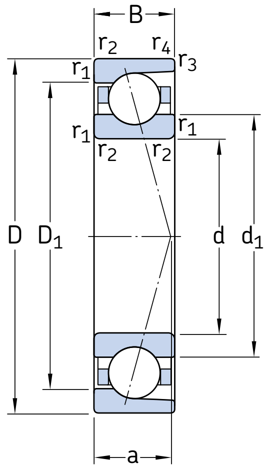
CD, ACD

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calculation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
15	28	7	3,97	1,9	0,08	9,6	56 000	85 000	0,015	**71902 CD/P4A**
	28	7	3,97	1,9	0,08	9,6	70 000	100 000	0,013	**71902 CD/HCP4A**
	28	7	3,77	1,8	0,078	–	50 000	75 000	0,015	**71902 ACD/P4A**
	28	7	3,77	1,8	0,078	–	60 000	90 000	0,013	**71902 ACD/HCP4A**
	32	9	5,20	2,45	0,104	9,3	50 000	75 000	0,028	**7002 CD/P4A**
	32	9	5,20	2,45	0,104	9,3	60 000	90 000	0,025	**7002 CD/HCP4A**
	32	9	4,94	2,32	0,098	–	45 000	67 000	0,028	**7002 ACD/P4A**
	32	9	4,94	2,32	0,098	–	53 000	80 000	0,025	**7002 ACD/HCP4A**
	35	11	7,41	3,8	0,14	8,5	48 000	70 000	0,043	**7202 CD/P4A**
	35	11	7,41	3,8	0,14	8,5	60 000	85 000	0,037	**7202 CD/HCP4A**
	35	11	7,28	3,6	0,134	–	43 000	63 000	0,043	**7202 ACD/P4A**
	35	11	7,28	3,6	0,134	–	50 000	75 000	0,037	**7202 ACD/HCP4A**
17	30	7	4,16	2,08	0,088	9,8	50 000	75 000	0,017	**71903 CD/P4A**
	30	7	4,16	2,08	0,088	9,8	63 000	90 000	0,017	**71903 CD/HCP4A**
	30	7	3,97	2	0,085	–	45 000	67 000	0,017	**71903 ACD/P4A**
	30	7	3,97	2	0,085	–	53 000	80 000	0,015	**71903 ACD/HCP4A**
	35	10	6,76	3,25	0,137	9,1	48 000	70 000	0,037	**7003 CD/P4A**
	35	10	6,76	3,25	0,137	9,1	53 000	80 000	0,032	**7003 CD/HCP4A**
	35	10	6,5	3,1	0,132	–	40 000	60 000	0,037	**7003 ACD/P4A**
	35	10	6,5	3,1	0,132	–	50 000	75 000	0,032	**7003 ACD/HCP4A**
	40	12	9,23	4,8	0,176	8,5	43 000	63 000	0,062	**7203 CD/P4A**
	40	12	9,23	4,8	0,176	8,5	53 000	75 000	0,054	**7203 CD/HCP4A**
	40	12	8,84	4,55	0,17	–	38 000	56 000	0,062	**7203 ACD/P4A**
	40	12	8,84	4,55	0,17	–	45 000	67 000	0,054	**7203 ACD/HCP4A**

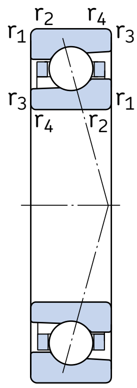


Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
15	18,9	23,7	0,3	0,2	6	17	17	26	26,6	0,3	0,2
	18,9	23,7	0,3	0,2	6	17	17	26	26,6	0,3	0,2
	18,9	23,7	0,3	0,2	9	17	17	26	26,6	0,3	0,2
	18,9	23,7	0,3	0,2	9	17	17	26	26,6	0,3	0,2
	20,6	26,4	0,3	0,2	8	17	17	30	30,6	0,3	0,2
	20,6	26,4	0,3	0,2	8	17	17	30	30,6	0,3	0,2
	20,6	26,4	0,3	0,2	10	17	17	30	30,6	0,3	0,2
	20,6	26,4	0,3	0,2	10	17	17	30	30,6	0,3	0,2
	21,4	29,1	0,6	0,3	9	19,2	19,2	30,8	32,6	0,6	0,3
	21,4	29,1	0,6	0,3	9	19,2	19,2	30,8	32,6	0,6	0,3
	21,4	29,1	0,6	0,3	12	19,2	19,2	30,8	32,6	0,6	0,3
	21,4	29,1	0,6	0,3	12	19,2	19,2	30,8	32,6	0,6	0,3
17	20,9	25,7	0,3	0,2	7	19	19	28	28,6	0,3	0,2
	20,9	25,7	0,3	0,2	7	19	19	28	28,6	0,3	0,2
	20,9	25,7	0,3	0,2	9	19	19	28	28,6	0,3	0,2
	20,9	25,7	0,3	0,2	9	19	19	28	28,6	0,3	0,2
	22,6	29,3	0,3	0,2	9	19	19	33	33,6	0,3	0,2
	22,6	29,3	0,3	0,2	9	19	19	33	33,6	0,3	0,2
	22,6	29,3	0,3	0,2	11	19	19	33	33,6	0,3	0,2
	22,6	29,3	0,3	0,2	11	19	19	33	33,6	0,3	0,2
	24,1	32,8	0,6	0,3	10	21,2	21,2	35,8	37,6	0,6	0,3
	24,1	32,8	0,6	0,3	10	21,2	21,2	35,8	37,6	0,6	0,3
	24,1	32,8	0,6	0,3	13	21,2	21,2	35,8	37,6	0,6	0,3
	24,1	32,8	0,6	0,3	13	21,2	21,2	35,8	37,6	0,6	0,3

Angular contact ball bearings
d **20** mm

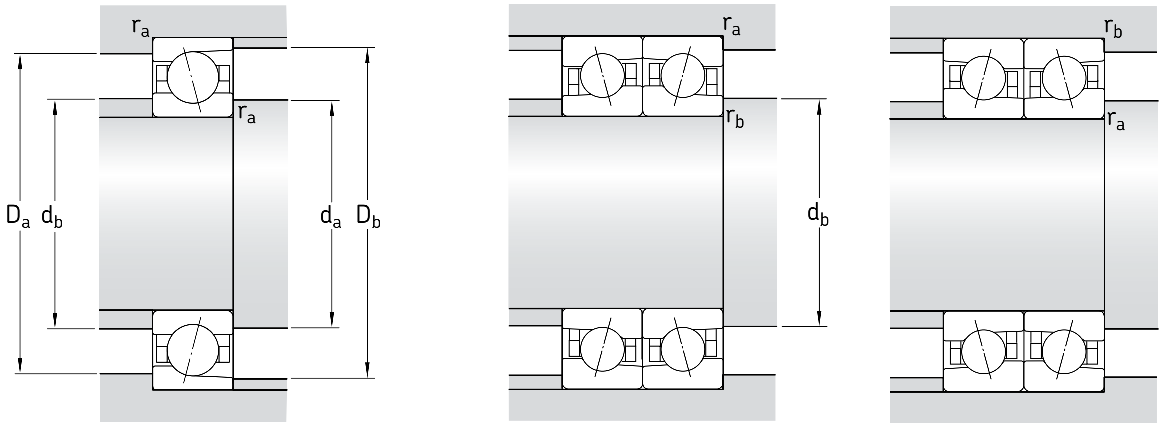


CD, ACD

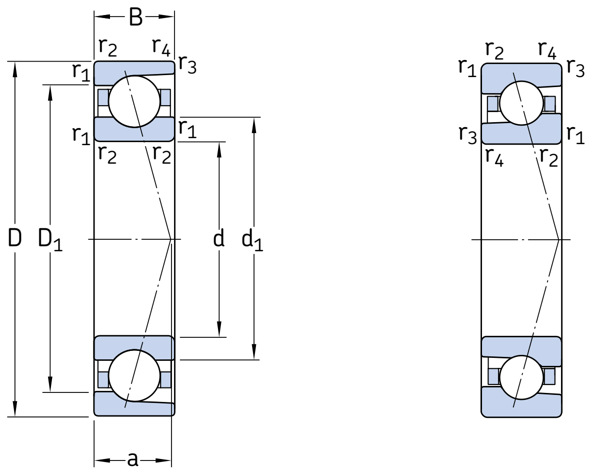


CE, ACE

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
20	37	9	6,05	3,2	0,137	9,8	43 000	63 000	0,035	**71904 CD/P4A**
	37	9	6,05	3,2	0,137	9,8	53 000	75 000	0,031	**71904 CD/HCP4A**
	37	9	4,68	2,12	0,09	9,8	56 000	85 000	0,035	**71904 CE/P4A**
	37	9	4,68	2,12	0,09	9,8	63 000	95 000	0,032	**71904 CE/HCP4A**
	37	9	5,72	3,05	0,129	–	38 000	56 000	0,035	**71904 ACD/P4A**
	37	9	5,72	3,05	0,129	–	45 000	67 000	0,031	**71904 ACD/HCP4A**
	37	9	4,42	2,04	0,085	–	48 000	75 000	0,035	**71904 ACE/P4A**
	37	9	4,42	2,04	0,085	–	56 000	85 000	0,032	**71904 ACE/HCP4A**
	42	12	8,71	4,3	0,18	9,2	38 000	56 000	0,065	**7004 CD/P4A**
	42	12	8,71	4,3	0,18	9,2	45 000	67 000	0,058	**7004 CD/HCP4A**
	42	12	7,02	3,05	0,129	9,2	50 000	80 000	0,063	**7004 CE/P4A**
	42	12	7,02	3,05	0,129	9,2	56 000	90 000	0,056	**7004 CE/HCP4A**
	42	12	8,32	4,15	0,173	–	34 000	50 000	0,065	**7004 ACD/P4A**
	42	12	8,32	4,15	0,173	–	40 000	60 000	0,058	**7004 ACD/HCP4A**
	42	12	6,76	2,9	0,122	–	45 000	70 000	0,063	**7004 ACE/P4A**
	42	12	6,76	2,9	0,122	–	50 000	80 000	0,056	**7004 ACE/HCP4A**
	47	14	11,9	5,85	0,245	8,7	36 000	53 000	0,10	**7204 CD/P4A**
	47	14	11,9	5,85	0,245	8,7	43 000	60 000	0,089	**7204 CD/HCP4A**
	47	14	11,4	5,6	0,236	–	32 000	48 000	0,10	**7204 ACD/P4A**
	47	14	11,4	5,6	0,236	–	38 000	56 000	0,089	**7204 ACD/HCP4A**



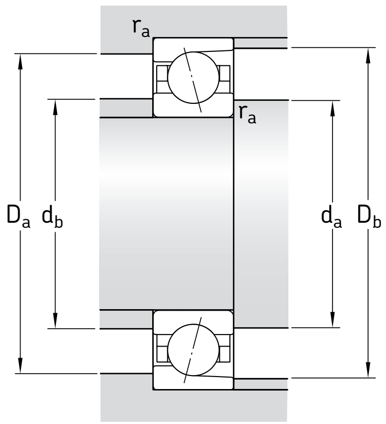
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
20	25,6	31,4	0,3	0,2	8	22	22	35	35,6	0,3	0,2
	25,6	31,4	0,3	0,2	8	22	22	35	35,6	0,3	0,2
	25,6	31,4	0,3	0,2	8	22	21,4	35	35,6	0,3	0,2
	25,6	31,4	0,3	0,2	8	22	21,4	35	35,6	0,3	0,2
	25,6	31,4	0,3	0,2	11	22	22	35	35,6	0,3	0,2
	25,6	31,4	0,3	0,2	11	22	22	35	35,6	0,3	0,2
	25,6	31,4	0,3	0,2	11	22	21,4	35	35,6	0,3	0,2
	25,6	31,4	0,3	0,2	11	22	21,4	35	35,6	0,3	0,2
	27,1	34,8	0,6	0,3	10	23,2	23,2	38,8	40	0,6	0,3
	27,1	34,8	0,6	0,3	10	23,2	23,2	38,8	40	0,6	0,3
	27,2	34,8	0,6	0,6	10	23,2	23,2	38,8	38,8	0,6	0,6
	27,2	34,8	0,6	0,6	10	23,2	23,2	38,8	38,8	0,6	0,6
	27,1	34,8	0,6	0,3	13	23,2	23,2	38,8	40	0,6	0,3
	27,1	34,8	0,6	0,3	13	23,2	23,2	38,8	40	0,6	0,3
	27,2	34,8	0,6	0,6	13	23,2	23,2	38,8	38,8	0,6	0,6
	27,2	34,8	0,6	0,6	13	23,2	23,2	38,8	38,8	0,6	0,6
	29,1	38,7	1	0,3	12	25,6	25,6	41,4	44,6	1	0,3
	29,1	38,7	1	0,3	12	25,6	25,6	41,4	44,6	1	0,3
	29,1	38,7	1	0,3	15	25,6	25,6	41,4	44,6	1	0,3
	29,1	38,7	1	0,3	15	25,6	25,6	41,4	44,6	1	0,3

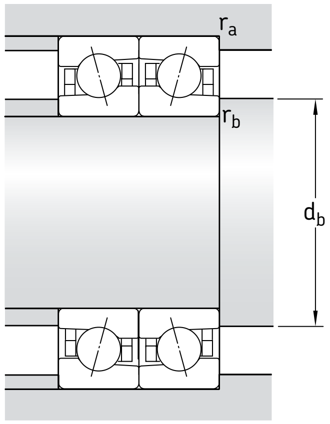


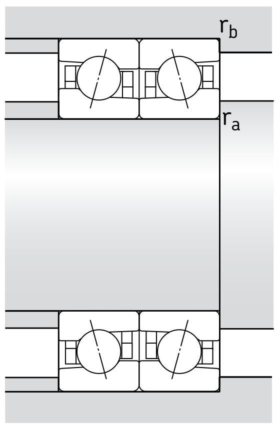
CD, ACD

CE, ACE

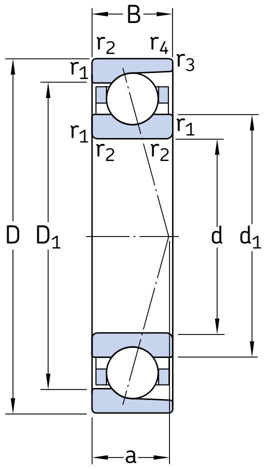
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
25	42	9	6,76	4	0,17	10	36 000	53 000	0,042	**71905 CD/P4A**
	42	9	6,76	4	0,17	10	45 000	63 000	0,037	**71905 CD/HCP4A**
	42	9	5,27	2,7	0,114	10	48 000	70 000	0,042	**71905 CE/P4A**
	42	9	5,27	2,7	0,114	10	53 000	85 000	0,038	**71905 CE/HCP4A**
	42	9	6,37	3,8	0,16	–	32 000	48 000	0,042	**71905 ACD/P4A**
	42	9	6,37	3,8	0,16	–	38 000	56 000	0,037	**71905 ACD/HCP4A**
	42	9	4,94	2,55	0,108	–	40 000	67 000	0,042	**71905 ACE/P4A**
	42	9	4,94	2,55	0,108	–	48 000	75 000	0,038	**71905 ACE/HCP4A**
	47	12	9,56	5,6	0,22	9,6	34 000	50 000	0,075	**7005 CD/P4A**
	47	12	9,56	5,2	0,22	9,6	38 000	56 000	0,066	**7005 CD/HCP4A**
	47	12	7,8	3,75	0,156	9,6	43 000	67 000	0,073	**7005 CE/P4A**
	47	12	7,8	3,75	0,156	9,6	50 000	75 000	0,064	**7005 CE/HCP4A**
	47	12	9,23	5	0,212	–	28 000	43 000	0,075	**7005 ACD/P4A**
	47	12	9,23	5	0,212	–	36 000	53 000	0,066	**7005 ACD/HCP4A**
	47	12	7,41	3,55	0,15	–	38 000	60 000	0,073	**7005 ACE/P4A**
	47	12	7,41	3,55	0,15	–	43 000	67 000	0,064	**7005 ACE/HCP4A**
	52	15	13,5	7,2	0,35	9,1	30 000	45 000	0,14	**7205 CD/P4A**
	52	15	13,5	7,2	0,305	9,1	38 000	53 000	0,12	**7205 CD/HCP4A**
	52	15	13	6,95	0,29	–	26 000	40 000	0,14	**7205 ACD/P4A**
	52	15	13	6,95	0,29	–	32 000	48 000	0,12	**7205 ACD/HCP4A**



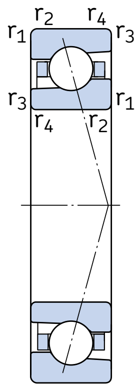




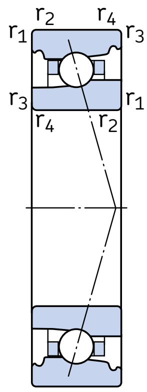
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
25	30,6	36,4	0,3	0,2	9	27	27	40	40,6	0,3	0,2
	30,6	36,4	0,3	0,2	9	27	27	40	40,6	0,3	0,2
	30,6	36,4	0,3	0,2	9	27	26,4	40	40,6	0,3	0,2
	30,6	36,4	0,3	0,2	9	27	26,4	40	40,6	0,3	0,2
	30,6	36,4	0,3	0,2	12	27	27	40	40,6	0,3	0,2
	30,6	36,4	0,3	0,2	12	27	27	40	40,6	0,3	0,2
	30,6	36,4	0,3	0,2	12	27	26,4	40	40,6	0,3	0,2
	30,6	36,4	0,3	0,2	12	27	26,4	40	40,6	0,3	0,2
	32,1	39,9	0,6	0,3	11	28,2	28,2	43,8	45	0,6	0,3
	32,1	39,9	0,6	0,3	11	28,2	28,2	43,8	45	0,6	0,3
	32,2	39,9	0,6	0,6	11	28,2	28,2	43,8	43,8	0,6	0,6
	32,2	39,9	0,6	0,6	11	28,2	28,2	43,8	43,8	0,6	0,6
	32,1	39,9	0,6	0,3	15	28,2	28,2	43,8	45	0,6	0,3
	32,1	39,9	0,6	0,3	15	28,2	28,2	43,8	45	0,6	0,3
	32,2	39,9	0,6	0,6	14	28,2	28,2	43,8	43,8	0,6	0,6
	32,2	39,9	0,6	0,6	15	28,2	28,2	43,8	43,8	0,6	0,6
	34,1	43,7	1	0,3	13	30,6	30,6	46,4	49,6	1	0,3
	34,1	43,7	1	0,3	13	30,6	30,6	46,4	49,6	1	0,3
	34,1	43,7	1	0,3	17	30,6	30,6	46,4	49,6	1	0,3
	34,1	43,7	1	0,3	17	30,6	30,6	46,4	49,6	1	0,3



CD, ACD

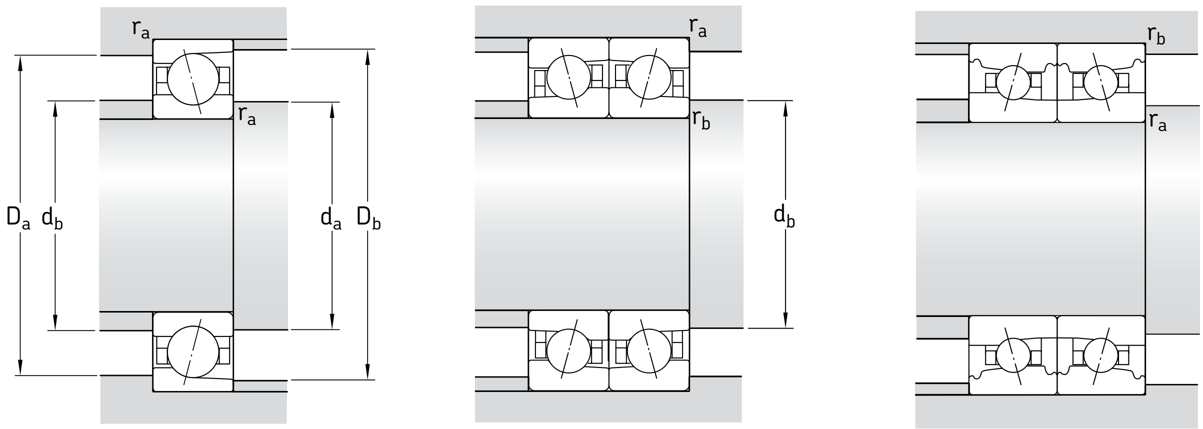


CE, ACE



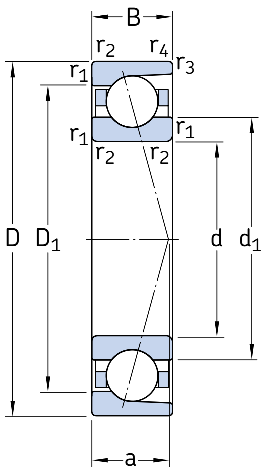
FB, DB

Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Calcu-lation factor**	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designation**
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
30	47	9	7,15	4,55	0,193	10	30 000	45 000	0,048	**71906 CD/P4A**
	47	9	7,15	4,55	0,193	10	38 000	53 000	0,043	**71906 CD/HCP4A**
	47	9	5,59	3,1	0,132	10	40 000	63 000	0,048	**71906 CE/P4A**
	47	9	5,59	3,1	0,132	10	45 000	70 000	0,043	**71906 CE/HCP4A**
	47	9	6,5	5,4	0,228	–	36 000	56 000	0,045	**71906 FB/P7**
	47	9	6,5	5,4	0,228	–	40 000	67 000	0,042	**C71906 FB/P7**
	47	9	6,76	4,3	0,183	–	26 000	40 000	0,048	**71906 ACD/P4A**
	47	9	6,76	4,3	0,183	–	32 000	48 000	0,043	**71906 ACD/HCP4A**
	47	9	5,27	2,9	0,125	–	36 000	56 000	0,048	**71906 ACE/P4A**
	47	9	5,27	2,9	0,125	–	40 000	63 000	0,043	**71906 ACE/HCP4A**
	47	9	6,24	5,2	0,22	–	32 000	50 000	0,045	**71906 DB/P7**
	47	9	6,24	5,2	0,22	–	38 000	60 000	0,042	**C71906 DB/P7**
	55	13	14,3	8	0,345	9,4	28 000	43 000	0,11	**7006 CD/P4A**
	55	13	14,3	8	0,34	9,4	32 000	48 000	0,094	**7006 CD/HCP4A**
	55	13	10,1	5,1	0,216	9,4	38 000	56 000	0,11	**7006 CE/P4A**
	55	13	10,1	5,1	0,216	9,4	43 000	67 000	0,095	**7006 CE/HCP4A**
	55	13	8,71	6,95	0,3	–	32 000	50 000	0,12	**7006 FB/P7**
	55	13	8,71	6,95	0,3	–	40 000	60 000	0,12	**C7006 FB/P7**
	55	13	13,8	7,65	0,325	–	24 000	38 000	0,11	**7006 ACD/P4A**
	55	13	13,8	7,65	0,325	–	30 000	45 000	0,094	**7006 ACD/HCP4A**
	55	13	9,56	4,9	0,208	–	32 000	50 000	0,11	**7006 ACE/P4A**
	55	13	9,56	4,9	0,208	–	38 000	60 000	0,095	**7006 ACE/HCP4A**
	55	13	8,32	6,7	0,285	–	30 000	45 000	0,12	**7006 DB/P7**
	55	13	8,32	6,7	0,285	–	34 000	53 000	0,12	**C7006 DB/P7**
	62	16	24,2	16	0,67	14	24 000	38 000	0,19	**7206 CD/P4A**
	62	16	24,2	16	0,67	14	32 000	45 000	0,17	**7206 CD/HCP4A**
	62	16	23,4	15,3	0,64	–	20 000	34 000	0,19	**7206 ACD/P4A**
	62	16	23,4	15,3	0,64	–	26 000	40 000	0,17	**7206 ACD/HCP4A**

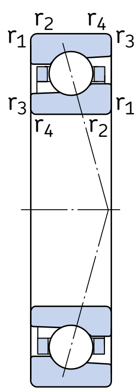


Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
30	35,6	41,4	0,3	0,2	10	32	32	45	45,6	0,3	0,2
	35,6	41,4	0,3	0,2	10	32	32	45	45,6	0,3	0,2
	35,6	41,4	0,3	0,2	10	32	31,4	45	45,6	0,3	0,2
	35,6	41,4	0,3	0,2	10	32	31,4	45	45,6	0,3	0,2
	36	43	0,3	0,3	11	32	32	45	45	0,3	0,3
	36	43	0,3	0,3	11	32	32	45	45	0,3	0,3
	35,6	41,4	0,3	0,2	14	32	32	45	45,6	0,3	0,2
	35,6	41,4	0,3	0,2	14	32	32	45	45,6	0,3	0,2
	35,6	41,4	0,3	0,2	14	32	31,4	45	45,6	0,3	0,2
	35,6	41,4	0,3	0,2	14	32	31,4	45	45,6	0,3	0,2
	36	43	0,3	0,3	14	32	32	45	45	0,3	0,3
	36	43	0,3	0,3	14	32	32	45	45	0,3	0,3
	37,7	47,3	1	0,3	12	34,6	34,6	50,4	53	1	0,3
	37,7	47,3	1	0,3	12	34,6	34,6	50,4	53	1	0,3
	38,3	46,8	1	1	12	34,6	32	50,4	50,4	1	0,3
	38,3	46,8	1	1	12	34,6	32	50,4	50,4	1	0,3
	39,5	47,3	1	1	13	34,6	34,6	50,4	50,4	1	1
	39,5	47,3	1	1	13	34,6	34,6	50,4	50,4	1	1
	37,7	47,3	1	0,3	17	34,6	34,6	50,4	53	1	0,3
	37,7	47,3	1	0,3	17	34,6	34,6	50,4	53	1	0,3
	38,3	46,8	1	1	17	34,6	32	50,4	50,4	1	0,3
	38,3	46,8	1	1	17	34,6	32	50,4	50,4	1	0,3
	39,5	47,3	1	1	16	34,6	34,6	50,4	50,4	1	1
	39,5	47,3	1	1	16	34,6	34,6	50,4	50,4	1	1
	40,2	51,8	1	0,3	14	35,6	35,6	56,4	59,6	1	0,3
	40,2	51,8	1	0,3	14	35,6	35,6	56,4	58,6	1	0,3
	40,2	51,8	1	0,3	19	35,6	35,6	56,4	59,6	1	0,3
	40,2	51,8	1	0,3	19	35,6	35,6	56,4	59,6	1	0,3

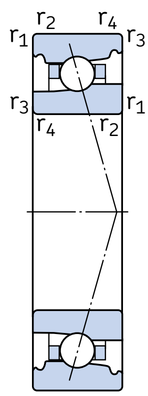
Angular contact ball bearings
d **35** mm



CD, ACD

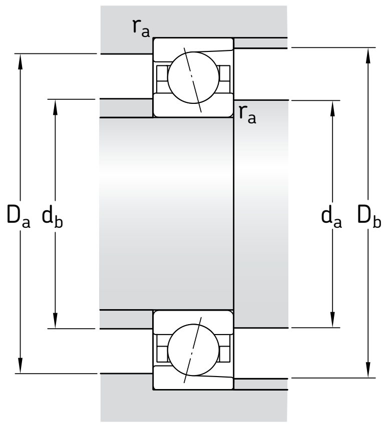


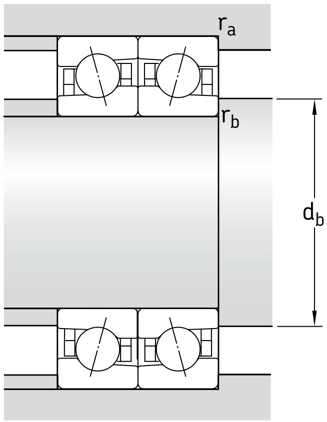
CE, ACE

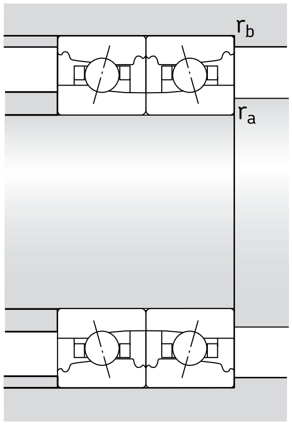


FB, DB

Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Calcu-lation factor**	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designation**
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
35	55	10	9,75	6,55	0,275	10	26 000	40 000	0,074	**71907 CD/P4A**
	55	10	9,75	6,55	0,275	10	32 000	45 000	0,065	**71907 CD/HCP4A**
	55	10	7,61	4,4	0,186	10	36 000	53 000	0,075	**71907 CE/P4A**
	55	10	7,61	4,4	0,186	10	40 000	60 000	0,066	**71907 CE/HCP4A**
	55	10	6,89	6,3	0,265	–	30 000	48 000	0,075	**71907 FB/P7**
	55	10	6,89	6,3	0,265		36 000	56 000	0,071	**C71907 FB/P7**
	55	10	9,23	6,2	0,26	–	22 000	36 000	0,074	**71907 ACD/P4A**
	55	10	9,23	6,2	0,26	–	28 000	43 000	0,065	**71907 ACD/HCP4A**
	55	10	7,15	4,15	0,176	–	30 000	48 000	0,075	**71907 ACE/P4A**
	55	10	7,15	4,15	0,176	–	36 000	56 000	0,066	**71907 ACE/HCP4A**
	55	10	6,5	6	0,255	–	28 000	43 000	0,075	**71907 DB/P7**
	55	10	6,5	6	0,255	–	32 000	50 000	0,071	**C71907 DB/P7**
	62	14	15,6	9,5	0,4	9,7	22 000	36 000	0,15	**7007 CD/P4A**
	62	14	15,6	9,5	0,4	9,7	28 000	43 000	0,13	**7007 CD/HCP4A**
	62	14	10,8	6	0,255	9,7	32 000	50 000	0,15	**7007 CE/P4A**
	62	14	10,8	6	0,255	9,7	36 000	56 000	0,13	**7007 CE/HCP4A**
	62	14	9,23	8,15	0,345	–	28 000	45 000	0,17	**7007 FB/P7**
	62	14	9,23	8,15	0,345	–	36 000	53 000	0,16	**C7007 FB/P7**
	62	14	14,8	9	0,38	–	19 000	32 000	0,15	**7007 ACD/P4A**
	62	14	14,8	9	0,38	–	24 000	38 000	0,13	**7007 ACD/HCP4A**
	62	14	10,4	5,7	0,24	–	28 000	45 000	0,15	**7007 ACE/P4A**
	62	14	10,4	5,7	0,24	–	32 000	50 000	0,13	**7007 ACE/HCP4A**
	62	14	8,84	7,8	0,335	–	26 000	40 000	0,17	**7007 DB/P7**
	62	14	8,84	7,8	0,335	–	30 000	48 000	0,16	**C7007 DB/P7**
	72	17	31,9	2,16	0,915	14	20 000	34 000	0,28	**7207 CD/P4A**
	72	17	31,9	21,6	0,915	14	26 000	38 000	0,24	**7207 CD/HCP4A**
	72	17	30,7	2,08	0,88	–	18 000	30 000	0,28	**7207 ACD/P4A**
	72	17	30,7	20,8	0,88	–	20 000	34 000	0,24	**7207 ACD/HCP4A**

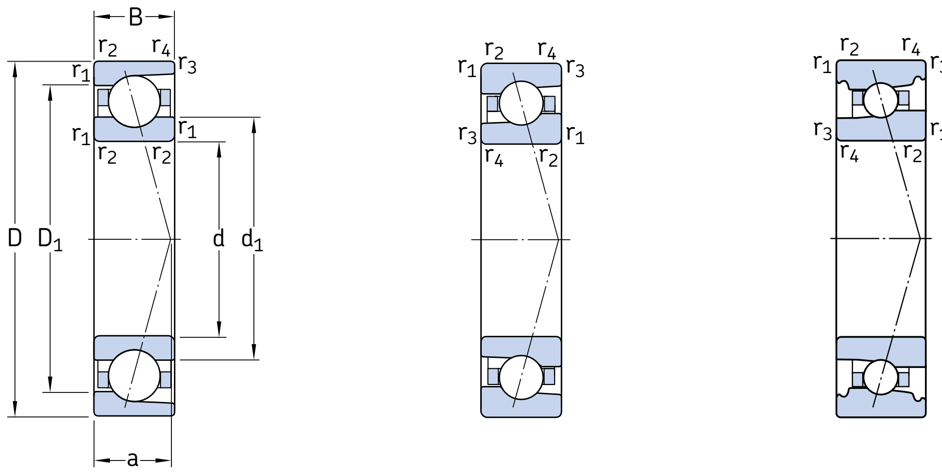






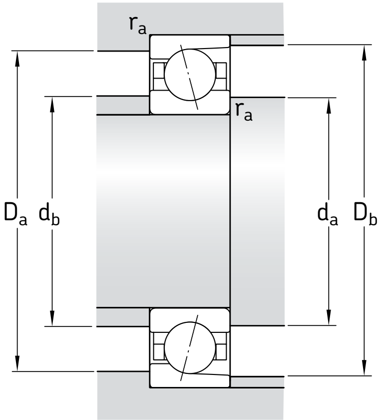
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
35	41,6	48,4	0,6	0,2	11	38,2	38,2	51,8	53,6	0,6	0,2
	41,6	48,4	0,6	0,2	11	38,2	38,2	51,8	53,6	0,6	0,2
	41,6	48,4	0,6	0,2	11	38,2	36,4	51,8	53,6	0,6	0,2
	41,6	48,4	0,6	0,2	11	38,2	36,4	51,8	53,6	0,6	0,2
	42,5	49,5	0,6	0,6	12	38,2	38,2	51,8	51,8	0,6	0,6
	42,5	49,5	0,6	0,6	12	38,2	38,2	51,8	51,8	0,6	0,6
	41,6	48,4	0,6	0,2	16	38,2	38,2	51,8	53,6	0,6	0,2
	41,6	48,4	0,6	0,2	16	38,2	38,2	51,8	53,6	0,6	0,2
	41,6	48,4	0,6	0,2	16	38,2	36,4	51,8	53,6	0,6	0,2
	41,6	48,4	0,6	0,2	16	38,2	36,4	51,8	53,6	0,6	0,2
	42,5	49,5	0,6	0,6	16	38,2	38,2	51,8	51,8	0,6	0,6
	42,5	49,5	0,6	0,6	16	38,2	38,2	51,8	51,8	0,6	0,6
	43,7	53,3	1	0,3	14	39,6	39,6	57,4	60	1	0,3
	43,7	53,3	1	0,3	14	39,6	39,6	57,4	60	1	0,3
	44,3	52,8	1	1	14	39,6	39,6	57,4	57,4	1	1
	44,3	52,8	1	1	14	39,6	39,6	57,4	57,4	1	1
	45,5	53,4	1	1	15	39,6	39,6	57,4	57,4	1	1
	45,5	53,4	1	1	15	39,6	39,6	57,4	57,4	1	1
	43,7	53,3	1	0,3	19	39,6	39,6	57,4	60	1	0,3
	43,7	53,3	1	0,3	19	39,6	39,6	57,4	60	1	0,3
	44,3	52,8	1	1	19	39,6	39,6	57,4	57,4	1	1
	44,3	52,8	1	1	19	39,6	39,6	57,4	57,4	1	1
	45,5	53,4	1	1	18	39,6	39,6	57,4	57,4	1	1
	45,5	53,4	1	1	18	39,6	39,6	57,4	57,4	1	1
	46,8	60,2	1,1	0,3	16	42	42	65	69,6	1	0,3
	46,8	60,2	1,1	0,3	16	42	42	65	69,6	1	0,3
	46,8	60,2	1,1	0,3	21	42	42	65	69,6	1	0,3
	46,8	60,2	1,1	0,3	21	42	42	65	69,6	1	0,3

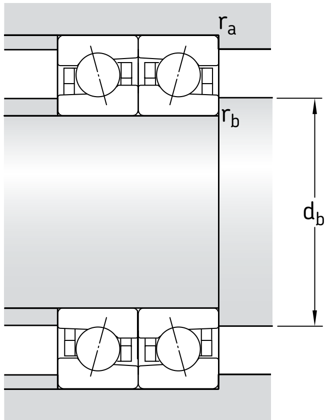
Angular contact ball bearings
d **40** mm

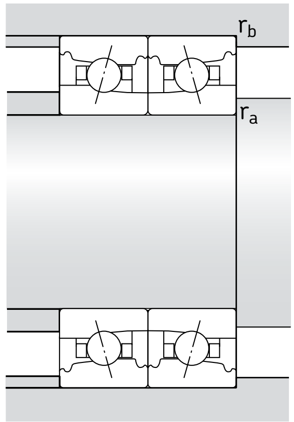


CD, ACD | CE, ACE | FB, DB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calculation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
40	62	12	12,4	8,5	0,36	10	20 000	34 000	0,11	**71908 CD/P4A**
	62	12	12,4	8,5	0,36	10	28 000	40 000	0,096	**71908 CD/HCP4A**
	62	12	9,56	5,7	0,24	10	30 000	48 000	0,11	**71908 CE/P4A**
	62	12	9,56	5,7	0,24	10	34 000	53 000	0,097	**71908 CE/HCP4A**
	62	12	7,15	7,2	0,305	–	28 000	43 000	0,12	**71908 FB/P7**
	62	12	7,15	7,2	0,305	–	30 000	50 000	0,12	**C71908 FB/P7**
	62	12	11,7	8	0,34	–	18 000	30 000	0,11	**71908 ACD/P4A**
	62	12	11,7	8	0,34	–	22 000	36 000	0,096	**71908 ACD/HCP4A**
	62	12	9,23	5,4	0,228	–	28 000	43 000	0,11	**71908 ACE/P4A**
	62	12	9,23	5,4	0,228	–	30 000	48 000	0,097	**71908 ACE/HCP4A**
	62	12	6,89	6,8	0,29	–	24 000	38 000	0,12	**71908 DB/P7**
	62	12	6,89	6,8	0,29	–	28 000	45 000	0,12	**C71908 DB/P7**
	68	15	16,8	11	0,465	10	19 000	32 000	0,19	**7008 CD/P4A**
	68	15	16,8	11	0,465	10	24 000	38 000	0,16	**7008 CD/HCP4A**
	68	15	11,7	6,8	0,29	10	30 000	45 000	0,18	**7008 CE/P4A**
	68	15	11,7	6,8	0,29	10	32 000	50 000	0,17	**7008 CE/HCP4A**
	68	15	9,75	9,5	0,4	–	26 000	40 000	0,21	**7008 FB/P7**
	68	15	9,75	9,5	0,4	–	32 000	48 000	0,20	**C7008 FB/P7**
	68	15	15,9	10,4	0,44	–	18 000	30 000	0,19	**7008 ACD/P4A**
	68	15	15,9	10,4	0,44	–	20 000	34 000	0,16	**7008 ACD/HCP4A**
	68	15	11,1	6,55	0,275	–	26 000	40 000	0,18	**7008 ACE/P4A**
	68	15	11,1	6,55	0,275	–	30 000	45 000	0,17	**7008 ACE/HCP4A**
	68	15	9,36	9	0,38	–	22 000	36 000	0,21	**7008 DB/P7**
	68	15	9,36	9	0,38	–	26 000	43 000	0,20	**C7008 DB/P7**
	80	18	41	28	1,18	14	18 000	30 000	0,36	**7208 CD/P4A**
	80	18	41	28	1,18	14	22 000	34 000	0,30	**7208 CD/HCP4A**
	80	18	39	27	1,14	–	16 000	26 000	0,36	**7208 ACD/P4A**
	80	18	39	27	1,14	–	19 000	32 000	0,30	**7208 ACD/HCP4A**

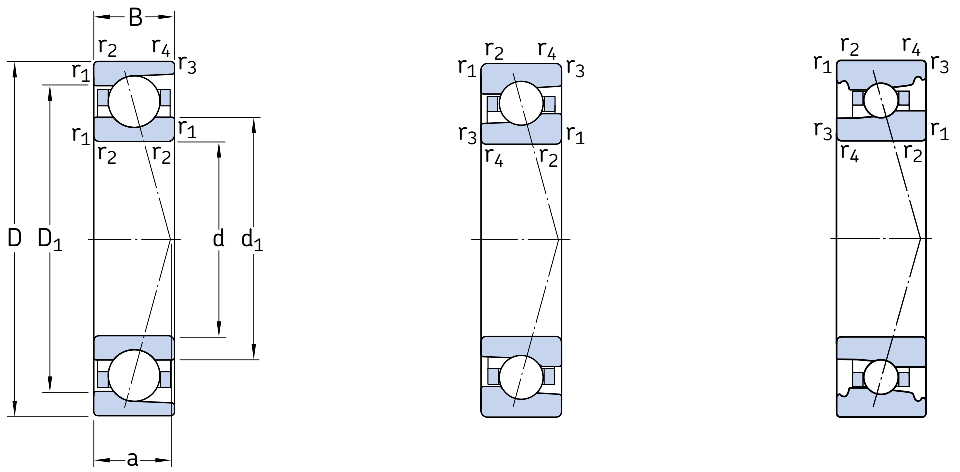






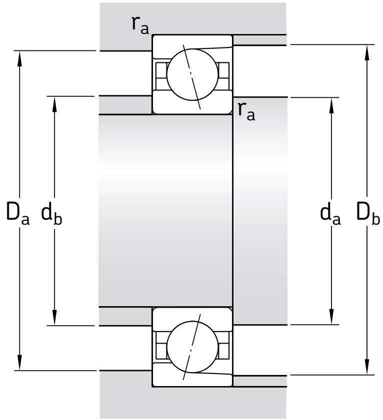
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
40	47,1	54,9	0,6	0,2	13	43,2	43,2	58,8	60,6	0,6	0,2
	47,1	54,9	0,6	0,2	13	43,2	43,2	58,8	60,6	0,6	0,2
	47,1	54,9	0,6	0,2	13	43,2	41,4	58,8	60,6	0,6	0,2
	47,1	54,9	0,6	0,2	13	43,2	41,4	58,8	60,6	0,6	0,2
	48,5	55,6	0,6	0,6	14	43,2	43,2	58,8	58,8	0,6	0,6
	48,5	55,6	0,6	0,6	14	43,2	43,2	58,8	58,8	0,6	0,6
	47,1	54,9	0,6	0,2	18	43,2	43,2	58,8	60,6	0,6	0,2
	47,1	54,9	0,6	0,2	18	43,2	43,2	58,8	60,6	0,6	0,2
	47,1	54,9	0,6	0,2	18	43,2	41,4	58,8	60,6	0,6	0,2
	47,1	54,9	0,6	0,2	18	43,2	41,4	58,8	60,6	0,6	0,2
	48,5	55,6	0,6	0,6	18	43,2	43,2	58,8	58,8	0,6	0,6
	48,5	55,6	0,6	0,6	18	43,2	43,2	58,8	58,8	0,6	0,6
	49,2	58,8	1	0,3	15	44,6	44,6	63,4	66	1	0,3
	49,2	58,8	1	0,3	15	44,6	44,6	63,4	66	1	0,3
	49,8	58,3	1	1	15	44,6	44,6	63,4	63,4	1	1
	49,8	58,3	1	1	15	44,6	44,6	63,4	63,4	1	1
	51	58,9	1	1	16	44,6	44,6	63,4	63,4	1	1
	51	58,9	1	1	16	44,6	44,6	63,4	63,4	1	1
	49,2	58,8	1	0,3	20	44,6	44,6	63,4	66	1	0,3
	49,2	58,8	1	0,3	20	44,6	44,6	63,4	66	1	0,3
	49,8	58,3	1	1	20	44,6	44,6	63,4	63,4	1	1
	49,8	58,3	1	1	20	44,6	44,6	63,4	63,4	1	1
	51	58,9	1	1	20	44,6	44,6	63,4	63,4	1	1
	51	58,9	1	1	20	44,6	44,6	63,4	63,4	1	1
	53,3	66,7	1,1	0,6	17	47	47	73	75,8	1	0,6
	53,3	66,7	1,1	0,6	17	47	47	73	75,8	1	0,6
	53,3	66,7	1,1	0,6	23	47	47	73	75,8	1	0,6
	53,3	66,7	1,1	0,6	23	47	47	73	75,8	1	0,6

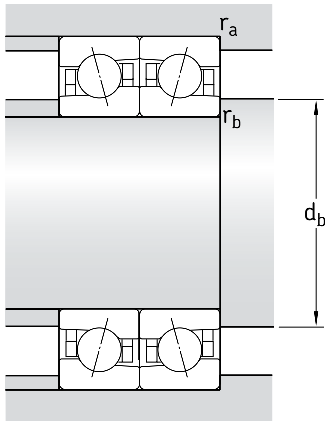
Angular contact ball bearings
d **45** mm

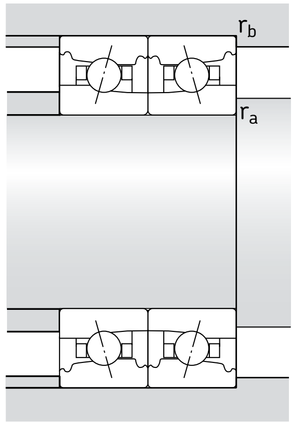


CD, ACD CE, ACE FB, DB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
45	68	12	13	9,5	0,4	11	19 000	32 000	0,13	**71909 CD/P4A**
	68	12	13	9,5	0,4	11	24 000	36 000	0,11	**71909 CD/HCP4A**
	68	12	10,1	6,4	0,27	11	28 000	43 000	0,13	**71909 CE/P4A**
	68	12	10,1	6,4	0,27	11	32 000	48 000	0,12	**71909 CE/HCP4A**
	68	12	9,95	9,8	0,415	–	24 000	38 000	0,13	**71909 FB/P7**
	68	12	9,95	9,8	0,415	–	28 000	45 000	0,12	**C71909 FB/P7**
	68	12	12,4	9	0,38	–	17 000	28 000	0,13	**71909 ACD/P4A**
	68	12	12,4	9	0,38	–	20 000	34 000	0,11	**71909 ACD/HCP4A**
	68	12	9,56	6,1	0,255	–	24 000	38 000	0,13	**71909 ACE/P4A**
	68	12	9,56	6,1	0,255	–	28 000	43 000	0,12	**71909 ACE/HCP4A**
	68	12	9,56	9,5	0,4	–	22 000	34 000	0,13	**71909 DB/P7**
	68	12	9,56	9,5	0,4	–	26 000	40 000	0,12	**C71909 DB/P7**
	75	16	28,6	22,4	0,95	15	18 000	30 000	0,23	**7009 CD/P4A**
	75	16	28,6	22,4	0,95	15	20 000	34 000	0,20	**7009 CD/HCP4A**
	75	16	14	8,5	0,36	15	26 000	40 000	0,23	**7009 CE/P4A**
	75	16	14	8,5	0,36	15	30 000	45 000	0,21	**7009 CE/HCP4A**
	75	16	12,7	12,2	0,52	–	22 000	36 000	0,26	**7009 FB/P7**
	75	16	12,7	12,2	0,52		28 000	43 000	0,25	**C7009 FB/P7**
	75	16	27,6	21,6	0,9	–	16 000	26 000	0,23	**7009 ACD/P4A**
	75	16	27,6	21,6	0,9	–	19 000	32 000	0,20	**7009 ACD/HCP4A**
	75	16	13,3	8	0,34	–	24 000	36 000	0,23	**7009 ACE/P4A**
	75	16	13,3	8	0,34	–	26 000	40 000	0,21	**7009 ACE/HCP4A**
	75	16	12,1	11,8	0,5	–	20 000	32 000	0,26	**7009 DB/P7**
	75	16	12,1	11,8	0,5	–	24 000	38 000	0,25	**C7009 DB/P7**
	85	19	42,3	31	0,132	14	17 000	28 000	0,41	**7209 CD/P4A**
	85	19	42,3	31	1,32	14	20 000	32 000	0,34	**7209 CD/HCP4A**
	85	19	41	30	1,25	–	15 000	24 000	0,41	**7209 ACD/P4A**
	85	19	41	30	1,25	–	17 000	28 000	0,34	**7209 ACD/HCP4A**

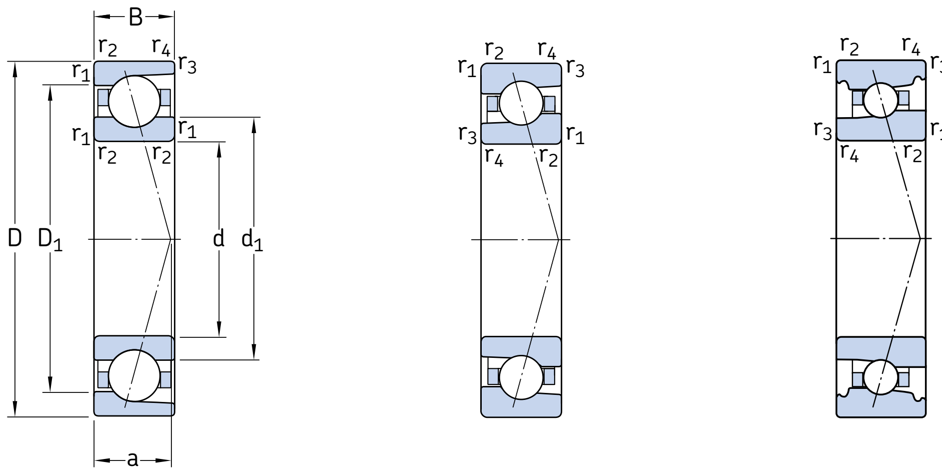






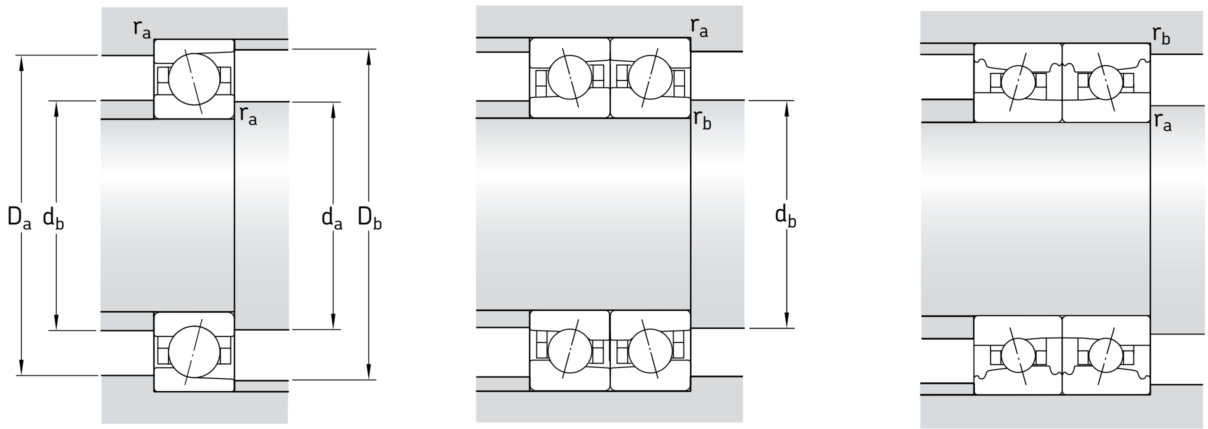
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
45	52,6	60,4	0,6	0,2	14	48,2	48,2	64,8	66,6	0,6	0,2
	52,6	60,4	0,6	0,2	14	48,2	48,2	64,8	66,6	0,6	0,2
	52,6	60,4	0,6	0,2	14	43,2	46,4	64,8	66,6	0,6	0,2
	52,6	60,4	0,6	0,2	14	43,2	46,4	64,8	66,6	0,6	0,2
	53,5	61,6	0,6	0,6	15	48,2	48,2	64,8	64,8	0,6	0,6
	53,5	61,6	0,6	0,6	15	48,2	48,2	64,8	64,8	0,6	0,6
	52,6	60,4	0,6	0,2	19	48,2	48,2	64,8	66,6	0,6	0,2
	52,6	60,4	0,6	0,2	19	48,2	48,2	64,8	66,6	0,6	0,2
	52,6	60,4	0,6	0,2	19	43,2	46,4	64,8	66,6	0,6	0,2
	52,6	60,4	0,6	0,2	19	43,2	46,4	64,8	66,6	0,6	0,2
	53,5	61,6	0,6	0,6	19	48,2	48,2	64,8	64,8	0,6	0,6
	53,5	61,6	0,6	0,6	19	48,2	48,2	64,8	64,8	0,6	0,6
	54,2	65,8	1	0,3	16	49,6	49,6	70,4	73	1	0,3
	54,2	65,8	1	0,3	16	49,6	49,6	70,4	73	1	0,3
	55,3	64,8	1	1	16	49,6	49,6	70,4	70,4	1	1
	55,3	64,8	1	1	16	49,6	49,6	70,4	70,4	1	1
	56,4	65,6	1	1	18	49,6	49,6	70,4	70,4	1	1
	56,4	65,6	1	1	18	49,6	49,6	70,4	70,4	1	1
	54,2	65,8	1	0,3	22	49,6	49,6	70,4	73	1	0,3
	54,2	65,8	1	0,3	22	49,6	49,6	70,4	73	1	0,3
	55,3	64,8	1	1	22	49,6	49,6	70,4	70,4	1	1
	55,3	64,8	1	1	22	49,6	49,6	70,4	70,4	1	1
	56,4	65,6	1	1	22	49,6	49,6	70,4	70,4	1	1
	56,4	65,6	1	1	22	49,6	49,6	70,4	70,4	1	1
	57,3	72,7	1,1	0,6	18	52	52	78	80,8	1	0,6
	57,3	72,7	1,1	0,6	18	52	52	78	80,8	1	0,6
	57,3	72,7	1,1	0,6	25	52	52	78	80,8	1	0,6
	57,3	72,7	1,1	0,6	25	52	52	78	80,8	1	0,6

Angular contact ball bearings
d **50** mm



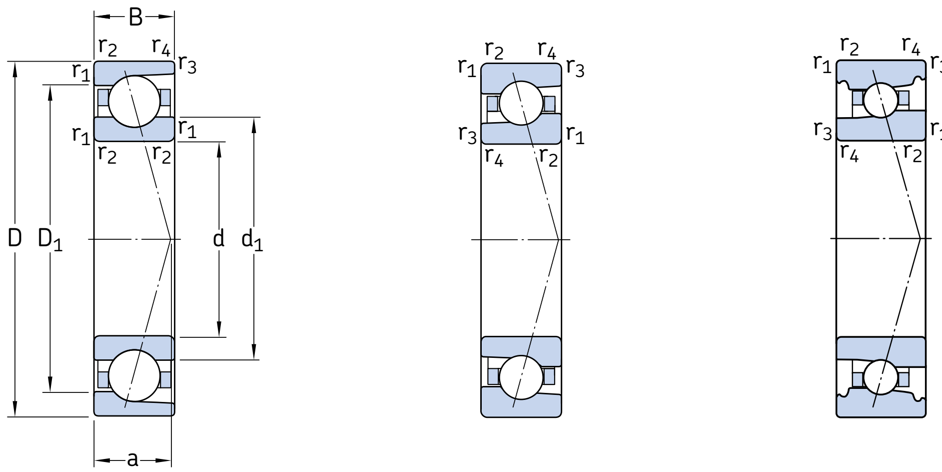
CD, ACD · CE, ACE · FB, DB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
50	72	12	13,5	10,4	0,44	11	17 000	28 000	0,13	**71910 CD/P4A**
	72	12	13,5	10,4	0,44	11	22 000	34 000	0,11	**71910 CD/HCP4A**
	72	12	10,6	7,1	0,3	11	26 000	40 000	0,13	**71910 CE/P4A**
	72	12	10,6	7,1	0,3	11	28 000	45 000	0,13	**71910 CE/HCP4A**
	72	12	10,1	10,6	0,45	–	22 000	36 000	0,14	**71910 FB/P7**
	72	12	10,1	10,6	0,45	–	26 000	43 000	0,13	**C71910 FB/P7**
	72	12	12,7	9,8	0,415	–	16 000	26 000	0,13	**71910 ACD/P4A**
	72	12	12,7	9,8	0,415	–	19 000	30 000	0,11	**71910 ACD/HCP4A**
	72	12	9,95	6,7	0,285	–	22 000	36 000	0,13	**71910 ACE/P4A**
	72	12	9,95	6,7	0,285	–	26 000	40 000	0,13	**71910 ACE/HCP4A**
	72	12	9,75	10,2	0,43	–	20 000	32 000	0,14	**71910 DB/P7**
	72	12	9,75	10,2	0,43	–	24 000	38 000	0,13	**C71910 DB/P7**
	80	16	29,6	24	1,02	15	17 000	28 000	0,25	**7010 CD/P4A**
	80	16	29,6	24	1,02	15	19 000	32 000	0,21	**7010 CD/HCP4A**
	80	16	14,8	9,5	0,4	15	24 000	36 000	0,25	**7010 CE/P4A**
	80	16	14,8	9,5	0,4	15	28 000	43 000	0,23	**7010 CE/HCP4A**
	80	16	13,3	13,4	0,57	–	22 000	34 000	0,28	**7010 FB/P7**
	80	16	13,3	13,4	0,57	–	26 000	40 000	0,27	**C7010 FB/P7**
	80	16	28,1	23,2	0,98	–	15 000	24 000	0,25	**7010 ACD/P4A**
	80	16	28,1	23,2	0,98	–	17 000	28 000	0,21	**7010 ACD/HCP4A**
	80	16	14	9	0,38	–	22 000	34 000	0,25	**7010 ACE/P4A**
	80	16	14	9	0,38	–	24 000	38 000	0,23	**7010 ACE/HCP4A**
	80	16	12,5	12,9	0,54	–	19 000	30 000	0,28	**7010 DB/P7**
	80	16	12,5	12,9	0,54	–	22 000	34 000	0,27	**C7010 DB/P7**
	90	20	44,9	34	1,43	15	16 000	26 000	0,46	**7210 CD/P4A**
	90	20	44,9	34	1,43	15	19 000	30 000	0,38	**7210 CD/HCP4A**
	90	20	42,3	32,5	1,39	–	14 000	22 000	0,46	**7210 ACD/P4A**
	90	20	42,3	32,5	1,37	–	16 000	26 000	0,38	**7210 ACD/HCP4A**



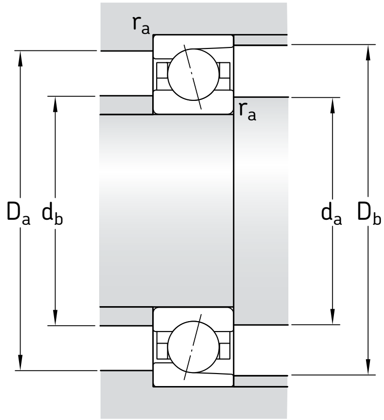
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
50	57,1	64,9	0,6	0,2	14	53,2	53,2	68,8	70,6	0,6	0,2
	57,1	64,9	0,6	0,2	14	53,2	53,2	68,8	70,6	0,6	0,2
	57,1	64,9	0,6	0,2	14	53,2	51,4	68,8	70,6	0,6	0,2
	57,1	64,9	0,6	0,2	14	53,2	51,4	68,8	70,6	0,6	0,2
	58	66	0,6	0,6	16	53,2	53,2	68,8	68,8	0,6	0,6
	58	66	0,6	0,6	16	53,2	53,2	68,8	68,8	0,6	0,6
	57,1	64,9	0,6	0,2	20	53,2	53,2	68,8	70,6	0,6	0,2
	57,1	64,9	0,6	0,2	20	53,2	53,2	68,8	70,6	0,6	0,2
	57,1	64,9	0,6	0,2	20	53,2	51,4	68,8	70,6	0,6	0,2
	57,1	64,9	0,6	0,2	20	53,2	51,4	68,8	70,6	0,6	0,2
	58	66	0,6	0,6	20	53,2	53,2	68,8	68,8	0,6	0,6
	58	66	0,6	0,6	20	53,2	53,2	68,8	68,8	0,6	0,6
	59,2	70,8	1	0,3	17	54,6	54,6	75,4	78	1	0,3
	59,2	70,8	1	0,3	17	54,6	54,6	75,4	78	1	0,3
	60,3	69,8	1	1	17	54,6	54,6	75,4	75,4	1	1
	60,3	69,8	1	1	17	54,6	54,6	75,4	75,4	1	1
	61,4	70,7	1	1	19	54,6	54,6	75,4	75,4	1	1
	61,4	70,7	1	1	19	54,6	54,6	75,4	75,4	1	1
	59,2	70,8	1	0,3	23	54,6	54,6	75,4	78	1	0,3
	59,2	70,8	1	0,3	23	54,6	54,6	75,4	78	1	0,3
	60,3	69,8	1	1	23	54,6	54,6	75,4	75,4	1	1
	60,3	69,8	1	1	23	54,6	54,6	75,4	75,4	1	1
	61,4	70,7	1	1	23	54,6	54,6	75,4	75,4	1	1
	61,4	70,7	1	1	23	54,6	54,6	75,4	75,4	1	1
	62,3	77,7	1,1	0,6	20	57	57	83	85,8	1	0,6
	62,3	77,7	1,1	0,6	20	57	57	83	85,8	1	0,6
	62,3	77,7	1,1	0,6	27	57	57	83	85,8	1	0,6
	62,3	77,7	1,1	0,6	27	57	57	83	85,8	1	0,6

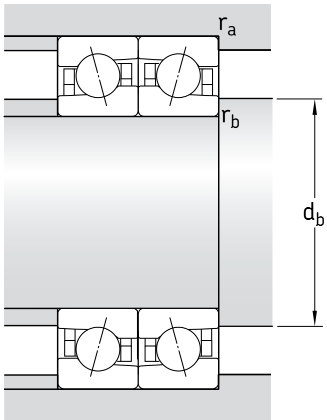
Angular contact ball bearings
d **55** mm

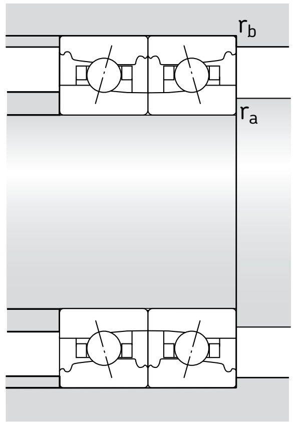


CD, ACD   CE, ACE   FB, DB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
55	80	13	19,5	14,6	0,62	10	16 000	26 000	0,18	**71911 CD/P4A**
	80	13	19,5	14,6	0,62	10	19 000	30 000	0,15	**71911 CD/HCP4A**
	80	13	15,3	10	0,425	10	24 000	36 000	0,18	**71911 CE/P4A**
	80	13	15,3	10	0,425	10	26 000	40 000	0,15	**71911 CE/HCP4A**
	80	13	13,3	14	0,585	–	20 000	32 000	0,18	**71911 FB/P7**
	80	13	13,3	14	0,585	–	24 000	38 000	0,17	**C71911 FB/P7**
	80	13	18,2	13,7	0,585	–	15 000	24 000	0,18	**71911 ACD/P4A**
	80	13	18,2	13,7	0,585	–	17 000	28 000	0,15	**71911 ACD/HCP4A**
	80	13	14,6	9,5	0,4	–	20 000	32 000	0,18	**71911 ACE/P4A**
	80	13	14,6	9,5	0,4	–	24 000	36 000	0,15	**71911 ACE/HCP4A**
	80	13	12,7	13,4	0,57	–	18 000	30 000	0,18	**71911 DB/P7**
	80	13	12,7	13,4	0,57	–	22 000	34 000	0,17	**C71911 DB/P7**
	90	18	39,7	32,5	1,37	15	15 000	24 000	0,37	**7011 CD/P4A**
	90	18	39,7	32,5	1,37	15	17 000	28 000	0,31	**7011 CD/HCP4A**
	90	18	15,6	10,6	0,45	15	22 000	34 000	0,39	**7011 CE/P4A**
	90	18	15,6	10,6	0,45	15	24 000	38 000	0,36	**7011 CE/HCP4A**
	90	18	18,6	18,6	0,8	–	19 000	30 000	0,40	**7011 FB/P7**
	90	18	18,6	18,6	0,8	–	22 000	36 000	0,38	**C7011 FB/P7**
	90	18	37,1	31	1,32	–	14 000	22 000	0,37	**7011 ACD/P4A**
	90	18	37,1	31	1,32	–	16 000	26 000	0,31	**7011 ACD/HCP4A**
	90	18	14,8	10	0,425	–	19 000	30 000	0,39	**7011 ACE/P4A**
	90	18	14,8	10	0,425	–	22 000	34 000	0,36	**7011 ACE/HCP4A**
	90	18	17,8	18	0,765	–	17 000	28 000	0,40	**7011 DB/P7**
	90	18	17,8	18	0,765	–	20 000	32 000	0,38	**C7011 DB/P7**
	100	21	55,3	43	1,8	14	14 000	22 000	0,61	**7211 CD/P4A**
	100	21	55,3	43	1,8	14	17 000	26 000	0,51	**7211 CD/HCP4A**
	100	21	52,7	40,5	1,73	–	13 000	20 000	0,61	**7211 ACD/P4A**
	100	21	52,7	40,5	1,73	–	15 000	24 000	0,51	**7211 ACD/HCP4A**

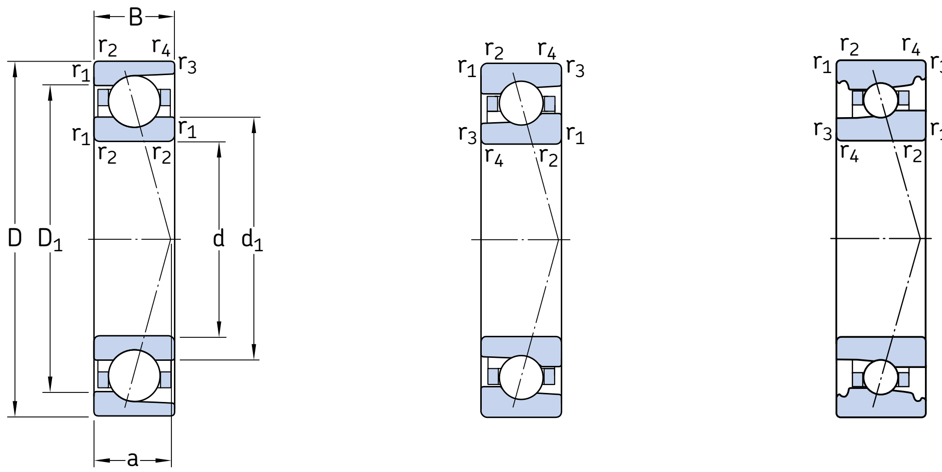






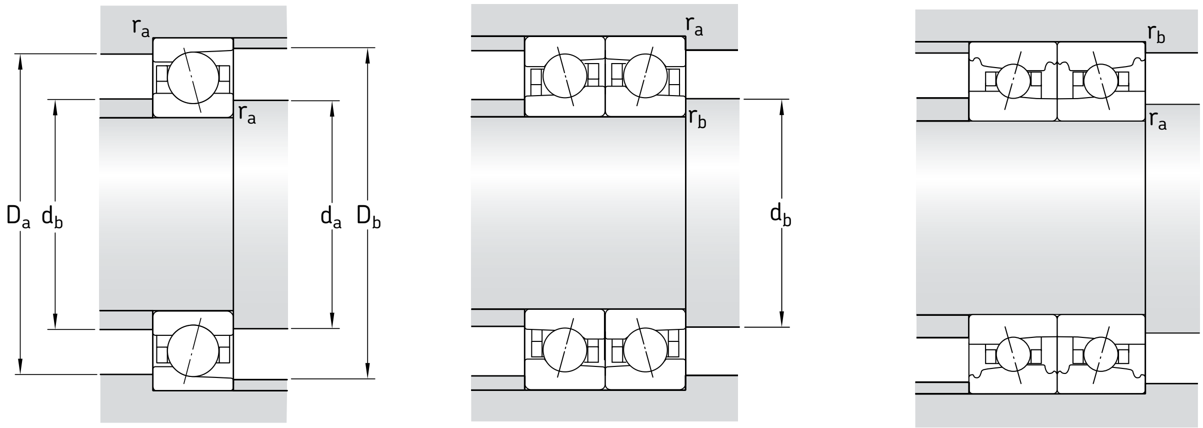
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
55	62,7	72,3	1	0,3	16	59,6	59,6	75,4	78	1	0,3
	62,7	72,3	1	0,3	16	59,6	59,6	75,4	78	1	0,3
	62,7	72,3	1	0,3	16	59,6	57	75,4	78	1	0,3
	62,7	72,3	1	0,3	16	59,6	57	75,4	78	1	0,3
	63,9	73,2	1	1	18	59,6	59,6	75,4	75,4	1	1
	63,9	73,2	1	1	18	59,6	59,6	75,4	75,4	1	1
	62,7	72,3	1	0,3	22	59,6	59,6	75,4	78	1	0,3
	62,7	72,3	1	0,3	22	59,6	59,6	75,4	78	1	0,3
	62,7	72,3	1	0,3	22	59,6	57	75,4	78	1	0,3
	62,7	72,3	1	0,3	22	59,6	57	75,4	78	1	0,3
	63,9	73,2	1	1	22	59,6	59,6	75,4	75,4	1	1
	63,9	73,2	1	1	22	59,6	59,6	75,4	75,4	1	1
	65,8	79,2	1,1	0,6	19	61	61	84	86,8	1	0,6
	65,8	79,2	1,1	0,6	19	61	61	84	86,8	1	0,6
	67,8	77,3	1,1	1,1	19	61	61	84	84	1	1
	67,8	77,3	1,1	1,1	19	61	61	84	84	1	1
	68,2	79,4	1,1	1,1	21	61	61	84	84	1	1
	68,2	79,4	1,1	1,1	21	61	61	84	84	1	1
	65,8	79,2	1,1	0,6	26	61	61	84	86,8	1	0,6
	65,8	79,2	1,1	0,6	26	61	61	84	86,8	1	0,6
	67,8	77,3	1,1	1,1	26	61	61	84	84	1	1
	67,8	77,3	1,1	1,1	26	61	61	84	84	1	1
	68,2	79,4	1,1	1,1	26	61	61	84	84	1	1
	68,2	79,4	1,1	1,1	26	61	61	84	84	1	1
	68,9	86,1	1,5	0,6	21	64	64	91	95,8	1,5	0,6
	68,9	86,1	1,5	0,6	21	64	64	91	95,8	1,5	0,6
	68,9	86,1	1,5	0,6	29	64	64	91	95,8	1,5	0,6
	68,9	86,1	1,5	0,6	29	64	64	91	95,8	1,5	0,6

Angular contact ball bearings
d **60** mm



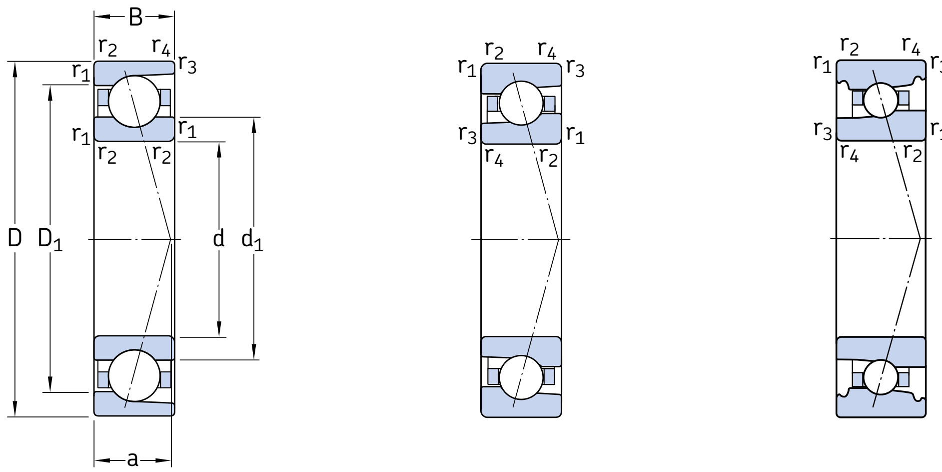
CD, ACD CE, ACE FB, DB

Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Calcu-lation factor**	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designation**
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
60	85	13	19,9	15,3	0,655	11	15 000	24 000	0,19	**71912 CD/P4A**
	85	13	19,9	15,3	0,655	11	18 000	28 000	0,16	**71912 CD/HCP4A**
	85	13	15,6	10,6	0,45	11	22 000	34 000	0,19	**71912 CE/P4A**
	85	13	15,6	10,6	0,45	11	24 000	38 000	0,16	**71912 CE/HCP4A**
	85	13	13,8	15	0,64	–	19 000	30 000	0,20	**71912 FB/P7**
	85	13	13,8	15	0,64	–	22 000	36 000	0,18	**C71912 FB/P7**
	85	13	18,6	14,6	0,62	–	14 000	22 000	0,19	**71912 ACD/P4A**
	85	13	18,6	14,6	0,62	–	16 000	26 000	0,16	**71912 ACD/HCP4A**
	85	13	14,8	10	0,425	–	19 000	30 000	0,19	**71912 ACE/P4A**
	85	13	14,8	10	0,425	–	22 000	34 000	0,16	**71912 ACE/HCP4A**
	85	13	13	14,3	0,61	–	17 000	28 000	0,20	**71912 DB/P7**
	85	13	13	14,3	0,61	–	20 000	32 000	0,18	**C71912 DB/P7**
	95	18	40,3	34,5	1,5	15	14 000	22 000	0,40	**7012 CD/P4A**
	95	18	40,3	34,5	1,5	15	16 000	26 000	0,34	**7012 CD/HCP4A**
	95	18	16,3	11,6	0,49	15	20 000	30 000	0,42	**7012 CE/P4A**
	95	18	16,3	11,6	0,49	15	22 000	36 000	0,39	**7012 CE/HCP4A**
	95	18	19	20,4	0,865	–	18 000	28 000	0,44	**7012 FB/P7**
	95	18	19	20,4	0,865	–	20 000	32 000	0,42	**C7012 FB/P7**
	95	18	39	33,5	1,4	–	13 000	20 000	0,40	**7012 ACD/P4A**
	95	18	39	33,5	1,4	–	15 000	24 000	0,34	**7012 ACD/HCP4A**
	95	18	15,3	11	0,46	–	18 000	28 000	0,42	**7012 ACE/P4A**
	95	18	15,3	11	0,465	–	20 000	32 000	0,39	**7012 ACE/HCP4A**
	95	18	18,2	19,6	0,83	–	16 000	26 000	0,44	**7012 DB/P7**
	95	18	18,2	19,6	0,83	–	18 000	30 000	0,42	**C7012 DB/P7**
	110	22	67,6	53	2,24	14	13 000	20 000	0,80	**7212 CD/P4A**
	110	22	67,6	53	2,24	14	16 000	24 000	0,65	**7212 CD/HCP4A**
	110	22	63,7	50	2,12	–	11 000	18 000	0,80	**7212 ACD/P4A**
	110	22	63,7	50	2,12	–	14 000	22 000	0,65	**7212 ACD/HCP4A**



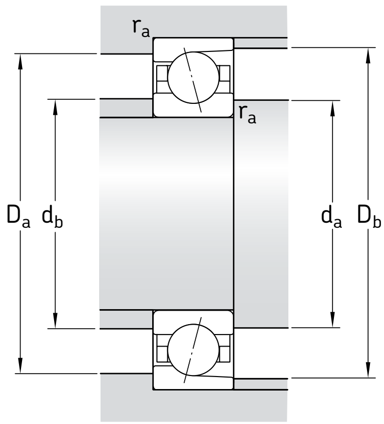
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
60	67,7	77,3	1	0,3	16	64,6	64,6	80,4	83	1	0,3
	67,7	77,3	1	0,3	16	64,6	64,6	80,4	83	1	0,3
	67,7	77,3	1	0,3	16	64,6	62	80,4	83	1	0,3
	67,7	77,3	1	0,3	16	64,6	62	80,4	83	1	0,3
	68,9	78,4	1	1	18	64,6	64,6	80,4	80,4	1	1
	68,9	78,4	1	1	18	64,6	64,6	80,4	80,4	1	1
	67,7	77,3	1	0,3	24	64,6	64,6	80,4	83	1	0,3
	67,7	77,3	1	0,3	24	64,6	64,6	80,4	83	1	0,3
	67,7	77,3	1	0,3	24	64,6	62	80,4	83	1	0,3
	67,7	77,3	1	0,3	24	64,6	62	80,4	83	1	0,3
	68,9	78,4	1	1	24	64,6	64,6	80,4	80,4	1	1
	68,9	78,4	1	1	24	64,6	64,6	80,4	80,4	1	1
	70,8	84,2	1,1	0,6	20	66	66	89	91,8	1	0,6
	70,8	84,2	1,1	0,6	20	66	66	89	91,8	1	0,6
	72,8	82,3	1,1	1,1	20	66	66	89	89	1	1
	72,8	82,3	1,1	1,1	20	66	66	89	89	1	1
	73,2	84,4	1,1	1,1	22	66	66	89	89	1	1
	73,2	84,4	1,1	1,1	22	66	66	89	89	1	1
	70,8	84,2	1,1	0,6	27	66	66	89	91,8	1	0,6
	70,8	84,2	1,1	0,6	27	66	66	89	91,8	1	0,6
	72,8	82,3	1,1	1,1	27	66	66	89	89	1	1
	72,8	82,3	1,1	1,1	27	66	66	89	89	1	1
	73,2	84,4	1,1	1,1	27	66	66	89	89	1	1
	73,2	84,4	1,1	1,1	27	66	66	89	89	1	1
	75,4	94,6	1,5	0,6	23	69	69	101	105	1,5	0,6
	75,4	94,6	1,5	0,6	23	69	69	101	105	1,5	0,6
	75,4	94,6	1,5	0,6	31	69	69	101	105	1,5	0,6
	75,4	94,6	1,5	0,6	31	69	69	101	105	1,5	0,6

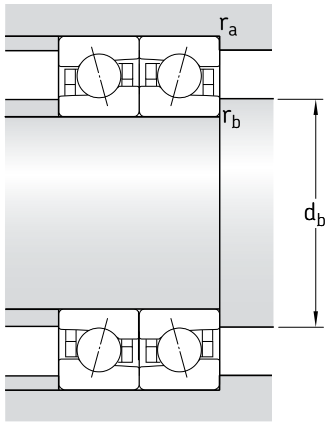
Angular contact ball bearings
d **65** mm

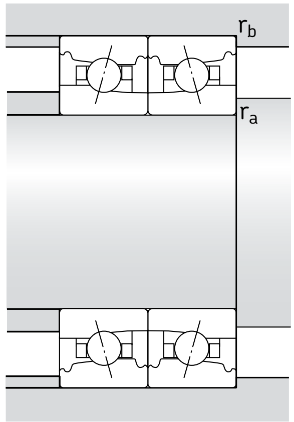


CD, ACD　　CE, ACE　　FB, DB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
65	90	13	20,8	17	0,71	11	14 000	22 000	0,21	**71913 CD/P4A**
	90	13	20,8	17	0,71	11	17 000	26 000	0,17	**71913 CD/HCP4A**
	90	13	16,3	11,6	0,49	11	20 000	30 000	0,20	**71913 CE/P4A**
	90	13	16,3	11,6	0,49	11	22 000	36 000	0,17	**71913 CE/HCP4A**
	90	13	14,3	16,6	0,71	–	18 000	28 000	0,20	**71913 FB/P7**
	90	13	14,3	16,6	0,71	–	20 000	32 000	0,19	**C71913 FB/P7**
	90	13	19,5	16	0,68	–	13 000	20 000	0,21	**71913 ACD/P4A**
	90	13	19,5	16	0,68	–	15 000	24 000	0,17	**71913 ACD/HCP4A**
	90	13	15,3	11	0,465	–	18 000	28 000	0,20	**71913 ACE/P4A**
	90	13	15,3	11	0,465	–	20 000	32 000	0,17	**71913 ACE/HCP4A**
	90	13	13,8	16	0,68	–	16 000	26 000	0,20	**71913 DB/P7**
	90	13	13,8	16	0,68	–	18 000	30 000	0,19	**C71913 DB/P7**
	100	18	41,6	37,5	1,6	16	14 000	22 000	0,42	**7013 CD/P4A**
	100	18	41,6	37,5	1,6	16	15 000	24 000	0,36	**7013 CD/HCP4A**
	100	18	16,8	12,7	0,54	16	19 000	28 000	0,44	**7013 CE/P4A**
	100	18	16,8	12,7	0,54	16	22 000	34 000	0,41	**7013 CE/HCP4A**
	100	18	20,8	22	0,93	–	17 000	26 000	0,45	**7013 FB/P7**
	100	18	20,8	22	0,93	–	19 000	30 000	0,43	**C7013 FB/P7**
	100	18	39	35,5	1,5	–	12 000	19 000	0,42	**7013 ACD/P4A**
	100	18	39	35,5	1,5	–	14 000	22 000	0,36	**7013 ACD/HCP4A**
	100	18	15,9	12	0,51	–	17 000	26 000	0,44	**7013 ACE/P4A**
	100	18	15,9	12	0,51	–	19 000	30 000	0,41	**7013 ACE/HCP4A**
	100	18	19,9	21,2	0,9	–	15 000	24 000	0,45	**7013 DB/P7**
	100	18	19,9	21,2	0,9	–	17 000	28 000	0,43	**C7013 DB/P7**
	120	23	76,1	60	2,5	14	12 000	19 000	1,00	**7213 CD/P4A**
	120	23	72,8	57	2,4	–	10 000	17 000	1,00	**7213 ACD/P4A**

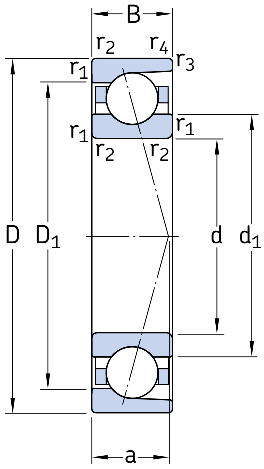




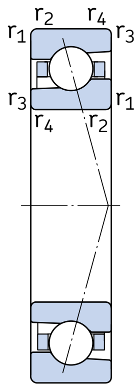


Dimensions						**Abutment and fillet dimensions**					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
65	72,7	82,3	1	0,3	17	69,6	69,6	85,4	88	1	0,3
	72,7	82,3	1	0,3	17	69,6	69,6	85,4	88	1	0,3
	72,7	82,3	1	0,3	17	69,6	67	85,4	88	1	0,3
	72,7	82,3	1	0,3	17	69,6	67	85,4	88	1	0,3
	74	83,4	1	1	19	69,6	69,6	85,4	85,4	1	1
	74	83,4	1	1	19	69,6	69,6	85,4	85,4	1	1
	72,7	82,3	1	0,3	25	69,6	69,6	85,4	88	1	0,3
	72,7	82,3	1	0,3	25	69,6	69,6	85,4	88	1	0,3
	72,7	82,3	1	0,3	25	69,6	67	85,4	88	1	0,3
	72,7	82,3	1	0,3	25	69,6	67	85,4	88	1	0,3
	74	83,4	1	1	25	69,6	69,6	85,4	85,4	1	1
	74	83,4	1	1	25	69,6	69,6	85,4	85,4	1	1
	75,8	89,2	1,1	0,6	20	71	71	94	96,8	1	0,6
	75,8	89,2	1,1	0,6	20	71	71	94	96,8	1	0,6
	77,8	87,3	1,1	1,1	20	71	71	94	94	1	1
	77,8	87,3	1,1	1,1	20	71	71	94	94	1	1
	78	89,7	1,1	1,1	23	71	71	94	94	1	1
	78	89,7	1,1	1,1	23	71	71	94	94	1	1
	75,8	89,2	1,1	0,6	28	71	71	94	96,8	1	0,6
	75,8	89,2	1,1	0,6	28	71	71	94	96,8	1	0,6
	77,8	87,3	1,1	1,1	28	71	71	94	94	1	1
	77,8	87,3	1,1	1,1	28	71	71	94	94	1	1
	78	89,7	1,1	1,1	28	71	71	94	94	1	1
	78	89,7	1,1	1,1	28	71	71	94	94	1	1
	81,9	103,1	1,5	0,6	24	74	74	111	115	1,5	0,6
	81,9	103,1	1,5	0,6	33	74	74	111	115	1,5	0,6

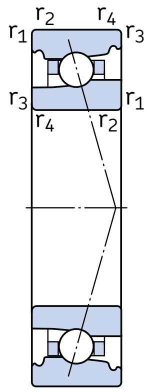
Angular contact ball bearings
d **70** mm



CD, ACD



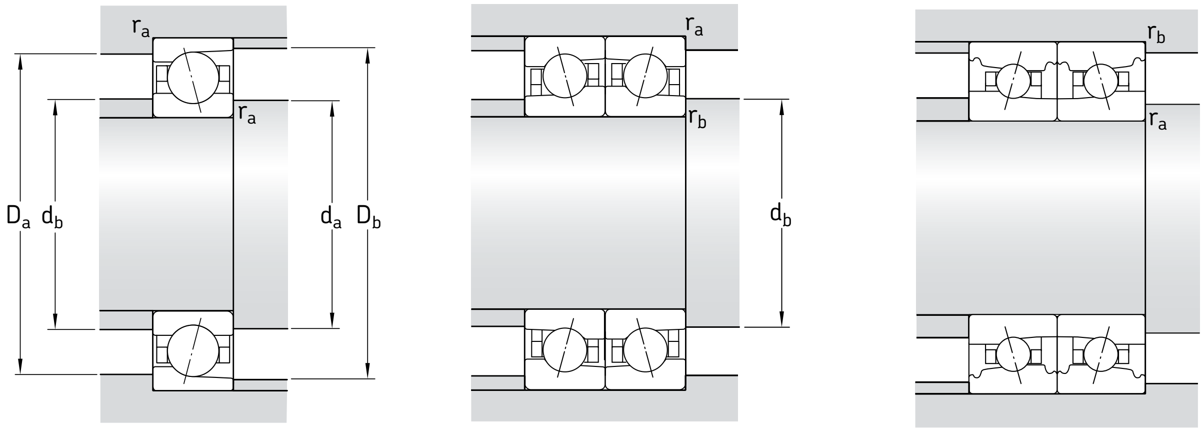
CE, ACE



FB, DB

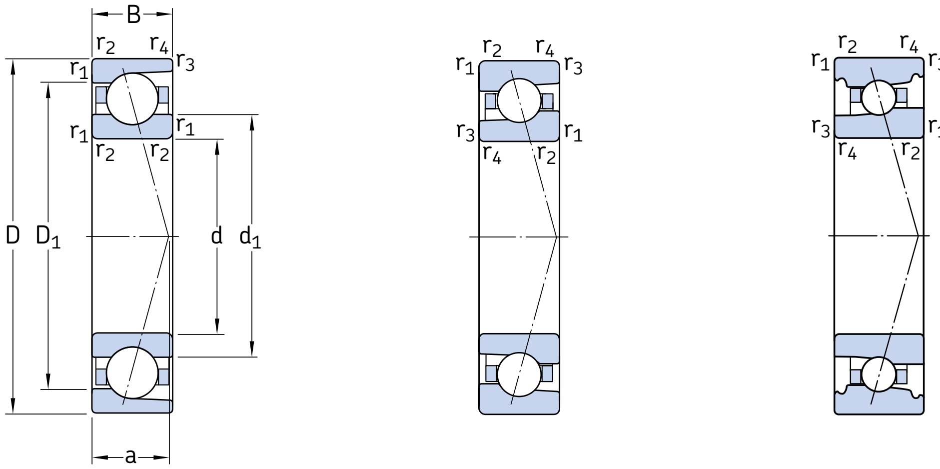
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
70	100	16	34,5	34	1,43	16	13 000	20 000	0,33	**71914 CD/P4A**
	100	16	34,5	34	1,43	16	16 000	24 000	0,28	**71914 CD/HCP4A**
	100	16	21,6	15	0,64	16	18 000	28 000	0,32	**71914 CE/P4A**
	100	16	21,6	15	0,64	16	20 000	32 000	0,28	**71914 CE/HCP4A**
	100	16	18,2	21,2	0,9	–	16 000	26 000	0,35	**71914 FB/P7**
	100	16	18,2	21,2	0,9	–	18 000	30 000	0,33	**C71914 FB/P7**
	100	16	32,5	32,5	1,37	–	11 000	18 000	0,33	**71914 ACD/P4A**
	100	16	32,5	32,5	1,37	–	14 000	22 000	0,28	**71914 ACD/HCP4A**
	100	16	20,3	14,3	0,6	–	16 000	26 000	0,32	**71914 ACE/P4A**
	100	16	20,3	14,3	0,6	–	18 000	28 000	0,28	**71914 ACE/HCP4A**
	100	16	17,2	20	0,85	–	14 000	22 000	0,35	**71914 DB/P7**
	100	16	17,2	20	0,85	–	17 000	26 000	0,33	**C71914 DB/P7**
	110	20	52	45,5	1,93	15	12 000	19 000	0,59	**7014 CD/P4A**[1]
	110	20	52	45,5	1,93	15	14 000	22 000	0,49	**7014 CD/HCP4A**[1]
	110	20	22,5	16,6	0,695	15	17 000	26 000	0,61	**7014 CE/P4A**
	110	20	22,5	16,6	0,695	15	19 000	30 000	0,56	**7014 CE/HCP4A**
	110	20	26	28	1,2	–	15 000	24 000	0,64	**7014 FB/P7**
	110	20	26	28	1,2	–	18 000	28 000	0,61	**C7014 FB/P7**
	110	20	48,8	44	1,86	–	10 000	17 000	0,59	**7014 ACD/P4AX**[1]
	110	20	48,8	44	1,86	–	13 000	20 000	0,49	**7014 ACD/HCP4A**[1]
	110	20	21,6	15,6	0,67	–	15 000	24 000	0,61	**7014 ACE/P4A**
	110	20	21,6	15,6	0,67	–	17 000	28 000	0,56	**7014 ACE/HCP4A**
	110	20	24,7	27	1,14	–	14 000	22 000	0,64	**7014 DB/P7**
	110	20	24,7	27	1,14	–	16 000	24 000	0,61	**C7014 DB/P7**
	125	24	79,3	64	2,75	15	11 000	18 000	1,10	**7214 CD/P4A**
	125	24	76,1	62	2,6	–	9 500	16 000	1,10	**7214 ACD/P4A**

[1] Bearings with PEEK cage as standard



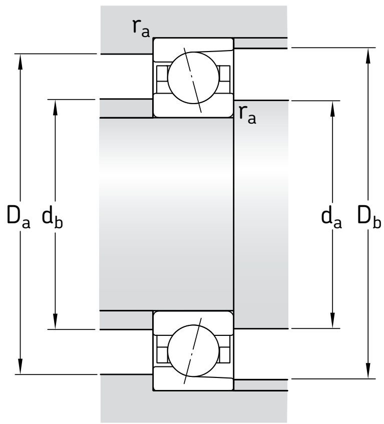
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
70	79,2	90,8	1	0,3	19	74,6	74,6	95,4	98	1	0,3
	79,2	90,8	1	0,3	19	74,6	74,6	95,4	98	1	0,3
	79,2	90,8	1	0,3	19	74,6	72	95,4	98	1	0,3
	79,2	90,8	1	0,3	19	74,6	72	95,4	98	1	0,3
	80,9	91,7	1	1	22	74,6	74,6	95,4	95,4	1	1
	80,9	91,7	1	1	22	74,6	74,6	95,4	95,4	1	1
	79,2	90,8	1	0,3	28	74,6	74,6	95,4	98	1	0,3
	79,2	90,8	1	0,3	28	74,6	74,6	95,4	98	1	0,3
	79,2	90,8	1	0,3	28	74,6	72	95,4	98	1	0,3
	79,2	90,8	1	0,3	28	74,6	72	95,4	98	1	0,3
	80,9	91,7	1	1	28	74,6	74,6	95,4	95,4	1	1
	80,9	91,7	1	1	28	74,6	74,6	95,4	95,4	1	1
	82,3	97,7	1,1	0,6	22	76	76	104	106	1	0,6
	82,3	97,7	1,1	0,6	22	76	76	104	106	1	0,6
	84,3	95,8	1,1	1,1	22	76	76	104	104	1	1
	84,3	95,8	1,1	1,1	22	76	76	104	104	1	1
	85	97,8	1,1	1,1	25	76	76	104	104	1	1
	85	97,8	1,1	1,1	25	76	76	104	104	1	1
	82,3	97,7	1,1	0,6	31	76	76	104	106	1	0,6
	82,3	97,7	1,1	0,6	31	76	76	104	106	1	0,6
	84,3	95,8	1,1	1,1	31	76	76	104	104	1	1
	84,3	95,8	1,1	1,1	31	76	76	104	104	1	1
	85	97,8	1,1	1,1	31	76	76	104	104	1	1
	85	97,8	1,1	1,1	31	76	76	104	104	1	1
	86,9	108,1	1,5	0,6	25	79	79	116	120	1,5	0,6
	86,9	108,1	1,5	0,6	35	79	79	116	120	1,5	0,6

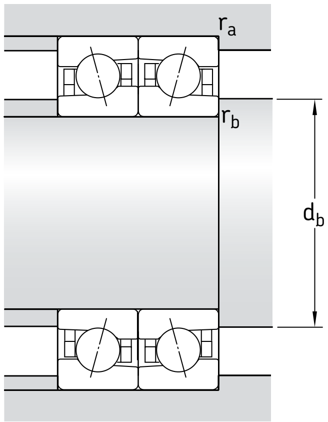
Angular contact ball bearings
d **75** mm

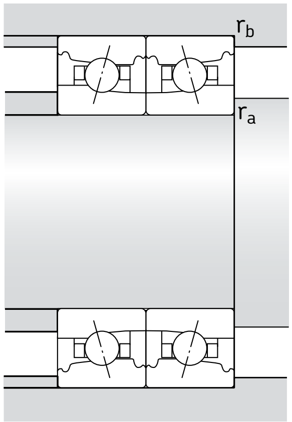


CD, ACD CE, ACE FB, DB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
75	105	16	35,8	37,5	1,56	16	12 000	19 000	0,35	**71915 CD/P4A**
	105	16	35,8	37,5	1,56	16	15 000	22 000	0,30	**71915 CD/HCP4A**
	105	16	22,5	16,6	0,695	16	17 000	26 000	0,35	**71915 CE/P4A**
	105	16	22,5	16,6	0,695	16	19 000	30 000	0,29	**71915 CE/HCP4A**
	105	16	18,6	22,4	0,95	–	15 000	24 000	0,35	**71915 FB/P7**
	105	16	18,6	22,4	0,95	–	17 000	28 000	0,33	**C71915 FB/P7**
	105	16	33,8	35,5	1,5	–	10 000	17 000	0,35	**71915 ACD/P4A**
	105	16	33,8	35,5	1,5	–	13 000	20 000	0,30	**71915 ACD/HCP4A**
	105	16	21,6	15,6	0,67	–	15 000	24 000	0,35	**71915 ACE/P4A**
	105	16	21,6	15,6	0,67	–	17 000	28 000	0,29	**71915 ACE/HCP4A**
	105	16	17,8	21,6	0,915	–	14 000	22 000	0,35	**71915 DB/P7**
	105	16	17,8	21,6	0,915	–	16 000	24 000	0,33	**C71915 DB/P7**
	115	20	52,7	49	2,08	16	11 000	18 000	0,62	**7015 CD/P4A**
	115	20	52,7	49	2,08	16	14 000	22 000	0,52	**7015 CD/HCP4A**
	115	20	22,9	17,3	0,735	16	16 000	26 000	0,64	**7015 CE/P4A**
	115	20	22,9	17,3	0,735	16	18 000	28 000	0,59	**7015 CE/HCP4A**
	115	20	26,5	30,5	1,29	–	14 000	22 000	0,68	**7015 FB/P7**
	115	20	26,5	30,5	1,29	–	17 000	26 000	0,65	**C7015 FB/P7**
	115	20	49,4	46,5	1,96	–	9 500	16 000	0,62	**7015 ACD/P4A**
	115	20	49,4	46,5	1,96	–	12 000	19 000	0,52	**7015 ACD/HCP4A**
	115	20	21,6	16,3	0,695	–	14 000	22 000	0,64	**7015 ACE/P4A**
	115	20	21,6	16,3	0,695	–	16 000	26 000	0,59	**7015 ACE/HCP4A**
	115	20	25,5	29	1,22	–	13 000	20 000	0,68	**7015 DB/P7**
	115	20	25,5	29	1,22	–	15 000	24 000	0,65	**C7015 DB/P7**
	130	25	83,2	69,5	2,9	15	10 000	17 000	1,20	**7215 CD/P4A**
	130	25	79,3	67	2,8	–	9 000	15 000	1,20	**7215 ACD/P4A**

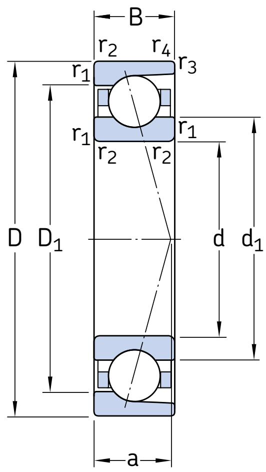




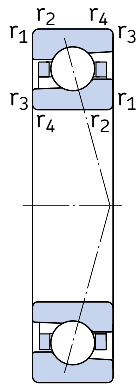


Dimensions						**Abutment and fillet dimensions**					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
75	84,2	95,8	1	0,3	20	79,6	79,6	100	103	1	0,3
	84,2	95,8	1	0,3	20	79,6	79,6	100	103	1	0,3
	84,2	95,8	1	0,3	20	79,6	77	100	103	1	0,3
	84,2	95,8	1	0,3	20	79,6	77	100	103	1	0,3
	86	96,7	1	1	23	79,6	79,6	100	100	1	1
	86	96,7	1	1	23	79,6	79,6	100	100	1	1
	84,2	95,8	1	0,3	29	79,6	79,6	100	103	1	0,3
	84,2	95,8	1	0,3	29	79,6	79,6	100	103	1	0,3
	84,2	95,8	1	0,3	29	79,6	77	100	103	1	0,3
	84,2	95,8	1	0,3	29	79,6	77	100	103	1	0,3
	86	96,7	1	1	29	79,6	79,6	100	100	1	1
	86	96,7	1	1	29	79,6	79,6	100	100	1	1
	87,3	102,7	1,1	0,6	23	81	81	109	111	1	0,6
	87,3	102,7	1,1	0,6	23	81	81	109	111	1	0,6
	89,3	100,8	1,1	1,1	23	81	81	109	109	1	1
	89,3	100,8	1,1	1,1	23	81	81	109	109	1	1
	90	102,8	1,1	1,1	26	81	81	109	109	1	1
	90	102,8	1,1	1,1	26	81	81	109	109	1	1
	87,3	102,7	1,1	0,6	32	81	81	109	111	1	0,6
	87,3	102,7	1,1	0,6	32	81	81	109	111	1	0,6
	89,3	100,8	1,1	1,1	32	81	81	109	109	1	1
	89,3	100,8	1,1	1,1	32	81	81	109	109	1	1
	90	102,8	1,1	1,1	32	81	81	109	109	1	1
	90	102,8	1,1	1,1	32	81	81	109	109	1	1
	91,9	113,1	1,5	0,6	26	84	84	121	125	1,5	0,6
	91,9	113,1	1,5	0,6	37	84	84	121	125	1,5	0,6

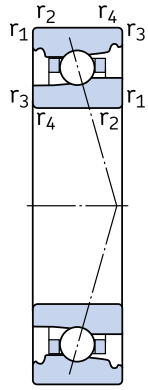
Angular contact ball bearings
d **80** mm



CD, ACD



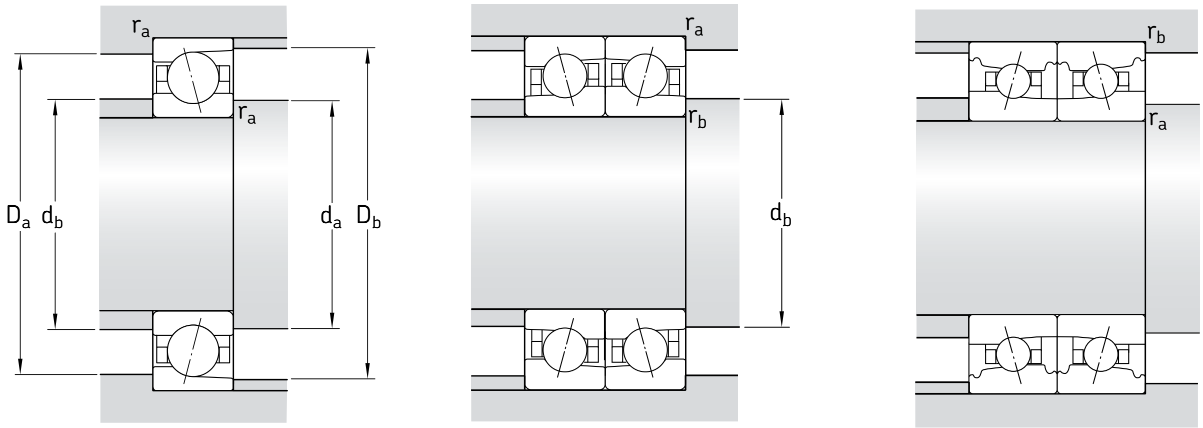
CE, ACE



FB, DB

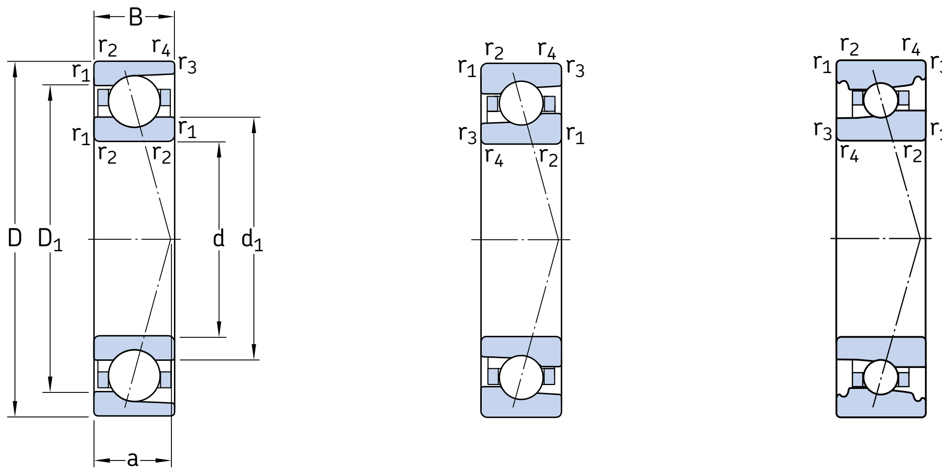
Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Calcu-lation factor**	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designation**
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
80	110	16	36,4	39	1,66	16	11 000	18 000	0,37	**71916 CD/P4A**
	110	16	36,4	39	1,66	16	15 000	22 000	0,31	**71916 CD/HCP4A**
	110	16	22,9	17,3	0,735	16	16 000	26 000	0,36	**71916 CE/P4A**
	110	16	22,9	17,3	0,735	16	18 000	28 000	0,31	**71916 CE/HCP4A**
	110	16	20,8	25,5	1,08	–	14 000	22 000	0,38	**71916 FB/P7**
	110	16	20,8	25,5	1,08	–	16 000	26 000	0,36	**C71916 FB/P7**
	110	16	34,5	36,5	1,56	–	9 500	16 000	0,37	**71916 ACD/P4A**
	110	16	34,5	36,5	1,56	–	12 000	19 000	0,31	**71916 ACD/HCP4A**
	110	16	21,6	16,3	0,695	–	14 000	22 000	0,36	**71916 ACE/P4A**
	110	16	21,6	16,3	0,695	–	16 000	26 000	0,31	**71916 ACE/HCP4A**
	110	16	19,9	24,5	1,02	–	13 000	20 000	0,38	**71916 DB/P7**
	110	16	19,9	24,5	1,02	–	15 000	24 000	0,36	**C71916 DB/P7**
	125	22	65	61	2,55	16	10 000	17 000	0,85	**7016 CD/P4A**[1]
	125	22	65	61	2,55	16	13 000	20 000	0,71	**7016 CD/HCP4A**[1]
	125	22	29,1	21,6	0,9	16	15 000	24 000	0,85	**7016 CE/P4A**
	125	22	29,1	21,6	0,9	16	17 000	26 000	0,77	**7016 CE/HCP4A**
	125	22	35,1	39	1,63	–	13 000	20 000	0,89	**7016 FB/P7**
	125	22	35,1	39	1,63	–	16 000	24 000	0,84	**C7016 FB/P7**
	125	22	62,4	58,5	2,45	–	9 000	15 000	0,85	**7016 ACD/P4A**[1]
	125	22	62,4	58,5	2,45	–	11 000	18 000	0,71	**7016 ACD/HCP4A**[1]
	125	22	27,6	20,4	0,85	–	13 000	20 000	0,85	**7016 ACE/P4A**
	125	22	27,6	20,4	0,85	–	15 000	24 000	0,77	**7016 ACE/HCP4A**
	125	22	33,8	37,5	1,56	–	12 000	19 000	0,89	**7016 DB/P7**
	125	22	33,8	37,5	1,56	–	14 000	22 000	0,84	**C7016 DB/P7**
	140	26	97,5	81,5	3,35	15	9 500	16 000	1,45	**7216 CD/P4A**
	140	26	92,3	78	3,2	–	8 500	14 000	1,45	**7216 ACD/P4A**

[1] Bearing with PEEK cage as standard



Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
80	89,2	100,8	1	0,3	21	84,6	84,6	105	108	1	0,3
	89,2	100,8	1	0,3	21	84,6	84,6	105	108	1	0,3
	89,2	100,8	1	0,3	21	84,6	82	105	108	1	0,3
	89,2	100,8	1	0,3	21	84,6	82	105	108	1	0,3
	90,7	102,2	1	1	24	84,6	84,6	105	105	1	1
	90,7	102,2	1	1	24	84,6	84,6	105	105	1	1
	89,2	100,8	1	0,3	30	84,6	84,6	105	108	1	0,3
	89,2	100,8	1	0,3	30	84,6	84,6	105	108	1	0,3
	89,2	100,8	1	0,3	30	84,6	82	105	108	1	0,3
	89,2	100,8	1	0,3	30	84,6	82	105	108	1	0,3
	90,7	102,2	1	1	30	84,6	84,6	105	105	1	1
	90,7	102,2	1	1	30	84,6	84,6	105	105	1	1
	93,9	111,1	1,1	0,6	25	86	86	119	121	1	0,6
	93,9	111,1	1,1	0,6	25	86	86	119	121	1	0,6
	95,9	109,2	1,1	1,1	25	86	86	119	119	1	1
	95,9	109,2	1,1	1,1	25	86	86	119	119	1	1
	96,7	111,4	1,1	1,1	28	86	86	119	119	1	1
	96,7	111,4	1,1	1,1	28	86	86	119	119	1	1
	93,9	111,1	1,1	0,6	35	86	86	119	121	1	0,6
	93,9	111,1	1,1	0,6	35	86	86	119	121	1	0,6
	95,9	109,2	1,1	1,1	35	86	86	119	119	1	1
	95,9	109,2	1,1	1,1	35	86	86	119	119	1	1
	96,7	111,4	1,1	1,1	35	86	86	119	119	1	1
	96,7	111,4	1,1	1,1	35	86	86	119	119	1	1
	98,5	121,5	2	1	28	91	91	129	134	2	1
	98,5	121,5	2	1	39	91	91	129	134	2	1

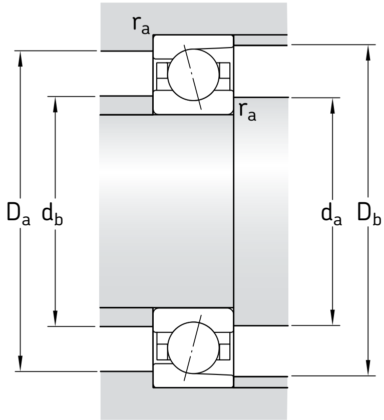
Angular contact ball bearings
d **85** mm

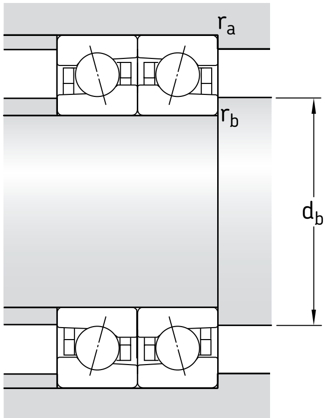


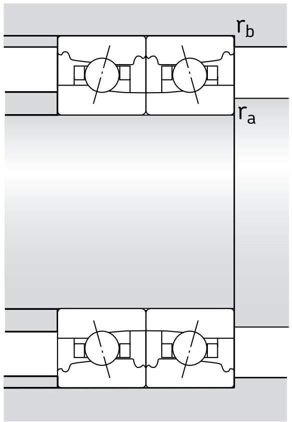
CD, ACD　　CE, ACE　　FB, DB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
85	120	18	46,2	48	2,04	16	10 000	17 000	0,53	**71917 CD/P4A**
	120	18	46,2	48	2,04	16	14 000	20 000	0,44	**71917 CD/HCP4A**
	120	18	29,1	21,6	0,9	16	15 000	24 000	0,52	**71917 CE/P4A**
	120	18	29,1	21,6	0,9	16	17 000	26 000	0,44	**71917 CE/HCP4A**
	120	18	22,5	27,5	1,16	–	13 000	20 000	0,54	**71917 FB/P7**
	120	18	22,5	27,5	1,16	–	15 000	24 000	0,51	**C71917 FB/P7**
	120	18	43,6	45,5	1,93	–	9 000	15 000	0,53	**71917 ACD/P4A**
	120	18	43,6	45,5	1,93	–	11 000	18 000	0,44	**71917 ACD/HCP4A**
	120	18	27,6	20,4	0,85	–	13 000	20 000	0,52	**71917 ACE/P4A**
	120	18	27,6	20,4	0,85	–	15 000	24 000	0,44	**71917 ACE/HCP4A**
	120	18	21,6	26,5	1,1	–	12 000	19 000	0,54	**71917 DB/P7**
	120	18	21,6	26,5	1,1	–	14 000	22 000	0,51	**C71917 DB/P7**
	130	22	67,6	65,5	2,65	16	9 500	16 000	0,89	**7017 CD/P4A**[1]
	130	22	67,6	65,5	2,65	16	12 000	19 000	0,74	**7017 CD/HCP4A**[1]
	130	22	29,6	22,8	0,93	16	14 000	22 000	0,89	**7017 CE/P4A**
	130	22	29,6	22,8	0,93	16	16 000	26 000	0,81	**7017 CE/HCP4A**
	130	22	35,8	40,5	1,66	–	13 000	20 000	0,90	**7017 FB/P7**
	130	22	35,8	40,5	1,66	–	15 000	24 000	0,85	**C7017 FB/P7**
	130	22	63,7	62	2,5	–	8 500	14 000	0,89	**7017 ACD/P4A**[1]
	130	22	63,7	62	2,5	–	10 000	17 000	0,74	**7017 ACD/HCP4A**[1]
	130	22	28,1	21,6	0,88	–	13 000	20 000	0,89	**7017 ACE/P4A**
	130	22	28,1	21,6	0,88	–	14 000	22 000	0,81	**7017 ACE/HCP4A**
	130	22	34,5	39	1,6	–	11 000	18 000	0,90	**7017 DB/P7**
	130	22	34,5	39	1,6	–	13 000	20 000	0,85	**C7017 DB/P7**
	150	28	99,5	88	3,45	15	9 000	15 000	1,80	**7217 CD/P4A**
	150	28	95,6	85	3,35	–	8 000	13 000	1,80	**7217 ACD/P4A**

[1] Bearing with PEEK cage as standard

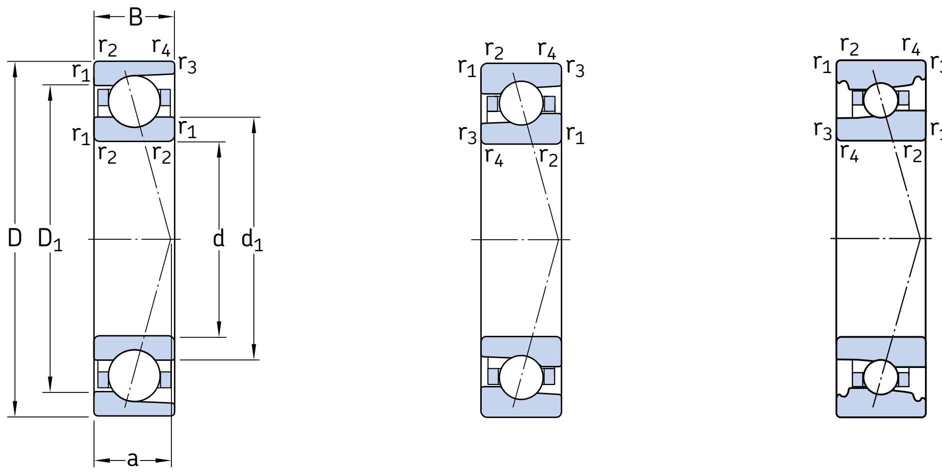






Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
85	95,8	109,2	1,1	0,6	23	91	91	114	116	1	0,6
	95,8	109,2	1,1	0,6	23	91	91	114	116	1	0,6
	95,8	109,2	1,1	0,6	23	91	88,2	114	116	1	0,6
	95,8	109,2	1,1	0,6	23	91	88,2	114	116	1	0,6
	98	110	1,1	1,1	26	91	91	114	114	1	1
	98	110	1,1	1,1	28	91	91	114	114	1	1
	95,8	109,2	1,1	0,6	33	91	91	114	116	1	0,6
	95,8	109,2	1,1	0,6	33	91	91	114	116	1	0,6
	95,8	109,2	1,1	0,6	33	91	88,2	114	116	1	0,6
	95,8	109,2	1,1	0,6	33	91	88,2	114	116	1	0,6
	98	110	1,1	1,1	33	91	91	114	114	1	1
	98	110	1,1	1,1	33	91	91	114	114	1	1
	98,9	116,1	1,1	0,6	26	91	91	124	126	1	0,6
	98,9	116,1	1,1	0,6	26	91	91	124	126	1	0,6
	100,9	114,2	1,1	1,1	26	91	91	124	124	1	1
	100,9	114,2	1,1	1,1	26	91	91	124	124	1	1
	101,7	116,4	1,1	1,1	29	91	91	124	124	1	1
	101,7	116,4	1,1	1,1	29	91	91	124	124	1	1
	98,9	116,1	1,1	0,6	36	91	91	124	126	1	0,6
	98,9	116,1	1,1	0,6	36	91	91	124	126	1	0,6
	100,9	114,2	1,1	1,1	36	91	91	124	124	1	1
	100,9	114,2	1,1	1,1	36	91	91	124	124	1	1
	101,7	116,4	1,1	1,1	36	91	91	124	124	1	1
	101,7	116,4	1,1	1,1	36	91	91	124	124	1	1
	106,5	129,5	2	1	30	96	96	139	144	2	1
	106,5	129,5	2	1	42	96	96	139	144	2	1

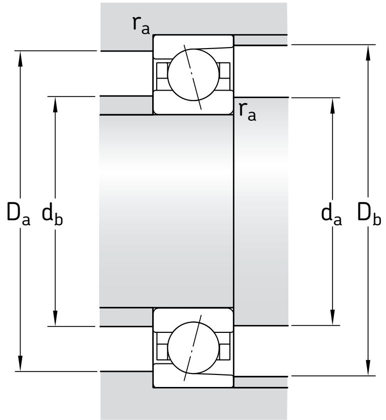
Angular contact ball bearings
d **90** mm

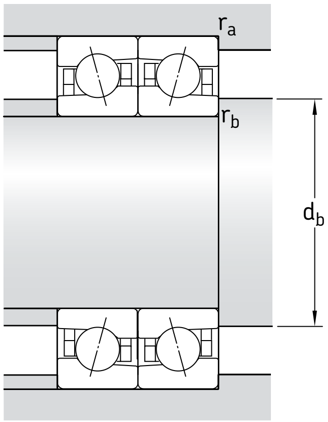


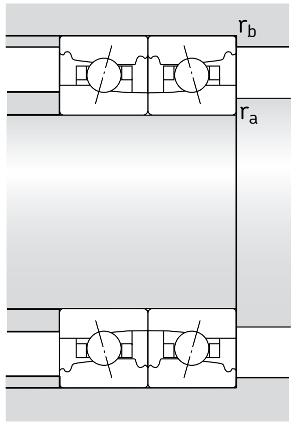
CD, ACD CE, ACE FB, DB

Principal dimensions			Basic load ratings		Fatigue load limit	Calculation factor	Attainable speeds when lubricating with		Mass	Designation
			dynamic	static			grease	oil-air		
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
90	125	18	47,5	51	2,08	16	9 500	16 000	0,55	**71918 CD/P4A**[1]
	125	18	47,5	51	2,08	16	13 000	19 000	0,47	**71918 CD/HCP4A**[1]
	125	18	29,6	22,8	0,93	16	14 000	22 000	0,54	**71918 CE/P4A**
	125	18	29,6	22,8	0,93	16	16 000	26 000	0,46	**71918 CE/HCP4A**
	125	18	23,4	30,5	1,25	–	13 000	20 000	0,57	**71918 FB/P7**
	125	18	23,4	30,5	1,25	–	14 000	24 000	0,54	**C71918 FB/P7**
	125	18	44,2	48	1,96	–	8 500	14 000	0,55	**71918 ACD/P4A**[1]
	125	18	44,2	48	1,96	–	10 000	17 000	0,47	**71918 ACD/HCP4A**[1]
	125	18	28,1	21,6	0,88	–	13 000	20 000	0,54	**71918 ACE/P4A**
	125	18	28,1	21,6	0,88	–	14 000	22 000	0,46	**71918 ACE/HCP4A**
	125	18	22,5	29	1,18	–	11 000	18 000	0,57	**71918 DB/P7**
	125	18	22,5	29	1,18	–	13 000	20 000	0,54	**C71918 DB/P7**
	140	24	79,3	76,5	3	16	9 000	15 000	1,15	**7018 CD/P4A**[1]
	140	24	79,3	76,5	3	16	11 000	18 000	0,95	**7018 CD/HCP4A**[1]
	140	24	37,1	28	1,1	16	13 000	20 000	1,15	**7018 CE/P4A**
	140	24	37,1	28	1,1	16	15 000	24 000	1,03	**7018 CE/HCP4A**
	140	24	39	42,5	1,66	–	12 000	18 000	1,20	**7018 FB/P7**
	140	24	39	42,5	1,66	–	14 000	22 000	1,15	**C7018 FB/P7**
	140	24	74,1	72	2,85	–	8 000	13 000	1,15	**7018 ACD/P4A**[1]
	140	24	74,1	72	2,85	–	9 500	16 000	0,95	**7018 ACD/HCP4A**[1]
	140	24	35,1	26,5	1,04	–	12 000	19 000	1,15	**7018 ACE/P4A**
	140	24	35,1	26,5	1,04	–	13 000	22 000	1,03	**7018 ACE/HCP4A**
	140	24	37,1	40,5	1,6	–	11 000	17 000	1,20	**7018 DB/P7**
	140	24	37,1	40,5	1,6	–	12 000	19 000	1,15	**C7018 DB/P7**
	160	30	127	112	4,25	15	8 500	14 000	2,25	**7218 CD/P4A**
	160	30	121	106	4,05	–	7 500	12 000	2,25	**7218 ACD/P4A**

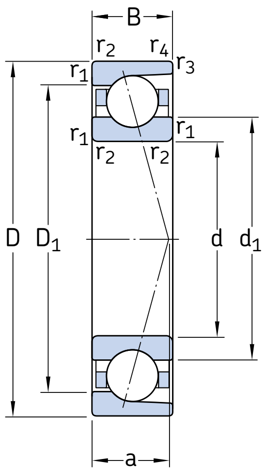
[1] Bearing with PEEK cage as standard



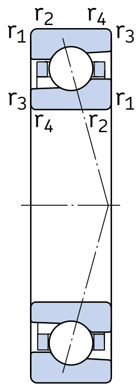




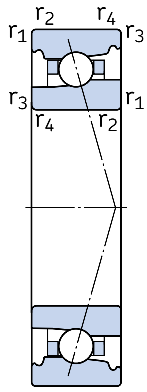
Dimensions						**Abutment and fillet dimensions**					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
90	100,8	114,2	1,1	0,6	23	96	96	119	121	1	0,6
	100,8	114,2	1,1	0,6	23	96	96	119	121	1	0,6
	100,8	114,2	1,1	0,6	23	96	93,2	119	121	1	0,6
	100,8	114,2	1,1	0,6	23	96	93,2	119	121	1	0,6
	103	115	1,1	1,1	27	96	96	119	119	1	1
	103	115	1,1	1,1	27	96	96	119	119	1	1
	100,8	114,2	1,1	0,6	34	96	96	119	121	1	0,6
	100,8	114,2	1,1	0,6	34	96	96	119	121	1	0,6
	100,8	114,2	1,1	0,6	34	96	93,2	119	121	1	0,6
	100,8	114,2	1,1	0,6	34	96	93,2	119	121	1	0,6
	103	115	1,1	1,1	34	96	96	119	119	1	1
	103	115	1,1	1,1	34	96	96	119	119	1	1
	105,4	124,6	1,5	0,6	28	97	97	133	136	1,5	0,6
	105,4	124,6	1,5	0,6	28	97	97	133	136	1,5	0,6
	107,4	122,7	1,5	1,5	28	97	97	133	133	1,5	1,5
	107,4	122,7	1,5	1,5	28	97	97	133	133	1,5	1,5
	108,7	125	1,5	1,5	28	97	97	133	133	1,5	1,5
	108,7	125	1,5	1,5	28	97	97	133	133	1,5	1,5
	105,4	124,6	1,5	0,6	39	97	97	133	136	1,5	0,6
	105,4	124,6	1,5	0,6	39	97	97	133	136	1,5	0,6
	107,4	122,7	1,5	1,5	39	97	97	133	133	1,5	1,5
	107,4	122,7	1,5	1,5	39	97	97	133	133	1,5	1,5
	108,7	125	1,5	1,5	31	97	97	133	133	1,5	1,5
	108,7	125	1,5	1,5	31	97	97	133	133	1,5	1,5
	111,6	138,4	2	1	32	101	101	149	154	2	1
	111,6	138,4	2	1	44	101	101	149	154	2	1



CD, ACD

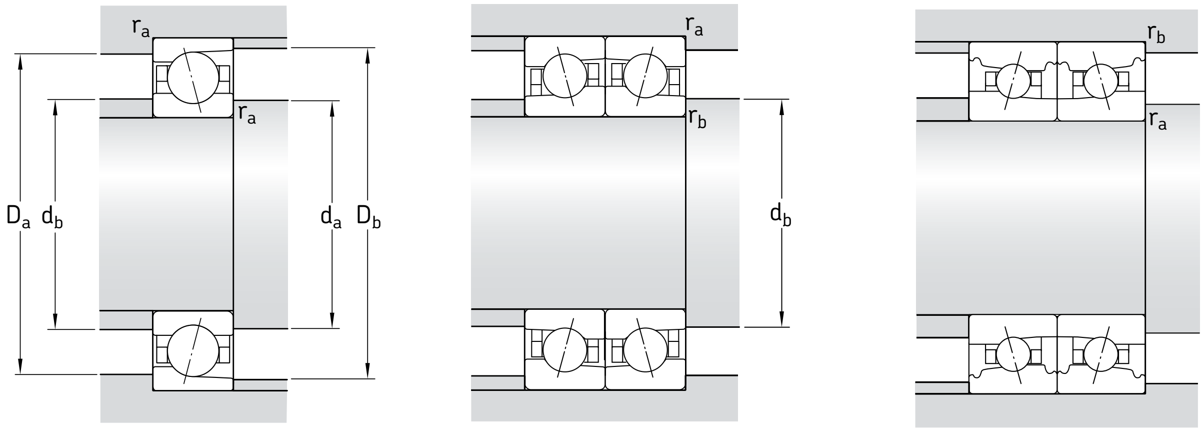


CE, ACE



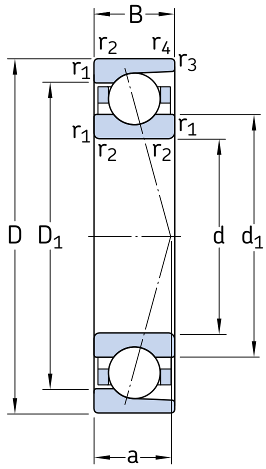
FB, DB

Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Calcu-lation factor**	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designation**
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
95	130	18	49,4	55	2,2	16	9 000	15 000	0,58	**71919 CD/P4A**
	130	18	49,4	55	2,2	16	12 000	18 000	0,49	**71919 CD/HCP4A**
	130	18	31,2	24,5	0,98	16	14 000	22 000	0,57	**71919 CE/P4A**
	130	18	31,2	24,5	0,98	16	15 000	24 000	0,48	**71919 CE/HCP4A**
	130	18	24,7	32,5	1,32	–	12 000	19 000	0,60	**71919 FB/P7**
	130	18	24,7	32,5	1,32	–	14 000	22 000	0,56	**C71919 FB/P7**
	130	18	46,2	52	2,08	–	8 500	14 000	0,58	**71919 ACD/P4A**
	130	18	46,2	52	2,08	–	9 500	16 000	0,49	**71919 ACD/HCP4A**
	130	18	29,6	23,2	0,93	–	12 000	19 000	0,57	**71919 ACE/P4A**
	130	18	29,6	23,2	0,93	–	14 000	22 000	0,48	**71919 ACE/HCP4A**
	130	18	23,4	31,5	1,25	–	11 000	17 000	0,60	**71919 DB/P7**
	130	18	23,4	31,5	1,25	–	12 000	20 000	0,56	**C71919 DB/P7**
	145	24	81,9	80	3,1	16	8 500	14 000	1,20	**7019 CD/P4A**
	145	24	81,9	80	3,1	16	10 000	17 000	1,00	**7019 CD/HCP4A**
	145	24	37,7	29	1,14	16	13 000	20 000	1,12	**7019 CE/P4A**
	145	24	37,7	29	1,14	16	14 000	22 000	1,07	**7019 CE/HCP4A**
	145	24	39	44	1,73	–	11 000	18 000	1,23	**7019 FB/P7**
	145	24	39	44	1,73	–	14 000	20 000	1,16	**C7019 FB/P7**
	145	24	76,1	76,5	2,9	–	8 000	13 000	1,20	**7019 ACD/P4A**
	145	24	76,1	76,5	2,9	–	9 000	15 000	1,00	**7019 ACD/HCP4A**
	145	24	35,8	28	1,08	–	11 000	18 000	1,12	**7019 ACE/P4A**
	145	24	35,8	28	1,08	–	13 000	20 000	1,07	**7019 ACE/HCP4A**
	145	24	37,1	42,5	1,63	–	10 000	16 000	1,23	**7019 DB/P7**
	145	24	37,1	42,5	1,63	–	12 000	18 000	1,16	**C7019 DB/P7**
	170	32	138	120	4,4	15	8 000	13 000	2,70	**7219 CD/P4A**
	170	32	133	114	4,25	–	7 500	12 000	2,70	**7219 ACD/P4A**

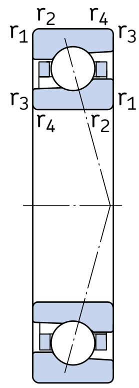


Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
95	105,8	119,2	1,1	0,6	24	101	101	124	126	1	0,6
	105,8	119,2	1,1	0,6	24	101	101	124	126	1	0,6
	105,8	119,2	1,1	0,6	24	101	98,2	124	126	1	0,6
	105,8	119,2	1,1	0,6	24	101	98,2	124	126	1	0,6
	108	120	1,1	1,1	27	101	101	124	124	1	1
	108	120	1,1	1,1	27	101	101	124	124	1	1
	105,8	119,2	1,1	0,6	35	101	101	124	126	1	0,6
	105,8	119,2	1,1	0,6	35	101	101	124	126	1	0,6
	105,8	119,2	1,1	0,6	35	101	98,2	124	126	1	0,6
	105,8	119,2	1,1	0,6	35	101	98,2	124	126	1	0,6
	108	120	1,1	1,1	35	101	101	124	124	1	1
	108	120	1,1	1,1	35	101	101	124	124	1	1
	110,4	129,6	1,5	0,6	28	102	102	138	141	1,5	0,6
	110,4	129,6	1,5	0,6	28	102	102	138	141	1,5	0,6
	112,4	127,7	1,5	1,5	28	102	102	138	138	1,5	1,5
	112,4	127,7	1,5	1,5	28	102	102	138	138	1,5	1,5
	113,7	130	1,5	1,5	32	102	102	138	138	1,5	1,5
	113,7	130	1,5	1,5	32	102	102	138	138	1,5	1,5
	110,4	129,6	1,5	0,6	40	102	102	138	141	1,5	0,6
	110,4	129,6	1,5	0,6	40	102	102	138	141	1,5	0,6
	112,4	127,7	1,5	1,5	40	102	102	138	138	1,5	1,5
	112,4	127,7	1,5	1,5	40	102	102	138	138	1,5	1,5
	113,7	130	1,5	1,5	40	102	102	138	138	1,5	1,5
	113,7	130	1,5	1,5	40	102	102	138	138	1,5	1,5
	118,1	146,9	2,1	1,1	34	107	107	158	163	2	1
	118,1	146,9	2,1	1,1	47	107	107	158	163	2	1

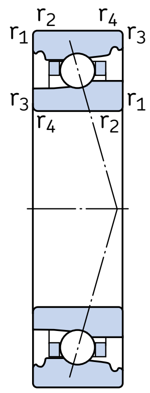
Angular contact ball bearings
d **100** mm



CD, ACD

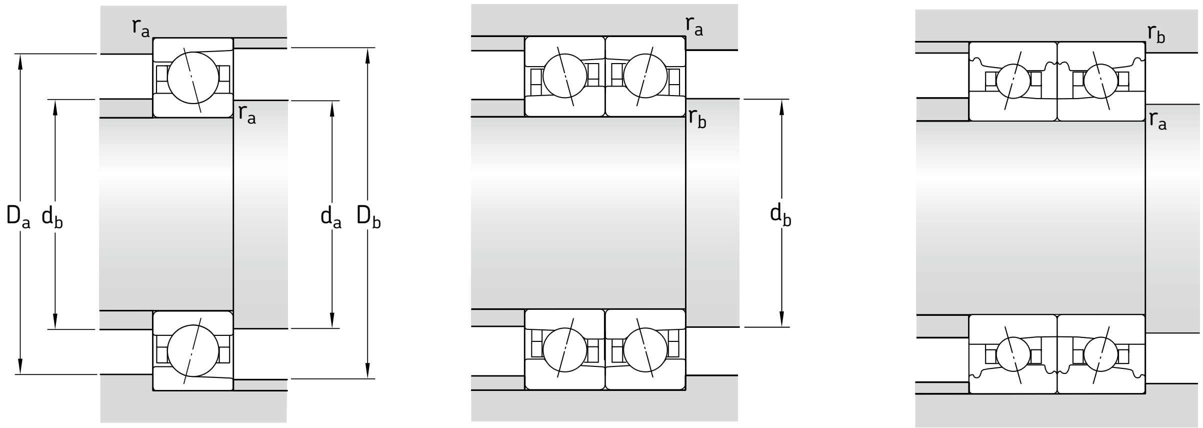


CE, ACE



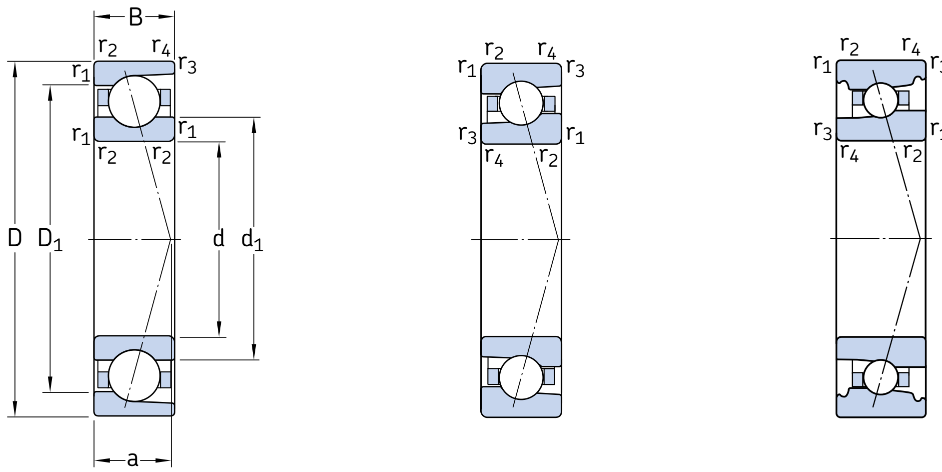
FB, DB

Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Calcu-lation factor**	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designation**
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
100	140	20	60,5	65,5	2,55	16	8 500	14 000	0,80	**71920 CD/P4A**
	140	20	60,5	65,5	2,55	16	11 000	17 000	0,66	**71920 CD/HCP4A**
	140	20	37,7	29	1,14	16	13 000	20 000	0,77	**71920 CE/P4A**
	140	20	37,7	29	1,14	16	14 000	22 000	0,65	**71920 CE/HCP4A**
	140	20	31,9	40	1,53	–	11 000	18 000	0,79	**71920 FB/P7**
	140	20	31,9	40	1,53	–	13 000	20 000	0,75	**C71920 FB/P7**
	140	20	57,2	63	2,4	–	8 000	13 000	0,80	**71920 ACD/P4A**
	140	20	57,2	63	2,4	–	9 000	15 000	0,66	**71920 ACD/HCP4A**
	140	20	35,8	28	1,08	–	11 000	18 000	0,77	**71920 ACE/P4A**
	140	20	35,8	28	1,08	–	13 000	20 000	0,65	**71920 ACE/HCP4A**
	140	20	30,2	38	1,46	–	10 000	16 000	0,79	**71920 DB/P7**
	140	20	30,2	38	1,46	–	12 000	18 000	0,75	**C71920 DB/P7**
	150	24	83,2	85	3,2	16	8 500	14 000	1,25	**7020 CD/P4A**
	150	24	83,2	85	3,2	16	9 500	16 000	1,05	**7020 CD/HCP4A**
	150	24	39	30,5	1,16	16	12 000	19 000	1,25	**7020 CE/P4A**
	150	24	39	30,5	1,16	16	14 000	22 000	1,12	**7020 CE/HCP4A**
	150	24	39,7	46,5	1,76	–	11 000	17 000	1,28	**7020 FB/P7**
	150	24	39,7	46,5	1,76	–	13 000	20 000	1,21	**C7020 FB/P7**
	150	24	79,3	80	3,05	–	7 500	12 000	1,25	**7020 ACD/P4A**
	150	24	79,3	80	3,05	–	9 000	15 000	1,05	**7020 ACD/HCP4A**
	150	24	36,4	29	1,1	–	11 000	17 000	1,25	**7020 ACE/P4A**
	150	24	36,4	29	1,1	–	12 000	19 000	1,12	**7020 ACE/HCP4A**
	150	24	37,7	44	1,7	–	9 500	15 000	1,28	**7020 DB/P7**
	150	24	37,7	44	1,7	–	11 000	18 000	1,21	**C7020 DB/P7**
	180	34	156	137	4,9	15	7 500	12 000	3,25	**7220 CD/P4A**
	180	34	148	129	4,65	–	7 000	11 000	3,25	**7220 ACD/P4A**



Dimensions						**Abutment and fillet dimensions**					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
100	112,3	127,7	1,1	0,6	26	106	106	134	136	1	0,6
	112,3	127,7	1,1	0,6	26	106	106	134	136	1	0,6
	112,3	127,7	1,1	0,6	26	106	104	134	136	1	0,6
	112,3	127,7	1,1	0,6	26	106	104	134	136	1	0,6
	114,5	128,9	1,1	1,1	30	106	106	134	134	1	1
	114,5	128,9	1,1	1,1	30	106	106	134	134	1	1
	112,3	127,7	1,1	0,6	38	106	106	134	136	1	0,6
	112,3	127,7	1,1	0,6	38	106	106	134	136	1	0,6
	112,3	127,7	1,1	0,6	38	106	104	134	136	1	0,6
	112,3	127,7	1,1	0,6	38	106	104	134	136	1	0,6
	114,5	128,9	1,1	1,1	38	106	106	134	134	1	1
	114,5	128,9	1,1	1,1	38	106	106	134	134	1	1
	115,4	134,6	1,5	0,6	29	107	107	143	146	1,5	0,6
	115,4	134,6	1,5	0,6	29	107	107	143	146	1,5	0,6
	117,4	132,7	1,5	1,5	29	107	107	143	143	1,5	1,5
	117,4	132,7	1,5	1,5	29	107	107	143	143	1,5	1,5
	118,7	135	1,5	1,5	32	107	107	143	143	1,5	1,5
	118,7	135	1,5	1,5	32	107	107	143	143	1,5	1,5
	115,4	134,6	1,5	0,6	41	107	107	143	146	1,5	0,6
	115,4	134,6	1,5	0,6	41	107	107	143	146	1,5	0,6
	117,4	132,7	1,5	1,5	41	107	107	143	143	1,5	1,5
	117,4	132,7	1,5	1,5	41	107	107	143	143	1,5	1,5
	118,7	135	1,5	1,5	41	107	107	143	143	1,5	1,5
	118,7	135	1,5	1,5	41	107	107	143	143	1,5	1,5
	124,7	155,3	2,1	1,1	36	112	112	168	173	2	1
	124,7	155,3	2,1	1,1	50	112	112	168	173	2	1

Angular contact ball bearings
d **105 – 110** mm

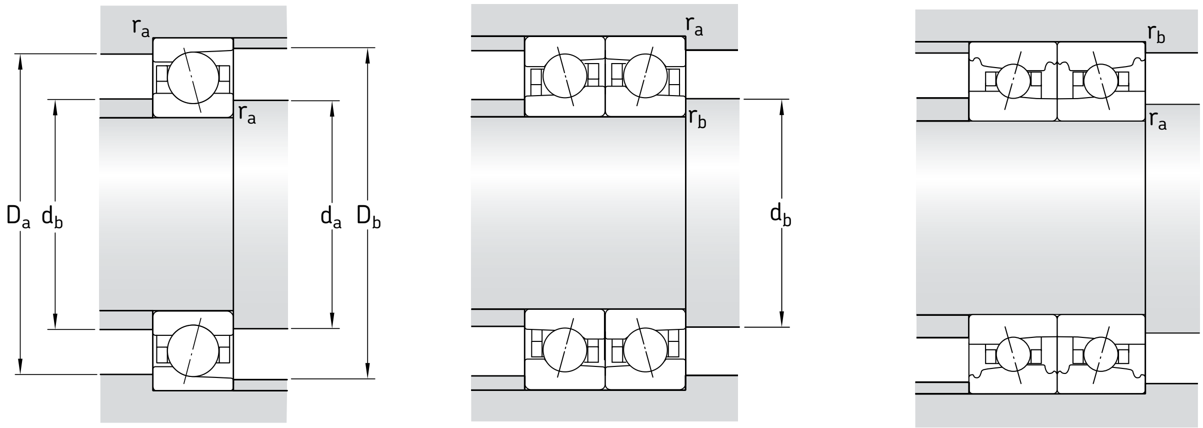


CD, ACD   CE, ACE   FB, DB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
105	145	20	61,8	69,5	2,6	16	8 500	14 000	0,82	**71921 CD/P4A**
	145	20	61,8	69,5	2,6	16	10 000	16 000	0,69	**71921 CD/HCP4A**
	145	20	57,2	65,5	2,5	–	7 500	12 000	0,82	**71921 ACD/P4A**
	145	20	57,2	65,5	2,5	–	9 000	15 000	0,69	**71921 ACD/HCP4A**
	160	26	95,6	96,5	3,6	16	8 000	13 000	1,60	**7021 CD/P4A**
	160	26	904	93	3,4	–	7 500	12 000	1,60	**7021 ACD/P4A**
	190	36	172	153	5,3	15	7 500	12 000	3,85	**7221 CD/P4A**
	190	36	163	146	5,1	–	6 700	10 000	3,85	**7221 ACD/P4A**
110	150	20	62,4	72	2,7	17	8 000	13 000	0,86	**71922 CD/P4A**[1]
	150	20	62,4	72	2,7	17	10 000	16 000	0,72	**71922 CD/HCP4A**[1]
	150	20	39,7	32	1,2	17	12 000	18 000	0,84	**71922 CE/P4A**
	150	20	39,7	32	1,2	17	13 000	20 000	0,71	**71922 CE/HCP4A**
	150	20	33,8	45	1,66	–	10 000	16 000	0,85	**71922 FB/P7**
	150	20	33,8	45	1,66	–	12 000	19 000	0,81	**C71922 FB/P7**
	150	20	58,5	68	2,55	–	7 500	12 000	0,86	**71922 ACD/P4A**[1]
	150	20	58,5	68	2,55	–	8 500	14 000	0,72	**71922 ACD/HCP4A**[1]
	150	20	37,1	30,5	1,12	–	10 000	16 000	0,84	**71922 ACE/P4A**
	150	20	37,1	30,5	1,12	–	12 000	19 000	0,71	**71922 ACE/HCP4A**
	150	20	32,5	43	1,6	–	9 500	15 000	0,85	**71922 DB/P7**
	150	20	32,5	43	1,6	–	11 000	17 000	0,81	**C71922 DB/P7**
	170	28	111	108	3,9	16	7 500	12 000	1,95	**7022 CD/P4A**
	170	28	49,4	62	2,2	–	9 500	15 000	2,00	**7022 FB/P7**
	170	28	49,4	62	2,2	–	11 000	18 000	1,90	**C7022 FB/P7**
	170	28	104	104	3,75	–	7 000	11 000	1,95	**7022 ACD/P4A**
	170	28	46,8	60	2,12	–	8 500	14 000	2,00	**7022 DB/P7**
	170	28	46,8	60	2,12	–	10 000	16 000	1,90	**C7022 DB/P7**
	200	38	178	166	5,6	15	7 000	11 000	4,55	**7222 CD/P4A**
	200	38	168	160	5,4	–	6 700	10 000	4,55	**7222 ACD/P4A**

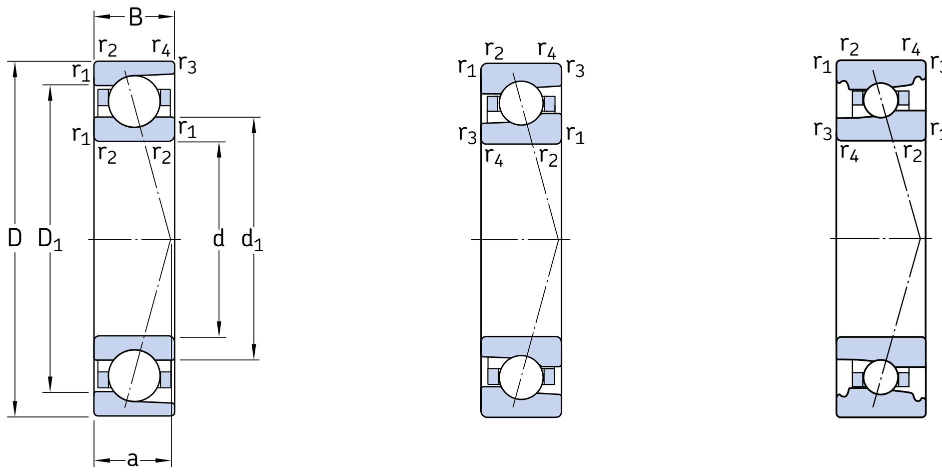
[1] Bearing with PEEK cage as standard

SKF



Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
105	117,3	132,7	1,1	0,6	27	111	111	139	141	1	0,6
	117,3	132,7	1,1	0,6	27	111	111	139	141	1	0,6
	117,3	132,7	1,1	0,6	39	111	111	139	141	1	0,6
	117,3	132,7	1,1	0,6	39	111	111	139	141	1	0,6
	121,9	143,1	2	1	31	114	114	151	155	2	1
	121,9	143,1	2	1	44	114	114	151	155	2	1
	131,2	163,8	2,1	1,1	38	117	117	178	183	2	1
	131,2	163,8	2,1	1,1	53	117	117	178	183	2	1
110	122,3	137,7	1,1	0,6	27	116	116	144	146	1	0,6
	122,3	137,7	1,1	0,6	27	116	116	144	146	1	0,6
	122,3	137,7	1,1	0,6	27	116	114	144	146	1	0,6
	122,3	137,7	1,1	0,6	27	116	114	144	146	1	0,6
	124,5	138,9	1,1	1,1	31	116	116	144	144	1	1
	124,5	138,9	1,1	1,1	31	116	116	144	144	1	1
	122,3	137,7	1,1	0,6	40	116	116	144	146	1	0,6
	122,3	137,7	1,1	0,6	40	116	116	144	146	1	0,6
	122,3	137,7	1,1	0,6	40	116	114	144	146	1	0,6
	122,3	137,7	1,1	0,6	40	116	114	144	146	1	0,6
	124,5	138,9	1,1	1,1	40	116	116	144	144	1	1
	124,5	138,9	1,1	1,1	40	116	116	144	144	1	1
	128,5	151,5	2	1	33	119	119	161	165	2	1
	133,2	150,5	2	2	37	119	119	161	161	2	2
	133,2	150,5	2	2	37	119	119	161	161	2	2
	128,5	151,5	2	1	47	119	119	161	165	2	1
	133,2	150,5	2	2	47	119	119	161	161	2	2
	133,2	150,5	2	2	47	119	119	161	161	2	2
	138,7	171,3	2,1	1,1	40	122	122	188	193	2	1
	138,7	171,3	2,1	1,1	55	122	122	188	193	2	1

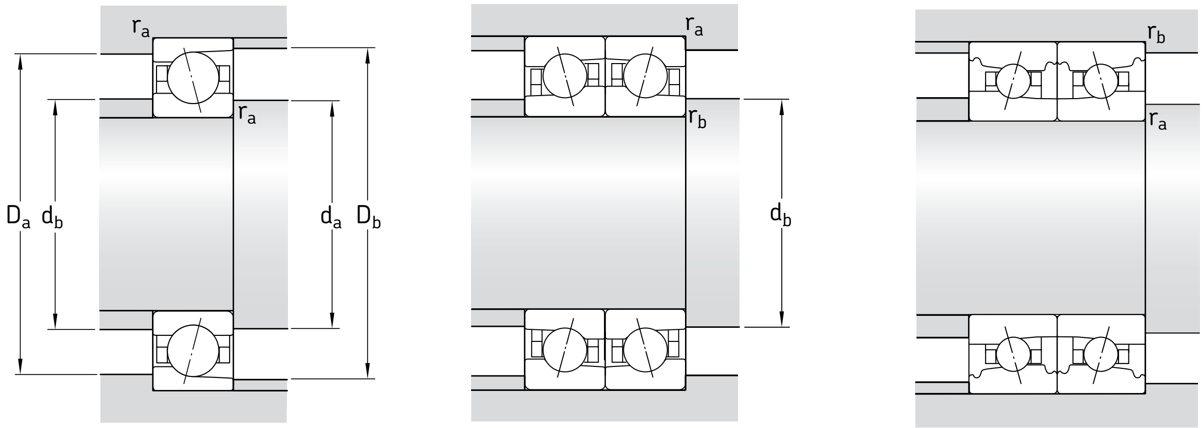
Angular contact ball bearings
d **120 – 140** mm



CD, ACD CE, ACE FB, DB

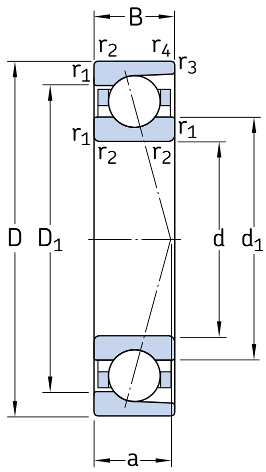
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
120	165	22	78	91,5	3,25	16	7 500	12 000	1,15	**71924 CD/P4A**
	165	22	78	91,5	3,25	16	9 000	14 000	0,97	**71924 CD/HCP4A**
	165	22	49,4	40,5	1,43	16	11 000	16 000	1,15	**71924 CE/P4A**
	165	22	49,4	40,5	1,43	16	12 000	19 000	0,96	**71924 CE/HCP4A**
	165	22	37,7	51	1,8	–	9 500	15 000	1,17	**71924 FB/P7**
	165	22	37,7	51	1,8	–	11 000	17 000	1,10	**C71924 FB/P7**
	165	22	72,8	86,5	3,05	–	7 000	11 000	1,15	**71924 ACD/P4A**
	165	22	72,8	86,5	3,05	–	8 000	13 000	0,97	**71924 ACD/HCP4A**
	165	22	46,2	38	1,37	–	9 500	15 000	1,15	**71924 ACE/P4A**
	165	22	46,2	38	1,37	–	11 000	17 000	0,96	**71924 ACE/HCP4A**
	165	22	36,4	49	1,73	–	8 500	13 000	1,17	**71924 DB/P7**
	165	22	36,4	49	1,73	–	10 000	15 000	1,10	**C71924 DB/P7**
	180	28	114	122	4,25	16	7 000	11 000	2,10	**7024 CD/P4A**
	180	28	52	68	2,36	–	9 000	14 000	2,15	**7024 FB/P7**
	180	28	52	68	2,36	–	10 000	17 000	2,00	**C7024 FB/P7**
	180	28	111	116	4	–	6 700	10 000	2,10	**7024 ACD/P4A**
	180	28	49,4	65,5	2,28	–	8 000	13 000	2,15	**7024 DB/P7**
	180	28	49,4	65,5	2,28	–	9 000	15 000	2,00	**C7024 DB/P7**
	215	40	199	193	6,3	15	6 700	10 000	5,40	**7224 CD/P4A**
	215	40	190	183	6	–	6 000	9 000	5,40	**7224 ACD/P4A**
130	180	24	92,3	108	3,65	16	7 000	11 000	1,55	**71926 CD/P4A**[1]
	180	24	92,3	108	3,65	16	8 500	13 000	1,30	**71926 CD/HCP4A**[1]
	180	24	87,1	102	3,45	–	6 700	10 000	1,55	**71926 ACD/P4A**[1]
	180	24	87,1	102	3,45	–	7 500	12 000	1,30	**71926 ACD/HCP4A**[1]
	200	33	148	156	5,2	16	6 700	10 000	3,20	**7026 CD/P4A**
	200	33	140	150	4,9	–	6 000	9 000	3,20	**7026 ACD/P4A**
140	190	24	95,6	116	3,9	17	6 700	10 000	1,65	**71928 CD/P4A**
	190	24	95,6	116	3,9	17	8 000	12 000	1,35	**71928 CD/HCP4A**
	190	24	90,4	110	3,65	–	6 000	9 000	1,65	**71928 ACD/P4A**
	190	24	90,4	110	3,65	–	7 000	11 000	1,35	**71928 ACD/HCP4A**
	210	33	153	166	5,3	16	6 700	10 000	3,40	**7028 CD/P4A**
	210	33	146	156	5,1	–	5 600	8 500	3,40	**7028 ACD/P4A**

[1] Bearing with PEEK cage as standard



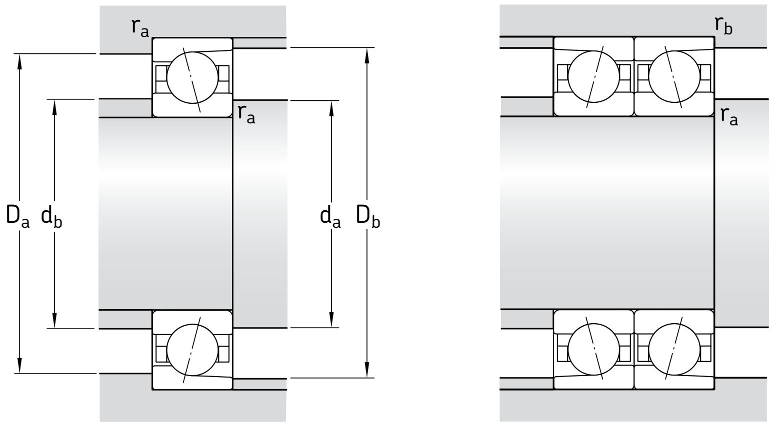
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
120	133,9	151,1	1,1	0,6	30	126	126	159	161	1	0,6
	133,9	151,1	1,1	0,6	30	126	126	159	161	1	0,6
	133,9	151,1	1,1	0,6	30	126	124	159	161	1	0,6
	133,9	151,1	1,1	0,6	30	126	124	159	161	1	0,6
	136,5	151,9	1,1	1,1	34	126	126	159	159	1	1
	136,5	151,9	1,1	1,1	34	126	126	159	159	1	1
	133,9	151,1	1,1	0,6	44	126	126	159	161	1	0,6
	133,9	151,1	1,1	0,6	44	126	126	159	161	1	0,6
	133,9	151,1	1,1	0,6	44	126	124	159	161	1	0,6
	133,9	151,1	1,1	0,6	44	126	124	159	161	1	0,6
	136,5	151,9	1,1	1,1	44	126	126	159	159	1	1
	136,5	151,9	1,1	1,1	44	126	126	159	159	1	1
	138,5	161,5	2	1	34	129	129	171	175	2	1
	143,2	160,5	2	2	39	129	129	171	171	2	2
	143,2	160,5	2	2	39	129	129	171	171	2	2
	138,5	161,5	2	1	49	129	129	171	175	2	1
	143,2	160,5	2	2	49	129	129	171	171	2	2
	143,2	160,5	2	2	49	129	129	171	171	2	2
	150,3	186,7	2,1	1,1	43	132	132	203	208	2	1
	150,3	186,7	2,1	1,1	60	132	132	203	208	2	1
130	145,4	164,6	1,5	0,6	33	137	137	173	176	1,5	0,6
	145,4	164,6	1,5	0,6	33	137	137	173	176	1,5	0,6
	145,4	164,6	1,5	0,6	48	137	137	173	176	1,5	0,6
	145,4	164,6	1,5	0,6	48	137	137	173	176	1,5	0,6
	151,6	178,4	2	1	39	139	139	191	195	2	1
	151,6	178,4	2	1	55	139	139	191	195	2	1
140	155,4	174,6	1,5	0,6	34	147	147	183	186	1,5	0,6
	155,4	174,6	1,5	0,6	34	147	147	183	186	1,5	0,6
	155,4	174,6	1,5	0,6	51	147	147	183	186	1,5	0,6
	155,4	174,6	1,5	0,6	51	147	147	183	186	1,5	0,6
	161,6	188,4	2	1	40	149	149	201	205	2	1
	161,6	188,4	2	1	58	149	149	201	205	2	1

Angular contact ball bearings
d **150 – 240** mm

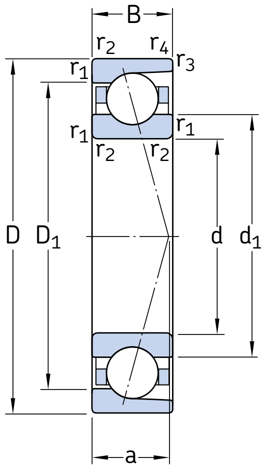


CD, ACD

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
150	210	28	125	146	4,75	16	6 300	9 500	2,55	**71930 CD/P4A**
	210	28	119	140	4,5	–	5 600	8 500	2,55	**71930 ACD/P4A**
	225	35	172	190	5,85	16	6 000	9 000	4,15	**7030 CD/P4A**
	225	35	163	180	5,6	–	5 300	8 000	4,15	**7030 ACD/P4A**
160	220	28	130	160	5	16	6 000	9 000	2,70	**71932 CD/P4A**
	220	28	124	153	4,75	–	5 300	8 000	2,70	**71932 ACD/P4A**
	240	38	195	216	6,55	16	5 600	8 500	5,10	**7032 CD/P4A**
	240	38	182	204	6,2	–	5 000	7 500	5,10	**7032 ACD/P4A**
170	230	28	133	166	5,1	16	5 600	8 500	2,85	**71934 CD/P4A**
	230	28	124	160	4,8	–	5 000	7 500	2,85	**71934 ACD/P4A**
	260	42	212	245	7,1	16	5 300	8 000	6,85	**7034 CD/P4A**
	260	42	199	232	6,7	–	4 800	7 000	6,85	**7034 ACD/P4A**
180	250	33	168	212	6,1	16	5 300	8 000	4,20	**71936 CD/P4A**
	250	33	159	200	5,85	–	4 800	7 000	4,20	**71936 ACD/P4A**
	280	46	242	290	8,15	16	5 000	7 500	8,90	**7036 CD/P4A**
	280	46	229	275	7,65	–	4 300	6 300	8,90	**7036 ACD/P4A**
190	260	33	172	220	6,2	16	5 000	7 500	4,35	**71938 CD/P4A**
	260	33	163	208	5,85	–	4 500	6 700	4,35	**71938 ACD/P4A**
	290	46	247	300	8,3	16	4 800	7 000	9,35	**7038 CD/P4A**
	290	46	234	290	8	–	4 300	6 300	9,35	**7038 ACD/P4A**
200	280	38	208	265	7,2	16	4 800	7 000	6,10	**71940 CD/P4A**
	280	38	199	250	6,8	–	4 300	6 300	6,10	**71940 ACD/P4A**
	310	51	296	390	10,2	16	4 500	6 700	12,0	**7040 CD/P4A**
	310	51	281	365	9,8	–	4 000	6 000	12,0	**7040 ACD/P4A**
220	300	38	221	300	7,8	16	4 300	6 300	6,60	**71944 CD/P4A**
	300	38	208	285	7,5	–	3 800	5 600	6,60	**71944 ACD/P4A**
	340	56	338	455	11,6	16	4 000	6 000	16,0	**7044 CD/P4A**
	340	56	338	455	11,6	–	3 600	5 300	16,0	**7044 ACD/P4A**
240	320	38	225	310	6	17	3 800	5 600	8,50	**71948 CD/P4A**
	320	38	212	300	7,5	–	3 200	4 800	8,50	**71948 ACD/P4A**
	360	56	345	490	12	16	3 800	5 600	17,0	**7048 CD/P4A**
	360	56	325	465	11,4	–	3 200	4 800	17,0	**7048 ACD/P4A**

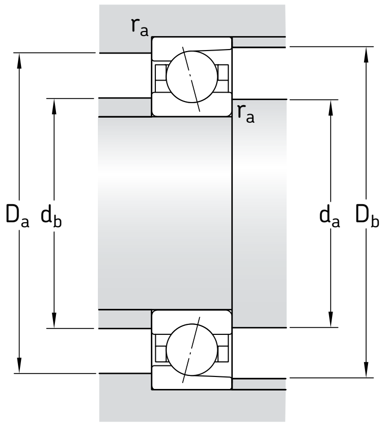


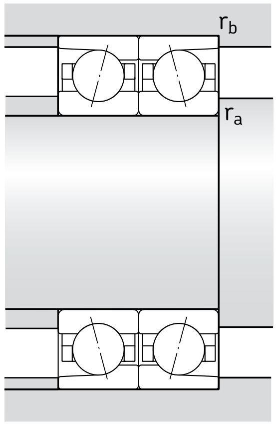
Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
150	168,5	191,5	2	1	38	159	160	201	205	2	1
	168,5	191,5	2	1	56	159	160	201	205	2	1
	173,1	201,9	2,1	1	43	161	161	214	220	2	1
	173,1	201,9	2,1	1	62	161	161	214	220	2	1
160	178,5	201,5	2	1	40	169	170	211	215	2	1
	178,5	201,5	2	1	58	169	170	211	215	2	1
	184,7	215,3	2,1	1	46	171	171	229	235	2	1
	184,7	215,3	2,1	1	66	171	171	229	235	2	1
170	188,5	211,5	2	1	41	179	180	221	225	2	1
	188,5	211,5	2	1	61	179	180	221	225	2	1
	198,7	231,3	2,1	1,1	50	181	181	249	254	2	1
	198,7	231,3	2,1	1,1	71	181	181	249	254	2	1
180	201,6	228,4	2	1	45	189	190	241	245	2	1
	201,6	228,4	2	1	67	189	190	241	245	2	1
	211,8	248,2	2,1	1,1	54	191	191	269	274	2	1
	211,8	248,2	2,1	1,1	77	191	191	269	274	2	1
190	211,6	238,4	2	1	47	199	200	251	255	2	1
	211,6	238,4	2	1	69	199	200	251	255	2	1
	221,8	258,2	2,1	1,1	55	201	201	279	284	2	1
	221,8	258,2	2,1	1,1	79	201	201	279	284	2	1
200	224,7	255,3	2,1	1	51	209	211	271	275	2	1
	224,7	255,3	2,1	1	75	209	211	271	275	2	1
	233,9	276,1	2,1	1,1	60	211	211	299	304	2	1
	233,9	276,1	2,1	1,1	85	211	211	299	304	2	1
220	244,7	275,3	2,1	1	54	231	231	289	295	2	1
	244,7	275,3	2,1	1	80	231	231	289	295	2	1
	257	303	3	1,1	66	233	233	327	334	2,5	1
	257	303	3	1,1	94	233	233	327	334	2,5	1
240	264,7	295,3	2,1	1	57	251	251	309	315	2	1
	264,7	295,3	2,1	1	84	251	251	309	315	2	1
	277	323	3	1,1	68	253	253	347	354	2,5	1
	277	323	3	1,1	98	253	253	347	354	2,5	1



CD, ACD

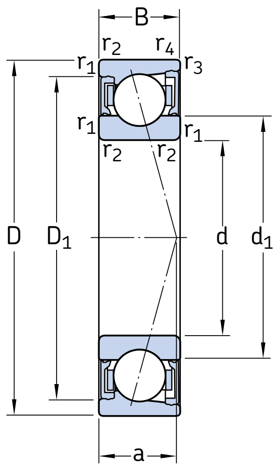
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calcu-lation factor	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u	f_0				
mm			kN		kN	–	r/min		kg	–
260	360	46	281	425	10,2	17	3 400	5 000	12,2	**71952 CD/P4A**
	360	46	265	400	9,65	–	2 800	4 300	12,2	**71952 ACD/P4A**
280	380	46	291	455	10,6	17	3 200	4 800	12,9	**71956 CD/P4A**
	380	46	276	430	10	–	2 600	4 000	12,9	**71956 ACD/P4A**
300	420	56	371	600	13,4	17	2 400	3 600	20,5	**71960 CD/P4A**
	420	56	351	560	12,7	–	2 200	3 400	20,5	**71960 ACD/P4A**
320	440	56	377	620	13,7	17	2 200	3 400	21,5	**71964 CD/P4A**
	440	56	351	585	12,9	–	2 000	3 200	21,5	**71964 ACD/P4A**



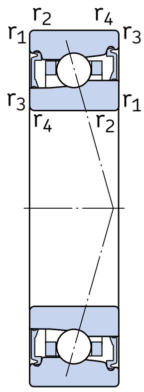


Dimensions						Abutment and fillet dimensions					
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm					
260	291,8	328,2	2,1	1,1	65	271	271	349	354	2	1
	291,8	328,2	2,1	1,1	96	271	271	349	354	2	1
280	311,8	348,2	2,1	1,1	67	291	291	369	374	2	1
	311,8	348,2	2,1	1,1	100	291	291	369	374	2	1
300	337	383	3	1,1	76	313	313	405	414	2,5	1
	337	383	3	1,1	112	313	313	405	414	2,5	1
320	357,2	403	3	1,1	79	333	333	425	434	2,5	1
	357,2	403	3	1,1	117	333	333	425	434	2,5	1

Sealed angular contact ball bearings
d **30 – 35** mm

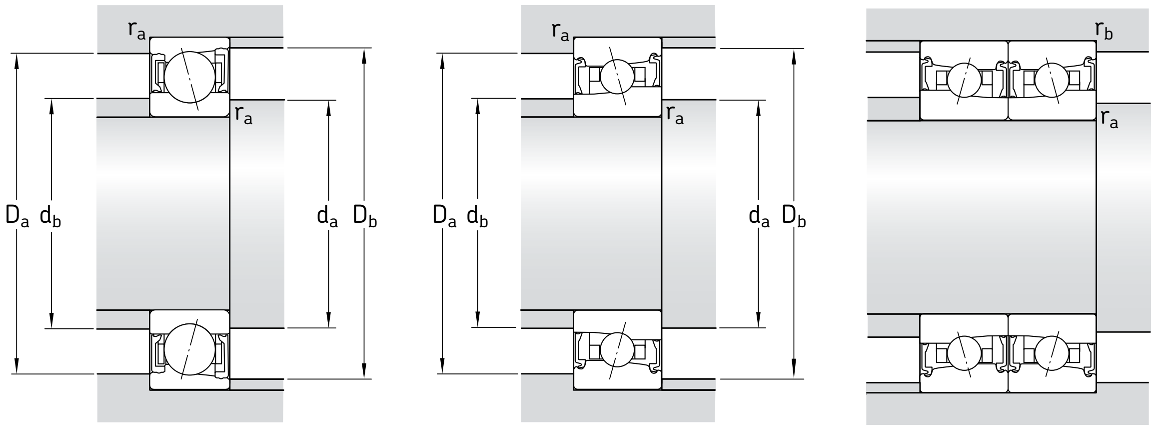


CD, ACD



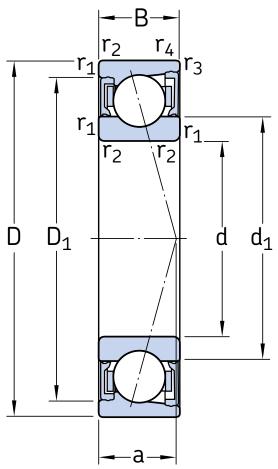
DB, FB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calculation factor	Attainable speed when lubricating with grease	Mass	Designation
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
30	47	9	7,15	4,55	0,193	10	30 000	0,048	**S71906 CD/P4A**
	47	9	7,15	4,55	0,193	10	38 000	0,043	**S71906 CD/HCP4A**
	47	9	6,5	5,4	0,228	–	36 000	0,045	**S71906 FB/P7**
	47	9	6,5	5,4	0,228	–	40 000	0,042	**SC71906 FB/P7**
	47	9	6,76	4,3	0,183	–	26 000	0,048	**S71906 ACD/P4A**
	47	9	6,76	4,3	0,183	–	32 000	0,043	**S71906 ACD/HCP4A**
	47	9	6,24	5,2	0,22	–	32 000	0,045	**S71906 DB/P7**
	47	9	6,24	5,2	0,22	–	38 000	0,042	**SC71906 DB/P7**
	55	13	14,3	8	0,345	9,4	28 000	0,11	**S7006 CD/P4A**
	55	13	14,3	8	0,34	9,4	32 000	0,094	**S7006 CD/HCP4A**
	55	13	8,71	6,95	0,3	–	32 000	0,12	**S7006 FB/P7**
	55	13	8,71	6,95	0,3	–	40 000	0,12	**SC7006 FB/P7**
	55	13	13,8	7,65	0,325	–	24 000	0,11	**S7006 ACD/P4A**
	55	13	13,8	7,65	0,325	–	30 000	0,094	**S7006 ACD/HCP4A**
	55	13	8,32	6,7	0,285	–	30 000	0,12	**S7006 DB/P7**
	55	13	8,32	6,7	0,285	–	34 000	0,12	**SC7006 DB/P7**
35	55	10	9,75	6,55	0,275	10	26 000	0,074	**S71907 CD/P4A**
	55	10	9,75	6,55	0,275	10	32 000	0,065	**S71907 CD/HCP4A**
	55	10	6,89	6,3	0,265	–	30 000	0,075	**S71907 FB/P7**
	55	10	6,89	6,3	0,265	–	36 000	0,071	**SC71907 FB/P7**
	55	10	9,23	6,2	0,26	–	22 000	0,074	**S71907 ACD/P4A**
	55	10	9,23	6,2	0,26	–	28 000	0,065	**S71907 ACD/HCP4A**
	55	10	6,5	6	0,255	–	28 000	0,075	**S71907 DB/P7**
	55	10	6,5	6	0,255	–	32 000	0,071	**SC71907 DB/P7**
	62	14	15,6	9,5	0,4	9,7	22 000	0,15	**S7007 CD/P4A**
	62	14	15,6	9,5	0,4	9,7	28 000	0,13	**S7007 CD/HCP4A**
	62	14	9,23	8,15	0,345	–	28 000	0,17	**S7007 FB/P7**
	62	14	9,23	8,15	0,345	–	36 000	0,16	**SC7007 FB/P7**
	62	14	14,8	9	0,38	–	19 000	0,15	**S7007 ACD/P4A**
	62	14	14,8	9	0,38	–	24 000	0,13	**S7007 ACD/HCP4A**
	62	14	8,84	7,8	0,335	–	26 000	0,17	**S7007 DB/P7**
	62	14	8,84	7,8	0,335	–	30 000	0,16	**SC7007 DB/P7**

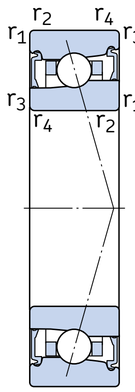


Dimensions						Abutment and fillet dimensions				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
30	35,6	44	0,3	0,2	10	32	45	45,6	0,3	0,2
	35,6	44	0,3	0,2	10	32	45	45,6	0,3	0,2
	36,0	43	0,3	0,3	11	32	45	45	0,3	0,3
	36,0	43	0,3	0,3	11	32	45	45	0,3	0,3
	35,6	44	0,3	0,2	14	32	45	45,6	0,3	0,2
	35,6	44	0,3	0,2	14	32	45	45,6	0,3	0,2
	36,0	43	0,3	0,3	14	32	45	45	0,3	0,3
	36,0	43	0,3	0,3	14	32	45	45	0,3	0,3
	37,7	49,5	1	0,3	12	34,6	50,4	53	1	0,3
	37,7	49,5	1	0,3	12	34,6	50,4	53	1	0,3
	39,5	47,3	1	1	13	34,6	50,4	50,4	1	1
	39,5	47,3	1	1	13	34,6	50,4	50,4	1	1
	37,7	49,5	1	0,3	17	34,6	50,4	53	1	0,3
	37,7	49,5	1	0,3	17	34,6	50,4	53	1	0,3
	39,5	47,3	1	1	16	34,6	50,4	50,4	1	1
	39,5	47,3	1	1	16	34,6	50,4	50,4	1	1
35	41,6	50,1	0,6	0,2	11	38,2	51,8	53,6	0,6	0,2
	41,6	50,1	0,6	0,2	11	38,2	51,8	53,6	0,6	0,2
	42,5	49,5	0,6	0,6	12	38,2	51,8	51,8	0,6	0,6
	42,5	49,5	0,6	0,6	12	38,2	51,8	51,8	0,6	0,6
	41,6	50,1	0,6	0,2	16	38,2	51,8	53,6	0,6	0,2
	41,6	50,1	0,6	0,2	16	38,2	51,8	53,6	0,6	0,2
	42,5	49,5	0,6	0,6	16	38,2	51,8	51,8	0,6	0,6
	42,5	49,5	0,6	0,6	16	38,2	51,8	51,8	0,6	0,6
	43,7	55,5	1	0,3	14	39,6	57,4	60	1	0,3
	43,7	55,5	1	0,3	14	39,6	57,4	60	1	0,3
	45,5	53,4	1	1	15	39,6	57,4	57,4	1	1
	45,5	53,4	1	1	15	39,6	57,4	57,4	1	1
	43,7	55,5	1	0,3	19	39,6	57,4	60	1	0,3
	43,7	55,5	1	0,3	19	39,6	57,4	60	1	0,3
	45,5	53,4	1	1	18	39,6	57,4	57,4	1	1
	45,5	53,4	1	1	18	39,6	57,4	57,4	1	1

Sealed angular contact ball bearings
d **40 – 45** mm

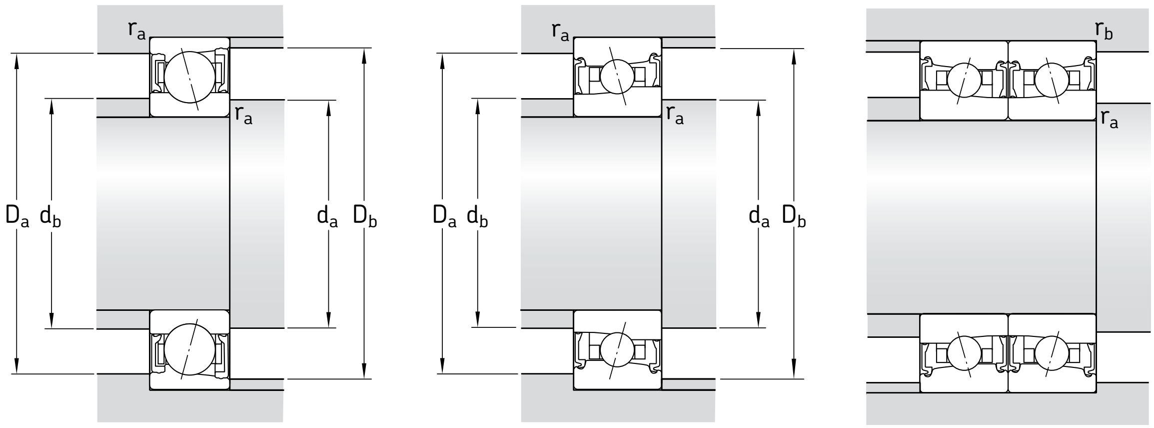


CD, ACD



DB, FB

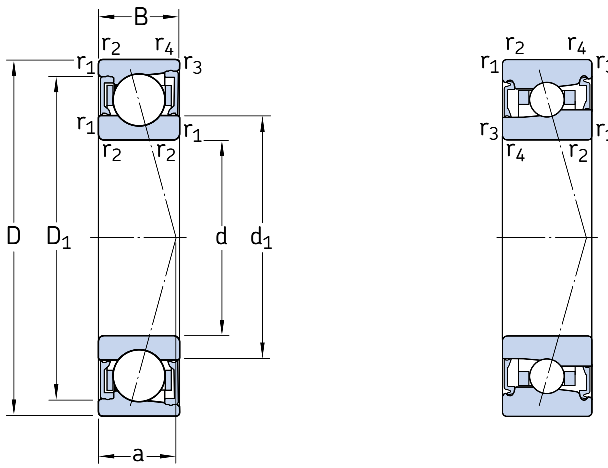
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calculation factor	Attainable speed when lubricating with grease	Mass	Designation
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
40	62	12	12,4	8,5	0,36	10	20 000	0,11	**S71908 CD/P4A**
	62	12	12,4	8,5	0,36	10	28 000	0,096	**S71908 CD/HCP4A**
	62	12	7,15	7,2	0,305	–	28 000	0,12	**S71908 FB/P7**
	62	12	7,15	7,2	0,305	–	30 000	0,12	**SC71908 FB/P7**
	62	12	11,7	8	0,34	–	18 000	0,11	**S71908 ACD/P4A**
	62	12	11,7	8	0,34	–	22 000	0,096	**S71908 ACD/HCP4A**
	62	12	6,89	6,8	0,29	–	24 000	0,12	**S71908 DB/P7**
	62	12	6,89	6,8	0,29	–	28 000	0,12	**SC71908 DB/P7**
	68	15	16,8	11	0,465	10	19 000	0,19	**S7008 CD/P4A**
	68	15	16,8	11	0,465	10	24 000	0,16	**S7008 CD/HCP4A**
	68	15	9,75	9,5	0,4	–	26 000	0,21	**S7008 FB/P7**
	68	15	9,75	9,5	0,4	–	32 000	0,2	**SC7008 FB/P7**
	68	15	15,9	10,4	0,44	–	18 000	0,19	**S7008 ACD/P4A**
	68	15	15,9	10,4	0,44	–	20 000	0,16	**S7008 ACD/HCP4A**
	68	15	9,36	9	0,38	–	22 000	0,21	**S7008 DB/P7**
	68	15	9,36	9	0,38	–	26 000	0,2	**SC7008 DB/P7**
45	68	12	13	9,5	0,4	11	19 000	0,13	**S71909 CD/P4A**
	68	12	13	9,5	0,4	11	24 000	0,11	**S71909 CD/HCP4A**
	68	12	9,95	9,8	0,415	–	24 000	0,13	**S71909 FB/P7**
	68	12	9,95	9,8	0,415	–	28 000	0,12	**SC71909 FB/P7**
	68	12	12,4	9	0,38	–	17 000	0,13	**S71909 ACD/P4A**
	68	12	12,4	9	0,38	–	20 000	0,11	**S71909 ACD/HCP4A**
	68	12	9,56	9,5	0,4	–	22 000	0,13	**S71909 DB/P7**
	68	12	9,56	9,5	0,4	–	26 000	0,12	**SC71909 DB/P7**
	75	16	28,6	22,4	0,95	15	18 000	0,23	**S7009 CD/P4A**
	75	16	28,6	22,4	0,95	15	20 000	0,2	**S7009 CD/HCP4A**
	75	16	12,7	12,2	0,52	–	22 000	0,26	**S7009 FB/P7**
	75	16	12,7	12,2	0,52	–	28 000	0,25	**SC7009 FB/P7**
	75	16	27,6	21,6	0,9	–	16 000	0,23	**S7009 ACD/P4A**
	75	16	27,6	21,6	0,9	–	19 000	0,2	**S7009 ACD/HCP4A**
	75	16	12,1	11,8	0,5	–	20 000	0,26	**S7009 DB/P7**
	75	16	12,1	11,8	0,5	–	24 000	0,25	**SC7009 DB/P7**



2.2

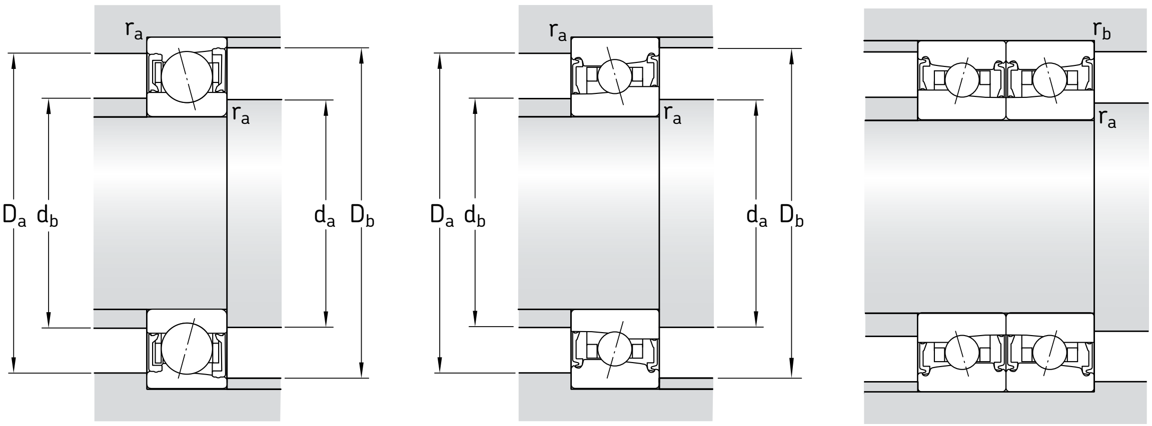
Dimensions						Abutment and fillet dimensions				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
40	47,1	57,1	0,6	0,2	13	43,2	58,8	60,6	0,6	0,2
	47,1	57,1	0,6	0,2	13	43,2	58,8	60,6	0,6	0,2
	48,5	55,6	0,6	0,6	14	43,2	58,8	58,8	0,6	0,6
	48,5	55,6	0,6	0,6	14	43,2	58,8	58,8	0,6	0,6
	47,1	57,1	0,6	0,2	18	43,2	58,8	60,6	0,6	0,2
	47,1	57,1	0,6	0,2	18	43,2	58,8	60,6	0,6	0,2
	48,5	55,6	0,6	0,6	18	43,2	58,8	58,8	0,6	0,6
	48,5	55,6	0,6	0,6	18	43,2	58,8	58,8	0,6	0,6
	49,2	61	1	0,3	15	44,6	63,4	66	1	0,3
	49,2	61	1	0,3	15	44,6	63,4	66	1	0,3
	51,0	58,9	1	1	16	44,6	63,4	63,4	1	1
	51,0	58,9	1	1	16	44,6	63,4	63,4	1	1
	49,2	61	1	0,3	20	44,6	63,4	66	1	0,3
	49,2	61	1	0,3	20	44,6	63,4	66	1	0,3
	51,0	58,9	1	1	20	44,6	63,4	63,4	1	1
	51,0	58,9	1	1	20	44,6	63,4	63,4	1	1
45	52,6	62,6	0,6	0,2	14	48,2	64,8	66,6	0,6	0,2
	52,6	62,6	0,6	0,2	14	48,2	64,8	66,6	0,6	0,2
	53,5	61,6	0,6	0,6	15	48,2	64,8	64,8	0,6	0,6
	53,5	61,6	0,6	0,6	15	48,2	64,8	64,8	0,6	0,6
	52,6	62,6	0,6	0,2	19	48,2	64,8	66,6	0,6	0,2
	52,6	62,6	0,6	0,2	19	48,2	64,8	66,6	0,6	0,2
	53,5	61,6	0,6	0,6	19	48,2	64,8	64,8	0,6	0,6
	53,5	61,6	0,6	0,6	19	48,2	64,8	64,8	0,6	0,6
	54,2	68,3	1	0,3	16	49,6	70,4	73	1	0,3
	54,2	68,3	1	0,3	16	49,6	70,4	73	1	0,3
	56,4	65,6	1	1	18	49,6	70,4	70,4	1	1
	56,4	65,6	1	1	18	49,6	70,4	70,4	1	1
	54,2	68,3	1	0,3	22	49,6	70,4	73	1	0,3
	54,2	68,3	1	0,3	22	49,6	70,4	73	1	0,3
	56,4	65,6	1	1	22	49,6	70,4	70,4	1	1
	56,4	65,6	1	1	22	49,6	70,4	70,4	1	1

Sealed angular contact ball bearings
d **50 – 55** mm



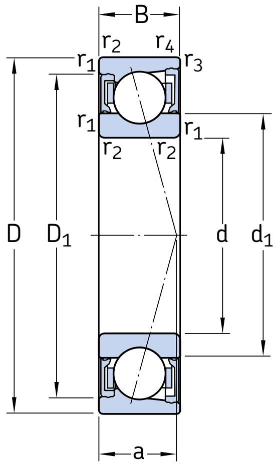
CD, ACD DB, FB

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calculation factor	Attainable speed when lubricating with grease	Mass	Designation
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
50	72	12	13,5	10,4	0,44	11	17 000	0,13	**S71910 CD/P4A**
	72	12	13,5	10,4	0,44	11	22 000	0,11	**S71910 CD/HCP4A**
	72	12	10,1	10,6	0,45	–	22 000	0,14	**S71910 FB/P7**
	72	12	10,1	10,6	0,45	–	26 000	0,13	**SC71910 FB/P7**
	72	12	12,7	9,8	0,415	–	16 000	0,13	**S71910 ACD/P4A**
	72	12	12,7	9,8	0,415	–	19 000	0,11	**S71910 ACD/HCP4A**
	72	12	9,75	10,2	0,43	–	20 000	0,14	**S71910 DB/P7**
	72	12	9,75	10,2	0,43	–	24 000	0,13	**SC71910 DB/P7**
	80	16	29,6	24	1,02	15	17 000	0,25	**S7010 CD/P4A**
	80	16	29,6	24	1,02	15	19 000	0,21	**S7010 CD/HCP4A**
	80	16	13,3	13,4	0,57	–	22 000	0,28	**S7010 FB/P7**
	80	16	13,3	13,4	0,57	–	26 000	0,27	**SC7010 FB/P7**
	80	16	28,1	23,2	0,98	–	15 000	0,25	**S7010 ACD/P4A**
	80	16	28,1	23,2	0,98	–	17 000	0,21	**S7010 ACD/HCP4A**
	80	16	12,5	12,9	0,54	–	19 000	0,28	**S7010 DB/P7**
	80	16	12,5	12,9	0,54	–	22 000	0,27	**SC7010 DB/P7**
55	80	13	19,5	14,6	0,62	10	16 000	0,18	**S71911 CD/P4A**
	80	13	19,5	14,6	0,62	10	19 000	0,15	**S71911 CD/HCP4A**
	80	13	13,3	14	0,585	–	20 000	0,18	**S71911 FB/P7**
	80	13	13,3	14	0,585	–	24 000	0,17	**SC71911 FB/P7**
	80	13	18,2	13,7	0,585	–	15 000	0,18	**S71911 ACD/P4A**
	80	13	18,2	13,7	0,585	–	17 000	0,15	**S71911 ACD/HCP4A**
	80	13	12,7	13,4	0,57	–	18 000	0,18	**S71911 DB/P7**
	80	13	12,7	13,4	0,57	–	22 000	0,17	**SC71911 DB/P7**
	90	18	39,7	32,5	1,37	15	15 000	0,37	**S7011 CD/P4A**
	90	18	39,7	32,5	1,37	15	17 000	0,31	**S7011 CD/HCP4A**
	90	18	18,6	18,6	0,8	–	19 000	0,4	**S7011 FB/P7**
	90	18	18,6	18,6	0,8	–	22 000	0,38	**SC7011 FB/P7**
	90	18	37,1	31	1,32	–	14 000	0,37	**S7011 ACD/P4A**
	90	18	37,1	31	1,32	–	16 000	0,31	**S7011 ACD/HCP4A**
	90	18	17,8	18	0,765	–	17 000	0,4	**S7011 DB/P7**
	90	18	17,8	18	0,765	–	20 000	0,38	**SC7011 DB/P7**

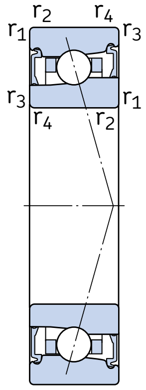


Dimensions						**Abutment and fillet dimensions**				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
50	57,1	67,1	0,6	0,2	14	53,2	68,8	70,6	0,6	0,2
	57,1	67,1	0,6	0,2	14	53,2	68,8	70,6	0,6	0,2
	58,0	66	0,6	0,6	16	53,2	68,8	68,8	0,6	0,6
	58,0	66	0,6	0,6	16	53,2	68,8	68,8	0,6	0,6
	57,1	67,1	0,6	0,2	20	53,2	68,8	70,6	0,6	0,2
	57,1	67,1	0,6	0,2	20	53,2	68,8	70,6	0,6	0,2
	58,0	66	0,6	0,6	20	53,2	68,8	68,8	0,6	0,6
	58,0	66	0,6	0,6	20	53,2	68,8	68,8	0,6	0,6
	59,2	73..3	1	0,3	17	54,6	75,4	78	1	0,3
	59,2	73..3	1	0,3	17	54,6	75,4	78	1	0,3
	61,4	70,7	1	1	19	54,6	75,4	75,4	1	1
	61,4	70,7	1	1	19	54,6	75,4	75,4	1	1
	59,2	73..3	1	0,3	23	54,6	75,4	78	1	0,3
	59,2	73..3	1	0,3	23	54,6	75,4	78	1	0,3
	61,4	70,7	1	1	23	54,6	75,4	75,4	1	1
	61,4	70,7	1	1	23	54,6	75,4	75,4	1	1
55	62,7	74,5	1	0,3	16	59,6	75,4	78	1	0,3
	62,7	74,5	1	0,3	16	59,6	75,4	78	1	0,3
	63,9	73,2	1	1	18	59,6	75,4	75,4	1	1
	63,9	73,2	1	1	18	59,6	75,4	75,4	1	1
	62,7	74,5	1	0,3	22	59,6	75,4	78	1	0,3
	62,7	74,5	1	0,3	22	59,6	75,4	78	1	0,3
	63,9	73,2	1	1	22	59,6	75,4	75,4	1	1
	63,9	73,2	1	1	22	59,6	75,4	75,4	1	1
	65,8	81,7	1,1	0,6	19	61	84	86,8	1	0,6
	65,8	81,7	1,1	0,6	19	61	84	86,8	1	0,6
	68,2	79,4	1,1	1,1	21	61	84	84	1	1
	68,2	79,4	1,1	1,1	21	61	84	84	1	1
	65,8	81,7	1,1	0,6	26	61	84	86,8	1	0,6
	65,8	81,7	1,1	0,6	26	61	84	86,8	1	0,6
	68,2	79,4	1,1	1,1	26	61	84	84	1	1
	68,2	79,4	1,1	1,1	26	61	84	84	1	1

Sealed angular contact ball bearings
d **60 – 65** mm

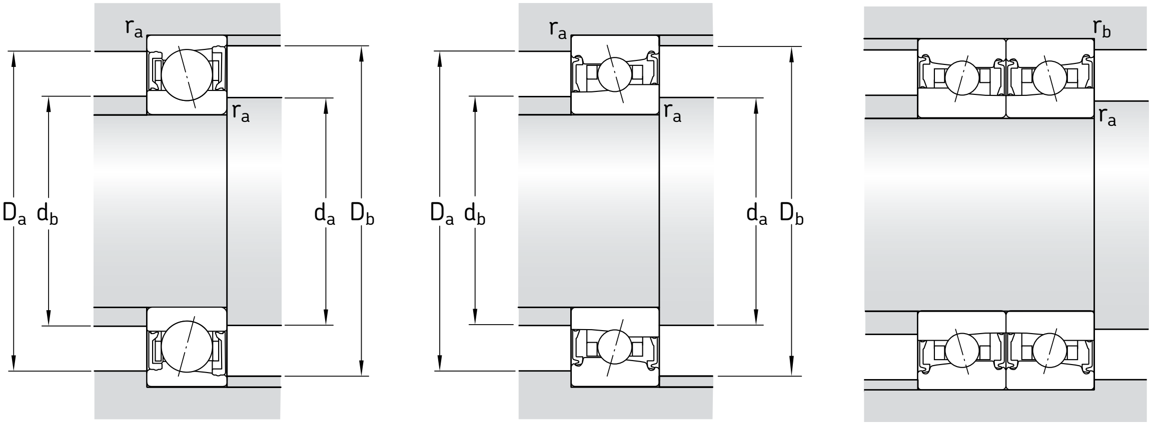


CD, ACD

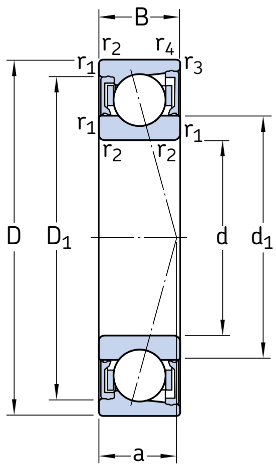


DB, FB

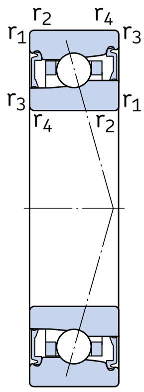
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calculation factor	Attainable speed when lubricating with grease	Mass	Designation
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
60	85	13	19,9	15,3	0,655	11	15 000	0,19	**S71912 CD/P4A**
	85	13	19,9	15,3	0,655	11	18 000	0,16	**S71912 CD/HCP4A**
	85	13	13,8	15	0,64	–	19 000	0,2	**S71912 FB/P7**
	85	13	13,8	15	0,64	–	22 000	0,18	**SC71912 FB/P7**
	85	13	18,6	14,6	0,62	–	14 000	0,19	**S71912 ACD/P4A**
	85	13	18,6	14,6	0,62	–	16 000	0,16	**S71912 ACD/HCP4A**
	85	13	13	14,3	0,61	–	17 000	0,2	**S71912 DB/P7**
	85	13	13	14,3	0,61	–	20 000	0,18	**SC71912 DB/P7**
	95	18	40,3	34,5	1,5	15	14 000	0,4	**S7012 CD/P4A**
	95	18	40,3	34,5	1,5	15	16 000	0,34	**S7012 CD/HCP4A**
	95	18	19	20,4	0,865	–	18 000	0,44	**S7012 FB/P7**
	95	18	19	20,4	0,865	–	20 000	0,42	**SC7012 FB/P7**
	95	18	39	33,5	1,4	–	13 000	0,4	**S7012 ACD/P4A**
	95	18	39	33,5	1,4	–	15 000	0,34	**S7012 ACD/HCP4A**
	95	18	18,2	19,6	0,83	–	16 000	0,44	**S7012 DB/P7**
	95	18	18,2	19,6	0,83	–	18 000	0,42	**SC7012 DB/P7**
65	90	13	20,8	17	0,71	11	14 000	0,21	**S71913 CD/P4A**
	90	13	20,8	17	0,71	11	17 000	0,17	**S71913 CD/HCP4A**
	90	13	14,3	16,6	0,71	–	18 000	0,2	**S71913 FB/P7**
	90	13	14,3	16,6	0,71	–	20 000	0,19	**SC71913 FB/P7**
	90	13	19,5	16	0,68	–	13 000	0,21	**S71913 ACD/P4A**
	90	13	19,5	16	0,68	–	15 000	0,17	**S71913 ACD/HCP4A**
	90	13	13,8	16	0,68	–	16 000	0,2	**S71913 DB/P7**
	90	13	13,8	16	0,68	–	18 000	0,19	**SC71913 DB/P7**
	100	18	41,6	37,5	1,6	16	14 000	0,42	**S7013 CD/P4A**
	100	18	41,6	37,5	1,6	16	15 000	0,36	**S7013 CD/HCP4A**
	100	18	20,8	22	0,93	–	17 000	0,45	**S7013 FB/P7**
	100	18	20,8	22	0,93	–	19 000	0,43	**SC7013 FB/P7**
	100	18	39	35,5	1,5	–	12 000	0,42	**S7013 ACD/P4A**
	100	18	39	35,5	1,5	–	14 000	0,36	**S7013 ACD/HCP4A**
	100	18	19,9	21,2	0,9	–	15 000	0,45	**S7013 DB/P7**
	100	18	19,9	21,2	0,9	–	17 000	0,43	**SC7013 DB/P7**



Dimensions						Abutment and fillet dimensions				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
60	67,7	79,5	1	0,3	16	64,6	80,4	83	1	0,3
	67,7	79,5	1	0,3	16	64,6	80,4	83	1	0,3
	68,9	78,4	1	1	18	64,6	80,4	80,4	1	1
	68,9	78,4	1	1	18	64,6	80,4	80,4	1	1
	67,7	79,5	1	0,3	24	64,6	80,4	83	1	0,3
	67,7	79,5	1	0,3	24	64,6	80,4	83	1	0,3
	68,9	78,4	1	1	24	64,6	80,4	80,4	1	1
	68,9	78,4	1	1	24	64,6	80,4	80,4	1	1
	70,8	86,6	1,1	0,6	20	66	89	91,8	1	0,6
	70,8	86,6	1,1	0,6	20	66	89	91,8	1	0,6
	73,2	84,4	1,1	1,1	22	66	89	89	1	1
	73,2	84,4	1,1	1,1	22	66	89	89	1	1
	70,8	86,6	1,1	0,6	27	66	89	91,8	1	0,6
	70,8	86,6	1,1	0,6	27	66	89	91,8	1	0,6
	73,2	84,4	1,1	1,1	27	66	89	89	1	1
	73,2	84,4	1,1	1,1	27	66	89	89	1	1
65	72,7	84,4	1	0,3	17	69,6	85,4	88	1	0,3
	72,7	84,4	1	0,3	17	69,6	85,4	88	1	0,3
	74,0	83,4	1	1	19	69,6	85,4	85,4	1	1
	74,0	83,4	1	1	19	69,6	85,4	85,4	1	1
	72,7	84,4	1	0,3	25	69,6	85,4	88	1	0,3
	72,7	84,4	1	0,3	25	69,6	85,4	88	1	0,3
	74,0	83,4	1	1	25	69,6	85,4	85,4	1	1
	74,0	83,4	1	1	25	69,6	85,4	85,4	1	1
	75,8	91,6	1,1	0,6	20	71	94	96,8	1	0,6
	75,8	91,6	1,1	0,6	20	71	94	96,8	1	0,6
	78,0	89,7	1,1	1,1	23	71	94	94	1	1
	78,0	89,7	1,1	1,1	23	71	94	94	1	1
	75,8	91,6	1,1	0,6	28	71	94	96,8	1	0,6
	75,8	91,6	1,1	0,6	28	71	94	96,8	1	0,6
	78,0	89,7	1,1	1,1	28	71	94	94	1	1
	78,0	89,7	1,1	1,1	28	71	94	94	1	1



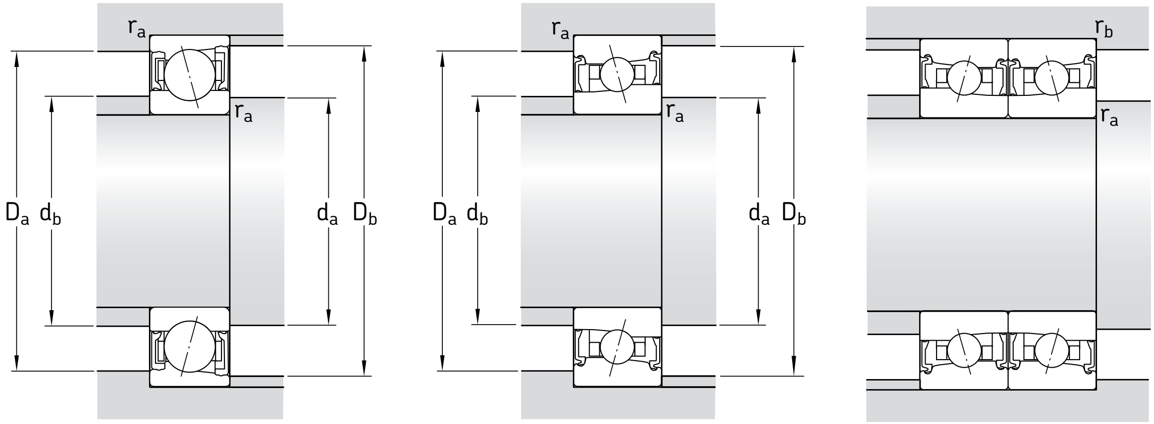
CD, ACD



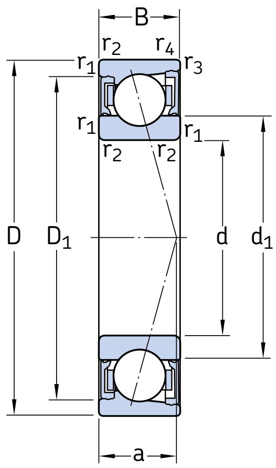
DB, FB

Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Calculation factor**	**Attainable speed** when lubricating with grease	**Mass**	**Designation**
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
70	100	16	34,5	34	1,43	16	13 000	0,33	**S71914 CD/P4A**
	100	16	34,5	34	1,43	16	16 000	0,28	**S71914 CD/HCP4A**
	100	16	18,2	21,2	0,9	–	16 000	0,35	**S71914 FB/P7**
	100	16	18,2	21,2	0,9	–	18 000	0,33	**SC71914 FB/P7**
	100	16	32,5	32,5	1,37	–	11 000	0,33	**S71914 ACD/P4A**
	100	16	32,5	32,5	1,37	–	14 000	0,28	**S71914 ACD/HCP4A**
	100	16	17,2	20	0,85	–	14 000	0,35	**S71914 DB/P7**
	100	16	17,2	20	0,85	–	17 000	0,33	**SC71914 DB/P7**
	110	20	52	45,5	1,93	15	12 000	0,59	**S7014 CD/P4A**[1]
	110	20	52	45,5	1,93	15	14 000	0,49	**S7014 CD/HCP4A**[1]
	110	20	26	28	1,2	–	15 000	0,64	**S7014 FB/P7**
	110	20	26	28	1,2	–	18 000	0,61	**SC7014 FB/P7**
	110	20	48,8	44	1,86	–	10 000	0,59	**S7014 ACD/P4A**[1]
	110	20	48,8	44	1,86	–	13 000	0,49	**S7014 ACD/HCP4A**[1]
	110	20	24,7	27	1,14	–	14 000	0,64	**S7014 DB/P7**
	110	20	24,7	27	1,14	–	16 000	0,61	**SC7014 DB/P7**
75	105	16	35,8	37,5	1,56	16	12 000	0,35	**S71915 CD/P4A**
	105	16	35,8	37,5	1,56	16	15 000	0,3	**S71915 CD/HCP4A**
	105	16	18,6	22,4	0,95	–	15 000	0,35	**S71915 FB/P7**
	105	16	18,6	22,4	0,95	–	17 000	0,33	**SC71915 FB/P7**
	105	16	33,8	35,5	1,5	–	10 000	0,35	**S71915 ACD/P4A**
	105	16	33,8	35,5	1,5	–	13 000	0,3	**S71915 ACD/HCP4A**
	105	16	17,8	21,6	0,915	–	14 000	0,35	**S71915 DB/P7**
	105	16	17,8	21,6	0,915	–	16 000	0,33	**SC71915 DB/P7**
	115	20	52,7	49	2,08	16	11 000	0,62	**S7015 CD/P4A**
	115	20	52,7	49	2,08	16	14 000	0,52	**S7015 CD/HCP4A**
	115	20	26,5	30,5	1,29	–	14 000	0,68	**S7015 FB/P7**
	115	20	26,5	30,5	1,29	–	17 000	0,65	**SC7015 FB/P7**
	115	20	49,4	46,5	1,96	–	9 500	0,62	**S7015 ACD/P4A**
	115	20	49,4	46,5	1,96	–	12 000	0,52	**S7015 ACD/HCP4A**
	115	20	25,5	29	1,22	–	13 000	0,68	**S7015 DB/P7**
	115	20	25,5	29	1,22	–	15 000	0,65	**SC7015 DB/P7**

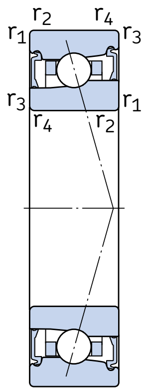
[1] Bearing with PEEK cage as standard



Dimensions						Abutment and fillet dimensions				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
70	79,2	93,6	1	0,3	19	74,6	95,4	98	1	0,3
	79,2	93,6	1	0,3	19	74,6	95,4	98	1	0,3
	80,9	91,7	1	1	22	74,6	95,4	95,4	1	1
	80,9	91,7	1	1	22	74,6	95,4	95,4	1	1
	79,2	93,6	1	0,3	28	74,6	95,4	98	1	0,3
	79,2	93,6	1	0,3	28	74,6	95,4	98	1	0,3
	80,9	91,7	1	1	28	74,6	95,4	95,4	1	1
	80,9	91,7	1	1	28	74,6	95,4	95,4	1	1
	82,3	100,5	1,1	0,6	22	76	104	106	1	0,6
	82,3	100,5	1,1	0,6	22	76	104	106	1	0,6
	85,0	97,8	1,1	1,1	25	76	104	104	1	1
	85,0	97,8	1,1	1,1	25	76	104	104	1	1
	82,3	100,5	1,1	0,6	31	76	104	106	1	0,6
	82,3	100,5	1,1	0,6	31	76	104	106	1	0,6
	85,0	97,8	1,1	1,1	31	76	104	104	1	1
	85,0	97,8	1,1	1,1	31	76	104	104	1	1
75	84,2	98,6	1	0,3	20	79,6	100	103	1	0,3
	84,2	98,6	1	0,3	20	79,6	100	103	1	0,3
	86,0	96,7	1	1	23	79,6	100	100	1	1
	86,0	96,7	1	1	23	79,6	100	100	1	1
	84,2	98,6	1	0,3	29	79,6	100	103	1	0,3
	84,2	98,6	1	0,3	29	79,6	100	103	1	0,3
	86,0	96,7	1	1	29	79,6	100	100	1	1
	86,0	96,7	1	1	29	79,6	100	100	1	1
	87,3	105,5	1,1	0,6	23	81	109	111	1	0,6
	87,3	105,5	1,1	0,6	23	81	109	111	1	0,6
	90,0	102,8	1,1	1,1	26	81	109	109	1	1
	90,0	102,8	1,1	1,1	26	81	109	109	1	1
	87,3	105,5	1,1	0,6	32	81	109	111	1	0,6
	87,3	105,5	1,1	0,6	32	81	109	111	1	0,6
	90,0	102,8	1,1	1,1	32	81	109	109	1	1
	90,0	102,8	1,1	1,1	32	81	109	109	1	1



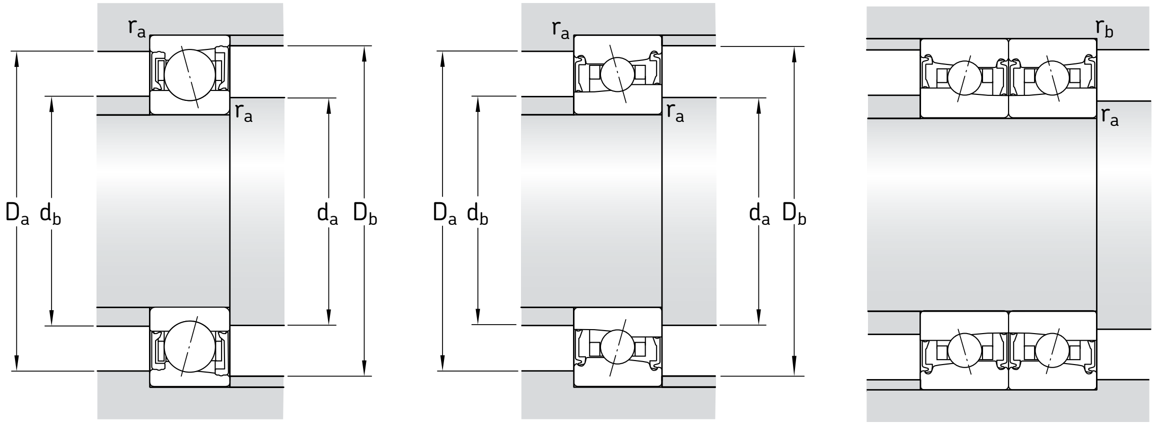
CD, ACD



DB, FB

Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Calculation factor**	**Attainable speed** when lubricating with grease	**Mass**	**Designation**
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
80	110	16	36,4	39	1,66	16	11 000	0,37	**S71916 CD/P4A**
	110	16	36,4	39	1,66	16	15 000	0,31	**S71916 CD/HCP4A**
	110	16	20,8	25,5	1,08	–	14 000	0,38	**S71916 FB/P7**
	110	16	20,8	25,5	1,08	–	16 000	0,36	**SC71916 FB/P7**
	110	16	34,5	36,5	1,56	–	9 500	0,37	**S71916 ACD/P4A**
	110	16	34,5	36,5	1,56	–	12 000	0,31	**S71916 ACD/HCP4A**
	110	16	19,9	24,5	1,02	–	13 000	0,38	**S71916 DB/P7**
	110	16	19,9	24,5	1,02	–	15 000	0,36	**SC71916 DB/P7**
	125	22	65	61	2,55	16	10 000	0,85	**S7016 CD/P4A**[1]
	125	22	65	61	2,55	16	13 000	0,71	**S7016 CD/HCP4A**[1]
	125	22	35,1	39	1,63	–	13 000	0,89	**S7016 FB/P7**
	125	22	35,1	39	1,63	–	16 000	0,84	**SC7016 FB/P7**
	125	22	62,4	58,5	2,45	–	9 000	0,85	**S7016 ACD/P4A**[1]
	125	22	62,4	58,5	2,45	–	11 000	0,71	**S7016 ACD/HCP4A**[1]
	125	22	33,8	37,5	1,56	–	12 000	0,89	**S7016 DB/P7**
	125	22	33,8	37,5	1,56	–	14 000	0,84	**SC7016 DB/P7**
85	120	18	46,2	48	2,04	16	10 000	0,53	**S71917 CD/P4A**
	120	18	46,2	48	2,04	16	14 000	0,44	**S71917 CD/HCP4A**
	120	18	22,5	27,5	1,16	–	13 000	0,54	**S71917 FB/P7**
	120	18	22,5	27,5	1,16	–	15 000	0,51	**SC71917 FB/P7**
	120	18	43,6	45,5	1,93	–	9 000	0,53	**S71917 ACD/P4A**
	120	18	43,6	45,5	1,93	–	11 000	0,44	**S71917 ACD/HCP4A**
	120	18	21,6	26,5	1,1	–	12 000	0,54	**S71917 DB/P7**
	120	18	21,6	26,5	1,1	–	14 000	0,51	**SC71917 DB/P7**
	130	22	67,6	65,5	2,65	16	9 500	0,89	**S7017 CD/P4A**[1]
	130	22	67,6	65,5	2,65	16	12 000	0,74	**S7017 CD/HCP4A**[1]
	130	22	35,8	40,5	1,66	–	13 000	0,9	**S7017 FB/P7**
	130	22	35,8	40,5	1,66	–	15 000	0,85	**SC7017 FB/P7**
	130	22	63,7	62	2,5	–	8 500	0,89	**S7017 ACD/P4A**[1]
	130	22	63,7	62	2,5	–	10 000	0,74	**S7017 ACD/HCP4A**[1]
	130	22	34,5	39	1,6	–	11 000	0,9	**S7017 DB/P7**
	130	22	34,5	39	1,6	–	13 000	0,85	**SC7017 DB/P7**

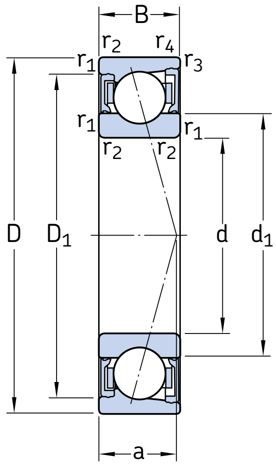
[1] Bearing with PEEK cage as standard



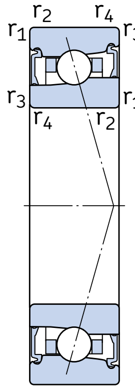
2.2

Dimensions						Abutment and fillet dimensions				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
80	89,2	103,6	1	0,3	21	84,6	105	108	1	0,3
	89,2	103,6	1	0,3	21	84,6	105	108	1	0,3
	90,7	102,2	1	1	24	84,6	105	105	1	1
	90,7	102,2	1	1	24	84,6	105	105	1	1
	89,2	103,6	1	0,3	30	84,6	105	108	1	0,3
	89,2	103,6	1	0,3	30	84,6	105	108	1	0,3
	90,7	102,2	1	1	30	84,6	105	105	1	1
	90,7	102,2	1	1	30	84,6	105	105	1	1
	93,9	113,9	1,1	0,6	25	86	119	121	1	0,6
	93,9	113,9	1,1	0,6	25	86	119	121	1	0,6
	96,7	111,4	1,1	1,1	28	86	119	119	1	1
	96,7	111,4	1,1	1,1	28	86	119	119	1	1
	93,9	113,9	1,1	0,6	35	86	119	121	1	0,6
	93,9	113,9	1,1	0,6	35	86	119	121	1	0,6
	96,7	111,4	1,1	1,1	35	86	119	119	1	1
	96,7	111,4	1,1	1,1	35	86	119	119	1	1
85	95,8	112	1,1	0,6	23	91	114	116	1	0,6
	95,8	112	1,1	0,6	23	91	114	116	1	0,6
	98,0	110	1,1	1,1	26	91	114	114	1	1
	98,0	110	1,1	1,1	28	91	114	114	1	1
	95,8	112	1,1	0,6	33	91	114	116	1	0,6
	95,8	112	1,1	0,6	33	91	114	116	1	0,6
	98,0	110	1,1	1,1	33	91	114	114	1	1
	98,0	110	1,1	1,1	33	91	114	114	1	1
	98,9	118,9	1,1	0,6	26	91	124	126	1	0,6
	98,9	118,9	1,1	0,6	26	91	124	126	1	0,6
	101,7	116,4	1,1	1,1	29	91	124	124	1	1
	101,7	116,4	1,1	1,1	29	91	124	124	1	1
	98,9	118,9	1,1	0,6	36	91	124	126	1	0,6
	98,9	118,9	1,1	0,6	36	91	124	126	1	0,6
	101,7	116,4	1,1	1,1	36	91	124	124	1	1
	101,7	116,4	1,1	1,1	36	91	124	124	1	1

Sealed angular contact ball bearings
d **90 – 95** mm



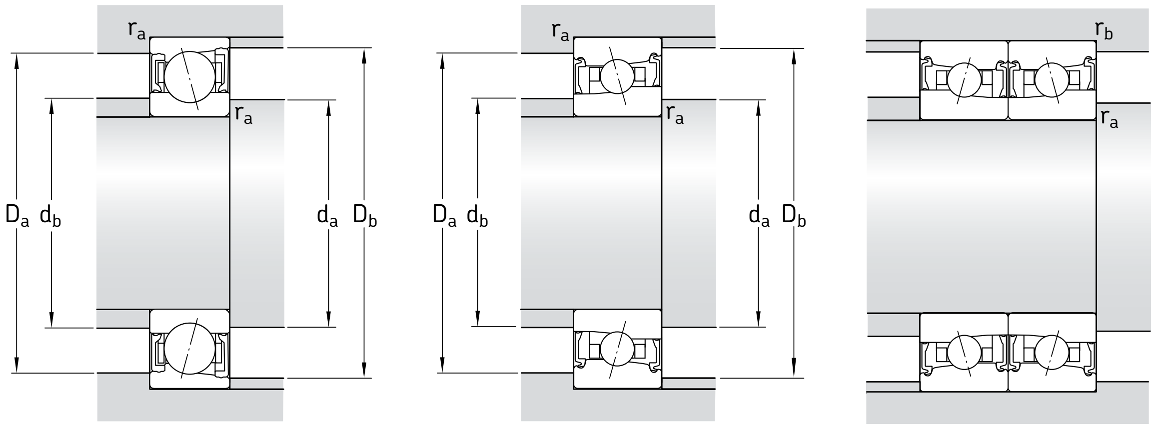
CD, ACD



DB, FB

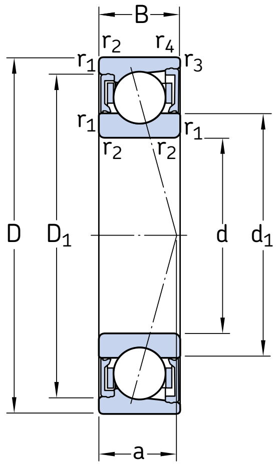
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calculation factor	Attainable speed when lubricating with grease	Mass	Designation
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
90	125	18	47,5	51	2,08	16	9 500	0,55	**S71918 CD/P4A**[1)]
	125	18	47,5	51	2,08	16	13 000	0,47	**S71918 CD/HCP4A**[1)]
	125	18	23,4	30,5	1,25	–	13 000	0,57	**S71918 FB/P7**
	125	18	23,4	30,5	1,25	–	14 000	0,54	**SC71918 FB/P7**
	125	18	44,2	48	1,96	–	8 500	0,55	**S71918 ACD/P4A**[1)]
	125	18	44,2	48	1,96	–	10 000	0,47	**S71918 ACD/HCP4A**[1)]
	125	18	22,5	29	1,18	–	11 000	0,57	**S71918 DB/P7**
	125	18	22,5	29	1,18	–	13 000	0,54	**SC71918 DB/P7**
	140	24	79,3	76,5	3	16	9 000	1,15	**S7018 CD/P4A**[1)]
	140	24	79,3	76,5	3	16	11 000	0,95	**S7018 CD/HCP4A**[1)]
	140	24	39	42,5	1,66	–	12 000	1,2	**S7018 FB/P7**
	140	24	39	42,5	1,66	–	14 000	1,15	**SC7018 FB/P7**
	140	24	74,1	72	2,85	–	8 000	1,15	**S7018 ACD/P4A**[1)]
	140	24	74,1	72	2,85	–	9 500	0,95	**S7018 ACD/HCP4A**[1)]
	140	24	37,1	40,5	1,6	–	11 000	1,2	**S7018 DB/P7**
	140	24	37,1	40,5	1,6	–	12 000	1,15	**SC7018 DB/P7**
95	130	18	49,4	55	2,2	16	9 000	0,58	**S71919 CD/P4A**
	130	18	49,4	55	2,2	16	12 000	0,49	**S71919 CD/HCP4A**
	130	18	24,7	32,5	1,32	–	12 000	0,6	**S71919 FB/P7**
	130	18	24,7	32,5	1,32	–	14 000	0,56	**SC71919 FB/P7**
	130	18	46,2	52	2,08	–	8 500	0,58	**S71919 ACD/P4A**
	130	18	46,2	52	2,08	–	9 500	0,49	**S71919 ACD/HCP4A**
	130	18	23,4	31,5	1,25	–	11 000	0,6	**S71919 DB/P7**
	130	18	23,4	31,5	1,25	–	12 000	0,56	**SC71919 DB/P7**
	145	24	81,9	80	3,1	16	8 500	1,2	**S7019 CD/P4A**
	145	24	81,9	80	3,1	16	10 000	1	**S7019 CD/HCP4A**
	145	24	39	44	1,73	–	11 000	1,23	**S7019 FB/P7**
	145	24	39	44	1,73	–	14 000	1,16	**SC7019 FB/P7**
	145	24	76,1	76,5	2,9	–	8 000	1,2	**S7019 ACD/P4A**
	145	24	76,1	76,5	2,9	–	9 000	1	**S7019 ACD/HCP4A**
	145	24	37,1	42,5	1,63	–	10 000	1,23	**S7019 DB/P7**
	145	24	37,1	42,5	1,63	–	12 000	1,16	**SC7019 DB/P7**

1) Bearing with PEEK cage as standard

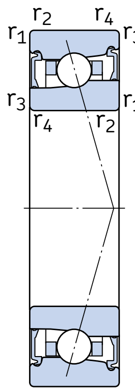


Dimensions						Abutment and fillet dimensions				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
90	100,8	117	1,1	0,6	23	96	119	121	1	0,6
	100,8	117	1,1	0,6	23	96	119	121	1	0,6
	103,0	115	1,1	1,1	27	96	119	119	1	1
	103,0	115	1,1	1,1	27	96	119	119	1	1
	100,8	117	1,1	0,6	34	96	119	121	1	0,6
	100,8	117	1,1	0,6	34	96	119	121	1	0,6
	103,0	115	1,1	1,1	34	96	119	119	1	1
	103,0	115	1,1	1,1	34	96	119	119	1	1
	105,4	128,1	1,5	0,6	28	97	133	136	1,5	0,6
	105,4	128,1	1,5	0,6	28	97	133	136	1,5	0,6
	108,7	125	1,5	1,5	28	97	133	133	1,5	1,5
	108,7	125	1,5	1,5	28	97	133	133	1,5	1,5
	105,4	128,1	1,5	0,6	39	97	133	136	1,5	0,6
	105,4	128,1	1,5	0,6	39	97	133	136	1,5	0,6
	108,7	125	1,5	1,5	31	97	133	133	1,5	1,5
	108,7	125	1,5	1,5	31	97	133	133	1,5	1,5
95	105,8	122	1,1	0,6	24	101	124	126	1	0,6
	105,8	122	1,1	0,6	24	101	124	126	1	0,6
	108,0	120	1,1	1,1	27	101	124	124	1	1
	108,0	120	1,1	1,1	27	101	124	124	1	1
	105,8	122	1,1	0,6	35	101	124	126	1	0,6
	105,8	122	1,1	0,6	35	101	124	126	1	0,6
	108,0	120	1,1	1,1	35	101	124	124	1	1
	108,0	120	1,1	1,1	35	101	124	124	1	1
	110,4	133,1	1,5	0,6	28	102	138	141	1,5	0,6
	110,4	133,1	1,5	0,6	28	102	138	141	1,5	0,6
	113,7	130	1,5	1,5	32	102	138	138	1,5	1,5
	113,7	130	1,5	1,5	32	102	138	138	1,5	1,5
	110,4	133,1	1,5	0,6	40	102	138	141	1,5	0,6
	110,4	133,1	1,5	0,6	40	102	138	141	1,5	0,6
	113,7	130	1,5	1,5	40	102	138	138	1,5	1,5
	113,7	130	1,5	1,5	40	102	138	138	1,5	1,5

Sealed angular contact ball bearings
d **100 – 105** mm



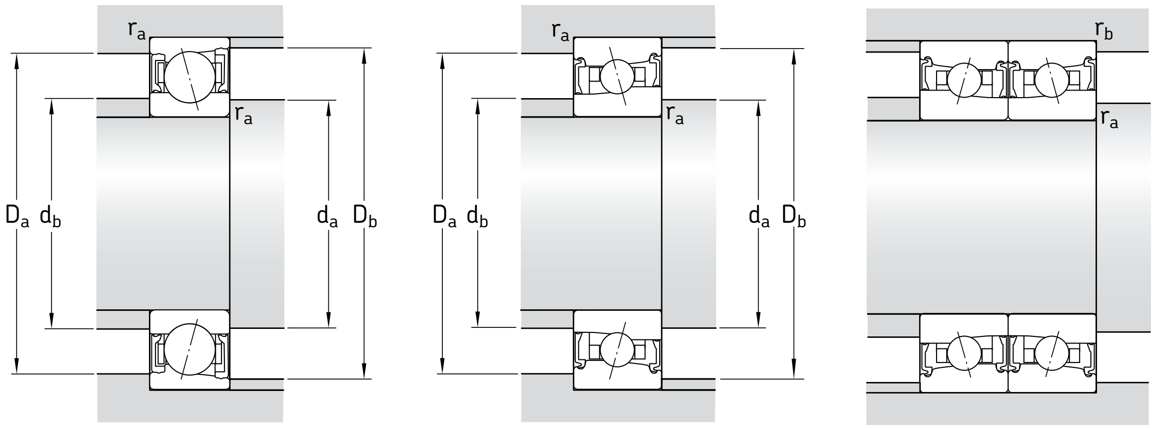
CD, ACD



DB, FB

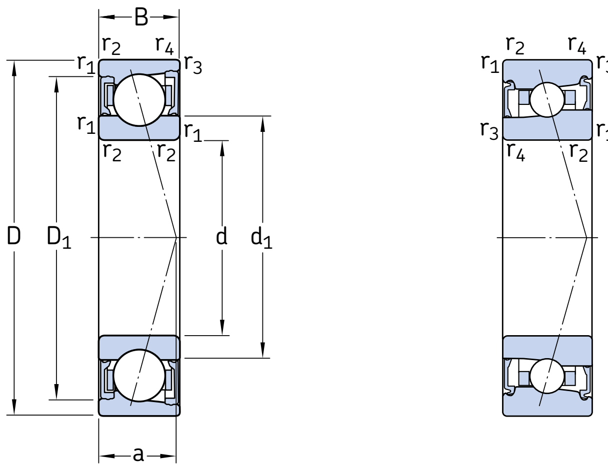
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calculation factor	Attainable speed when lubricating with grease	Mass	Designation
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
100	140	20	60,5	65,5	2,55	16	8 500	0,8	**S71920 CD/P4A**
	140	20	60,5	65,5	2,55	16	11 000	0,66	**S71920 CD/HCP4A**
	140	20	31,9	40	1,53	–	11 000	0,79	**S71920 FB/P7**
	140	20	31,9	40	1,53	–	13 000	0,75	**SC71920 FB/P7**
	140	20	57,2	63	2,4	–	8 000	0,8	**S71920 ACD/P4A**
	140	20	57,2	63	2,4	–	9 000	0,66	**S71920 ACD/HCP4A**
	140	20	30,2	38	1,46	–	10 000	0,79	**S71920 DB/P7**
	140	20	30,2	38	1,46	–	12 000	0,75	**SC71920 DB/P7**
	150	24	83,2	85	3,2	16	8 500	1,25	**S7020 CD/P4A**
	150	24	83,2	85	3,2	16	9 500	1,05	**S7020 CD/HCP4A**
	150	24	39,7	46,5	1,76	–	11 000	1,28	**S7020 FB/P7**
	150	24	39,7	46,5	1,76	–	13 000	1,21	**SC7020 FB/P7**
	150	24	79,3	80	3,05	–	7 500	1,25	**S7020 ACD/P4A**
	150	24	79,3	80	3,05	–	9 000	1,05	**S7020 ACD/HCP4A**
	150	24	37,7	44	1,7	–	9 500	1,28	**S7020 DB/P7**
	150	24	37,7	44	1,7	–	11 000	1,21	**SC7020 DB/P7**
105	145	20	61,8	69,5	2,6	16	8 500	0,82	**S71921 CD/P4A**
	145	20	61,8	69,5	2,6	16	10 000	0,69	**S71921 CD/HCP4A**
	145	20	57,2	65,5	2,5	–	7 500	0,82	**S71921 ACD/P4A**
	145	20	57,2	65,5	2,5	–	9 000	0,69	**S71921 ACD/HCP4A**
	160	26	95,6	96,5	3,6	16	8 000	1,6	**S7021 CD/P4A**
	160	26	904	93	3,4	–	7 500	1,6	**S7021 ACD/P4A**

1) Bearing with PEEK cage as standard



Dimensions						Abutment and fillet dimensions				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
100	112,3	130,5	1,1	0,6	26	106	134	136	1	0,6
	112,3	130,5	1,1	0,6	26	106	134	136	1	0,6
	114,5	128,9	1,1	1,1	30	106	134	134	1	1
	114,5	128,9	1,1	1,1	30	106	134	134	1	1
	112,3	130,5	1,1	0,6	38	106	134	136	1	0,6
	112,3	130,5	1,1	0,6	38	106	134	136	1	0,6
	114,5	128,9	1,1	1,1	38	106	134	134	1	1
	114,5	128,9	1,1	1,1	38	106	134	134	1	1
	115,4	138,1	1,5	0,6	29	107	143	146	1,5	0,6
	115,4	138,1	1,5	0,6	29	107	143	146	1,5	0,6
	118,7	135	1,5	1,5	32	107	143	143	1,5	1,5
	118,7	135	1,5	1,5	32	107	143	143	1,5	1,5
	115,4	138,1	1,5	0,6	41	107	143	146	1,5	0,6
	115,4	138,1	1,5	0,6	41	107	143	146	1,5	0,6
	118,7	135	1,5	1,5	41	107	143	143	1,5	1,5
	118,7	135	1,5	1,5	41	107	143	143	1,5	1,5
105	117,3	135,5	1,1	0,6	27	111	139	141	1	0,6
	117,3	135,5	1,1	0,6	27	111	139	141	1	0,6
	117,3	135,5	1,1	0,6	39	111	139	141	1	0,6
	117,3	135,5	1,1	0,6	39	111	139	141	1	0,6
	121,9	146,6	2	1	31	114	151	155	2	1
	121,9	146,6	2	1	44	114	151	155	2	1

Sealed angular contact ball bearings
d **110 – 120** mm

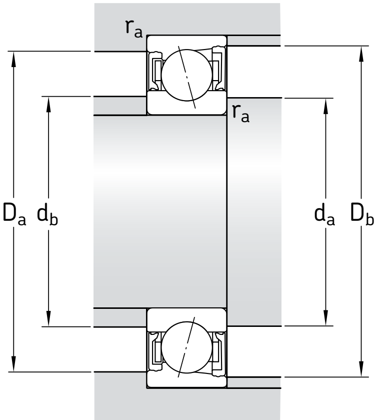


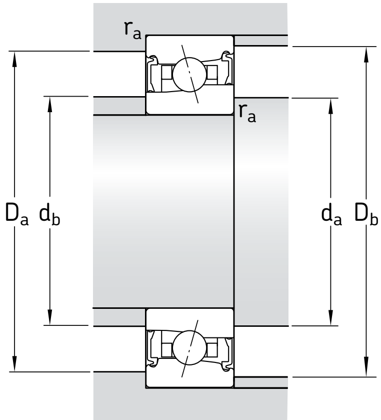
CD, ACD

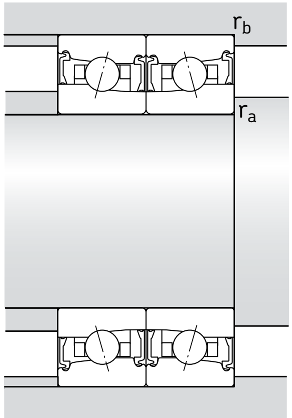
DB, FB

Principal dimensions			Basic load ratings		Fatigue load limit	Calculation factor	Attainable speed when lubricating with grease	Mass	Designation
			dynamic	static					
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
110	150	20	62,4	72	2,7	17	8 000	0,86	**S71922 CD/P4A**[1]
	150	20	62,4	72	2,7	17	10 000	0,72	**S71922 CD/HCP4A**[1]
	150	20	33,8	45	1,66	–	10 000	0,85	**S71922 FB/P7**
	150	20	33,8	45	1,66	–	12 000	0,81	**SC71922 FB/P7**
	150	20	58,5	68	2,55	–	7 500	0,86	**S71922 ACD/P4A**[1]
	150	20	58,5	68	2,55	–	8 500	0,72	**S71922 ACD/HCP4A**[1]
	150	20	32,5	43	1,6	–	9 500	0,85	**S71922 DB/P7**
	150	20	32,5	43	1,6	–	11 000	0,81	**SC71922 DB/P7**
	170	28	111	108	3,9	16	7 500	1,95	**S7022 CD/P4A**
	170	28	49,4	62	2,2	–	9 500	2	**S7022 FB/P7**
	170	28	49,4	62	2,2	–	11 000	1,9	**SC7022 FB/P7**
	170	28	104	104	3,75	–	7 000	1,95	**S7022 ACD/P4A**
	170	28	46,8	60	2,12	–	8 500	2	**S7022 DB/P7**
	170	28	46,8	60	2,12	–	10 000	1,9	**SC7022 DB/P7**
120	165	22	78	91,5	3,25	16	7 500	1,15	**S71924 CD/P4A**
	165	22	78	91,5	3,25	16	9 000	0,97	**S71924 CD/HCP4A**
	165	22	37,7	51	1,8	–	9 500	1,17	**S71924 FB/P7**
	165	22	37,7	51	1,8	–	11 000	1,1	**SC71924 FB/P7**
	165	22	72,8	86,5	3,05	–	7 000	1,15	**S71924 ACD/P4A**
	165	22	72,8	86,5	3,05	–	8 000	0,97	**S71924 ACD/HCP4A**
	165	22	36,4	49	1,73	–	8 500	1,17	**S71924 DB/P7**
	165	22	36,4	49	1,73	–	10 000	1,1	**SC71924 DB/P7**
	180	28	114	122	4,25	16	7 000	2,1	**S7024 CD/P4A**
	180	28	52	68	2,36	–	9 000	2,15	**S7024 FB/P7**
	180	28	52	68	2,36	–	10 000	2	**SC7024 FB/P7**
	180	28	111	116	4	–	6 700	2,1	**S7024 ACD/P4A**
	180	28	49,4	65,5	2,28	–	8 000	2,15	**S7024 DB/P7**
	180	28	49,4	65,5	2,28	–	9 000	2	**SC7024 DB/P7**

[1] Bearing with PEEK cage as standard

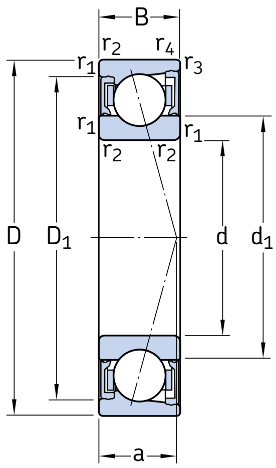






Dimensions						Abutment and fillet dimensions				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
110	122,3	140,5	1,1	0,6	27	116	144	146	1	0,6
	122,3	140,5	1,1	0,6	27	116	144	146	1	0,6
	124,5	138,9	1,1	1,1	31	116	144	144	1	1
	124,5	138,9	1,1	1,1	31	116	144	144	1	1
	122,3	140,5	1,1	0,6	40	116	144	146	1	0,6
	122,3	140,5	1,1	0,6	40	116	144	146	1	0,6
	124,5	138,9	1,1	1,1	40	116	144	144	1	1
	124,5	138,9	1,1	1,1	40	116	144	144	1	1
	128,5	155	2	1	33	119	161	165	2	1
	133,2	150,5	2	2	37	119	161	161	2	2
	133,2	150,5	2	2	37	119	161	161	2	2
	128,5	155	2	1	47	119	161	165	2	1
	133,2	150,5	2	2	47	119	161	161	2	2
	133,2	150,5	2	2	47	119	161	161	2	2
120	133,9	153,9	1,1	0,6	30	126	159	161	1	0,6
	133,9	153,9	1,1	0,6	30	126	159	161	1	0,6
	136,5	151,9	1,1	1,1	34	126	159	159	1	1
	136,5	151,9	1,1	1,1	34	126	159	159	1	1
	133,9	153,9	1,1	0,6	44	126	159	161	1	0,6
	133,9	153,9	1,1	0,6	44	126	159	161	1	0,6
	136,5	151,9	1,1	1,1	44	126	159	159	1	1
	136,5	151,9	1,1	1,1	44	126	159	159	1	1
	138,5	165	2	1	34	129	171	175	2	1
	143,2	160,5	2	2	39	129	171	171	2	2
	143,2	160,5	2	2	39	129	171	171	2	2
	138,5	165	2	1	49	129	171	175	2	1
	143,2	160,5	2	2	49	129	171	171	2	2
	143,2	160,5	2	2	49	129	171	171	2	2

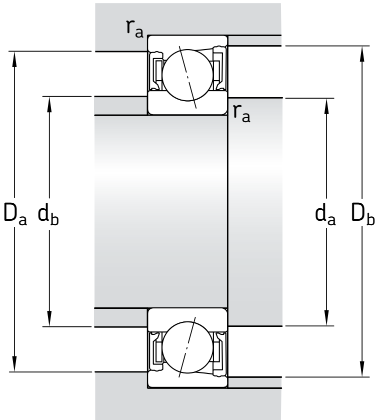
Sealed angular contact ball bearings
d **130 – 150** mm

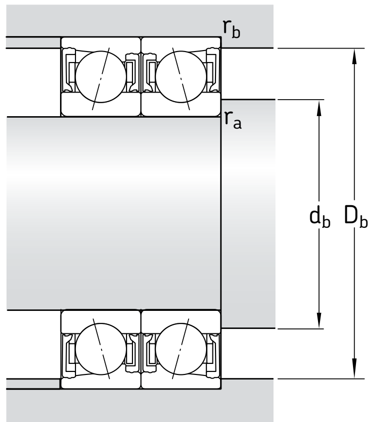


CD, ACD

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Calculation factor	Attainable speed when lubricating with grease	Mass	Designation
d	D	B	C	C_0	P_u	f_0			
mm			kN		kN	–	r/min	kg	–
130	180	24	92,3	108	3,65	16	7 000	1,55	**S71926 CD/P4A**[1]
	180	24	92,3	108	3,65	16	8 500	1,3	**S71926 CD/HCP4A**[1]
	180	24	87,1	102	3,45	–	6 700	1,55	**S71926 ACD/P4A**[1]
	180	24	87,1	102	3,45	–	7 500	1,3	**S71926 ACD/HCP4A**[1]
	200	33	148	156	5,2	16	6 700	3,2	**S7026 CD/P4A**
	200	33	140	150	4,9	–	6 000	3,2	**S7026 ACD/P4A**
140	190	24	95,6	116	3,9	17	6 700	1,65	**S71928 CD/P4A**
	190	24	95,6	116	3,9	17	8 000	1,35	**S71928 CD/HCP4A**
	190	24	90,4	110	3,65	–	6 000	1,65	**S71928 ACD/P4A**
	190	24	90,4	110	3,65	–	7 000	1,35	**S71928 ACD/HCP4A**
	210	33	153	166	5,3	16	6 700	3,4	**S7028 CD/P4A**
	210	33	146	156	5,1	–	5 600	3,4	**S7028 ACD/P4A**
150	210	28	125	146	4,75	16	6 300	2,55	**S71930 CD/P4A**
	210	28	119	140	4,5	–	5 600	2,55	**S71930 ACD/P4A**
	225	35	172	190	5,85	16	6 000	4,15	**S7030 CD/P4A**
	225	35	163	180	5,6	–	5 300	4,15	**S7030 ACD/P4A**

[1] Bearing with PEEK cage as standard



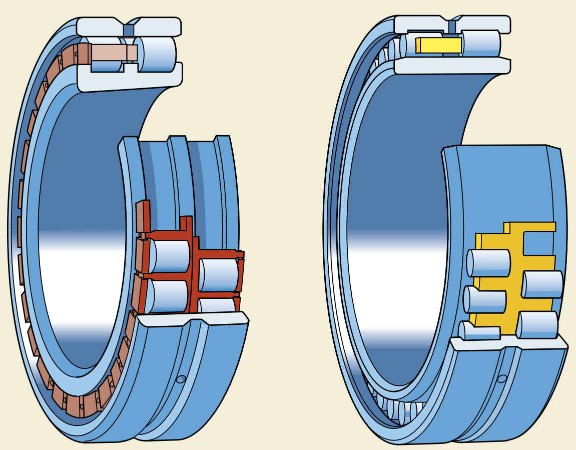


Dimensions						Abutment and fillet dimensions				
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a, d_b min	D_a max	D_b max	r_a max	r_b max
mm						mm				
130	145,4	168,1	1,5	0,6	33	137	173	176	1,5	0,6
	145,4	168,1	1,5	0,6	33	137	173	176	1,5	0,6
	145,4	168,1	1,5	0,6	48	137	173	176	1,5	0,6
	145,4	168,1	1,5	0,6	48	137	173	176	1,5	0,6
	151,6	183	2	1	39	139	191	195	2	1
	151,6	183	2	1	55	139	191	195	2	1
140	155,4	178,1	1,5	0,6	34	147	183	186	1,5	0,6
	155,4	178,1	1,5	0,6	34	147	183	186	1,5	0,6
	155,4	178,1	1,5	0,6	51	147	183	186	1,5	0,6
	155,4	178,1	1,5	0,6	51	147	183	186	1,5	0,6
	161,6	193	2	1	40	149	201	205	2	1
	161,6	193	2	1	58	149	201	205	2	1
150	168,5	195	2	1	38	159	201	205	2	1
	168,5	195	2	1	56	159	201	205	2	1
	173,1	206,5	2,1	1	43	161	214	220	2	1
	173,1	206,5	2,1	1	62	161	214	220	2	1

Cylindrical roller bearings

SKF produces high-precision single row and double row cylindrical roller bearings in three different designs and series. The characteristic features of these bearings are a low cross sectional height, high load carrying capacity, high rigidity and high-speed capability. They are therefore particularly well suited for machine tool spindles where the bearing arrangement must accommodate heavy radial loads and high speeds, while providing a high degree of stiffness.

Fig. 1



Double row cylindrical roller bearings

High-precision double row cylindrical roller bearings (→ **fig. 1**) are produced by SKF as standard in the NN design (**a**) and NNU design (**b**).

The rollers of NN design cylindrical roller bearings are guided between integral flanges on the inner ring, while the rollers of NNU design bearings are guided between integral flanges on the outer ring. In either case, the other ring has no flanges. Therefore, the bearing can accommodate axial displacement of the shaft relative to the housing in both directions, within the bearing (→ product table, starting on **page 212**).

These bearings are separable, i.e. the bearing ring with integral flanges, together with the roller and cage assembly can be separated from the flangeless ring, to facilitate mounting and dismounting.

NN design bearings can provide a unique balance between load carrying capacity, rigidity and speed and are therefore typically used as the non-tool end bearing in machine tool spindles. Boundary dimensions of NN design bearings are in accordance with ISO Dimension Series 30 (NN 30 series designation).

NNU design bearings, with a very low cross sectional height, provide a higher degree of stiffness than bearings in the NN 30 series. However, NN 30 series bearings can accommodate heavier loads. Boundary dimensions of NNU design bearings are in accordance with ISO Dimension Series 49 (NNU 49 series designation).

SKF double row cylindrical roller bearings are available with either a cylindrical or a tapered bore (taper 1:12). In machine tool applications, cylindrical roller bearings with a tapered bore are preferred, because the taper enables more accurate adjustment of clearance or preload during installation.

Annular groove and lubrication holes

To facilitate efficient lubrication, all bearings in the NNU 49 series and bearings in the NN 30 series with a bore diameter ≥ 140 mm, have an annular groove and three lubrication holes in the outer ring, designation suffix W33. Oil-air pipes can be inserted either in the holes in the annular groove, or positioned to the side of the bearing at a height specified in **table 8** on **page 83**.

NN 30 series bearings with a bore diameter ≤ 130 mm do not have an annular groove and lubrication holes as standard. These bearings are typically lubricated either

- initially with the requisite minimum quantity of grease or
- during operation with accurately metered, small quantities of oil injected through a pipe, positioned to the side of the bearing (→ **fig. 2**).

If these bearings require an annular groove and lubrication holes, check SKF for availability. When the oil-air lubrication method is used in combination with a bearing that has an annular groove and lubrication holes, the oil can be delivered either via a nozzle positioned to the side of the bearing, or directly to the bearing via the outer ring (→ **fig. 3**).

Bearings with a pre-ground raceway

When there is a demand for an exceptionally high degree of running accuracy, SKF recommends mounting the flangeless inner ring of an NNU 49 series bearing onto the shaft and then finish-grinding the raceway and other seat surfaces on the shaft.

For these applications, SKF can supply NNU 49 series bearings with a tapered bore and a pre-ground inner ring raceway. These bearings are identified by the designation suffix VU001. The finish-grinding allowance, which depends on the bore diameter of the pre-ground inner ring, is listed in **table 1**.

Table 1

Grinding allowance for the inner rings of NNU 49 K/VU001 bearings

Bore diameter over	incl.	**Grinding allowance**
mm		mm
–	**110**	0,2
110	**360**	0,3
360	**–**	0,4

Fig. 2

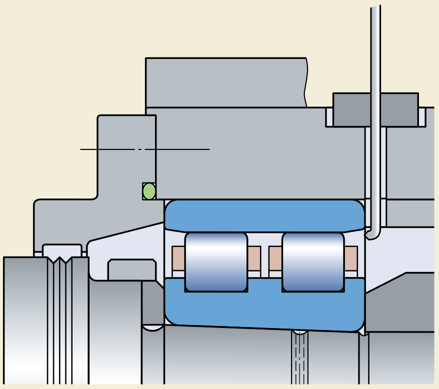
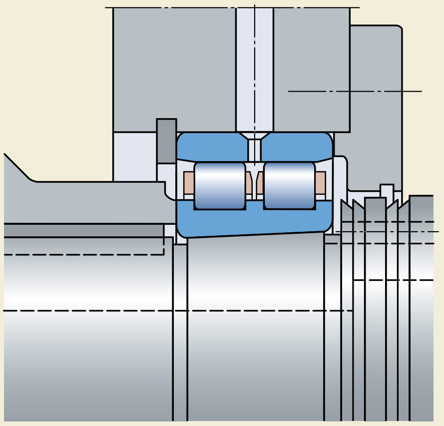


Fig. 3

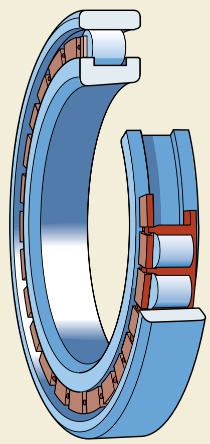


Single row cylindrical roller bearings

High-precision single row cylindrical roller bearings (→ **fig. 4**) in the N 10 series are designed for bearing arrangements where the very high load carrying capacity of a double row bearing is not required, but where increased speed capability is needed. Single row bearings have the same bore and outside diameter as a corresponding NN 30 double row bearing. Single row cylindrical roller bearings in the N 10 series are only available with a tapered bore (designation suffix K).

The rollers of single row cylindrical roller bearings in the N 10 series are guided between two integral flanges on the inner ring while the outer ring has no flanges. The flangeless outer ring enables these bearings to accommodate axial displacement of the shaft relative to the housing in both directions, within the bearing (→ product table, starting on **page 218**). As with double row bearings, single row bearings are separable, i.e. the inner ring with roller and cage assembly can be separated from the outer ring, to facilitate mounting and dismounting.

Fig. 4



Basic design bearings

SKF basic design single row cylindrical roller bearings are equipped, as standard, with a roller centred, two-piece injection moulded cage made of polyamide 66. These bearings are well suited for most precision applications.

High-speed design bearings

Single row cylindrical roller bearings for high-speed applications are equipped with an outer ring centred, injection moulded, window-type cage made of glass fibre reinforced polyetheretherketone (PEEK), designation suffix TNHA. This cage enables considerably higher speeds than the polyamide 66 cage used in basic design bearings.

To accommodate these higher speeds, reduce heat generated and to strengthen the cage to avoid damage caused by rapid starts and stops, SKF high-speed single row cylindrical roller bearings have one less roller than standard bearings.

Hybrid bearings

When an all-steel bearing cannot meet performance requirements, SKF high-precision cylindrical roller bearings in the NN 30 and N 10 series are available as hybrid bearings, designation suffix HC5. These bearings, which use rings of standard bearing steel, contain rollers made of bearing grade silicon nitride Si_3N_4. Hybrid bearings can operate at higher speeds, with lower temperature rise than similarly sized all-steel bearings. In addition, hybrid bearings provide a higher degree of stiffness, can operate longer under marginal lubrication conditions, and are less susceptible to damage caused by high-speed starts and stops than a similarly sized all-steel bearing.

In order to maximize the performance of a hybrid bearing, SKF recommends using hybrid single row bearings with an outer ring centred window-type PEEK cage, designation suffix TNHA/HC5. These bearings can attain speeds up to $n\,d_m$ = 2 000 000 mm/min, when under light load and lubricated with an oil-air system. They can attain speeds up to $n\,d_m$ = 1 400 000 mm/min, when grease lubricated. As an option to further improve lubricant flow, bearings in the N 10 series are available with special lubrication holes in the outer ring upon request.

Bearing data – general

Dimensions

The boundary dimensions of SKF high-precision cylindrical roller bearings in the Dimension Series 10, 30 and 49 are in accordance with ISO 15:1998. The maximum chamfer limits are in accordance with ISO 582:1995 and can be found in the section “Boundary dimensions” on **page 41**.

Tolerances

SKF high-precision cylindrical roller bearings are produced, as standard, to the SP (special precision) tolerance class for machine tool applications. SP tolerances for dimensional accuracy correspond approximately to the P5 tolerance class. Running accuracy corresponds to P4 tolerance class.

For bearing arrangements where an extremely high degree of running accuracy is required, double row bearings with a tapered bore, manufactured to the UP (ultra precision) tolerance class can be supplied on request. Dimensional accuracy for the UP tolerance class corresponds approximately to the P4 tolerance class. Running accuracy is better than P4 tolerance class.

The tolerance values are listed

- for SP tolerance class in **table 2** on **page 202**
- for UP tolerance class in **table 3** on **page 203**
- for SP and UP tolerance classes for tapered bore (taper 1:12) in **table 4** on **page 204**.

The symbols used in the tolerance tables are listed in **table 3** on **pages 44** and **45**, together with their definitions.

Table 2

Class SP tolerances for cylindrical roller bearings

Inner ring

d		Δ_{ds}[1)]		V_{dp}	Δ_{Bs}		V_{Bs}	K_{ia}	S_d
over	incl.	high	low	max	high	low	max	max	max
mm		µm		µm	µm		µm	µm	µm
–	**18**	0	–5	3	0	–100	5	3	8
18	**30**	0	–6	3	0	–100	5	3	8
30	**50**	0	–8	4	0	–120	5	4	8
50	**80**	0	–9	5	0	–150	6	4	8
80	**120**	0	–10	5	0	–200	7	5	9
120	**180**	0	–13	7	0	–250	8	6	10
180	**250**	0	–15	8	0	–300	10	8	11
250	**315**	0	–18	9	0	–350	13	10	13
315	**400**	0	–23	12	0	–400	15	12	15
400	**500**	0	–28	14	0	–450	25	12	18
500	**630**	0	–35	18	0	–500	30	15	20
630	**800**	0	–45	23	0	–750	35	15	23

1) SP tolerances for tapered bore (taper 1:12) can be found in **table 4** on **page 204**

Outer ring

D		Δ_{Ds}, Δ_{Dmp}[1)]		V_{Dp}	Δ_{Cs}, V_{Cs}	K_{ea}	S_D
over	incl.	high	low	max.		max	max
mm		µm		µm		µm	µm
30	**50**	0	–7	4	Values are identical to those of the inner ring of the same bearing	5	8
50	**80**	0	–9	5		5	8
80	**120**	0	–10	5		6	9
120	**150**	0	–11	6		7	10
150	**180**	0	–13	7		8	10
180	**250**	0	–15	8		10	11
250	**315**	0	–18	9		11	13
315	**400**	0	–20	10		13	13
400	**500**	0	–23	12		15	15
500	**630**	0	–88	14		17	18
630	**800**	0	–35	18		20	20
800	**1 000**	0	–50	25		25	30

1) Tolerance Δ_{Ds} applies to bearings with an outside diameter D ≤ 630 mm, and tolerance Δ_{Dmp} for larger bearings

Table 3

Class UP tolerances for cylindrical roller bearings

Inner ring

d		Δ_{ds}[1)]		V_{dp}	Δ_{Bs}		V_{Bs}	K_{ia}	S_d
over	incl.	high	low	max	high	low	max	max	max
mm		µm		µm	µm		µm	µm	µm
–	**18**	0	–4	2	0	–70	1,5	1,5	2
18	**30**	0	–5	2,5	0	–80	1,5	1,5	3
30	**50**	0	–6	3	0	–100	2	2	3
50	**80**	0	–7	3,5	0	–100	3	2	4
80	**120**	0	–8	4	0	–100	3	3	4
120	**180**	0	–10	5	0	–100	4	3	5
180	**250**	0	–12	6	0	–150	5	4	6
250	**315**	0	–15	8	0	–150	5	4	6
315	**400**	0	–19	10	0	–150	6	5	7
400	**500**	0	–23	12	0	–200	7	5	8
500	**630**	0	–26	13	0	–200	8	6	9
630	**800**	0	–34	17	0	–200	10	7	11

1) UP tolerances for tapered bore (taper 1:12) can be found in **table 4** on **page 204**

Outer ring

D		Δ_{Ds}		V_{Dp}	Δ_{Cs}, V_{Cs}	K_{ea}	S_D
over	incl.	high	low	max		max	max
mm		µm		µm		µm	µm
30	**50**	0	–5	3	Values are identical to those of the inner ring of the same bearing	3	2
50	**80**	0	–6	3		3	2
80	**120**	0	–7	4		3	3
120	**150**	0	–8	4		4	3
150	**180**	0	–9	5		4	3
180	**250**	0	–10	5		5	4
250	**315**	0	–12	6		6	4
315	**400**	0	–14	7		7	5
400	**500**	0	–17	9		8	5
500	**630**	0	–20	10		9	6
630	**800**	0	–25	13		11	7
800	**1 000**	0	–30	15		12	10

3

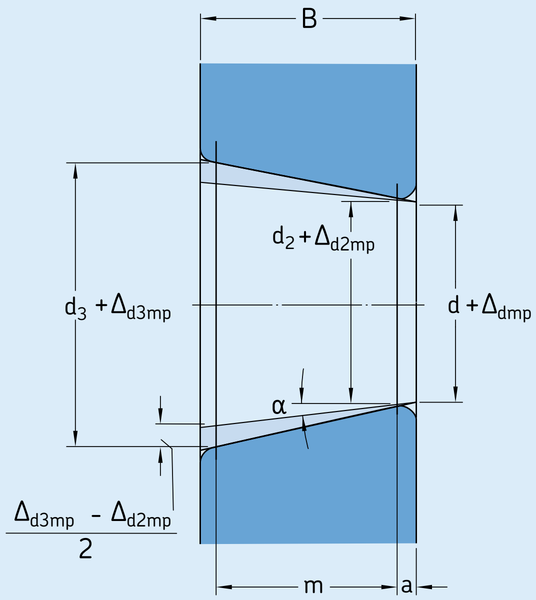
Table 4

Classes SP and UP tolerances for tapered bore, taper 1:12

Bore diameter		Class SP tolerances					Class UP tolerances				
d		Δ_{d2mp}		V_{dp}	$\Delta_{d3mp} - \Delta_{d2mp}$ [1)]		Δ_{d2mp}		V_{dp}	$\Delta_{d3mp} - \Delta_{d2mp}$ [1)]	
over	incl.	high	low	max	high	low	high	low	max	high	low
mm		µm		µm	µm		µm		µm	µm	
18	**30**	+10	0	3	+4	0	+6	0	2,5	+2	0
30	**50**	+12	0	4	+4	0	+7	0	3	+3	0
50	**80**	+15	0	5	+5	0	+8	0	3,5	+3	0
80	**120**	+20	0	5	+6	0	+10	0	4	+4	0
120	**180**	+25	0	7	+8	0	+12	0	5	+4	0
180	**250**	+30	0	8	+10	0	+14	0	6	+5	0
250	**315**	+35	0	9	+12	0	+15	0	8	+6	0
315	**400**	+40	0	12	+12	0	+17	0	10	+6	0
400	**500**	+45	0	14	+14	0	+19	0	12	+7	0
500	**630**	+50	0	18	+15	0	+20	0	13	+11	0
630	**800**	+65	0	23	+19	0	+22	0	17	+13	0

1) $\Delta_{d3mp} - \Delta_{d2mp}$ = angle deviation over measuring length m

Tapered bore, taper 1:12 (half angle of taper: α = 2° 23´ 9,4″)

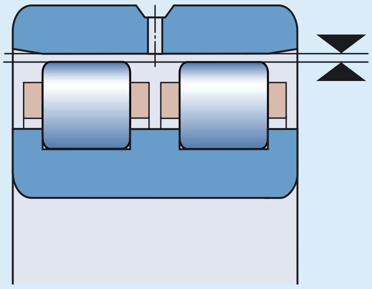


Measuring distance a

Chamfer dimension r_s min	Bore diameter d over	incl.	Measuring distance a
mm	mm		mm
0,6	–	–	2,5
1	–	–	3,5
1,1	–	120	4
	120	–	5
1,5	–	120	5
	120	–	6
2	–	80	5,5
	80	220	6
	220	–	7
2,1	–	280	7,5
	280	–	8,5
2,5	–	280	7,5
	280	–	8,5
3	–	–	9,5
4	–	–	11
5	–	–	12
6	–	–	16

Table 5

Radial internal clearance of high-precision cylindrical roller bearings



Bore diameter d		Radial internal clearance Bearing with a cylindrical bore C1		SPC2		Normal		C3		Bearing with a tapered bore C1		SPC2	
over	incl.	min	max	min	max	min	max	min	max	min	max	min	max
mm		µm								µm			
24	**30**	5	15	10	25	20	45	35	60	15	25	25	35
30	**40**	5	15	12	25	25	50	45	70	15	25	25	40
40	**50**	5	18	15	30	30	60	50	80	17	30	30	45
50	**65**	5	20	15	35	40	70	60	90	20	35	35	50
65	**80**	10	25	20	40	40	75	65	100	25	40	40	60
80	**100**	10	30	25	45	50	85	75	110	35	55	45	70
100	**120**	10	30	25	50	50	90	85	125	40	60	50	80
120	**140**	10	35	30	60	60	105	100	145	45	70	60	90
140	**160**	10	35	35	65	70	120	115	165	50	75	65	100
160	**180**	10	40	35	75	75	125	120	170	55	85	75	110
180	**200**	15	45	40	80	90	145	140	195	60	90	80	120
200	**225**	15	50	45	90	105	165	160	220	60	95	90	135
225	**250**	15	50	50	100	110	175	170	235	65	100	100	150
250	**280**	20	55	55	110	125	195	190	260	75	110	110	165
280	**315**	20	60	60	120	130	205	200	275	80	120	120	180
315	**355**	20	65	65	135	145	225	225	305	90	135	135	200
355	**400**	25	75	75	150	190	280	280	370	100	150	150	225
400	**450**	25	85	85	170	210	310	310	410	110	170	170	255
450	**500**	25	95	95	190	220	330	330	440	120	190	190	285
500	**560**	25	105	105	210	240	360	360	480	130	210	210	315
560	**630**	25	115	115	230	260	380	380	500	140	230	230	345
630	**710**	30	130	130	260	260	380	380	500	160	260	260	390
710	**800**	35	145	145	290	290	425	425	565	180	290	290	435

Radial internal clearance

Although this is not apparent from the bearing designation, SKF high-precision cylindrical roller bearings manufactured to the SP tolerance class are supplied with C1 radial internal clearance as standard. The bearing rings of individual bearings are matched at the factory and must be kept together as supplied, otherwise clearance in the bearing may change, influencing the performance characteristics of the final assembly. The bearings are usually supplied packed in a single box, however if the rings are packed separately, the rings for each bearing can be matched by their serial number.

Bearings in the NN 30 and N 10 series can also be supplied to order with reduced radial clearance (smaller than C1) when a minimum operational clearance or a preload after mounting is required. For additional information about clearance values and product availability, consult the SKF application engineering service.

Bearings made to SP tolerance class, particularly those in the NNU 49 series, are also available with a radial internal clearance greater than C1. When ordering, the requisite clearance should be indicated in the suffix designation

- SPC2 for clearance greater than C1
- CN for Normal clearance greater than SPC2 or
- C3 for clearance greater than Normal.

The values for the radial internal clearance are provided in **table 5** on **page 205**. They are in accordance with ISO 5753:1991 and are valid for unmounted bearings under zero measuring load.

The values for radial clearance SPC2 deviate from those standardized for C2. The clearance range is reduced and displaced toward the lower limit.

Radial internal clearance or preload in mounted bearings

To provide maximum running accuracy and stiffness, high-precision cylindrical roller bearings should have a minimum radial internal clearance or preload after mounting. Cylindrical roller bearings with a tapered bore are generally mounted with preload.

The amount of the operational clearance or preload depends on the speed, load, lubricant and required stiffness of the complete spindle/bearing system. It also depends on the accuracy of form of the bearing seats, which play a key role in being able to obtain the necessary clearance or preload. The operating temperature of the bearing should also be taken into consideration, since a reduction in clearance or an increase in preload may result.

Attainable speeds

The “Attainable speeds” quoted in the product tables are guideline values that are valid, provided the following conditions exist:

- The bearings have an operational clearance that is virtually zero.
- There is no preload.
- Seats and abutments meet the accuracy requirements prescribed on **page 61**.

In applications where operational clearance or preload is larger than +2 µm, or where the seats and abutments do not meet accuracy requirements, the speed ratings must be reduced.

The guideline values listed in **table 6** for the speed factor $A = n\ d_m$ depending on the preload (+) can be used when designing spindle bearing arrangements with bearings in the N 10 and NN 30 series. In special cases, or when designing bearing arrangements with bearings in the NNU 49 series, consult the SKF application engineering service.

Table 6

Rotational speed factor

Speed factor $n\ d_m$	**Preload (+)** min	max
mm/min	µm	
≤ 500 000	+2	+5
> 500 000 ≤ 1 000 000	+1	+3
> 1 000 000	0	+2

Cages

Depending on their size and design, SKF high-precision double row cylindrical roller bearings are equipped, as standard, with one of the following cages (→ **fig. 5**)

- two injection moulded cages of polyamide 66, roller centred, designation suffix TN
- two injection moulded cages of glass fibre reinforced polyamide 66, roller centred, designation suffix TN9
- one double pronged machined brass cage, roller centred, no designation suffix.

Single row cylindrical roller bearings in the N 10 series can incorporate any of the injection moulded cages listed above and are identified by the same designation suffix. In addition, single row N 10 series bearings can be equipped with an outer ring centred PEEK window-type cage (designation suffix TNHA). Bearings with a PEEK cage can be operated at higher speeds and temperatures.

Bearings with polyamide cage(s) can withstand the temperatures normally encountered in machine tool operations up to a maximum of +120 °C. The lubricants generally used for rolling bearings, with the exception of some synthetic oils and greases, have no detrimental effect on cage properties. Additional information about cages can be found in the section "Cages" on **page 46**.

Fig. 5

Equivalent dynamic bearing load

$$P = F_r$$

Equivalent static bearing load

$$P_0 = F_r$$

3

Application recommendations

Adjusting for clearance or preload

When adjusting a cylindrical roller bearing with a tapered bore for clearance or preload, the result is determined by how far the bearing is driven up on its tapered seat. The further a bearing is driven up the seat, the less clearance there will be, until eventually, there is a preload in the bearing. To quickly and accurately determine the amount of clearance or preload in the mounted bearing, SKF recommends using the gauges shown on **pages 295** to **305**.

Gauges are particularly useful when mounting two or three bearings in series, as it is not necessary to determine and measure the axial displacement of the inner ring.

If SKF gauges are not available, measure the clearance on the outer ring raceway of the assembled bearing and calculate the required axial drive-up distance.

Knowing the residual radial clearance, the axial displacement i.e. the additional distance through which the bearing inner ring assembly must be pushed up on its tapered seat can be obtained from

$$B_a = \frac{e\,c}{1\,000}$$

where

B_a = axial displacement, mm

e = a factor depending on the diameter ratio of the hollow shaft and the bearing series (→ **fig. 6** and **table 7**)

c = measured residual radial clearance and either
- plus the required preload, µm, for preload or
- minus the required clearance, µm, for clearance

If the bearing is to be mounted against a distance ring (→ **fig. 7**), the width of the distance ring must be appropriate to the value obtained for B_a. In all other cases, axial displacement must be measured from a reference surface on the spindle.

If a threaded nut is used to drive the inner ring assembly up the tapered seat, the angle through which the nut should be turned for a given clearance reduction can be calculated from the equation

$$\gamma = \frac{360\,e\,c}{1\,000\,p}$$

where

γ = requisite tightening angle of the nut, degrees

e = a factor depending on the diameter ratio of the hollow shaft and the bearing series (→ **fig. 6** and **table 7**)

c = measured residual radial clearance and either
- plus the required preload, µm, for preload or
- minus the required clearance, µm, for clearance

p = thread lead of the nut, mm

Procedures for mounting high-precision cylindrical roller bearings are described in the section “Mounting and dismounting”, starting on **page 84**.

Calculation example

Determine the axial displacement, i.e. the distance that an inner ring assembly of a NN 3040 K/SPW33 bearing should be driven up onto its tapered seat, if

- the measured residual radial internal clearance is 10 µm
- the requisite preload is 2 µm
- the mean bearing seat diameter is d_{om} = 203 mm
- the internal diameter of the hollow shaft is d_i = 140 mm.

Using e = 18 for d_i/d_{om} = 140/203 = 0,69 from **table 7** and c = 10 + 2 = 12 µm then

$$B_a = \frac{e\,c}{1\,000} = \frac{18 \times 12}{1\,000} = 0{,}216\ \text{mm}$$

Fig. 6

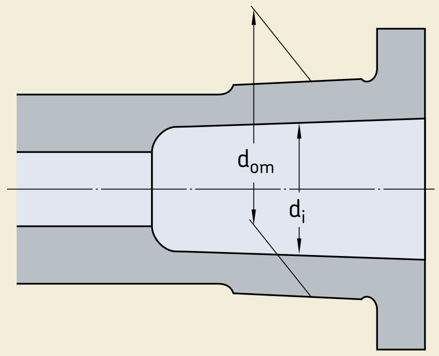


Fig. 7

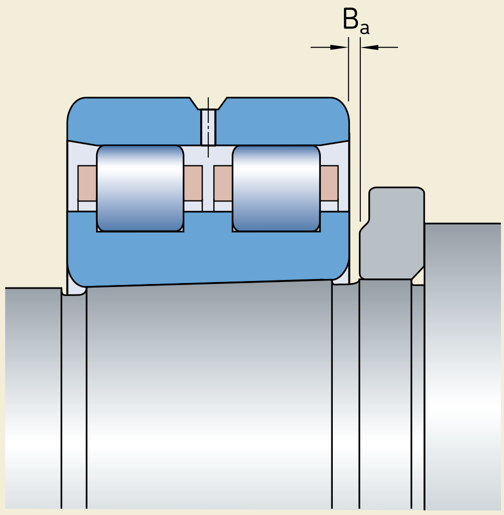
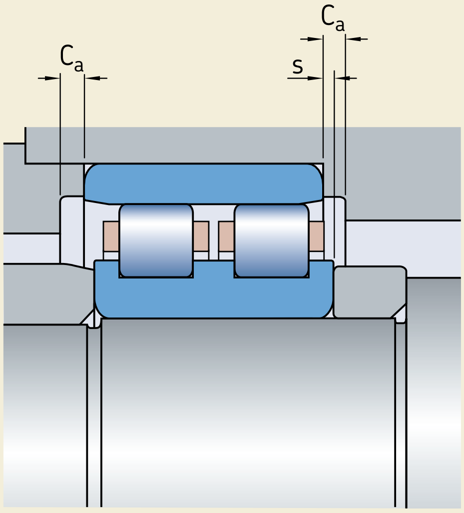


Fig. 8



Designing associated components

To be sure that bearings in the NN 30 and N 10 series, equipped with a polyamide cage (designation suffix TN or TN9), can accommodate axial displacement of the shaft relative to the housing, a space must be provided on both sides of the bearing (→ **fig. 8**). This prevents damage, such as the cage fouling the face of an adjacent component. The minimum width of this free space should be

$$C_a = 1{,}3\ s$$

where

C_a = minimum width of free space, mm

s = permissible axial displacement from the normal position of one bearing ring in relation to the other, mm (→ product tables, starting on **page 212**)

Table 7

Factor e

Hollow shaft diameter ratio d_i/d_{om}	**Factor e for bearings in the series** NN 30 K, N 10 K	NNU 49 K
≤ 0,2	12,5	12
0,3	14,5	13
0,4	15	14
0,5	16	15
0,6	17	18
0,7	18	17

3

Mounting and dismounting, using the oil injection method

Particularly where large bearings are involved, it is often necessary to make provisions during the bearing arrangement design stage, to facilitate mounting and dismounting of the bearing, or even to make it possible at all.

For high-precision cylindrical roller bearings with a bore diameter > 80 mm, SKF recommends the oil injection method. With the oil injection method, oil under high pressure is injected between the bearing bore and the bearing seat to form an oil film (→ **fig. 9**). This oil film separates the mating surfaces and appreciably reduces the friction between them and virtually eliminates the risk of damaging the bearing or the spindle. This method is typically used when mounting or dismounting bearings directly on tapered journals. Where bearings with a cylindrical bore are concerned, the oil injection method can only be used for dismounting.

To apply the SKF oil injection method, the spindle must contain ducts and grooves (→ **fig. 10**). Recommended dimensions for the appropriate grooves, ducts and threaded holes to connect the oil supply can be found in the section "Provision for mounting and dismounting" on **page 64**.

Designation system

The designation system for SKF high-precision cylindrical roller bearings is shown in **table 8**, together with the definitions.

Fig. 9

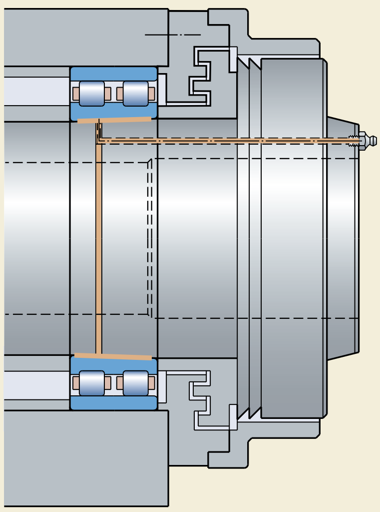


Fig. 10

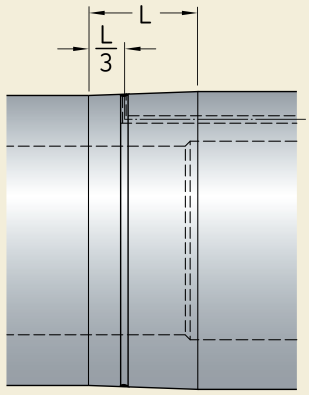


Table 8

Designation system for high-precision cylindrical roller bearings

Examples:									
N 1012 KTNHA/HC5SP	N	10	12	K	TNHA	/	HC5	SP	
NN 3020 KTN9/SPVR521	NN	30	20	K	TN9	/		SP	VR521
NNU 49/500 B/SPC3W33X	NNU	49	500	B		/		SPC3	W33X

Bearing design
N Single row cylindrical roller bearing with integral flanges on the inner ring, the outer ring has no flanges
NN Double row cylindrical roller bearing with integral flanges on the inner ring, the outer ring has no flanges
NNU Double row cylindrical roller bearing with integral flanges on the outer ring, the inner ring has no flanges

Dimension Series
10 ISO Dimension Series 10
30 ISO Dimension Series 30
49 ISO Dimension Series 49

Bearing size
05 (×5) 25 mm bore diameter
to
96 (×5) 480 mm bore diameter
from
/500 bore diameter uncoded in millimetres

Internal design and bore shape
– Cylindrical bore (no designation suffix)
B Modified internal design
K Tapered bore, taper 1:12

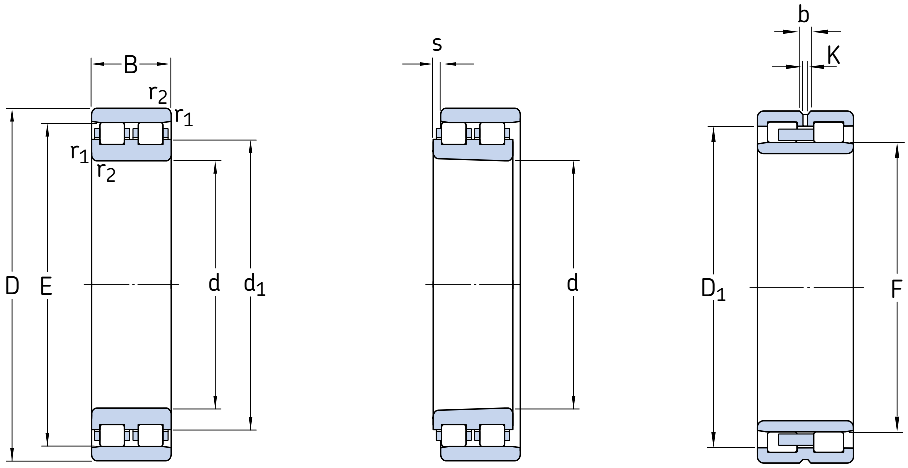
Cage
– Machined brass cage, roller centred (no designation suffix)
TN Injection moulded cage(s) of polyamide 66, roller centred
TN9 Injection moulded cage(s) of glass fibre reinforced polyamide 66, roller centred
TNHA Injection moulded window-type cage of glass fibre reinforced polyetheretherketone (PEEK), outer ring centred

Material of the rolling elements
– Carbon chromium steel (no designation suffix)
HC5 Bearing grade silicon nitride (hybrid bearings)

Tolerances and internal clearance
– Standard radial internal clearance C1 (no designation suffix)
C2 Radial internal clearance greater than C1
CN Radial internal clearance Normal
C3 Radial internal clearance greater than Normal
SP Dimensional accuracy approximately to ISO tolerance class 5 and running accuracy approximately to ISO tolerance class 4
UP Dimensional accuracy approximately to ISO tolerance class 4 and running accuracy better than to ISO tolerance class 4

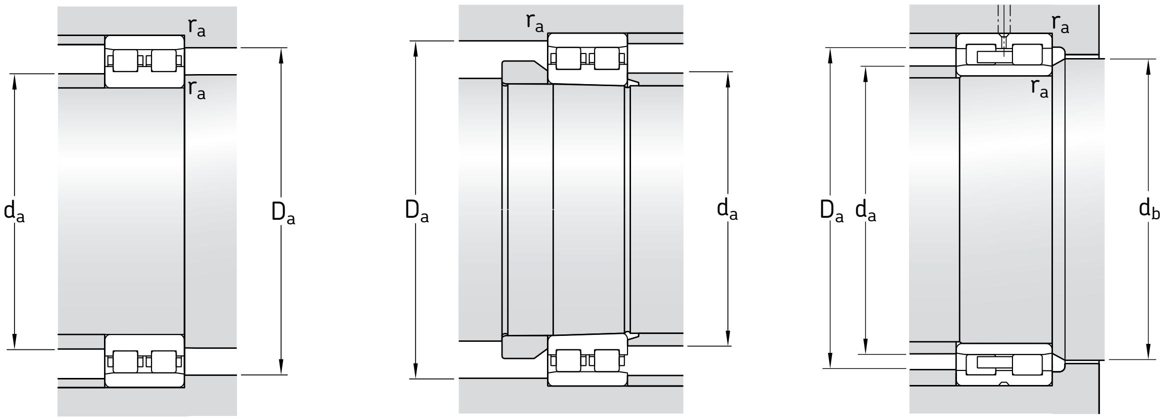
Other features
VU001 Inner ring raceway with finish-grinding allowance
VR521 Bearing supplied with measuring report
W33 Annular groove and three lubrication holes in the outer ring
W33X Annular groove and six lubrication holes in the outer ring

Double row cylindrical roller bearings
d **25 – 110** mm



NN 30 TN(9) NN 30 KTN(9) NNU 49 B/W33

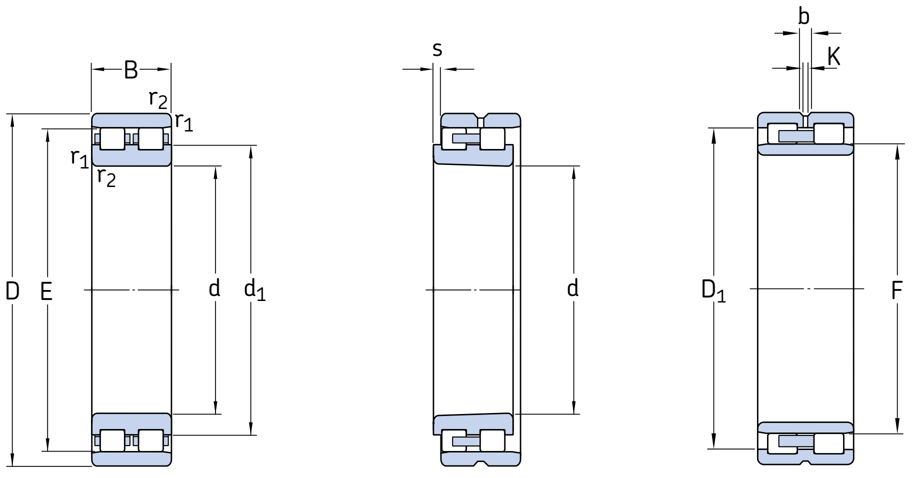
Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designations** Bearing with a tapered bore	cylindrical bore
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	–
25	47	16	26	30	3,1	19 000	22 000	0,12	**NN 3005 K/SP**	**NN 3005/SP**
30	55	19	30,8	37,5	3,9	16 000	18 000	0,19	**NN 3006 KTN/SP**	**NN 3006 TN/SP**
35	62	20	39,1	50	5,4	14 000	16 000	0,25	**NN 3007 K/SP**	**NN 3007/SP**
40	68	21	42,9	56	6,48	12 000	14 000	0,30	**NN 3008 KTN/SP**	**NN 3008 TN/SP**
45	75	23	50,1	65,5	7,65	11 000	13 000	0,38	**NN 3009 KTN/SP**	**NN 3009 TN/SP**
50	80	23	52,8	73,5	8,5	10 000	12 000	0,42	**NN 3010 KTN/SP**	**NN 3010 TN/SP**
55	90	26	69,3	96,5	11,6	9 500	11 000	0,62	**NN 3011 KTN/SP**	**NN 3011 TN/SP**
60	95	26	73,7	106	12,7	9 000	10 000	0,66	**NN 3012 KTN/SP**	**NN 3012 TN/SP**
65	100	26	76,5	116	13,7	8 500	9 500	0,71	**NN 3013 KTN/SP**	**NN 3013 TN/SP**
70	110	30	96,8	150	17,3	7 500	8 500	1,00	**NN 3014 KTN/SP**	**NN 3014 TN/SP**
75	115	30	96,8	150	17,6	7 000	8 000	1,10	**NN 3015 KTN/SP**	**NN 3015 TN/SP**
80	125	34	119	186	22	6 700	7 500	1,45	**NN 3016 KTN/SP**	**NN 3016 TN/SP**
85	130	34	125	204	23,2	6 300	7 000	1,60	**NN 3017 KTN9/SP**	**NN 3017 TN9/SP**
90	140	37	138	216	26	6 000	6 700	2,00	**NN 3018 KTN9/SP**	**NN 3018 TN9/SP**
95	145	37	142	232	27,5	5 600	6 300	2,10	**NN 3019 KTN9/SP**	**NN 3019 TN9/SP**
100	140	40	128	255	29	5 600	6 300	1,90	**NNU 4920 BK/SPW33**	**NNU 4920 B/SPW33**
	150	37	151	250	29	5 300	6 000	2,20	**NN 3020 KTN9/SP**	**NN 3020 TN9/SP**
105	145	40	130	260	29	5 300	6 000	2,00	**NNU 4921 BK/SPW33**	**NNU 4921 B/SPW33**
	160	41	190	305	36	5 000	5 600	2,70	**NN 3021 KTN9/SP**	**NN 3021 TN9/SP**
110	150	40	132	270	30	5 300	6 000	2,05	**NNU 4922 BK/SPW33**	**NNU 4922 B/SPW33**
	170	45	220	360	41,5	4 800	5 300	3,40	**NN 3022 KTN9/SP**	**NN 3022 TN9/SP**



Dimensions							Abutment and fillet dimensions					
d	d_1, D_1 ~	E, F	b	K	$r_{1,2}$ min	s[1]	d_a min	d_a max	d_b min	D_a min	D_a max	r_a max
mm							mm					
25	33,7	41,3	–	–	0,6	1,4	28,2	–	–	42	43	0,6
30	40,1	48,5	–	–	1	1,8	34,6	–	–	49	50	1
35	45,8	55	–	–	1	1,8	39,6	–	–	56	57	1
40	50,6	61	–	–	1	1,3	44,6	–	–	62	63	1
45	56,3	67,5	–	–	1	2	49,6	–	–	69	70	1
50	61,3	72,5	–	–	1	2	54,6	–	–	74	75	1
55	68,2	81	–	–	1,1	2	61	–	–	82	83,5	1
60	73,3	86,1	–	–	1,1	2	66	–	–	87	88,5	1
65	78,2	91	–	–	1,1	2	71	–	–	92	93,5	1
70	85,6	100	–	–	1,1	2,5	76	–	–	101	103,5	1
75	90,6	105	–	–	1,1	2,5	81	–	–	106	108,5	1
80	97	113	–	–	1,1	3	86	–	–	114	118,5	1
85	102	118	–	–	1,1	2,5	91	–	–	119	123,5	1
90	109	127	–	–	1,5	2,8	97	–	–	129	132	1,5
95	114	132	–	–	1,5	2,8	102	–	–	134	137	1,5
100	126	113	5,5	3	1,1	1,7	106	111	116	–	133,5	1
	119	137	–	–	1,5	2,8	107	–	–	139	142	1,5
105	131	118	5,5	3	1,1	1,7	111	116	121	–	138,5	1
	125	146	–	–	2	1,8	115	–	–	148	150	2
110	136	123	5,5	3	1,1	1,7	116	121	126	–	143,5	1
	132	155	–	–	2	3,8	120	–	–	157	160	2

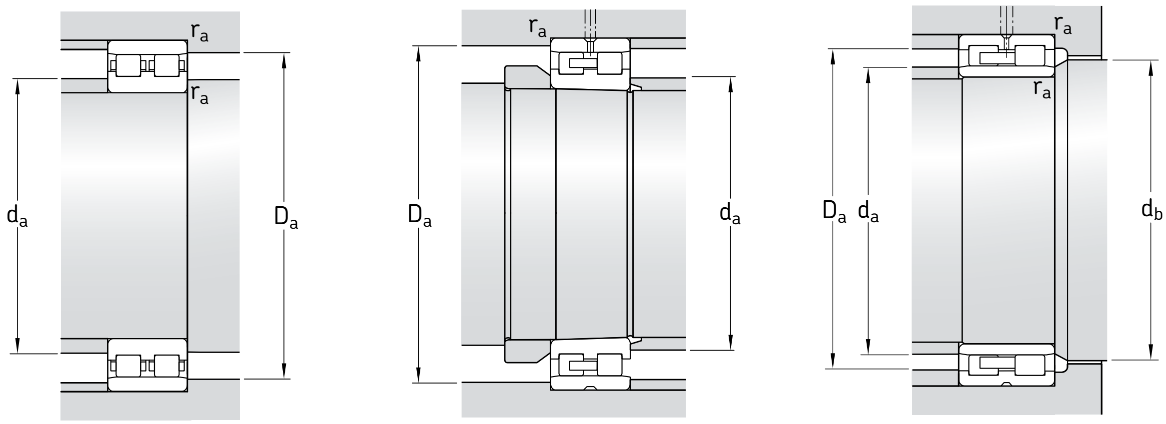
[1] s = permissible axial displacement from the normal position of one bearing ring in relation to the other

Double row cylindrical roller bearings
d **120 – 280** mm



NN 30 TN9 NN 30 K/W33 NNU 49 B/W33

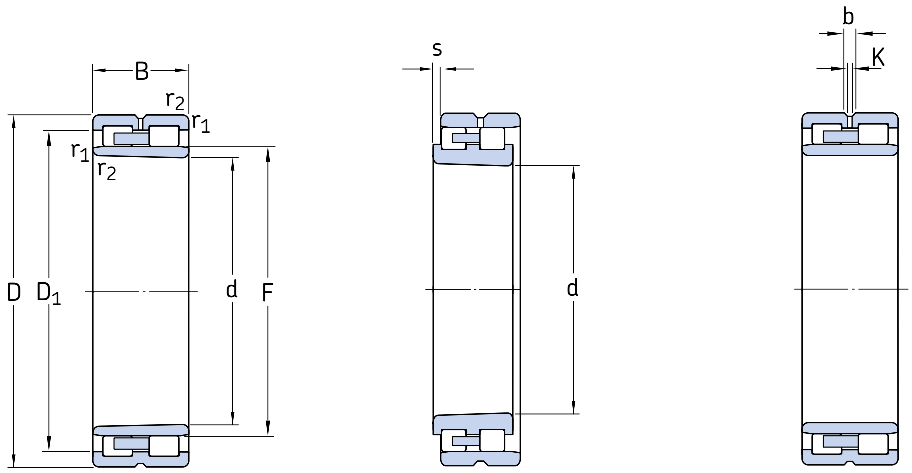
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Attainable speeds when lubricating with grease	oil-air	Mass	Designations Bearing with a tapered bore	cylindrical bore
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	–
120	165	45	176	340	37,5	4 800	5 300	2,80	**NNU 4924 BK/SPW33**	**NNU 4924 B/SPW33**
	180	46	229	390	44	4 500	5 000	3,70	**NN 3024 KTN9/SP**	**NN 3024 TN9/SP**
130	180	50	187	390	41,5	4 300	4 800	3,85	**NNU 4926 BK/SPW33**	**NNU 4926 B/SPW33**
	200	52	286	480	53	4 000	4 500	5,55	**NN 3026 KTN9/SP**	**NN 3026 TN9/SP**
140	190	50	190	400	41,5	4 000	4 500	4,10	**NNU 4928 BK/SPW33**	**NNU 4928 B/SPW33**
	210	53	297	520	56	3 800	4 300	6,00	**NN 3028 K/SPW33**	**–**
150	210	60	330	655	71	3 800	4 300	6,25	**NNU 4930 BK/SPW33**	**NNU 4930 B/SPW33**
	225	56	330	570	62	3 600	4 000	7,30	**NN 3030 K/SPW33**	**–**
160	220	60	330	680	72	3 600	4 000	6,60	**NNU 4932 BK/SPW33**	**NNU 4932 B/SPW33**
	240	60	369	655	69,5	3 400	3 800	8,80	**NN 3032 K/SPW33**	**–**
170	230	60	336	695	73,5	3 400	3 800	6,95	**NNU 4934 BK/SPW33**	**NNU 4934 B/SPW33**
	260	67	457	800	85	3 200	3 600	12,0	**NN 3034 K/SPW33**	**–**
180	250	69	402	850	88	3 000	3 400	10,5	**NNU 4936 BK/SPW33**	**NNU 4936 B/SPW33**
	280	74	561	1 000	102	2 800	3 200	16,0	**NN 3036 K/SPW33**	**–**
190	260	69	402	880	90	2 800	3 200	11,0	**NNU 4938 BK/SPW33**	**NNU 4938 B/SPW33**
	290	75	594	1 080	108	2 600	3 000	17,0	**NN 3038 K/SPW33**	**–**
200	280	80	484	1 040	106	2 600	3 000	15,0	**NNU 4940 BK/SPW33**	**NNU 4940 B/SPW33**
	310	82	644	1 140	118	2 400	2 800	21,0	**NN 3040 K/SPW33**	**–**
220	300	80	512	1 140	114	2 400	2 800	16,5	**NNU 4944 BK/SPW33**	**NNU 4944 B/SPW33**
	340	90	809	1 460	143	2 200	2 600	27,5	**NN 3044 K/SPW33**	**–**
240	320	80	528	1 220	118	2 200	2 600	17,5	**NNU 4948 BK/SPW33**	**NNU 4948 B/SPW33**
	360	92	842	1 560	153	2 000	2 400	30,5	**NN 3048 K/SPW33**	**–**
260	360	100	748	1 700	163	2 000	2 400	30,5	**NNU 4952 BK/SPW33**	**NNU 4952 B/SPW33**
	400	104	1 020	1 930	183	1 900	2 200	44,0	**NN 3052 K/SPW33**	**–**
280	380	100	765	1 800	170	1 900	2 200	32,5	**NNU 4956 BK/SPW33**	**NNU 4956 B/SPW33**
	420	106	1 080	2 080	196	1 800	2 000	47,5	**NN 3056 K/SPW33**	**–**



Dimensions							Abutment and fillet dimensions					
d	d_1, D_1 ~	E, F	b	K	$r_{1,2}$ min	s[1]	d_a min	d_a max	d_b min	D_a min	D_a max	r_a max
mm							mm					
120	151	134,5	5,5	3	1,1	1,7	126	133	137	–	158,5	1
	142	165	–	–	2	3,8	130	–	–	167	170	2
130	162	146	5,5	3	1,5	2,2	137	144	149	–	172	1,5
	156	182	–	–	2	3,8	140	–	–	183	190	2
140	172	156	5,5	3	1,5	2,2	147	154	159	–	182	1,5
	166	192	–	–	2	3,8	150	–	–	194	200	2
150	191	168,5	5,5	3	2	2	160	166	172	–	200	2
	178	206	–	–	2,1	4	161	–	–	208	214	2
160	201	178,5	5,5	3	2	2	170	176	182	–	210	2
	190	219	–	–	2,1	5	171	–	–	221	229	2
170	211	188,5	5,5	3	2	2	180	186	192	–	220	2
	204	236	–	–	2,1	5	181	–	–	238	249	2
180	226	202	8,3	4,5	2	1,1	190	199	205	–	240	2
	218	255	–	–	2,1	5	191	–	–	257	269	2
190	236	212	8,3	4,5	2	1,1	200	209	215	–	250	2
	228	265	–	–	2,1	5	201	–	–	267	279	2
200	253	225	11,1	6	2,1	3,7	211	222	228	–	269	2
	242	282	–	–	2,1	6,5	211	–	–	285	299	2
220	273	245	11,1	6	2,1	3,7	231	242	249	–	289	2
	265	310	–	–	3	7,4	233	–	–	313	327	2,5
240	293	265	11,1	6	2,1	3,7	251	262	269	–	309	2
	285	330	–	–	3	7,4	253	–	–	333	347	2,5
260	326	292	13,9	7,5	2,1	4,5	271	288	296	–	349	2
	312	364	–	–	4	7,4	275	–	–	367	385	3
280	346	312	13,9	7,5	2,1	4,5	291	308	316	–	369	2
	332	384	–	–	4	12,4	295	–	–	387	405	3

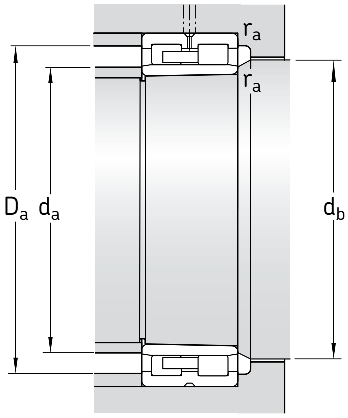
[1] s = permissible axial displacement from the normal position of one bearing ring in relation to the other

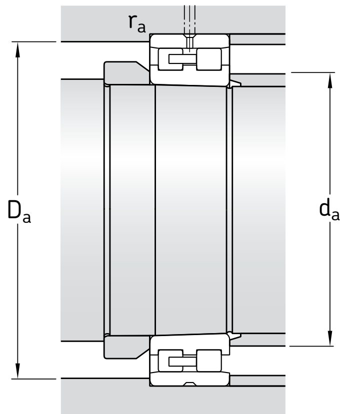
Double row cylindrical roller bearings
d **300 – 670** mm

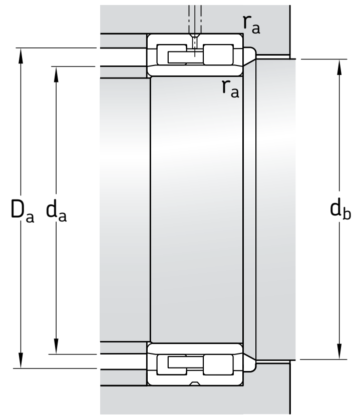


NNU 49 BK/W33 NN 30 K/W33 NNU 49 B/W33

Principal dimensions			**Basic load ratings**		**Fatigue load limit**	**Attainable speeds** when lubricating with		**Mass**	**Designations** Bearing with a tapered bore	cylindrical bore
d	D	B	dynamic C	static C_0	P_u	grease	oil-air			
mm			kN		kN	r/min		kg	–	–
300	420	118	1 020	2 360	224	1 800	2 000	48,0	**NNU 4960 BK/SPW33**	**NNU 4960 B/SPW33**
	460	118	1 250	2 400	228	1 700	1 900	66,5	**NN 3060 K/SPW33**	**–**
320	440	118	1 060	2 500	232	1 700	1 900	50,0	**NNU 4964 BK/SPW33**	**NNU 4964 B/SPW33**
	480	121	1 320	2 600	240	1 600	1 800	71,0	**NN 3064 K/SPW33**	**–**
340	460	118	1 100	2 650	245	1 500	1 700	53,0	**NNU 4968 BK/SPW33**	**NNU 4968 B/SPW33**
	520	133	1 650	3 250	290	1 400	1 600	94,5	**NN 3068 K/SPW33**	**–**
360	480	118	1 120	2 800	250	1 500	1 700	55,0	**NNU 4972 BK/SPW33**	**NNU 4972 B/SPW33**
	540	134	1 720	3 450	310	1 300	1 500	102	**NN 3072 K/SPW33**	**–**
380	520	140	1 450	3 600	320	1 300	1 500	83,5	**NNU 4976 BK/SPW33**	**NNU 4976 B/SPW33**
	560	135	1 680	3 450	305	1 300	1 500	105	**NN 3076 K/SPW33**	**–**
400	540	140	1 470	3 800	335	1 300	1 500	87,5	**NNU 4980 BK/SPW33**	**NNU 4980 B/SPW33**
	600	148	2 160	4 500	380	1 200	1 400	135	**NN 3080 K/SPW33**	**–**
420	560	140	1 510	4 000	345	1 200	1 400	91	**NNU 4984 BK/SPW33**	**NNU 4984 B/SPW33**
	620	150	2 120	4 500	380	1 100	1 300	140	**NN 3084 K/SPW33**	**–**
460	620	160	2 090	5 500	465	1 000	1 200	130	**NNU 4992 BK/SPW33**	**NNU 4992 B/SPW33**
	680	163	2 600	5 500	455	1 000	1 200	190	**NN 3092 K/SPW33**	**–**
500	670	170	2 330	6 100	510	950	1 100	165	**NNU 49/500 BK/SPW33X**	**NNU 49/500 B/SPW33X**
600	800	200	3 580	10 200	800	800	900	280	**NNU 49/600 BK/SPW33X**	**NNU 49/600 B/SPW33X**
670	900	230	4 950	13 700	930	700	800	410	**NNU 49/670 BK/SPW33X**	**NNU 49/670 B/SPW33X**





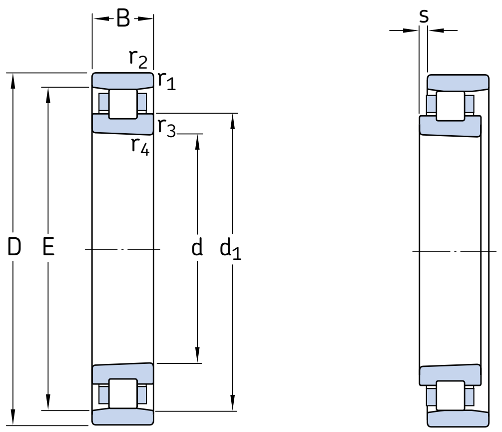


3.1

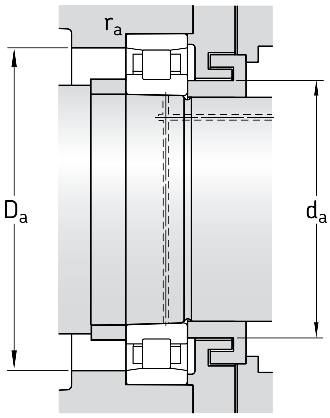
Dimensions							Abutment and fillet dimensions					
d	d_1, D_1 ~	E, F	b	K	$r_{1,2}$ min	s[1)]	d_a min	d_a max	d_b min	D_a min	D_a max	r_a max
mm							mm					
300	379	339	16,7	9	3	5,5	313	335	343	–	407	2,5
	360	418	16,7	9	4	8,9	315	–	–	421	445	3
320	399	359	16,7	9	3	5,5	333	355	363	–	427	2,5
	380	438	16,7	9	4	8,9	335	–	–	442	465	3
340	419	379	16,7	9	3	5,5	353	375	383	–	447	2,5
	409	473	16,7	9	5	10,9	358	–	–	477	502	4
360	439	399	16,7	9	3	5,5	373	395	403	–	467	2,5
	429	493	16,7	9	5	10,9	378	–	–	497	520	4
380	471	426	16,7	9	4	5,5	395	421	431	–	505	3
	449	513	16,7	9	5	11,9	398	–	–	517	542	4
400	491	446	16,7	9	4	5,5	415	441	451	–	524	3
	477	549	16,7	9	5	12,4	418	–	–	553	582	4
420	511	466	16,7	9	4	5,5	435	461	471	–	544	3
	497	569	16,7	9	5	12,4	438	–	–	574	602	4
460	565	510	16,7	9	4	3,2	475	504	515	–	605	3
	544	624	22,3	12	6	14,4	483	–	–	627	657	5
500	612	554	22,3	12	5	3,5	548	548	559	–	652	4
600	734	666	22,3	12	5	5,5	648	662	672	–	782	4
670	822	738	22,3	12	6	6	693	732	744	–	877	5

1) s = permissible axial displacement from the normal position of one bearing ring in relation to the other

Single row cylindrical roller bearings
d **40 – 100** mm



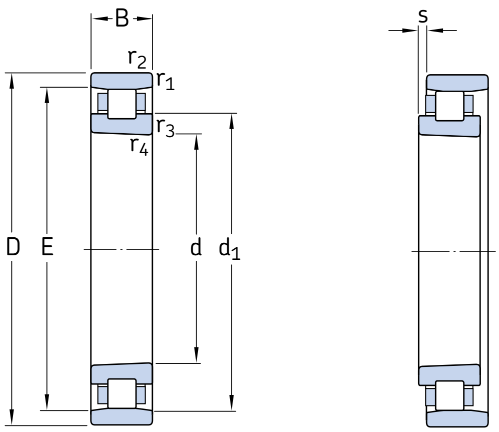
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Attainable speeds when lubricating with grease	oil-air	Mass	Designation Bearing with a tapered bore
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
40	68	15	25,1	28	3,2	15 000	17 000	0,19	**N 1008 KTN/SP**
	68	15	24,2	26,5	3,05	22 000	32 000	0,19	**N 1008 KTNHA/SP**
45	75	16	29,2	32,5	3,8	13 000	15 000	0,24	**N 1009 KTN/SP**
	75	16	28,1	31	3,65	20 000	28 000	0,24	**N 1009 KTNHA/SP**
50	80	16	30,8	36,5	4,25	12 000	14 000	0,26	**N 1010 KTN/SP**
	80	16	29,7	34,5	4,05	19 000	26 000	0,26	**N 1010 KTNHA/SP**
55	90	18	40,2	48	5,7	11 000	13 000	0,39	**N 1011 KTN/SP**
	90	18	39,1	46,5	5,5	17 000	24 000	0,39	**N 1011 KTNHA/SP**
60	95	18	42,9	53	6,3	10 000	12 000	0,42	**N 1012 KTN/SP**
	95	18	41,3	51	6,1	16 000	22 000	0,42	**N 1012 KTNHA/SP**
65	100	18	44,6	58,5	6,8	9 500	11 000	0,44	**N 1013 KTN/SP**
	100	18	44	56	6,55	15 000	20 000	0,44	**N 1013 KTNHA/SP**
70	110	20	57,2	75	8,65	9 000	10 000	0,62	**N 1014 KTN/SP**
	110	20	55	72	8,3	13 000	19 000	0,62	**N 1014 KTNHA/SP**
75	115	20	56,1	75	8,8	8 500	9 500	0,65	**N 1015 KTN/SP**
	115	20	55	72	8,5	13 000	18 000	0,65	**N 1015 KTNHA/SP**
80	125	22	69,3	93	11	8 000	9 000	0,89	**N 1016 KTN/SP**
	125	22	67,1	90	10,6	12 000	16 000	0,88	**N 1016 KTNHA/SP**
85	130	22	73,7	102	11,6	7 500	8 500	0,90	**N 1017 KTN9/SP**
	130	22	70,4	98	11,2	11 000	16 000	0,89	**N 1017 KTNHA/SP**
90	140	24	79,2	108	12,9	7 000	8 000	1,20	**N 1018 KTN9/SP**
	140	24	76,5	104	12,5	10 000	14 000	1,19	**N 1018 KTNHA/SP**
95	145	24	84,2	116	14	6 700	7 500	1,25	**N 1019 KTN9/SP**
	145	24	80,9	112	13,4	10 000	14 000	1,25	**N 1019 KTNHA/SP**
100	150	24	88	125	14,6	6 700	7 500	1,31	**N 1020 KTN9/SP**
	150	24	85,8	120	14,3	9 500	13 000	1,31	**N 1020 KTNHA/SP**



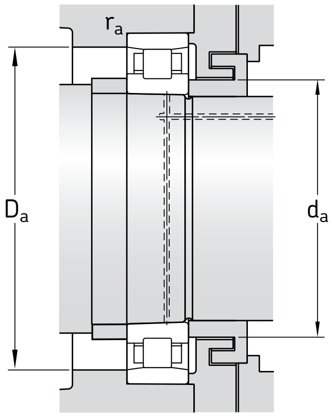
Dimensions						Abutment and fillet dimensions			
d	d_1 ~	E	$r_{1,2}$ min	$r_{3,4}$ min	s[1)]	d_a min	D_a min	D_a max	r_a max
mm						mm			
40	50,6	61	1	0,6	1,5	45	62	63	1
	50,6	61	1	0,6	1,5	45	62	63	1
45	56,3	67,5	1	0,6	1,5	50	69	70	1
	56,3	67,5	1	0,6	1,5	50	69	70	1
50	61,3	72,5	1	0,6	1,5	55	74	75	1
	61,3	72,5	1	0,6	1,5	55	74	75	1
55	68,2	81	1,1	0,6	1,5	61,5	82	83,5	1
	68,2	81	1,1	0,6	1,5	61,5	82	83,5	1
60	73,3	86,1	1,1	0,6	1,5	66,5	87	88,5	1
	73,3	86,1	1,1	0,6	1,5	66,5	87	88,5	1
65	78,2	91	1,1	0,6	1,5	71,5	92	93,5	1
	78,2	91	1,1	0,6	1,5	71,5	92	93,5	1
70	85,6	100	1,1	0,6	2	76,5	101	103,5	1
	85,6	100	1,1	0,6	2	76,5	101	103,5	1
75	90,6	105	1,1	0,6	2	81,5	106	108,5	1
	90,6	105	1,1	0,6	2	81,5	106	108,5	1
80	97	113	1,1	0,6	2	86,5	114	118,5	1
	97	113	1,1	0,6	2	86,5	114	118,5	1
85	102	118	1,1	0,6	2	91,5	119	123,5	1
	102	118	1,1	0,6	2	91,5	119	123,5	1
90	109	127	1,5	1	2	98	129	132	1,5
	109	127	1,5	1	2	98	129	132	1,5
95	114	132	1,5	1	2	103	134	137	1,5
	114	132	1,5	1	2	103	134	137	1,5
100	119	137	1,5	1	2	108	139	142	1,5
	119	137	1,5	1	2	108	139	142	1,5

[1)] s = permissible axial displacement from the normal position of one bearing ring in relation to the other

Single row cylindrical roller bearings
d **105 – 120** mm



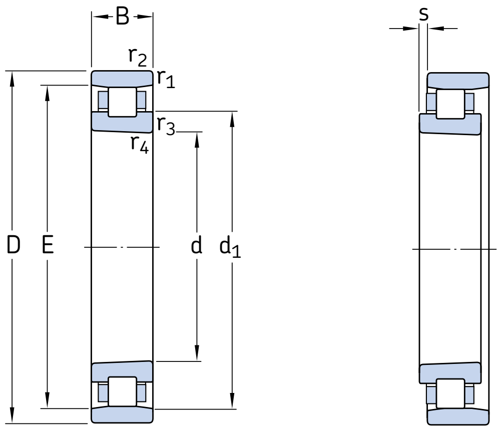
Principal dimensions			**Basic load ratings** dynamic static		**Fatigue load limit**	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designation** Bearing with a tapered bore
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
105	160	26	110	153	18	6 300	7 000	1,65	**N 1021 KTN9/SP**
	160	26	108	146	17,3	9 000	13 000	1,64	**N 1021 KTNHA/SP**
110	170	28	128	180	20,8	5 600	6 300	2,04	**N 1022 KTN9/SP**
	170	28	125	173	20	8 500	12 000	2,04	**N 1022 KTNHA/SP**
120	180	28	134	196	22	5 300	6 000	2,25	**N 1024 KTN9/SP**
	180	28	130	186	21,2	8 000	11 000	2,25	**N 1024 KTNHA/SP**



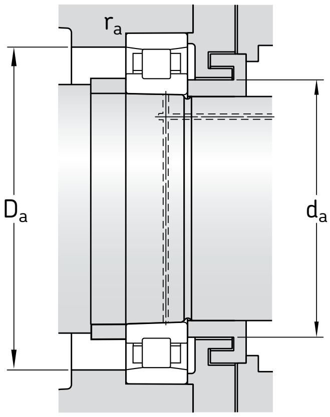
Dimensions						Abutment and fillet dimensions			
d	d_1 ~	E	$r_{1,2}$ min	$r_{3,4}$ min	s[1)]	d_a min	D_a min	D_a max	r_a max
mm						mm			
105	125	146	2	1,1	2	114	148	151	2
	125	146	2	1,1	2	114	148	151	2
110	132	155	2	1,1	3	119	157	161	2
	132	155	2	1,1	3	119	157	161	2
120	142	165	2	1,1	3	129	167	171	2
	142	165	2	1,1	3	129	167	171	2

1) s = permissible axial displacement from the normal position of one bearing ring in relation to the other

Hybrid single row cylindrical roller bearings
d **40 – 100** mm



Principal dimensions d	D	B	**Basic load ratings** dynamic C	static C_0	**Fatigue load limit** P_u	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designation** Bearing with a tapered bore
mm			kN		kN	r/min		kg	–
40	68	15	25,1	28	3,2	18 000	20 000	0,17	**N 1008 KTN/HC5SP**
	68	15	24,2	26,5	3,05	26 000	36 000	0,17	**N 1008 KTNHA/HC5SP**
45	75	16	29,2	32,5	3,8	16 000	18 000	0,22	**N 1009 KTN/HC5SP**
	75	16	28,1	31	3,65	22 000	32 000	0,21	**N 1009 KTNHA/HC5SP**
50	80	16	30,8	36,5	4,25	15 000	17 000	0,23	**N 1010 KTN/HC5SP**
	80	16	29,7	34,5	4,05	20 000	28 000	0,23	**N 1010 KTNHA/HC5SP**
55	90	18	40,2	48	5,7	13 000	15 000	0,35	**N 1011 KTN/HC5SP**
	90	18	39,1	46,5	5,5	19 000	26 000	0,35	**N 1011 KTNHA/HC5SP**
60	95	18	42,9	53	6,3	12 000	14 000	0,37	**N 1012 KTN/HC5SP**
	95	18	41,3	51	6,1	18 000	24 000	0,37	**N 1012 KTNHA/HC5SP**
65	100	18	44,6	58,5	6,8	11 000	13 000	0,39	**N 1013 KTN/HC5SP**
	100	18	44	56	6,55	17 000	22 000	0,39	**N 1013 KTNHA/HC5SP**
70	110	20	57,2	75	8,65	10 000	12 000	0,55	**N 1014 KTN/HC5SP**
	110	20	55	72	8,3	15 000	20 000	0,55	**N 1014 KTNHA/HC5SP**
75	115	20	56,1	75	8,8	9 500	11 000	0,57	**N 1015 KTN/HC5SP**
	115	20	55	72	8,5	14 000	20 000	0,57	**N 1015 KTNHA/HC5SP**
80	125	22	69,3	93	11	9 000	10 000	0,79	**N 1016 KTN/HC5SP**
	125	22	67,1	90	10,6	13 000	18 000	0,79	**N 1016 KTNHA/HC5SP**
85	130	22	73,7	102	11,6	9 000	10 000	0,80	**N 1017 KTN9/HC5SP**
	130	22	70,4	98	11,2	13 000	17 000	0,79	**N 1017 KTNHA/HC5SP**
90	140	24	79,2	108	12,9	8 500	9 500	1,08	**N 1018 KTN9/HC5SP**
	140	24	76,5	104	12,5	12 000	16 000	1,07	**N 1018 KTNHA/HC5SP**
95	145	24	84,2	116	14	8 000	9 000	1,12	**N 1019 KTN9/HC5SP**
	145	24	80,9	112	13,4	11 000	15 000	1,12	**N 1019 KTNHA/HC5SP**
100	150	24	88	125	14,6	7 500	8 500	1,17	**N 1020 KTN9/HC5SP**
	150	24	85,8	120	14,3	11 000	15 000	1,17	**N 1020 KTNHA/HC5SP**

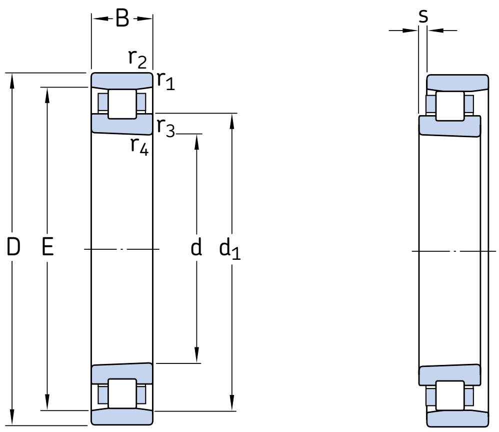


3.3

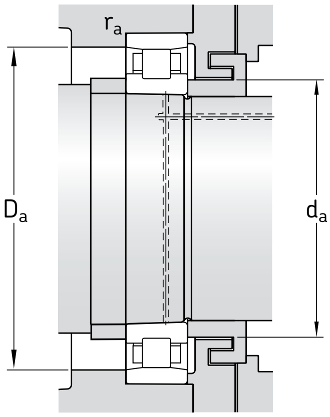
Dimensions						Abutment and fillet dimensions			
d	d_1 ~	E	$r_{1,2}$ min	$r_{3,4}$ min	s[1)]	d_a min	D_a min	D_a max	r_a max
mm						mm			
40	50,6	61	1	0,6	1,5	45	62	63	1
	50,6	61	1	0,6	1,5	45	62	63	1
45	56,3	67,5	1	0,6	1,5	50	69	70	1
	56,3	67,5	1	0,6	1,5	50	69	70	1
50	61,3	72,5	1	0,6	1,5	55	74	75	1
	61,3	72,5	1	0,6	1,5	55	74	75	1
55	68,2	81	1,1	0,6	1,5	61,5	82	83,5	1
	68,2	81	1,1	0,6	1,5	61,5	82	83,5	1
60	73,3	86,1	1,1	0,6	1,5	66,5	87	88,5	1
	73,3	86,1	1,1	0,6	1,5	66,5	87	88,5	1
65	78,2	91	1,1	0,6	1,5	71,5	92	93,5	1
	78,2	91	1,1	0,6	1,5	71,5	92	93,5	1
70	85,6	100	1,1	0,6	2	76,5	101	103,5	1
	85,6	100	1,1	0,6	2	76,5	101	103,5	1
75	90,6	105	1,1	0,6	2	81,5	106	108,5	1
	90,6	105	1,1	0,6	2	81,5	106	108,5	1
80	97	113	1,1	0,6	2	86,5	114	118,5	1
	97	113	1,1	0,6	2	86,5	114	118,5	1
85	102	118	1,1	0,6	2	91,5	119	123,5	1
	102	118	1,1	0,6	2	91,5	119	123,5	1
90	109	127	1,5	1	2	98	129	132	1,5
	109	127	1,5	1	2	98	129	132	1,5
95	114	132	1,5	1	2	103	134	137	1,5
	114	132	1,5	1	2	103	134	137	1,5
100	119	137	1,5	1	2	108	139	142	1,5
	119	137	1,5	1	2	108	139	142	1,5

[1)] s = permissible axial displacement from the normal position of one bearing ring in relation to the other

Hybrid single row cylindrical roller bearings
d **105– 120** mm



Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Attainable speeds when lubricating with grease	oil-air	Mass	Designation Bearing with a tapered bore
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
105	160	26	110	153	18	7 000	8 000	1,44	**N 1021 KTN9/HC5SP**
	160	26	108	146	17,3	10 000	14 000	1,44	**N 1021 KTNHA/HC5SP**
110	170	28	128	180	20,8	6 700	7 500	1,79	**N 1022 KTN9/HC5SP**
	170	28	125	173	20	9 500	13 000	1,78	**N 1022 KTNHA/HC5SP**
120	180	28	134	196	22	6 300	7 000	1,92	**N 1024 KTN9/HC5SP**
	180	28	130	186	21,2	9 000	12 000	1,92	**N 1024 KTNHA/HC5SP**



3.3

Dimensions						Abutment and fillet dimensions			
d	d_1 ~	E	$r_{1,2}$ min	$r_{3,4}$ min	s[1)]	d_a min	D_a min	D_a max	r_a max
mm						mm			
105	125	146	2	1,1	2	114	148	151	2
	125	146	2	1,1	2	114	148	151	2
110	132	155	2	1,1	3	119	157	161	2
	132	155	2	1,1	3	119	157	161	2
120	142	165	2	1,1	3	129	167	171	2
	142	165	2	1,1	3	129	167	171	2

1) s = permissible axial displacement from the normal position of one bearing ring in relation to the other

Double direction angular contact thrust ball bearings

Designs

Double direction angular contact thrust ball bearings were developed by SKF to axially locate spindles in both directions. These bearings are intended for mounting in combination with cylindrical roller bearings in the NN 30 K or N 10 K series in the same housing bore (→ **fig. 1**). This bearing combination simplifies machining of the housing bore.

Double direction angular contact thrust ball bearings are manufactured with the same bore size and nominal outside diameter as corresponding cylindrical roller bearings. However, the tolerance of the housing washer outside diameter, combined with the recommended housing fit (→ "Recommended shaft and housing fits" on **page 56**), results in an appropriate radial clearance in the housing bore. This clearance prevents radial loads from acting on the thrust bearing.

SKF manufactures double direction angular contact ball bearings to three different designs

- basic design, 2344(00) series
- high-speed design, BTM series
- hybrid design.

Basic design bearings, 2344(00) series

Bearings in the 2344(00) series (→ **fig. 2**) are separable and consist of

- a one-piece housing washer
- two ball and cage assemblies with a large number of balls
- two shaft washers separated by a spacer sleeve.

When mounted, these bearings become preloaded. The preload, combined with the 60° contact angle and the large number of balls provides a high degree of axial stiffness. Their optimized cage design makes these bearings suitable for relatively high-speed applications.

To facilitate efficient lubrication, the bearings have an annular groove and three lubrication holes in the housing washer.

Fig. 1

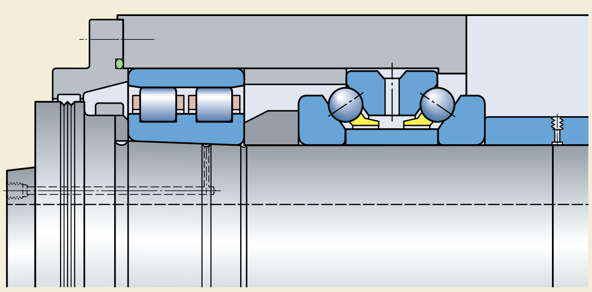
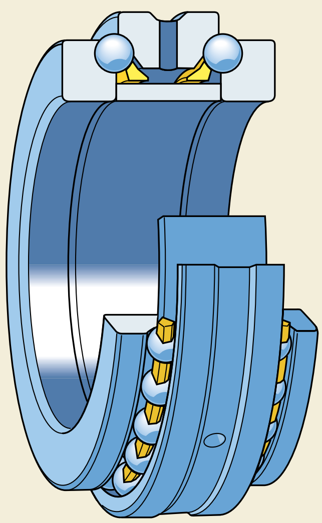


Fig. 2



High-speed design bearings, BTM series

Bearings in the BTM series (→ **fig. 3**) conform in design to two non-separable single row angular contact ball bearings arranged back-to-back, to carry thrust loads in both directions. When mounted, the bearings become preloaded.

These high-speed design bearings are fitted with the same ball and cage assemblies as basic design bearings in the 2344(00) series and are available with

- a 30° contact angle, BTM .. A/DB series, or
- a 40° contact angle, BTM .. B/DB series.

They have the same bore and outside diameter as bearings in the 2344(00) series, but a 25 % lower bearing height (→ **fig. 4**), which makes them particularly suitable for very compact arrangements. They do not have the same high load carrying capacity and axial stiffness as bearings in the 2344(00) series, but can operate at higher speeds.

Since bearings in the BTM series are only intended to accommodate axial loads, their axial load carrying capacity is quoted in the bearing tables. However, by ISO definition they are radial bearings, by virtue of having a 30° or 40° contact angle.

Hybrid bearings

SKF recommends the use of hybrid bearings instead of all-steel bearings for arrangements with particularly high engineering demands concerning

- speed capability
- stiffness
- service life.

SKF can supply basic design as well as high-speed design bearings equipped with ceramic balls. These hybrid bearings are identified by the suffix HC, e.g. BTM 65 A/HCP4CDBA.

The data for hybrid high-speed design bearings are listed in the product tables, starting on **page 236**. Details about the advantages offered by the ceramic material can be found in the section “Materials”, starting on **page 46**.

4

Fig. 3

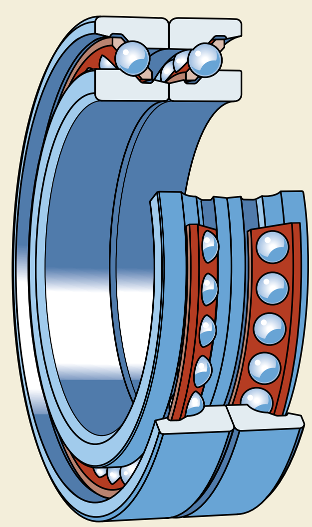
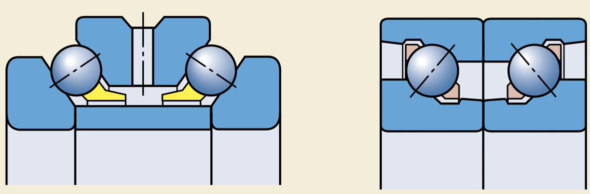


Fig. 4



Bearing markings

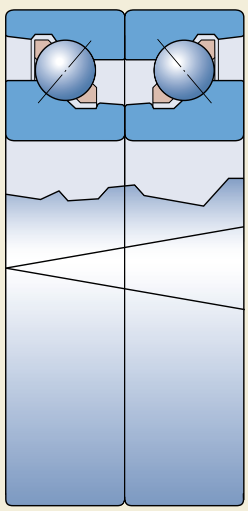
Each bearing is marked with its complete designation. The bearing washers carry additional markings to simplify mounting.

Basic bearings in the 2344(00) series are separable and should always be mounted in the order indicated by the markings so that the shaft washers and spacer are positioned correctly in relation to the housing washer. In addition, the serial number of the bearing is marked on its components – i.e. shaft washers, spacer and housing washer – to prevent mixing components from other bearings.

High-speed design bearings in the BTM series are non-separable single row bearings matched back-to-back and supplied in sets of two. The serial number of the set is marked on the side face of both inner rings to prevent mixing with other bearings. Each bearing in a set is marked with the complete designation of the bearing set. In addition, the actual deviation of the bore diameter from nominal is marked on the inner ring side face; this is to facilitate the selection of the bearing with the appropriate bore diameter in order to obtain the desired fit after mounting.

To facilitate appropriate mounting of the matched set, the outer ring outside diameter surfaces have a "V-shaped" marking (→ **fig. 5**). The bearings should be arranged in the order indicated by the "V-shaped" marking to perform properly.

Fig. 5



Bearing data – general

Dimensions

The dimensions of SKF double direction angular contact thrust ball bearings are not standardized but are generally accepted by the market. The bore and outside diameters of bearings in the 2344(00) and BTM series correspond to Diameter Series 0 for radial bearings and are in accordance with ISO 15:1998.

Tolerances

Basic design angular contact thrust ball bearings in the 2344(00) series are made to SP (Special Precision) tolerance class as standard. Bearings made to the UP (Ultra Precision) higher tolerance class can be supplied to order.

SKF high-speed design angular contact thrust ball bearings in the BTM series are made to P4C tolerance class, which differs from SP tolerance class. The bore diameter of bearings in the BTM series is considerably tighter and follows UP tolerance class for radial bearings.

Hybrid double direction angular contact thrust ball bearings are made to the same tolerances as corresponding all-steel bearings.

The tolerance values are listed

- for SP tolerance class in **table 1**
- for UP tolerance class in **table 1**
- for P4C tolerance class in **table 2** on **page 232.**

The symbols used in the tolerance tables are listed in **table 3** on **pages 44** and **45**, together with their definitions.

Table 1

Class SP and UP tolerances for double direction angular contact thrust ball bearings, 2344(00) series

Shaft washer and bearing height

d		Class SP tolerances Δ_{ds}		S_i [1]	Δ_{T2s}		Class UP tolerances Δ_{ds}		S_i [1]	Δ_{T2s}	
over	incl.	high	low	max	high	low	high	low	max	high	low
mm		µm		µm	µm		µm		µm	µm	
18	**30**	+1	–9	3	+50	–80	0	–6	1,5	+50	–80
30	**50**	+1	–11	3	+60	–100	0	–8	1,5	+60	–100
50	**80**	+2	–14	4	+70	–120	0	–9	2	+70	–120
80	**120**	+3	–18	4	+85	–140	0	–10	2	+85	–140
120	**180**	+3	–21	5	+95	–160	0	–13	3	+95	–160
180	**250**	+4	–26	5	+120	–200	0	–15	3	+120	–200

[1] The quoted tolerances are approximate, as raceway runout is measured in the direction of the ball load. When the bearing has been mounted, axial runout is generally smaller than what is quoted in the table.

Housing washer

D		Class SP tolerances Δ_{Ds}		Δ_{Cs}		S_e	Class UP tolerances Δ_{Ds}		Δ_{Cs}		S_e
over	incl.	high	low	high	low		high	low	high	low	
mm		µm		µm		µm	µm		µm		µm
30	**50**	–20	–27	0	–60	Values are identical to those of the shaft washer of the same bearing	–20	–27	0	–60	Values are identical to those of the shaft washer of the same bearing
50	**80**	–24	–33	0	–60		–24	–33	0	–60	
80	**120**	–28	–38	0	–60		–28	–38	0	–60	
120	**150**	–33	–44	0	–60		–33	–44	0	–60	
150	**180**	–33	–46	0	–60		–33	–46	0	–60	
180	**250**	–37	–52	0	–60		–37	–52	0	–60	
250	**315**	–41	–59	0	–60		–41	–59	0	–60	

4

Table 2

Class P4C tolerances for double direction angular contact thrust ball bearings, BTM series

Inner ring

d		Δ_{ds}		S_i[1)]	Δ_{B1s}	
over	incl.	high	low	max	high	low
mm		µm				
50	**80**	0	–7	3	0	–100
80	**120**	0	–8	4	0	–200
120	**180**	0	–10	4	0	–250

1) The tolerance values quoted are approximate, as raceway runout is measured in the direction of the ball load. When the bearing has been mounted, axial runout is generally smaller than what is quoted in the table.

Outer ring

D		Δ_{Ds}		Δ_{C1s}		S_e
over	incl.	high	low	high	low	
mm		µm				
80	**120**	-28	–38	0	–100	Values are identical to those of the inner ring of the same bearing
120	**150**	-33	–44	0	–200	
150	**180**	-33	–46	0	–250	
180	**250**	-37	–52	0	–250	

Preload

Double direction angular contact thrust ball bearings are manufactured as standard with a predetermined preload so that they will have a suitable operational preload after mounting.

The preload of basic design bearings in the 2344(00) series is adjusted by setting the width of the spacer sleeve.

The preload of high-speed design bearings in the BTM series, is obtained during manufacturing by precisely adjusting the standout of the inner rings versus the outer rings of the bearing set. Bearings in the BTM series are available with

- a light preload, designation suffix DBA
- a heavy preload, designation suffix DBB.

The preload values listed in **tables 3** and **4** apply to new bearings before mounting. Bearing components and bearing sets must be kept together as supplied and mounted in the indicated order.

Effect of an interference fit on the preload

The preload values listed in **tables 3** and **4** apply to bearings before mounting. When mounted, preload will increase. The main reasons for this are:

- When adjusting particularly thin-walled washers and spacers (2344(00) series) or inner rings (BTM series) against each other on a shaft, they cannot decrease in diameter, compared to measuring preload in unmounted condition.
- When fitting a bearing on a shaft, the interference fit between the shaft and shaft washers (2344(00) series) or inner rings (BTM series) respectively, causes the raceways to expand.

Double direction angular contact thrust ball bearings are usually fitted to shaft seats machined to h4 tolerance. This results in a transition fit that can be either an interference fit or a loose fit. If interference occurs, the radial preload will increase. The relation between the axial preload and radial (diametrical) preload increase can be expressed as

$$\delta_a = \frac{\delta_r}{\tan\alpha}$$

where
δ_a = axial preload increase, µm
δ_r = radial preload increase, µm
α = bearing contact angle, degrees
- 30°: $\tan\alpha$ = 0,58
- 40°: $\tan\alpha$ = 0,84
- 60°: $\tan\alpha$ = 1,73

For additional information, contact the application engineering service.

When there is a loose fit there is no need to compensate for mounted preload.

Table 3

Axial preload of double direction angular contact thrust ball bearings, 2344(00) series

Bore diameter d	Axial preload	Bore diameter d	Axial preload
mm	kN	mm	kN
40	0,36	**100**	0,69
45	0,39	**105**	0,71
50	0,415	**110**	0,735
55	0,44	**120**	0,8
60	0,47	**130**	0,87
65	0,49	**140**	0,94
70	0,515	**150**	1,015
75	0,545	**160**	1,1
80	0,575	**170**	1,185
85	0,60	**180**	1,29
90	0,625	**190**	1,385
95	0,655	**200**	1,525

Table 4

Axial preload of double direction angular contact thrust ball bearings, BTM series

Bore diameter d	Axial preload BTM .. A DBA	DBB	BTM .. B DBA	DBB
mm	kN		kN	
60	0,2	0,45	0,25	0,72
65	0,2	0,45	0,25	0,72
70	0,25	0,6	0,35	0,95
80	0,3	0,75	0,4	1,2
85	0,3	0,75	0,4	1,2
90	0,4	1	0,55	1,45
100	0,4	1	0,55	1,65
110	0,6	1,4	0,75	2,25
120	0,6	1,5	0,85	2,45
130	0,8	1,9	1,05	3

Cages

Depending on size, SKF double direction angular contact thrust ball bearings are equipped as standard (→ **fig. 6**) with either

- two separate machined brass cages, ball centred, designation suffix M1, or
- two separate injection moulded window-type cages of glass fibre reinforced polyamide 66, ball centred, designation suffix TN9.

The standard cage for bearings in the 2344(00) series is indicated in the product table designations. Bearings in the BTM series have polyamide cages as standard.

Bearings from both series may also be available with non-standard cages. Please check availability before ordering.

The cages enable the preloaded bearings to run reliably at high speeds and to withstand rapid starts and stops as well as alternating loads. They also provide good grease retention.

Bearings with polyamide cages can be operated without restriction at the temperatures normally encountered in machine tool operations up to a maximum of 120 °C. The lubricants generally used for rolling bearings have no detrimental effect on cage properties, with the exception of a few synthetic oils and greases with a synthetic oil base.

For detailed information about temperature resistance and applicability of cages refer to the section "Cage materials", starting on **page 47**.

Fig. 6

Attainable speeds

The "Attainable speeds" quoted in the product tables are guideline values and valid for bearings in the

- 2344(00) series with standard preload
- BTM series with light preload

provided they are fitted on a shaft machined to h4 tolerance, lightly loaded ($P \leq 0,05\ C$) and that heat dissipation from the bearing position is good.

For bearings in the BTM series with a heavy preload (designation suffix DBB), the actual values for "Attainable speeds" can be obtained by multiplying the values provided in the product tables by a factor of 0,55.

The guideline values provided in the product tables under "Oil-air lubrication" should be reduced for other oil lubrication methods. The values under "Grease lubrication" are maximum values, which can be attained using a high quality, soft consistency grease.

Equivalent dynamic bearing load

For double direction angular contact thrust ball bearings, which only accommodate axial loads,

$$P = F_a$$

Equivalent static bearing load

For double direction angular contact thrust ball bearings, which only accommodate axial loads,

$$P_0 = F_a$$

Designation system

The designation system for SKF double direction angular contact thrust ball bearings is shown in **table 5** together with the definitions.

Table 5

Designation system for double direction angular contact thrust ball bearings

Examples:										
234424 BM1/SP	2344	24		BM1	/		SP		
BTM 100 A/HCP4CDBA	BTM	100	A		/	HC	P4C	DB	A

Series
2344(00) Basic design bearings
BTM High-speed design bearings

Bearing size
2344(00) basic design bearings:
Size code of bearing × 5 = bore diameter
07 (×5) 35 mm bore diameter
to
40 (×5) 200 mm bore diameter

BTM high-speed design bearings:
in millimetres uncoded
60 60 mm bore diameter
to
130 130 mm bore diameter

Contact angle
– 60 degrees (no designation suffix)
A 30 degrees
B 40 degrees

Internal design and cages
B Modified internal design
M1 Machined brass cage, ball centred
TN9 Injection moulded window-type cage of glass fibre reinforced polyamide 66, ball centred (designation suffix TN9 is not indicated for bearings in the BTM series)

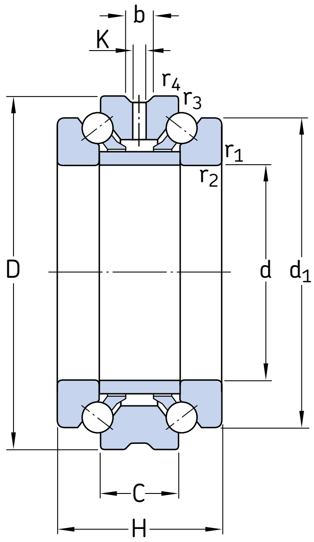
Material of the rolling elements
– Carbon chromium steel (no designation suffix)
HC Bearing grade silicon nitride (hybrid bearings)

Tolerances
P4C Dimensional accuracy approximately to ISO tolerance class 4 and running accuracy better than to ISO tolerance class 4 for radial bearings
SP Dimensional accuracy approximately to ISO tolerance class 5 and running accuracy approximately to ISO tolerance class 4 for thrust bearings
UP Dimensional accuracy approximately to ISO tolerance class 4 and running accuracy better than to ISO tolerance class 4 for thrust bearings

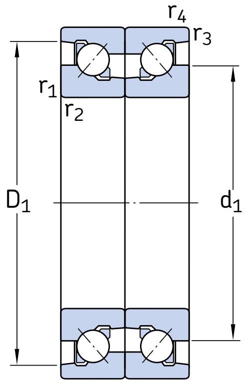
Bearing arrangement
DB Back-to-back arrangement; only valid for bearings in the BTM series

Preload
A Light preload
B Heavy preload
G.. Special preload, value in daN, e.g. G35

Double direction angular contact thrust ball bearings
d **35 – 95** mm



2344(00)

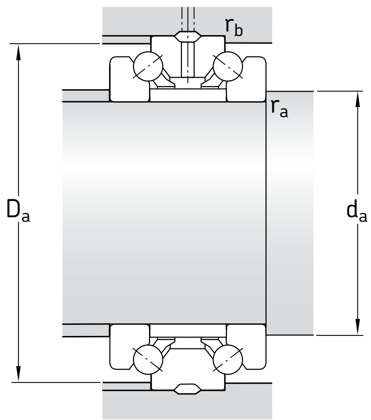


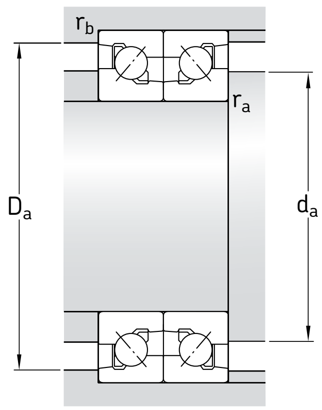
BTM

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Attainable speeds[1] when lubricating with grease	oil-air	Mass	Designation
d	D	H	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
35	62	34	18,6	49	1,83	10 000	13 000	0,38	**234407 BM1/SP**
40	68	36	21,6	60	2,24	9 500	12 000	0,46	**234408 BM1/SP**
45	75	38	24,7	71	2,6	9 000	11 000	0,58	**234409 BM1/SP**
50	80	38	25,5	78	2,85	8 500	10 000	0,62	**234410 BM1/SP**
55	90	44	33,8	104	3,8	7 000	8 500	0,94	**234411 BM1/SP**
60	95	33	23,6	47,5	2,04	9 000	12 000	0,77	**BTM 60 A/P4CDB**
	95	33	28	54	2,32	8 000	10 000	0,77	**BTM 60 B/P4CDB**
	95	44	34,5	108	4	7 000	8 500	1,00	**234412 TN9/SP**
65	100	33	24,5	52	2,2	8 500	11 000	0,82	**BTM 65 A/P4CDB**
	100	33	29	58,5	2,5	7 500	9 500	0,82	**BTM 65 B/P4CDB**
	100	44	35,8	116	4,3	6 700	8 000	1,05	**234413 TN9/SP**
70	110	36	30	64	2,75	8 000	10 000	1,12	**BTM 70 A/P4CDB**
	110	36	35,5	73,5	3,1	7 000	9 000	1,12	**BTM 70 B/P4CDB**
	110	48	43,6	143	5,3	6 300	7 500	1,45	**234414 TN9/SP**
75	115	48	44,2	150	5,6	6 000	7 000	1,55	**234415 BM1/SP**
80	125	40,5	36,5	81,5	3,4	7 000	9 000	1,60	**BTM 80 A/P4CDB**
	125	40,5	44	93	3,8	6 000	7 500	1,60	**BTM 80 B/P4CDB**
	125	54	54	180	6,55	5 300	6 300	2,10	**234416 TN9/SP**
85	130	40,5	36,5	85	3,45	6 700	8 500	1,70	**BTM 85 A/P4CDB**
	130	40,5	44	96,5	3,9	5 600	7 500	1,70	**BTM 85 B/P4CDB**
	130	54	54	190	6,7	5 300	6 300	2,20	**234417 TN9/SP**
90	140	45	44	98	3,9	6 300	8 000	2,30	**BTM 90 A/P4CDB**
	140	45	51	112	4,5	5 300	7 000	2,30	**BTM 90 B/P4CDB**
	140	60	62,4	220	7,65	4 800	5 600	3,00	**234418 TN9/SP**
95	145	60	63,7	232	7,8	4 800	5 600	3,05	**234419 BM1/SP**

[1] Speeds for BTM series bearings are applicable to those with a light preload (suffix DBA).
See the section “Attainable speeds” on **page 234**

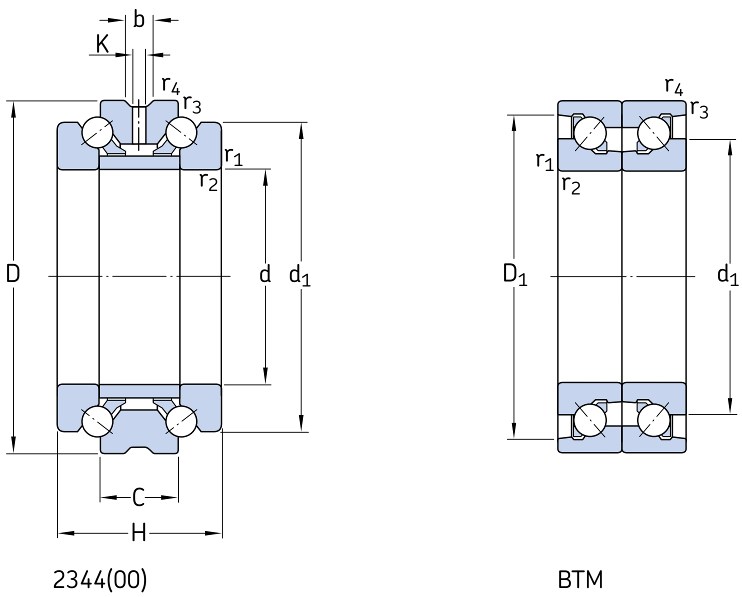
SKF





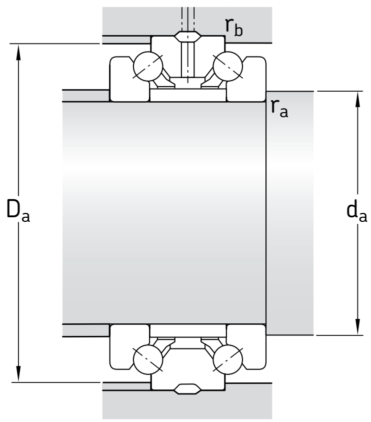
Dimensions								**Abutment and fillet dimensions**			
d	d_1 ~	C	D_1	b	K	$r_{1,2}$ min	$r_{3,4}$ min	d_a min	D_a min	r_a max	r_b max
mm								mm			
35	53	17	–	5,5	3	1	0,15	45	58	1	0,1
40	58,5	18	–	5,5	3	1	0,15	50	64	1	0,1
45	65	19	–	5,5	3	1	0,15	56	71	1	0,1
50	70	19	–	5,5	3	1	0,15	61	76	1	0,1
55	78	22	–	5,5	3	1,1	0,3	68	85	1	0,3
60	75,9	–	89	–	–	1,1	0,6	67	89	1	0,6
	75,9	–	89	–	–	1,1	0,6	67	89	1	0,6
	83	22	–	5,5	3	1,1	0,3	73	90	1	0,3
65	80,9	–	84,3	–	–	1,1	0,6	75	94	1	0,6
	80,9	–	84,3	–	–	1,1	0,6	75	94	1	0,6
	88	22	–	5,5	3	1,1	0,3	78	95	1	0,3
70	88,6	–	103,6	–	–	1,1	0,6	82	104	1	0,6
	88,6	–	103,6	–	–	1,1	0,6	82	104	1	0,6
	97	24	–	5,5	3	1,1	0,3	85	105	1	0,3
75	102	24	–	5,5	3	1,1	0,3	90	110	1	0,3
80	100	–	115	–	–	1,1	0,6	89	117	1	0,6
	100	–	115	–	–	1,1	0,6	89	117	1	0,6
	110	27	–	8,3	4,5	1,1	0,3	97	119	1	0,3
85	105,8	–	123,2	–	–	1,1	0,6	98	124	1	0,6
	105,8	–	123,2	–	–	1,1	0,6	98	124	1	0,6
	115	27	–	8,3	4,5	1,1	0,3	102	124	1	0,3
90	113	–	132	–	–	1,5	1	104	132	1,5	1
	113	–	132	–	–	1,5	1	104	132	1,5	1
	123	30	–	8,3	4,5	1,5	0,3	109	132	1,5	0,3
95	128	30	–	8,3	4,5	1,5	0,3	114	137	1,5	0,3

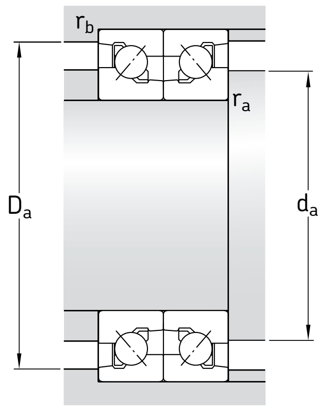
Double direction angular contact thrust ball bearings
d **100 – 200** mm



Principal dimensions			Basic load ratings		Fatigue load limit	Attainable speeds[1] when lubricating with		Mass	Designation
			dynamic	static		grease	oil-air		
d	D	H	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
100	150	45	45,5	110	4,25	5 600	7 000	2,40	**BTM 100 A/P4CDB**
	150	45	54	129	4,8	5 000	6 300	2,40	**BTM 100 B/P4CDB**
	150	60	66,3	245	8,15	4 800	5 600	3,15	**234420 TN9/SP**
105	160	66	74,1	275	8,8	4 300	5 000	4,05	**234421 BM1/SP**
110	170	54	63	153	5,3	5 000	6 300	3,90	**BTM 110 A/P4CDB**
	170	54	73,5	173	6,2	4 300	5 700	3,90	**BTM 110 B/P4CDB**
	170	72	92,3	335	10,4	4 000	4 800	5,05	**234422 BM1/SP**
120	180	54	65,5	163	5,6	4 500	6 000	4,35	**BTM 120 A/P4CDB**
	180	54	78	186	6,4	4 000	5 300	4,35	**BTM 120 B/P4CDB**
	180	72	93,6	360	10,8	3 800	4 500	5,70	**234424 TN9/SP**
130	200	63	81,5	208	6,8	4 300	5 300	6,25	**BTM 130 A/P4CDB**
	200	63	96,5	236	7,65	3 600	4 800	6,25	**BTM 130 B/P4CDB**
	200	84	117	455	13,2	3 400	4 000	8,15	**234426 TN9/SP**
140	210	84	117	475	13,2	3 200	3 800	8,65	**234428 BM1/SP**
150	225	90	140	570	15,3	3 000	3 600	10,5	**234430 BM1/SP**
160	240	96	156	640	16,6	2 800	3 400	14,0	**234432 BM1/SP**
170	260	108	195	780	19,6	2 400	3 000	17,5	**234434 BM1/SP**
180	280	120	225	915	22,4	2 000	2 600	23,0	**234436 BM1/SP**
190	290	120	225	950	22,8	2 000	2 600	24,0	**234438 BM1/SP**
200	310	132	265	1 100	25,5	1 900	2 400	31,0	**234440 BM1/SP**

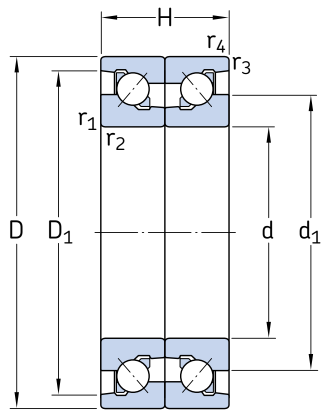
[1] Speeds for BTM series bearings are applicable to those with a light preload (suffix DBA).
See the section "Attainable speeds" on **page 234**





Dimensions								Abutment and fillet dimensions			
d	d_1 ~	C	D_1	b	K	$r_{1,2}$ min	$r_{3,4}$ min	d_a min	D_a min	r_a max	r_b max
mm								mm			
100	123	–	142	–	–	1,5	1	114	142	1,5	1
	123	–	142	–	–	1,5	1	114	142	1,5	1
	133	30	–	8,3	4,5	1,5	0,3	119	142	1,5	0,3
105	142	33	–	8,3	4,5	2	0,6	125	151	2	0,6
110	138	–	155	–	–	2	1	127	155	2	1
	138	–	155	–	–	2	1	127	155	2	1
	150	36	–	8,3	4,5	2	0,6	132	161	2	0,6
120	148	–	170	–	–	2	1	128	170	2	1
	148	–	170	–	–	2	1	128	170	2	1
	160	36	–	8,3	4,5	2	0,6	142	171	2	0,6
130	162	–	188	–	–	2	1	150	188	2	1
	162	–	188	–	–	2	1	150	188	2	1
	177	42	–	11,1	6	2	0,6	156	190	2	0,6
140	187	42	–	11,1	6	2,1	0,6	166	200	2	0,6
150	200	45	–	13,9	7,5	2,1	0,6	178	213	2	0,6
160	212	48	–	13,9	7,5	2,1	0,6	190	227	2	0,6
170	230	54	–	13,9	7,5	2,1	0,6	204	246	2	0,6
180	248	60	–	16,7	9	2,1	0,6	214	264	2	0,6
190	258	60	–	16,7	9	2,1	0,6	224	274	2	0,6
200	274	66	–	16,7	9	2,1	0,6	236	292	2	0,6

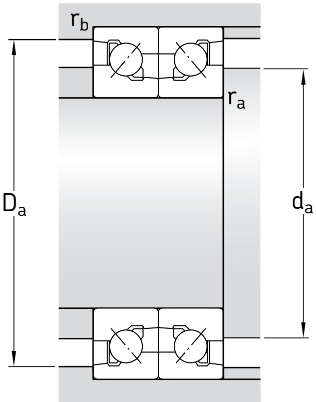
Hybrid double direction angular contact thrust ball bearings
d **60 – 130** mm



BTM

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Attainable speeds[1] when lubricating with grease	oil-air	Mass	Designation
d	D	H	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
60	95	33	23,6	47,5	2,04	11 000	14 000	0,77	**BTM 60 A/HCP4CDB**
	95	33	28	54	2,32	9 500	12 000	0,77	**BTM 60 B/HCP4CDB**
65	100	33	24,5	52	2,2	10 000	13 000	0,82	**BTM 65 A/HCP4CDB**
	100	33	29	58,5	2,5	9 000	11 000	0,82	**BTM 65 B/HCP4CDB**
70	110	36	30	64	2,75	9 500	12 000	1,05	**BTM 70 A/HCP4CDB**
	110	36	35,5	73,5	3,1	8 500	10 000	1,05	**BTM 70 B/HCP4CDB**
80	125	40,5	36,5	81,5	3,4	8 000	10 000	1,60	**BTM 80 A/HCP4CDB**
	125	40,5	44	93	3,8	7 500	9 000	1,60	**BTM 80 B/HCP4CDB**
85	130	40,5	36,5	85	3,45	8 000	10 000	1,70	**BTM 85 A/HCP4CDB**
	130	40,5	44	96,5	3,9	7 000	8 500	1,70	**BTM 85 B/HCP4CDB**
90	140	45	44	98	3,9	7 000	9 500	2,30	**BTM 90 A/HCP4CDB**
	140	45	51	112	4,5	6 300	8 000	2,30	**BTM 90 B/HCP4CDB**
100	150	45	45,5	110	4,25	6 700	8 500	2,40	**BTM 100 A/HCP4CDB**
	150	45	54	129	4,8	6 000	7 500	2,40	**BTM 100 B/HCP4CDB**
110	170	54	63	153	5,3	6 000	7 500	3,90	**BTM 110 A/HCP4CDB**
	170	54	73,5	173	6,2	5 300	6 700	3,90	**BTM 110 B/HCP4CDB**
120	180	54	65,5	163	5,6	5 600	7 000	4,35	**BTM 120 A/HCP4CDB**
	180	54	78	186	6,4	5 000	6 000	4,35	**BTM 120 B/HCP4CDB**
130	200	63	81,5	208	6,8	5 000	6 300	6,25	**BTM 130 A/HCP4CDB**
	200	63	96,5	236	7,65	4 500	5 600	6,25	**BTM 130 B/HCP4CDB**

[1] Speeds for BTM series bearings are applicable to those with a light preload (suffix DBA).
See the section “Attainable speeds” on **page 234**



4.2

Dimensions					Abutment and fillet dimensions			
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	d_a min	D_a min	r_a max	r_b max
mm					mm			
60	75,9	89	1,1	0,6	70	90	1	0,6
	75,9	89	1,1	0,6	70	90	1	0,6
65	80,9	94,3	1,1	0,6	75	94	1	0,6
	80,9	94,3	1,1	0,6	75	94	1	0,6
70	88,6	104	1,1	0,6	82	104	1	0,6
	88,6	104	1,1	0,6	82	104	1	0,6
80	100	115	1,1	0,6	89	117	1	0,6
	100	115	1,1	0,6	89	117	1	0,6
85	105	124	1,1	0,6	98	124	1	0,6
	105	124	1,1	0,6	98	124	1	0,6
90	113	132	1,5	0,6	104	132	1,5	0,6
	113	132	1,5	0,6	104	132	1,5	0,6
100	123	142	1,5	0,6	114	142	1,5	0,6
	123	142	1,5	0,6	114	142	1,5	0,6
110	138	155	2	1	127	155	2	1
	138	155	2	1	127	155	2	1
120	148	170	2	1	128	170	2	1
	148	170	2	1	128	170	2	1
130	162	188	2	1	150	188	2	1
	162	188	2	1	150	188	2	1

Angular contact thrust ball bearings for screw drives

Overview

Machine tools require screw drives that can position a workpiece or machine component quickly, efficiently and precisely. To meet these requirements, screw drives are usually supported at both ends by high-precision bearings that can provide a high degree of stiffness. In addition, these bearings may also have to accommodate high accelerations and high speeds. To meet all of these operating conditions, SKF has adapted bearings specifically for screw drive applications.

SKF bearings for screw drives are single or double direction angular contact thrust ball bearings that are available in numerous designs and sizes. In addition to the single direction angular contact thrust ball bearings that were originally designed for screw drives (→ **fig. 1**), the SKF assortment also includes double direction bearings that can be inserted in a housing bore (→ **fig. 2**) or bolted to a machine wall (→ **fig. 3**). They are also available as cartridge units with a flanged housing that is ready for installation (→ **fig. 4**).

The characteristic properties of SKF angular contact thrust ball bearings for screw drives include

- high axial load carrying capacity
- high axial stiffness
- very high running accuracy
- low frictional moment
- excellent performance characteristics at high speeds and accelerations.

These properties make SKF angular contact thrust ball bearings suitable for screw drives and other bearing arrangements where safe radial and axial support is required together with extremely precise axial guidance of the shaft.

Fig. 1

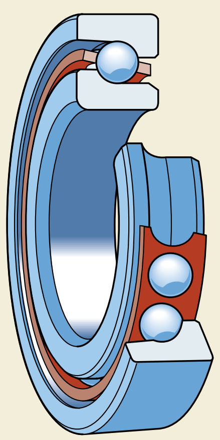
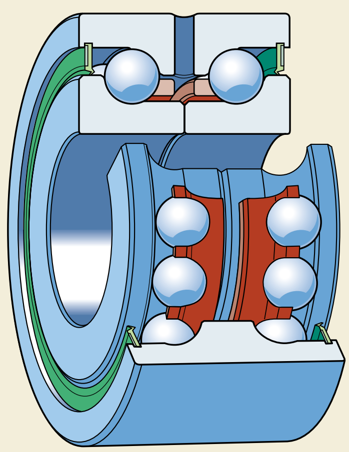


Fig. 2



Single direction angular contact thrust ball bearings

Single direction SKF angular contact thrust ball bearings (→ **fig. 1**) correspond in design to single-row radial angular contact ball bearings. They are non-separable. Key features include

- 60° contact angle
- particularly close osculation between the balls and raceways
- robust, window-type, polyamide 66 cage for an optimum number of balls
- universally matchable design is standard: matchable in any order, in sets with up to four bearings.

These bearings undergo a unique heat treatment, that provides a balance between service life and dimensional stability. As a result, preload, stiffness and frictional moment remain relatively constant throughout the life of the bearing, making it suitable for high speeds and accelerations.

Single direction angular contact thrust ball bearings only accommodate axial loads in one direction and are therefore adjusted against a second bearing or mounted as bearing sets.

Bearings for single bearing arrangements

Single direction SKF angular contact thrust ball bearings for screw drives are only produced as universally matchable bearings but they can also be used for bearing arrangements with only one bearing in each position.

Fig. 3

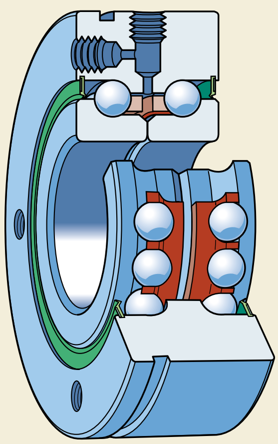
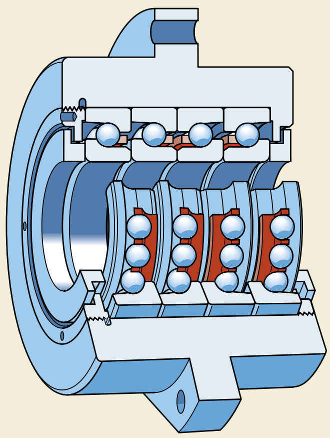


Fig. 4



Universally matchable bearings for mounting as sets

Standard single direction SKF angular contact thrust ball bearings for screw drives are universally matchable bearings for mounting as sets with up to four bearings per set. The bearings are specifically manufactured so that when mounted in random order, but immediately adjacent to each other, a given preload or an even load distribution will be obtained without the use of shims or similar devices. They have very tight tolerances for the bore and outside diameter as well as for radial runout.

Back-to-back bearing arrangements

For back-to-back arrangements (→ **fig. 5a**), the load lines diverge toward the bearing axis. Axial loads acting in both directions can be accommodated, but only by one bearing in each direction. Bearings mounted back-to-back provide a relatively stiff bearing arrangement that can also accommodate tilting moments.

Face-to-face bearing arrangements

In face-to-face arrangements (→ **fig. 5b**), the load lines converge toward the bearing axis. Axial loads acting in both directions can be accommodated, but only by one bearing in each direction. Bearing sets in face-to-face arrangements are less suited to accommodate tilting moments than those in a back-to-back arrangement.

Tandem bearing arrangements

In a tandem arrangement (→ **fig. 5c**), the load lines are parallel to each other. In this arrangement, the radial and axial loads are equally shared by the bearings. The bearing set can only accommodate axial loads acting in one direction and is therefore typically used with a third bearing or another bearing set that accommodates the axial loads in the opposite direction.

Other bearing arrangements

Combinations of tandem arrangements with back-to-back or face-to-face arrangements (→ **fig. 6**) are usually selected to maximize the stiffness or load carrying ability of a bearing set in a particular direction. This is the case for example when extended, preloaded, vertical or overhung screw drives must be supported.

Universally matchable bearings can be used for all combinations as per **fig. 6**. Universally matchable bearings have the designation suffix G, followed by the symbol for the preload class A or B, e.g. BSD 2047 CGA. They are also marked "MATCHABLE". A "V-shaped" marking on the outer ring outside surface indicates the direction of the contact angle (→ **fig. 6**). This marking also facilitates correct bearing assembly in relation to the axial load. The "V-shaped" marking should point in the direction from which the axial load will act on the inner ring.

When ordering these bearings, it is necessary to state the number of individual bearings required and not the number of sets.

Fig. 5

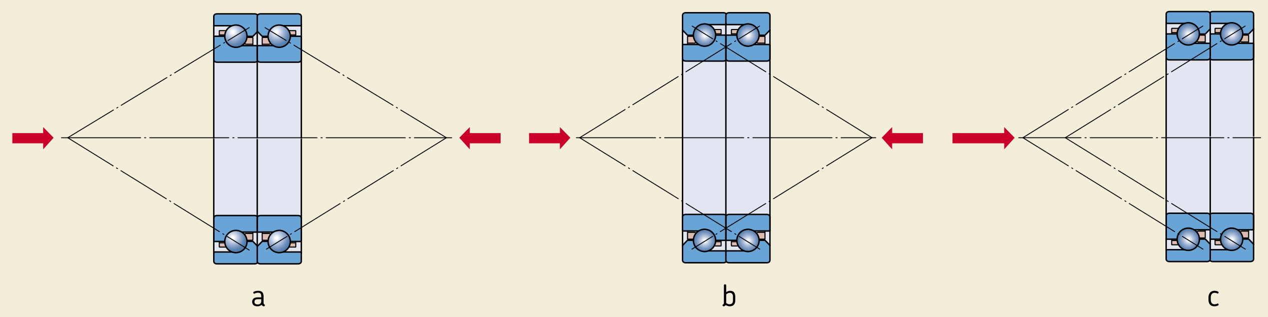
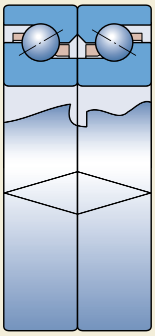
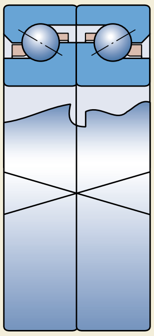


Fig. 6

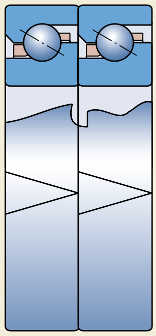
Bearing sets with 2 bearings



Back-to-back arrangement (DB[1])

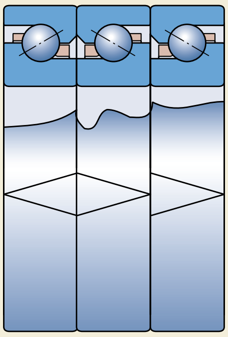


Face-to-face arrangement (DF[1])

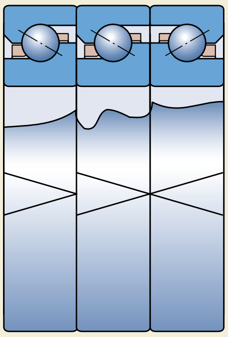


Tandem arrangement (DT[1])

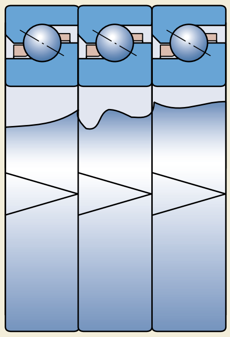
Bearing sets with 3 bearings



Back-to-back and tandem arrangement (TBT[1])

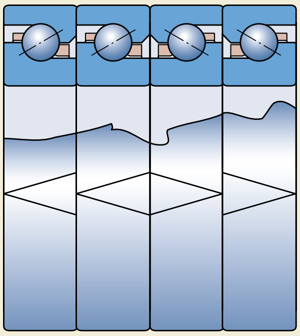


Tandem and face-to-face arrangement (TFT[1])

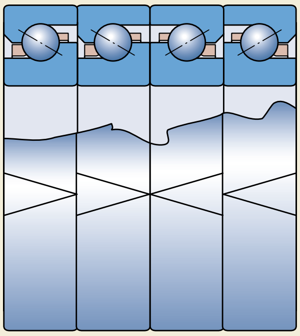


Tandem arrangement (TT[1])

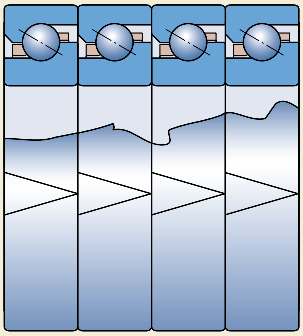
Bearing sets with 4 bearings



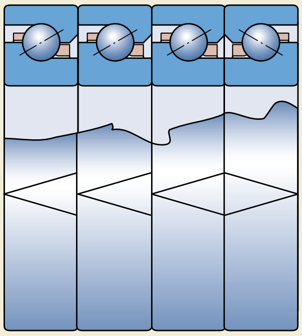
Back-to-back arrangement (QBC[1])



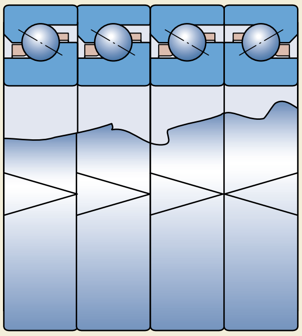
Face-to-face arrangement (QFC[1])



Tandem arrangement (QT[1])



Tandem and back-to-back arrangement (QBT[1])



Tandem and face-to-face arrangement (QFT[1])

[1] Designation suffix for matched bearing sets

Matched bearing sets

Single direction SKF angular contact thrust ball bearings can be supplied on request as matched bearing sets comprising two, three or four bearings. Matched bearing sets can be supplied in the same arrangements as described for universally matchable bearings (→ **fig. 6**, **page 247**). Bearing sets can be supplied in preload class A or B. Bearing sets have the following designation suffixes

- combinations of two bearings: DB, DF or DT
- combinations of three bearings: TBT, TFT or TT
- combinations of four bearings: QBC, QFC, QT, QBT or QFT.

The outside surface of a matched bearing set has a "V-shaped" marking extending across all of the bearings in the set (→ **fig. 7**). This mark is designed to facilitate proper mounting and indicates how the bearing set is to be mounted in relation to the axial load. The "V-shaped" marking should point in the direction in which the axial load will act on the inner ring, or for axial loads in both directions, the "V-shaped" marking should point in the direction of the greater of the two loads.

When ordering bearing sets state the number of sets and not the number of individual bearings required.

Sealed bearings

SKF also supplies individual bearings or bearing sets as sealed bearings. The bearings may have a low-friction seal on one or both sides (→ **fig. 8**). The seals are made of an oil and wear-resistant acrylonitrile-butadiene rubber (NBR) and are sheet steel reinforced. The permissible operating temperature range for these seals is –40 to +120 °C.

Sealed single direction bearings have 25 to 35 % of the free space filled at the factory with a calcium complex soap grease, based on ester/mineral oil.

Contact the SKF application engineering service for more information about sealed bearings.

Fig. 7

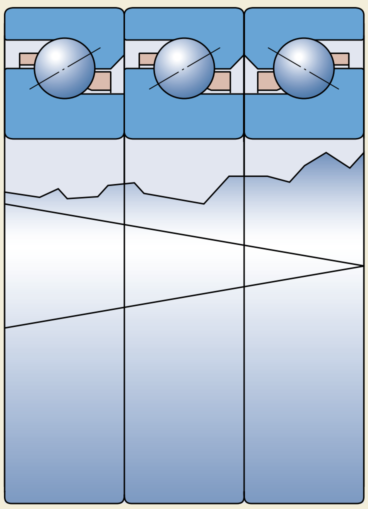
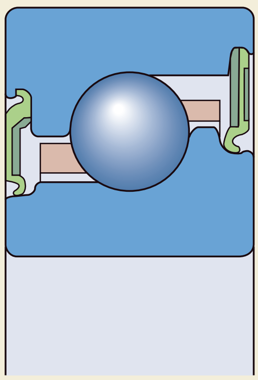


Fig. 8



Markings on bearings and bearing sets

Each bearing is marked with different codes and marks on the bearing outside surface (→ **fig. 9**):

1 SKF trademark
2 Complete designation of the bearing (**a**) or bearing set (**b**)
3 Country of origin
4 "MATCHABLE" label for individual bearings (**a**) or a serial number for bearings in a set (**b**)
5 Date of manufacture, coded

There is also a "V-shaped" marking on the bearing outside surface. For individual universally matchable bearings the V points in the direction from which an axial load can be applied to the inner ring (→ **fig. 10**).

Matched bearing sets are marked with a continuous "V-shaped" marking covering all the bearings in the set (→ **fig. 7**, **page 248**). The bearings must be installed as per this mark. The point of the "V-shaped" marking indicates the direction in which the axial load will be applied to the inner ring, or for axial loads in both directions, the "V-shaped" marking should point in the direction of the greater of the two loads.

Fig. 10

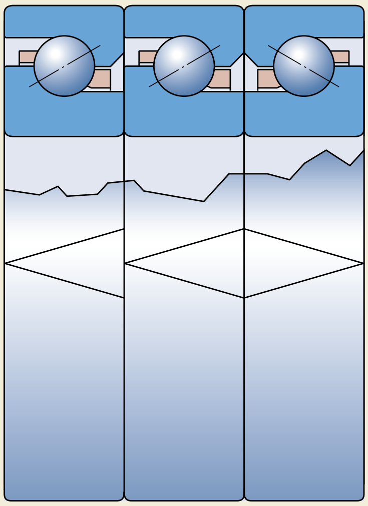
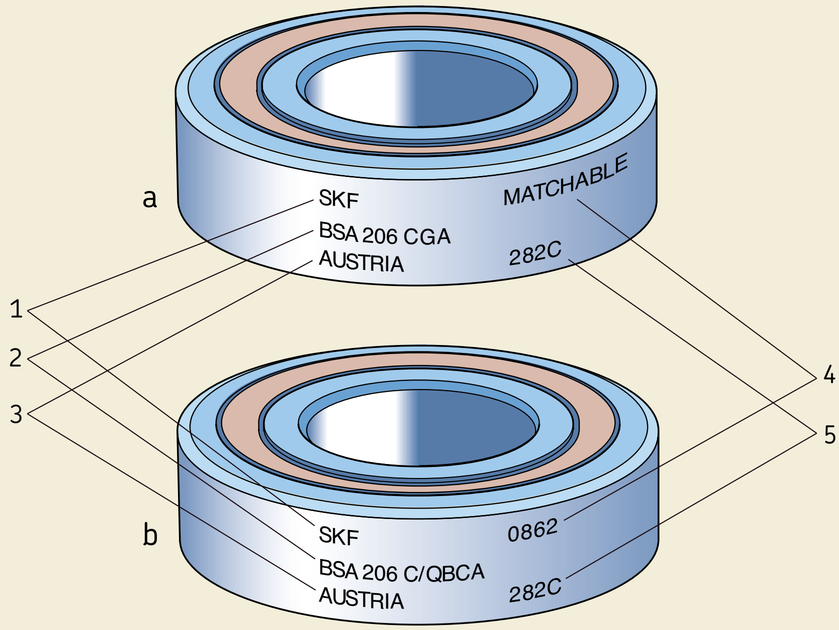


Fig. 9



Double direction angular contact thrust ball bearings

Double direction SKF angular contact thrust ball bearings for screw drives in the BEAS series (→ **fig. 11**) correspond in design to two single direction bearings arranged back-to-back. Double direction angular contact thrust ball bearings are non-separable and have

- a one-piece outer ring
- a two-piece inner ring
- a polyamide 66 cage
- a seal on both sides
- a 60° contact angle
- close osculation between the balls and raceways.

They are available with contact seals (designation suffix 2RS, → **fig. 12a**) or non-contact shields (designation suffix 2Z, → **fig. 12b**). The seals are made of an oil and wear-resistant acrylonitrile-butadiene rubber (NBR) and are sheet steel reinforced. The permissible operating temperature range is –40 to +120 °C.

The bearings are filled as standard with a high-grade, low-viscosity lithium soap grease with ester oil as its base. The quantity of grease fills some 25 to 35 % of the free space in the bearing. Under normal operating conditions the service life of the initial fill will outlast the bearing. The permissible temperature range for the grease is –55 to +110 °C.

Sealed bearings are ready-to-mount. They should not be washed or heated above 80 °C. Heat should only be applied using an induction heater that rapidly heats the bearing rings, without affecting non-metallic components, like the cage.

All bearings have an annular groove and lubrication holes in the outer ring, to relubricate the bearings easily and reliably, if required.

The preload set at the factory is produced for these bearings by pressing the two inner ring halves together, e.g. with a lock nut that also holds the bearing at the end of the screw drive. The preload, combined with design features stated above, provide high axial stiffness and also make these bearings suitable for accommodating radial loads.

Fig. 11

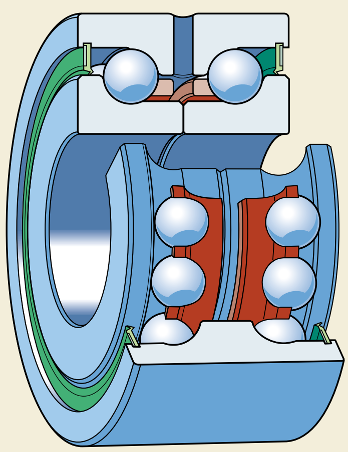
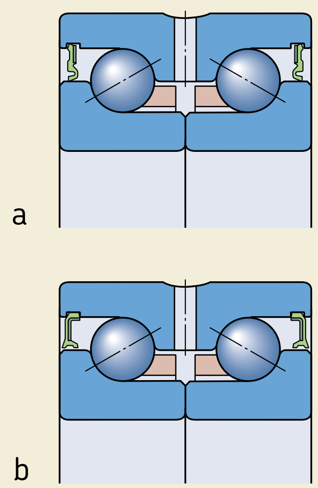


Fig. 12



Double direction angular contact thrust ball bearings for bolt mounting

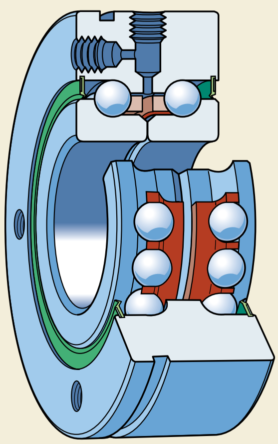
Double direction SKF angular contact thrust ball bearings in the BEAM series (→ **fig. 13**) are intended for bolt mounting and are typically used when space is tight or quick mounting is required. They correspond in design to bearings in the BEAS series, except that the outer ring is much thicker and equipped with through holes for attachment bolts. By bolting directly onto an associated component, the design and mounting process are simplified.

To enable relubrication, if required, one sideface and the bearing outside surface have a M6 threaded hole. The holes are plugged on delivery with a set screw. The sideface with the threaded hole should be mounted opposite the machine wall. PE design bearings do not have a threaded hole on the outside surface of the bearing and can only be relubricated via the threaded hole in the sideface.

Bearings in the BEAM series have an annular groove on their outside surface that can be used to dismount the bearing from its seat on the screw drive.

5

Fig. 13



Cartridge units with a flanged housing

Single direction angular contact thrust ball bearings are also available as ready-to-mount flanged cartridge units (→ **fig. 14**). These cartridge units, which can accommodate heavy axial loads, have been designed for screw drive applications requiring a high degree of stiffness and quick mounting. SKF cartridge units are available with

- two bearing pairs in a back-to-back arrangement, designation suffix QBC (→ **fig. 15a**)
- two bearing pairs in a face-to-face arrangement, designation suffix QFC (→ **fig. 15b**).

Cartridge units with different bearing arrangements or preload are available on request.

SKF cartridge units are lubricated with a low-viscosity grease and are ready-to-mount. The quantity of grease fills some 25 to 35 % of the free space in the bearing. Under normal operating conditions the service life of the initial fill will outlast the bearings.

Cartridge units should be located at the end of the screw drive with an SKF KMT precision lock nut and bolted to the machine wall.

The flanged housings are made of high-quality steel and protected on both sides with a labyrinth seal to prevent both the ingress of contaminants and grease leakage. These seals do not limit the speeds attainable for single direction angular contact thrust ball bearings.

Fig. 14

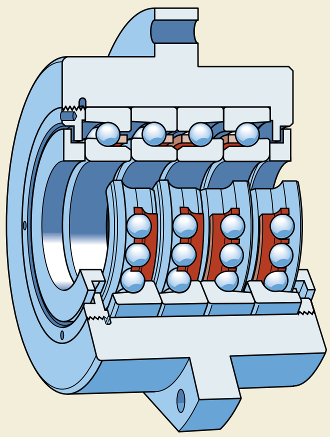
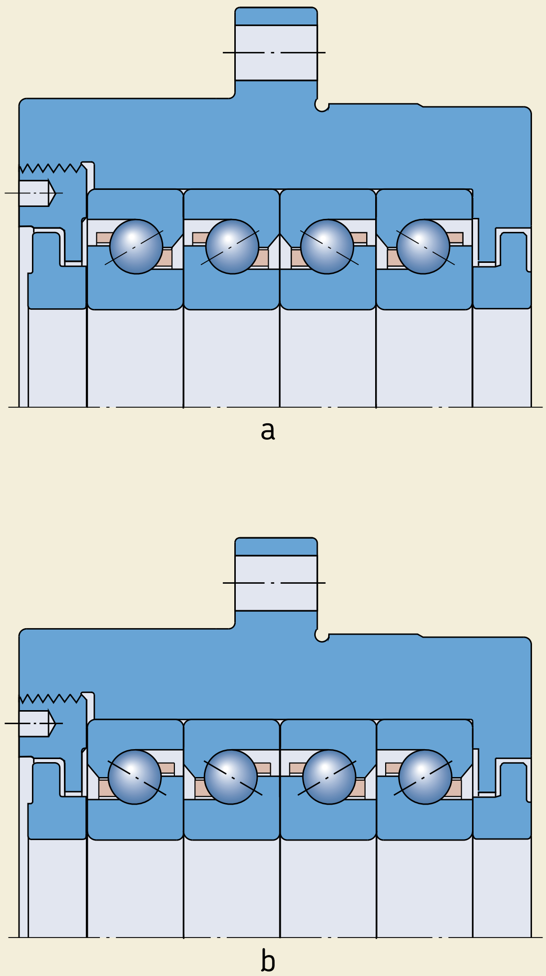


Fig. 15



Bearing data – general

Dimensions

The boundary dimensions of single direction angular contact thrust ball bearings in the BSA 2 and BSA 3 series are in accordance with the values for Dimension Series 02 and 03 in accordance with ISO 15:1998.

The dimensions of the other bearings and bearing units are not standardized but are common in the market.

Tolerances

Angular contact thrust ball bearings for screw drives are produced as standard with the tolerances listed in **table 1** on **page 254**. They meet class P4 tolerances for dimensional accuracy and class P2 tolerances for running accuracy for radial bearings, in accordance with ISO 492:2002.

The values stated for single direction bearings apply to individual bearings. For matched bearing sets the axial runout is usually within 2,5 µm if the bearing seats are machined precisely and the bearings are mounted properly.

Cartridge units with a flanged housing for screw drives are produced to the tolerances listed in **table 2** on **page 254**.

The symbols used in the tolerance tables are listed in **table 3** on **pages 44** and **45**, together with their definitions.

Preload in unmounted bearings

Single direction bearings

For single direction SKF angular contact thrust ball bearings used as individual bearings, the preload is only obtained after mounting and depends on its adjustment against a second bearing or bearing set, which provides axial location in the opposite direction.

Universally matchable bearings for mounting in sets are supplied in two preload classes

- class A, light preload
- class B, medium preload.

The preload values are listed in **table 3** on **page 255** and are not standardized. The values do not cover influences from the fits or operating conditions. They apply to bearing sets with two bearings in a back-to-back or face-to-face arrangement. Bearing sets with different preloads can be supplied on request.

Bearing sets, consisting of three or four bearings, have a heavier preload than sets with two bearings. Guideline values for preload in these bearing sets are obtained by multiplying the values listed in **table 3** by a factor of

- 1,35 for TBT and TFT arrangements
- 1,6 for QBT and QFT arrangements
- 2 for QBC and QFC arrangements.

Double direction bearings

Double direction SKF angular contact thrust ball bearings are supplied with the preload listed in **table 3**. The values do not cover influences from fit or operating conditions. Bearings with different preloads are available on request.

Cartridge units with a flanged housing

SKF cartridge units have a light preload according to class A as standard, whereby the values listed in **table 3** for the relevant individual bearing must be doubled. For availability of bearing units with class B or special preload contact the SKF application engineering service.

Axial stiffness

Single direction SKF angular contact thrust ball bearings can provide a very high degree of axial stiffness. The nominal values listed in **table 3** on **page 255**, apply to unmouted bearing sets with two bearings in a back-to-back or face-to-face arrangement.

Bearing sets comprising three or four bearings can provide a higher degree of axial stiffness than sets with two bearings. The degree of stiffness for these bearing sets can be calculated by multiplying the values listed in **table 3** by a factor of

- 1,45 to 1,65 for TBT and TFT arrangements
- 1,8 to 2,25 for QBT and QFT arrangements
- 2 for QBC and QFC arrangements.

Table 1

Tolerances of angular contact thrust ball bearings for screw drives

Inner ring and bearing height

d		Single direction bearings					Double direction bearings				
		Δ_{ds}, Δ_{dmp}		Δ_{Ts}		S_{ia}	Δ_{ds}, Δ_{dmp}		Δ_{Bs}		S_{ia}
over	incl.	high	low	high	low	max	high	low	high	low	max
mm		µm		µm		µm	µm		µm		µm
10	**18**	0	–4	0	–80	1,5	0	–5	0	–250	2
18	**25**	0	–4	0	–120	2,5	0	–5	0	–250	2
25	**30**	0	–4	0	–120	2,5	0	–5	0	–250	2,5
30	**50**	0	–5	0	–120	2,5	0	–5	0	–250	2,5
50	**60**	0	–5	0	–120	2,5	0	–8	0	–250	2,5
60	**80**	0	–5	0	–150	2,5	0	–8	0	–250	3

Outer ring

D		Single direction bearings			Double direction bearings			
		Δ_{Ds}, Δ_{Dmp}		S_{ea}	Δ_{Ds}, Δ_{Dmp}		Δ_{Cs}	S_{ea}
over	incl.	high	low	max	high	low	max	max
mm		µm		µm	µm		µm	µm
30	**50**	0	–5	2,5	0	–10	Values are identical to those for the inner ring of the same bearing	5 .. 8
50	**80**	0	–6	4	0	–10		5 .. 10
80	**110**	0	–6	5	0	–10		6 .. 11
110	**120**	0	–6	5	0	–15		6 .. 11
120	**150**	0	–7	5	0	–15		7 .. 13

Table 2

Tolerances of cartridge units with a flanged housing

d		Δ_{ds}, Δ_{dmp}		Δ_{D2s}		Δ_{Ts}		S_{ia} [1)]
over	incl.	high	low	high	low	high	low	max
mm		µm		µm		mm		µm
18	**30**	0	–4	0	–13	0	–1,5	2,5
30	**50**	0	–5	0	–15	0	–1,5	2,5
50	**60**	0	–5	0	–15	0	–1,5	2,5

1) Axial runout of a single bearing

The tolerance for the rectangularity of the flange to the housing seat diameter D_2 is 5 to 10 µm depending on the size

Table 3

Single and double direction bearings:
Preload, axial and pivotal stiffness, frictional moment and maximum axial load carrying ability for unmounted bearings

Designation	Preload		Axial stiffness/ pivotal stiffness		Frictional moment[1)]		Max. axial load carrying ability
	Preload class		Preload class		Preload class		
	A	B	A	B	A	B	
–	N		N/µm (Nm/mrad)		Nm		kN
Bearing sets with two single direction bearings in a back-to back or face-to-face arrangement							
BSA 201 CG	650	1 300	350	455	0,016	0,03	7,25
BSA 202 CG	775	1 550	415	535	0,023	0,04	8,5
BSA 203 CG	1 040	2 080	535	700	0,045	0,08	13
BSA 204 CG	1 480	2 960	660	860	0,056	0,1	19,5
BSA 205 CG	1 580	3 160	730	935	0,077	0,13	20,8
BSA 206 CG	2 250	4 500	925	1 180	0,13	0,22	31,5
BSA 207 CG	2 950	5 900	1 090	1 390	0,2	0,35	42,7
BSA 305 CG	2 400	4 800	905	1 155	0,12	0,22	36
BSA 308 CG	5 000	10 000	1 350	1 720	0,39	0,68	78,2
BSD 2047 CG	1 480	2 960	660	860	0,06	0,1	19,5
BSD 2562 CG	2 400	4 800	905	1 155	0,12	0,22	36
BSD 3062 CG	2 250	4 500	925	1 180	0,13	0,23	31,5
BSD 3572 CG	2 950	5 900	1 090	1 390	0,2	0,35	42,7
BSD 4072 CG	2 950	5 900	1 090	1 390	0,2	0,35	42,7
BSD 4090 CG	5 000	10 000	1 350	1 720	0,39	0,68	78,2
BSD 4575 CG	2 900	5 800	1 185	1 515	0,26	0,42	40,2
BSD 45100 CG	6 500	13 000	1 535	1 965	0,55	0,97	107
BSD 50100 CG	6 500	13 000	1 535	1 965	0,55	0,97	107
BSD 55100 CG	6 500	13 000	1 535	1 965	0,55	0,97	107
BSD 55120 CG	7 900	15 800	1 770	2 260	0,8	1,4	130
BSD 60120 CG	7 900	15 800	1 770	2 260	0,8	1,4	130
Double direction bearings							
BEAS 008032	300	–	250/20	–	0,08	–	–
BEAS 012042	600	–	350 / 80	–	0,16	–	–
BEAS 015045	650	–	400/65	–	0,2	–	–
BEAS 017047	720	–	420 / 80	–	0,24	–	–
BEAS 020052	1 650	–	650 / 150	–	0,3	–	–
BEAS 025057	1 920	–	770 / 200	–	0,4	–	–
BEAS 030062	2 170	–	870 / 300	–	0,5	–	–
BEAM 012055	600	–	350 / 80	–	0,16	–	–
BEAM 017062	720	–	420 / 80	–	0,24	–	–
BEAM 020068	1 650	–	650 / 150	–	0,3	–	–
BEAM 025075	1 920	–	770 / 200	–	0,4	–	–
BEAM 030080	2 170	–	870 / 300	–	0,5	–	–
BEAM 030100	3 900	–	950 / 470	–	0,8	–	–
BEAM 035090	2 250	–	900 / 400	–	0,6	–	–
BEAM 040100	2 550	–	1 000 / 570	–	0,7	–	–
BEAM 040115	4 750	–	1 150 / 720	–	1,3	–	–
BEAM 050115	3 100	–	1 250 / 1 000	–	0,9	–	–
BEAM 050140	5 720	–	1 350 / 1 500	–	2,6	–	–
BEAM 060145	4 700	–	1 400 / 1 750	–	2	–	–

[1)] The guideline values for the frictional moment for the double direction bearings in the BEAS and BEAM series apply to bearings with seals (designation suffix 2RS). For bearings with shields (designation suffix 2Z) the frictional moment is only half

5

The lower value of the factor applies to bearings under light axial load (P ≤ 0,05 C) and the larger value to bearings under heavy axial load (P > 0,1 C). Bearing sets with a heavier preload provide an even greater degree of stiffness. However, this should be avoided as heavier preload substantially increases friction and heat generated by the bearing. In cases where an extremely high degree of stiffness is required, contact the SKF application engineering service. They have simulation tools to estimate the friction behaviour when preload is increased.

The axial and pivotal stiffness of double direction angular contact thrust ball bearings in the BEAS and BEAM series are shown in **table 3** and apply to the preload set at the factory, without influences from the fit or operation.

For cartridge units, axial stiffness is listed in the product table.

Frictional moment

All angular contact thrust ball bearings for screw drives are designed for low friction operation. The friction depends on the preload in the bearing set and increases accordingly.

The guideline values for the frictional moment listed in **table 3** on **page 255** apply to unmounted bearings that will operate at low speeds. The starting torque is typically double the frictional moment value.

Bearing sets, consisting of three or four bearings, have a higher frictional moment than sets with two bearings. The frictional moment for these bearing sets can be calculated by multiplying the values listed in **table 3** by a factor of

- 1,35 for TBT and TFT arrangements
- 1,55 for QBT and QFT arrangements
- 2 for QBC and QFC arrangements.

Guideline values for the frictional moment in cartridge units are listed in the product table.

Axial load carrying ability

With increasing axial load, the contact conditions in the bearing change. The pressure angles, especially the pressure ellipses, are larger and there may be increased stress in the shoulder/raceway transition on the bearing rings. This stress is kept to a minimum for SKF bearings by appropriate measures, such as ground and rounded transition zones. Even so, the guideline values listed in **table 3** on **page 255** for the maximum axial load should not be exceeded.

Lifting force

External axial loads can change the preload in a bearing set or double direction bearing, causing one ball set to become more heavily loaded, leaving the other ball set without its requisite load. The force used to describe this phenomenon is called lifting force.

When the lifting force is sufficient, the balls in the under-loaded ball set start to slide in the raceway, which can cause smearing and eventual bearing failure.

A guideline value for the lifting force is obtained by multiplying the current preload by a factor of 2,8. This guideline value applies to bearing sets with two bearings in a back-to-back or face-to-face arrangement and to double direction bearings. The lifting force for example for a bearing or bearing pair preloaded to 1 000 N is: 2,8 × 1 000 = 2 800 N.

Contact the SKF application engineering service for additional information.

Cages

SKF angular contact thrust ball bearings for screw drives have cages that match the operating conditions – high accelerations and decelerations (→ **fig. 16**). Depending on the series, these bearings are equipped with either a ball

Fig. 16

guided window-type or a snap type cage made of glass-fibre reinforced polyamide 66.

These cages are particularly light to minimize centrifugal forces and can be used at operating temperatures up to +120 °C – much higher than temperatures typically occurring in machine tool applications.

The lubricants generally used in machine tools do not have a detrimental effect on the cage properties, with the exception of a few synthetic oils or greases with a synthetic oil base. For more detailed information about the suitability of polyamide cages, contact the SKF application engineering service.

Speeds

The attainable speeds listed in the product tables are guideline values and apply to bearings under light load ($P \leq 0,05\ C$) and assume good heat dissipation from the bearing.

Single direction bearings

The speed ratings for oil-air lubrication listed for single direction bearings must be reduced if other oil lubrication methods are used. The values provided for grease lubrication are maximum values that can be attained with a low consistency, high quality grease. Speeds should also be reduced for a bearing set with two, three or four bearings used immediately adjacent to each other. In these cases, guideline values can be calculated by multiplying the values in the product table with the reduction factor that coincides with the preload and the number of bearings in an arrangement (→ **table 4**). If the speeds calculated are not adequate for the application, contact the SKF application engineering service.

Table 4

Speed reduction factors for bearing sets with single direction bearings

Number of bearings per set	**Reduction factor** Preload class A	B
2	0,8	0,4
3	0,65	0,3
4	0,5	0,25

Double direction bearings

The attainable speeds listed for double direction bearings depend on the type of seal. They are limited for bearings with

- seals, designation suffix 2RS, by the permissible sliding speed at the sealing lip
- shields, designation suffix 2Z, by the speeds permitted for grease lubrication.

Cartridge units with a flanged housing

The attainable speeds listed in the product table for cartridge units apply to mounted, grease lubricated units with four bearings.

Load ratings for bearing sets

The dynamic load rating C and the static load rating C_0 as well as the fatigue load limit P_u, listed in the product table for single direction bearings, apply to axial loads for individual bearings. For bearing sets, the relevant values for individual bearings must be multiplied by the values listed in **table 5**.

The values listed in the product tables for load ratings and fatigue load limits apply to

- one ball set for double direction bearings and
- two ball sets for cartridge units.

Equivalent dynamic bearing load

If individual single direction bearings, bearing sets or double direction bearings have to accommodate both radial and axial loads, the equivalent dynamic bearing load for each load direction is obtained from

$P = XF_r + YF_a$ for $F_a/F_r \leq 2,17$
$P = 0,92\ F_r + F_a$ for $F_a/F_r > 2,17$

For bearings that accommodate axial loads only

$P = F_a$

where
P = equivalent dynamic bearing load, kN
F_r = actual radial bearing load, kN
F_a = actual axial bearing load, kN
X = radial load factor for the bearing (→ **table 5**)
Y = axial load factor for the bearing (→ **table 5**)

Preload should be taken into account as axial load. For bearing sets in any arrangement, the equivalent dynamic bearing load must be calculated separately for both load directions.

For double direction bearings the factors X and Y are the same as for bearing sets with two bearings in a DB or DF arrangement as listed in **table 5**.

Equivalent static bearing load

If individual single direction bearings, bearing sets or double direction bearings have to accommodate both radial and axial loads, the equivalent static bearing load for each load direction is obtained from

$P_0 = F_a + 4\ F_r$

where
P_0 = equivalent static bearing load, kN
F_a = actual axial bearing load, kN
F_r = actual radial bearing load, kN

Preload should be taken into account as axial load. For bearing sets in any arrangement, the equivalent static bearing load must be calculated separately for both load directions.

The equation for equivalent static bearing load also applies to individual bearings and to bearings in a tandem arrangement, if the load ratio F_a/F_r is not lower than 4. For F_a/F_r between 2,5 and 4 the equation still provides usable approximation values.

Table 5

Load ratings, fatigue load limit and calculation factors for bearing sets with single direction bearings

Number of bearings per set	**Arrangement** Designation	Symbol	Load direction	**Load rating of bearing set** dynamic	static	**Fatigue load limit of bearing set**	**Calculation factors** X	Y
2	**DB**	<>	→	C	C_0	P_u	1,9	0,55
	DF	><	→	C	C_0	P_u	1,9	0,55
	DT	<<	→	1,63 C	2 C_0	2 P_u	–	–
3	**TBT**	<>>	→	C	C_0	P_u	1,43	0,76
		<>>	←	1,63 C	2 C_0	2 P_u	2,32	0,35
	TFT	><<	←	C	C_0	P_u	1,43	0,76
		><<	→	1,63 C	2 C_0	2 P_u	2,32	0,35
	TT	<<<	→	2,16 C	3 C_0	3 P_u	–	–
4	**QBT**	<<<>	←	C	C_0	P_u	1,17	0,88
		<<<>	→	2,16 C	3 C_0	3 P_u	2,52	0,26
	QFT	><<<	←	C	C_0	P_u	1,17	0,88
		><<<	→	2,16 C	3 C_0	3 P_u	2,52	0,26
	QBC	<<>>	→	1,63 C	2 C_0	2 P_u	1,9	0,55
	QFC	>><<	→	1,63 C	2 C_0	2 P_u	1,9	0,55
	QT	<<<<	→	2,64 C	4 C_0	4 P_u	–	–

Lubrication

Single direction bearings can be lubricated with grease or oil. In general, however, grease lubrication is preferred as it simplifies the design and maintenance of the bearing arrangement.

The bearings must be lubricated with a grease volume that fills approximately 25 to 35 % of the free space in the bearing. Guideline values for suitable lubricant quantities are listed in **table 6**.

Sealed double direction bearings and cartridge units have 25 to 35 % of the free space filled at the factory with a lithium soap grease based on synthetic ester oil. The permissible temperature range is between –35 and +160 °C. The base oil viscosity is 54,9 mm^2/s at 40 °C and 9,1 mm^2/s at 100 °C.

If double direction bearings have to accommodate heavy loads and run for long periods at high speeds, relubrication may be necessary. When relubricating, the application should ideally be at normal operating temperature and the bearing should be rotating. The grease should be applied slowly until fresh grease escapes from the seal. Excessive pressure should be avoided as this could damage the seals.

Greases

For most operating conditons, a calcium complex soap grease based on ester/mineral oil is recommended. For detailed grease recommendations, contact the SKF application engineering service.

Table 6

Guideline values for grease quantity for single direction angular contact thrust ball bearings

Bearing designation	**Lubrication grease quantity when filling the free space in the bearing by**			
	10 to 15 %	25 to 35 %	45 to 60 %	70 to 100 %
–	g			
BSA 201 CG	0,1–0,2	0,3–0,4	0,5–0,7	0,8–1,2
BSA 202 CG	0,1–0,2	0,4–0,5	0,6–0,8	1,0–1,4
BSA 203 CG	0,1–0,2	0,3–0,4	0,5–0,7	0,8–1,2
BSA 204 CG	0,4–0,5	0,9–1,2	1,6–2,2	2,5–3,6
BSA 205 CG	0,4–0,7	1,1–1,5	2,0–2,6	3,1–4,4
BSA 206 CG	0,6–0,8	1,4–2,0	2,5–3,4	3,9–5,6
BSA 207 CG	0,7–1,1	1,8–2,5	3,2–4,2	4,9–7,0
BSA 305 CG	0,6–0,9	1,5–2,1	2,7–3,6	4,2–6,0
BSA 308 CG	1,8–2,6	4,4–6,1	7,9–10,6	12,3–17,6
BSD 2047 CG	0,4–0,6	0,9–1,3	1,7–2,2	2,6–3,7
BSD 2562 CG	0,6–0,9	1,4–2,0	2,6–3,4	4,0–5,7
BSD 3062 CG	0,5–0,8	1,3–1,8	2,4–3,2	3,7–5,3
BSD 3572 CG	0,6–0,9	1,5–2,1	2,7–3,6	4,3–6,1
BSD 4072 CG	0,6–0,9	1,5–2,1	2,7–3,6	4,2–6,0
BSD 4090 CG	1,5–2,3	3,8–5,2	6,8–9,1	10,6–15,2
BSD 4575 CG	0,7–1,0	1,7–2,3	3,1–4,1	4,8–6,8
BSD 45100 CG	1,9–2,9	4,8–6,7	8,6–11,5	13,4–19,2
BSD 50100 CG	1,8–2,8	4,6–6,4	8,3–11,0	12,9–18,4
BSD 55100 CG	0,9–1,3	2,2–3,0	3,9–5,2	6,1–8,7
BSD 55120 CG	1,1–1,6	2,7–3,8	4,9–6,5	7,6–10,8
BSD 60120 CG	1,1–1,6	2,7–3,7	4,8–6,4	7,5–10,7

For relatively low speeds, heavily loaded screw drive bearings that are exposed to vibration during operation, a lithium soap grease with a mineral base oil and EP additives like SKF LGEP 2 should be used. This grease has a permissible temperature range of –20 to +110 °C and a base oil viscosity of 200 mm^2/s at 40 °C and 16 mm^2/s at 100 °C. Note that high viscosity greases increase friction and heat generated by the bearing but provide excellent protection against false brinelling.

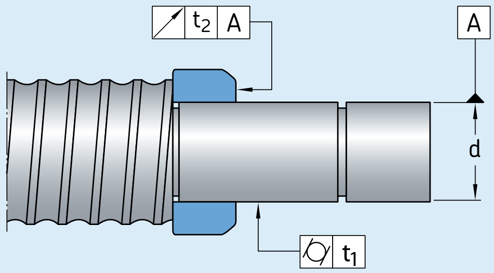
Design of associated components

Precision of associated components

Associated components should be produced very precisely so that high-precision angular contact thrust ball bearings can meet the demands for high running accuracy. All dimension and form deviations must be kept as low as possible for associated components.

The bearing seats on the screw drive and the seats in the housing bore should follow the tolerances listed in **tables 7** to **9**.

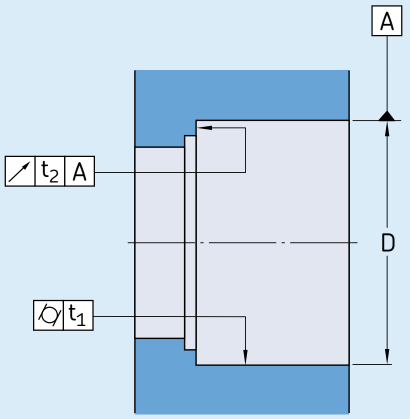
Table 7



Accuracy of seats on screw drives

Nominal diameter d over	incl.	Tolerances Diameter (h4) high	low	Cylindricity (IT2) t_1	Runout (IT2) t_2
mm		µm			
10	**18**	0	–5	2	2
18	**30**	0	–6	2,5	2,5
30	**50**	0	–7	2,5	2,5
50	**80**	0	–8	3	3

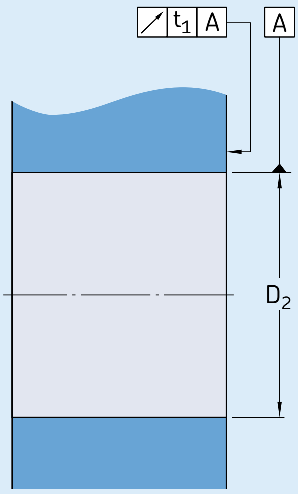
Table 8



Accuracy of seats in housings

Nominal diameter D over	incl.	Tolerances Diameter (H5) high	low	Cylindricity (IT2) t_1	Runout (IT3) t_2
mm		µm			
–	**50**	+11	0	2,5	4
50	**80**	+13	0	3	5
80	**120**	+15	0	4	6
120	**150**	+18	0	5	8

Table 9



Accuracy of the housing bore and sidefaces for bearings for bolt mounting and cartridge units

Nominal diameter D_2 over	incl.	Housing bore Tolerance (H6) high	low	Sideface Axial runout (IT3) t_1
mm		µm		µm
50	**80**	+19	0	5
80	**120**	+22	0	6
120	**150**	+25	0	8

5

Bearing arrangement design

Screw drives are typically supported at both ends with bearing sets in a face-to-face or back-to-back arrangement (→ **fig. 17**). For short screw drives an overhung support at one end is also common (→ **fig. 18**). For stretched screw drives, for example, particularly stiff bearing arrangements can be designed, if two tandem arrangements are used at both ends that are adjusted against each other (→ **fig. 19**).

If misalignment cannot be avoided between the bearing positions, face-to-face bearing sets are recommended.

If temperature differences between the screw drive and machine bed require a non-locating bearing in one position, needle roller bearings are suitable, among others. In this case, only the weight of the screw drive loads the bearing, making it unnecessary to calculate the bearing life.

Fig. 17

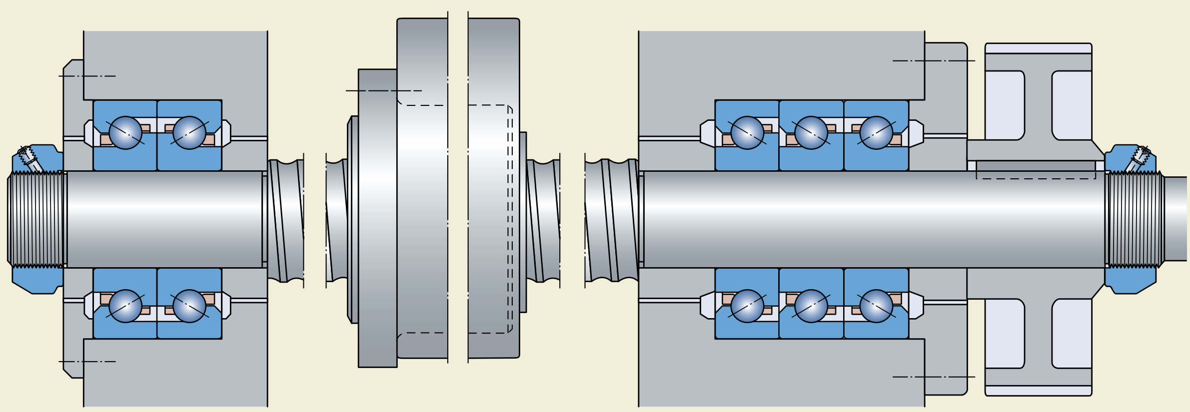


Fig. 18

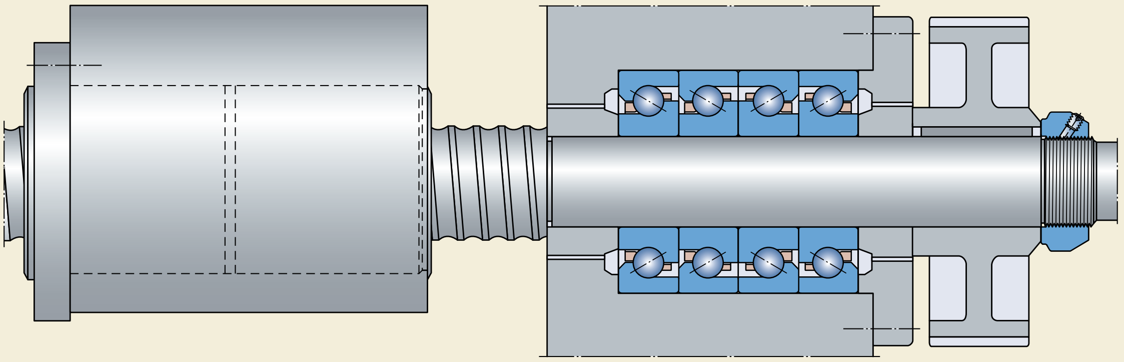
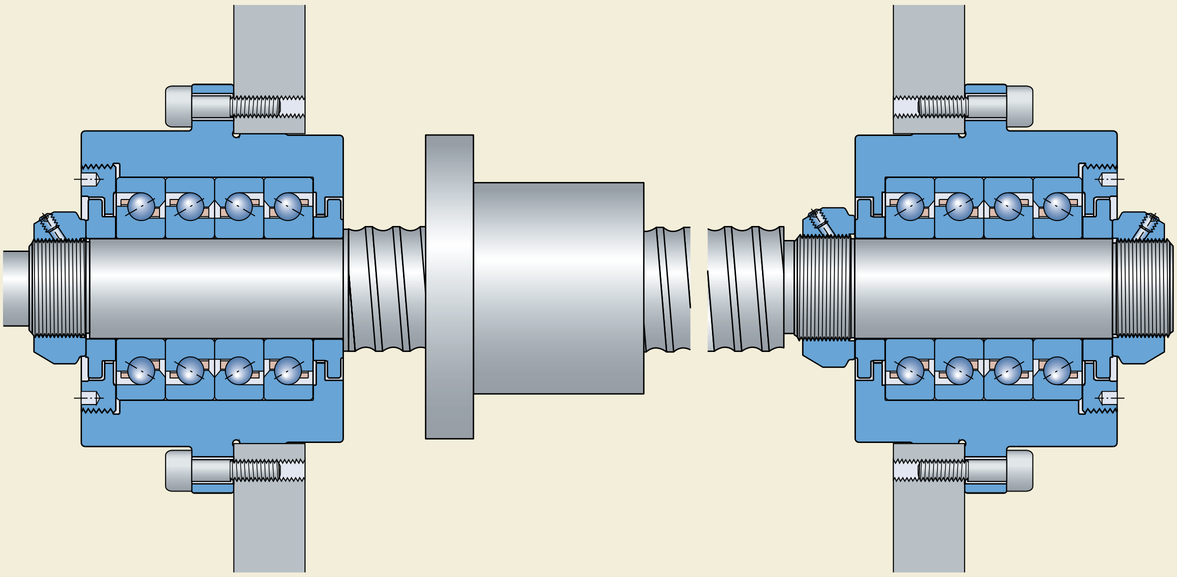


Fig. 19



Designation system

The designation system for SKF angular contact thrust ball bearings for screw drives is shown in **table 10** together with the definitions.

Table 10

Designation system for angular contact thrust ball bearings for screw drives

Examples:							
BSA 206 CGA	BSA 2	06	CG	/			A
BSD 2562 C/QBCA	BSD	2562	C	/	Q	BC	A
BEAS 020052-2RS/PE	BEAS	020052	-2RS	/	PE		
FBSD 50/QFCA	FBSD	50		/	Q	FC	A

Bearing series

BSA 2 Single direction bearing in the 02 ISO Dimension Series
BSA 3 Single direction bearing in the 03 ISO Dimension Series
BSD Single direction bearing, not standardized
BEAM Double direction bearing, for bolt mounting, not standardized
BEAS Double direction bearing, not standardized
FBSA Cartridge unit with bearings in the 02 ISO Dimension Series
FBSD Cartridge unit with non-standardized bearings

Bearing size

Single direction bearings with standardized dimensions and cartridge units
01 12 mm bore diameter
02 15 mm bore diameter
03 17 mm bore diameter
04 (×5) 20 mm bore diameter
to
12 (×5) 60 mm bore diameter

Single direction bearings, not standardized
2047 20 mm bore diameter and 47 mm outside diameter

Double direction bearings, not standardized
060145 60 mm bore diameter and 145 mm outside diameter

Contact angle and design

– 60° contact angle
C Modified internal design
G Bearing for universal matching in sets of up to four bearings per set
PE Diameter tolerances and axial runout to P5 tolerance class for radial bearings
2RS Sheet steel reinforced, acrylonitrile-butadiene rubber (NBR) contact seal on both sides of the bearing
2Z Shield of pressed sheet steel on both sides of the bearing

Number of bearings per set

D Two bearings
T Three bearings
Q Four bearings

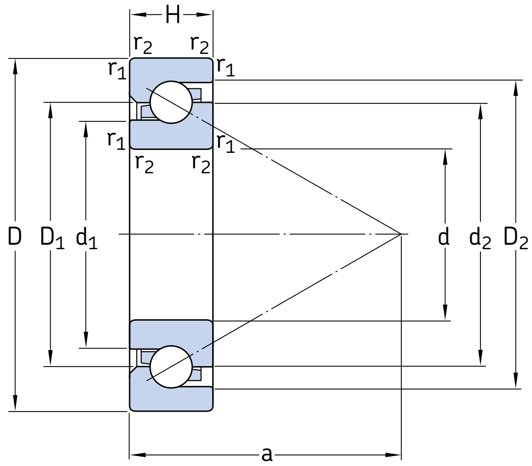
Bearing arrangement

B Back-to-back
F Face-to-face
T Tandem
BT Back-to-back and tandem arrangement
FT Face-to-face and tandem arrangement
BC Tandem back-to-back arrangement
FC Tandem face-to-face arrangement

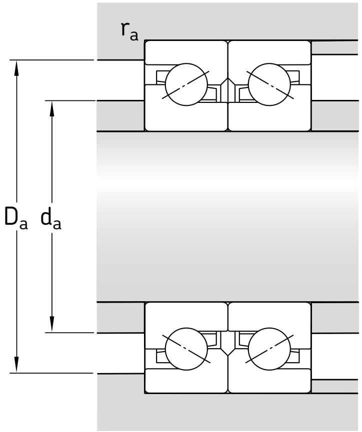
Preload

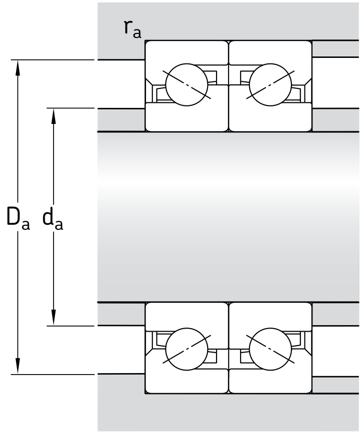
A Light preload
B Medium preload
G.. Special preload, value in daN (= 10 N)

Single direction angular contact thrust ball bearings for screw drives
d **12 – 60** mm



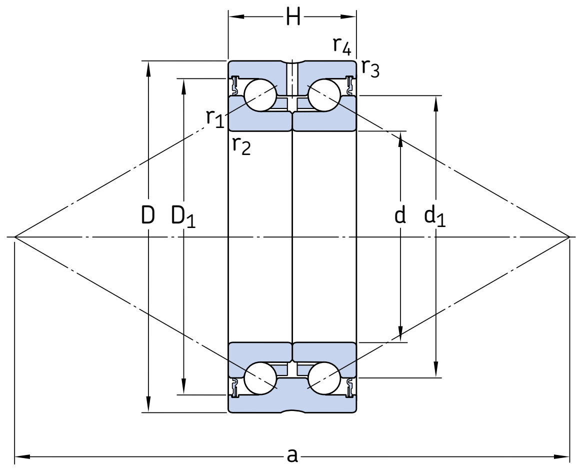
Principal dimensions			**Basic load ratings** dynamic	static	**Fatigue load limit**	**Attainable speeds** when lubricating with grease	oil-air	**Mass**	**Designation**
d	D	H	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
12	32	10	11,4	18	0,67	14 000	17 000	0,043	**BSA 201 CG**
15	35	11	12,2	20,4	0,765	12 000	15 000	0,054	**BSA 202 CG**
17	40	12	18,3	37,5	1,37	11 000	14 000	0,078	**BSA 203 CG**
20	47	14	24	52	1,93	9 500	12 000	0,12	**BSA 204 CG**
	47	15	24	52	1,93	9 500	12 000	0,13	**BSD 2047 CG**
25	52	15	24,5	56	2,08	9 000	11 000	0,15	**BSA 205 CG**
	62	15	36,5	86,5	3,2	8 000	9 500	0,24	**BSD 2562 CG**
	62	17	36,5	86,5	3,2	8 000	9 500	0,27	**BSA 305 CG**
30	62	15	32	80	3	8 000	9 500	0,22	**BSD 3062 CG**
	62	16	32	80	3	8 000	9 500	0,23	**BSA 206 CG**
35	72	15	39	104	3,9	7 500	9 000	0,3	**BSD 3572 CG**
	72	17	39	104	3,9	7 500	9 000	0,33	**BSA 207 CG**
40	72	15	39	104	3,9	7 500	9 000	0,26	**BSD 4072 CG**
	90	20	69,5	183	6,8	6 000	7 000	0,68	**BSD 4090 CG**
	90	23	69,5	183	6,8	6 000	7 000	0,77	**BSA 308 CG**
45	75	15	35,5	104	3,9	7 500	9 000	0,26	**BSD 4575 CG**
	100	20	88	240	8,8	5 600	6 700	0,77	**BSD 45100 CG**
50	100	20	88	240	8,8	5 600	6 700	0,71	**BSD 50100 CG**
55	100	20	88	240	8,8	5 600	6 700	0,66	**BSD 55100 CG**
	120	20	95	285	10,6	5 000	6 000	1,14	**BSD 55120 CG**
60	120	20	95	285	10,6	5 000	6 000	1,07	**BSD 60120 CG**

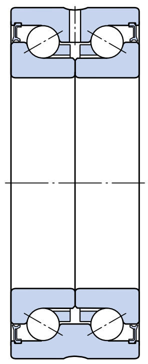




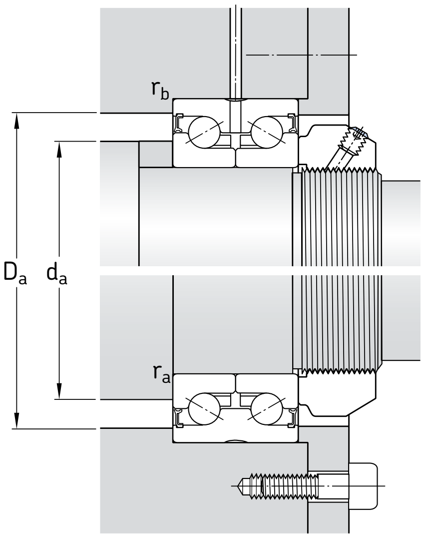
Dimensions							Abutment and fillet dimensions		
d	d_1 ~	d_2 ~	D_1 ~	D_2 ~	$r_{1,2}$ min	a	d_a min	D_a max	r_a max
mm							mm		
12	18	22,3	21,7	27	0,6	24	18	29	0,6
15	21	25,3	24,8	30	0,6	27	21	31	0,6
17	24,4	29,3	28,6	34,8	0,6	31	23	36	0,6
20	29,2	34,8	34,2	41,1	1	36	28	41	1
	29,2	34,8	34,2	41,1	1	37	28	41	1
25	33,2	38,8	38,2	45,1	1	40	32	45	1
	39,4	46,3	45,6	54,2	1,1	47	34	55	1
	39,4	46,3	45,6	54,2	1,1	48	34	55	1
30	41	47,3	46,6	54,4	1	48	38	54	1
	41	47,3	46,6	54,4	1	48	37	54	1
35	48,4	55,3	54,6	63,1	1,1	55	44	63	1
	48,4	55,3	54,6	63,1	1,1	56	44	63	1
40	48,4	55,3	54,6	63,1	1,1	55	48	64	1
	56,9	66,8	66,1	77,8	1,5	69	50	80	1,5
	56,9	66,8	66,1	77,8	1,5	69	50	80	1,5
45	59,6	67,3	60,4	54	1,1	59	53	67	1
	65,5	76,8	76,1	89,4	1,5	76	54	90	1,5
50	65,5	76,8	76,1	89,4	1,5	76	60	90	1,5
55	65,5	76,8	76,1	89,4	1,5	76	65	90	1,5
	78,7	91,4	90,6	106	1	89	65	110	1
60	78,7	91,4	90,6	106	1	89	70	108	1

Double direction angular contact thrust ball bearings for screw drives
d **8 – 30** mm



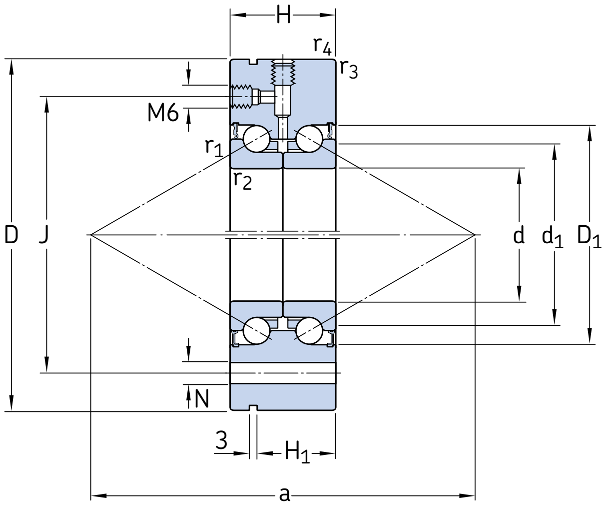


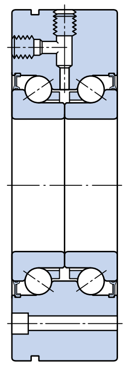
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Attainable speed	Mass	Designation
d	D	H	C	C_0	P_u			
mm			kN		kN	r/min	kg	–
8	32	20	12,5	16,3	0,6	5 300	0,09	**BEAS 008032-2RS**
	32	20	12,5	16,3	0,6	8 800	0,09	**BEAS 008032-2Z**
12	42	25	16,8	24,5	0,915	4 000	0,20	**BEAS 012042-2RS**
	42	25	16,8	24,5	0,915	6 700	0,20	**BEAS 012042-2Z**
15	45	25	18	28	1,04	3 900	0,21	**BEAS 015045-2RS**
	45	25	18	28	1,04	6 500	0,21	**BEAS 015045-2Z**
17	47	25	19	31	1,16	3 800	0,22	**BEAS 017047-2RS**
	47	25	19	31	1,16	6 300	0,22	**BEAS 017047-2Z**
20	52	26	26	46,5	1,73	3 400	0,31	**BEAS 020052-2RS**
	52	26	26	46,5	1,73	6 000	0,31	**BEAS 020052-2Z/PE**
	52	26	26	46,5	1,73	6 000	0,31	**BEAS 020052-2Z**
25	57	28	27,6	55	2,04	3 400	0,34	**BEAS 025057-2RS**
	57	28	27,6	55	2,04	5 600	0,34	**BEAS 025057-2Z**
30	62	28	29	64	2,36	3 200	0,39	**BEAS 030062-2RS**
	62	28	29	64	2,36	5 300	0,39	**BEAS 030062-2Z**



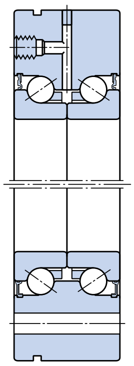
Dimensions						Abutment and fillet dimensions			
d	d_1 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	D_a max	r_a max	r_b max
mm						mm			
8	19	26,5	0,3	0,6	43	12	26	0,3	0,6
	19	26,5	0,3	0,6	43	12	26	0,3	0,6
12	25	33,5	0,3	0,6	56	16	35	0,3	0,6
	25	33,5	0,3	0,6	56	16	35	0,3	0,6
15	28	36	0,3	0,6	61	20	35	0,3	0,6
	28	36	0,3	0,6	61	20	35	0,3	0,6
17	30	38	0,3	0,6	65	23	40	0,3	0,6
	30	38	0,3	0,6	65	23	40	0,3	0,6
20	34,5	44	0,3	0,6	74	26	45	0,3	0,6
	34,5	44	0,3	0,6	74	26	45	0,3	0,6
	34,5	44	0,3	0,6	74	26	45	0,3	0,6
25	40,5	49	0,3	0,6	84	32	50	0,3	0,6
	40,5	49	0,3	0,6	84	32	50	0,3	0,6
30	45,5	54	0,3	0,6	93	40	54	0,3	0,6
	45,5	54	0,3	0,6	93	40	54	0,3	0,6

Double direction angular contact thrust ball bearings for bolt mounting
d **12 – 60** mm



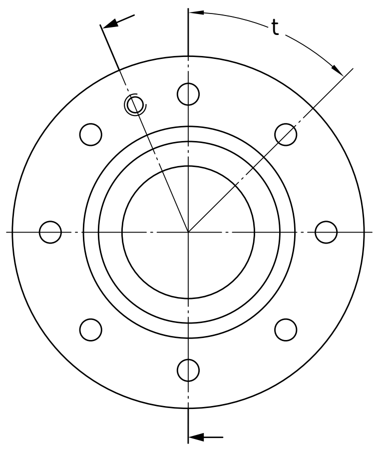


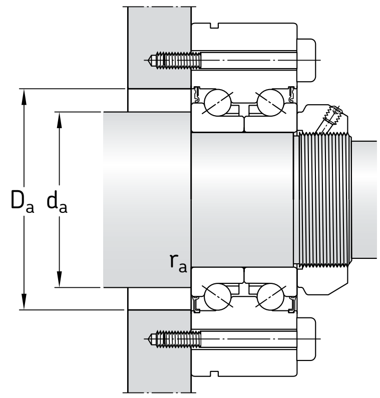
Design for
d = 60 mm



Design PE

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Attainable speed	Mass	Designation
d	D	H	C	C_0	P_u			
mm			kN		kN	r/min	kg	–
12	55	25	16,8	24,5	0,915	4 000	0,37	**BEAM 012055-2RS**
	55	25	16,8	24,5	0,915	6 700	0,37	**BEAM 012055-2Z**
17	62	25	19	31	1,16	3 800	0,45	**BEAM 017062-2RS**
	62	25	19	31	1,16	3 800	0,45	**BEAM 017062-2RS/PE**
	62	25	19	31	1,16	6 300	0,45	**BEAM 017062-2Z**
	62	25	19	31	1,16	6 300	0,45	**BEAM 017062-2Z/PE**
20	68	28	26	46,5	1,73	3 400	0,61	**BEAM 020068-2RS**
	68	28	26	46,5	1,73	3 400	0,61	**BEAM 020068-2RS/PE**
	68	28	26	46,5	1,73	6 000	0,61	**BEAM 020068-2Z**
	68	28	26	46,5	1,73	6 000	0,61	**BEAM 020068-2Z/PE**
25	75	28	27,6	55	2,04	3 400	0,72	**BEAM 025075-2RS**
	75	28	27,6	55	2,04	3 400	0,72	**BEAM 025075-2RS/PE**
	75	28	27,6	55	2,04	5 600	0,72	**BEAM 025075-2Z**
	75	28	27,6	55	2,04	5 600	0,72	**BEAM 025075-2Z/PE**
30	80	28	29,1	64	2,36	2 600	0,78	**BEAM 030080-2RS**
	80	28	29,1	64	2,36	2 600	0,78	**BEAM 030080-2RS/PE**
	80	28	29,1	64	2,36	4 500	0,78	**BEAM 030080-2Z**
	100	38	60	108	4	2 600	1,65	**BEAM 030100-2RS**
	100	38	60	108	4	4 300	1,65	**BEAM 030100-2Z**
35	90	34	41	88	3,25	2 400	1,15	**BEAM 035090-2RS**
	90	34	41	88	3,25	4 000	1,15	**BEAM 035090-2Z**
40	100	34	43,6	102	3,75	2 200	1,45	**BEAM 040100-2RS**
	100	34	43,6	102	3,75	3 800	1,45	**BEAM 040100-2Z**
	115	46	71,5	150	5,5	1 800	2,20	**BEAM 040115-2RS**
	115	46	71,5	150	5,5	3 000	2,20	**BEAM 040115-2Z**
50	115	34	46,8	127	4,65	2 000	1,85	**BEAM 050115-2RS**
	115	34	46,8	127	4,65	3 600	1,85	**BEAM 050115-2Z**
	140	54	112	250	9,3	1 700	4,70	**BEAM 050140-2RS**
	140	54	112	250	9,3	2 800	4,70	**BEAM 050140-2Z**
60	145	45	85,2	216	8	1 600	4,30	**BEAM 060145-2RS**
	145	45	85,2	216	8	2 600	4,30	**BEAM 060145-2Z**

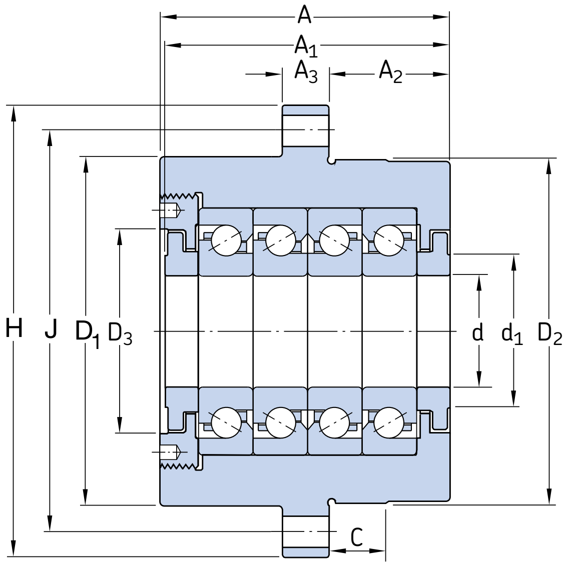




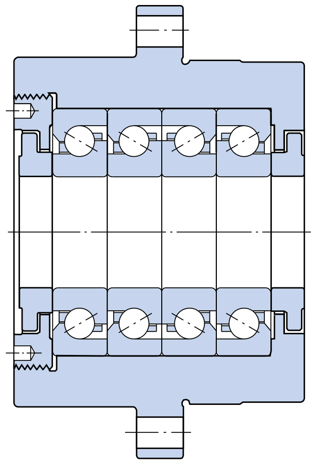
Dimensions							Abutment and fillet dimensions			Holes for attachment bolts to DIN 912			
										Size	Dimensions		
d	d_1 ~	D_1 ~	H_1	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	D_a max	r_a max		J	N	t
mm							mm			–	mm		No. of holes × degree
12	25	33,5	17	0,3	0,6	56	16	33	0,6	M6	42	6,8	3×120°
	25	33,5	17	0,3	0,6	56	16	33	0,6	M6	42	6,8	3×120°
17	30	38	17	0,3	0,6	65	23	38	0,6	M6	48	6,8	3×120°
	30	38	17	0,3	0,6	65	23	38	0,6	M6	48	6,8	3×120°
	30	38	17	0,3	0,6	65	23	38	0,6	M6	48	6,8	3×120°
	30	38	17	0,3	0,6	65	23	38	0,6	M6	48	6,8	3×120°
20	34,5	44	19	0,3	0,6	74	25	44	0,6	M6	53	6,8	4×90°
	34,5	44	19	0,3	0,6	74	25	44	0,6	M6	53	6,8	4×90°
	34,5	44	19	0,3	0,6	74	25	44	0,6	M6	53	6,8	4×90°
	34,5	44	19	0,3	0,6	74	25	44	0,6	M6	53	6,8	4×90°
25	40,5	49	19	0,3	0,8	84	32	49	0,6	M6	58	6,8	4×90°
	40,5	49	19	0,3	0,8	84	32	49	0,6	M6	58	6,8	4×90°
	40,5	49	19	0,3	0,8	84	32	49	0,6	M6	58	6,8	4×90°
	40,5	49	19	0,3	0,8	84	32	49	0,6	M6	58	6,8	4×90°
30	45,5	54	19	0,3	0,6	93	40	54	0,6	M6	63	6,8	6×60°
	45,5	54	19	0,3	0,6	93	40	54	0,6	M6	63	6,8	6×60°
	45,5	54	19	0,3	0,6	93	40	54	0,6	M6	63	6,8	6×60°
	51	65	30	0,3	0,6	106	47	65	0,6	M8	80	8,8	8×45°
	51	65	30	0,3	0,6	106	47	65	0,6	M8	80	8,8	8×45°
35	52	63	25	0,3	0,6	107	45	63	0,6	M8	75	8,8	4×90°
	52	63	25	0,3	0,6	107	45	63	0,6	M8	75	8,8	4×90°
40	58	68	25	0,3	0,6	117	50	68	0,6	M8	80	8,8	4×90°
	58	68	25	0,3	0,6	117	50	68	0,6	M8	80	8,8	4×90°
	65	80	36	0,6	0,6	134	56	80	0,6	M8	94	8,8	12×30°
	65	80	36	0,6	0,6	134	56	80	0,6	M8	94	8,8	12×30°
50	72	82	25	0,3	0,6	141	63	82	0,6	M8	94	8,8	6×60°
	72	82	25	0,3	0,6	141	63	82	0,6	M8	94	8,8	6×60°
	80	98	45	0,6	0,6	166	63	98	0,6	M10	113	11	12×30°
	80	98	45	0,6	0,6	166	63	98	0,6	M10	113	11	12×30°
60	85	100	35	0,6	0,6	168	82	100	0,6	M8	120	8,8	8×45°
	85	100	35	0,6	0,6	168	82	100	0,6	M8	120	8,8	8×45°

5.3

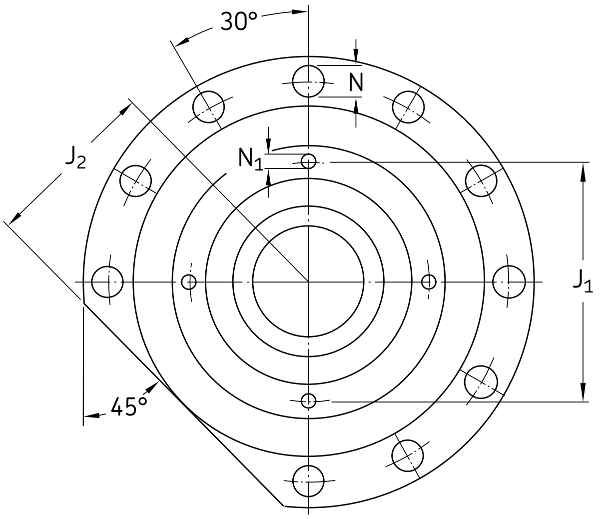
Cartridge units with a flanged housing
d **20 – 60** mm



Design QBCA


Design QFCA

Dimensions																Designation Bearing unit with preload class A
d	A	A_1	A_2	A_3	C	d_1	D_1	D_2	D_3	H	J	J_1	J_2	N	N_1	
mm															–	
20	77	74,3	32	13	15	26	64	60	37	90	76	43,8	32	6,6	2,7	**FBSA 204/QBCA**
	77	72,7	32	13	15	26	64	60	37	90	76	43,8	32	6,6	2,7	**FBSA 204/QFCA**
25	82	80,3	32	15	15	38	88	80	52	120	102	60	44	9,2	4,3	**FBSD 25/QBCA**
	82	78,7	32	15	15	38	88	80	52	120	102	60	44	9,2	4,3	**FBSD 25/QFCA**
30	82	80,3	32	15	15	38	88	80	52	120	102	60	44	9,2	4,3	**FBSD 30/QBCA**
	82	78,7	32	15	15	38	88	80	52	120	102	60	44	9,2	4,3	**FBSD 30/QFCA**
35	82	80,3	32	15	15	45	98	90	59	130	113	65	49	9,2	4,3	**FBSD 35/QBCA**
	82	78,7	32	15	15	45	98	90	59	130	113	65	49	9,2	4,3	**FBSD 35/QFCA**
40	106	104,3	43,5	17	20	55	128	124	75	165	146	88	64	11,4	5,2	**FBSD 40/QBCA**
	106	102,7	43,5	17	20	55	128	124	75	165	146	88	64	11,4	5,2	**FBSD 40/QFCA**
45	106	104,3	43,5	17	20	70	128	124	82	165	146	97	64	11,4	6,2	**FBSD 45/QBCA**
	106	102,7	43,5	17	20	70	128	124	82	165	146	97	64	11,4	6,2	**FBSD 45/QFCA**
50	106	104,3	43,5	17	20	70	128	124	82	165	146	97	64	11,4	6,2	**FBSD 50/QBCA**
	106	102,7	43,5	17	20	70	128	124	82	165	146	97	64	11,4	6,2	**FBSD 50/QFCA**
55	106	104,3	43,5	17	20	86	148	144	103	185	166	113	74	11,4	6,2	**FBSD 55/QBCA**
	106	104,3	43,5	17	20	86	148	144	103	185	166	113	74	11,4	6,2	**FBSD 55/QFCA**
60	106	104,3	43,5	17	20	86	148	144	103	185	166	113	74	11,4	6,2	**FBSD 60/QBCA**
	106	104,3	43,5	17	20	86	148	144	103	185	166	113	74	11,4	6,2	**FBSD 60/QFCA**



Dimension	Mass	Basic load ratings		Fatigue load limit	Axial stiffness		Frictional moments		Attainable speeds	
		dynamic	static		Preload class		Preload class		Preload class	
d		C	C_0	P_u	A	B	A	B	A	B
mm	kg	kN		kN	N/mm		Nm		r/min	
20	1,75	39	104	3,86	1 320	1 720	0,11	0,2	4 300	2 200
	1,75	39	104	3,86	1 320	1 720	0,11	0,2	4 300	2 200
25	3,50	60	173	6,4	1 810	2 310	0,24	0,43	4 000	2 000
	3,50	60	173	6,4	1 810	2 310	0,24	0,43	4 000	2 000
30	3,40	52	160	6	1 850	2 360	0,26	0,45	4 000	2 000
	3,40	52	160	6	1 850	2 360	0,26	0,45	4 000	2 000
35	4,25	64	208	7,8	2 180	2 780	0,4	0,69	3 800	1 900
	4,25	64	208	7,8	2 180	2 780	0,4	0,69	3 800	1 900
40	9,60	114	366	13,6	2 700	3 440	0,77	1,358	3 000	1 500
	9,60	114	366	13,6	2 700	3 440	0,77	1,358	3 000	1 500
45	9,35	143	480	17,6	3 070	3 930	1,1	1,942	2 800	1 400
	9,35	143	480	17,6	3 070	3 930	1,1	1,942	2 800	1 400
50	9,05	143	480	17,6	3 070	3 930	1,1	1,942	2 800	1 400
	9,05	143	480	17,6	3 070	3 930	1,1	1,942	2 800	1 400
55	11,7	155	570	21,2	3 540	4 520	1,6	2,8	2 600	1 300
	11,7	155	570	21,2	3 540	4 520	1,6	2,8	2 600	1 300
60	11,4	155	570	21,2	3 540	4 520	1,6	2,8	2 600	1 300
	11,4	155	570	21,2	3 540	4 520	1,6	2,8	2 600	1 300


KMT 12

Locking devices

Locking devices

Locking devices are used to locate high-precision bearings axially on a spindle or shaft. They should be made very accurately and provide even support around the entire circumference of the shaft washer or inner ring. Locking devices should also be simple to mount and dismount.

Lock nuts

Industrial design lock nuts with locking washers are not entirely suitable for high-precision applications because of the relatively wide manufacturing tolerances of the thread and abutment surfaces, which may lead to shaft deformations and alter the axis of rotation.

As a result, SKF has developed a full line of precision lock nuts (→ **fig. 1**) that are manufactured within very tight tolerances. These simple to mount devices that locate bearings and other components accurately and efficiently on the shaft, meet the requirements of machine tool applications, both technically and economically.

Precision lock nuts are part of the SKF standard product assortment and are generally available from stock.

Stepped sleeves

An alternate method of locating a high-precision bearing on a shaft is to use a stepped sleeve (→ **fig. 2**). A stepped sleeve is a pressure joint with two slightly different bore diameters that have an interference fit on a stepped shaft. These sleeves are typically used in high-speed, lightly loaded applications where shock loads are minimal. SKF designed the stepped sleeve for precision applications but does not manufacture or supply them.

Design recommendations and suitable dimensions are provided in the tables starting on **page 288**.

Fig. 1

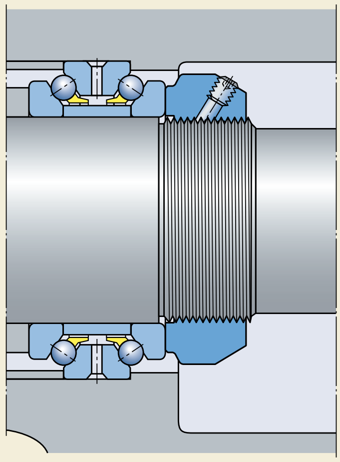


Fig. 2

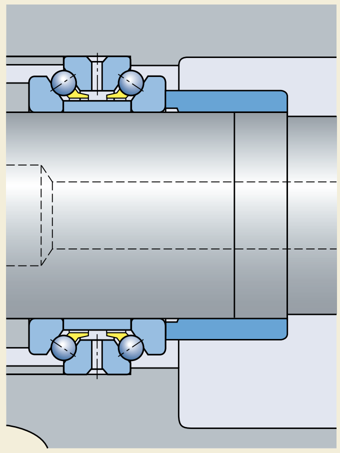
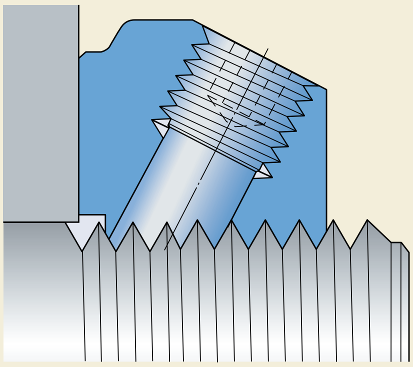


Fig. 3



Precision lock nuts with locking pins

SKF manufactures two different types of precision lock nuts with locking pins: KMT and KMTA lock nuts. Both enable bearings and other components to be simply and reliably located in the axial direction on shafts, with a high degree of accuracy.

Their special design feature consists of three sintered steel locking pins (→ **fig. 3**), which are equally spaced around the circumference of the lock nut. These pins are pressed against the shaft thread by grub screws to prevent the nut from turning.

Mounting is easy and the design simple. Additional locking washers, slots or steps in the shaft are not required. The locking pins and grub screws are arranged at the same angle to the shaft axis as that of the thread flanks. The ends of the pins are machined in a single operation with the nut thread and consequently have the same thread profile. Therefore, when the grub screws are tightened, the locking pins do not deform. The locking effect is achieved purely by friction between the lock nut and shaft thread flanks, and the locking pins and shaft thread flanks. When the nut is locked, the thread flanks are not relieved of loads axially and the axial forces are carried by the lock nut thread flanks (not by the locking pins).

Another advantage of KMT and KMTA lock nuts is that they are adjustable. The three equally spaced locking pins enable the nut to be accurately positioned at right angles to the shaft, or they can be used to adjust for inaccuracies or deviations of other components that are to be located on the shaft. As the locking pins are not deformed, KMT and KMTA lock nuts retain their high precision irrespective of the number of times they are mounted and dismounted.

KMT lock nuts

KMT lock nuts (→ **fig. 4**) are designed as slotted nuts. Lock nuts up to and including size 15 have two additional diametrically opposed flats to accommodate a spanner.

KMTA lock nuts

KMTA lock nuts (→ **fig. 5**) have a cylindrical outside surface and are primarily intended for applications where space is limited. As the outside surface is cylindrical, the nut can also be used to form part of a gap-type seal. Holes around the circumference and in one side face facilitate mounting.

Fig. 4

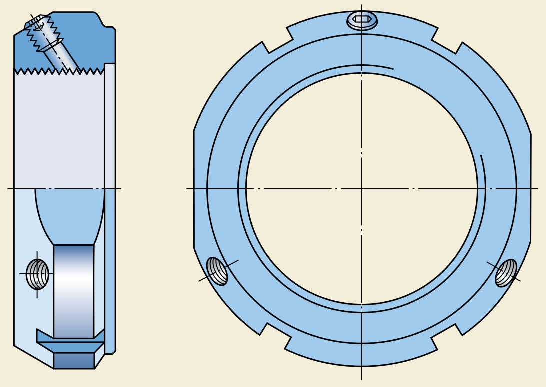
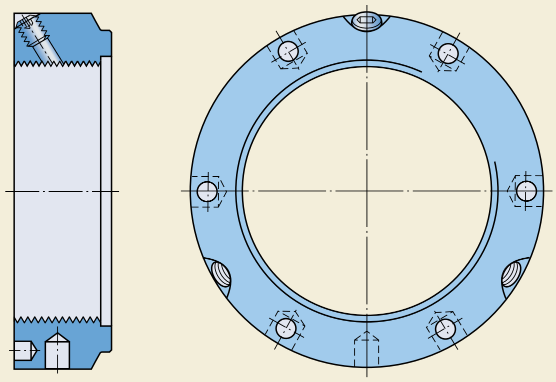


Fig. 5



Product data – general

Dimensions

KMT and KMTA lock nuts have a metric ISO thread in accordance with ISO 965-3:1998.

Tolerances

The metric ISO thread is machined to tolerance 5H in accordance with ISO 965-3:1998. The maximum runout between the thread and the locating face is 0,005 mm for nuts up to and including size 26.

Material

SKF lock nuts in the KMT and KMTA series are made of high-strength steel; their surfaces are phosphated and protected by a solventless rust inhibitor.

Mating shaft threads

SKF recommends that the mating thread on the shaft be made to 6g in accordance with ISO 965-3:1998.

Loosening torque

KMT and KMTA lock nuts are locked on the shaft by friction. The friction, and therefore the loosening torque, varies as a result of the accuracy of the tightening torque of the grub screws, the surface finish of the shaft thread, the amount of lubricant on the thread, etc.

Experience shows that the locking mechanism of KMT and KMTA lock nuts is more than adequate for machine tool applications, provided the lock nuts are properly mounted and there is only a limited amount of lubricant on the thread.

For additional information about loosening torque contact the SKF application engineering service.

Mounting

KMT lock nuts have slots around the circumference with two diametrically opposed flats on all nuts up to and including size 15. Various types of spanners can be used depending on the nut size, including hook and impact spanners. Sizes of appropriate spanners are provided in the product table.

KMTA lock nuts can be tightened using a pin wrench with a stud to engage one of the holes in the circumference. Alternatively, a pin-type face spanner or a tommy bar can be used. Appropriate spanner sizes, in accordance with DIN 1810:1979, are provided in the product table.

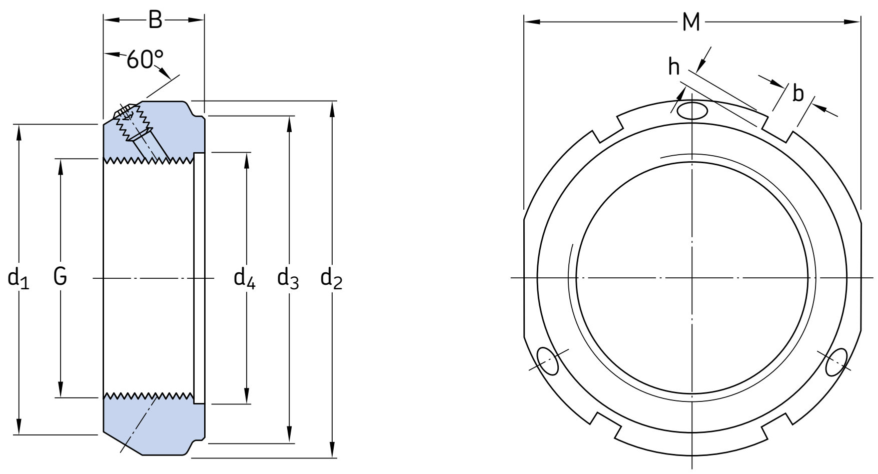
To lock a KMT or KMTA lock nut, all three grub screws should first be gently tightened until the thread of the locking pin engages the shaft thread. The grub screws should then be firmly tightened to the recommended tightening torque quoted in the product tables.

If there is a need to compensate for misalignment between the abutment surfaces of the nut and an adjacent component, the grub screw at the position of greatest deviation should be loosened and the other two screws should be tightened equally. The loosened screw should then be retightened. If this procedure is inadequate, it should be repeated until the desired accuracy has been achieved. Progress should be verified using a dial indicator.

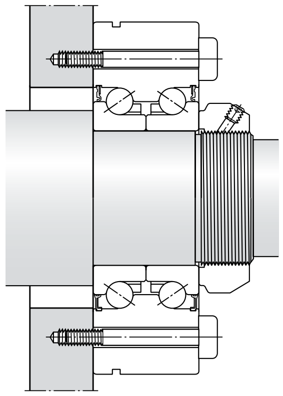
Dismounting

When dismounting a KMT or KMTA lock nut, the locking pins may still be firmly engaged with the shaft thread, even after the grub screws have been loosened. To disengage the locking pins, gently tap the nut in the vicinity of the grub screws with a rubber hammer. The nuts can then be unscrewed easily from the shaft thread.

KMT precision lock nuts with locking pins
M 10×0,75 – M 200×3

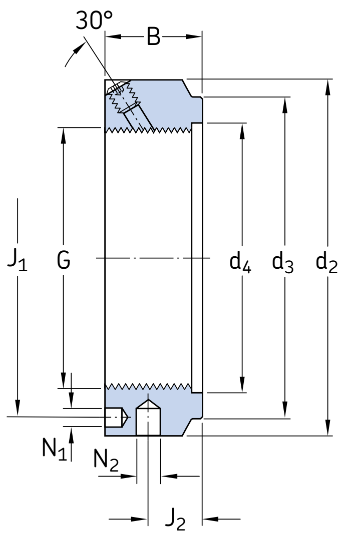


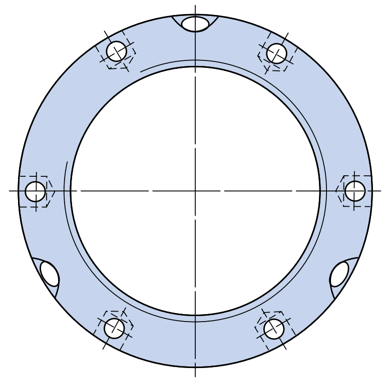
Dimensions									Axial load carrying capacity static	Mass	Designations Lock nut	Appropriate spanner	Grub screws Size	Recomm. tightening torque
G	d_1	d_2	d_3	d_4	B	b	h	M						
mm									kN	kg	–		–	Nm
M 10×0,75	21	28	23	11	14	4	2	24	35	0,045	**KMT 0**	HN 2/3	M 5	4,5
M 12×1	23	30	25	13	14	4	2	27	40	0,05	**KMT 1**	HN 3	M 5	4,5
M 15×1	26	33	28	16	16	4	2	30	60	0,075	**KMT 2**	HN 4	M 5	4,5
M 17×1	29	37	33	18	18	5	2	34	80	0,1	**KMT 3**	HN 4	M 6	8
M 20×1	32	40	35	21	18	5	2	36	90	0,11	**KMT 4**	HN 5	M 6	8
M 25×1,5	36	44	39	26	20	5	2	41	130	0,13	**KMT 5**	HN 5	M 6	8
M 30×1,5	41	49	44	32	20	5	2	46	160	0,16	**KMT 6**	HN 6	M 6	8
M 35×1,5	46	54	49	38	22	5	2	50	190	0,19	**KMT 7**	HN 7	M 6	8
M 40×1,5	54	65	59	42	22	6	2,5	60	210	0,3	**KMT 8**	HN 8/9	M 8	18
M 45×1,5	60	70	64	48	22	6	2,5	65	240	0,33	**KMT 9**	HN 9/10	M 8	18
M 50×1,5	64	75	68	52	25	7	3	70	300	0,4	**KMT 10**	HN 10/11	M 8	18
M 55×2	74	85	78	58	25	7	3	80	340	0,54	**KMT 11**	HN 12/13	M 8	18
M 60×2	78	90	82	62	26	8	3,5	85	380	0,61	**KMT 12**	HN 13	M 8	18
M 65×2	83	95	87	68	28	8	3,5	90	460	0,71	**KMT 13**	HN 14	M 8	18
M 70×2	88	100	92	72	28	8	3,5	95	490	0,75	**KMT 14**	HN 15	M 8	18
M 75×2	93	105	97	77	28	8	3,5	100	520	0,8	**KMT 15**	HN 15/16	M 8	18
M 80×2	98	110	100	83	32	8	3,5	–	620	0,9	**KMT 16**	HN 16/17	M 8	18
M 85×2	107	120	110	88	32	10	4	–	650	1,15	**KMT 17**	HN 17/18	M 10	35
M 90×2	112	125	115	93	32	10	4	–	680	1,2	**KMT 18**	HN 18/19	M 10	35
M 95×2	117	130	120	98	32	10	4	–	710	1,25	**KMT 19**	HN 19/20	M 10	35
M 100×2	122	135	125	103	32	10	4	–	740	1,3	**KMT 20**	HN 20	M 10	35



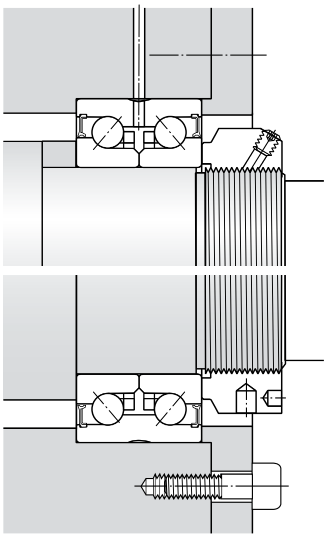
Dimensions								Axial load carrying capacity static	Mass	Designations Lock nut	Appropriate spanner	Grub screws Size	Recomm. tightening torque
G	d_1	d_2	d_3	d_4	B	b	h						
mm								kN	Nm	kg	–	–	Nm
M 110×2	132	145	134	112	32	10	4	800	1,45	**KMT 22**	HN 22	M 10	35
M 120×2	142	155	144	122	32	10	4	860	1,6	**KMT 24**	TMFN 23-30	M 10	35
M 130×2	152	165	154	132	32	12	5	920	1,7	**KMT 26**	TMFN 23-30	M 10	35
M 140×2	162	175	164	142	32	14	6	980	1,8	**KMT 28**	TMFN 23-30	M 10	35
M 150×2	172	185	174	152	32	14	6	1 040	1,95	**KMT 30**	TMFN 23-30	M 10	35
M 160×3	182	195	184	162	32	14	6	1 100	2,1	**KMT 32**	TMFN 30-40	M 10	35
M 170×3	192	205	192	172	32	14	6	1 160	2,2	**KMT 34**	TMFN 30-40	M 10	35
M 180×3	202	215	204	182	32	16	7	1 220	2,3	**KMT 36**	TMFN 30-40	M 10	35
M 190×3	212	225	214	192	32	16	7	1 280	2,4	**KMT 38**	TMFN 30-40	M 10	35
M 200×3	222	235	224	202	32	18	8	1 340	2,5	**KMT 40**	TMFN 30-40	M 10	35

KMTA precision lock nuts with locking pins
M 25×1,5 – M 200×3





Dimensions									Axial load carrying capacity	Mass	Designations		Grub screws	
G	d_2	d_3	d_4	B	J_1	J_2	N_1	N_2	static		Lock nut	Appropriate spanner	Size	Recomm. tightening torque
mm									kN	kg	–		–	Nm
M 25×1,5	42	35	26	20	32,5	11	4,3	4	130	0,13	**KMTA 5**	B 40-42	M 6	8
M 30×1,5	48	40	32	20	40,5	11	4,3	5	160	0,16	**KMTA 6**	B 45-50	M 6	8
M 35×1,5	53	47	38	20	45,5	11	4,3	5	190	0,19	**KMTA 7**	B 52-55	M 6	8
M 40×1,5	58	52	42	22	50,5	12	4,3	5	210	0,23	**KMTA 8**	B 58-62	M 6	8
M 45×1,5	68	58	48	22	58	12	4,3	6	240	0,33	**KMTA 9**	B 68-75	M 6	8
M 50×1,5	70	63	52	24	61,5	13	4,3	6	300	0,34	**KMTA 10**	B 68-75	M 6	8
M 55×1,5	75	70	58	24	66,5	13	4,3	6	340	0,37	**KMTA 11**	B 68-75	M 6	8
M 60×1,5	84	75	62	24	74,5	13	5,3	6	380	0,49	**KMTA 12**	B 80-90	M 8	18
M 65×1,5	88	80	68	25	78,5	13	5,3	6	460	0,52	**KMTA 13**	B 80-90	M 8	18
M 70×1,5	95	86	72	26	85	14	5,3	8	490	0,62	**KMTA 14**	B 95-100	M 8	18
M 75×1,5	100	91	77	26	88	13	6,4	8	520	0,66	**KMTA 15**	B 95-100	M 8	18
M 80×2	110	97	83	30	95	16	6,4	8	620	1	**KMTA 16**	B 110-115	M 8	18
M 85×2	115	102	88	32	100	17	6,4	8	650	1,15	**KMTA 17**	B 110-115	M 10	35
M 90×2	120	110	93	32	108	17	6,4	8	680	1,2	**KMTA 18**	B 120-130	M 10	35
M 95×2	125	114	98	32	113	17	6,4	8	710	1,25	**KMTA 19**	B 120-130	M 10	35
M 100×2	130	120	103	32	118	17	6,4	8	740	1,3	**KMTA 20**	B 120-130	M 10	35
M 110×2	140	132	112	32	128	17	6,4	8	800	1,45	**KMTA 22**	B 135-145	M 10	35
M 120×2	155	142	122	32	140	17	6,4	8	860	1,85	**KMTA 24**	B 155-165	M 10	35
M 130×3	165	156	132	32	153	17	6,4	8	920	2	**KMTA 26**	B 155-165	M 10	35
M 140×3	180	166	142	32	165	17	6,4	10	980	2,45	**KMTA 28**	B 180-195	M 10	35
M 150×3	190	180	152	32	175	17	6,4	10	1 040	2,6	**KMTA 30**	B 180-195	M 10	35



Dimensions									Axial load carrying capacity	Mass	Designations		Grub screws	
G	d_2	d_3	d_4	B	J_1	J_2	N_1	N_2	static		Lock nut	Appropriate spanner	Size	Recomm. tightening torque
mm									kN	kg	–		–	Nm
M 160×3	205	190	162	32	185	17	8,4	10	1 100	3,15	**KMTA 32**	B 205-220	M 10	35
M 170×3	215	205	172	32	195	17	8,4	10	1 160	3,3	**KMTA 34**	B 205-220	M 10	35
M 180×3	230	215	182	32	210	17	8,4	10	1 220	3,9	**KMTA 36**	B 230-245	M 10	35
M 190×3	240	225	192	32	224	17	8,4	10	1 280	4,1	**KMTA 38**	B 230-245	M 10	35
M 200×3	245	237	202	32	229	17	8,4	10	1 340	3,85	**KMTA 40**	B 230-245	M 10	35

Stepped sleeves

Stepped sleeves (→ **fig. 1**) are pressure joints having two slightly different inside diameters that mate with a stepped shaft. An interference fit maintains the sleeve's position axially and determines its axial load carrying capacity. The stepped design of the fitting surface simplifies alignment during the mounting procedure but also facilitates dismounting using the oil injection method. Stepped sleeves do not create any stresses that might reduce the running accuracy of a shaft, but enhance shaft stiffness. They are typically used in very high speed, lightly loaded applications where there are minimal shock loads. Compared to threaded lock nuts, stepped sleeves provide superior mounting accuracy, provided the sleeve and its seats are manufactured to specification and mounting recommendations are followed.

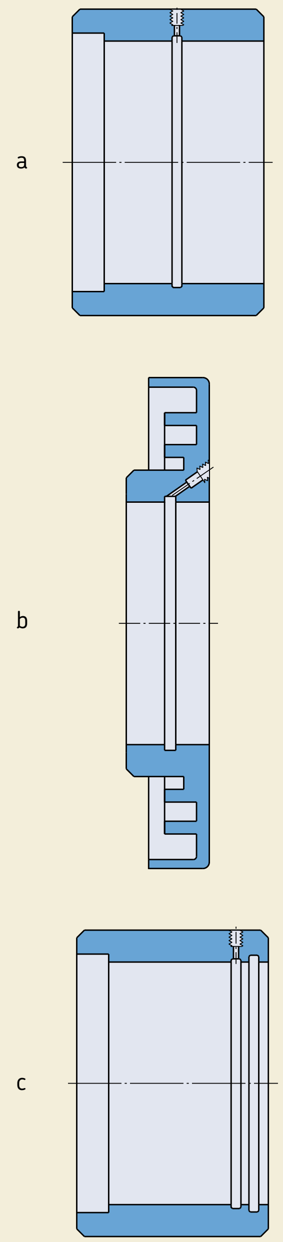
SKF designed stepped sleeves for precision applications, but does not manufacture or supply them. Design recommendations and suitable dimensions are provided in the following.

Designs

Stepped sleeves (→ **fig. 1**) can have either a conventional sleeve form (**a**) or they can be ring-shaped (**b**). Ring-shaped stepped sleeves are typically used in applications where the sleeve will also be used to form part of a labyrinth seal.

In applications where there are relatively light axial loads, the side of the sleeve with the smaller diameter can have a loose fit on the shaft. However, if the oil injection method will be used to dismount the sleeve, the end of the sleeve with the loose fit should be sealed with an O-ring (**c**). Stepped sleeves with a loose fit for the smaller diameter exert only half of the axial retaining force of normal stepped sleeves.

Fig. 1



Product data – general

Dimensions

Recommended dimensions for stepped sleeves with or without an O-ring and their seats are provided in the tables on **pages 288** to **290**. When dimensioning and manufacturing stepped sleeves and their corresponding shaft seats, the difference in the degree of interference between the two seats should be as small as possible. Experience has shown that dismounting becomes much more difficult when the difference is too large. The best approach is to start with the difference between diameters – the so-called step – as it is easier to keep within narrow tolerances for this diameter difference than for the diameter itself.

Thin-walled shafts may be subject to a relatively large diametrical deformation as a result of high contact pressures. Therefore, the sleeves for these shafts should have a relief closest to the bearing to avoid deformation of the bearing seat. The length of the relief should be 15–20 % of the shaft diameter.

Material

SKF recommends using a heat-treatable steel with a yield point of at least 550 N/mm^2. The fitting surfaces of both the sleeve and shaft should be hardened and ground.

Axial load carrying capacity

The degree of the actual interference fit determines the axial load carrying capacity. Stepped sleeves for solid or thick-walled hollow shafts should be made according to the specifications provided in the tables on **pages 288** to **290**. When made to these specifications, the following are approximate surface pressures between the shaft and sleeve and the approximate retaining axial force per millimetre hub width

- for about 30 mm shaft diameter: 40 N/mm^2 pressure and 300 N/mm axial retaining force
- for about 100 mm shaft diameter: 35 N/mm^2 pressure and 550 N/mm axial retaining force
- for about 200 mm shaft diameter: 22 N/mm^2 pressure and 1 000 N/mm axial retaining force.

Based on these values, it is possible to estimate the retaining force that can be exerted by a mounted stepped sleeve.

When designing the stepped sleeve, axial shock forces on the sleeve must also be taken into consideration. If necessary, a threaded nut which is lightly tightened and which can also serve as a mounting aid, can be used to secure the sleeve.

Mounting and dismounting

Mounting

To mount a stepped sleeve on a shaft, the sleeve should be heated to a temperature higher than the shaft as listed in the tables on **pages 288** to **290**. Then it should be pushed onto its shaft seat. After it has cooled, oil or an SKF mounting fluid should be injected between the mating surfaces, and a suitable tool like the one shown in **fig. 2**, should be used to bring the sleeve to its final position. To avoid local stress peaks, the oil should be injected slowly and the oil pressure regulated. As the sleeve “floats” on an oil film, any stresses produced during the shrinking of the sleeve is relieved and the components can be correctly positioned relative to each other. With the tool still in position, the oil pressure between the mating surfaces should be released and the oil must be allowed to drain. Normally it takes some 24 hours before the sleeve can support its full load.

SKF recommends using a hydraulic nut and a suitable distance sleeve for positioning the stepped sleeve. When using a hydraulic nut, the force of the nut against the bearing arrangement can be controlled by the oil pressure. When the required axial force has been obtained, the final position is reached.

If stepped sleeves are to be mounted against bearings that are already greased, care should be taken that the injected oil does not mix with the grease and impair its lubricating properties.

Dismounting

To dismount a stepped sleeve, inject oil between the sleeve and shaft. When sufficient oil pressure has been built up to separate the mating surfaces, an axial force will result due to the different bore diameters and the sleeve will slide from its seat without requiring any additional external force. As the sleeve may be ejected from its seat quite suddenly, SKF recommends placing a stop at the end of the shaft.

Oil injection equipment, pressure media

The oil injection equipment necessary to mount and dismount stepped sleeves is available from SKF. Product details can be found in the catalouge “SKF Maintenance and Lubrication Products” or online at www.skf.com.

When selecting a suitable pump, keep in mind that the maximum permissible pressure should be considerably greater than the calculated surface pressure.

SKF LHDF 900 dismounting fluid is suitable for mounting and dismounting stepped sleeves. With a viscosity of 900 mm^2/s at 20 °C, LHDF 900 will provide an adequate oil film even if the mating surface of the sleeve or shaft is scratched. It must be remembered, however, that the fluid has a low flow rate and care should be taken that the oil injection equipment and sleeve are not overloaded, i.e. their permissible pressures are not exceeded.

For mounting, it is also possible to use SKF mounting fluid LHMF 300. This fluid has a viscosity of 300 mm^2/s at 20 °C. The advantage of LHMF 300 is that when mounting is complete, this fluid will leave the joint quickly and completely, so that metal-to-metal contact is restored relatively quickly.

Mounting and dismounting fluids should never be mixed, therefore LHMF 300 is coloured red and LHDF 900 is coloured blue.

Special stepped sleeve designs

Their special characteristics enable stepped sleeves to be used successfully to secure and join other components. They enable hubs to be mounted and dismounted simply and can also replace various types of driver plates, dogs etc. The V-belt pulley shown in **fig. 3**, for example, is designed as a stepped sleeve with an integral labyrinth seal. In this case, the sleeve not only locates the bearing axially, it is also used to transmit torque.

Fig. 2

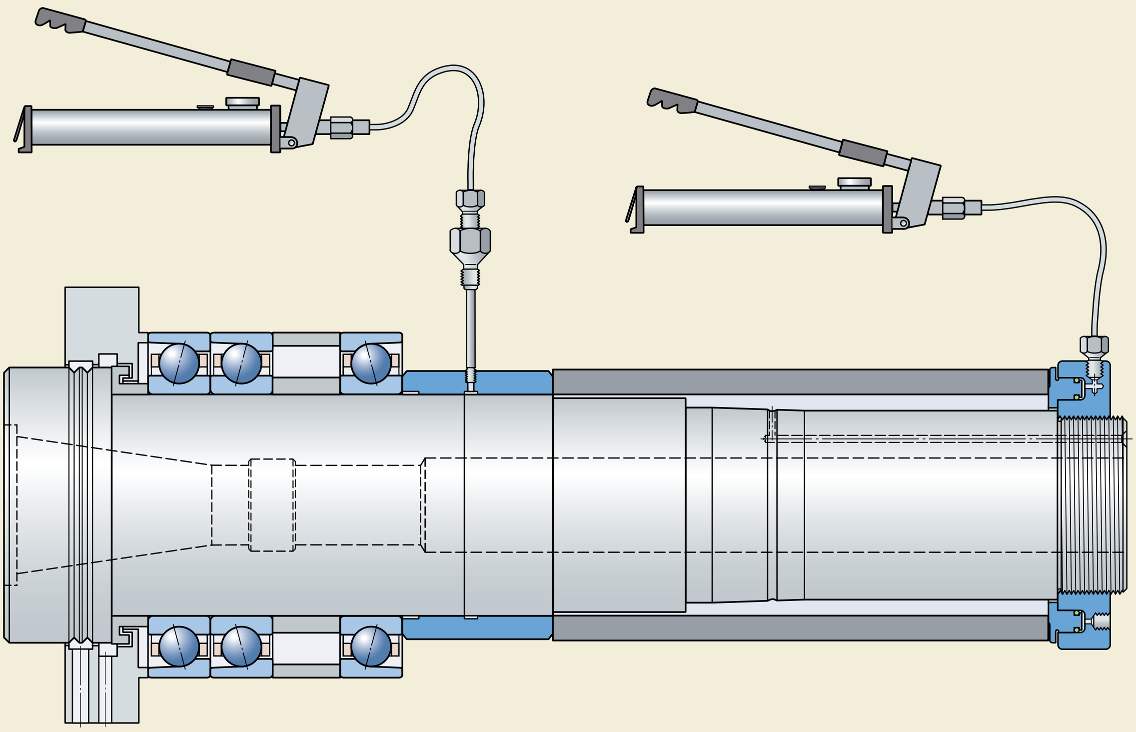
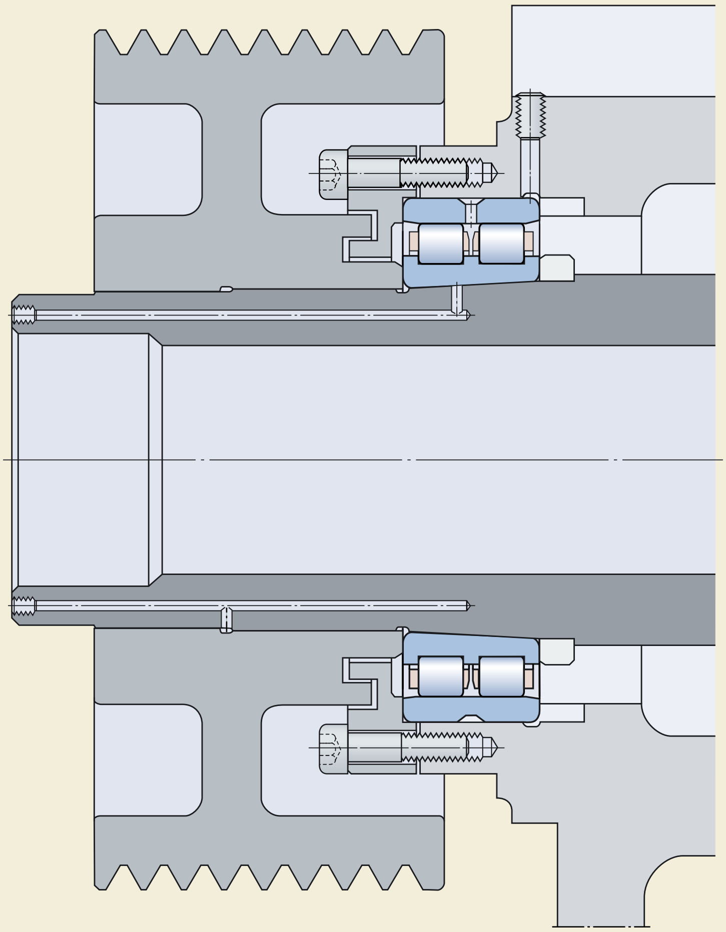
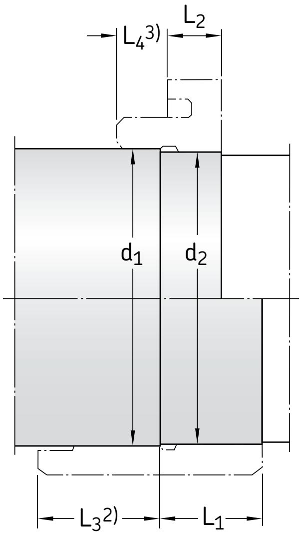


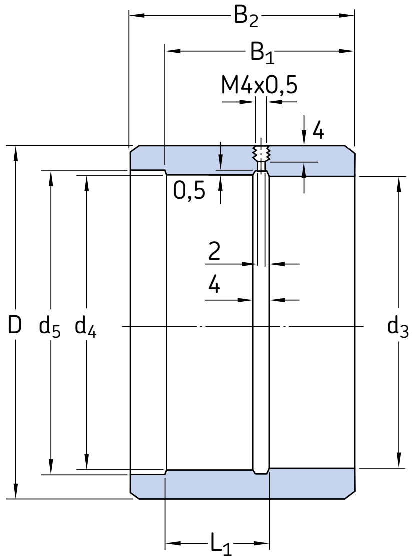
Fig. 3



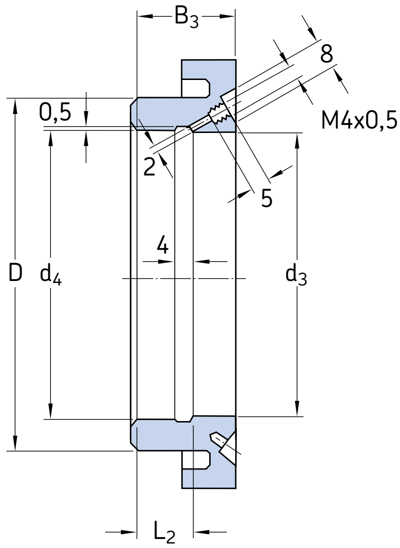
Recommended dimensions for stepped sleeves and their seats
d_1 **17 – 200** mm



Shaft

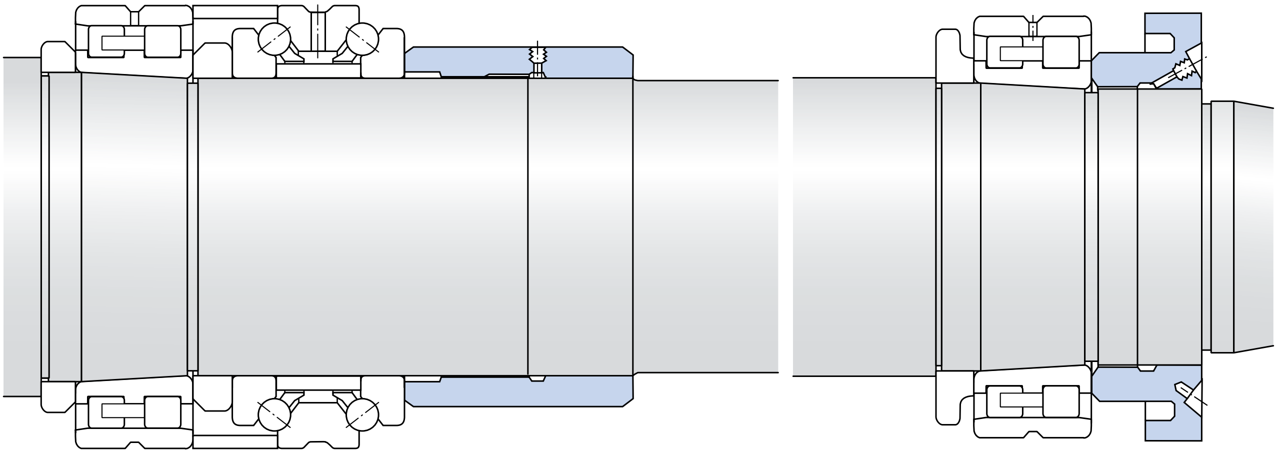


Stepped sleeve



Stepped ring

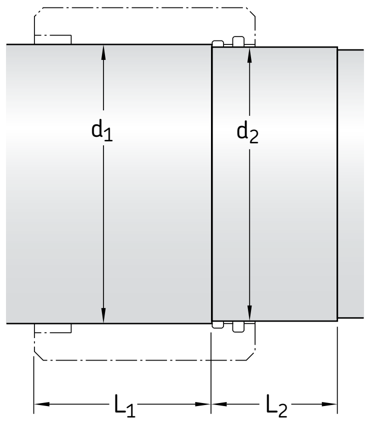
Dimensions Shaft		Stepped sleeve or ring									**Temperature differential**[1)]
d_1 h4	d_2 h4	d_3 H4	d_4 H4	d_5 +0,5	D	B_1	B_2	B_3	L_1 j13	L_2 J13	
mm											°C
17	16,968	16,95	16,977	19	27	26	31	13	15	8,5	150
20	19,964	19,94	19,971	22	30	28	33	14	16	9	150
25	24,956	24,92	24,954	27	35	30	35	15	17	9,5	150
30	29,946	29,91	29,954	32	40	32	38	16	18	10	140
35	34,937	34,90	34,943	37	47	34	40	17	19	10,5	140
40	39,937	39,90	39,943	42	52	36	42	18	20	11	130
45	44,927	44,88	44,933	47	58	38	46	19	21	11,5	130
50	49,917	49,86	49,923	52	63	40	48	20	22	12	130
55	54,908	54,85	54,922	57	70	42	50	21	23	12,5	120
60	59,908	59,85	59,922	62	75	44	54	22	24	13	120
65	64,898	64,83	64,912	67	80	46	56	23	25	13,5	120
70	69,898	69,83	69,912	72	86	48	58	24	26	14	110
75	74,898	74,83	74,912	77	91	50	60	25	27	14,5	100
80	79,888	79,82	79,912	82	97	52	62	26	28	15	100
85	84,880	84,81	84,900	87	102	54	64	27	29	15,5	100
90	89,880	89,80	89,900	92	110	56	68	28	30	16	100
95	94,870	94,79	94,900	97	114	58	70	29	31	16,5	90
100	99,870	99,79	99,900	102	120	60	72	30	32	17	90
105	104,870	104,78	104,89	107	125	62	74	31	33	17,5	90
110	109,860	109,77	109,89	112	132	64	76	32	34	18	90



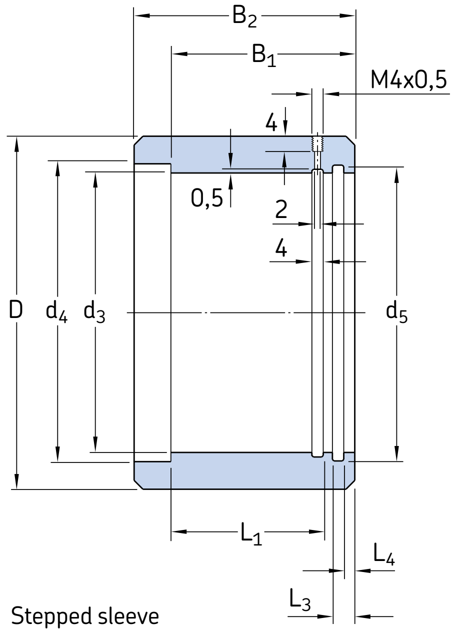
Dimensions Shaft		Stepped sleeve or ring									**Temperature differential**[1]
d_1 h4	d_2 h4	d_3 H4	d_4 H4	d_5 +0,5	D	B_1	B_2	B_3	L_1 j13	L_2 J13	
mm											°C
120	119,860	119,77	119,890	122	142	68	80	34	36	19	80
130	129,852	129,75	129,868	132	156	72	84	36	38	20	90
140	139,852	139,74	139,858	142	166	76	88	38	40	21	90
150	149,842	149,73	149,858	152	180	80	95	40	42	22	80
160	159,842	159,73	159,858	162	190	84	99	42	44	23	80
170	169,842	169,72	169,848	172	205	88	103	44	46	24	80
180	179,832	179,71	179,848	182	220	92	110	46	48	25	80
190	189,834	189,70	189,836	192	230	96	114	48	50	26	80
200	199,834	199,70	199,836	202	245	100	118	50	52	27	70

[1] The difference in temperature between shaft and sleeve or ring when mounting
[2] L_3 = length of stepped sleeve over diameter $d_1 = L_1 + B_2 - B_1 - 4$ (mm)
[3] L_4 = length of stepped ring over diameter $d_1 = L_2 - 4$ + recessed d_4 section (mm)

Recommended dimensions for stepped sleeves with O-ring and their seats
d_1 **17 – 200** mm

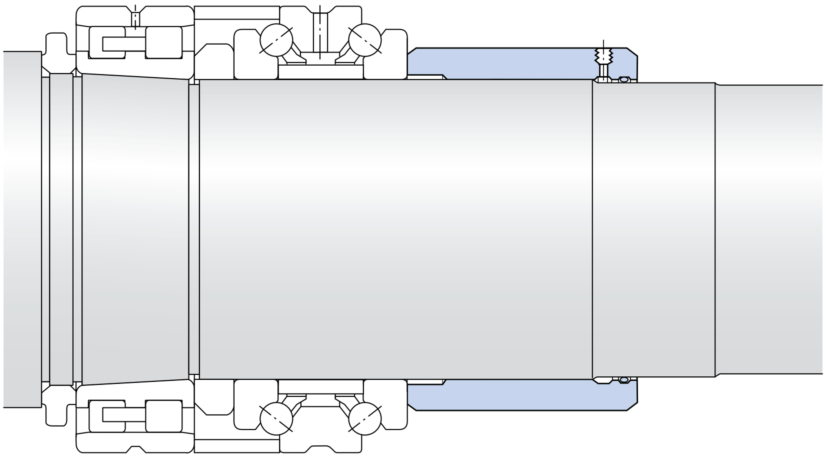


Shaft



Stepped sleeve

Dimensions Shaft			Stepped sleeve									**Appropriate O-ring**	**Temperature differential**[1)]
d_1 h4	d_2 f7	L_1 j13	d_3 H4	d_4 +0,5	d_5 H9	D	B_1	B_2	L_2 j13	L_3	L_4 +0,2		
mm			mm									–	°C
17	16,95	17	16,977	19	20,6	27	26	31	16	6,5	3,1	16,3×2,4	150
20	19,95	19	19,971	22	23,6	30	28	33	18	6,5	3,1	19,3×2,4	150
25	24,90	21	24,954	27	29,5	35	30	35	20	7	3,9	24,2×3	150
30	29,90	24	29,954	32	34,5	40	32	38	22	7	3,9	29,2×3	140
35	34,90	26	34,943	37	39,5	47	34	40	24	7	3,9	34,2×3	140
40	39,90	28	39,943	42	44,5	52	36	42	26	7	3,9	39,2×3	130
45	44,90	32	44,933	47	49,5	58	38	46	28	7	3,9	44,2×3	130
50	49,90	34	49,923	52	54,5	63	40	48	30	7	3,9	49,2×3	130
55	54,90	36	54,922	57	59,5	70	42	50	32	7	3,9	54,2×3	120
60	59,90	40	59,922	62	64,5	75	44	54	34	7	3,9	60×3	120
65	64,85	42	64,912	67	69,5	80	46	56	36	7	3,9	65×3	120
70	69,85	42	69,912	72	74,5	86	48	58	36	8	3,9	69,5×3	110
75	74,85	44	74,912	77	79,5	91	50	60	38	8	3,9	74,5×3	100
80	79,85	46	79,912	82	84,5	97	52	62	40	8	3,9	79,5×3	100
85	84,85	48	84,900	87	89,5	102	54	64	42	8	3,9	85×3	100
90	89,85	52	89,900	92	94,5	110	56	68	44	8	3,9	90×3	100
95	94,85	54	94,900	97	99,5	114	58	70	46	8	3,9	94,5×3	90
100	99,85	54	99,900	102	104,5	120	60	72	46	9	3,9	100×3	90
105	104,85	56	104,890	107	109,5	125	62	74	48	9	3,9	105×3	90
110	109,85	58	109,890	112	114,5	132	64	76	50	9	3,9	110×3	90
120	119,85	62	119,890	122	124,5	142	68	80	54	9	3,9	120×3	80



Dimensions Shaft			Stepped sleeve									**Appropriate O-ring**	**Temperature differential**[1]
d_1 h4	d_2 f7	L_1 j13	d_3 H4	d_4 +0,5	d_5 H9	D	B_1	B_2	L_2 j13	L_3	L_4 +0,2		
mm			mm									–	°C
130	129,80	66	129,868	132	134,4	156	72	84	58	9	3,9	130×3	90
140	139,80	70	139,858	142	144,4	166	76	88	62	9	3,9	140×3	90
150	149,80	73	149,858	152	159	180	80	95	62	13	7,4	149,2×5,7	80
160	159,80	77	159,858	162	169	190	84	99	66	13	7,4	159,2×5,7	80
170	169,80	81	169,848	172	179	205	88	103	70	13	7,4	169,2×5,7	80
180	179,80	88	179,848	182	189	220	92	110	74	13	7,4	179,2×5,7	80
190	189,80	92	189,836	192	199	230	96	114	78	13	7,4	189,2×5,7	80
200	199,80	96	199,836	202	209	245	100	118	82	13	7,4	199,2×5,7	70

6.4

[1] The difference in temperature between shaft and sleeve when mounting


GB 3015/2

Gauges

Fig. 1

Fig. 2

Overview

Conventional measuring methods and instruments are not always suitable for checking tapered seats or to measure the inside or outside envelope diameter of the roller set of a cylindrical roller bearing. Therefore, SKF has developed an assortment of gauges specially designed to take the accurate measurements necessary when mounting cylindrical roller bearings with a tapered bore in a machine tool application. Of course, these gauges are also useful for other applications.

Ring gauges in the GRA 30 series (→ **fig. 1**) and DMB taper gauges (→ **fig. 2**) can be used to check the most common tapered seats. Measurements can be made quickly and accurately. While a GRA ring gauge can only be used to check a tapered seat for a particular bearing size, the taper gauges in the DMB series can be used for a range of diameters, as well as for tapers other than 1:12.

To precisely adjust the radial internal clearance or preload when mounting a cylindrical roller bearing with a tapered bore, it is necessary to accurately measure the inside or outside envelope diameter of the roller set. SKF internal clearance gauges in the GB 30 (→ **fig. 3**) and GB 49 series (→ **fig. 4**) enable simple and accurate measuring.

For information about other SKF measuring devices, consult the SKF application engineering service.

Fig. 3

Fig. 4

Fig. 5

GRA 30 ring gauges

SKF ring gauges in the GRA 30 series (→ **fig. 5**) are typically used to check tapered shaft seats for cylindrical roller bearings in the NN 30 K series. Shaft seats for bearings in the NNU 49 BK series can also be checked with a GRA 30 series gauge, because only the bearing width differs slightly from a bearing in the NN 30 K series. GRA 30 ring gauges can even be used to check the shaft seat for a bearing in the N 10 K series.

GRA 30 ring gauges are available for tapered seats up to 200 mm in diameter. For seats with diameters larger than 200 mm, SKF recommends using a taper gauge. Ring gauges for diameters above 200 mm would be difficult to handle because of their weight.

Measuring options

GRA 30 ring gauges are used primarily to determine the position of the tapered seat relative to a reference surface on the shaft. The reference face of a GRA 30 ring gauge is on the side of its large bore diameter. The reference surface on the shaft may be either in front of, or behind the gauging face of the ring gauge.

GRA 30 ring gauges can also be used to check whether the centreline of the tapered seat is at right angles to a reference surface on the shaft. This is achieved by measuring the distance between the reference face on the ring gauge and the reference surface on the shaft.

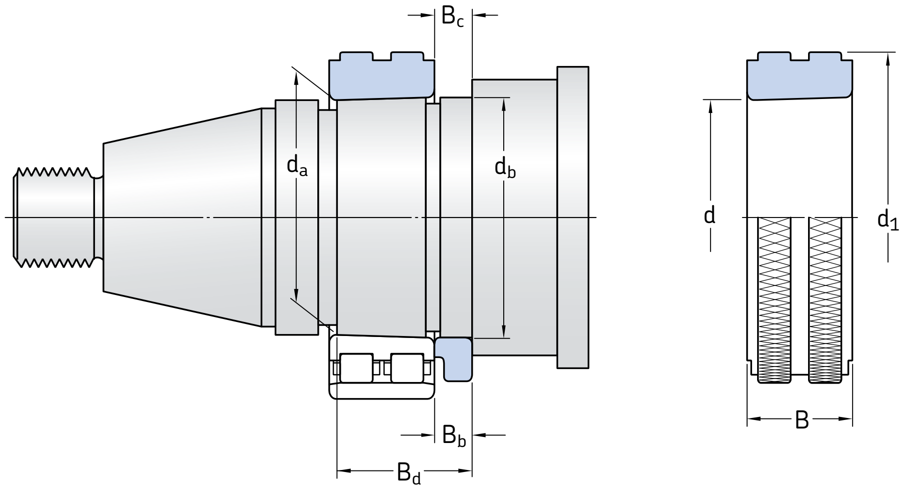
Form errors of the taper can be detected using blue dye.

7

Tapered seat dimensions

SKF recommends using the tapered seat dimensions for bearings in the NN 30 K series listed in the product tables. If other dimensions are used, the reference length B_c should always be longer than B_b, the width of the intermediate spacer ring. This is necessary because the bearing will be driven up further onto the seat than the ring gauge, depending on the bearing internal clearance or preload that should be achieved. Therefore, always make the reference length longer than the width of the intermediate ring at least by a value corresponding to the difference $B_c – B_b$ according to the values listed in the product table.

GRA 30 ring gauges
d **25 – 200** mm



Bearing Designation	**Bearing seat** Dimensions d_a	d_b	B_b	B_c Nominal	Tolerance	B_d	**Ring gauge** Dimensions d	d_1	B	Mass	Designation
–	mm						mm			kg	–
NN 3005 K	25,10	27	4	4,2	±0,1	19	25	46	16	0,13	**GRA 3005**
NN 3006 KTN	30,10	32	6	6,2	±0,1	24	30	52	19	0,18	**GRA 3006**
NN 3007 K	35,10	37	6	6,2	±0,1	25	35	57	20	0,21	**GRA 3007**
NN 3008 KTN	40,10	42	8	8,2	±0,1	28	40	62	21	0,26	**GRA 3008**
NN 3009 KTN	45,10	47	8	8,2	±0,1	30	45	67	23	0,31	**GRA 3009**
NN 3010 KTN	50,10	52	8	8,2	±0,1	30	50	72	23	0,34	**GRA 3010**
NN 3011 KTN	55,15	57	8	8,3	±0,12	32,5	55	77	26	0,42	**GRA 3011**
NN 3012 KTN	60,15	62	10	10,3	±0,12	34,5	60	82	26	0,45	**GRA 3012**
NN 3013 KTN	65,15	67	10	10,3	±0,12	34,5	65	88	26	0,51	**GRA 3013**
NN 3014 KTN	70,15	73	10	10,3	±0,12	38,5	70	95	30	0,69	**GRA 3014**
NN 3015 KTN	75,15	78	10	10,3	±0,12	38,5	75	100	30	0,73	**GRA 3015**
NN 3016 KTN	80,15	83	12	12,3	±0,12	44,5	80	105	34	0,88	**GRA 3016**
NN 3017 KTN9	85,20	88	12	12,4	±0,15	44	85	112	34	1,00	**GRA 3017**
NN 3018 KTN9	90,20	93	12	12,4	±0,15	47	90	120	37	1,30	**GRA 3018**
NN 3019 KTN9	95,20	98	12	12,4	±0,15	47	95	128	37	1,55	**GRA 3019**
NN 3020 KTN9	100,20	103	12	12,4	±0,15	47	100	135	37	1,70	**GRA 3020**
NN 3021 KTN9	105,20	109	12	12,4	±0,15	51	105	142	41	2,10	**GRA 3021**
NN 3022 KTN9	110,25	114	12	12,5	±0,15	54,5	110	150	45	2,60	**GRA 3022**
NN 3024 KTN9	120,25	124	15	15,5	±0,15	58,5	120	162	46	3,05	**GRA 3024**
NN 3026 KTN9	130,25	135	15	15,5	±0,15	64,5	130	175	52	3,95	**GRA 3026**
NN 3028 K	140,30	145	15	15,6	±0,15	65	140	188	53	4,75	**GRA 3028**
NN 3030 K	150,30	155	15	15,6	±0,15	68	150	200	56	5,60	**GRA 3030**
NN 3032 K	160,30	165	15	15,6	±0,15	72	160	215	60	6,80	**GRA 3032**
NN 3034 K	170,30	176	15	15,6	±0,15	79	170	230	67	8,80	**GRA 3034**
NN 3036 K	180,35	187	20	20,7	±0,15	90,5	180	245	74	11,5	**GRA 3036**
NN 3038 K	190,35	197	20	20,7	±0,18	91,5	190	260	75	13,0	**GRA 3038**
NN 3040 K	200,35	207	20	20,7	±0,18	98,5	200	270	82	15,0	**GRA 3040**

DMB taper gauges

SKF taper gauges in the DMB series enable a quick and accurate check of the diameter and the angle of external tapers. They are suitable for final checks as well as for intermediate checks during machining. DMB taper gauges are available for taper diameters from 40 to 360 mm.

A DMB taper gauge (→ **fig. 6**) comprises two saddles (**a**) that are firmly joined together at a fixed distance. A gauge pin (**b**) is positioned in each of the saddles. Each saddle holds two adjustable radial stops (**c** and **d**) at 90° intervals from the gauge pins. An axial stop (**e**) is provided to locate the gauge axially on the taper.

The gauge pins and the radial stops can be set to measure any taper angle between 0° and 6° and any diameter within the range of the gauge. Special markings on the scales show the settings for 1:12 and 1:30 tapers.

Measuring accuracy

The measuring accuracy of DMB taper gauges is within 1 µm for diameters up to and including 280 mm and within 1,5 µm for diameters larger than 280 mm.

Fig. 6

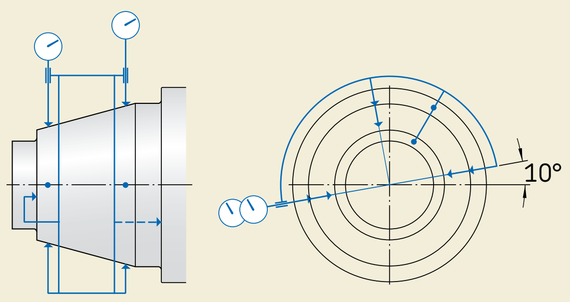
Measuring

Set the radial stops and straight edges of the gauge pins to the desired diameter and taper angle, using the scale. Then, adjust the axial stop on the taper to be measured. Put the gauge on a reference taper and set the dials to zero. The gauge is now ready to take measurements.

To take a measurement, put the DMB taper gauge on the taper to be measured, making sure that it is up against the axial stop. Then take a reading. The readings on the dials are the diameter deviations. A difference in the readings between the two dials indicates a deviation in the taper angle.

While measuring, the gauge should be inclined at about 10° from the horizontal plane (→ **fig. 7**). In this position, the gauge is located on the taper by the radial and axial stops.

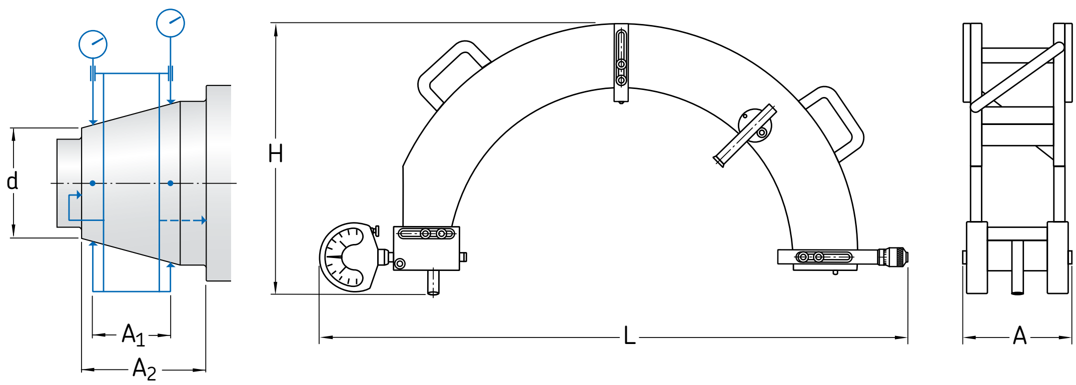
Fig. 7



Scope of delivery

As standard, DMB taper gauges are supplied together with two dial indicators. Since standard dial indicators are used, DMB taper gauges can also be supplied without dial indicators on request. Also, a tailored reference taper can be supplied on request.

DMB taper gauges
d **40 – 360** mm



Taper Diameter		**Taper gauge** Dimensions					Mass	Designation
d from	to	A	A_1	A_2	H	L		
mm		mm					kg	–
40	**55**	36	18	28	140	320	2,50	**DMB 4/5.5**
50	**85**	38	20	30	160	350	2,50	**DMB 5/8.5**
80	**120**	48	30	40	190	380	3,00	**DMB 8/12**
120	**160**	58	40	50	190	425	3,50	**DMB 12/16**
160	**200**	74	50	64	190	465	4,50	**DMB 16/20**
200	**240**	84	60	74	215	505	5,50	**DMB 20/24**
240	**280**	99	75	89	240	540	7,00	**DMB 24/28**
280	**320**	114	90	104	265	590	8,50	**DMB 28/30**
320	**360**	114	90	104	290	640	10,0	**DMB 32/36**

GB 30 internal clearance gauges

SKF internal clearance gauges in the GB 30 series are designed for use with double row cylindrical roller bearings ranging from NN 3006 K to NN 3040 K. They can also be used for single row bearings in the N 10 K series. GB 30 series internal clearance gauges are able to accurately measure the outside envelope diameter of the roller set i.e. the diameter over the rollers when in contact with the inner ring raceway.

Design

GB 30 series internal clearance gauges consist of a gauge body that holds two diametrically opposed ground gauging zones. The gauge body can be expanded by means of an adjustment screw. This enables the gauge to be pushed over the inner ring with roller and cage assembly, without damaging the rollers or the gauging zones. The gauging zone that is connected to one half of the gauge body transmits the diameter measured by both gauging zones to a dial indicator.

The smaller size gauges, GB 3006 to GB 3020 (→ **fig. 8**), with a two-piece body, have a measuring accuracy of 1 µm. The larger size gauges, GB 3021 to GB 3040 (→ **fig. 9**), with a slotted body, have a measuring accuracy of 2 µm.

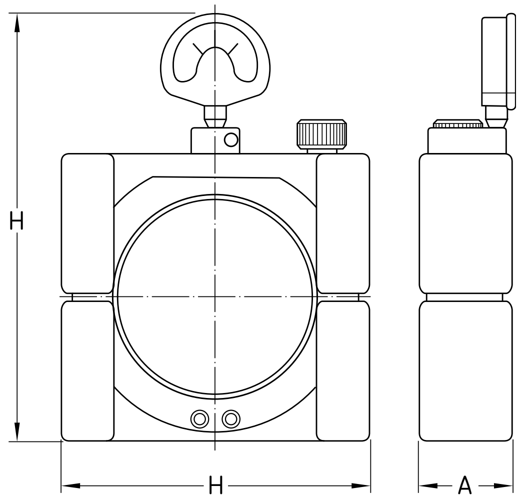
Measuring

Start by measuring the raceway diameter of the mounted outer ring, using a bore gauge. Modify the recorded dimension by the value necessary to achieve the desired radial internal clearance or preload and adjust the GB 30 gauge to that dimension. Set the dial indicator on the GB 30 gauge to zero and place the gauge on the inner ring with roller and cage assembly. Now the inner ring can be pushed onto the tapered seat until the dial indicator on the pre-set gauge shows zero again.

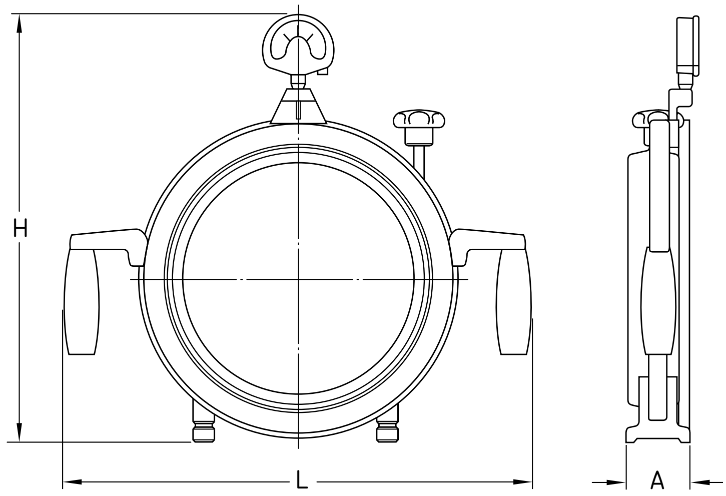
Fig. 8

Fig. 9

GB 30 internal clearance gauges for cylindrical roller bearings



GB 3006 – GB 3020



GB 3021 – GB 3040

Bearing Designation	**Internal clearance gauge** Dimensions L	 H	 A	 Mass	 Designation
–	mm			kg	–
NN 3006 KTN	107	175	36	2,00	**GB 3006**
NN 3007 K	112	180	37	2,00	**GB 3007**
NN 3008 KTN	117	185	39	2,00	**GB 3008**
NN 3009 KTN	129	197	40	2,50	**GB 3009**
NN 3010 KTN	134	202	40	2,50	**GB 3010**
NN 3011 KTN	144	212	43	3,50	**GB 3011**
NN 3012 KTN	152	222	44	4,00	**GB 3012**
NN 3013 KTN	157	225	44	4,00	**GB 3013**
NN 3014 KTN	164	232	48	5,00	**GB 3014**
NN 3015 KTN	168	236	48	5,00	**GB 3015**
NN 3016 KTN	176	244	52	6,00	**GB 3016**
NN 3017 KTN9	185	253	53	6,50	**GB 3017**
NN 3018 KTN9	198	266	56	8,00	**GB 3018**
NN 3019 KTN9	203	271	56	9,00	**GB 3019**
NN 3020 KTN9	212	280	56	9,00	**GB 3020**
NN 3021 KTN9	322	350	46	10,5	**GB 3021**
NN 3022 KTN9	332	362	46	11,0	**GB 3022**
NN 3024 KTN9	342	376	48	12,0	**GB 3024**
NN 3026 KTN9	364	396	54	13,0	**GB 3026**
NN 3028 K	378	410	54	14,5	**GB 3028**
NN 3030 K	391	426	58	15,0	**GB 3030**
NN 3032 K	414	446	60	16,0	**GB 3032**
NN 3034 K	430	464	62	17,0	**GB 3034**
NN 3036 K	454	490	70	17,5	**GB 3036**
NN 3038 K	468	504	70	18,0	**GB 3038**
NN 3040 K	488	520	74	19,0	**GB 3040**

GB 49 internal clearance gauges

SKF internal clearance gauges in the GB 49 series are designed for use with double row cylindrical roller bearings ranging from NNU 4920 BK to NNU 4960 BK. GB 49 series internal clearance gauges are able to accurately measure the internal envelope diameter of the roller set when the rollers are in contact with the outer ring raceway.

Design

GB 49 series internal clearance gauges have a slotted gauge body, so that both gauging ring halves can be brought to bear on the roller set with the appropriate pressure, as a result of the inherent resilience of the material. The outside cylindrical surface of the gauging ring has two diametrically opposed ground gauging zones. An adjustment screw permits the body of the gauge to be compressed, so that the gauge can be positioned inside the roller set without damaging the rollers or the gauging zones.

Depending on their size, GB 49 internal clearance gauges are available in two different designs. The smaller size gauges, GB 4920 to GB 4938 (→ **fig. 10**), have a measuring accuracy of 1 µm. The larger size gauges, GB 4940 to GB 4960 (→ **fig. 11**), have a measuring accuracy of 2 µm.

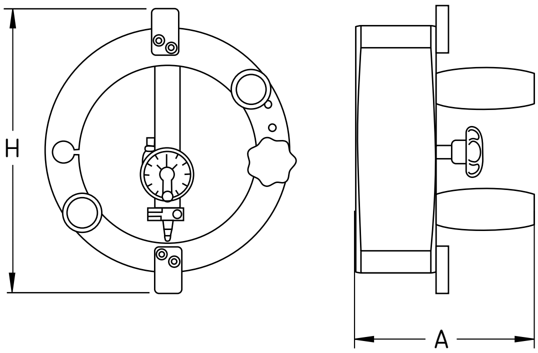
Measuring

Insert the GB 49 gauge in the roller and cage assembly, and loosen the adjustment screw until the two gauging surfaces are in contact with the roller set. Then set the dial indicator to zero.

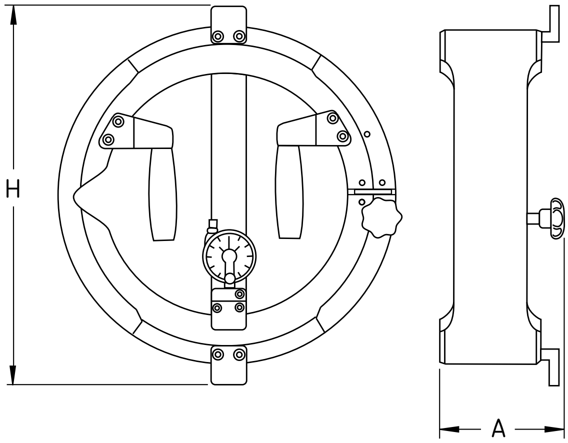
Measure the diameter inside the roller set using a stirrup gauge. Then without disturbing the measurement, set the indicator of the stirrup gauge to zero. Drive the inner ring up on its seat until the indicator of the stirrup gauge shows the deviation from zero corresponding to the desired radial internal clearance or preload.

Fig. 10

Fig. 11



GB 4920 – GB 4938



GB 4940 – GB 4960

Bearing	Internal clearance gauge			
Designation	Dimensions		Mass	Designation
	A	H		
–	mm		kg	–
NNU 4920 BK/SPW33	128	138	2,50	**GB 4920**
NNU 4921 BK/SPW33	128	143	3,00	**GB 4921**
NNU 4922 BK/SPW33	128	148	3,00	**GB 4922**
NNU 4924 BK/SPW33	133	162	3,50	**GB 4924**
NNU 4926 BK/SPW33	138	176	4,00	**GB 4926**
NNU 4928 BK/SPW33	138	186	4,50	**GB 4928**
NNU 4930 BK/SPW33	148	204	6,00	**GB 4930**
NNU 4932 BK/SPW33	148	212	6,50	**GB 4932**
NNU 4934 BK/SPW33	148	224	8,00	**GB 4934**
NNU 4936 BK/SPW33	157	237	9,50	**GB 4936**
NNU 4938 BK/SPW33	157	248	10,5	**GB 4938**
NNU 4940 BK/SPW33	105	263	12,0	**GB 4940**
NNU 4944 BK/SPW33	105	283	13,0	**GB 4944**
NNU 4948 BK/SPW33	105	303	14,0	**GB 4948**
NNU 4952 BK/SPW33	120	340	15,0	**GB 4952**
NNU 4956 BK/SPW33	120	360	17,0	**GB 4956**
NNU 4960 BK/SPW33	135	387	19,0	**GB 4960**


SKF
VOGEL

Other SKF products and services

8

Lubrication systems

Under the name VOGEL AG, world leader in the field of centralized lubrication systems, SKF supplies components, assemblies and complete lubrication systems for machine tools, printing presses, general machinery and construction vehicles as well as railway applications. The product assortment includes

- total-loss centralized lubrication systems
- circulating oil lubrication systems
- minimal quantity lubrication systems
- chain lubrication systems.

VOGEL systems are designed to meet the lubrication needs of the latest generation of high-speed machines and avoid lubrication related damage and failures. VOGEL's oil, grease or oil + air systems meter the exact amount of lubricant needed and continuously monitor lubrication conditions close to the lubrication point. VOGEL systems contribute to higher process availability in production operations and support proper running conditions in spindles and high-precision bearings.

Oil + air lubrication system

Oil + air lubrication is a type of minimal quantity lubrication system. Prominent applications for oil + air lubrication systems include high-speed rolling bearings for machine tool spindles, and closed gearboxes that require economical lubrication.

Oil + air systems supply a continuous, finely metered flow of oil that can be adjusted to meet different application demands, either by metered quantity, or by changing the pulse frequency.

Function: A stream of air in a narrow tube pulls a droplet of oil apart, thereby forming a streak that is fed in the direction of the lubrication point. The bearing is continuously supplied with fine droplets of oil via the outlet nozzle. The carrier air escapes from the bearing nearly oil-free.

Oil + air lubrication system

Minimal quantity lubrication (MQL)

Minimal quantity lubrication makes it possible to deliver extremely small quantities of cutting fluid in machine tool applications. Cutting fluid is delivered between the tool and work piece by an aerosol, i.e. by oil droplets that are finely dispersed in an air stream. This lubrication method enables higher cutting speeds, resulting in increased productivity. Additional benefits include longer tool life and reduced cutting fluid use, which can significantly reduce machining costs while reducing environmental impact. VOGEL also offers permanent monitoring of the aerosol supply and concentration by sensors.

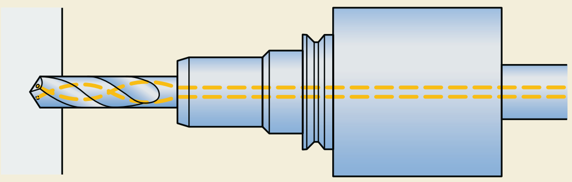
SKF, VOGEL and other well-known companies in the fields of mechanical engineering, components and production have jointly developed the HPC (High Performance Cutting) standard. This standard provides simplified integration of MQL through the definition of uniform interfaces and performance profiles.

Internal minimal quantity lubrication (MQL)

With internal MQL, the aerosol is transported by either the rotating spindle or turret through the tool holder and tool. The metered oil quantity is completely dispersed when adjusted properly.

The overall MQL system consists of harmonized components that work together to lubricate the cutting area. In order to meet specific application requirements, Vogel offers different configurable product series, ranging from manually regulated Vario units to stored program controlled (SPC) Digital Super units.

Internal MQL: The aerosol is transported through the rotating cutting tool



Vario

Vario Super

Digital Super

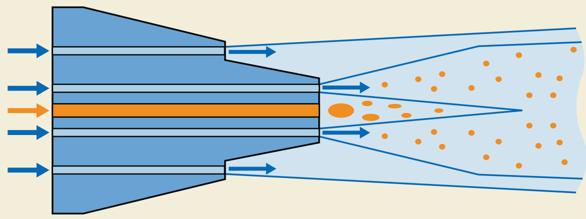
8

External minimal quantity lubrication (MQL)

With external MQL, lubricant and air are fed to the active area between the tool and workpiece via tubing and nozzles that are not integrated into the machine's design. Therefore the nozzle must be adjusted to the respective application. This relatively rigid system is suitable for machining operations where the tools and work piece contours do not change. It can also be used for series-produced parts. VOGEL's Basic, Smart and Vectolub product families are extremely well suited for these types of jobs.

For additional information refer to the VOGEL brochure "Overview of Products for Industry: Centralized lubrication and minimal quantity lubrication for machinery and systems", or visit www.vogelag.com or www.skf.com.

External MQL: Spraying of microdrops



Basic

Smart

Vectolub VTEC

Machine tool service centres

In order to reduce downtime and meet customers' precision machine tool bearing needs, SKF has three machine tool service centres located in

- Villar Perosa, Italy
- Lansdale, Pennsylvania, US
- Chino, Japan.

These service centres provide custom preloaded and matched sets of high-precision bearings, with very short turn-around times. This translates into quicker deliveries, shorter lead times and reduced inventories.

For additional information, visit www.machinetool.skf.com.

Spindle service

SKF is operating a worldwide network of spindle service centres, where professional reconditioning of almost any machine tool spindle can be accommodated.

Service centres are presently located in Austria, Brazil, China, France, Germany, India, Italy, Japan, Malaysia, Mexico, Russia, Sweden, UK and the US.

The services offered at these locations include complete spindle reconditioning, bearing replacement, shaft and nose restoration, performance upgrades and root cause analysis.

For additional information refer to the brochure “SKF spindle service”, or visit www.spindleservice.skf.com.

Actuation systems

Electromechanical applications often require superior performance from their actuators and actuation systems. This is often demonstrated in terms of speed, accuracy, reliability and safety. SKF provides a complete range of actuation products and systems, designed to satisfy the most demanding requirements in virtually any application. Extensive knowledge and experience in application engineering is also offered. The assortment includes

- telescopic pillars
- linear actuators
- rotary actuators
- control units.

For additional information refer to the catalogue "Linear motion standard range", or visit www.linearmotion.skf.com.

Telescopic pillars

Linear actuators

Rotary actuators

Control units

8

Linear motion products

SKF Linear Motion offers a wide range of products and services involving high-precision components, units and systems for linear movements to provide solutions for guiding, driving and positioning.

For additional information refer to the catalogue "Linear motion standard range", or visit www.linearmotion.skf.com.

Ball and roller screws

SKF high-efficiency ball and roller screws are used to displace loads by transforming rotary motion into linear motion. These screws contain balls or rollers between a nut and the screw shaft.

The wide range covers products that fit nearly all requirements:

- Miniature ball screws, either with ball recirculation by an integrated tube or with inserts, are very compact. Backdriving makes them highly efficient.
- Large ball screws enable designers to select the right screw for their application: simple transport screws, very fast screws with long leads, or preloaded screws for greater precision.
- Ground ball screws provide a high degree of rigidity and precision.
- Roller screws go far beyond the limits of any ball screws in terms of loads, precision and rigidity. SKF roller screws are an excellent choice for applications where there are high speeds and accelerations and tough operating conditions.
- End bearings and flange accessories supplement the range of ball and roller screws.

Guidance systems

To provide engineers with a wide range of choices when designing a guidance system, the SKF assortment of high performance guidance products and systems consists of:

- Shaft guides comprising linear ball bearings and precision shafts, enable designers to build economical and simple linear guidance systems to suit a wide range of applications.
- Profile rail guides enable unlimited travel, provide good rigidity and are capable of withstanding moment loads in all directions. They are ready to mount, reliable and easy to maintain.
- Precision rail guides. The modular range consists of a matrix of rail guide modules that enable a wide choice of combinations of rails and rolling element assemblies.
- Cam-roller guides, marketed as Speedi-Roll by SKF, are linear guidance systems with high load-carrying capacity, rigidity and torque resistance. Speedi-Roll consists of a guide rail and a carriage with either four or six rollers. The rail consists of a drawn and anodized aluminium profile with hardened steel angled raceways fitted to both sides.
- Miniature slides provide an excellent solution for precise and short strokes in compact frame dimensions. They are typically used in medical, measurement and micro mechanical applications.
- Standard slides are fitted with SKF standard components. Several driven or guided versions covering a wide range of strokes and load carrying capacities are available.
- Precision slides with top and base made of cast iron, are fitted with SKF precision rail guides, incorporating crossed roller units and driven by pre-loaded planetary roller screws. Precision slides can be assembled to form multi-axis systems. Limit switches are available.
- Complete systems are designed from SKF standard components or as special solutions tailored for an application.

Mounting, dismounting and maintenance products

Rolling bearings are precision products that are of extreme importance to the proper operation of any machine. In order for roller bearings to achieve maximum service life and provide reliable performance, it is imperative that they are mounted, dismounted and maintained properly. To enable proper mounting, dismounting and maintenance, SKF develops and markets a wide assortment of maintenance tools, lubricants and lubricators, as well as auxiliary products.

The assortment includes: pullers, fitters, heaters, hydraulic equipment, oil injection equipment, bearing lubricants and lubricators. Also, basic condition monitoring solutions for measuring temperature, speed and noise, oil cleanliness, vibration and bearing condition are available.

In special seminars, SKF provides users with expert knowledge about bearing installation, dismounting and maintenance.

For additional information refer to the catalogue “SKF Maintenance and Lubrication Products”, or visit www.mapro.skf.com.

Condition monitoring products

SKF condition monitoring products provide value-added "smart" solutions that enable customers to increase the effectiveness of their reliability and maintenance programmes.

Using advanced technology to develop products that are capable of performing increasingly complex analysis and diagnostics, SKF's smart solutions can provide vital operational information that can optimize and enhance the maintenance decision-making process, and help identify and address the root cause of machine problems.

The condition monitoring product assortment includes portable instruments, on-line systems, software, sensors and accessories.

For additional information refer to the publication "Integrated Condition Monitoring", or visit www.skf.com.

SKF Microlog MX series – CMXA 44 portable maintenance instrument

The MX series, portable maintenance instrument, represents a new concept in vibration analysis instrumentation. The MX redefines traditional approaches to vibration analysis and simplifies industrial maintenance, servicing and inspection techniques. It also offers new possibilities for manufacturers of rotating and reciprocating machinery.

The MX series was created to provide a simple, easy to use instrument for a wide range of applications. It is in effect, several instruments combined into a single, fully ruggedized, hand-held device. The MX series provides users the flexibility to choose from a range of different service, testing and analysis applications, including

- machinery maintenance
- on-the-spot machinery health checking
- inspection/machinery screening
- condition assessment
- analysis and diagnosis of noise and vibration related problems
- single and dual plane balancing.

Microlog MX series

8

Product index

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