Super-precision double direction angular contact thrust ball bearings

BTW series

SKF – the knowledge engineering company

From one simple but inspired solution to a misalignment problem in a textile mill in Sweden, and fifteen employees in 1907, SKF has grown to become a global industrial knowledge leader. Over the years, we have built on our expertise in bearings, extending it to seals, mechatronics, services and lubrication systems. Our knowledge network includes 46 000 employees, 15 000 distributor partners, offices in more than 130 countries, and a growing number of SKF Solution Factory sites around the world.

Research and development

We have hands-on experience in over forty industries based on our employees' knowledge of real life conditions. In addition, our world-leading experts and university partners pioneer advanced theoretical research and development in areas including tribology, condition monitoring, asset management and bearing life theory. Our ongoing commitment to research and development helps us keep our customers at the forefront of their industries.

Meeting the toughest challenges

Our network of knowledge and experience, along with our understanding of how our core technologies can be combined, helps us create innovative solutions that meet the toughest of challenges. We work closely with our customers throughout the asset life cycle, helping them to profitably and responsibly grow their businesses.

Working for a sustainable future

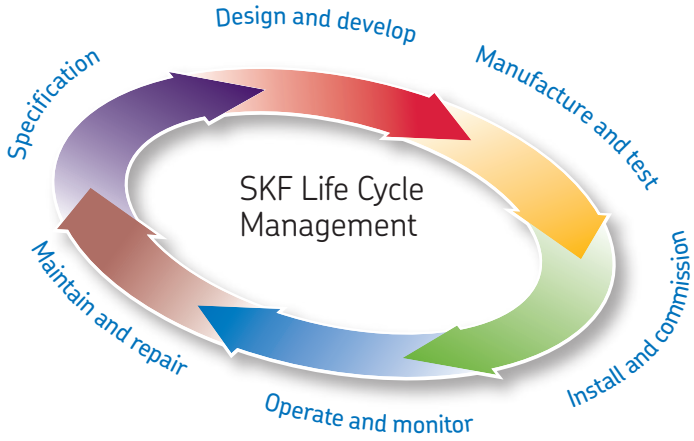
Since 2005, SKF has worked to reduce the negative environmental impact from our operations and those of our suppliers. Our continuing technology development resulted in the introduction of the SKF BeyondZero portfolio of products and services which improve efficiency and reduce energy losses, as well as enable new technologies harnessing wind, solar and ocean power. This combined approach helps reduce the environmental impact both in our operations and our customers' operations.

SKF Solution Factory makes SKF knowledge and manufacturing expertise available locally to provide unique solutions and services to our customers.

Working with SKF IT and logistics systems and application experts, SKF Authorized Distributors deliver a valuable mix of product and application knowledge to customers worldwide.

Our knowledge – your success

SKF Life Cycle Management is how we combine our technology platforms and advanced services, and apply them at each stage of the asset life cycle, to help our customers to be more successful, sustainable and profitable.



Working closely with you

Our objective is to help our customers improve productivity, minimize maintenance, achieve higher energy and resource efficiency, and optimize designs for long service life and reliability.

Innovative solutions

Whether the application is linear or rotary or a combination, SKF engineers can work with you at each stage of the asset life cycle to improve machine performance by looking at the entire application. This approach doesn't just focus on individual components like bearings or seals. It looks at the whole application to see how each component interacts with each other.

Design optimization and verification

SKF can work with you to optimize current or new designs with proprietary 3-D modelling software that can also be used as a virtual test rig to confirm the integrity of the design.

Bearings
SKF is the world leader in the design, development and manufacture of high performance rolling bearings, plain bearings, bearing units and housings.

Machinery maintenance
Condition monitoring technologies and maintenance services from SKF can help minimize unplanned downtime, improve operational efficiency and reduce maintenance costs.

Sealing solutions
SKF offers standard seals and custom engineered sealing solutions to increase uptime, improve machine reliability, reduce friction and power losses, and extend lubricant life.

Mechatronics
SKF fly-by-wire systems for aircraft and drive-by-wire systems for off-road, agricultural and forklift applications replace heavy, grease or oil consuming mechanical and hydraulic systems.

Lubrication solutions
From specialized lubricants to state-of-the-art lubrication systems and lubrication management services, lubrication solutions from SKF can help to reduce lubrication related downtime and lubricant consumption.

Actuation and motion control
With a wide assortment of products – from actuators and ball screws to profile rail guides – SKF can work with you to solve your most pressing linear system challenges.

Contents

SKF super-precision double direction angular contact thrust ball bearings

Double direction angular contact thrust ball bearings were developed by SKF to axially locate machine tool spindles in both directions. In these applications, a high degree of system rigidity is one of the main performance challenges, as the magnitude of elastic deformation under load determines the productivity and accuracy of the equipment.

To keep up with the ever increasing performance challenges of precision applications, SKF developed a new generation of double direction angular contact thrust ball bearings. These super-precision bearings in the BTW series have a new, optimized design enabling them to accommodate higher speeds compared to bearings in the former 2344(00) series. The benefits of the new design are evident by the improved overall bearing performance.

Bearings in the BTW series are characterized by:

- high-speed capability
- high axial load carrying capacity
- high stiffness
- low friction
- extended bearing service life

Bearings in the BTW series provide excellent reliability and superior accuracy for various applications, including surface grinding machines, milling machines, machining centres and lathes.

The assortment

SKF bearings in the BTW series accommodate shaft diameters ranging from 35 to 200 mm. The bearings are manufactured with a standard preload to two tolerance classes.

To accommodate increased operational speeds, the bearings are available in a hybrid variant. On request, bearings can be supplied with an annular groove and three lubrication holes in the housing washers.

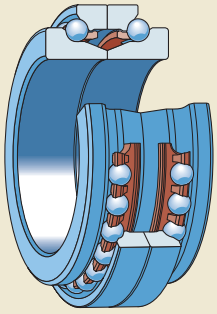
Bearings in the BTW series are dimensionally interchangeable with bearings in the former 2344(00) series.

The new, optimized design

Features of bearings in the BTW series include:

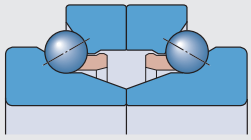
- a set of two angular contact thrust ball bearings
- a high number of large balls
- a separable design
- a 60° contact angle
- two separate cages, made of either polyamide 66 or machined brass

The new design double direction angular contact thrust ball bearings consist of a set of two single row angular contact thrust ball bearings, arranged back-to-back. This configuration enables the bearings to accommodate axial loads in both directions while providing a high degree of system rigidity.

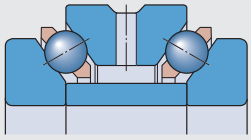


Bearings in the BTW series consist of a set of two single row angular contact thrust ball bearings, arranged back-to-back.

Features and benefits of bearings in the BTW series



BTW series



2344(00) series

Compared to bearings in the former 2344(00) series, bearings in the BTW series have:

- an optimized internal geometry and raceway osculation, for higher speed capability
- an improved raceway finish, to reduce friction, noise and vibration levels and accommodate higher speeds
- a simplified design (without a spacer sleeve), for easier handling, faster and more accurate mounting, more accurate preload control and improved system rigidity
- an optimized cage design (polyamide 66 and brass), for higher speed capability and more effective lubricant supply to the ball/raceway contact areas
- lower weight, for more economical bearing arrangements

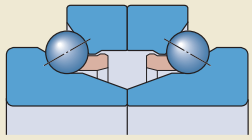
When compared to bearings in the former 2344(00) series, bearings in the new BTW series provide a number of advantages. The new design no longer incorporates a spacer sleeve. Therefore, bearing handling and mounting are easier, and preload is more accurately controlled. Also, manufacturing upgrades have enabled the bearings to accommodate higher speeds with reduced noise and vibration levels.

Depending on the size, the bearings are equipped with two polyamide 66 or machined brass cages. The window-type polyamide 66 cages of bearings in the former 2344(00) series are replaced by an improved snap-type cage design. The design of the machined brass cages has also been optimized. The redesigned cages enable more effective lubricant supply to the ball/raceway contact areas. Both cage types are ball-centred.

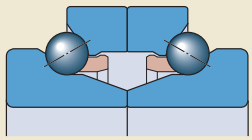
Hybrid variant

Bearings in the BTW series are available with ceramic (bearing grade silicon nitride) balls. As ceramic balls are considerably lighter and harder than steel balls, hybrid bearings can provide a higher degree of rigidity and run considerably faster than comparably sized all-steel bearings. The lower weight of the ceramic balls reduces the centrifugal forces within the bearing and generates less heat. Lower centrifugal forces are particularly important in machine tool applications where there are frequent rapid starts and stops. Less heat generated by the bearing means less energy consumption and longer bearing and grease service life.

Hybrid bearings in the BTW series are identified by the designation suffix HC.



Steel balls



Ceramic balls

The bearings are available in an all-steel and hybrid variant.

SKF super-precision bearings in the BTW series replace SKF high-precision bearings in the 2344(00) series (→ *Setting the highest standard for precision bearings*, **page 24**).

Applications

SKF super-precision double direction angular contact thrust ball bearings in the BTW series offer solutions to many bearing arrangement challenges. Their ability, among others, to provide a high degree of rigidity and accommodate heavy loads at high speeds, is beneficial for a variety of applications.

Lathe spindles, for example, require high load carrying capacity and high positioning accuracy. Depth of cut and feed rates are usually pushed to the limit, and depend on the required surface finish.

The fabrication of semiconductor silicon wafer chips for electronic circuits comprises various precision processes. The grinding of the wafer chips to extremely thin levels as well as the polishing (and strengthening) of the chips call for superior running accuracy and a high degree of rigidity.

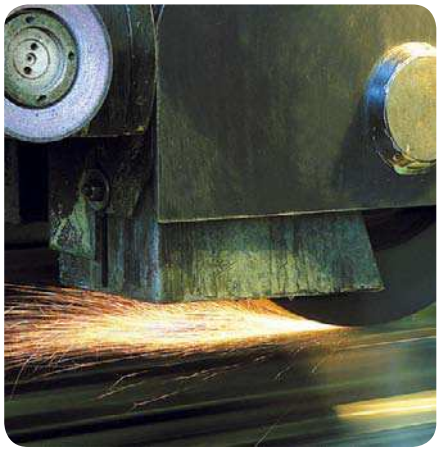
For these and other precision applications, there is an optimal arrangement incorporating bearings in the BTW series, which provides the best possible combination of rigidity, load carrying capacity, heat generation and bearing service life.

Applications
- CNC lathes
- Surface grinding machines
- External grinding machines
- Milling machines
- Machining centres
- Turntables for the grinding and polishing of silicon wafer

Requirements
- High-speed capability
- High axial load carrying capacity
- High degree of system rigidity
- High positioning accuracy
- Long service life
- Increased machine uptime

Solution

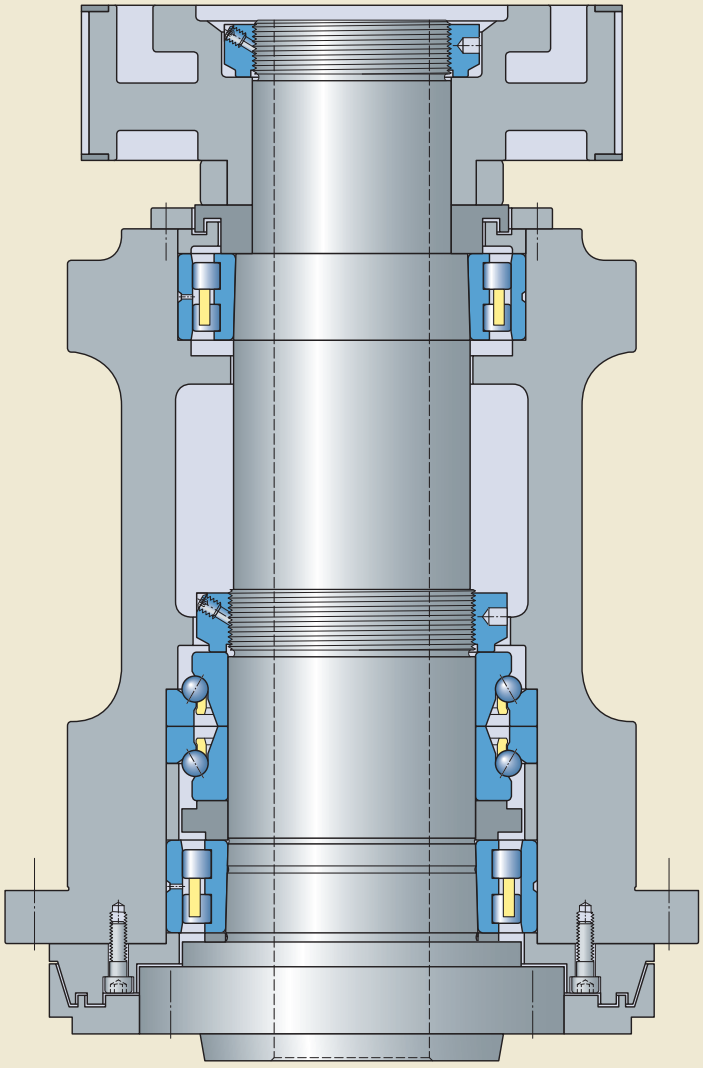
SKF super-precision double direction angular contact thrust ball bearings in the BTW series



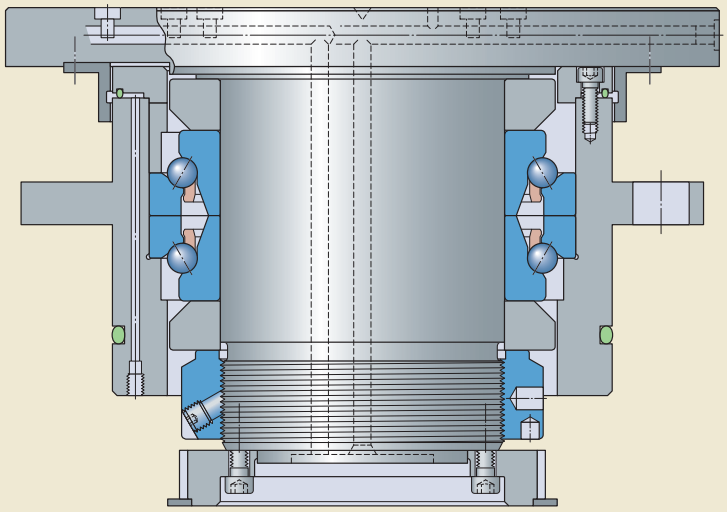
Application examples

Super-precision double direction angular contact thrust ball bearings are common in, but not limited to, machine tool applications. Depending on the type of machine tool and its intended purpose, spindles may require different bearing arrangements.

In lathe spindles, machining centres and surface grinding spindles, there are typically heavy combined loads at the tool end of the shaft. A high degree of rigidity and high load carrying capacity are key operational requirements. Therefore, it is common to have a double direction angular contact thrust ball bearing in the BTW series in combination with a double row cylindrical roller bearing at the tool end. For belt-driven spindles, heavy radial loads at the non-tool end are typically accommodated by a double row cylindrical roller bearing.

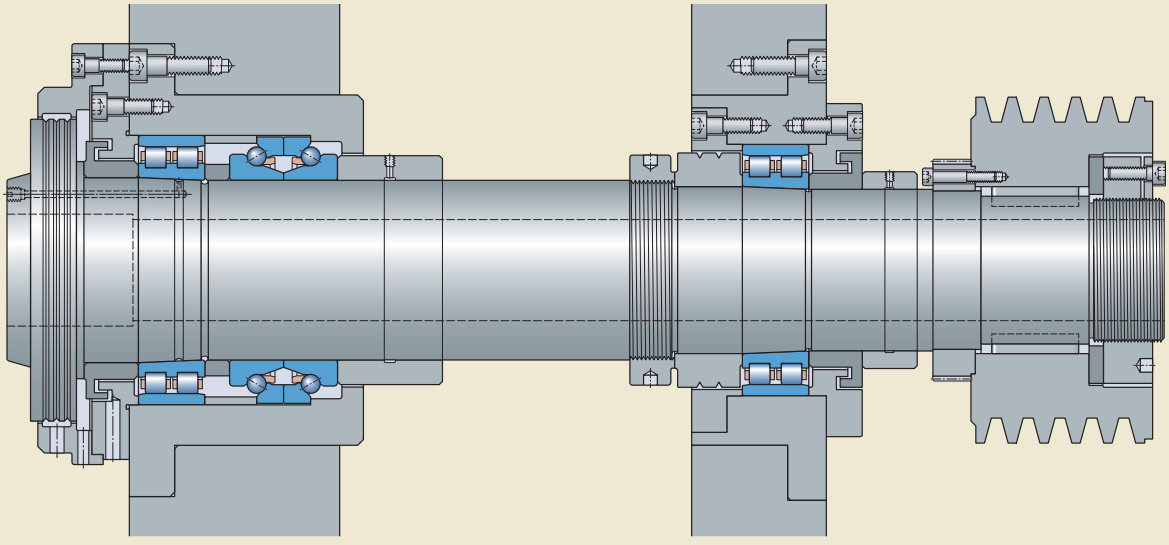


Vertical machining centre
In a vertical machining centre, where there are relatively heavy combined loads and a high degree of axial and radial stiffness is required, the following bearing arrangement represents an excellent solution to meet the application demands. At the tool end, there is a super-precision double direction angular contact thrust ball bearing in combination with a high-precision double row cylindrical roller bearing, e.g. BTW 160 CM/SP and NN 3032 K/SPW33. The non-tool end has a high-precision double row cylindrical roller bearing, e.g. NN 3030 K/SPW33.



Turntable for the grinding and polishing of silicon wafers
Turntable applications require good running accuracy and a high degree of system rigidity. This arrangement has a super-precision double direction angular contact thrust ball bearing, e.g. BTW 100 CTN9/SP, to meet these operational requirements.

CNC lathe
This belt-driven lathe spindle is designed for large diameter bar stock. The tool end has a super-precision double direction angular contact thrust ball bearing in combination with a high-precision double row cylindrical roller bearing, e.g. BTW 100 CTN9/SP and NN 3020 KTN9/SP, to accommodate heavy combined loads. A high-precision double row cylindrical roller bearing, e.g. NN 3018 KTN9/SP, is at the non-tool end.



Lubrication

Heat resulting from friction is a constant threat to production equipment. One way to reduce heat and the wear associated with friction, particularly in bearings, is to be sure that the correct quantity of the appropriate lubricant reaches all moving parts.

Grease lubrication

In most applications with bearings in the BTW series, grease with a mineral base oil and lithium thickener is suitable. These greases, which adhere well to the bearing surfaces, can accommodate operating temperatures ranging from –30 to +100 °C.

Initial grease fill

In high-speed applications, less than 30% of the free space in the bearings should be filled with grease. The initial grease fill depends on the bearing size as well as the speed factor, which 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]

Diagram 1

Factor K for initial grease fill (estimated)

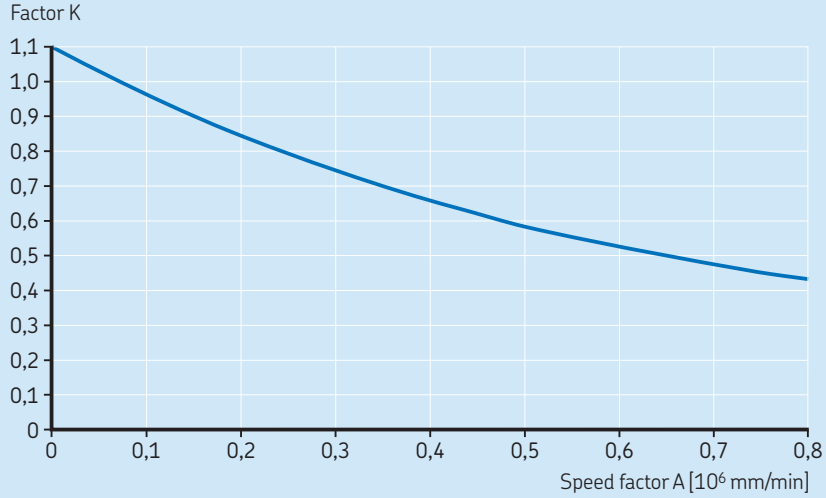


Table 1

Reference grease quantity for initial grease fill estimation

Bearing Bore diameter d	Reference grease quantity[1] G_{ref}
mm	cm^3
35	1,9
40	2,5
45	3,1
50	3,3
55	4,8
60	5,2
65	5,6
70	7,4
75	7,8
80	10,6
85	11,2
90	14,4
95	15,1
100	15,7
110	26,5
120	28,4
130	40,4
140	45,3
150	55,8
160	66,7
170	90,1
180	116,7
190	122,1
200	157,1

[1] Refers to a 30% filling grade.

The initial grease fill can be estimated by

$G = K\, G_{ref}$

where

G = initial grease fill [cm^3]

K = a calculation factor dependent on the speed factor A (→ **diagram 1**)

G_{ref} = reference grease quantity (→ **table 1**) [cm^3]

Running-in of grease lubricated bearings

A grease lubricated super-precision bearing will initially run with a relatively high frictional moment. If the bearing is run at high speed without a running-in period, the temperature rise can be considerable. The relatively 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.

The time required to stabilize the operating temperature depends on a number of factors – the type of grease, the initial grease fill, how the grease is applied to the bearings and the running-in procedure (→ **diagram 2**).

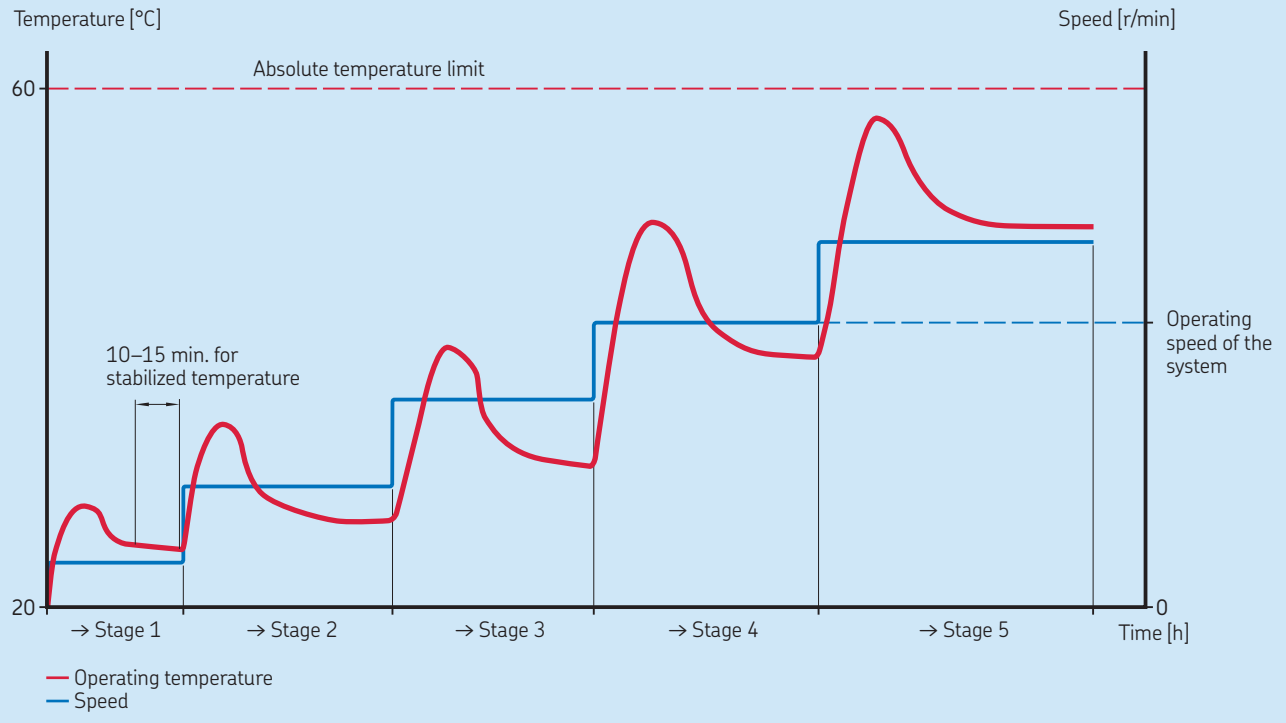
Super-precision bearings can typically operate with a minimum quantity of lubricant when properly run-in, enabling the lowest frictional moment and temperature to be achieved. Grease that collects on each side of the bearing acts as a reservoir, enabling oil to bleed into the raceway to provide effective 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.

For additional information about running-in of grease lubricated bearings, refer to the *SKF Interactive Engineering Catalogue* available online at www.skf.com.

Diagram 2

Graphic representation of a running-in procedure



Oil lubrication

Where speeds are constantly very high (generally, speed factor A > 600 000 mm/min), bearings in the BTW series should be lubricated with oil, as the service life of grease is too short under these conditions and oil provides the added benefit of cooling.

High quality lubricating oils without EP additives are generally recommended for super-precision double direction angular contact thrust ball bearings. Oils with a viscosity of 40 to 100 mm^2/s at 40 °C are typically used.

Circulating oil

With a circulating oil lubrication system, oil is pumped to a position above the bearing so that it can run down through the bearing and settle in a sump. The oil is filtered and, if required, cooled before being returned to the bearing. This method is suitable for super-precision double direction angular contact thrust ball 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.

Oil-air lubrication method

In an oil-air lubrication system, oil is supplied to the feed lines at given intervals by a metering unit. The oil coats the inside surface of the feed lines and "creeps" toward the nozzles (→ **fig. 1**), where it is delivered to the bearings.

Guidelines for the quantity of oil to be supplied to each bearing for very high speed operation can be obtained from

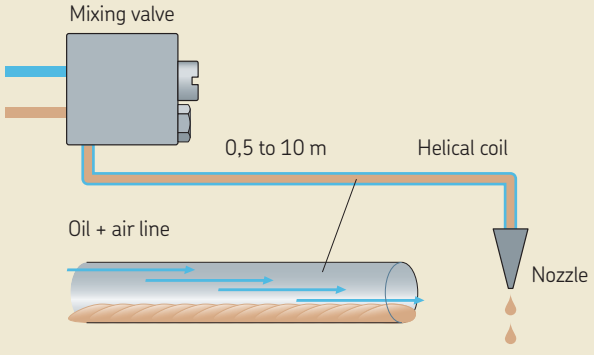
$$Q = \frac{q\ d\ H}{100}$$

where
Q = oil flow rate [mm^3/h]
d = bearing bore diameter [mm]
H = bearing height [mm]
q = a factor of 2 to 5

The calculated oil flow rate should be verified during operation and adjusted, depending on the resulting temperatures.

A filter that prevents particles > 5 µm from reaching the bearings should also be incorporated.

Fig. 1



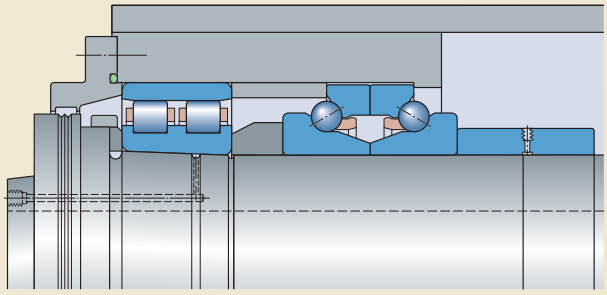
Bearing arrangement design

Because they can only accommodate axial loads, BTW series bearings are intended to be mounted in the same housing bore as a high- or super-precision NN 30 K or N 10 K series cylindrical roller bearing.

To avoid radial loads from acting on the bearing, both housing washers are manufactured to tolerances such that sufficient radial clearance in the housing bore seat will be obtained when both bearings are mounted with the recommended shaft and housing fits (→ **fig. 1**).

For information about fits and corresponding tolerance limits, refer to the *SKF Interactive Engineering Catalogue* available online at www.skf.com.

Fig. 1



Bearing data – general

Boundary dimensions

The bore and outside diameters of bearings in the BTW series are in accordance with ISO 15:2011, Diameter Series 0 for radial bearings. The remaining principal dimensions are not standardized either nationally or internationally, but are common in the marketplace.

Chamfer dimensions

Minimum values for the chamfer dimensions in the radial direction (r_1, r_3) and the axial direction (r_2, r_4) are provided in the product table. The values for the chamfers on the shaft washers are in accordance with ISO 15:2011. The values for the chamfers on the housing washers are not standardized.

The appropriate maximum chamfer limits are in accordance with ISO 582:1995.

Tolerances

Bearings in the BTW series are manufactured, standard, to an SP (special precision) tolerance class (→ **table 1**), which is approximately in accordance with ISO tolerance class 5 for dimensional accuracy and approximately in accordance with ISO tolerance class 4 for running accuracy.

On request, bearings can be supplied to a higher precision UP (ultra precision) tolerance class (→ **table 2**), which is approximately in accordance with ISO tolerance class 4 for dimensional accuracy and better than ISO tolerance class 4 for running accuracy.

The tolerance symbols used in these tables are listed together with their definitions in **table 3**.

Table 1

Class SP tolerances

Shaft washer and bearing height

d		Δ_{dmp}		Δ_{B1s}		Δ_{T2s}		S_i[1]
over	incl.	high	low	high	low	high	low	max
mm		µm		µm		µm		µm
30	**50**	1	–11	0	–100	0	–200	3
50	**80**	2	–14	0	–100	0	–200	4
80	**120**	3	–18	0	–200	0	–400	4
120	**180**	3	–21	0	–250	0	–500	5
180	**250**	4	–26	0	–250	0	–500	5

Housing washer

D		Δ_{Dmp}		Δ_{C1s}		S_e
over	incl.	high	low	high	low	max
mm		µm		µm		
50	**80**	–24	–33	0	–50	Values are identical to those for the shaft washer of the same bearing (S_i)
80	**120**	–28	–38	0	-50	
120	**150**	–33	–44	0	-100	
150	**180**	–33	–46	0	–100	
180	**250**	–37	–52	0	–125	
250	**315**	–41	–59	0	–125	

[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.

Axial preload

The axial preload of bearings in the BTW series is obtained during manufacturing by precisely adjusting the standout of the shaft washers relative to their housing washer. The preload values are listed in **table 4** on **page 18** and apply to bearings prior to mounting. Bearing components must be kept together as supplied.

Effect of an interference fit on preload

Bearings in the BTW series have a heavier axial preload when mounted compared to the built-in preload, predetermined during manufacture (→ **table 4**, **page 18**). The increase in preload depends mainly on the actual tolerances for the bearing seats on the shaft and in the housing bore.

Table 2

Class UP tolerances

Shaft washer and bearing height

d		Δ_{dmp}		Δ_{B1s}		Δ_{T2s}		S_i[1]
over	incl.	high	low	high	low	high	low	max
mm		µm		µm		µm		µm
30	**50**	0	–8	0	–100	0	–200	1,5
50	**80**	0	–9	0	–100	0	–200	2
80	**120**	0	–10	0	–200	0	–400	2
120	**180**	0	–13	0	–250	0	–500	3
180	**250**	0	–15	0	–250	0	–500	3

Housing washer

D		Δ_{Dmp}		Δ_{C1s}		S_e
over	incl.	high	low	high	low	max
mm		µm		µm		
50	**80**	–24	–33	0	–50	Values are identical to those for the shaft washer of the same bearing (S_i)
80	**120**	–28	–38	0	–50	
120	**150**	–33	–44	0	–100	
150	**180**	–33	–46	0	–100	
180	**250**	–37	–52	0	–125	
250	**315**	–41	–59	0	–125	

[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.

Table 3

Tolerance symbols

Tolerance symbol	Definition
	Bore diameter
d	Nominal bore diameter
d_{mp}	Mean bore diameter; arithmetical mean of the largest and smallest single bore diameters in one plane
Δ_{dmp}	Deviation of the mean bore diameter from the nominal ($\Delta_{dmp} = d_{mp} - d$)
	Outside diameter
D	Nominal outside diameter
D_{mp}	Mean outside diameter; arithmetical mean of the largest and smallest single outside diameters in one plane
Δ_{Dmp}	Deviation of the mean outside diameter from the nominal ($\Delta_{Dmp} = D_{mp} - D$)
	Height
B, C	Nominal width of an inner ring and outer ring, respectively
B_s, C_s	Single width of an inner ring and outer ring, respectively
B_{1s}, C_{1s}	Single width of an inner ring and outer ring, respectively, of a bearing specifically manufactured for paired mounting

Tolerance symbol	Definition
	Height
Δ_{Bs}, Δ_{Cs}	Deviation of a single inner ring width or single outer ring width from the nominal ($\Delta_{Bs} = B_s - B$; $\Delta_{Cs} = C_s - C$)
Δ_{B1s}, Δ_{C1s}	Deviation of a single inner ring width or single outer ring width, of a bearing specifically manufactured for paired mounting, from the nominal ($\Delta_{B1s} = B_{1s} - B_1$; $\Delta_{C1s} = C_{1s} - C_1$)
T	Nominal height of a thrust bearing (H)
T_s	Single height
Δ_{Ts}	Deviation of a single height from the nominal
Δ_{T2s}	Deviation of the total height from the nominal
	Running accuracy
S_i	Thickness variation, measured from the middle of the raceway to the back (seat) face of the shaft washer (axial runout)
S_e	Thickness variation, measured from the middle of the raceway to the back (seat) face of the housing washer (axial runout)

C

Bearings in the BTW series are usually fitted to shaft seats machined to h4 tolerance class. This results in a transition fit that is either an interference fit or a loose fit. If interference occurs, radial (diametrical) preload will increase. The relationship between the axial and radial preload increase can be expressed as

$\partial_a = \partial_r / \tan \alpha$

where
∂_a = axial preload increase [µm]
∂_r = radial preload increase [µm]
tan α = tan (contact angle)
= 1,73 for 60° contact angle

When there is a loose fit, there is no need to compensate for mounted preload.

Axial stiffness

Axial stiffness depends on the deformation of the bearing under load and can be expressed as a ratio of the load to bearing resilience. However, since the relation between resilience and load is not linear, only guideline values can be provided (**→ table 5**). These values apply to mounted bearing pairs under static conditions and subjected to moderate loads. Exact values can be calculated using advanced computer methods. For additional information, contact the SKF application engineering service.

Equivalent loads

The equivalent dynamic bearing load can be calculated using

$P = F_a$

The equivalent static bearing load can be calculated using

$P_0 = F_a$

where
P = equivalent dynamic bearing load [kN]
P_0 = equivalent static bearing load [kN]
F_a = axial component of the load [kN]

Attainable speeds

The attainable speeds listed in the product table should be regarded as guideline values. They are valid for bearings with standard preload that are fitted on a shaft seat machined to h4 tolerance class under light load (P ≤ 0,05 C). In addition, good heat dissipation from the bearing arrangement is a prerequisite.

The values provided for oil lubrication apply to the oil-air lubrication method and should be reduced if other oil lubrication methods, such as circulating oil, are used. The values provided for grease lubrication are maximum values that can be attained with good lubricating grease that has a low consistency and low viscosity.

Table 4

Axial preload prior to mounting

Bearing Bore diameter d	**Axial preload** for standard preload class
mm	N
35	340
40	360
45	390
50	415
55	440
60	470
65	490
70	515
75	545
80	575
85	600
90	625
95	655
100	690
110	735
120	800
130	870
140	940
150	1 015
160	1 100
170	1 185
180	1 290
190	1 385
200	1 525

Table 5

Static axial stiffness

Bearing Bore diameter d	**Static axial stiffness** for standard preload class of all-steel bearings	of hybrid bearings
mm	N/µm	
35	455	500
40	481	529
45	513	564
50	559	614
55	580	639
60	618	680
65	653	719
70	673	741
75	714	786
80	735	809
85	763	840
90	792	871
95	822	904
100	880	968
110	893	982
120	979	1 077
130	1 032	1 135
140	1 089	1 198
150	1 125	1 238
160	1 220	1 341
170	1 225	1 348
180	1 314	1 445
190	1 361	1 497
200	1 395	1 535

Cages

Depending on the size, bearings in the BTW series are equipped with either polyamide 66 or machined brass cages as follows:

- Bearings with a bore diameter d = 35 to 130 mm are equipped with two separate injection moulded snap-type cages made of glass fibre reinforced polyamide 66 (→ **fig. 1**), ball centred, designation suffix TN9.
- Bearings with a bore diameter d = 140 to 200 mm are equipped with two separate machined brass cages, ball centred, designation suffix M.

The standard cage is indicated in the product table designations.

Polyamide 66 cages can withstand temperatures up to 120 °C. Typical lubricants for machine tool applications generally do not have any detrimental effect on the cage properties. However, some synthetic oils and greases with a synthetic base oil may be detrimental and should be investigated.

Fig. 1

Materials and heat treatment

Depending on the size, the rings of all-steel bearings in the BTW series are made from either SKF Grade 3 or SKF Grade 24 steel, in accordance with ISO 683-17:1999. The balls of all-steel bearings are made of SKF Grade 3 steel. The balls of hybrid bearings are made of bearing grade silicon nitride Si_3N_4.

The bearings undergo a special heat treatment to achieve a good balance between hardness, toughness and dimensional stability.

Bearing markings

Each SKF bearing in the BTW series has various identifiers on the external surfaces of the washers (→ **fig. 2**):

1 SKF trademark
2 Complete designation of the bearing
3 Country of manufacture
4 Date of manufacture, coded
5 Serial number on shaft washer
6 Serial number on housing washer

These markings are evident on both sides of the complete bearing i.e. on each single row angular contact thrust ball bearing in the set.

Serial numbers

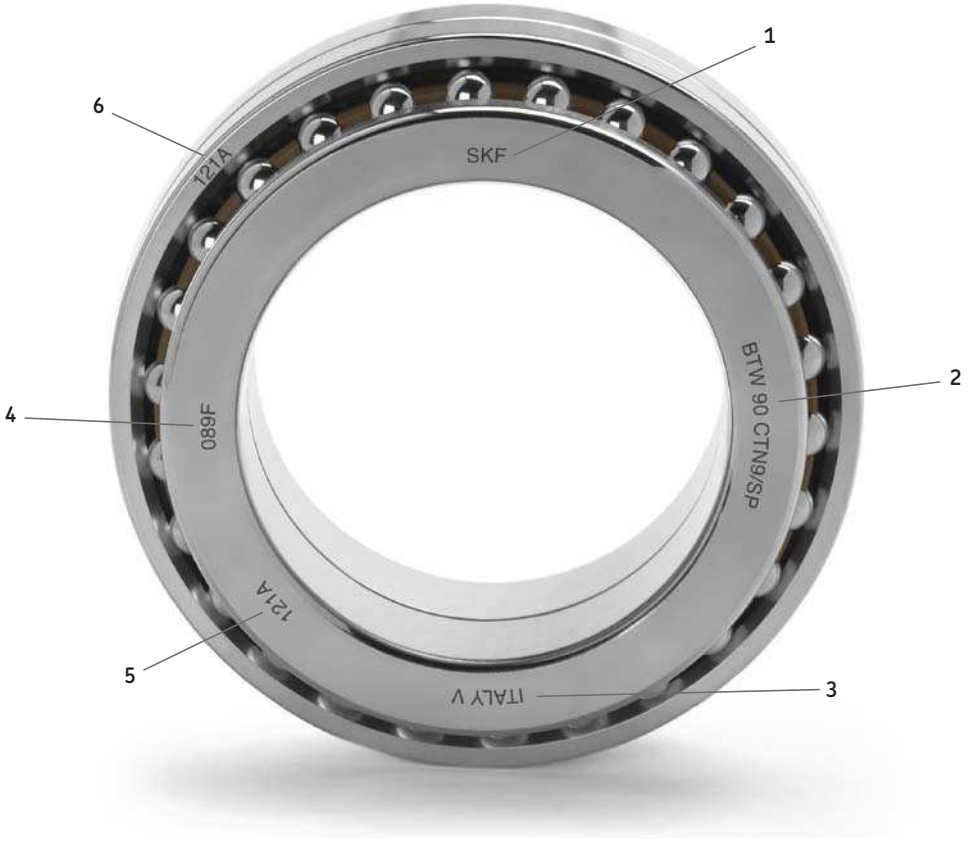
To prevent possible mixing of components, the shaft and housing washers of bearings in the BTW series are marked with a serial number for easy identification. The serial number is made up of a number and a letter. As bearings in the BTW series consist of two single row angular contact thrust ball bearings, the letter in the serial number identifies those washers belonging together, for example:

- serial number on shaft washer #1: 121A
- serial number on housing washer #1: 121A
- serial number on shaft washer #2: 121B
- serial number on housing washer #2: 121B

Packaging

SKF super-precision bearings are distributed in new SKF illustrated boxes (→ **fig. 3**). Bearings in the BTW series are supplied in a single box. The bearings inside are packed separately; they are identified by a serial number and must be kept together.

Fig. 2



Designation system

The designations for SKF bearings in the BTW series are provided in **table 6** together with their definitions.

Designation conversions

When converting designations of bearings in the former 2344(00) series to bearings in the new BTW series, use the conversion guidelines provided in **table 7**. For example, a bearing with the designation 234428 BM1/SP would be replaced by a bearing with the designation BTW 140 CM/SP.

Table 6

Designation system for SKF bearings in the BTW series

Example: BTW 90 CTN9/HCSP	BTW	90	C	TN9	/	HC	SP

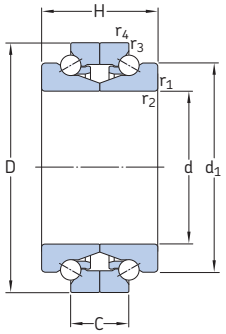
Bearing series and internal design	
BTW	Double direction angular contact thrust ball bearing, basic design
Bearing size	
35	35 mm bore diameter
to	
200	200 mm bore diameter
Contact angle	
C	60° contact angle
Cage	
M	Machined brass, ball centred
TN9	Injection moulded glass fibre reinforced polyamide 66, ball centred
Ball material	
–	Carbon chromium steel (no designation suffix)
HC	Bearing grade silicon nitride Si_3N_4 (hybrid bearings)
Tolerance class	
SP	Dimensional accuracy approximately in accordance with ISO tolerance class 5 and running accuracy approximately in accordance with ISO tolerance class 4 for thrust bearings
UP	Dimensional accuracy approximately in accordance with ISO tolerance class 4 and running accuracy better than ISO tolerance class 4 for thrust bearings

Fig. 3

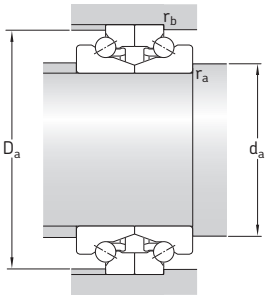
Table 7

Designation conversion guidelines

Bearing characteristic	Designation system for bearings in the 2344(00) series	BTW series
Bearing series	2344	BTW
Bearing size	Size code (x5 = bore diameter)	Bore diameter
Contact angle	(no designation suffix)	C
Cage	BM1 TN9	M TN9
Ball material	HC	HC
Tolerance class	SP UP	SP UP



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	–
35	62	34	16,8	39	1,83	11 000	14 000	0,35	**BTW 35 CTN9/SP**
40	68	36	19,5	46,5	2,24	10 000	13 000	0,42	**BTW 40 CTN9/SP**
45	75	38	22,1	54	2,6	9 500	12 000	0,53	**BTW 45 CTN9/SP**
50	80	38	22,5	60	2,85	9 000	11 000	0,58	**BTW 50 CTN9/SP**
55	90	44	30,2	80	3,8	7 500	9 000	0,87	**BTW 55 CTN9/SP**
60	95	44	30,7	83	4	7 500	9 000	0,93	**BTW 60 CTN9/SP**
65	100	44	31,9	90	4,3	7 000	8 500	1,00	**BTW 65 CTN9/SP**
70	110	48	39	112	5,3	6 700	8 000	1,35	**BTW 70 CTN9/SP**
75	115	48	39,7	116	5,6	6 300	7 500	1,45	**BTW 75 CTN9/SP**
80	125	54	47,5	140	6,55	5 600	6 700	1,95	**BTW 80 CTN9/SP**
85	130	54	48,8	146	6,7	5 600	6 700	2,05	**BTW 85 CTN9/SP**
90	140	60	55,9	173	7,65	5 000	6 000	2,70	**BTW 90 CTN9/SP**
95	145	60	57,2	180	7,8	5 000	6 000	2,80	**BTW 95 CTN9/SP**
100	150	60	59,2	193	8,15	5 000	6 000	3,00	**BTW 100 CTN9/SP**
110	170	72	81,9	260	10,4	4 300	5 000	4,70	**BTW 110 CTN9/SP**
120	180	72	85,2	280	10,8	4 000	4 800	5,05	**BTW 120 CTN9/SP**
130	200	84	106	360	13,2	3 600	4 300	7,60	**BTW 130 CTN9/SP**
140	210	84	106	375	13,2	3 200	3 800	8,60	**BTW 140 CM/SP**
150	225	90	127	440	15,3	3 000	3 600	10,5	**BTW 150 CM/SP**
160	240	96	140	510	16,6	2 800	3 400	13,0	**BTW 160 CM/SP**
170	260	108	174	610	19,6	2 400	3 000	17,5	**BTW 170 CM/SP**
180	280	120	199	710	22,4	2 000	2 600	23,0	**BTW 180 CM/SP**
190	290	120	203	735	22,8	2 000	2 600	24,0	**BTW 190 CM/SP**
200	310	132	238	865	25,5	1 900	2 400	31,0	**BTW 200 CM/SP**



C

Dimensions					Abutment and fillet dimensions			
d	d_1 ~	C	$r_{1,2}$ min	$r_{3,4}$ min	d_a min	D_a max	r_a max	r_b max
mm					mm			
35	50,8	17	1	0,3	45	58	1	0,1
40	56,4	18	1	0,3	50	64	1	0,1
45	62,5	19	1	0,3	56	71	1	0,1
50	67,5	19	1	0,3	61	76	1	0,1
55	75,2	22	1,1	0,6	68	85	1	0,3
60	80,2	22	1,1	0,6	73	90	1	0,3
65	85,2	22	1,1	0,6	78	95	1	0,3
70	93,5	24	1,1	0,6	85	105	1	0,3
75	98,5	24	1,1	0,6	90	110	1	0,3
80	106,2	27	1,1	0,6	97	119	1	0,3
85	112	27	1,1	0,6	102	124	1	0,3
90	119	30	1,5	0,6	109	132	1,5	0,3
95	124	30	1,5	0,6	114	137	1,5	0,3
100	129	30	1,5	0,6	119	142	1,5	0,3
110	145	36	2	1	132	161	2	0,6
120	155	36	2	1	142	171	2	0,6
130	171	42	2	1	156	190	2	0,6
140	181	42	2,1	1	166	200	2	0,6
150	194	45	2,1	1	178	213	2	0,6
160	207	48	2,1	1	190	227	2	0,6
170	223	54	2,1	1	204	246	2	0,6
180	239	60	2,1	1	214	264	2	0,6
190	249	60	2,1	1	224	274	2	0,6
200	264	66	2,1	1	236	292	2	0,6

Setting the highest standard for precision bearings

SKF has developed and is continuing to develop a new, improved generation of super-precision bearings. The new assortment delivers improved accuracy and extended bearing service life when compared to previous designs.

Table 1 on **page 26** and **27** provides an overview of the new assortment of SKF super-precision bearings.

Super-precision angular contact ball bearings

Bearings in the 718 *(SEA)* series

Bearings in the 718 *(SEA)* series provide optimum performance in applications where a low cross section and high degree of rigidity, speed and superior accuracy are critical design parameters. They are particularly suitable for machine tool applications, multi-spindle drilling heads, robotic arms, measuring devices, racing car wheels and other precision applications. The standard assortment accommodates shaft diameters ranging from 10 to 160 mm.

Bearings in the 719 .. D *(SEB)* and 70 .. D *(EX)* series

For applications where a high load carrying capacity is an additional operational requirement, SKF offers high-capacity bearings in the 719 .. D *(SEB)* and 70 .. D *(EX)* series. The ability of the new design super-precision bearings in these two series to accommodate heavy loads in applications where radial space is often limited, makes them an excellent choice for demanding applications. Open bearings in the 719 .. D *(SEB)* series accommodate shaft diameters ranging from 10 to 360 mm; sealed bearings from 10 to 150 mm.

Open bearings in the 70 .. D *(EX)* series accommodate shaft diameters ranging from 6 to 240 mm; sealed bearings from 10 to 150 mm.

Bearings in the 72 .. D *(E 200)* series

High-capacity bearings in the 72 .. D *(E 200)* series offer solutions to many bearing arrangement challenges. Their ability, among others, to provide a high degree of rigidity and accommodate heavy loads at relatively high speeds, is beneficial for a variety of applications. The extended range of bearings in this series now accommodates shaft diameters ranging from 7 to 140 mm. And, there is also a relubrication-free, sealed variant, available on request.

Bearings in the S719 .. B *(HB .. /S)* and S70 .. B *(HX .. /S)* series

High-speed sealed bearings in the S719 .. B *(HB .. /S)* and S70 .. B *(HX .. /S)* series can virtually eliminate the problem of premature bearing failures resulting from contamination. The standard assortment accommodates shaft diameters ranging from 30 to 120 mm. These relubrication-free bearings are particularly suitable for metal cutting and woodworking machines. The bearings are also available in an open variant.

Bearings in the 719 .. E *(VEB)* and 70 .. E *(VEX)* series

Compared to high-speed B design bearings, high-speed E design bearings have a higher speed capability and can accommodate heavier loads. This desirable combination makes these bearings an excellent choice for demanding applications.

Open bearings in the 719 .. E *(VEB)* series accommodate shaft diameters ranging from 8 to 120 mm; sealed bearings from 20 to 120 mm.

Open bearings in the 70 .. E *(VEX)* series accommodate shaft diameters ranging from 6 to 120 mm; sealed bearings from 10 to 120 mm.

Bearings made from NitroMax steel

In extremely demanding applications such as high-speed machining centres and milling machines, bearings are frequently subjected to difficult operating conditions such as very high speeds, thin-film lubrication conditions, and contaminated and corrosive environments. To enable longer bearing service life and reduce the costs associated with downtime, SKF has developed a superior high-nitrogen steel.

The SKF assortment of super-precision angular contact ball bearings made from NitroMax steel have ceramic (bearing grade silicon nitride) rolling elements as standard.

Super-precision cylindrical roller bearings

SKF produces super-precision single row and double row cylindrical roller bearings. 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.

Single row cylindrical roller bearings are produced in the N 10 series as basic design bearings and as high-speed design bearings. High-speed single row cylindrical roller bearings in the N 10 series are available with a tapered bore only and for shaft diameters ranging from 40 to 80 mm. Compared to previous high-speed design, they can accommodate a speed increase of up to 30% in grease lubricated applications and up to 15% in oil-air lubricated applications.

Double row cylindrical roller bearings are produced as standard in the NN design and NNU design.

Super-precision double direction angular contact thrust ball bearings

Double direction angular contact bearings, as their name implies, were developed by SKF to axially locate machine tool spindles in both directions.

The new optimized design of super-precision bearings in the BTW series consists of a set of two single row angular contact thrust ball bearings, arranged back-to-back. This configuration enables the bearings to accommodate axial loads in both directions while providing a high degree of system rigidity. These bearings can accommodate higher speeds compared to bearings in the former 2344*(00)* series. The bearings are available for shaft diameters ranging from 35 to 200 mm.

The redesigned high-speed BTM series accommodate higher speeds, anywhere from 6% to 12% depending on the size; minimize heat generation, even at higher speeds; provide high load carrying capacity and maintain a high degree of system rigidity. The range of BTM bearings series has been expanded to accommodate shaft diameters from 60 to 180 mm.

Super-precision angular contact thrust ball bearings for screw drives

Single direction angular contact thrust ball bearings in the BSA and BSD *(BS)* series are available for shaft diameters ranging from 12 to 75 mm. These bearings are characterized by superior axial stiffness and high axial load carrying capacity.

Double direction angular contact thrust ball bearings in the BEAS series have been developed for machine tool applications where space is tight and easy mounting is required. The bearings are available for shaft diameters ranging from 8 to 30 mm. Bearings in the BEAM series, which can accommodate shaft diameters ranging from 12 to 60 mm, can be bolt-mounted to an associated component.

Cartridge units are another solution for simple and quick mounting. Units in the FBSA *(BSDU and BSQU)* series incorporate SKF single direction angular contact thrust ball bearings and can accommodate shaft diameters ranging from 20 to 60 mm.

Super-precision axial-radial cylindrical roller bearings

SKF axial-radial cylindrical roller bearings are suitable for arrangements that have simultaneously acting (radial and axial) loads as well as moment loads.

Their internal design, together with close tolerance manufacturing processes, enable these bearings to attain better than P4 running accuracy.

Axial-radial cylindrical roller bearings are commonly used to support rotating tables, indexing tables and milling heads.

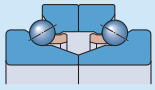
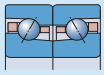
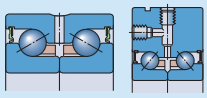
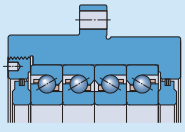
Table 1

Overview of SKF super-precision bearings

ISO dimension series	Bearing type and design *SKF publication[1,2]*		Variant		SKF assortment SKF bearings in the series
18	**Angular contact ball bearings: Basic design** *Super-precision angular contact ball bearings: 718 (SEA) series (Publication No. 06810)*		Open	All-steel Hybrid	718 .. D *(SEA)* 718 .. D/HC *(SEA /NS)*
19	**Angular contact ball bearings: High-speed, B design** *Super-precision angular contact ball bearings: High-speed, B design, sealed as standard (Publication No. 06939)*		Open Sealed	All-steel Hybrid All-steel Hybrid	719 .. B *(HB)* 719 .. B/HC *(HB /NS)* S719 .. B *(HB /S)* S719 .. B/HC *(HB /S/NS)*
	Angular contact ball bearings: High-speed, E design *Super-precision angular contact ball bearings: High-speed, E design (Publication No. 10112)*		Open Sealed	All-steel Hybrid All-steel Hybrid	719 .. E *(VEB)* 719 .. E/HC *(VEB /NS)* S719 .. E *(VEB /S)* S719 .. E/HC *(VEB /S/NS)*
	Angular contact ball bearings: High-capacity, basic design *Super-precision angular contact ball bearings: High-capacity 719 .. D (SEB) and 70 .. D (EX) series (Publication No. 10527)*		Open Sealed	All-steel Hybrid All-steel Hybrid	719 .. D *(SEB)* 719 .. D/HC *(SEB /NS)* S719 .. D *(SEB /S)* S719 .. D/HC *(SEB /S/NS)*
10	**Angular contact ball bearings: High-speed, B design** *Super-precision angular contact ball bearings: High-speed, B design, sealed as standard (Publication No. 06939)*		Open Sealed	All-steel Hybrid All-steel Hybrid	70 .. B *(HX)* 70 .. B/HC *(HX /NS)* S70 .. B *(HX /S)* S70 .. B/HC *(HX /S/NS)*
	Angular contact ball bearings: High-speed, E design *Super-precision angular contact ball bearings: High-speed, E design (Publication No. 10112)*		Open Sealed	All-steel Hybrid All-steel Hybrid	70 .. E *(VEX)* 70 .. E/HC *(VEX /NS)* S70 .. E *(VEX /S)* S70 .. E/HC *(VEX /S/NS)*
	Angular contact ball bearings: High-capacity, basic design *Super-precision angular contact ball bearings: High-capacity 719 .. D (SEB) and 70 .. D (EX) series (Publication No. 10527)*		Open Sealed	All-steel Hybrid All-steel Hybrid	70 .. D *(EX)* 70 .. D/HC *(EX /NS)* S70 .. D *(EX /S)* S70 .. D/HC *(EX /S/NS)*
02	**Angular contact ball bearings: High-capacity, basic design** *Super-precision angular contact ball bearings: High-capacity (Publication No. 06981)*		Open Sealed	All-steel Hybrid All-steel Hybrid	72 .. D *(E 200)* 72 .. D/HC *(E 200 /NS)* S72 .. D *(E 200 /S)* S72 .. D/HC *(E 200 /S/NS)*
49	**Double row cylindrical roller bearings: NNU design**		Open	All-steel	NNU 49 BK

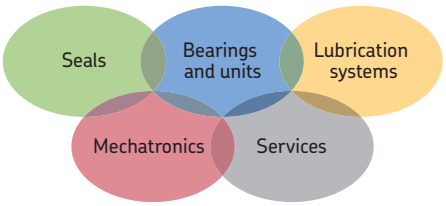
[1] Where applicable, information can be found in the SKF publication *High-precision bearings* (Publication No. 6002).
[2] For additional information about super-precision angular contact ball bearings made from NitroMax steel, refer to the SKF publication *Extend bearing service life with NitroMax* (Publication No. 10126).

Overview of SKF super-precision bearings

ISO dimension series	Bearing type and design *SKF publication[1,2]*		Variant		SKF assortment SKF bearings in the series
10	**Single row cylindrical roller bearings: Basic design**		Open	All-steel Hybrid	N 10 KTN N 10 KTN/HC5
	Single row cylindrical roller bearings: High-speed design *Super-precision cylindrical roller bearings: High-speed (Publication No. 07016)*		Open	All-steel Hybrid	N 10 KPHA N 10 KPHA/HC5
30	**Double row cylindrical roller bearings: NN design**		Open	All-steel Hybrid	NN 30 KTN NN 30 KTN/HC5
– (Non-standardized)	**Angular contact thrust ball bearings: Double direction, basic design** *Super-precision double direction angular contact thrust ball bearings (Publication No. 10097)*		Open	All-steel Hybrid	BTW BTW /HC
	Angular contact thrust ball bearings: Double direction, high-speed design *Higher-speed capability with the new BTM bearing series design (Publication No. 12119)*		Open	All-steel Hybrid	BTM BTM /HC
02	**Angular contact thrust ball bearings: Single direction** *Super-precision angular contact thrust ball bearings for screw drives (Publication No. 06570)*		Open Sealed	All-steel All-steel	BSA 2 *(BS 200)* BSA 2 .. *(BS 200 ..)*
03	**Angular contact thrust ball bearings: Single direction** *Super-precision angular contact thrust ball bearings for screw drives (Publication No. 06570)*		Open Sealed	All-steel All-steel	BSA 3 *(BS 3)* BSA 3 .. *(BS 3 ..)*
– (Non-standardized)	**Angular contact thrust ball bearings: Single direction** *Super-precision angular contact thrust ball bearings for screw drives (Publication No. 06570)*		Open Sealed	All-steel All-steel	BSD *(BS ../)* BSD .. *(BS ..)*
	Angular contact thrust ball bearings: Double direction		Sealed	All-steel	BEAS *(BEAS)* BEAM *(BEAM)*
	Cartridge unit with angular contact thrust ball bearings		Sealed	All-steel	FBSA *(BSDU, BSQU)* –

[1] Where applicable, information can be found in the SKF publication *High-precision bearings* (Publication No. 6002).
[2] For additional information about super-precision angular contact ball bearings made from NitroMax steel, refer to the SKF publication *Extend bearing service life with NitroMax* (Publication No. 10126).

D



The Power of Knowledge Engineering

Drawing on five areas of competence and application-specific expertise amassed over more than 100 years, SKF brings innovative solutions to OEMs and production facilities in every major industry worldwide. These five competence areas include bearings and units, seals, lubrication systems, mechatronics (combining mechanics and electronics into intelligent systems), and a wide range of services, from 3-D computer modelling to advanced condition monitoring and reliability and asset management systems. A global presence provides SKF customers uniform quality standards and worldwide product availability.

PUB BU/P9 10097/3 EN · November 2012

This publication supersedes all information about SKF bearings in the 2344(00) series in the SKF publication *High-precision bearings* (Publication No. 6002).

Certain image(s) used under license from Shutterstock.com