Super-precision cylindrical roller bearings: High-speed

N 10 series



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SNFA is now a part of the SKF Group. Our new, super-precision bearings are built on the combined expertise of SKF and SNFA, using the best technology from each.

The result is leading-edge products. In addition to the most comprehensive assortment of state of the art super-precision bearings, customers now have access to the advanced modelling and virtual testing services that are at the core of SKF's technical expertise.

This unique capability – the most sophisticated in the industry – enables super-precision bearing customers to go beyond bearings and look at all aspects of their application.

With core competencies in bearings, seals, lubrication, mechatronics and services, your SKF-SNFA team is poised to partner with you to meet the requirements of your next generation of machine tools.

SKF – the knowledge engineering company

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High-speed super-precision single row cylindrical roller bearings

Machine tools and other precision applications require superior bearing performance. 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. Another performance challenge is keeping the amount of friction and heat generated by the bearing to a minimum during high-speed operation.

To meet these demanding performance criteria, N 10 series cylindrical roller bearings have an optimized internal geometry and a redesigned cage, enabling them to accommodate a speed increase of up to 30%.

The bearings are characterized by:

- high-speed capability
- high load carrying capacity
- high stiffness
- low friction
- low cross sectional height

The non-locating bearing position is typically at the non-tool end of a spindle. If the bearing at this position has a loose fit, it can have a negative influence on the total rigidity of the bearing arrangement. Therefore, for a high degree of stiffness at the non-tool end of a spindle, N 10 series cylindrical roller bearings with a tapered bore should be used. They accommodate axial displacement within the bearing and enable an interference fit for both the inner and outer rings.

Bearings in the N 10 series provide high reliability and superior accuracy for applications such as high-speed milling machines, machining centres and lathes.



The assortment

SKF-SNFA bearings in the N 10 series can accommodate shaft diameters ranging from 40 to 80 mm. The bearings are available with a tapered bore only and are manufactured to two tolerance classes. To accommodate increased operational speeds, the bearings are available in a hybrid variant.

The bearing overall dimensions are in accordance with ISO Dimension Series 10 and have a low cross sectional height. They are able to accommodate relatively large diameter shafts to provide the necessary system rigidity within a relatively small bearing envelope. When compared to a set of angular contact ball bearings with the same load carrying capacity and the same degree of rigidity, an N 10 series bearing requires a much smaller radial space. This enables compact spindle bearing arrangements.

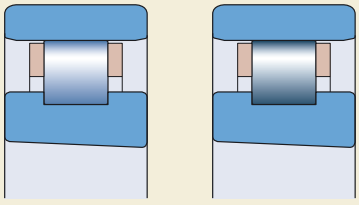
Hybrid variant

Bearings in the N 10 series are available with ceramic (bearing grade silicon nitride) rollers. As ceramic rollers are considerably lighter and harder than steel rollers, 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 rollers 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 N 10 series are identified by the designation suffix HC5.

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





Steel rollers Ceramic rollers

SKF-SNFA super-precision single row cylindrical roller bearings: N 10 series

Features and benefits

- An inner ring with two integral flanges for roller guidance provides high load carrying capacity, high degree of rigidity.
- The improved internal geometry of the inner ring enables high-speed capability.
- An optimized PEEK cage accommodates high speeds and temperatures up to 150 °C.
- The optimized roller profile (hybrid bearings) enables high speeds, low levels of heat generation.
- ISO Dimension Series 10 enables compact bearing arrangements.
- The separable design facilitates mounting and dismounting.
- A tapered bore enables preload or clearance adjustments.
- A flangeless outer ring accommodates axial displacement, within the bearing, due to spindle elongation, and also enables an interference fit for both the inner and outer rings.

High-speed design

Super-precision single row cylindrical roller bearings in the N 10 series are designed for bearing arrangements requiring increased speed capability, high load carrying capacity and a high degree of radial stiffness.

The features of high-speed N 10 series bearings include, among others, an optimized internal geometry, a flangesless outer ring and a high-speed cage.

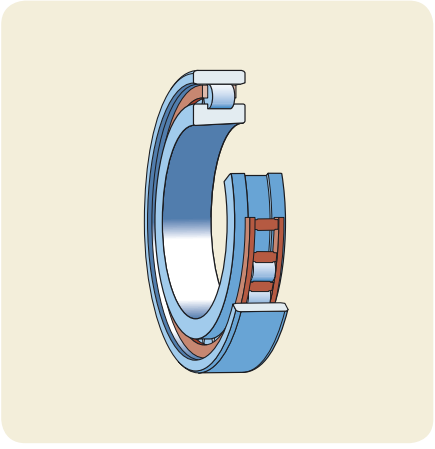
The bearings are separable, making it possible to separate the inner ring with roller and cage assembly from the outer ring to facilitate mounting and dismounting.

Optimized, high-speed cage

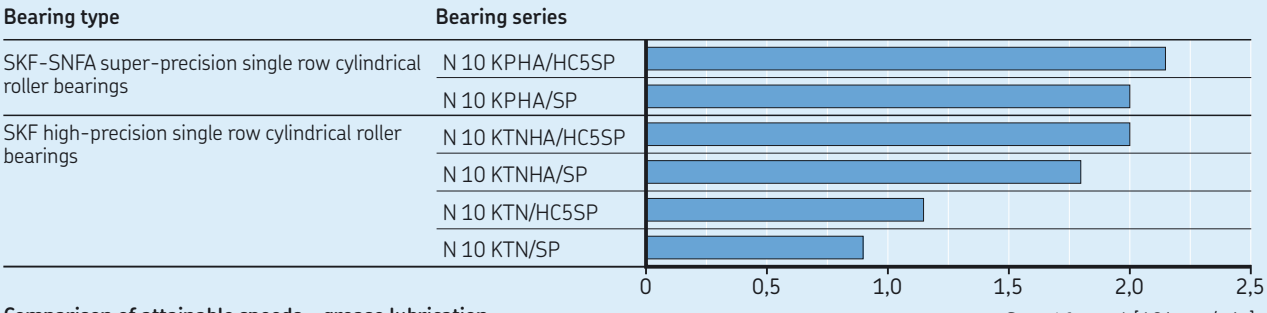
N 10 series bearings are equipped with an outer ring centred, window-type cage made of carbon fibre reinforced polyetheretherketone (PEEK). The symmetrical, self-centring design enables the cage to be better guided on the raceway of the outer ring, compared to previous designs. The cage also offers excellent guidance for the rollers and provides access for the lubricant (typically oil-air) to reach the contact areas between the cage and the inner ring flanges. The exceptional properties of PEEK provide a superior combination of strength and flexibility at high operational speeds. PEEK can also accommodate high operating temperatures while providing high wear resistance.

Compared to previous high-speed design bearings, the new, optimized cage can accommodate a speed increase of up to 30% in grease lubricated applications and up to 15% in oil-air lubricated applications.

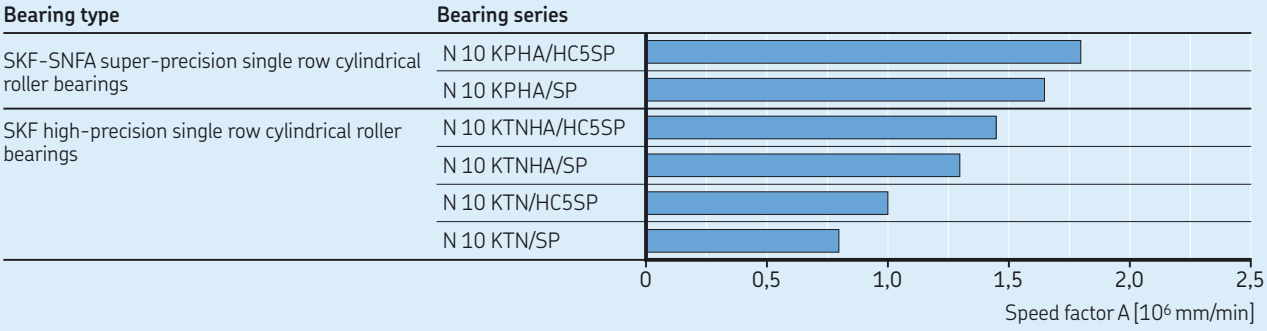
High-speed design cylindrical roller bearing



Comparison of attainable speeds – oil-air lubrication



Comparison of attainable speeds – grease lubrication



Applications

In applications requiring a high degree of system rigidity, cylindrical roller bearings are typically an excellent choice.

The SKF-SNFA assortment of super-precision single row cylindrical roller bearings in the N 10 series is very well suited to meet this requirement as well as other demands placed on precision bearing arrangements.

High-speed milling machines and machining centres require high positioning accuracy and low levels of heat generation. In addition, these applications are often subjected to heavy radial loads at the non-tool end of the spindle. The ability of bearings in the N 10 series to accommodate heavy loads at high speeds, and still provide a high degree of radial stiffness, makes them an excellent solution for these and similar applications.

Applications
- Machine tools
- High-speed milling machines
- High-speed machining centres
- Lathe electro-spindles

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

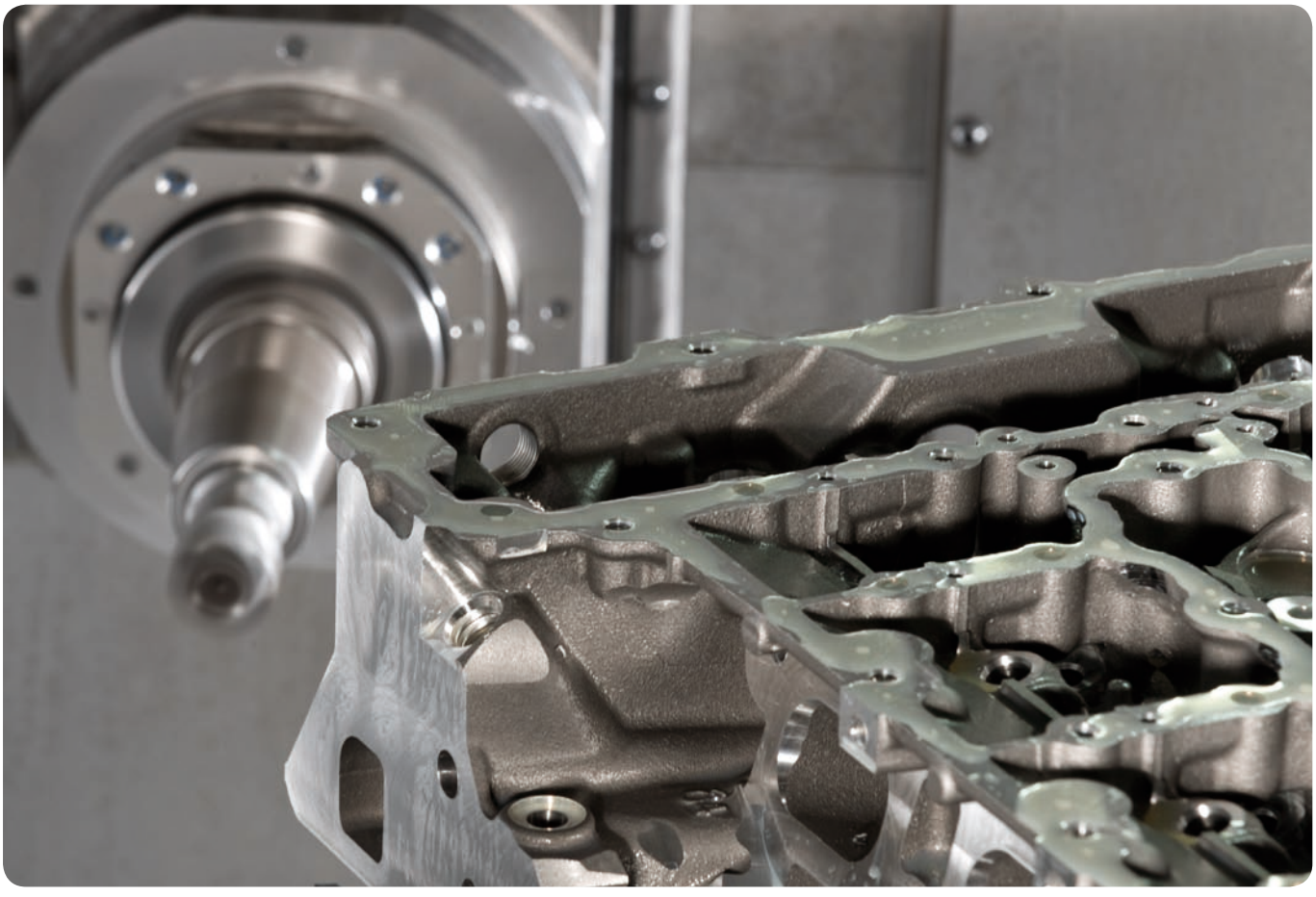
Solution



SKF-SNFA high-speed super-precision single row cylindrical roller bearings in the N 10 series







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 the tapered shaft seat. The further the bearing is driven up the seat, the more the clearance is reduced, until eventually, there is preload in the bearing. To quickly and accurately determine the amount of clearance or preload in the mounted bearing, SKF recommends using a GB 30 series internal clearance gauge (→ **fig. 1**).

If SKF gauges are not available, the axial displacement, i.e. the additional distance through which the bearing inner ring must be pushed up on its tapered seat, can be calculated. For additional information, refer to the *SKF Interactive Engineering Catalogue* available online at www.skf.com.

Fig. 1



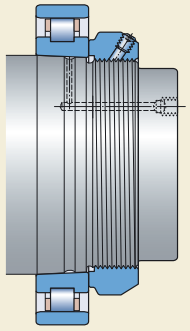


Preparing for oil injection

For bearings in the N 10 series, particularly the larger sizes, SKF recommends using the SKF oil injection method to facilitate mounting and dismounting. With this method, oil under high pressure is injected between the bearing inner ring bore and the shaft seat to form an oil film that separates the mating surfaces and appreciably reduces the friction between them. The distribution of oil between the mating surfaces is accomplished by a circumferential oil distribution groove in the shaft that communicates with a supply duct in the shaft (→ **fig. 1**).

It is necessary to make provision for the SKF oil injection method. This is usually done at the design stage of the bearing arrangement. For additional information about the SKF oil injection method and recommended dimensions for distribution grooves and oil supply ducts, refer to the *SKF Interactive Engineering Catalogue* available online at www.skf.com.

Fig. 1

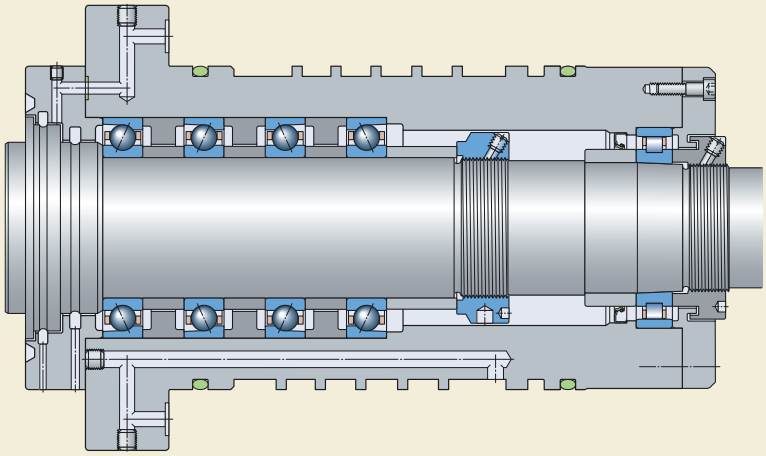




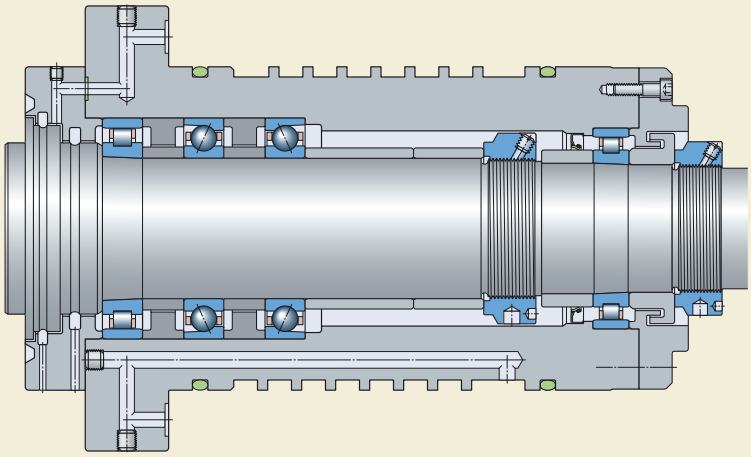
Application examples

High-speed super-precision single row cylindrical roller 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.

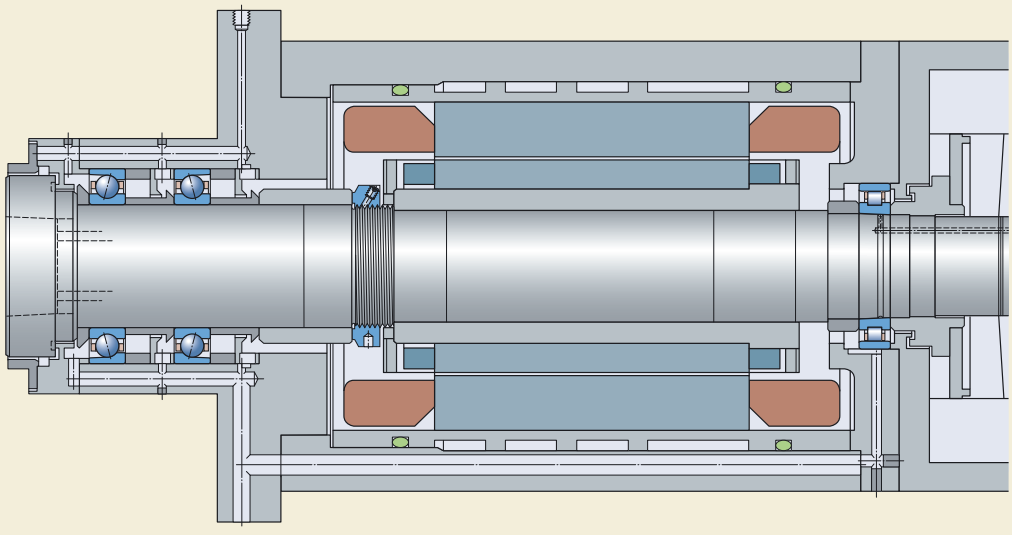
For high-speed machining centres and lathes, for example, there is typically a compromise between rigidity and load carrying capacity. In these applications, the spindle is often driven directly by a motor. The spindle is then referred to as a motorized spindle or electro-spindle. As there are only very light radial loads at the non-tool end (compared with a belt-driven spindle), but a high degree of rigidity is required, a super-precision single row cylindrical roller bearing is frequently used at that end. A cylindrical roller bearing at the non-tool end accommodates thermal elongation of the shaft within the bearing. Angular contact ball bearings at the tool end locate the shaft axially.



High-speed milling machine
For high-speed milling machines, where a high degree of system rigidity is required, a super-precision single row cylindrical roller bearing at the non-tool end, e.g. N 1013 KPHA/SP, is suitable. A matched set of four super-precision hybrid angular contact ball bearings, e.g. 7014 ACD/HCP4AQBCB, incorporating a set of precision-matched spacer rings, can be used at the tool end, providing an overall robust bearing arrangement.



High-speed milling machine
In a high-speed milling machine where there are relatively heavy combined loads at the tool end, a high degree of rigidity and high load carrying capacity are important operational requirements. It is common to have a super-precision hybrid single row cylindrical roller bearing, e.g. N 1014 KPHA/HC5SP, in combination with a matched set of back-to-back super-precision hybrid angular contact ball bearings, e.g. 7014 ACD/HCP4ADBB, at the tool end. A super-precision hybrid single row cylindrical roller bearing, e.g. N 1013 KPHA/HC5SP, is suitable for the non-tool end.



Electro-spindle for a high-speed machining centre
For high-speed machining centres where speeds can exceed 1 200 000 mm/min, a super-precision cylindrical roller bearing, e.g. N 1009 KPHA/SP, is used at the non-tool end. A matched set of super-precision angular contact ball bearings mounted back-to-back, e.g. 7012 CD/P4ADBB, are used at the 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 necessary parts.

Grease lubrication

In most applications with bearings in the N 10 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]

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 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.

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

Diagram 1

Factor K for initial grease fill estimation

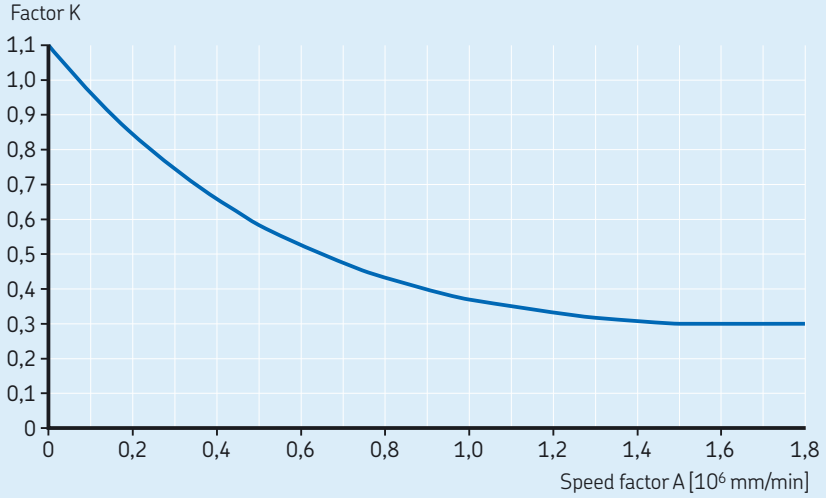


Table 1

Reference grease quantity for initial grease fill estimation

Bearing Bore diameter d	Size	**Reference grease quantity**[1] G_{ref}
mm	–	cm^3
40	**08**	3,1
45	**09**	4,1
50	**10**	4,4
55	**11**	6,1
60	**12**	6,5
65	**13**	6,9
70	**14**	9,2
75	**15**	9,6
80	**16**	12,5

[1] Refers to a 30% filling grade.

Oil lubrication

Where speeds are constantly very high (generally, speed factor A > 1 800 000 mm/min), bearings in the N 10 series should be oil lubricated, as the service life of grease is too short under these conditions and oil provides the added benefit of cooling.

Oil-air lubrication method

In some precision applications, the very high operational speeds and requisite low operating temperatures require 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. The oil nozzles should be positioned correctly (→ **table 2**) to make sure that the oil is introduced into the contact area between the rollers and raceways and to avoid interference with the cage.

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

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

where
Q = oil flow rate [mm³/h]
d = bearing bore diameter [mm]
B = bearing width [mm]
q = a factor of 1 to 2

Different bearing types and designs show varying sensitivity to oil quantity change. Roller bearings, which are very sensitive to lubricant quantity, can experience a significant increase in operating temperature. Therefore, SKF recommends testing and verifying the calculated oil flow rate prior to operation in a production environment.

High quality lubricating oils with a viscosity of 40 to 100 mm²/s at 40 °C are typically used, as are oils with EP additives, which are preferable for roller bearings. A filter that prevents particles > 5 µm from reaching the bearings should also be incorporated.

Fig. 1

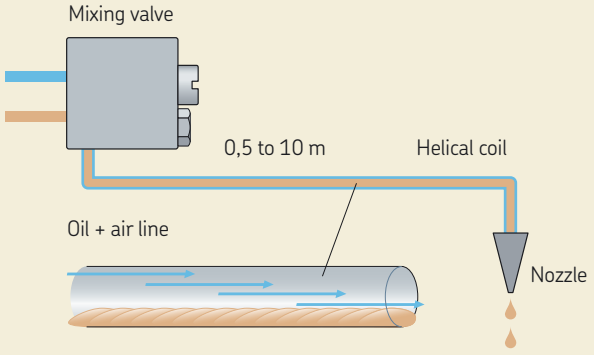
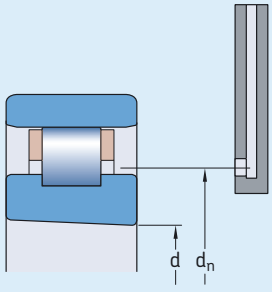


Table 2

Oil nozzle position for oil-air lubrication



Bearing Bore diameter d	Size	**Oil nozzle position** d_n
mm	–	mm
40	**08**	52,1
45	**09**	57,9
50	**10**	63
55	**11**	70,1
60	**12**	75,2
65	**13**	80,1
70	**14**	87,7
75	**15**	92,7
80	**16**	99,3

Bearing data – general

Boundary dimensions

The boundary dimensions of bearings in the N 10 series are in accordance with ISO 15:1998, Dimension Series 10.

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 outer ring are in accordance with ISO 15:1998. The values for the chamfers on the inner ring are smaller and are not standardized.

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

Tolerances

Bearings in the N 10 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 in an ultra-precision (UP) 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.

Additional tolerances for tapered bores are provided in **table 3**.

The tolerance symbols used in these tables are listed together with their definitions in **table 4**.

Radial internal clearance

Bearings in the N 10 series are manufactured, standard, with C1 radial internal clearance. On request, the bearings can be supplied with a special reduced radial internal clearance (smaller than C1), when a minimum operational clearance or preload after mounting is required.

The bearing rings of individual bearings are matched at the factory and must be kept together. (When packed separately, bearing rings have a serial number.) If bearing rings are swapped, the "new" radial internal clearance in the bearing could fall outside the

Table 1

Class SP tolerances

Inner ring d over	incl.	Δ_{ds}[1] high	low	V_{dp} max	Δ_{Bs} high	low	V_{Bs} max	K_{ia} max	S_d max
mm		µm		µm	µm		µm	µm	µm
30	**50**	0	–8	4	0	–120	5	4	8
50	**80**	0	–9	5	0	–150	6	4	8

Outer ring D over	incl.	Δ_{Ds} high	low	V_{Dp} max	Δ_{Cs}, V_{Cs}	K_{ea} max	S_D max
mm		µm		µm		µm	µm
50	**80**	0	–9	5	Values are identical to	5	8
80	**120**	0	–10	5	those for the inner ring of	6	9
120	**150**	0	–11	6	the same bearing (Δ_{Bs}, V_{Bs})	7	10

[1] For SP tolerances for tapered bores, refer to **Table 3**.

Table 2

Class UP tolerances

Inner ring d over	incl.	Δ_{ds}[1] high	low	V_{dp} max	Δ_{Bs} high	low	V_{Bs} max	K_{ia} max	S_d max
mm		µm		µm	µm		µm	µm	µm
30	**50**	0	–6	3	0	–100	2	2	3
50	**80**	0	–7	3,5	0	–100	3	2	4

Outer ring D over	incl.	Δ_{Ds} high	low	V_{Dp} max	Δ_{Cs}, V_{Cs}	K_{ea} max	S_D max
mm		µm		µm		µm	µm
50	**80**	0	–6	3	Values are identical to	3	2
80	**120**	0	–7	4	those for the inner ring of	3	3
120	**150**	0	–8	4	the same bearing (Δ_{Bs}, V_{Bs})	4	3

[1] For UP tolerances for tapered bores, refer to **Table 3**.

specifications and complicate the mounting procedure.

The values for C1 radial internal clearance are listed in **table 5**, on **page 16**. They are in accordance with ISO 5753:1991 and valid for unmounted bearings under zero measuring load.

Axial displacement

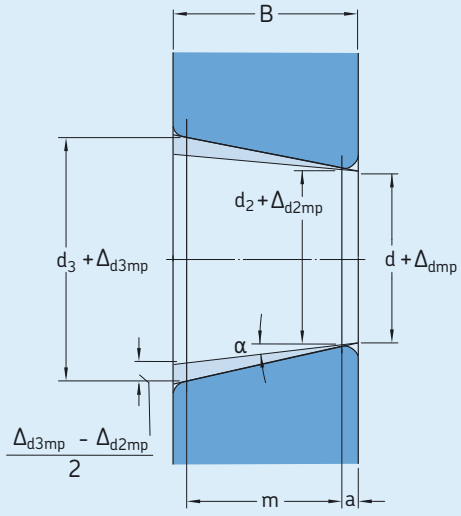
Bearings in the N 10 series can accommodate thermal elongation of the shaft, within the bearing. This enables the inner and outer rings to be mounted with an interference fit. The permissible axial displacement s from the normal position of one bearing ring in relation to the other is provided in the product table.

Radial stiffness

Radial stiffness depends on the deformation of the bearing under load and can be expressed as the ratio of the load to bearing resilience. However, since there is not a direct linear relationship between bearing resilience and load, constant values for axial

Table 3

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



Half angle of taper:
α = 2° 23' 9,4"

Measuring distance a = 2,5 mm

Bore diameter d		Class SP tolerances					Class UP tolerances				
		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	
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

[1] $\Delta_{d3mp} - \Delta_{d2mp}$ = angle deviation over the measuring distance m

Table 4

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 ($\Delta_{dmp} = d_{mp} - d$)
V_{dp}	Bore diameter variation; difference between the largest and smallest single bore diameters in one plane
	Outside diameter
D	Nominal outside diameter
D_s	Single outside diameter
Δ_{Ds}	Deviation of a single outside diameter from the nominal ($\Delta_{Ds} = D_s - D$)
V_{Dp}	Outside diameter variation; difference between the largest and smallest single outside diameters in one plane

Tolerance symbol	Definition
	Width
B, C	Nominal width of inner ring and outer ring, respectively
B_s, C_s	Single width of inner ring and outer ring, respectively
Δ_{Bs}, Δ_{Cs}	Deviation of single inner ring width or single outer ring width from the nominal ($\Delta_{Bs} = B_s - B$; $\Delta_{Cs} = C_s - C$)
V_{Bs}, V_{Cs}	Ring width variation; difference between the largest and smallest single widths of inner ring and of outer ring, respectively
	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

stiffness cannot be quoted. Exact values of radial stiffness, for bearings in the N 10 series, for a given load can be calculated using advanced computer methods, but guideline values are listed in **table 6**. These values apply to mounted bearings with zero clearance under static conditions and subjected to moderate loads.

Equivalent loads

The equivalent dynamic bearing load can be calculated using

$P = F_r$

The equivalent static bearing load can be calculated using

$P_0 = F_r$

where
P = equivalent dynamic bearing load [kN]
P_0 = equivalent static bearing load [kN]
F_r = radial component of the load [kN]

Attainable speeds

The attainable speeds listed in the product table should be regarded as guideline values. They are valid under the following conditions:

- The bearings have small operational clearance (2 to 3 µm).
- Housing and shaft seats and abutments meet the accuracy requirements for precision applications.

The speed ratings must be reduced when:

- operational clearance is smaller than 2 µm
- preload is set
- the housing and shaft seats and abutments do not meet accuracy requirements

The values provided for oil lubrication apply to the oil-air lubrication method 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 good lubricating grease that has a low consistency and low viscosity.

Cage material

Bearings in the N 10 series have a cage made of carbon fibre reinforced polyetheretherketone (PEEK) (→ **fig. 1**) that can withstand temperatures up to 150 °C.

The technical specifications of carbon fibre reinforced PEEK are provided in **table 7**.

Materials and heat treatment

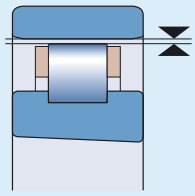
The rings and rollers of all-steel bearings in the N 10 series are made from SKF Grade 3 steel, in accordance with ISO 683-17:1999.

Rollers 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 and dimensional stability. The hardness of the rings and rolling elements is optimized for wear-resistance and the bearing rings are heat stabilized to accommodate temperatures up to 150 °C.

Table 5

Radial internal clearance



Bearing Bore diameter d	Size	**Radial internal clearance** C1 min	max
mm	–	µm	
40	**08**	15	25
45	**09**	17	30
50	**10**	17	30
55	**11**	20	35
60	**12**	20	35
65	**13**	20	35
70	**14**	25	40
75	**15**	25	40
80	**16**	25	40

Table 6

Static radial stiffness

Bearing Bore diameter d	Size	**Static radial stiffness** of all-steel bearings	of hybrid bearings
mm	–	N/µm	
40	08	155	172
45	09	176	196
50	10	194	215
55	11	229	254
60	12	250	277
65	13	271	301
70	14	305	339
75	15	303	337
80	16	347	385

Table 7

Technical specifications of carbon fibre reinforced polyetheretherketone (PEEK)

Property	**Specification**
Density [g/cm³]	1,41
Thermal linear expansion coefficient [10⁻⁶ /K]	25
Elasticity traction modulus [MPa]	7 700
Melting point [°C]	340

Packaging

SKF-SNFA super-precision bearings are distributed in dual branded boxes (→ **fig. 2**). Bearings in the N 10 series are usually supplied in a single box. However, if the bearing rings are packed separately, they are identified by a serial number and must be kept together.

Designation system

The designations for SKF-SNFA bearings in the N 10 series are provided in **table 8** together with their definitions.

Fig. 1



Fig. 2



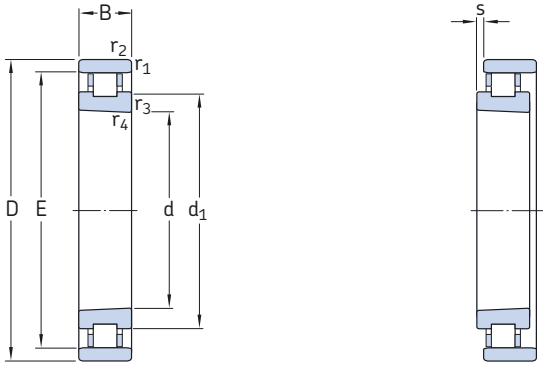
Table 8

Designation system for SKF-SNFA super-precision single row cylindrical roller bearings in the N 10 series

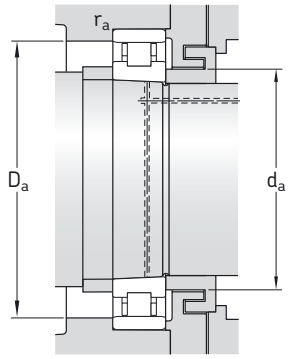
Example: N 1016 KPHA/HC5SP	N	10	16	K	PHA	/	HC5	SP

Bearing design	
N	Single row cylindrical roller bearing with integral flanges on the inner ring
Dimension Series	
10	In accordance with ISO Dimension Series 10
Bearing size	
08	(x5) 40 mm bore diameter
to	
16	(x5) 80 mm bore diameter
Bore shape	
K	Tapered bore (taper 1:12)
Cage material and design	
PHA	Carbon fibre reinforced polyetheretherketone (PEEK), outer ring centred, high-speed design
Rolling elements	
–	Carbon chromium steel (no designation suffix)
HC5	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
UP	Dimensional accuracy approximately in accordance with ISO tolerance class 4 and running accuracy better than ISO tolerance class 4

Super-precision single row cylindrical roller bearings
d **40 – 80** mm



Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Attainable speeds when lubricating with grease	oil-air	Mass	Designation
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
40	68	15	23,3	25	2,9	30 000	36 000	0,190	**N 1008 KPHA/SP**
	68	15	23,3	25	2,9	32 000	38 000	0,172	**N 1008 KPHA/HC5SP**
45	75	16	27	30	3,45	28 000	34 000	0,240	**N 1009 KPHA/SP**
	75	16	27	30	3,45	30 000	36 000	0,202	**N 1009 KPHA/HC5SP**
50	80	16	28,6	33,5	3,8	26 000	30 000	0,260	**N 1010 KPHA/SP**
	80	16	28,6	33,5	3,8	28 000	32 000	0,217	**N 1010 KPHA/HC5SP**
55	90	18	37,4	44	5,2	22 000	28 000	0,380	**N 1011 KPHA/SP**
	90	18	37,4	44	5,2	24 000	30 000	0,316	**N 1011 KPHA/HC5SP**
60	95	18	40,2	49	5,85	20 000	26 000	0,400	**N 1012 KPHA/SP**
	95	18	40,2	49	5,85	22 000	28 000	0,330	**N 1012 KPHA/HC5SP**
65	100	18	42,9	54	6,3	20 000	24 000	0,430	**N 1013 KPHA/SP**
	100	18	42,9	54	6,3	22 000	26 000	0,354	**N 1013 KPHA/HC5SP**
70	110	20	53,9	69,5	8	18 000	22 000	0,610	**N 1014 KPHA/SP**
	110	20	53,9	69,5	8	20 000	24 000	0,501	**N 1014 KPHA/HC5SP**
75	115	20	52,8	69,5	8,15	17 000	20 000	0,640	**N 1015 KPHA/SP**
	115	20	52,8	69,5	8,15	19 000	22 000	0,531	**N 1015 KPHA/HC5SP**
80	125	22	66	86,5	10,2	16 000	19 000	0,880	**N 1016 KPHA/SP**
	125	22	66	86,5	10,2	18 000	20 000	0,731	**N 1016 KPHA/HC5SP**



C

Dimensions						Abutment and fillet dimensions				
d	d_1 ~	E ~	$r_{1,2}$ min	$r_{3,4}$ min	s[1)]	d_a min	d_a max	D_a min	D_a max	r_a max
mm						mm				
40	50,6	61	1	0,6	1,5	45	59	62	63	1
	50,6	61	1	0,6	1,5	45	59	62	63	1
45	56,3	67,5	1	0,6	1,5	50	65	69	70	1
	56,3	67,5	1	0,6	1,5	50	65	69	70	1
50	61,3	72,5	1	0,6	1,5	55	70	74	75	1
	61,3	72,5	1	0,6	1,5	55	70	74	75	1
55	68,2	81	1,1	0,6	1,5	61,5	79	82	83,5	1
	68,2	81	1,1	0,6	1,5	61,5	79	82	83,5	1
60	73,3	86,1	1,1	0,6	1,5	66,5	84	87	88,5	1
	73,3	86,1	1,1	0,6	1,5	66,5	84	87	88,5	1
65	78,2	91	1,1	0,6	1,5	71,5	89	92	93,5	1
	78,2	91	1,1	0,6	1,5	71,5	89	92	93,5	1
70	85,6	100	1,1	0,6	2	76,5	98	101	103,5	1
	85,6	100	1,1	0,6	2	76,5	98	101	103,5	1
75	90,6	105	1,1	0,6	2	81,5	102	106	108,5	1
	90,6	105	1,1	0,6	2	81,5	102	106	108,5	1
80	97	113	1,1	0,6	2	86,5	110	114	118,5	1
	97	113	1,1	0,6	2	86,5	110	114	118,5	1

[1)] Permissible axial displacement from the normal position of one bearing ring in relation to the other.

Setting the highest standard for precision bearings

SKF, together with SNFA, is developing a new, improved generation of super-precision bearings. By combining the best design criteria from both brands, the new SKF-SNFA assortment delivers improved accuracy and extended bearing service life when compared to previous designs.

Table 1 provides an overview of the growing, new assortment of SKF-SNFA super-precision bearings. The full assortment of SKF high-precision bearings will ultimately be replaced completely by super-precision bearings.

Super-precision angular contact ball bearings

Bearings in the 718 *(SEA)*[1)] 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.

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.

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 bearing range, available on request.

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-SNFA single direction angular contact thrust ball bearings and can accommodate shaft diameters ranging from 20 to 60 mm.





[1)] Where applicable, designations in parentheses and italics refer to the corresponding SNFA equivalent.

Table 1

Overview of the transition to SKF-SNFA super-precision bearings

ISO Dimension Series	Bearing type and design	Variant		Previous assortment SKF bearings in the series	Previous assortment SNFA bearings in the series	New assortment SKF-SNFA bearings in the series	SKF publication
18	**Angular contact ball bearings: Basic design**	Open	All-steel	–	SEA	718 .. D *(SEA)*	*Super-precision angular contact ball bearings: 718 (SEA) series* (Publication No. 6810)
			Hybrid	–	SEA /NS	718 .. D/HC *(SEA /NS)*	
19	**Angular contact ball bearings: High-speed, B design**	Open	All-steel	719 .. B	HB	719 .. B *(HB)*	*Super-precision angular contact ball bearings: High-speed, B design* (Publication No. 6939)
			Hybrid	C719 .. B	HB /NS	719 .. B/HC *(HB /NS)*	
		Sealed	All-steel	S719 .. B	HB /S	S719 .. B *(HB /S)*	
			Hybrid	SC719 .. B	HB /S/NS	S719 .. B/HC *(HB /S/NS)*	
10	**Angular contact ball bearings: High-speed, B design**	Open	All-steel	70 .. B	HX	70 .. B *(HX)*	
			Hybrid	C70 .. B	HX /NS	70 .. B/HC *(HX /NS)*	
		Sealed	All-steel	S70 .. B	HX /S	S70 .. B *(HX /S)*	
			Hybrid	SC70 .. B	HX /S/NS	S70 .. B/HC *(HX /S/NS)*	
	Single row cylindrical roller bearings: High-speed design	Open	All-steel	N 10 KTNHA	–	N 10 KPHA	*Super-precision cylindrical roller bearings: High-speed* (Publication No. 7016)
			Hybrid	N 10 KTNHA/HC5	–	N 10 KPHA/HC5	
02	**Angular contact ball bearings: High-capacity, basic design**	Open	All-steel	72 .. D	E 200	72 .. D *(E 200)*	*Super-precision angular contact ball bearings: High-capacity* (Publication No. 6981)
			Hybrid	72 .. D/HC	E 200 /NS	72 .. D/HC *(E 200 /NS)*	
		Sealed	All-steel	S72 .. D	E 200 /S	S72 .. D *(E 200 /S)*	
			Hybrid	S72 .. D/HC	E 200 /S/NS	S72 .. D/HC *(E 200 /S/NS)*	
	Angular contact thrust ball bearings: Single direction	Open	All-steel	BSA 2	BS 200	BSA 2 *(BS 200)*	*Super-precision angular contact thrust ball bearings for screw drives* (Publication No. 6570)
		Sealed	All-steel	BSA 2 ..	BS 200 ..	BSA 2 .. *(BS 200..)*	
03	**Angular contact thrust ball bearings: Single direction**	Open	All-steel	BSA 3	–	BSA 3 *(BS 3)*	
		Sealed	All-steel	BSA 3 ..	–	BSA 3 .. *(BS 3 ..)*	
– (Non-standardized)	**Angular contact thrust ball bearings: Single direction**	Open	All-steel	BSD	BS /	BSD *(BS ../)*	
		Sealed	All-steel	BSD ..	–	BSD .. *(BS ..)*	
	Angular contact thrust ball bearings: Double direction	Sealed	All-steel	BEAS BEAM	– –	BEAS *(BEAS)* BEAM *(BEAM)*	
	Cartridge unit with angular contact thrust ball bearings	Sealed	All-steel	FBSA FBSD	BSDU, BSQU –	FBSA *(BSDU, BSQU)* –	

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 ISO 9001 and other customer specific requirements.

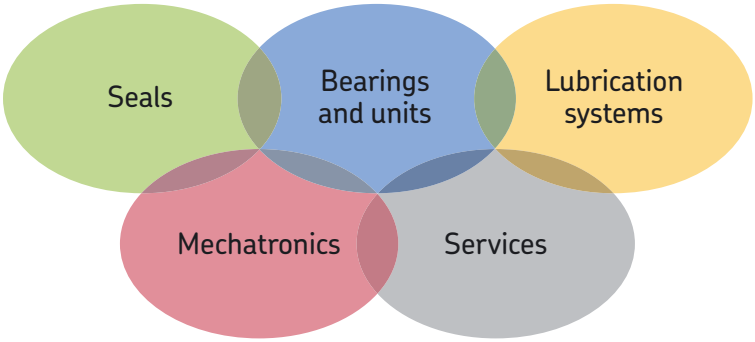
With over 100 manufacturing sites worldwide and sales companies in 70 countries, SKF is a truly international corporation. In addition, our distributors and dealers in some 15 000 locations around the world, an e-business marketplace and a global distribution system put SKF close to customers for the 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.



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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.



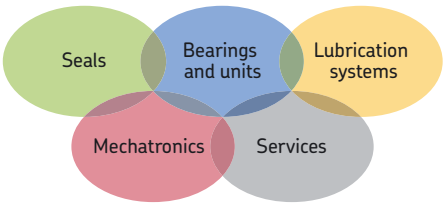
Maintaining a 350 km/h R&D lab
In addition to SKF's renowned research and development facilities in Europe and the United States, Formula One car racing provides a unique environment for SKF to push the limits of bearing technology. For over 50 years, SKF products, engineering and knowledge have helped 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.



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.

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