Koyo®

Precision Ball & Roller Bearings for Machine Tools

JTEKT

JTEKT CORPORATION

JTEKT Koyo TOYODA

CAT. NO. B2005E-3

Proposal of Various Products for Machine Tools

Product line-up for machining centers

➡P.164

Oil air lubricator
- High reliability
- Clean environment

➡P.168

Spindle unit
- High speed
- High precision
- Minimal temperature increase

➡P.58、104

Spindle bearings
- High speed
- High precision
- Minimal temperature increase

➡P.58

Motor bearings
- High speed
- Minimal temperature increase

➡P.168

Air clean unit
- Clean environment

➡P.152

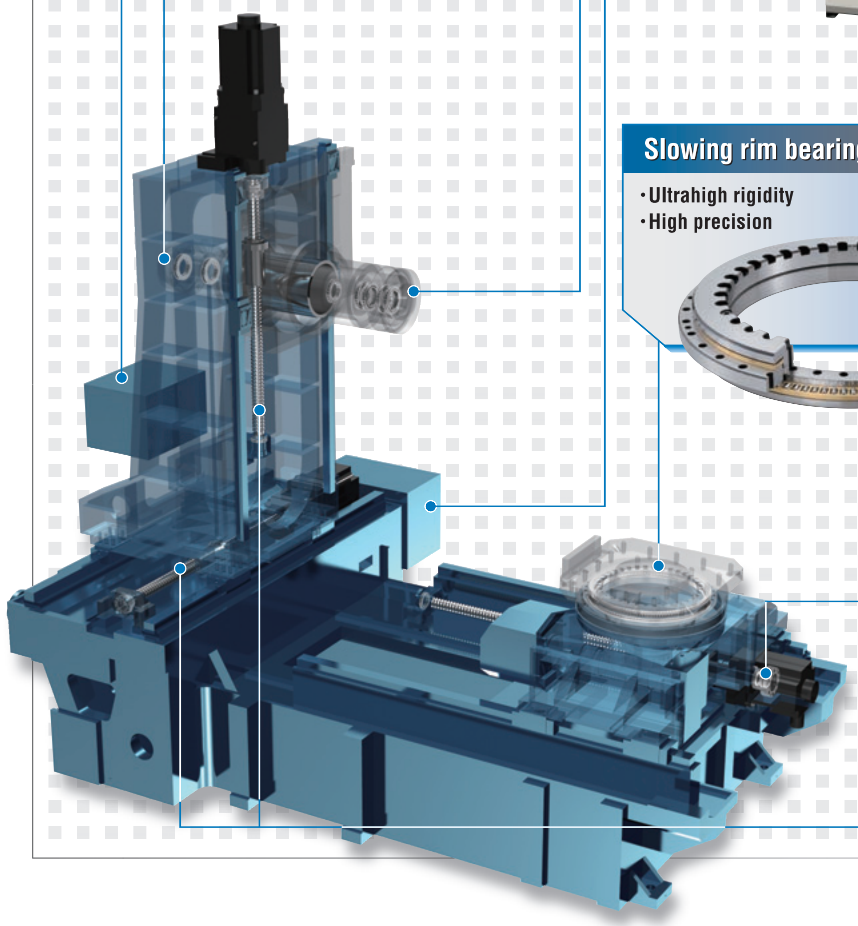
Ball screw support bearings
- High rigidity
- High precision

Slowing rim bearings for table
- Ultrahigh rigidity
- High precision

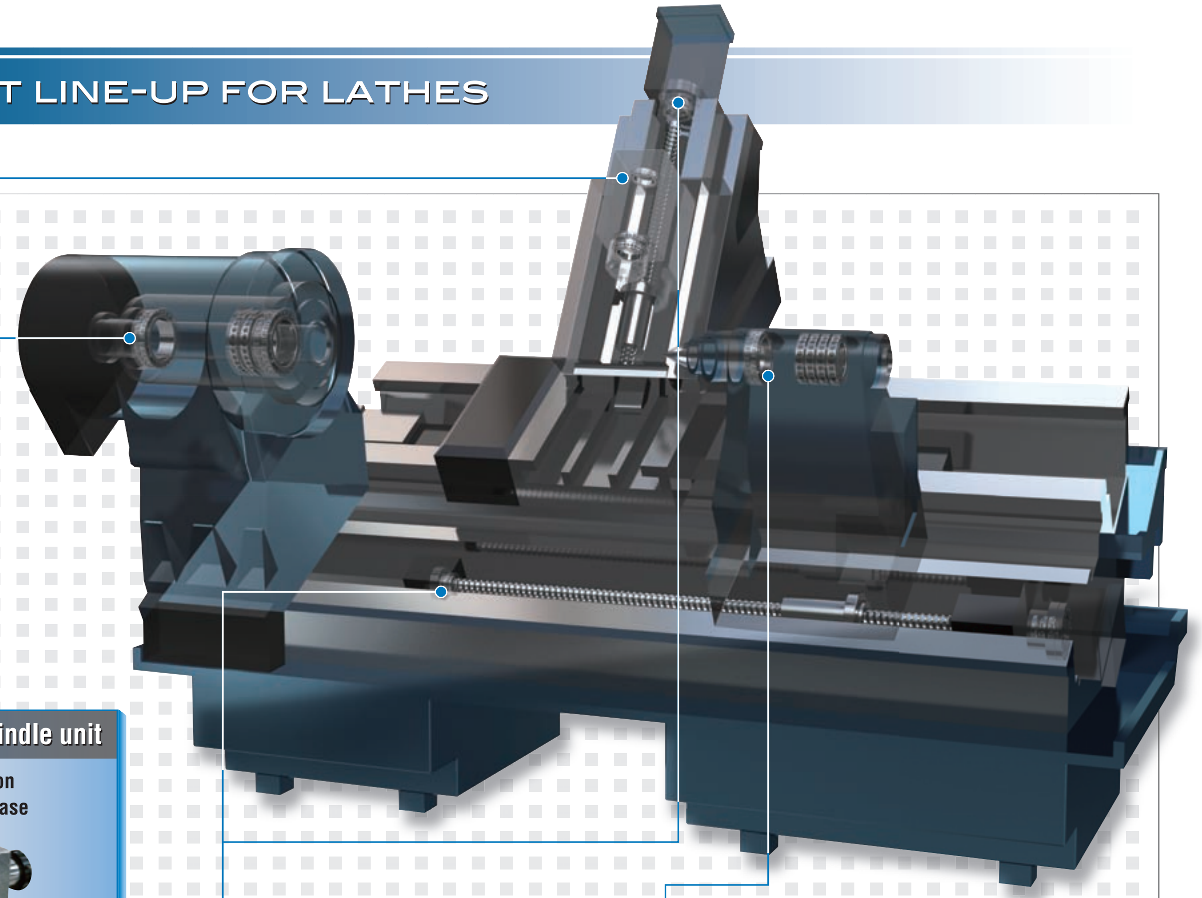
➡P.152

Ball screw support bearing unit
- Easy installation
- High rigidity
- High precision

Ball screw
- High transmission efficiency



Product line-up for lathes



Spindle unit
- High rigidity
- High precision
- Minimal temperature increase

➡P.58、104、120、138

Spindle bearings
- High rigidity
- High precision
- Minimal temperature increase

Ball screw
- High transmission efficiency

➡P.58、104

Tailstock bearings
- High rigidity
- High precision
- Minimal temperature increase

➡P.152

Ball screw support bearing unit
- Easy installation
- High rigidity
- High precision

➡P.152

Ball screw support bearings
- High rigidity
- High precision

Please consult JTEKT for detailed information on products not listed in this catalog.

Koyo®

Precision
Ball & Roller Bearings
for Machine Tools

CAT. NO. B2005E-3

Koyo®

Catalog
Precision Ball & Roller Bearings for Machine Tools Preface

Thank you for your valuable support of **KOYO** products.

Nowadays, there is a pressing demand in the industrial world for sophisticating machine tools in all aspects.
Accordingly, ball & roller bearings for machine tools must be more compact and lightweight and exhibit such features as longer service life, higher performance, and higher reliability. This is made possible only through a wide range of high technologies.

We are confident that this catalog will be of help to the user in the design of machine tools and in the use of precision rolling bearings.

JTEKT continually offers the best technologies, quality, and services, through inspiration from the market and putting efforts into research and technical developments.
We hope that you will be as satisfied with our products and services as you have been in the past.

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Ⅰ. Precision Ball & Roller Bearings

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Koyo®

Precision Ball & Roller Bearings

Technical Descriptions

1. Types and structures of precision ball & roller bearings for machine tools

Table 1. 1(1) Types and structures of precision ball & roller bearings for machine tools

1 Spindle bearings

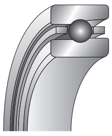
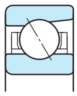
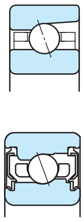
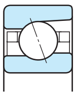
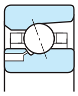
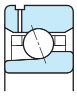
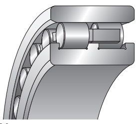
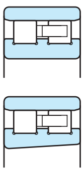
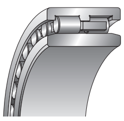
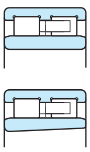
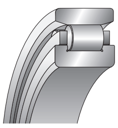
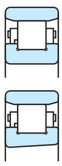
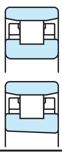
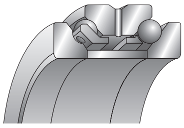
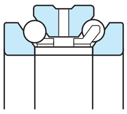
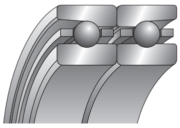
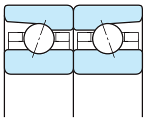
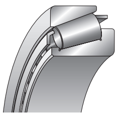
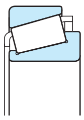
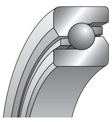
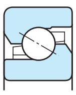
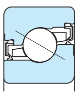
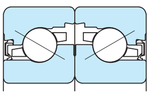
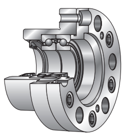
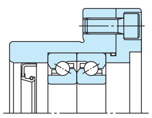
Bearing types	Cross-sections	Bearing series		Contact angles	Features and descriptions	Page No.
 Angular contact ball bearings		Standard types	79C 70C 72C	15°	· Some bearing series support contact angle of 40° (B).	58
			70 72	30°		
	High Ability  Both-side sealed type	High-speed types	HAR9C HAR0C	15°	· Improvements in high-speed performance are made through the use of balls that have a smaller diameter than standard bearing balls. Also, a large number of balls contributes to higher rigidity. · Rolling elements are available in steel and in ceramic. · Consult JTEKT, as the HAR000 series can correspond to the non-contact seal.	
			HAR9CA HAR0CA	20°		
			HAR9 HAR0	30°		
	High Ability 		3NCHAC9C 3NCHAC0C	15°	· Large-diameter balls enable high load-carrying capacity. · Ceramic balls realize excellent high-speed performance.	
			3NCHAC9CA 3NCHAC0CA	20°		
	High Ability 	Ultrahigh-speed types	3NCHAD0CA	20°	· These bearings have holes for oil / air lubrication. They are suitable for ultrahigh-speed applications. · Ceramic balls realize excellent high-speed performance.	
	High Ability NX series 	Extremely ultrahigh-speed types	3NCHAX9CA 3NCHAX0CA	20°	· This type of bearing produces less heat and has better high-speed performance than conventional High Ability Series products.	
 NN-type double row cylindrical roller bearings		Standard types	NN30 NN30K	—	· Bearings with tapered bores (K) are also available for applications using tapered shafts. · For radial internal clearance values, use non-interchangeable bearings. · Bearings provided with a lubrication hole or groove on the outer ring are also available (W)	104
 NNU-type double row cylindrical roller bearings			NNU49 NNU49K			
 N-type single row cylindrical roller bearings			N10 N10K	—	· Bearings with tapered bores (K) are also available for applications using tapered shafts. · For radial internal clearance values, use non-interchangeable bearings. · This type of bearing produces less heat and has better high-speed performance than double row cylindrical roller bearings.	
	High Ability NX series 	Ultrahigh-speed types	HAN10B HAN10BK	—	· This type of bearing produces less heat and has better high-speed performance than conventional single-row cylindrical roller bearings.	

Table 1. 1(2) Types and structures of precision ball & roller bearings for machine tools

Bearing types	Cross-sections	Bearing series	Contact angles	Features and descriptions	Page No.
 Double-direction angular contact thrust ball bearings		2344B	60°	· Placed on the small tapered-bore diameter side of NN30K, or used together with NN30.	120
		2347B		· Placed on the large tapered-bore diameter side of NN30K.	
		2394B	60°	· Placed on the small tapered-bore diameter side of NNU49K, or used together with NNU49.	
		2397B		· Placed on the large tapered-bore diameter side of NNU49K.	
 High-speed pair-mounted angular contact ball bearings		ACT0DB	30°	· High-speed bearings of the same bore and outside diameters as double-direction angular contact thrust ball bearings 2344B. · They are placed on the small tapered-bore diameter side of NN30K.	
		ACT0BDB	40°		
 Tapered roller bearings		329JR 320JR 302JR 322JR	Nominal contact angles: greater than 10° and equal to or less than 17°	· Metric series single row tapered roller bearings complying with ISO standards.	138

2 Support bearings and support bearing units for precision ball screws

Bearing types	Cross-sections	Bearing series	Contact angles	Features and descriptions	Page No.
 Support bearings for precision ball screws	  Both-side sealed type  Matching example of one-side sealed type	SAC	60°	· Standard preloads are specified, respectively, for 2-, 3-, and 4-row matched bearings. · Flush-ground G-type bearings are also available. · The support bearing for precision ball screws can correspond to the type with contact-seal. Consult JTEKT if desiring information about the type with seal and the matching method.	152
 Support bearing units for precision ball screws		BSU	(60°)	· Support bearing units consist of a support bearing for precision ball screws (SAC) and a precision housing. · Fitting this bearing unit is very simple.	

2. Selection of bearings

In order to select the optimum bearing to realize the intended design of a machine, it is necessary to consider specific operating conditions of the machine, bearing requirements, designs of parts around the bearing, marketability, and cost performance.

Table 2. 1 specifies the general procedure for selecting a bearing, and operating conditions to be taken into consideration. Note, however, that when selecting a bearing, priority should be given to meeting the most critical requirement rather than following a given procedure.

Table 2. 1 Procedure for selecting bearings and operating conditions to be taken into consideration

Selection procedure	Operating condition to be taken into consideration	Related information on bearings	Page No.
① Bearing types and arrangements	· Installation space · Magnitude, direction, and types of load applied to bearings · Rotational speeds · Running accuracy · Noise/frictional torque · Rigidity · Method of mounting and dismounting · Bearing arrangements · Marketability and cost performance	· Bearing types · Bearing arrangement examples	15 16
↓			
② Bearing dimensions	· Dimensions of bearing mounting positions · Dynamic equivalent load and rating life · Rotational speeds	· Bearing rating life · Basic dynamic load ratings · Dynamic equivalent loads · Permissible axial loads	18 18 24 28
↓			
③ Bearing tolerance class	· Running accuracy (runout) · Noise/frictional torque · Rotational speeds	· Bearing tolerances (Dimension tables)	
↓			
④ Fitting and internal clearance	· Loading condition · Operational temperature distribution · Shaft and housing materials · Dimensions and tolerances } · Fitting · Temperature differences between inner ring and outer ring · Rotational speed · Amount of preload	· Recommended fitting · Running accuracy of shafts and housings · Bearing preload · Internal clearance of bearings (Dimension tables)	32 39 29
↓			
⑤ Type and material of cage	· Rotational speeds · Noise · Lubrication methods		
↓			
⑥ Lubrication method, lubricant, and sealing device	· Operating temperatures · Rotational speeds · Sealing device · Lubrication methods · Lubricants	· Limiting speeds of bearings · Lubrication of bearings	34 35
↓			
⑦ Method of mounting and dismounting, and mounting dimensions	· Method of mounting and dismounting	· Handling of bearings	172
↓			
Decision on final specifications of bearing and parts around bearing			

For more information about specifications, fill out the supplementary **table 7 "Specification report of bearing for main shaft of machine tool"** on page 204, and contact **JTEKT**.

3. Selection of bearing types

When selecting a bearing type, it is of critical importance to fully understand the operating conditions of the bearing.

Table 3. 1 shows principal items to be considered and how to select a bearing type.

Table 3. 1 Selection of bearing types

Items to be considered	How to select a type
① Installation space Bearing can be installed in target equipment	· When designing a shaft system, critical factors on the whole are shaft rigidity and strength, therefore, shaft diameter, namely, the bore diameter of the bearing is determined first. · The installation space determined by types and the dimension series of the bearings used for the spindles of machine tools are shown in **Fig. 3. 1**. Select the optimum bearing from the types illustrated.
② Load Load magnitude, type and direciton which applied (The load capacity of the bearing is expressed in terms of the basic load rating, the value of which is given in the bearing dimension tables.)	· Select the optimum bearing type taking into consideration the magnitude of the load applied to the bearing, whether the load is axial or radial, whether, in the case of axial load, the load is unidirectional or bidirectional, the level of vibration and shock, and other relevant factors. · Radial load capacity varies as shown below with the bore diameter remaining the same. (Small) → (Large) Angular contact ball bearings Cylindrical roller bearings Tapered roller bearings
③ Rotational speeds Bearing types compatible with the machine's operating speed (Standard values for rotational speed limits of bearings are expressed in limiting speed given in the bearing dimension tables.)	· Limiting speeds of bearings largely depends not only on the bearing type, but also on other factors such as bearing size, running accuracy, type and materials of the cage, magnitude of load, and lubrication. Select a bearing taking these fully into consideration. · In general, angular contact ball bearings and cylindrical roller bearings are often used for high-speed applications.
④ Running accuracy Bearing types meeting requirements for running accuracy (Dimension and running accuracies are standardized by JIS and the like for each bearing type.)	· The spindles of machine tools, which need to rotate with high accuracy, require precision bearings meeting tolerance class 5 or better. · In general, angular contact ball bearings and cylindrical roller bearings are used.
⑤ Rigidity Bearing types meeting the rigidity requirements for machine shaft systems (When a load is applied to a bearing, elastic deformation occurs at the contacts between the raceway and rolling elements.The smaller the elastic deformation, the higher the rigidity.)	· In order to improve the machining precision of a machine tool, the rigidity of bearings as well as the rigidity of the shaft should be improved. · In general, roller bearings exhibit a high rigidity, while ball bearings exhibit low rigidity. Bearings of the same type and dimensions vary in rigidity with the number of rolling elements and contact angle. · The rigidity of a bearing is increased by applying a preload to the bearing (to provide a clearance of a negative value). This method is suitable for angular contact ball bearings and tapered roller bearings.
⑥ Mounting and dismounting Bearing types should be selected taking into consideration the frequency and method of mounting and dismounting on occasions such as periodic inspection	· If the bearing is to be mounted and dismounted frequently, cylindrical roller bearings and tapered roller bearings are advantageous, as the inner ring and outer ring are separable.

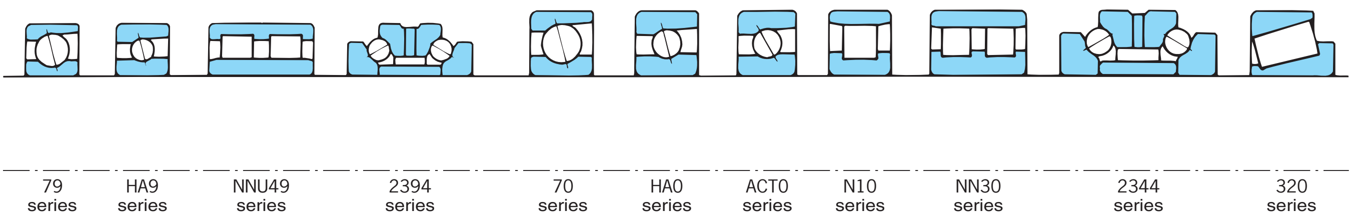


Fig. 3. 1 Installation space determined by types and dimension series of precision rolling bearings for machine tools

4. Spindle bearing arrangements

Fig. 4. 1 presents typical arrangements for spindle bearings for machine tools.

For high-speed spindles, the use of ceramic bearings enables higher speed.

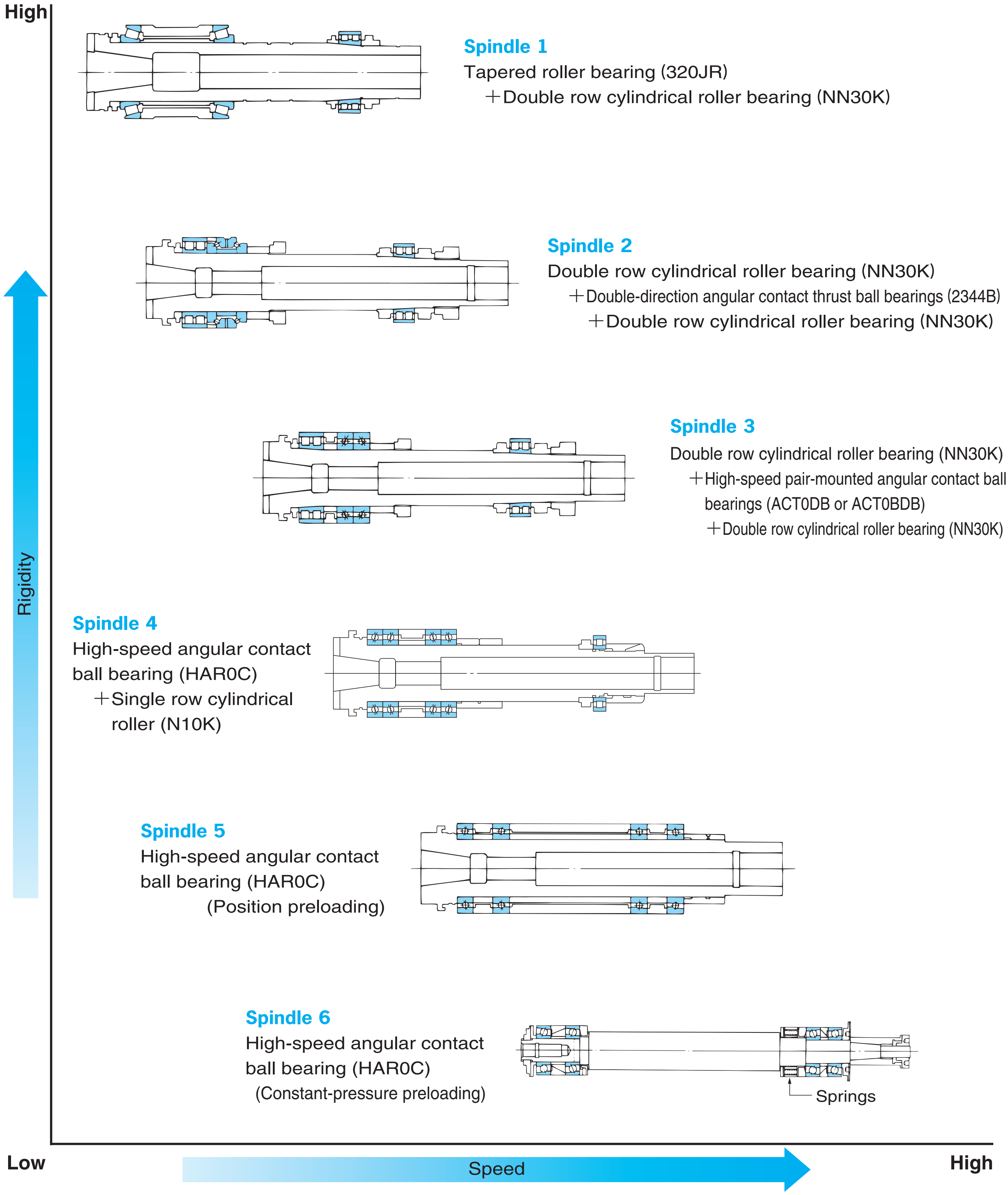


Fig. 4. 1 Examples of spindle bearing arrangements

Table 4. 1 Detailed examples of spindle bearing arrangements

(The $d_m n$ value represents the product of the pitch diameter of ball set d_m and the rotational speed n.)

Spindle	$d_m n$ Value	Features	Principal applications
1	Grease lubrication: 0.2×10^6	Both radial and axial loads are accepted by the tapered roller bearing. This arrangement produces high rigidity but is not suitable for high-speed operation.	Large lathes General-purpose lathes Milling machines
2	Grease lubrication: 0.4×10^6	In this structure, radial load is accepted by a double row cylindrical roller bearing and axial load is accepted by a double-direction angular contact thrust ball bearing. This arrangement produces high rigidity.	CNC lathes Machining centers Boring machines Milling machines
3	Grease lubrication: 0.5×10^6	A high-speed matched pair angular contact ball bearing is used instead of the double-direction angular contact thrust ball bearing in Spindle 2. Contact angles of the high-speed pair-mounted angular contact ball bearings are 30° for ACT0DB and 40° for ACT0BDB.	CNC lathes Machining centers Milling machines
4	Grease lubrication: 0.7×10^6 Oil / air lubrication: 1.05×10^6	Both radial and axial loads are accepted by the angular contact ball bearing. This arrangement is superior to Spindle 3 in high-speed performance, but inferior in radial and axial rigidity.	CNC lathes Machining centers Milling machines
5	Grease lubrication: 0.85×10^6 Oil / air lubrication: 1.1×10^6	High-speed angular contact ball bearings are used in both the front and rear to provide greater high-speed performance. Factors such as thermal expansion should be taken into consideration for preload settings.	Boring machines Machining centers
6	Grease lubrication: 1.0×10^6 Oil / air lubrication: 1.45×10^6	Constant-pressure preloading is used to prevent increase in preload due to heat. This arrangement produces a lower rigidity than that produced by position preloading, but is superior in high-speed performance.	Grinding machines

5. Service life of bearings

5. 1 Rating life of bearings

When a bearing rotates under a load, the surfaces of the inner and outer ring raceways and the surfaces of the rolling elements are constantly subjected to repetitive loads. Even under proper operating conditions this results in scale-like damage (known as flaking) of the surfaces due to fatigue.

The total number of rotations before this damage occurs is known as "(fatigue) service life" of the bearing.

A substantial variation in "(fatigue) service life" occurs even if bearings of the same structure, dimensions, materials, machining method, etc. are operated under the same conditions.

This variation in fatigue, an intrinsic phenomenon to the material, should be examined statistically.

The total number of rotations at which 90% of the same type of bearings individually operated under the same conditions are free of damage caused by rolling fatigue (in other words, service life of 90% reliability), is referred to as "basic rating life of the bearing."

In some cases, however, bearings, when actually mounted and operated on a machine, may become inoperative due to causes other than damage by fatigue (wear, seizure, creep, fretting, brinelling, cracking, etc.).

By giving sufficient consideration to the selection of bearings, installation, lubrication, and the like, it is possible to avoid such causes.

5. 2 Service life calculation of bearings

5. 2. 1 Basic dynamic load ratings

The strength of a bearing against rolling fatigue—that is, the basic dynamic load rating representing the bearing load capacity—is the net radial load (in the case of a radial bearing) or central axial load (in the case of a thrust bearing) such that its magnitude and direction are constant and the bearing can attain a basic rating life of 1 million rotations under the condition that the inner ring rotates while the outer ring is stationary (or vice versa).

These are called "basic dynamic radial load rating (C_r)" or "basic dynamic axial load rating (C_a)," respectively. Values for these items are given in the bearing dimension tables.

5. 2. 2 Basic rating life

The relationship among the basic dynamic load rating, the dynamic equivalent load, and the basic rating life is expressed by equation (5. 1).

If a bearing is to be operated at a constant rotational speed, its service life is conveniently expressed in hours as determined by equation (5. 2).

(Total number of rotations)

$$L_{10}=\left(\frac{C}{P}\right)^{p} \quad \cdots\cdots (5.\ 1)$$

(Hours)

$$L_{10h}=\frac{10^{6}}{60n}\left(\frac{C}{P}\right)^{p} \quad \cdots\cdots (5.\ 2)$$

where,

L_{10}	:	basic rating life	10^6 rotations
L_{10h}	:	basic rating life	h
P	:	dynamic equivalent load	N
C	:	basic dynamic load rating	N
n	:	rotational speed	min^{-1}
p	:	$p=3$ for ball bearings $p=10/3$ for roller bearings	

When a bearing is operated with a dynamic equivalent load of P and a rotational speed of n, the basic dynamic load rating C of the bearing, which is suitable for meeting the design service life, is given by equation (5. 3). Thus the bearing dimensions are determined by selecting a bearing from the bearing dimension tables, which meets requirement C.

$$C=P\left(L_{10h}\times\frac{60n}{10^{6}}\right)^{1/p} \quad \cdots\cdots (5.\ 3)$$

[Reference] A method for determining the rating life of a bearing in a simplified method

A formula for determining service life, in which a service life coefficient (f_h) and speed coefficient (f_n) are applied in equation (5. 2), is shown below.

$$L_{10h}=500\ f_h^{\ p} \quad \cdots\cdots (5.\ 4)$$

Service life coefficient :

$$f_h=f_n\frac{C}{P} \quad \cdots\cdots (5.\ 5)$$

Speed coefficient :

$$f_n=\left(\frac{10^6}{500\times 60n}\right)^{1/p}$$

$$=(0.03n)^{-1/p} \quad \cdots\cdots (5.\ 6)$$

Values of f_n, f_h, and L_{10h} are approximated by the nomograms shown in **Fig. 5. 1**.

How to use nomograms

■ Operating conditions (example)

· Cylindrical roller bearing

NN3014K $C=96.9$ kN

· Rotational speed

$n=7\ 000\ \text{min}^{-1}$

· Dynamic equivalent load

$P=4.9$ kN

① Speed coefficient :

Since $n=7\ 000$

f_n reads: $f_n=0.2$

② Service life coefficient :

f_h is obtained as follows.

$$f_h=f_n\frac{C}{P}=0.2\times\frac{96.9}{4.9}=3.96$$

③ Rating life :

Since $f_h=3.96$,

L_{10h} is: $L_{10h}=49\ 000$

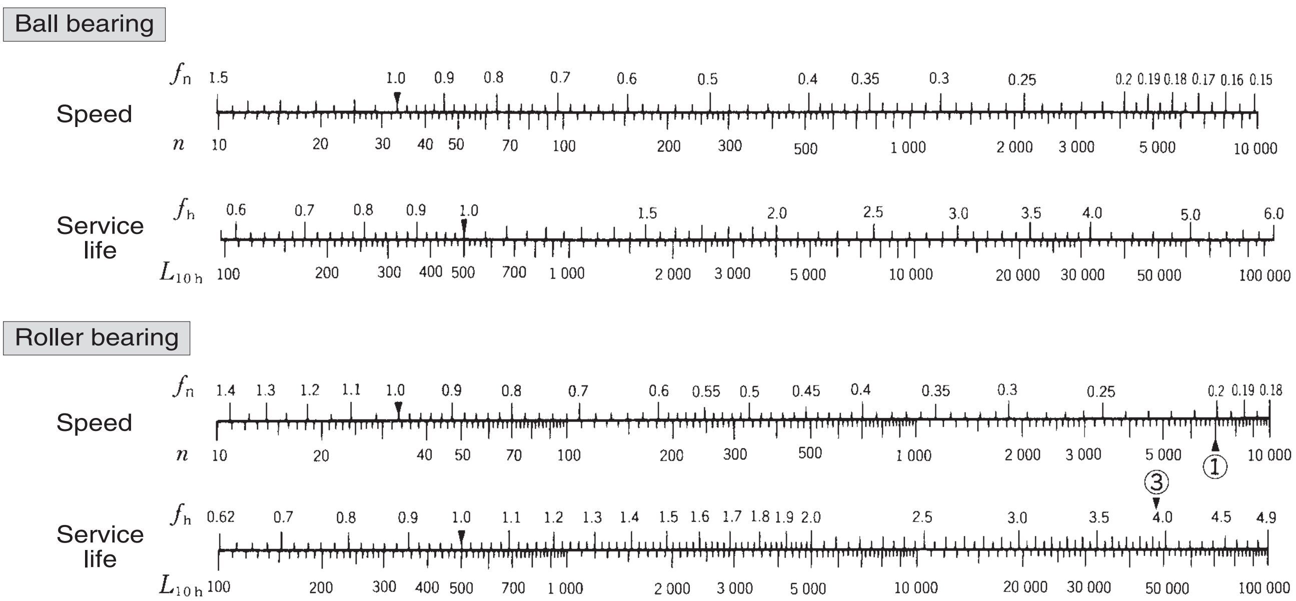


Fig. 5. 1 Rotational speed (n) vs. speed coefficient (f_n) and service life coefficient (f_h) vs. service life (L_{10h})

5. 2. 3 Modified rating life L_{nm}

The life of rolling bearings was standardized as a basic rating life in the 1960s, but in actual applications, sometimes the actual life and the basic rating life have been quite different due to the lubrication status and the influence of the usage environment. To make the calculated life closer to the actual life, a corrected rating life has been considered since the 1980s. In this corrected rating life, bearing characteristic factor a_2 (a correction factor for the case in which the characteristics related to the life are changed due to the bearing materials, manufacturing process, and design) and usage condition factor a_3 (a correction factor that takes into account usage conditions that have a direct influence on the bearing life, such as the lubrication) or factor a_{23} formed from the interdependence of these two factors, are considered with the basic rating life. These factors were handled differently by each bearing manufacturer, but they have been standardized as a modified rating life in **ISO 281** in 2007. In 2013, **JIS B 1518** (dynamic load ratings and rating life) was amended to conform to the ISO.

The basic rating life (L_{10}) shown in equation (5. 1) is the (fatigue) life with a dependability of 90% under normal usage conditions for rolling bearings that have standard factors such as internal design, materials, and manufacturing quality. **JIS B 1518**:2013 specifies a calculation method based on **ISO 281**:2007. To calculate accurate bearing life under a variety of operating conditions, it is necessary to consider elements such as the effect of changes in factors that can be anticipated when using different reliabilities and system approaches, and interactions between factors. Therefore, the specified calculation method considers additional stress due to the lubrication status, lubricant contamination, and fatigue load limit C_u (refer to **2)** b) on the inside of the bearing. The life that uses this life modification factor a_{ISO}, which considers the above factors, is called modified rating life L_{nm} and is calculated with the following equation (5. 7).

$$L_{nm} = a_1\, a_{ISO}\, L_{10} \quad \cdots\cdots\cdots\cdots\cdots\cdots (5.\ 7)$$

In this equation,

L_{nm} : Modified rating life — 10^6 rotations
(This rating life has been modified for one of or a combination of the following: reliability of 90% or higher, fatigue load limit, special bearing characteristics, lubrication contamination, and special operating conditions.)

L_{10} : Basic rating life — 10^6 rotations
(reliability: 90%)

a_1 : Life modification factor for reliability
……………………………refer to section **1)**

a_{ISO} : Life modification factor
……………………………refer to section **2)**

[Remark] When bearing dimensions are to be selected given L_{nm} greater than 90% in reliability, the strength of shaft and housing must be considered.

1) Life modification factor for reliability a_1

The term "reliability" is defined as "for a group of apparently identical rolling bearings, operating under the same conditions, the percentage of the group that is expected to attain or exceed a specified life" in **ISO 281**:2007. Values of a_1 used to calculate a modified rating life with a reliability of 90% or higher (a failure probability of 10% or less) are shown in **Table 5. 1**.

Table 5. 1 Life modification factor for reliability a_1

Reliability, %	L_{nm}	a_1
90	L_{10m}	1
95	L_{5m}	0.64
96	L_{4m}	0.55
97	L_{3m}	0.47
98	L_{2m}	0.37
99	L_{1m}	0.25
99.2	$L_{0.8m}$	0.22
99.4	$L_{0.6m}$	0.19
99.6	$L_{0.4m}$	0.16
99.8	$L_{0.2m}$	0.12
99.9	$L_{0.1m}$	0.093
99.92	$L_{0.08m}$	0.087
99.94	$L_{0.06m}$	0.080
99.95	$L_{0.05m}$	0.077

(**Table 5. 1** Citation from **JIS B 1518**:2013)

2) Life modification factor a_{ISO}

a) System approach

The various influences on bearing life are dependent on each other. The system approach of calculating the modified life has been evaluated as a practical method for determining life modification factor a_{ISO} (ref. **Fig. 5. 2**). Life modification factor a_{ISO} is calculated with the following equation. A diagram is available for each bearing type (radial ball bearings, radial roller bearings, thrust ball bearings, and thrust roller bearings). (Each diagram (**Figs. 5. 3** to **5. 6**) is a citation from **JIS B 1518**:2013.)

Note that in practical use, this is set so that life modification factor $a_{ISO} \leqq 50$.

$$a_{ISO} = f\left(\frac{e_c C_u}{P},\ \kappa\right) \quad \cdots\cdots\cdots\cdots\cdots (5.\ 8)$$

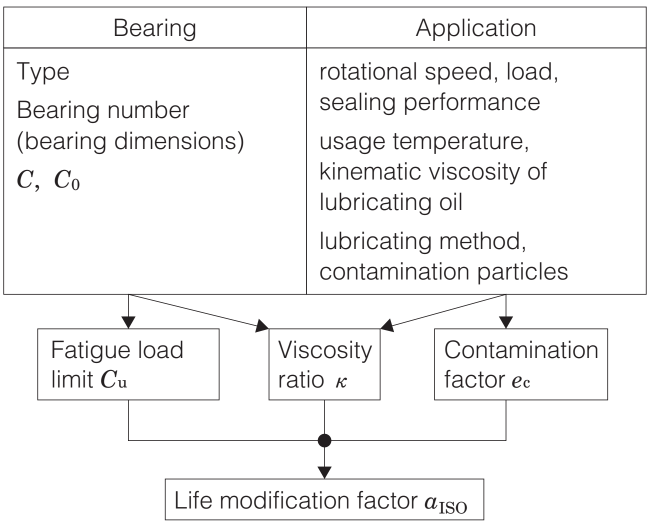


Fig. 5. 2 System approach

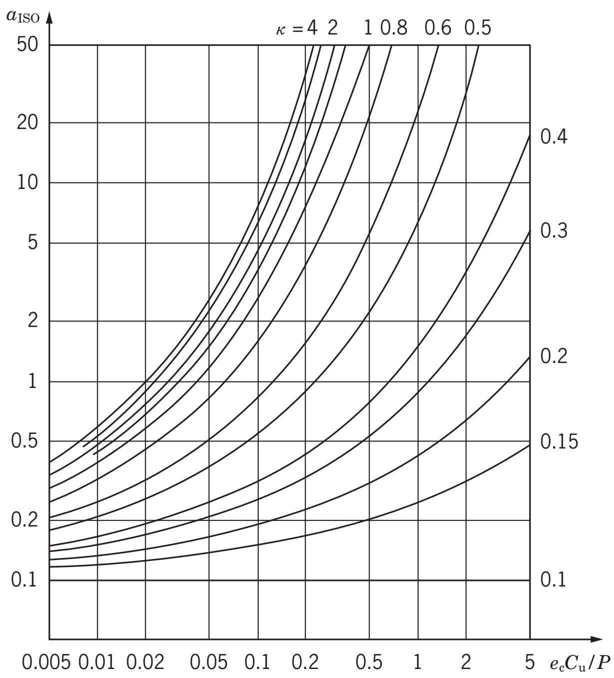


Fig. 5. 3 Life modification factor a_{ISO} (Radial ball bearings)

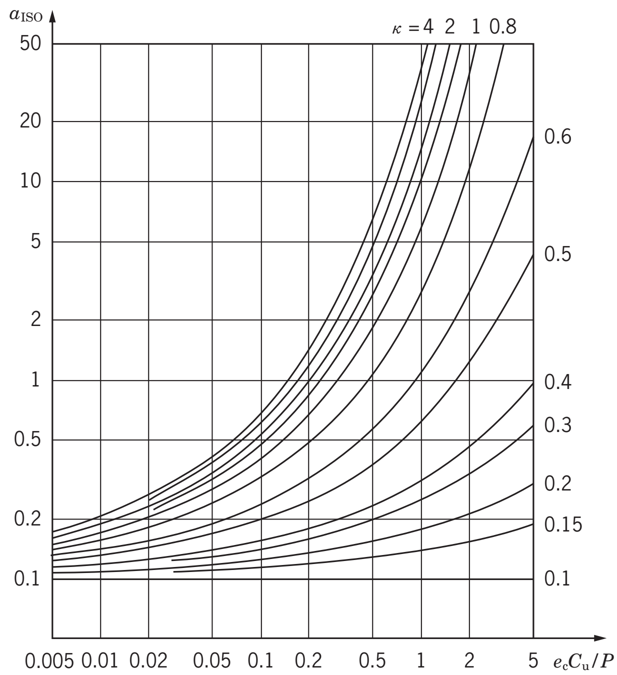


Fig. 5. 4 Life modification factor a_{ISO} (Radial roller bearings)

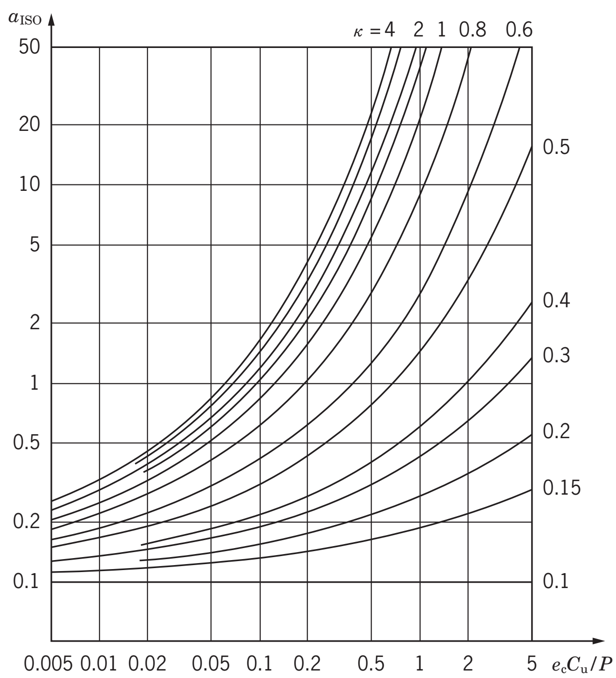


Fig. 5. 5 Life modification factor a_{ISO} (Thrust ball bearings)

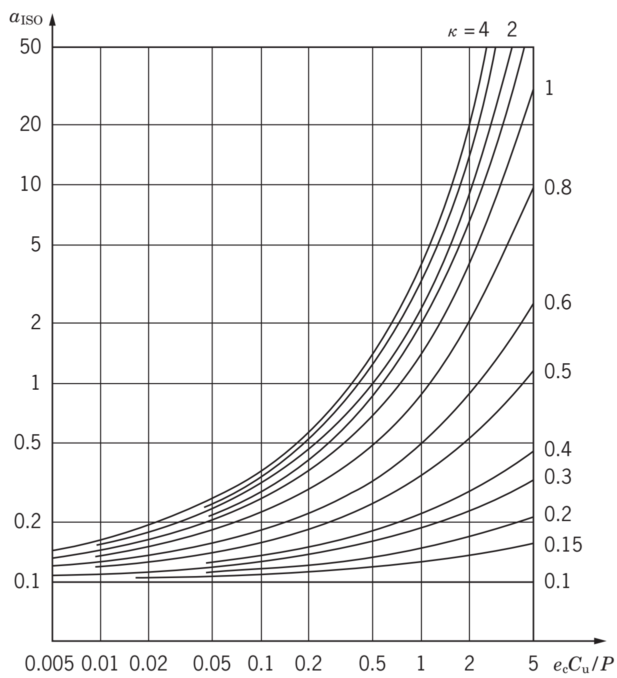


Fig. 5. 6 Life modification factor a_{ISO} (Thrust roller bearings)

(**Figs. 5. 3** to **5. 6** Citation from **JIS B 1518**:2013)

b) Fatigue load limit C_u

For regulated steel materials or alloy steel that has equivalent quality, the fatigue life is unlimited so long as the load condition does not exceed a certain value and so long as the lubrication conditions, lubrication cleanliness class, and other operating conditions are favorable. For general high-quality materials and bearings with high manufacturing quality, the fatigue stress limit is reached at a contact stress of approximately 1.5 GPa between the raceway and rolling elements. If one or both of the material quality and manufacturing quality are low, the fatigue stress limit will also be low.

The term "fatigue load limit" C_u is defined as "bearing load under which the fatigue stress limit is just reached in the most heavily loaded raceway contact" in **ISO 281**:2007. and is affected by factors such as the bearing type, size, and material.

For details on the fatigue load limits of special bearings and other bearings not listed in this catalog, contact JTEKT.

c) Contamination factor e_c

If solid particles in the contaminated lubricant are caught between the raceway and the rolling elements, indentations may form on one or both of the raceway and the rolling elements. These indentations will lead to localized increases in stress, which will decrease the life. This decrease in life attributable to the contamination of the lubricant can be calculated from the contamination level as contamination factor e_c.

D_{pw} shown in this table is the pitch diameter of ball/roller set, which is expressed simply as $D_{pw}=(D+d)/2$. (D: Outside diameter, d: Bore diameter)

For information such as details on special lubricating conditions or detailed investigations, contact JTEKT.

Table 5. 2 Values of contamination factor e_c

Contamination level	e_c	
	D_{pw}<100 mm	D_{pw}≧100 mm
Extremely high cleanliness: The size of the particles is approximately equal to the thickness of the lubricant oil film, this is found in laboratory-level environments.	1	1
High cleanliness: The oil has been filtered by an extremely fine filter, this is found with standard grease-packed bearings and sealed bearings.	0.8 to 0.6	0.9 to 0.8
Standard cleanliness: The oil has been filtered by a fine filter, this is found with standard grease-packed bearings and shielded bearings.	0.6 to 0.5	0.8 to 0.6
Minimal contamination: The lubricant is slightly contaminated.	0.5 to 0.3	0.6 to 0.4
Normal contamination: This is found when no seal is used and a coarse filter is used in an environment in which wear debris and particles from the surrounding area penetrate into the lubricant.	0.3 to 0.1	0.4 to 0.2
High contamination: This is found when the surrounding environment is considerably contaminated and the bearing sealing is insufficient.	0.1 to 0	0.1 to 0
Extremely high contamination	0	0

(**Table 5. 2** Citation from **JIS B 1518**:2013)

d) Viscosity ratio κ

The lubricant forms an oil film on the roller contact surface, which separates the raceway and the rolling elements. The status of the lubricant oil film is expressed by viscosity ratio κ, the actual kinematic viscosity at the operating temperature ν divided by the reference kinematic viscosity ν_1 as shown in the following equation.

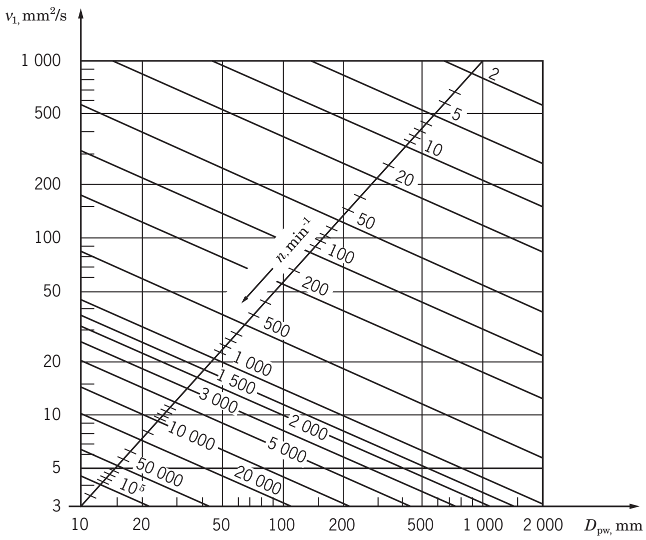
A κ greater than 4, equal to 4, or less than 0.1 is not applicable.

For details on lubricants such as grease and lubricants with extreme pressure additives, contact JTEKT.

$$\kappa = \frac{\nu}{\nu_1} \quad \cdots\cdots(5.\ 9)$$

ν : Actual kinematic viscosity at the operating temperature; the viscosity of the lubricant at the operating temperature

ν_1 : Reference kinematic viscosity; determined according to the speed and pitch diameter of ball/roller set D_{pw} of the bearing (ref. **Fig. 5. 7**)



(**Fig. 5. 7** Citation from **JIS B 1518**:2013)

Fig. 5. 7 Reference kinematic viscosity ν_1

5. 2. 4 Service life of bearing system comprising two or more bearings

Even for systems which comprise two or more bearings, if one bearing is damaged, the entire system malfunctions.

Where all bearings used in an application are regarded as one system, the service life of the bearing system can be calculated using the following equation.

$$\frac{1}{L^e} = \frac{1}{L_1^{\,e}} + \frac{1}{L_2^{\,e}} + \frac{1}{L_3^{\,e}} + \cdots\cdots\cdots\cdots\cdots\cdots \quad (5.\ 10)$$

where :

L : rating life of system

L_1 , L_2 , L_3 … : rating life of each bearing

e: constant
- e=10/9 ……ball bearing
- e= 9/8 ……roller bearing
- The mean value is for a system using both ball and roller bearings.

[Example]

When a shaft is supported by two roller bearings whose service lives are 50 000 hours and 30 000 hours respectively, the rating life of the bearing system supporting this shaft is calculated as follows, using equation (5. 10) :

$$\frac{1}{L^{9/8}} = \frac{1}{50\ 000^{9/8}} + \frac{1}{30\ 000^{9/8}}$$

$L \fallingdotseq 20\ 000$ h

The equation suggests that the rating life of these bearings as a system becomes shorter than that of the bearing with the shorter life.

This fact is very important in estimating bearing service life for applications using two or more bearings.

5. 3 Dynamic equivalent loads

Bearings are used under different conditions. For example, they are often subjected to a resultant load consisting of radial and axial loads, the magnitudes of which may vary.

Consequently, it is not possible to directly compare the actual load that a bearing receives and the basic dynamic load rating.

In such a case, a calculation is carried out for comparison and examination, in which a load having a constant magnitude and direction, is applied to the bearing center such that it would make the service life of the bearing the same as that resulting from the actual load and rotational speed.

This theoretical load is known as the dynamic equivalent load (P).

5. 3. 1 Calculation of dynamic equivalent load

The dynamic equivalent loads of a radial bearing and a thrust bearing ($\alpha \neq 90°$) receiving a resultant load constant in magnitude and direction is obtained as illustrated below.

$$P = XF_r + YF_a \quad \cdots\cdots (5.\ 11)$$

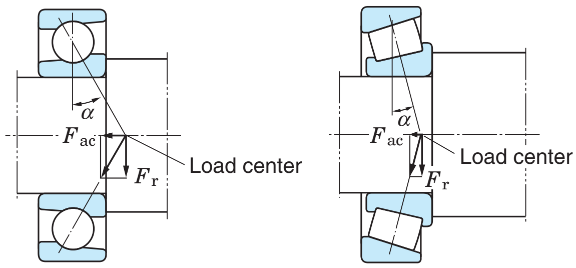
where,

- P : dynamic equivalent load N
  (For radial bearings, "P_r : dynamic equivalent radial load" and for thrust bearings, "P_a : dynamic equivalent axial load," respectively, are used.)
- F_r : radial load N
- F_a : axial load N
- X : radial load coefficient
- Y : axial load coefficient
  (Values of X and Y are noted in the bearing dimension tables.)

1) If $F_a/F_r \leq e$ for a single row radial bearing, $X=1$ and $Y=0$ are used.
Hence, the dynamic equivalent load will be $P_r = F_r$.
(e denotes the limit of F_a/F_r, whose values are listed in the bearing dimension tables.)

2) Application of a radial load to a single row angular contact ball bearing, or tapered roller bearing, produces a component of force (F_{ac}) in the axial direction (**Fig. 5. 8**).
Therefore, a pair of bearings are usually used to arrange face-to-face or back-to-back.
The component of force in the axial direction is determined by the following equation.

$$F_{ac} = \frac{F_r}{2Y} \quad \cdots\cdots (5.\ 12)$$

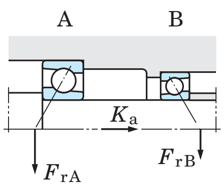
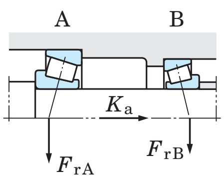
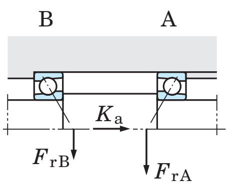
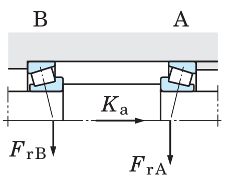
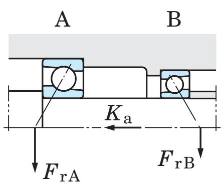
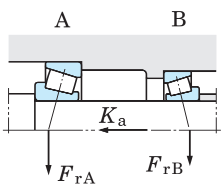
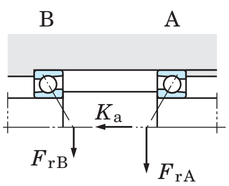
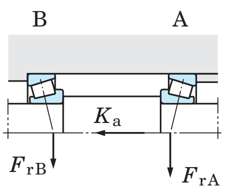


(Dimensions representing the position of load center are noted in the bearing dimension tables.)

Fig. 5. 8 Components of force in axial direction

Table 5. 3 (page 25) shows ways of determining the dynamic equivalent load where a radial load and external axial load (K_a) are applied to these bearings.

Table 5. 3 Calculations of dynamic equivalent loads for two opposing single row angular contact ball bearings or tapered roller bearings

Bearing arrangement		Loading condition	Bearing	Axial load	Dynamic equivalent load
Back-to-back	Face-to-face				
 	 	$\frac{F_{rB}}{2Y_B} + K_a \geqq \frac{F_{rA}}{2Y_A}$	Bearing A	$\frac{F_{rB}}{2Y_B} + K_a$	$P_A = XF_{rA} + Y_A\left(\frac{F_{rB}}{2Y_B} + K_a\right)$ Note that $P_A = F_{rA}$ if $P_A < F_{rA}$
			Bearing B	—	$P_B = F_{rB}$
		$\frac{F_{rB}}{2Y_B} + K_a < \frac{F_{rA}}{2Y_A}$	Bearing A	—	$P_A = F_{rA}$
			Bearing B	$\frac{F_{rA}}{2Y_A} - K_a$	$P_B = XF_{rB} + Y_B\left(\frac{F_{rA}}{2Y_A} - K_a\right)$ Note that $P_B = F_{rB}$ if $P_B < F_{rB}$
 	 	$\frac{F_{rB}}{2Y_B} \leqq \frac{F_{rA}}{2Y_A} + K_a$	Bearing A	—	$P_A = F_{rA}$
			Bearing B	$\frac{F_{rA}}{2Y_A} + K_a$	$P_B = XF_{rB} + Y_B\left(\frac{F_{rA}}{2Y_A} + K_a\right)$ Note that $P_B = F_{rB}$ if $P_B < F_{rB}$
		$\frac{F_{rB}}{2Y_B} > \frac{F_{rA}}{2Y_A} + K_a$	Bearing A	$\frac{F_{rB}}{2Y_B} - K_a$	$P_A = XF_{rA} + Y_A\left(\frac{F_{rB}}{2Y_B} - K_a\right)$ Note that $P_A = F_{rA}$ if $P_A < F_{rA}$
			Bearing B	—	$P_B = F_{rB}$

[Remarks] 1. These calculations are applicable where during operation the internal clearance and preload are 0 (zero).
2. Radial loads are assumed to be positive even if they are applied in the opposite direction of the arrows shown above.

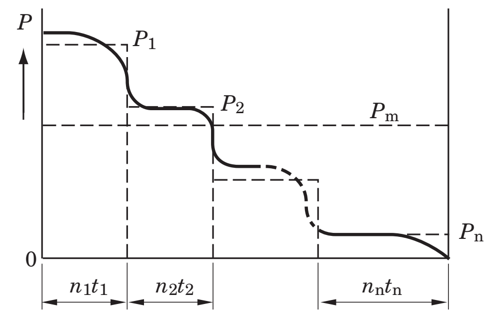
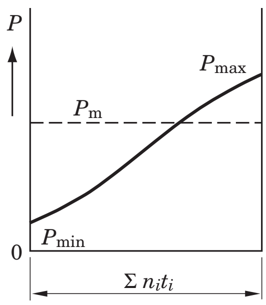
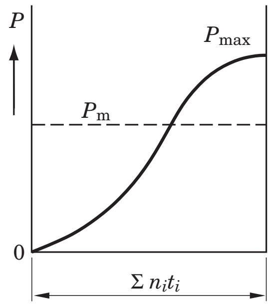
5. 3. 2 Mean dynamic equivalent loads for variable loads

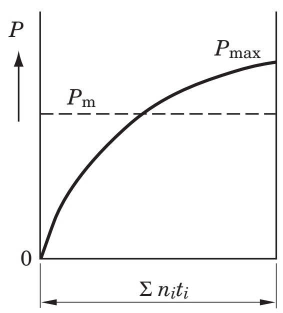
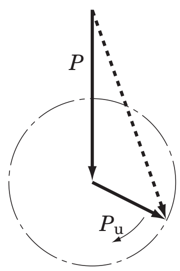
When a load, applied to a bearing, varies in magnitude and direction, it is necessary to obtain a mean dynamic equivalent load that may result in the same service life as would result under actual variation conditions.

Ways of determining the mean dynamic equivalent load P_m suitable for different variation conditions are shown in **Table 5. 4**, **(1)** to **(4)**.

In the case when a stationary load and a rotational load are applied simultaneously, as shown in **(5)**, the mean dynamic equivalent load is given by equation (5. 17).

Table 5. 4 Ways of determining mean dynamic equivalent loads from variable loads

(1) Stepwise variation	(2) Simple variation	(3) Sine like curve variation
		
$P_m = \sqrt[p]{\dfrac{P_1^p n_1 t_1 + P_2^p n_2 t_2 + \cdots\cdots + P_n^p n_n t_n}{n_1 t_1 + n_2 t_2 + \cdots\cdots + n_n t_n}}$ ...... (5. 13)	$P_m = \dfrac{P_{min} + 2P_{max}}{3}$ ...... (5. 14)	$P_m = 0.68 P_{max}$ ...... (5. 15)

(4) Sine like curve variation (Upper portion of a sine curve)	(5) Stationary and rotational loads being applied at the same time
	
$P_m = 0.75 P_{max}$ ...... (5. 16)	$P_m = f_m (P + P_u)$ ...... (5. 17)

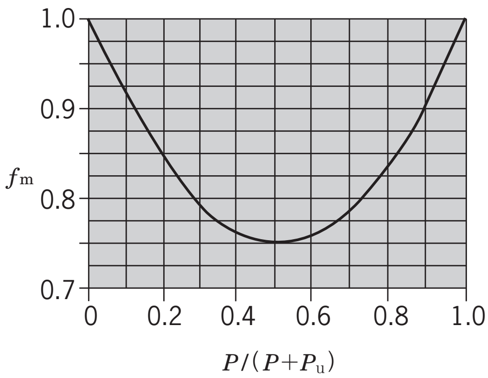


Fig. 5. 9 f_m Coefficient

· In **(1)** to **(4)** in **Table 5. 4**:

P_m : mean dynamic equivalent load N
P_1 : dynamic equivalent load applied at a rotational speed of n_1 for t_1 hours N
P_2 : dynamic equivalent load applied at a rotational speed of n_2 for t_2 hours N
⋮
P_n : dynamic equivalent load applied at a rotational speed of n_n for t_n hours N
P_{min} : minimum dynamic equivalent load N
P_{max} : maximum dynamic equivalent load N
$\Sigma n_i t_i$: total number of rotations in a period from t_1 to t_i
p : $p=3$ for ball bearings
$p=10/3$ for roller bearings

(Reference) The mean rotational speed n_m is obtained by the following equation.

$$n_m=\frac{n_1t_1+n_2t_2+\cdots\cdots+n_nt_n}{t_1+t_2+\cdots\cdots+t_n}$$

· In **(5)** in **Table 5. 4**:

P_m : mean dynamic equivalent load N
f_m : coefficient (see **Fig. 5. 9**)
P : stationary load N
P_u : rotational load N

5. 4 Basic static load rating and static equivalent load

5. 4. 1 Basic static load rating

Excessive static load or impact load even at very low rotation causes partial permanent deformation of the rolling element and raceway contacting surfaces. This permanent deformation increases with the load; if it exceeds a certain limit, smooth rotation will be hindered.

The basic static load rating is the static load which responds to the calculated contact stress shown below, at the contact center between the raceway and rolling elements which receive the maximum load.

· Self-aligning ball bearings ··· 4 600 MPa
· Other ball bearings ··············· 4 200 MPa
· Roller bearings ······················ 4 000 MPa

The total extent of contact stress-caused permanent deformation on surfaces of rolling elements and raceway will be approximately 0.000 1 times greater than the rolling element diameter.

The basic static load rating for radial bearings is specified as the basic static radial load rating, and for thrust bearings, as the basic static axial load rating. These load ratings are listed in the bearing specification table, using C_{0r} and C_{0a} respectively.

These values are prescribed by ISO 78/1987 and are subject to change by conformance to the latest ISO standards.

5. 4. 2 Static equivalent load

The static equivalent load is a theoretical load calculated such that, during rotation at very low speed or when bearings are stationary, the same contact stress as that imposed under actual loading condition is generated at the contact center between raceway and rolling element to which the maximum load is applied.

For radial bearings, radial load passing through the bearing center is used for the calculation; for thrust bearings, axial load in a direction along the bearing axis is used.

The static equivalent load can be calculated using the following equations.

[Radial bearings]

···The greater value obtained by the following two equations is used.

$P_{0r}=X_0F_r+Y_0F_a$ ······························ (5. 18)
$P_{0r}=F_r$ ··· (5. 19)

[Thrust bearings]

($\alpha\neq90°$)
$P_{0a}=X_0F_r+F_a$ ································· (5. 20)
[When $F_a<X_0F_r$, the solution becomes less accurate.]

($\alpha=90°$)
$P_{0a}=F_a$ ··· (5. 21)

where,

P_{0r} : static equivalent radial load N
P_{0a} : static equivalent axial load N
F_r : radial load N
F_a : axial load N
X_0 : static radial load factor
Y_0 : static axial load factor
(values of X_0 and Y_0 are listed in the bearing specification table.)

5. 4. 3 Safety coefficient

The allowable static equivalent load for a bearing is determined by the basic static load rating of the bearing; however, bearing service life, which is affected by permanent deformation, differs in accordance with the performance required of the bearing and operating conditions.

Therefore, a safety coefficient is designated, based on empirical data, so as to ensure safety in relation to basic static load rating.

$$f_s = \frac{C_0}{P_0} \quad \cdots\cdots (5.\ 22)$$

where,

f_s : safety coefficient (ref. **Table 5. 5**)
C_0 : basic static load rating N
P_0 : static equivalent load N

Table 5. 5 Values of safety coefficient f_s

Operating condition		f_s (min.) Ball bearing	f_s (min.) Roller bearing
With bearing rotation	When high accuracy is required	2	3
	Normal operation	1	1.5
	When impact load is applied	1.5	3
Without bearing rotation (occasional oscillation)	Normal operation	0.5	1
	When impact load or uneven distribution load is applied	1	2

[Remark] For spherical thrust roller bearings, $f_s \geqq 4$.

5. 5 Service life of greases

The previous section explained the fatigue service life of bearings. Spindle bearings for machine tools, however, rarely have a problem of bearing service life caused by load.

When grease lubrication is used, ineffective lubrication may occasionally occur, resulting in bearing failures. It is therefore necessary to give sufficient consideration to selecting the brand and the amount of grease to be used, for given operating conditions.

Refer to "**8. Lubrication of bearings**" for grease lubrication.

5. 6 Permissible axial loads

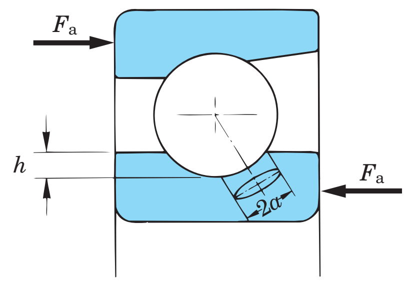
A large axial load may be applied to the bearings for main shafts of machine tools when, for example, tools are changed.

Application of a large axial load to an angular contact ball bearing may cause the contact ellipse formed between the ball and raceway surface to deviate beyond the raceway surface (see **Fig. 5. 10**).

Furthermore, if the stress becomes excessive, the rolling elements and raceway surface may sustain permanent deformation (nicks), possibly resulting in increased runout or vibration.

The smaller one of the following values is defined as the permissible axial load (static). And the permissible axial load (static) for each bearing is shown in the dimension list of the bearings.

- The load generated when the end of the contact ellipse formed between the ball and the raceway reaches the shoulder of the inner or outer ring.
- The load generated when the pressure of the contact surface between the ball and the raceway reaches the standard value calculated based on the actual results.



where,

h : bearing shoulder height
a : half length of the contact ellipses' major axis
F_a : axial load

Fig. 5. 10 Contact ellipse

6. Rigidity and preload of bearings

6. 1 Rigidity of bearings

The rigidity of a bearing has a considerable influence on the rigidity of the spindle of the machine tool. The rigidity of a bearing can be improved by the following methods.

① Roller bearings, in which line contact is made between the raceway surface and the rolling element, are used when a high radial rigidity is required.

② In the case where high axial rigidity is required, stack mounting angular contact ball bearings, are generally used.
Furthermore, bearings with a large contact angle are used.

③ For high-speed and high-rigidity requirements, it is effective to reduce the diameter and increase the number of rolling elements.
It is also possible to improve the rigidity of a bearing by using ceramics (silicon nitride) for the rolling elements which is superior in Young's modulus.
Bearings having ceramic rolling elements also offer improved high-speed performance since their density is lower than that of bearing steel, yielding a small centrifugal force even under high-speed rotation.

④ Apply a preload to the bearing.

6. 2 Preload of bearings

Preloading means setting the inner clearance to be a negative value and loading the bearing after mounting it.

In case of the angular contact ball bearing and tapered roller bearing, an axial load is applied when preloading. And in case of the cylindrical roller bearing, a radial load is applied when preloading.

6. 2. 1 Objective of preload

- To improve rigidity
- To improve the positioning accuracy in the radial and axial directions, and to improve the running accuracy as well, by minimizing the runout of the shaft
- To reduce smearing by controlling whirl slip, orbital slip, and rotational slip of rolling elements in high-speed rotations
- To prevent noise caused by vibration and resonance

6. 2. 2 Methods for preloading

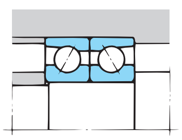
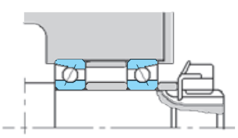
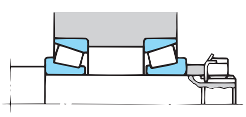
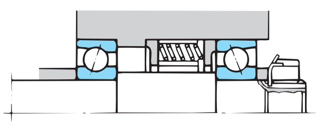
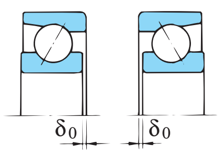
There are two major methods for preloading the angular contact ball bearing and tapered roller bearing; position preloading and constant-pressure preloading.

In the position preloading method, the bearing and spacer, whose dimensions are adjusted to the specified values beforehand, are used. In the constant-pressure preloading method, coil springs or disk springs are used to preload the bearing.

Usage examples and comparison of these methods are shown in **Fig. 6. 1**.

Also, these preloading methods can be switched over when rotating, and the amount of the preload (load) can be gradually changed in accordance with the speed of the rotation.

Table 6. 1 Methods for preloading

Position preloading			Constant-pressure preloading
When applying the same preload, the displacement to load is smaller and the rigidity is higher than when using the constant-pressure preloading method. When rotating at high speed, the use of this method is limited because the preload amount varies depending on the mounting conditions, centrifugal force and temperature rise.			This method is applicable when rotating at high speed because there is less preload variation when rotating than when using the position preloading method, and almost constant preload can be maintained. However, the improvement of the rigidity of the shaft is not as good as when using the position preloading method.
			
① A method using matched pair bearings with the preload adjusted. 	② A method using a spacer of preadjusted size.	③ A method using a nut or bolt capable of adjusting the amount of preload in the axial direction. (In this case, confirm that the appropriate preload is applied while measuring the starting torque, etc. This method is not suitable for conditions which require high precision, because the bearing tends to tilt easily. In these conditions, methods 1) and 2) are recommended.)	A method using coil springs or disk springs to apply preload. When using the coil springs, place them on the circumference at regular intervals so that the pressure is applied equally.

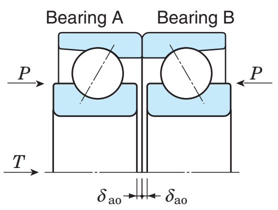
6. 2. 3 Preload and axial rigidity

Fig. 6. 1 shows the relationship between preload (position preload) and rigidity, namely, axial displacement of a back-to-back arrangement bearing.

Applying a preload P (by tightening the inner ring in the axial direction), as shown in **Fig. 6. 1**, results in bearings A and B respectively being displaced by δ_{ao}. The clearance between the inner rings $2\delta_{ao}$ will then become 0 (zero).

When an external axial load T is applied to these bearings, their resultant displacement as a pair-mounted bearing set can be obtained as δ_a.

- P : amount of preload
- T : external axial load
- T_A : axial load applied to bearing A
- T_B : axial load applied to bearing B
- δ_a : displacement of pair-mounted bearing set
- δ_{aA} : displacement of bearing A
- δ_{aB} : displacement of bearing B
- $2\delta_{aO}$: clearance between inner rings before applying preload



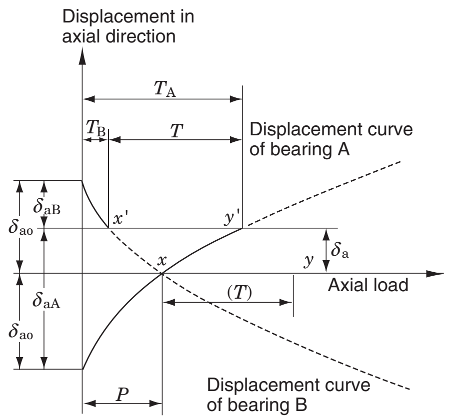


Fig. 6. 1 Preload diagram for position preloading

[Reference] How to determine δ_a in Fig. 6. 1

① Obtain the displacement curve of bearing A.

② Obtain the displacement curve of bearing B: this is the curve symmetrical with respect to the transverse axis and the intersection x at the preload P.

③ Assuming an external load T, obtain a line x–y on the transverse axis passing through x. By parallel displacement of line x–y along the displacement curve of bearing B, the intersection y' passing through the displacement curve of bearing A is obtained.

④ δ_a is determined as the distance between the lines x'–y' and x–y.

Fig. 6. 2 shows the relationship between preload and rigidity when a constant-pressure preload is applied to the same pair-mounted bearing as shown in **Fig. 6. 1**.

Since the rigidity of the spring is negligible in this case, the rigidity of the bearing is approximately equal to that of a single bearing given a preload P.

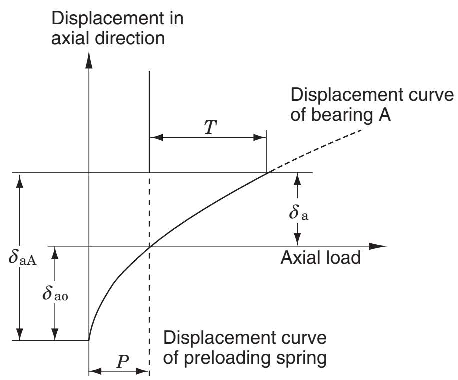


Fig. 6. 2 Preload diagram of constant-pressure preloading

Comparison of axial rigidity of the position preloading and the constant-pressure preloading is shown in **Fig. 6. 3**.

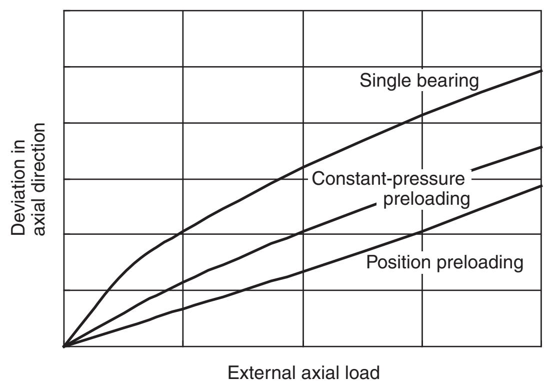


Fig. 6. 3 Comparison of axial rigidity

6. 2. 4 Amount of preload

If the amount of preload to the bearing is increased, the rigidity is improved.

However, as the load is applied to the bearing, the life may become shorter and abnormal heat may be generated, resulting in serious failure, including early damage, seizure, etc.

Also, in case of position preloading, the amount of preload varies depending on the mounting conditions, including fitting of the bearing, the centrifugal force generated during the operation and the temperature rise.

6. 2. 5 Variation of position preloading due to fitting and rotation

1) Preload in mounting the bearing

The angular contact ball bearing is shown as a model in **Fig. 6. 4a**.

In case of the bearing for the main shaft of a machine tool, for which the inner ring is usually rotated, the interference fit is employed for the inner ring, and the clearance fit is employed for the outer ring. However, the diameter of the inner ring raceway will expand due to interference, and the axial clearance changes as shown in **Fig. 6. 4b**, resulting in the increase in the amount of preload.

Furthermore, if the inner ring is tightened by the shaft nut, etc., the width of the inner ring and the spacer will shrink, resulting in increase in preload.

This is the preload generated when the bearing is mounted.

2) Change of preload during rotation

During rotation, the preload is changed by centrifugal force and temperature rise.

When rotating, the inner ring is affected by the centrifugal force and the raceway expands. Due to this expansion, the preload increases as shown in **Fig. 6. 4c**.

Influence of temperature rise is described below.

When rotating, the temperature of the bearing increases and the components expand because of rotation resistance, stirring resistance generated by the lubricant, and other external factors.

The temperature increase of the inner ring and the rolling elements is larger than that of the outer ring, which radiates heat easily. Therefore, the internal clearance changes because of the expansion as shown in **Fig. 6. 4d**, and the preload is increased.

Also, the temperature difference is generated between the outer ring and the housing, and the outer ring becomes hotter than the housing, reducing the clearance of the fitting surface of the outer ring. If the clearance of the fitting surface of the outer ring is too small, the fitting of the outer ring becomes interference fitting because of the temperature difference, and the internal clearance changes due to the shrinkage of the raceway of the outer ring, increasing the preload as shown in **Fig. 6. 4e**.

As a result, it is also important to take into consideration the case where the housing cools off excessively.

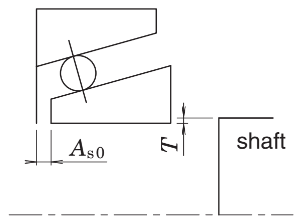


Fig. 6. 4a Bearing before mounting

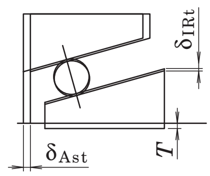


Fig. 6. 4b Change of dimension due to inner ring interference

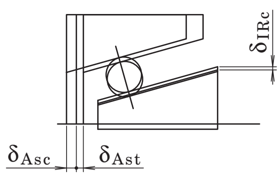


Fig. 6. 4c Change of dimension due to centrifugal expansion of inner ring raceway

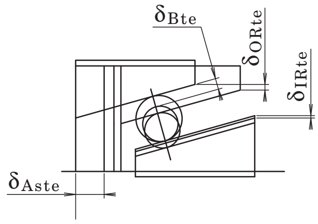


Fig. 6. 4d Change of dimension due to heat expansion

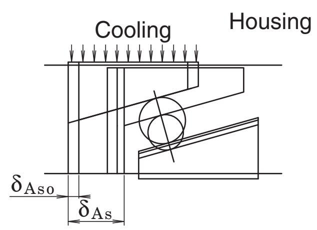


Fig. 6. 4e Change of dimension due to shrinkage of outer ring raceway

A_{s0} : initial stand-out value (The sum of the stand-out value of a pair of bearings is the size of the clearance for which the preload is provided.)
T : interference of inner ring
δ_{IRt} : expansion of inner ring raceway due to inner ring interference
δ_{Ast} : change of bearing stand-out value due to inner ring interference
δ_{IRc} : centrifugal expansion of inner ring raceway
δ_{Asc} : change of bearing stand-out value due to centrifugal expansion of inner ring raceway
δ_{IRte} : heat expansion of inner ring raceway
δ_{ORte} : heat expansion of outer ring raceway
δ_{Bte} : heat expansion of rolling element
δ_{Aste} : change of bearing stand-out value due to temperature rise of each component
δ_{Aso} : change of bearing stand-out value due to shrinkage of outer ring raceway
δ_{As} : total of change of stand-out value due to mounting conditions and rotation

6. 2. 6 Selecting preload and fitting

To maintain the initial performance of the bearing and use it in stable condition, it is necessary to select an ideal preloading method and preload amount considering the use conditions as well as the mounting conditions.

Especially, when using the bearing at high speed, it is indispensable to select an ideal preload, taking into consideration the preload change, the pressure between the raceway and the rolling elements generated by centrifugal force, and the factors which cause spin slide of the angular contact ball bearing.

The standard preload amount of each bearing is shown in the table of bearing dimensions. Also, the interferences of the bearings for main shafts in standard use condition are shown in **Figs. 6. 2** and **6. 3**.

Consult JTEKT for detailed information about preloads and fittings when using the bearings at high speed with value $d_m n$ set at 80×10^4 or more or with a heavy load of $C_r/P_r < 13$.

Table 6. 2 Shaft fits (in the case of a rotating inner ring)

Bearing type		Shaft diameter (mm) over	Shaft diameter (mm) up to	Tolerance class of bearing and fits: Class 5 – Tolerance class of shaft or dimensional tolerance of shaft diameter (µm)	Class 5 – Target interference (µm)	Classes 4, 2 – Tolerance class of shaft or dimensional tolerance of shaft diameter (µm)	Classes 4, 2 – Target interference (µm)
Angular contact ball bearings	General	All shaft diameter		js 5	—	js 4	—
	Amount of preload preset for matched pair bearings	6	10	0 −4	0~2	0 −2.5	0~2
		10	18	+1 −4	0~2	0 −3	0~2
		18	30	+1 −5	0~2.5	+1 −3	0~2.5
		30	50	+1 −6	0~3.5	+1 −4	0~3.5
		50	80	+2 −6	0~4	+1 −4	0~4
		80	120	+3 −7	0~4.5	+2 −4	0~4.5
		120	180	+4 −8	0~5	+2 −6	0~5
		180	250	+5 −9	0~6	+3 −6	0~6
Cylindrical roller bearings (cylindrical bored in inner ring)		25	40	js 4	—	js 3	—
		40	140	k 4	—	k 3	—
		140	200	m 5	—	m 4	—
		200	400	n 5	—	n 4	—
Double-direction angular contact thrust ball bearings High-speed matched pair angular contact ball bearings Support bearings for precision ball screws		All shaft diameter		h 5	—	h 4	—
Tapered roller bearings (metric series)		25	40	js 5	—	—	
		40	140	k 5	—		
		140	200	m 5	—		

[Remark] Consult **JTEKT** for specific operating conditions (high-speed rotation, rotating outer ring, heavy load, etc.).

Table 6. 3 Housing fits (in the case of a rotating inner ring)

Bearing type		Housing bore diameter (mm) over	up to	Bearing on fixed side — Tolerance class of bearing and fits — Class 5: Tolerance class of housing bore	Class 5: Target clearance (µm)	Classes 4, 2: Tolerance class of housing bore	Classes 4, 2: Target clearance (µm)	Bearing on free side — Tolerance class of bearing and fits — Class 5: Tolerance class of housing bore	Class 5: Target clearance (µm)	Classes 4, 2: Tolerance class of housing bore	Classes 4, 2: Target clearance (µm)
Angular contact ball bearings	General	All housing bore diameter		JS 5	—	JS 4	—	H 5	—	H 4	—

Bearing type		Housing bore diameter (mm) over	up to	(Bearing on fixed side) (Tolerance class of bearing and fits) Classes 5, 4, 2: Dimensional tolerance of housing bore (µm)	Target clearance (µm)	(Bearing on free side) (Tolerance class of bearing and fits) Classes 5, 4, 2: Dimensional tolerance of housing bore (µm)	Target clearance (µm)
Angular contact ball bearings	Amount of preload preset for matched pair bearings	18	30	±4.5	0～4	+9 / 0	6～10
		30	50	±5.5	0～4	+11 / 0	7～11
		50	80	±6.5	0～5	+13 / 0	8～13
		80	120	±7.5	0～5	+15 / 0	10～15
		120	180	±9	0～6	+18 / 0	13～19
		180	250	±10	0～7	+20 / 0	17～24
		250	315	±11.5	0～7	+23 / 0	22～29
		315	400	±12.5	0～8	+25 / 0	26～33

(Bearing type)	Housing bore diameter (mm) over / up to	Fixed side Class 5: Tolerance class of housing bore	Class 5: Target clearance (µm)	Fixed side Classes 4, 2: Tolerance class of housing bore	Classes 4, 2: Target clearance (µm)	Free side Class 5: Tolerance class of housing bore	Class 5: Target clearance (µm)	Free side Classes 4, 2: Tolerance class of housing bore	Classes 4, 2: Target clearance (µm)
Cylindrical roller bearings	All housing bore diameter	K 5	0	K 4	0	—			
Double-direction angular contact thrust ball bearings / High-speed matched pair angular contact ball bearings	All housing bore diameter	K 5	—	K 4	—	—			
Support bearings for precision ball screws	All housing bore diameter	H 6	—	H 6	—	—			
Tapered roller bearings (metric series)	All housing bore diameter	K 5	—	—		H 5	—	—	

[Remark] Consult **JTEKT** for specific operating conditions (high-speed rotation, outer ring rotation, heavy load, etc.).

7. Limiting speeds of bearings

The rotational speed of a bearing is restricted chiefly by temperature increases caused by frictional heat generated within the bearing. When a speed limit is reached, it becomes impossible to continue operation due to seizure and the like.

The permissible rotational speed of a bearing represents the value of limiting speed at which the bearing can continue operation without cousing seizure-generated temperatures.

Accordingly, the limiting speed differs with bearing types, dimensions, accuracy, lubrication methods, quality and quantity of lubricant, shape and material of cages, loading conditions (including amount of preload), etc.

The limiting speed for grease lubrication or oil (oil / air) lubrication of bearings are given in their dimension tables.

These values are the limiting speed that are applicable where a bearing of a standard design is operated under normal loading conditions ($C_r/P_r \geqq 13$, $F_a/F_r \leqq$ approx. 0.2).

C_r : basic dynamic load rating
P_r : dynamic equivalent load
F_r : radial load
F_a : axial load

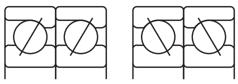
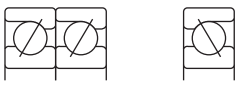
Spindle bearings for machine tools are used in one of 2-, 3-, or 4-row combinations. The limiting speed of a stack mounting bearing is lower than that of a single row bearing.

The speed coefficients are shown in **Table 7. 1**. In this table, the correlations between the preload amounts and the matching methods of the bearings mounted to the shafts with position preloading are shown. Differences are made due to the heat radiation and the variation in the preload amount of each bearing.

Where a lubricant can efficiently remove the heat generated in the bearing, the limiting speed of a bearing will be greater than those given in the bearing dimension tables.

If the rotational speed of a bearing exceeds 80% of the value listed in the bearing dimension tables, careful consideration should be given to the amount of preload, lubrication method, lubricant, distance between the bearings, etc. Consult JTEKT.

Table 7. 1 Speed coefficients

Matching method	Prefix	Preload in mounting			
		Preload S	Preload L	Preload M	Preload H
	DB	0.85	0.80	0.65	0.55
	DBB	0.80	0.75	0.60	0.45
	DBD	0.75	0.70	0.55	0.40

* The speed coefficients vary depending on the distance between the bearings.

8. Lubrication

Lubrication is a critical issue for bearings, on which their performance greatly depends.
The suitability of a lubricant and lubrication method has great influence on the performance of a bearing.

Lubrication plays the following roles.

- Lubrication of each part of the bearing reduces wear and friction.
- Removes heat in the bearing generated by friction and other causes.
- Extends the service life of bearings by constantly forming an adequate oil film on the rolling contact surfaces.
- Rust prevention and dust proofing for bearings

Lubrication is very important for spindle bearings of machine tools since such bearings require a low temperature increase under high-speed operation.

Relationships between the quantity of lubricant and power loss and between the quantity of lubricant and the temperature increase of the bearing are shown in **Fig. 8. 1**. Relationships between the viscosity of lubricant and power loss and between the viscosity of lubricant and the temperature increase of the bearing are shown in **Fig. 8. 2**.

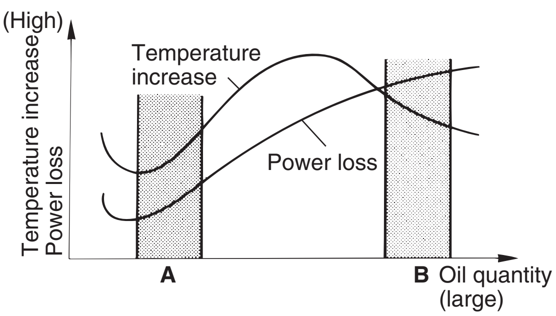


Fig. 8. 1 Relationships between lubricant quantity and power loss and between lubricant quantity and the temperature increase of the bearing

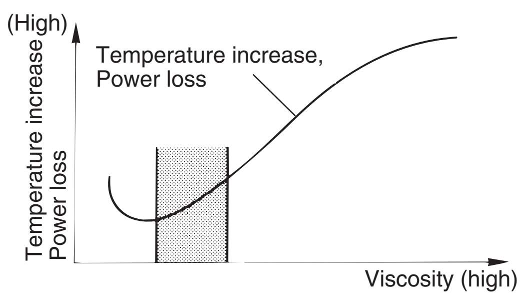


Fig. 8. 2 Relationships between viscosity of lubricant and power loss and between viscosity of lubricant and the temperature increase of the bearing

The quantity of lubricant needed to meet the low temperature increase requirement lies in zone A where the quantity of oil is small so the agitation loss is low, and zone B in which a large quantity of oil transfers heat from the bearing to the outside. Regarding the viscosity of lubricant, those which are of relatively low viscosity are suitable for meeting the above-mentioned requirement.

Note, however, that an excessively small quantity of oil or excessively low viscosity will not maintain a suitable lubricant film during operation, and further induce the chances of seizure.

For bearing lubrication methods, grease, oil / air, or oil mist lubrication is recommended in zone A in **Fig. 8. 1**, and jet lubrication, in zone B.

Table 8. 1 shows a comparison of features for various lubrication methods. It is important to select a lubrication method and a lubricant to best suit to the machine specifications.

Table 8. 1 Comparison of features of different lubrication methods

(○ : advantageous
△ : somewhat disadvantageous
× : disadvantageous)

Item \ Lubrication method	Grease lubrication	Oil / air lubrication	Oil mist lubrication	Jet lubrication
Total cost	○	△	△	×
Temperature increase of bearing	△	○	△	○
High-speed reliability	×	○	△	○
Power loss	○	○	○	×
Volume occupied by lubricator	○	△	△	×
Environmental contamination	○	△	×	△
Service life of lubricant	×	○	○	○

8. 1 Grease lubrication

Grease lubrication is most usually employed because it requires no special lubricator and the use of a relatively simple housing structure is sufficient.

However, to meet machine tool bearing requirements (high-speed operation, low temperature increase, and long service life of sealed grease), the following should be taken into consideration.

8. 1. 1 Types of grease

In order to meet the low level temperature increase requirement of a bearings during operation, a grease low in base oil viscosity is suitable.

In general, grease NLGI 2 in consistency and approximately 10-30 mm^2/s in base oil viscosity is often used for spindle bearings of machine tools. In cases where bearings are subjected to high loads, a grease with a base oil viscosity of approximately 100 mm^2/s, and an extreme-pressure agent may be used to secure lubricant film during operation.

Table 8. 2 shows grease for spindle bearings of machine tools.

8. 1. 2 Sealing device

For spindle bearings of machine tools, it is important to use a reliable sealing device to prevent mixing of coolant, chips, wear particle of drive belt, gear lubricant, and so forth.

Where grease lubrication is adopted, foreign matter have a great influence on the service life of a bearing.

An example of sealing device for grease lubrication is shown in **Fig. 8. 3**.

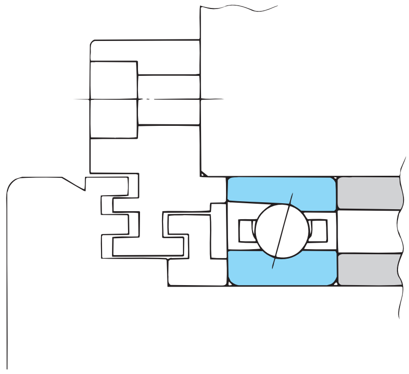


Fig. 8. 3 Example of sealing device for grease lubrication (labyrinth seal)

Table 8. 2 Grease for spindle bearings of machine tools (representative examples)

Grease name	Manufacturer	Thickener	Base oil	Base oil viscosity mm^2/s (40℃)	Application
Beacon 325 Maltemp PS 2 Isoflex NBU 15 Klüberspeed BF 72-22	Exxon Mobil Kyodo oil NOK klüber NOK klüber	Lithium Lithium Barium complex Urea	Diester Diester+mineral oil Ester Ester	12 14 20 22	High-speed operation, low temperature
Stabrags NBU 8 EP Alvania No. 2	NOK klüber Showa shell sekiyu	Barium complex Lithium	Mineral oil Mineral oil	95 130	High-load operation, wear resistance

8. 2 Oil lubrication

8. 2. 1 Oil / air lubrication

In this lubrication method, a small amount of oil of a specified quantity is supplied intermittently to each bearing by compressed air.

A schematic drawing of an oil / air lubrication system is shown in **Fig. 8. 4**.

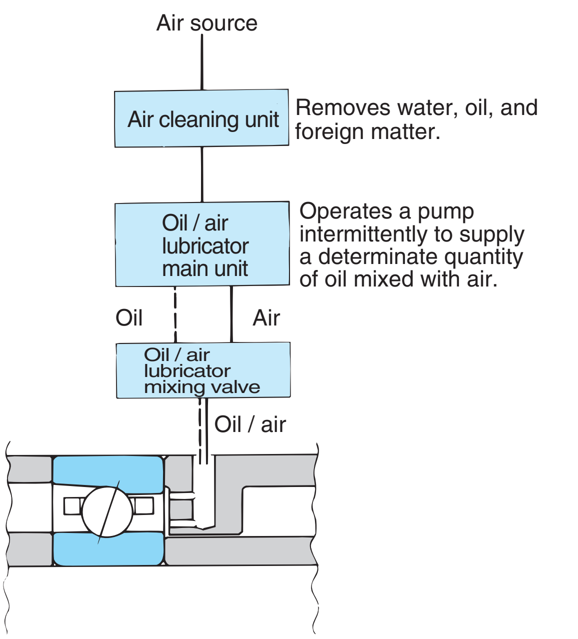


Fig. 8. 4 Oil / air lubrication system

Since oil / air lubrication has features as shown below, it has become popular in many high-speed spindle.

1. Compared with grease lubrication, oil / air lubrication allows bearings to meet the low temperature increase and high-speed operation requirements (see **Fig. 8. 5**).

   This lubrication method eliminates concerns about the service life of lubricant as new oil is constantly supplied to the bearings. Furthermore, compressed air, which increases the pressure in the housing, is effective in preventing foreign matter from entering into the housing.

2. Compared with oil mist lubrication, oil / air lubrication is simple to adjust the quantity of oil with a high degree of accuracy. This leads to a high reliability for bearings during high-speed operation.

   In addition, unlike oil mist lubrication, oil / air lubrication is free from environmental contamination and also reduces oil consumption.

3. Compared with jet lubrication, oil / air lubrication suppresses power losses of bearings (see **Fig. 8. 6**).

   This feature saves space because a smaller drive motor and cooling unit can be used.

   The structure of the main shaft can also be simple and compact.

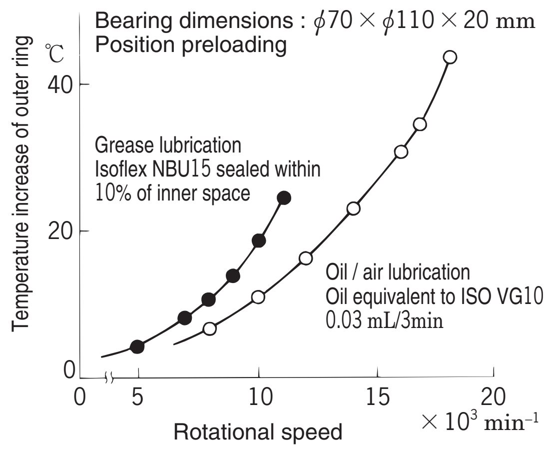


Fig. 8. 5 Comparison of the temperature increase between oil / air lubrication and grease lubrication

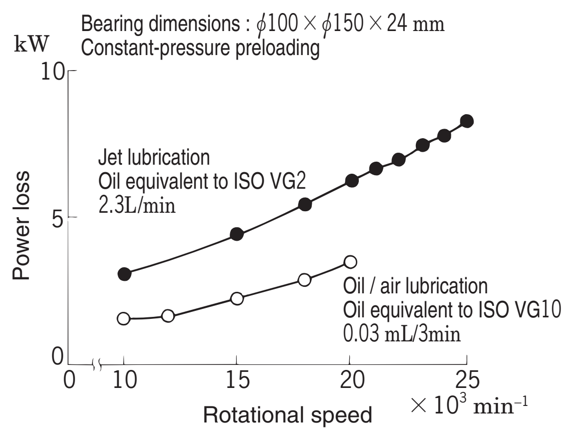


Fig. 8. 6 Comparison of power loss between oil / air lubrication and jet lubrication

In order to take advantage of oil / air lubrication features, **JTEKT** has produced oil / air lubricators and air cleaning units, of which we have special knowhow and have shipped to many customers.

Consult **JTEKT** for the appliation of the oil / air lubrication systems.

For details of the oil / air lubricator and air cleaning unit, see "Ⅱ. **Oil / Air Lubrication System.**"

Refer to **Table 9. 4** on page 41 for information about the dimensions of the spacers for oil / air lubrication.

Refer to **Supplementary table 6** on page 203 for information about the blow intervals of the oil / air.

8. 2. 2 Oil mist lubrication

Similar to oil / air lubrication, oil mist lubrication supplies a small quantity of oil to each bearing by compressed air.

Fig. 8. 7 shows an oil mist lubrication system.

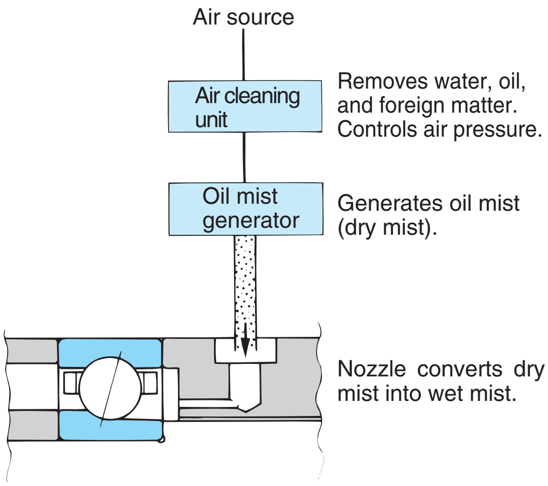


Fig. 8. 7 Oil mist lubrication system

The cost of oil mist lubrication is relatively low. The high-speed performance attained by this method is better than by grease lubrication.

To obtain maximum performance from this method, due consideration should be given to the following.

1. Oil quantity settings

The quantity of oil is set by the rate at which the oil mist generator produces oil drops. Since the rate of oil turned to mist depends on the type of oil, air pressure, flow rate, etc., it is important to determine the amount of oil drops required after the characteristics of the whole system have been sufficiently understood.

2. Distribution of mist to several bearings

In general, a single oil mist generator is used to distribute the mist to several bearings.

Each bearing should be checked to see if it is supplied with an adequate quantity of oil.

3. Installation of suitable nozzle(s)

The nozzle converts dry mist into wet mist suitable for lubrication of bearings and supplies mist to the inside of bearings.

For reliable operation, the nozzle design should be given sufficient consideration.

A well-designed nozzle reduces the quantity of oil so that contamination by oil mist will also be reduced.

8. 2. 3 Jet lubrication

Jet lubrication is a method in which a large quantity of lubricant is injected at a high velocities through the bearing side to lubricate and cool the bearing simultaneously.

Fig. 8. 8 shows a jet lubrication system.

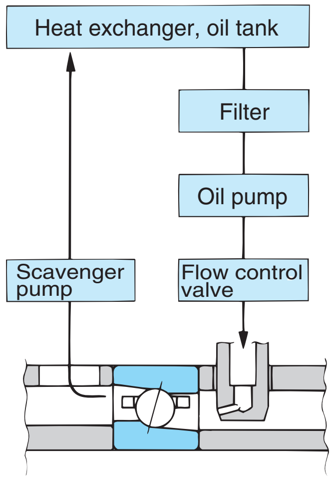


Fig. 8. 8 Jet lubrication system

Owing to its high reliability for high-speed operation, the jet lubrication is often applied to such bearings designed for high-speed and high-temperature operation, for example, gas turbine engines. Also, jet lubrication is sometimes employed for the high-speed spindles of machine tools. If this is the case, give due consideration to the following points.

1. Use oil of extremely low viscosity of approximately 2 mm^2/s to restrain power loss and temperature increase.

2. To improve cooling efficiency, set the velocity of the lubricant ejected from the nozzle to at least 20% of the peripheral speed of the outer surface of the inner ring, thereby allowing more oil to pass through the bearing.

   Installing several nozzles on the circumference for a larger quantity of oil is also effective to some degree.

3. A pump or similar device should be used to discharge oil smoothly. For this reason, the discharge port should be as large as possible to ensure a smooth discharge of oil.

   After discharge, the lubricant should be cooled with a heat exchanger of adequate capacity in order to minimize temperature changes.

   It is also essential to maintain clean lubricant by installing an appropriate filter, ensuring an airtight oil tank, and so forth.

9. Designing peripheral parts of bearings

9. 1 Tolerances of shafts and housings

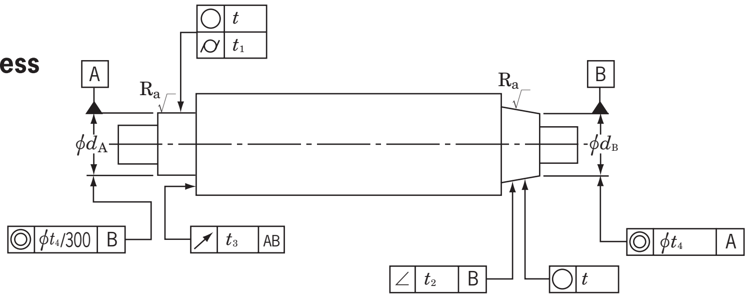
When the inner and outer rings of a bearing are mounted on a shaft and a housing with a certain interference, the shapes of the shaft and housing tend to influence the raceway surface of the bearing leading to a change in running accuracy.

Therefore, shafts and housings need to be finished to maximum possible precision.

Recommended values for tolerances and surface roughness of shafts and housings are shown in **Tables 9. 1** and **9. 2**.

Refer to "Ⅲ. **Handling of Bearings**" for details about handling and mounting of the bearings.

Table 9. 1 Tolerances and surface roughness of shafts

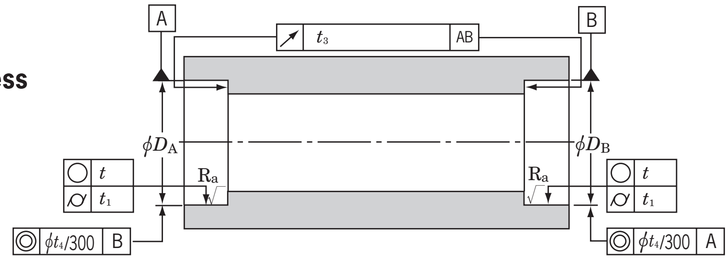


Unit : μm

Shaft diameter (mm)		Roundness(◯)		Cylindricity(⌭)		Inclination(∠)	Deflection(↗)		Coaxiality(◎)		Roughness	
		t		t_1		t_2	t_3		t_4		R_a	
		Tolerance class of bearing		Tolerance class of bearing		Tolerance class of bearing	Tolerance class of bearing		Tolerance class of bearing		Tolerance class of bearing	
over	up to	Class 5	Classes 4, 2	Class 5	Classes 4, 2	Classes 4, 2	Class 5	Classes 4, 2	Class 5	Classes 4, 2	Class 5	Classes 4, 2
18	**30**	2	1.2	2	1.2	2	4		9	6	0.2	0.1
30	**50**	2	1.2	2	1.2	2	4		11	7	0.2	0.1
50	**80**	2.5	1.5	2.5	1.5	2.5	5		13	8	0.2	0.1
80	**120**	3	2	3	2	3	6		15	10	0.4	0.2
120	**180**	4	2.5	4	2.5	4	8		18	12	0.4	0.2
180	**250**	5	3.5	5	3.5	5	10		20	14	0.4	0.2
250	**315**	6	4	6	4	6	12		23	16	0.4	0.2
315	**400**	6.5	4.5	6.5	4.5	6.5	13		25	18	0.4	0.2

[Remarks]
1. Tolerances, symbols, and reference planes for shafts comply with ISO/R1101.
2. When determining the tolerance in relation to the permissible accuracy of shapes, the shaft diameters d_A and d_B are used as reference dimensions.

Table 9. 2 Tolerances and surface roughness of housings

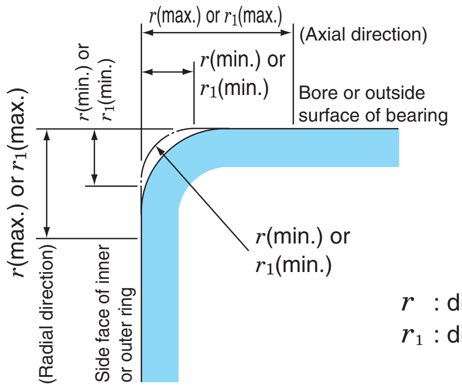


Unit : μm

Housing bore diameter (mm)		Roundness(◯)		Cylindricity(⌭)		Deflection(↗)		Coaxiality(◎)		Roughness	
		t		t_1		t_3		t_4		R_a	
		Tolerance class of bearing		Tolerance class of bearing		Tolerance class of bearing		Tolerance class of bearing		Tolerance class of bearing	
over	up to	Class 5	Classes 4, 2	Class 5	Classes 4, 2	Class 5	Classes 4, 2	Class 5	Classes 4, 2	Class 5	Classes 4, 2
18	**30**	2	1.2	2	1.2	4		9	6	0.3	0.1
30	**50**	2	1.2	2	1.2	4		11	7	0.3	0.1
50	**80**	2.5	1.5	2.5	1.5	5		13	8	0.4	0.2
80	**120**	3	2	3	2	6		15	10	0.8	0.4
120	**180**	4	2.5	4	2.5	8		18	12	0.8	0.4
180	**250**	5	3.5	5	3.5	10		20	14	0.8	0.4
250	**315**	6	4	6	4	12		23	16	1.6	0.8
315	**400**	6.5	4.5	6.5	4.5	13		25	18	1.6	0.8
400	**500**	7.5	5	7.5	5	15		27	20	1.6	0.8
500	**630**	8	5.5	8	5.5	16		30	22	1.6	0.8

[Remarks]
1. Tolerances, symbols, and reference planes for housings comply with ISO/R1101.
2. When determining the tolerance in relation to the permissible accuracy of shapes, the housing bore diameters D_A and D_B are used as reference dimensions.

9. 2 Limits of chamfer dimensions and fillet radii of shafts and housings



[Remark]

An imaginary arc with a radius of r (min) is defined as being tangent to both the side face of the inner ring and the bore surface of the bearing; or to both the side face of outer ring and the outside surface of the bearing. Although an exact shape is not specified for chamfered surfaces, the outline in the axial plane shall not extend beyond the imaginary arc.

r : dimension for chamfering inner and outer rings
r_1 : dimension for chamfering the front and the likes of the inner and outer rings

Table 9. 3 Limits of chamfer dimensions and fillet radii of shafts and housings

(1) Radial bearings (not applicable to tapered roller bearings)

Unit : mm

r(min.) or r_1(min.)	Nominal bore diameter d (mm)		r(max.) or r_1(max.)		(Refer.) Fillet radius of shaft or housing r_a
	over	up to	Radial direction	Axial direction [1]	max.
0.05	—	—	0.1	0.2	0.05
0.08	—	—	0.16	0.3	0.08
0.1	—	—	0.2	0.4	0.1
0.15	—	—	0.3	0.6	0.15
0.2	—	—	0.5	0.8	0.2
0.3	—	40	0.6	1	0.3
	40	—	0.8	1	
0.6	—	40	1	2	0.6
	40	—	1.3	2	
1	—	50	1.5	3	1
	50	—	1.9	3	
1.1	—	120	2	3.5	1
	120	—	2.5	4	
1.5	—	120	2.3	4	1.5
	120	—	3	5	
2	—	80	3	4.5	2
	80	220	3.5	5	
	220	—	3.8	6	
2.1	—	280	4	6.5	2
	280	—	4.5	7	
2.5	—	100	3.8	6	2
	100	280	4.5	6	
	280	—	5	7	
3	—	280	5	8	2.5
	280	—	5.5	8	
4	—	—	6.5	9	3
5	—	—	8	10	4
6	—	—	10	13	5
7.5	—	—	12.5	17	6
9.5	—	—	15	19	8
12	—	—	18	24	10
15	—	—	21	30	12
19	—	—	25	38	15

[Note] 1) For bearings 2mm or less in nominal width, the value of r (max.) in the axial direction shall be the same as that in the radial direction.

(2) Metric tapered roller bearings

Unit : mm

r(min.) or r_1(min.) [2]	Nominal bore [1] or nominal outside diameter d or D(mm)		r(max.) or r_1(max.)		(Refer.) Fillet radius of shaft or housing r_a
	over	up to	Radial direction	Axial direction	max.
0.3	—	40	0.7	1.4	0.3
	40	—	0.9	1.6	
0.6	—	40	1.1	1.7	0.6
	40	—	1.3	2	
1	—	50	1.6	2.5	1
	50	—	1.9	3	
1.5	—	120	2.3	3	1.5
	120	250	2.8	3.5	
	250	—	3.5	4	
2	—	120	2.8	4	2
	120	250	3.5	4.5	
	250	—	4	5	
2.5	—	120	3.5	5	2
	120	250	4	5.5	
	250	—	4.5	6	
3	—	120	4	5.5	2.5
	120	250	4.5	6.5	
	250	400	5	7	
	400	—	5.5	7.5	
4	—	120	5	7	3
	120	250	5.5	7.5	
	250	400	6	8	
	400	—	6.5	8.5	
5	—	180	6.5	8	4
	180	—	7.5	9	
6	—	180	7.5	10	5
	180	—	9	11	
7.5	—	—	*12.5*	*17*	*6*
9.5	—	—	*15*	*19*	*8*

[Notes] 1) Inner rings are classified by d, outer rings, by D.
2) Values in italics comply with **JTEKT** standards.

9. 3 Spacers for oil / air lubrication

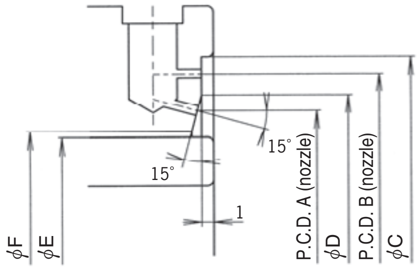
The dimensions of the spacers for oil / air lubrication are shown in **Table 9. 4**.

Table 9. 4(1) Dimensions of the spacers for oil / air lubrication
Angular contact ball bearings

7000 series

7200 series

7900 series



* Commonly used in contact angles of 15° and 30°.
** Cage: Outer ring guided
Arrangement: These are the recommended dimensions for a back-to-back (DB) arrangement.

Nozzle diameter

7000, 7200 series		7900 series	
Bore dia. No.	Nozzle diameter (φ)	Bore dia. No.	Nozzle diameter (φ)
00-09	0.8	00-10	0.8
10-40	1.0	11-40	1.0

Unit : mm

Bore dia. No.	Nominal bore dia.	7000 series						7200 series						7900 series					
		A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
00	10	15.2	20.7	23.5	18.0	11.5	12.5	18.2	23.5	26.3	20.9	14.5	15.5	14.7	18.1	20.9	16.4	11.0	12.0
01	12	18.4	23.8	26.6	21.1	14.7	15.7	19.0	25.9	28.7	22.5	15.3	16.3	16.7	20.1	22.9	18.4	13.0	14.0
02	15	21.3	26.7	29.5	24.0	17.6	18.6	22.8	29.4	32.2	26.1	19.1	20.1	19.7	24.0	26.8	21.9	16.0	17.0
03	17	24.6	29.8	32.6	27.2	20.9	21.9	25.8	33.4	36.2	29.6	22.1	23.1	21.7	26.0	28.8	23.9	18.0	19.0
04	20	28.5	35.8	38.6	32.2	24.8	25.8	30.5	39.6	42.4	35.1	26.8	27.8	26.2	31.8	34.6	29.0	22.5	23.5
05	25	33.0	40.2	43.0	36.6	29.3	30.3	35.3	44.1	46.9	39.7	31.6	32.6	32.0	37.3	40.1	34.7	28.3	29.3
06	30	39.0	47.1	49.9	43.1	35.3	36.3	41.7	52.7	55.5	47.2	38.0	39.0	36.3	41.7	44.5	39.0	32.6	33.6
07	35	45.0	54.0	56.8	49.5	41.3	42.3	48.3	61.3	64.1	54.8	44.6	45.6	41.7	48.4	51.2	45.1	38.0	39.0
08	40	50.5	59.3	62.1	54.9	46.8	47.8	53.2	67.0	69.8	60.1	49.5	50.5	47.9	54.8	57.6	51.4	44.2	45.2
09	45	55.4	65.4	68.2	60.4	51.7	52.7	56.8	71.7	74.5	64.3	53.1	54.1	53.2	60.9	63.7	57.1	49.5	50.5
10	50	60.9	70.9	73.9	65.9	57.0	58.0	63.5	78.1	81.1	70.8	59.6	60.6	57.7	65.3	68.1	61.5	54.0	55.0
11	55	66.8	78.7	81.7	72.8	62.9	63.9	70.7	87.6	90.6	79.2	66.8	67.8	64.1	72.1	74.9	68.1	60.2	61.2
12	60	71.9	83.9	86.9	77.9	68.0	69.0	77.7	96.6	99.6	87.2	73.8	74.8	68.8	77.5	80.5	73.2	64.9	65.9
13	65	77.2	89.0	92.0	83.1	73.3	74.3	82.4	102.5	105.5	92.5	78.5	79.5	73.8	82.1	85.1	78.0	69.9	70.9
14	70	83.3	97.2	100.2	90.3	79.4	80.4	87.2	108.0	111.0	97.6	83.3	84.3	80.8	90.4	93.4	85.6	76.9	77.9
15	75	88.3	102.1	105.1	95.2	84.4	85.4	91.7	113.5	116.5	102.6	87.8	88.8	85.6	95.0	98.0	90.3	81.7	82.7
16	80	94.7	110.5	113.5	102.6	90.8	91.8	98.7	121.5	124.5	110.1	94.8	95.8	92.3	100.3	103.3	96.3	88.4	89.4
17	85	100.8	116.5	119.5	108.7	96.9	97.9	105.2	130.0	133.0	117.6	101.3	102.3	101.1	108.7	111.7	104.9	97.2	98.2
18	90	106.1	123.8	126.8	115.0	102.2	103.2	111.7	138.5	141.5	125.1	107.8	108.8	104.2	113.7	116.7	109.0	100.3	101.3
19	95	119.6	130.7	133.7	125.2	115.7	116.7	118.3	146.9	149.9	132.6	114.4	115.4	107.0	118.4	121.4	112.7	103.1	104.1
20	100	121.0	132.4	135.4	126.7	117.1	118.1	125.8	156.4	159.4	141.1	121.9	122.9	112.9	127.3	130.3	120.1	109.0	110.0
21	105	125.1	144.2	147.2	134.7	121.2	122.2	144.6	165.4	168.4	155.0	140.7	141.7	120.7	132.4	135.4	126.6	116.8	117.8
22	110	129.7	151.0	154.0	140.4	125.8	126.8	150.7	171.8	174.6	161.3	146.8	147.8	123.2	137.3	140.3	130.3	119.3	120.3
24	120	138.5	161.0	164.0	149.8	134.6	135.6	163.3	186.7	189.7	175.0	159.4	160.4	137.5	150.7	153.7	144.1	133.6	134.6
26	130	153.5	177.0	180.0	165.3	149.6	150.6	174.7	199.4	202.4	187.1	170.8	171.8	149.4	164.2	167.2	156.8	145.5	146.5
28	140	171.7	187.1	190.1	179.4	167.8	168.8	178.1	214.7	217.7	196.4	174.2	175.2	159.4	174.2	177.2	166.8	155.5	156.5
30	150	174.8	200.5	203.5	187.7	170.9	171.9	191.4	231.7	234.7	211.6	187.5	188.5	170.6	191.2	194.2	180.9	166.7	167.7
32	160	188.2	213.7	216.7	201.0	184.3	185.3	207.4	245.7	248.7	226.6	203.5	204.5	180.7	201.2	204.2	191.0	176.8	177.8
34	170	201.7	231.0	234.0	216.4	197.8	198.8	220.8	262.6	265.6	241.7	216.9	217.9	190.7	211.2	214.2	201.0	186.8	187.8
36	180	215.0	247.8	250.8	231.4	211.1	212.1	229.0	274.5	277.5	251.8	225.1	226.1	204.1	228.1	231.1	216.1	200.2	201.2
38	190	225.1	257.9	260.9	241.5	221.2	222.2	244.1	289.5	292.5	266.8	240.2	241.2	214.1	238.1	241.1	226.1	210.2	211.2
40	200	238.5	274.8	277.8	256.7	234.6	235.6	257.3	306.3	309.3	281.8	253.4	254.4	227.5	255.0	258.0	241.3	223.6	224.6

Table 9. 4(2) Dimensions of the spacers for oil / air lubrication

High Ability

Angular contact ball bearings

HAR000 series

HAR900 series

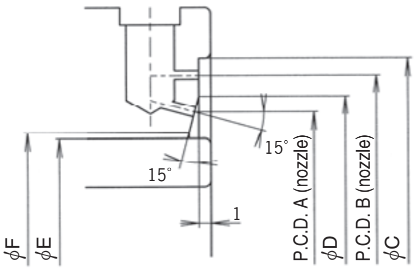
3NCHAR000 series

3NCHAR900 series

* Commonly used in contact angles of 15°, 20° and 30°

** Cage: Outer ring guided

Arrangement: These are the recommended dimensions for a back-to-back (DB) arrangement.



Nozzle diameter

HAR000, 3NCHAR000 series		HAR900, 3NCHAR900 series	
Bore dia. No.	Nozzle diameter (φ)	Bore dia. No.	Nozzle diameter (φ)
06-10	0.8	08-10	0.8
11-34	1.0	11-34	1.0

Unit : mm

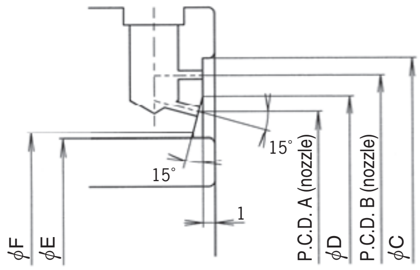
Bore dia. No.	Nominal bore dia.	HAR000, 3NCHAR000 series						HAR900, 3NCHAR900 series					
		A	B	C	D	E	F	A	B	C	D	E	F
06	30	39.7	45.9	48.7	42.8	36.0	37.0	—	—	—	—	—	—
07	35	45.6	51.9	54.7	48.8	41.9	42.9	—	—	—	—	—	—
08	40	51.4	57.4	60.2	54.4	47.7	48.7	49.1	53.7	56.5	51.4	45.4	46.4
09	45	57.0	63.6	66.4	60.3	53.3	54.3	54.6	59.2	62.0	56.9	50.9	51.9
10	50	62.5	68.6	71.6	65.6	58.6	59.6	58.8	64.1	66.9	61.5	55.1	56.1
11	55	69.7	76.6	79.6	73.2	65.8	66.8	65.3	70.6	73.6	68.0	61.4	62.4
12	60	74.7	81.6	84.6	78.2	70.8	71.8	70.3	75.6	78.6	73.0	66.4	67.4
13	65	79.4	86.6	89.6	83.0	75.5	76.5	75.1	80.9	83.9	78.0	71.2	72.2
14	70	86.2	95.0	98.0	90.6	82.3	83.3	82.6	88.6	91.6	85.6	78.7	79.7
15	75	91.2	99.9	102.9	95.6	87.3	88.3	88.5	93.6	96.6	91.1	84.6	85.6
16	80	98.1	107.9	110.9	103.0	94.2	95.2	93.5	98.6	101.6	96.1	89.6	90.6
17	85	104.0	112.9	115.9	108.5	100.1	101.1	100.7	106.5	109.5	103.6	96.8	97.8
18	90	110.7	121.4	124.4	116.1	106.8	107.8	104.7	111.5	114.5	108.1	100.8	101.8
19	95	115.7	126.4	129.4	121.1	111.8	112.8	110.7	116.5	119.5	113.6	106.8	107.8
20	100	119.4	131.3	134.3	125.4	115.5	116.5	116.4	124.9	127.9	120.7	112.5	113.5
21	105	127.6	139.1	142.1	133.4	123.7	124.7	122.6	129.9	132.9	126.3	118.7	119.7
22	110	136.5	147.3	150.3	141.9	132.6	133.6	127.6	134.9	137.9	131.3	123.7	124.7
24	120	146.5	157.3	160.3	151.9	142.6	143.6	139.9	147.9	150.9	143.9	136.0	137.0
26	130	160.7	173.7	176.7	167.2	156.8	157.8	152.2	160.9	163.9	156.6	148.3	149.3
28	140	170.7	183.7	186.7	177.2	166.8	167.8	162.2	170.9	173.9	166.6	158.3	159.3
30	150	182.7	197.2	200.2	190.0	178.8	179.8	176.5	187.3	190.3	181.9	172.6	173.6
32	160	195.1	210.2	213.2	202.7	191.2	192.2	186.5	197.3	200.3	191.9	182.6	183.6
34	170	209.6	226.1	229.1	217.9	205.7	206.7	196.5	207.3	210.3	201.9	192.6	193.6

Table 9. 4(3) Dimensions of the spacers for oil / air lubrication

High Ability
Angular contact ball bearings

3NCHAC000 series
3NCHAC900 series
3NCHAX000 series
3NCHAX900 series

* Commonly used in contact angles of 15° and 20°
** Cage: Outer ring guided
Arrangement: These are the recommended dimensions for a back-to-back (DB) arrangement.



Nozzle diameter

3NCHAC000, 3NCHAX000 series		3NCHAC900, 3NCHAX900 series	
Bore dia. No.	Nozzle diameter (φ)	Bore dia. No.	Nozzle diameter (φ)
00-09	0.8	00-10	0.8
10-34	1.0	11-34	1.0

Unit : mm

Bore dia. No.	Nominal bore dia.	3NCHAC000, 3NCHAX000 series						3NCHAC900, 3NCHAX900 series					
		A	B	C	D	E	F	A	B	C	D	E	F
00	10	15.7	20.7	23.5	18.2	12.0	13.0	15.0	18.1	20.9	16.6	11.3	12.3
01	12	18.8	23.8	26.6	21.3	15.1	16.1	16.7	20.1	22.9	18.4	13.0	14.0
02	15	21.8	26.7	29.5	24.3	18.1	19.1	20.0	24.0	26.8	22.0	16.3	17.3
03	17	25.1	29.8	32.6	27.5	21.4	22.4	22.3	26.0	28.8	24.2	18.6	19.6
04	20	29.1	35.8	38.6	32.5	25.4	26.4	26.6	31.8	34.6	29.2	22.9	23.9
05	25	33.6	40.2	43.0	36.9	29.9	30.9	32.4	37.3	40.1	34.9	28.7	29.7
06	30	39.7	47.1	49.9	43.4	36.0	37.0	36.8	41.7	44.5	39.3	33.1	34.1
07	35	45.8	54.0	56.8	49.9	42.1	43.1	42.2	48.4	51.2	45.3	38.5	39.5
08	40	51.2	59.3	62.1	55.3	47.5	48.5	48.5	54.8	57.6	51.7	44.8	45.8
09	45	56.2	65.4	68.2	60.8	52.5	53.5	53.8	60.9	63.7	57.4	50.1	51.1
10	50	61.7	70.9	73.9	66.3	57.8	58.8	58.2	65.3	68.1	61.8	54.5	55.5
11	55	67.7	78.7	81.7	73.2	63.8	64.8	64.7	72.1	74.9	68.4	61.0	62.0
12	60	72.8	83.9	86.9	78.4	68.9	69.9	69.5	77.5	80.5	73.5	65.6	66.6
13	65	78.1	89.0	92.0	83.6	74.2	75.2	74.1	82.1	85.1	78.1	70.2	71.2
14	70	84.4	97.2	100.2	90.8	80.5	81.5	81.6	90.4	93.4	86.0	77.7	78.7
15	75	89.4	102.1	105.1	95.8	85.5	86.5	86.4	95.0	98.0	90.7	82.5	83.5
16	80	96.0	110.5	113.5	103.3	92.1	93.1	91.5	100.3	103.3	95.9	87.6	88.6
17	85	102.0	116.5	119.5	109.3	98.1	99.1	98.2	108.7	111.7	103.5	94.3	95.3
18	90	107.5	123.8	126.8	115.7	103.6	104.6	103.2	113.7	116.7	108.5	99.3	100.3
19	95	119.6	130.7	133.7	125.2	115.7	116.7	107.9	118.4	121.4	113.2	104.0	105.0
20	100	117.8	134.0	137.0	125.9	113.9	114.9	114.0	127.3	130.3	120.7	110.1	111.1
21	105	126.7	144.2	147.2	135.5	122.8	123.8	121.8	132.3	135.3	127.1	117.9	118.9
22	110	131.4	151.0	154.0	141.2	127.5	128.5	124.3	137.3	140.3	130.8	120.4	121.4
24	120	140.2	161.0	164.0	150.6	136.3	137.3	138.9	150.8	153.8	144.9	135.0	136.0
26	130	155.4	177.0	180.0	166.2	151.5	152.5	151.2	164.5	167.5	157.9	147.3	148.3
28	140	169.7	187.1	190.1	178.4	165.8	166.8	157.8	174.3	177.3	166.1	153.9	154.9
30	150	177.5	200.5	203.5	189.0	173.6	174.6	171.8	191.2	194.2	181.5	167.9	168.9
32	160	193.8	214.0	217.0	203.9	189.9	190.9	185.0	201.2	204.2	193.1	181.1	182.1
34	170	207.8	230.7	233.7	219.3	203.9	204.9	195.0	211.2	214.2	203.1	191.1	192.1

Table 9. 4(4) Dimensions of the spacers for oil / air lubrication

High Ability

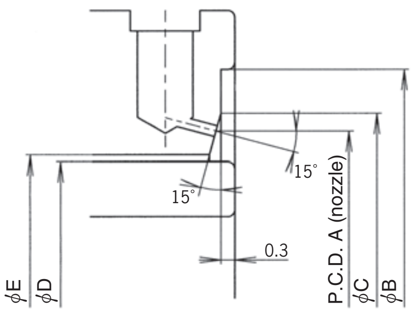
Angular contact ball bearings

3NCHAD000 series

* These are the recommended dimensions for a back-to-back (DB) arrangement.

Unit : mm

Bore dia. No.	Nominal bore dia.	3NCHAD000 series				
		A	B	C	D	E
07	35	41.3	54.7	43.3	39.1	39.7
08	40	46.4	60.2	48.6	44.2	44.8
09	45	52.2	66.4	54.4	49.6	50.2
10	50	57.2	71.6	59.4	54.6	55.2
11	55	63.8	79.6	66.3	61.0	61.6
12	60	68.8	84.6	71.3	66.0	66.6
13	65	73.8	89.6	76.3	71.0	71.6
14	70	79.6	98.0	82.4	76.8	77.4
15	75	84.6	102.9	87.4	81.8	82.4
16	80	91.7	110.9	94.4	87.9	89.5
17	85	96.7	115.9	99.4	92.9	94.5
18	90	101.9	124.4	105.2	98.1	99.7
19	95	106.9	129.4	110.2	103.1	104.7
20	100	112.7	134.3	115.6	107.5	109.7
21	105	119.3	142.1	122.4	114.1	116.3
22	110	125.6	150.3	129.0	120.4	122.6
24	120	135.6	160.3	139.0	130.4	132.6
26	130	148.4	176.7	152.1	141.6	145.4



Nozzle diameter

3NCHAD000 series	
Bore dia. No.	Nozzle diameter (φ)
07-10	0.8
11-26	1.0

These bearings are useful only with oil / air lubrication.
Please use with lubricating spacers as shown below.

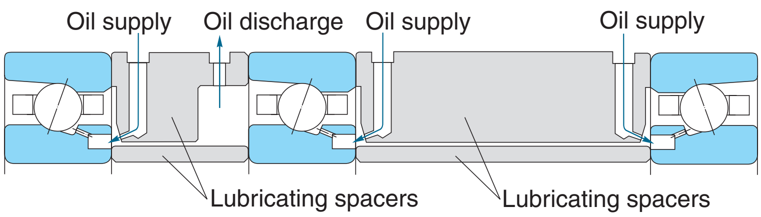
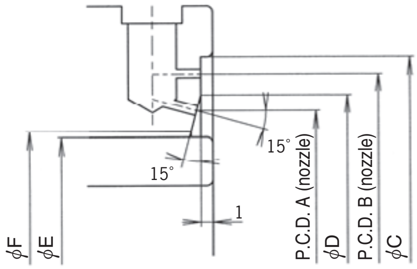


Table 9. 4(5) Dimensions of the spacers for oil / air lubrication
Cylindrical Roller bearings

NN3000 series

N1000 series

3NCN1000 series



Nozzle diameter

NN3000 series		N1000, 3NCN1000 series	
Bore dia. No.	Nozzle diameter (φ)	Bore dia. No.	Nozzle diameter (φ)
05-09	0.8	06-10	0.8
10-40	1.0	11-32	1.0

Unit : mm

Bore dia. No.	Nominal bore dia.	NN3000 series						N1000, 3NCN1000 series					
		A	B	C	D	E	F	A	B	C	D	E	F
05	25	34.9	40.7	41.9	37.7	31.9	32.9	—	—	—	—	—	—
06	30	40.6	47.4	48.6	43.4	37.5	38.5	40.7	47.3	48.6	43.5	37.5	38.5
07	35	47.4	53.9	55.1	50.1	44.0	45.0	47.0	53.7	55.2	49.8	44.0	45.0
08	40	53.6	60.0	61.2	56.4	50.0	51.0	54.0	60.0	61.4	56.8	50.0	51.0
09	45	58.5	66.2	67.4	61.3	54.5	55.5	58.1	67.2	68.8	60.9	53.5	54.5
10	50	63.4	71.1	72.3	66.2	59.5	60.5	62.1	71.2	72.8	64.9	57.5	58.5
11	55	70.5	79.5	80.8	73.3	66.0	67.0	71.1	79.7	81.6	73.9	66.0	67.0
12	60	75.5	84.5	85.9	78.3	71.1	72.1	76.2	84.8	86.6	79.0	71.1	72.1
13	65	80.5	89.5	91.0	83.3	76.0	77.0	80.5	89.2	91.1	83.3	75.5	76.5
14	70	88.2	98.2	100.0	91.2	83.0	84.0	88.6	98.5	100.8	91.4	83.0	84.0
15	75	93.2	103.3	105.0	96.2	88.0	89.0	93.8	103.5	105.8	96.8	88.0	89.0
16	80	100.0	110.8	113.0	103.0	94.0	95.0	100.7	111.4	113.9	103.7	94.0	95.0
17	85	105.0	115.8	118.0	108.0	99.0	100.0	105.4	116.4	118.8	108.4	99.0	100.0
18	90	112.6	124.5	127.0	115.6	106.0	107.0	112.7	125.2	128.1	115.7	106.0	107.0
19	95	117.5	129.5	132.0	120.5	111.0	112.0	117.7	130.2	132.8	120.7	111.0	112.0
20	100	122.5	134.5	137.0	125.5	116.0	117.0	120.1	135.5	139.8	123.1	114.0	115.0
21	105	128.3	143.0	146.4	131.3	121.4	122.4	125.8	142.5	147.5	128.8	119.9	120.9
22	110	136.4	152.0	155.2	139.4	128.4	129.4	135.8	151.5	156.0	138.8	128.4	129.4
24	120	146.4	162.0	165.2	149.4	138.4	139.4	143.3	162.3	167.8	146.3	136.4	137.4
26	130	160.4	178.5	182.6	163.4	151.4	152.4	159.8	179.3	183.8	162.8	149.4	150.4
28	140	170.5	188.5	192.8	173.5	161.4	162.4	167.7	187.0	193.8	170.7	159.4	160.4
30	150	183.2	202.4	206.8	186.2	173.4	174.4	179.9	202.0	209.3	182.9	170.9	171.9
32	160	192.9	214.0	219.8	195.9	182.4	183.4	191.0	218.5	223.8	194.0	181.4	182.4
34	170	207.2	230.0	237.0	210.2	195.4	196.4	—	—	—	—	—	—
36	180	221.6	248.3	256.2	224.6	208.4	209.4	—	—	—	—	—	—
38	190	229.5	259.0	266.2	232.5	216.4	217.4	—	—	—	—	—	—
40	200	248.0	276.0	283.4	251.0	233.4	234.4	—	—	—	—	—	—

10. Heat treatment and materials technology

At JTEKT, we use our proprietary heat treatment technology to produce bearings with long service lives and a variety of cages that provide the optimal performance for specific usage applications.

This section will introduce the heat treatment and materials technology of JTEKT.

10. 1 Rings

10. 1. 1 SH bearing overview

SH bearings are bearings for which special heat treatment (SH treatment) has been applied to the inner and outer rings.

By forming a compressive residual stress layer on the ring surface (the goal of which is the improvement of the service life), we have improved the surface hardness. (See **Fig. 10. 1** and **Fig. 10. 2**.)

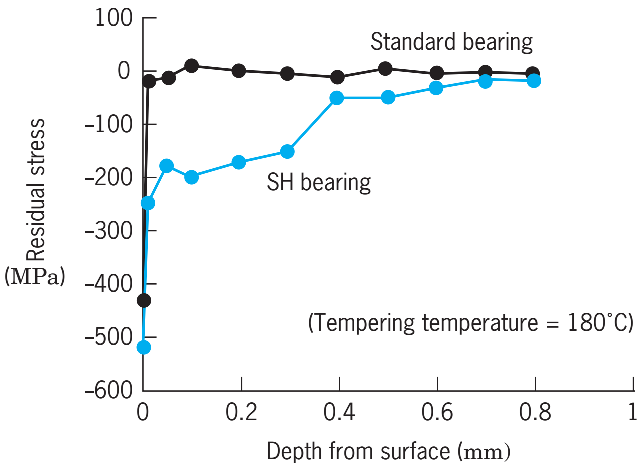


Fig. 10. 1 Compressive residual stress layer

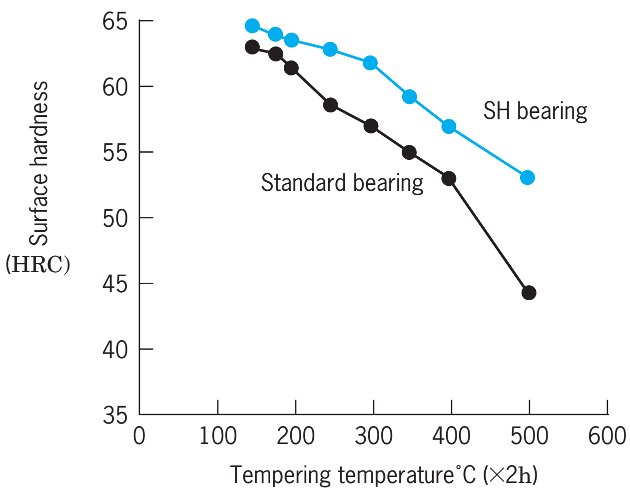


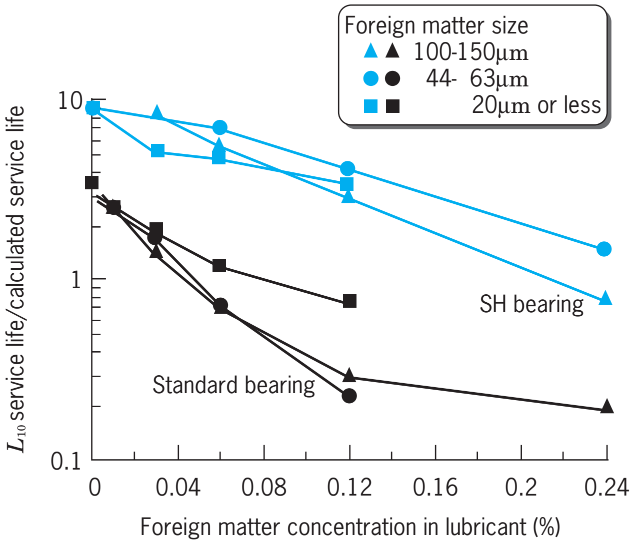
Fig. 10. 2 Surface hardness

10. 1. 2 Performance

In clean oil, these bearings achieve a bearing rating life that is two or more times that of standard bearings.

(Also, in dirty oil, these bearings achieve a bearing rating life that is three or more times that of standard bearings.)

(See **Fig. 10. 3**.)



Test bearing : Ball bearing 63/22 (equivalent)
Tester : KS radial tester
Lubricant : Oil bath with turbine oil #68
Foreign matter : Bearing steel powder

Fig. 10. 3 Relationship between lubricant cleanliness and bearing service life

10. 2 Cage material

Compared to metal, engineering plastic is lighter and has better self-lubricating and wear resistance properties. When it is used in cages, it generates a small amount of heat and causes little grease degradation due to wear. Therefore, engineering plastic is widely used in precision bearings for machine tool use.

10. 2. 1 Types and features of cage materials

Material	Cage code	Features
Brass	FW·FY	Excellent heat resistance and hardness
Polyamide resin	FG	A standard thermo plastic resin with low cost and excellent wear resistance and oil resistance
Phenolic resin	FT	A cloth base material impregnated with phenolic resin; excellent heat resistance, wear resistance, and oil resistance
PEEK resin	PG	The highest level of heat resistance among all thermo plastic resins and excellent properties such as wear resistance, creep resistance, and fatigue characteristics

Angular contact ball bearings
Outer ring guided
Phenolic resin cage

Angular contact ball bearings
Ball guided
Polyamide resin cage

10. 2. 2 Scope of cage materials

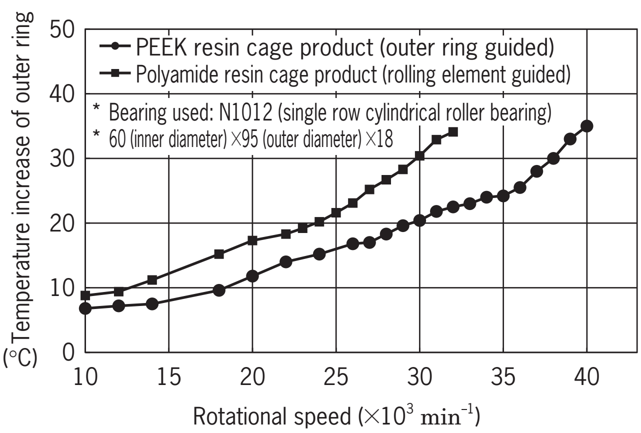
Material	Angular contact ball bearings	
	Oil/air lubrication	Grease lubrication
Brass		
Polyamide resin		Ball guided
Phenolic resin	Outer ring guided	
PEEK resin	Outer ring guided	

Material	Cylindrical roller bearings	
	Oil/air lubrication	Grease lubrication
Brass	Roller guided	Roller guided
Polyamide resin	Roller guided	Roller guided
Phenolic resin		
PEEK resin	Outer ring guided	

Double row cylindrical roller bearings
Roller guided
Brass cage

Single row cylindrical roller bearings
Roller guided
Brass cage

10. 2. 3 Example evaluation of the high-speed properties of a PEEK resin cage product and a polyamide resin cage product



Single row cylindrical roller bearings
Roller guided
Polyamide resin cage

Single row cylindrical roller bearings
Outer ring guided
PEEK resin cage

11. High Ability angular contact ball bearings

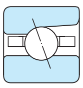
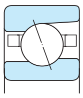
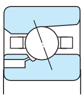
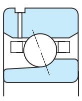
High Ability angular contact ball bearings are optimized for use on machine-tool spindles. They excel in high-speed performance and rapid acceleration/deceleration, and are especially superior in ultrahigh-speed applications when used with oil / air lubrication. Even with grease lubrication, these bearings are superior to conventional products in high-speed applications.

11. 1 Types and applications

High Ability angular contact bearings are available in the varieties listed in **Table 11. 1**, all of which differ in structure and rolling-element material.

Select the type that is best suited for the application.

Table 11. 1 High Ability bearing types and principal applications

Principal applications	Taype	Specification		
		Bearing dimension series	Contact angle	Material of rolling element
High-speed, high-rigidity type	Type R 	10 19	15° 20° 30°	Steel or ceramics
High-speed, high load-rating type	Type C 	10 19	15° 20°	ceramics
Ultrahigh-speed, low-noise type for oil / air lubrication	Type D 	10	20°	ceramics
Extremely ultrahigh-speed type for oil / air lubrication	Type X 	10 19	20°	ceramics

11. 2 Features

● 20 to 30% reduction in temperature increase (compared with JTEKT's conventional products)

JTEKT has conducted various tests and analyses and developed elaborate machining techniques to improve the performance of bearings used with machining tool spindles. The result is a substantial reduction in frictional heat generated in bearings rotating at a high speed.

● 1.2- to 1.5-time increases in speed limits (compared with JTEKT's conventional products)

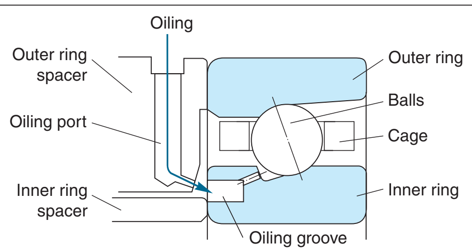
Speed limits have been extended through re-designing for high-speed rotation and heat reduction. Use of ceramic balls as rolling elements enables additional high-speed rotation.

● Improved high-speed performance achieved by position preloading

Low increases in temperature during operation ensure reduced changes in preload. Preload can be given by position preloading even at high speeds, which has been hitherto unavailable with conventional systems. The result is high-precision machining with stability.

● Conventional bearings easily replaced

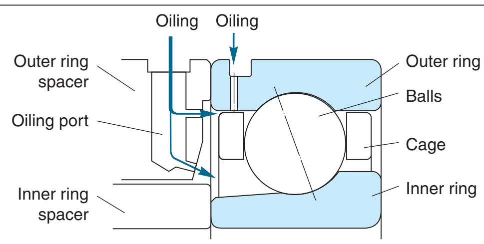
Dimensions of High Ability bearings conform to ISO standards. Replacement of conventional bearings with High Ability bearings requires minimal geometry changes of the present spindle or housing.



The oiling nozzle should be aligned with the oiling groove in the inner ring.

Fig. 11. 1 Lubrication method for Type D

High Ability Type D bearings are designed for oil / air lubrication. Their inner rings have an oiling groove to ensure lubrication on the rolling contact surface for improved lubrication reliability.



Lubrication is accomplished from one side via the outer ring.

Fig. 11. 2 Lubrication method used in Type X

The oiling port in Type X is provided at its outer ring to ensure improved lubrication reliability on the guide ways of the cage. High Ability Type X bearings deliver the best high-speed performance.

11. 3 Performance

High Ability bearings exhibit their maximum performance when used in pairs or when more than two units are combined and when preload is given by position preloading. Shown below is the operating performance of High Ability bearings with preload given by position preloading.

1) Performance of Types R and C

Fig. 11. 3 compares relationships between rotational speed and increases in bearing temperature of Types R and C and conventional high-precision bearings.

High Ability bearings exhibit smaller temperature increases and higher speed limits than conventional bearings whether grease lubrication or oil / air lubrication is applied.

As shown in **Fig. 11. 4**, this type has excellent anti-seizure characteristics with small quantity of lubricant oil in comparison with a conventional type. Thus, the quantity of the lubricant oil can be reduced.

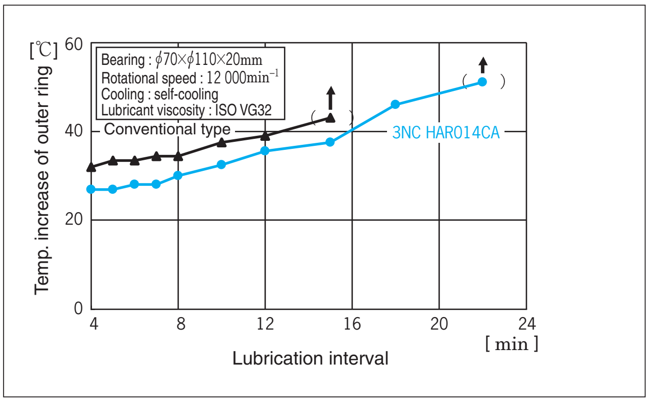


Fig. 11. 4 Comparison of seizure limit oil quantity of Type R and conventional type

High Ability bearings also allow the possible change in lubrication of the spindle from oil / air to grease. **Fig. 11. 5** shows an evaluation example.

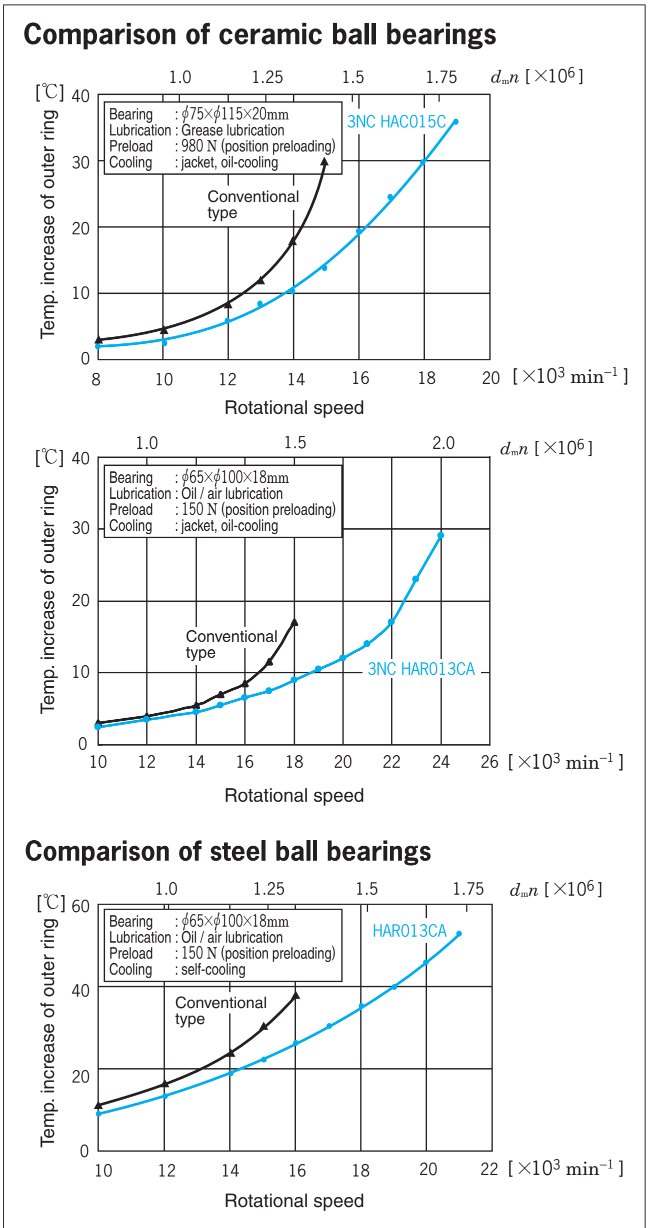


Fig. 11. 3 Comparison of increases in bearing temp.

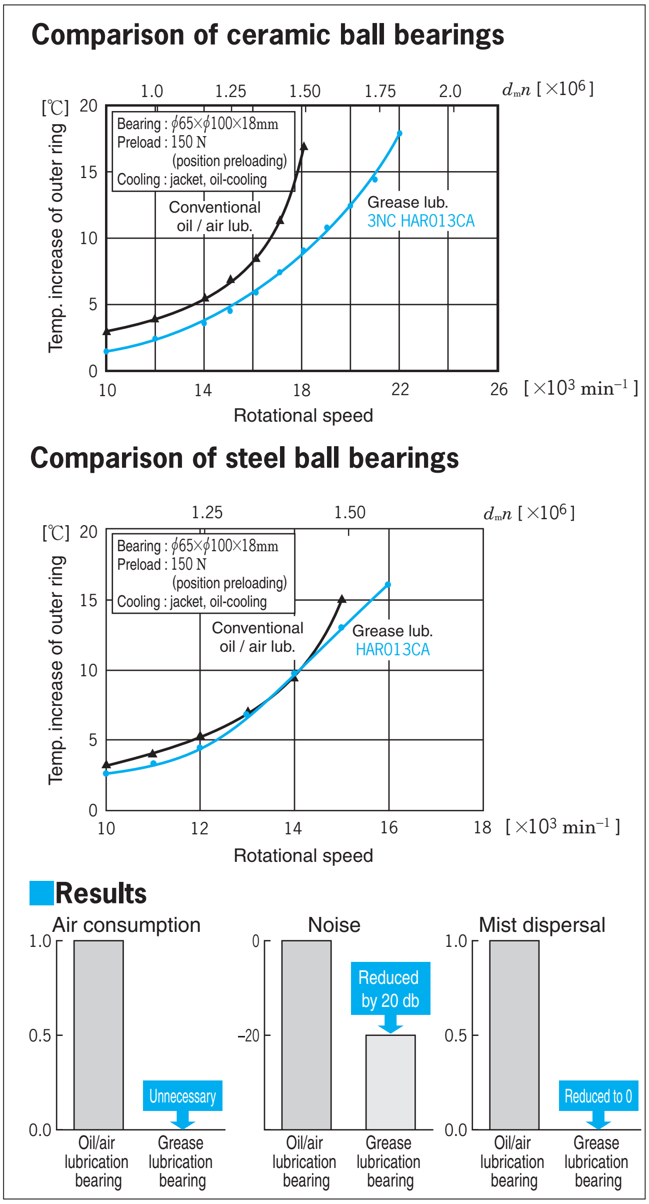


Fig. 11. 5 Comparison of high-speed performance achieved by grease lubrication

2) Performance of Type D

Fig. 11. 6 compares the high-speed performance of Types D and R.

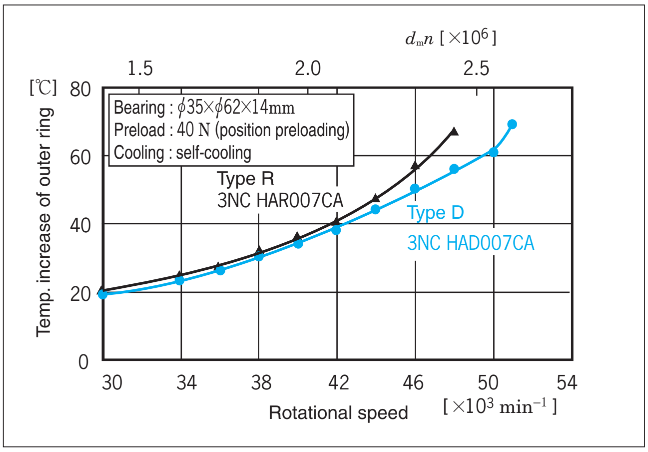


Fig. 11. 6 Comparison of increases in the bearing temp. of Types R and D

Also, Type D causes little wind roar when the bearing is rotating, and is effective in reducing the noise of the spindle device and the air consumption. (**Figs. 11. 7** and **11. 8**)

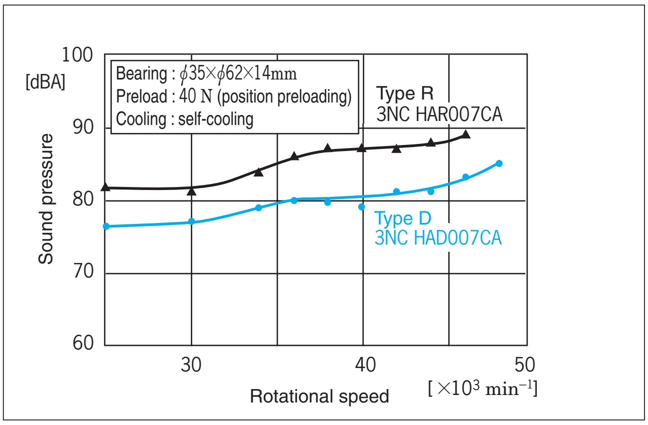


Fig. 11. 7 Comparison of noise by Types R and D

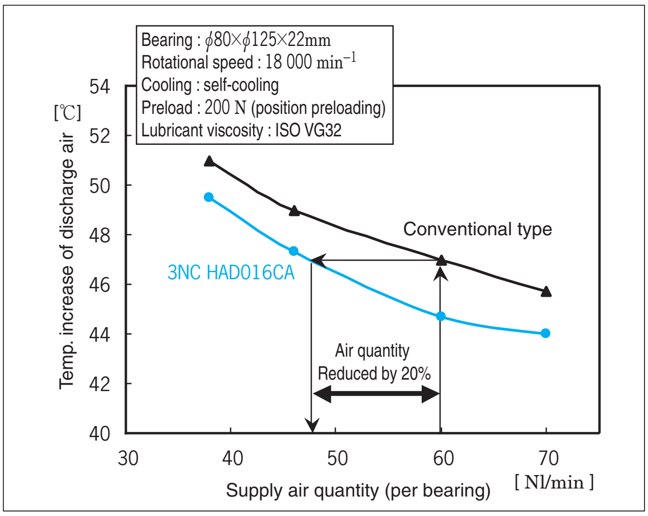


Fig. 11. 8 Comparison of air quantity of Type D and conventional type

3) Performance of Type X

Fig. 11. 9 shows an evaluation example of the Type X bearing operated with a preload given by constant pressure preloading. The maximum rotational speed achieved in this test, or 45 000 min^{-1}, equals 4.05×10^6 in d_mn value.

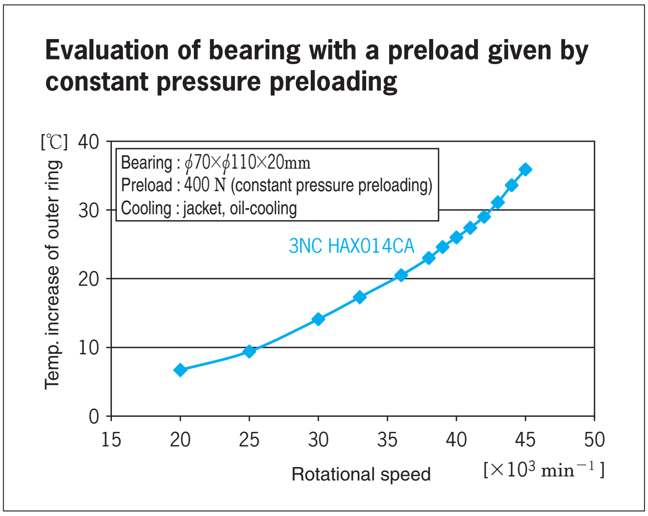


Fig. 11. 9 Temp. increases in Type X bearing

12. Ceramic bearings for machine tool spindles

Compared with bearing steel, ceramics [silicon nitride (Si_3N_4)] has superior properties such as light weight and high elasticity.

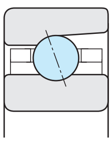
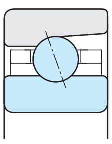
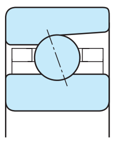
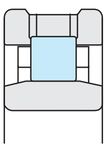
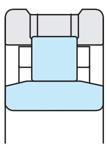
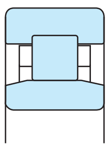
One of the advantages of ceramics when used as a material for bearings is a reduction in the slip of rolling elements caused by centrifugal force and gyroscopic moments under high-speed rotation. Ceramic material is highly effective for meeting the low temperature increase requirements of the bearing.

Other advantages include improved rigidity and improvements in seizure life and grease service life. Ceramic bearings, although varying depending on operating conditions, allow approximately 30% to 50% improvement in speed as compared with steel bearings.

12. 1 Ceramic bearing structures and types

There are three types of ceramic bearings differing in their combinations of ceramic parts. Select the most suitable one from **Table 12. 1** according to the machine tool specifications.

Table 12. 1 Ceramic bearing structures and types

	Codes, types, and structures of ceramic bearings		
Code [1]	3NC	6NC	NC
Description	Rolling element : ceramics	Inner ring Rolling element : ceramics	Inner and outer rings Rolling element : ceramics (Full-ceramic)
Angular contact ball bearing			
Cylindrical roller bearing			

Note 1) A code is placed before a basic bearing number.

12. 2 Properties of ceramics (Si_3N_4)

Sintered in a high temperature and high-pressure gas atmospheric condition (HIP), ceramics (silicon nitride) has many superior properties such as heat resistance, light weight, low coefficient of linear expansion, and a high elastic modulus.

Table 12. 2 shows a comparison of properties with ceramics and bearing steel.

Table 12. 2 Comparison of properties with ceramics and bearing steel

Item	Unit	Ceramics (Si_3N_4)	Bearing steel (SUJ2)
Heat resistance (in the air)	℃	800	120
Density	g/cm^3	3.2	7.8
Coefficient of linear expansion	K^{-1}	3.2×10^{-6}	12.5×10^{-6}
Vickers' hardness	HV	1 300~2 000	700~800
Young's modulus	GPa	320	208
Poisson's ratio	—	0.29	0.3
Thermal conductivity	W/(m·K)	20	41.9~50.2
Corrosion resistance	—	Good	Not good
Magnetism	—	Non-magnetic material	Ferromagnetic material
Electrical conductivity	—	Not applicable (insulant)	Applicable (electric conductor)
Bonding form of material	—	Covalent bond	Metallic bond

12.3 Load ratings of ceramic bearings

JTEKT has adopted the following values as a standard for load ratings of ceramic bearings. These values are determined from a number of experiments and their results.

(1) Dynamic load rating :
Dynamic load rating of steel bearings (C)$\times1.0$ or greater

(2) Static load rating :
Static load rating of steel bearings (C_0)$\times1.0$

The load applied to a spindle bearing for a machine tool is generally very small as compared with bearing load ratings. Accordingly, it is rare that a bearing reaches its fatigue service life or brinelling occur in its raceway surfaces.

Sufficient care, however, should be taken to ensure that no impact load is applied to the bearing during handling and operation.

12. 4 Sample test data of ceramic bearings

1) High-speed performance of bearings

Ceramic is superior to bearing steel in high-speed rotation performance because it has lower density and linear expansion coefficient.

■ Comparison with steel bearing (1)

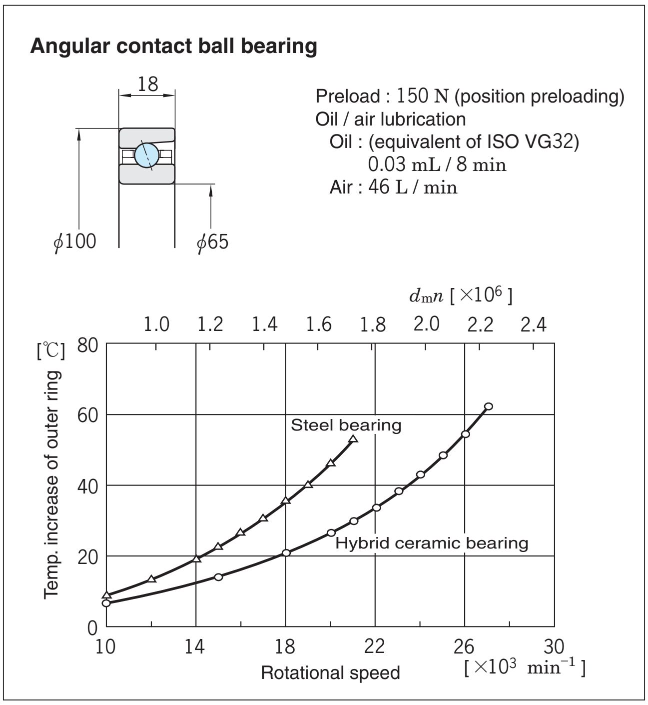


Fig. 12. 1 Comparison of Angular contact ball bearing

■ Comparison with steel bearing (2)

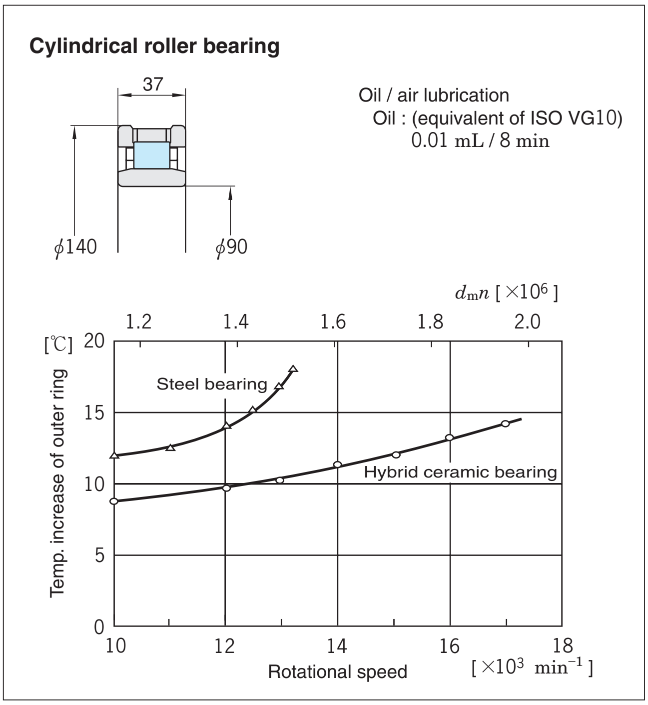


Fig. 12. 2 Comparison of cylindrical roller bearing

■ High-speed performance (1)

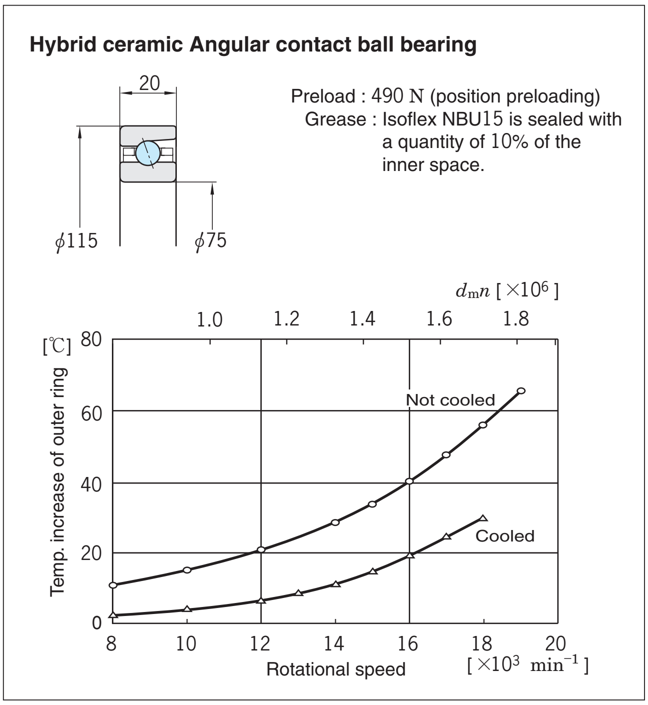


Fig. 12. 3 High speed performance with grease lub.

■ High-speed performance (2)

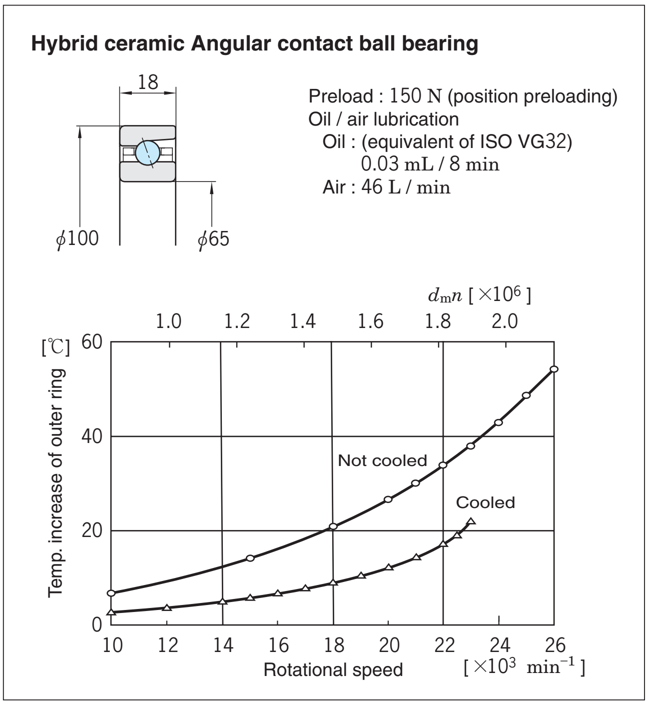


Fig. 12. 4 High speed performance with oil / air lub.

The 6NC type hybrid ceramic bearings, whose balls and inner ring are both made of ceramic, are superior in high-speed performance to the 3NC type.

In addition, the low-torque 6NC type bearings exhibit lower power losses at high rotational speeds.

■ High-speed performance (3)

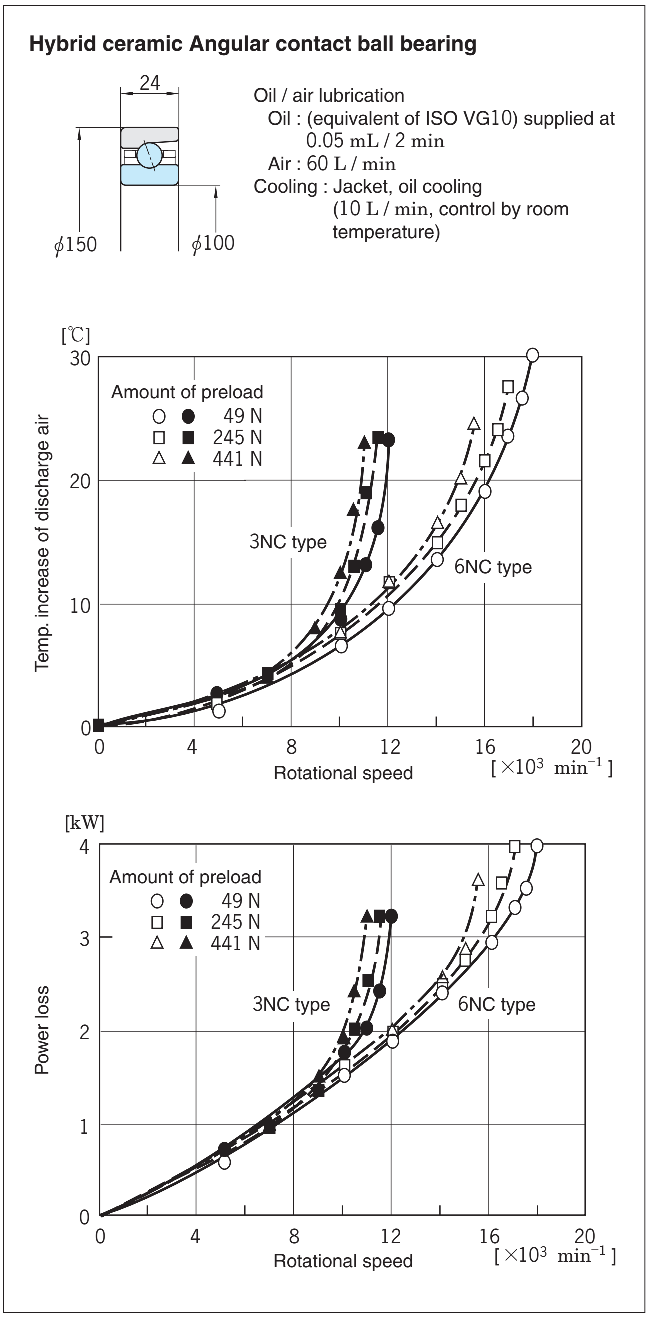


Fig. 12. 5 Comparison of 3NC type and 6NC type hybrid ceramic bearings

Since ceramics and steel have different co-efficients of linear expansion, Young's moduli, and Poisson's ratios, care should be taken when fitting for mounting a 6NC type hybrid ceramic bearing on a shaft is selected.

Consult **JTEKT**.

2) Rigidity of bearing

Since ceramics have a greater Young's modulus than bearing steel, the rigidity of a ceramic bearing is higher than that of a steel bearing.

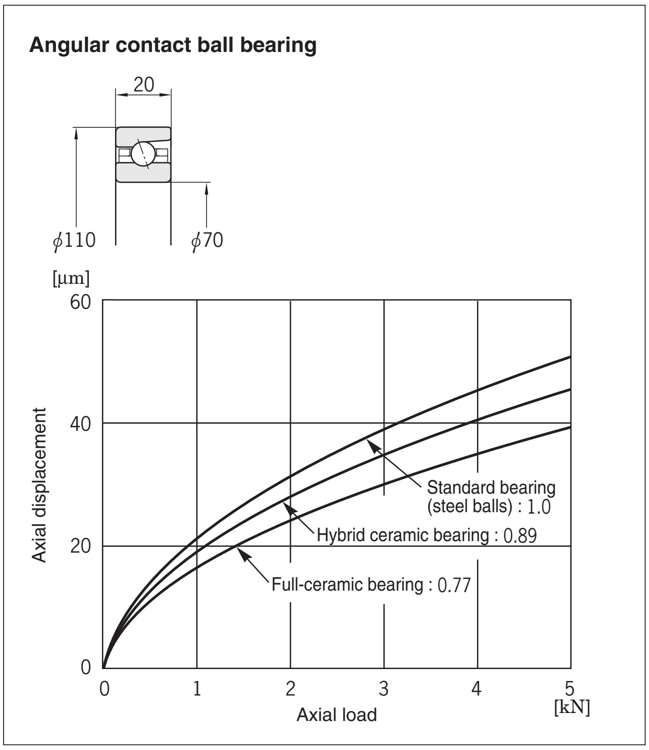


Fig. 12. 6 Comparison of axial displacement

3) Changes in shaft dimensions

Compared with steel bearings, ceramic bearings have higher rigidity and lower temperature increase, thus reducing the risk of changes in shaft dimensions.

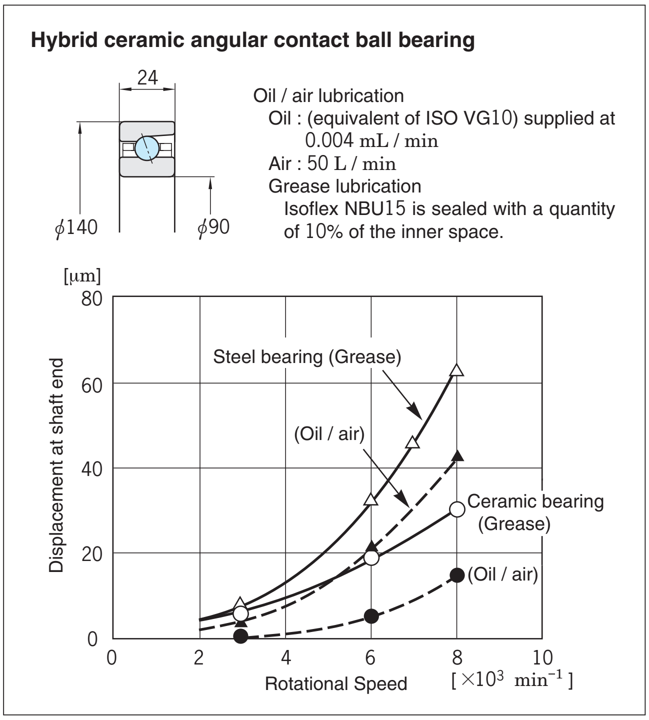


Fig. 12. 7 Comparison of displacement at shaft end

4) Fatigue service life and seizure life of bearings

Ceramic bearings are superior to steel bearings in both seizure life and fatigue service life.

■ Seizure life test results (1)

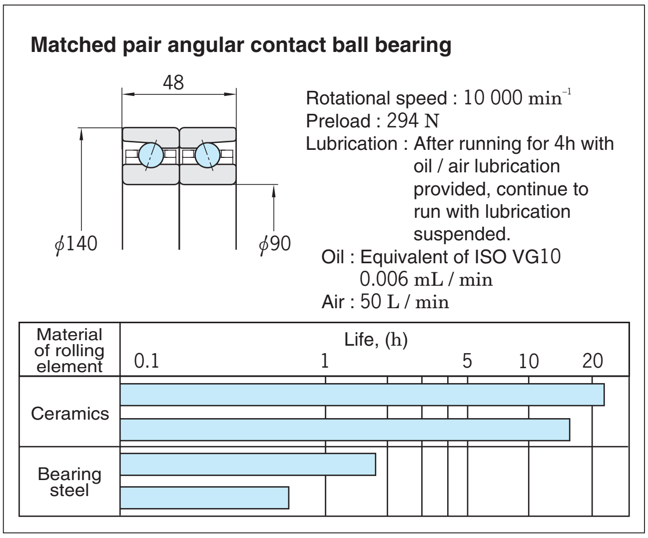


Fig. 12. 8 Seizure life test results of hybrid ceramic bearings and steel bearings

■ Seizure life test results (2)

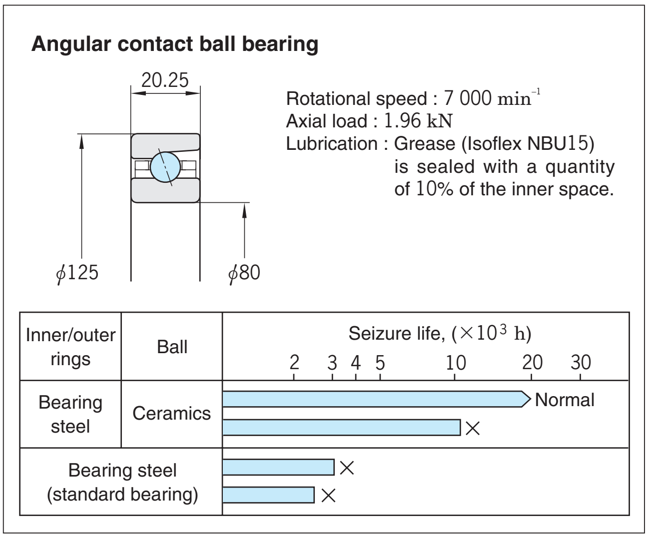


Fig. 12. 9 Seizure life test results of hybrid ceramic bearing and steel bearing

■ Seizure life test results (3)

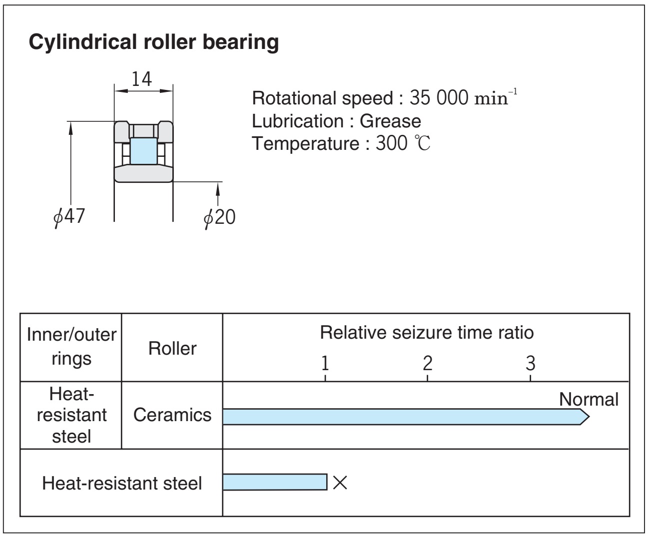


Fig. 12. 10 Seizure life test results of hybrid ceramic bearings and heat resisting steel bearings

■ Fatigue service life test result

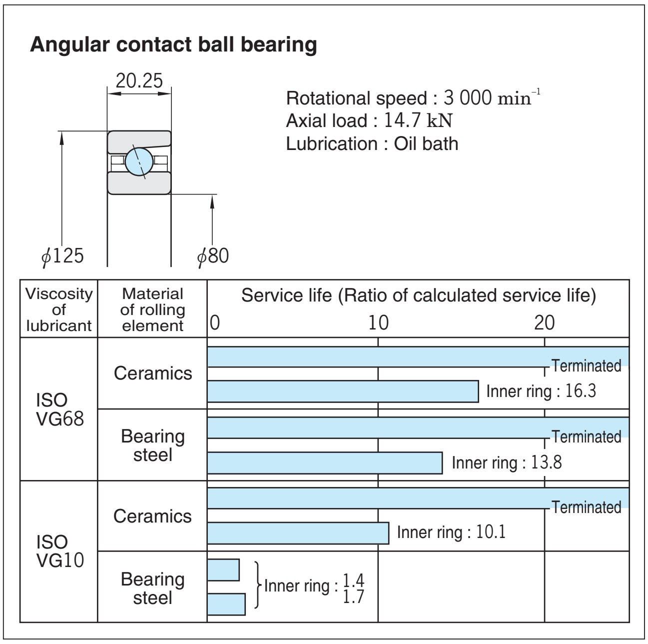


Fig. 12. 11 Life test results of a hybrid ceramic bearing

Koyo®

Precision Ball & Roller Bearings

Bearing Dimension Tables

1. Angular Contact Ball Bearings

Contents

1. Angular contact ball bearings

The angular contact ball bearing can receive a radial load, unidirectional axial load, or a combination of the above loads.

There are four different contact angles to choose from when angular contact ball bearings are considered: 15° (contact angle symbol: C), 20° (CA), 30° (A: to be omitted), and 40° (B).

Of these types, the 15° (contact angle symbol: C), 20° (CA) and 30° (A) bearings are usually used for spindle of machine tools (see **Fig. 1. 1**).

The greater the contact angle, the higher the axial rigidity, and the smaller the contact angle, the more advantageous for high-speed rotations.

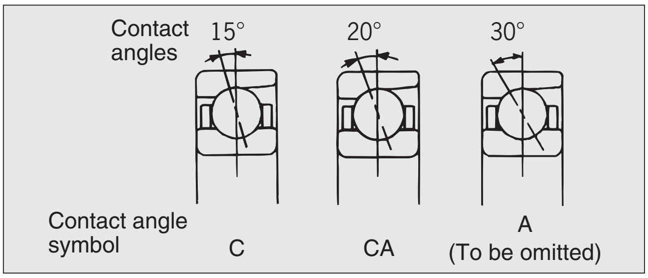


Fig. 1. 1 Contact angles of angular contact ball bearings

1. 1 Types and features of angular contact ball bearings

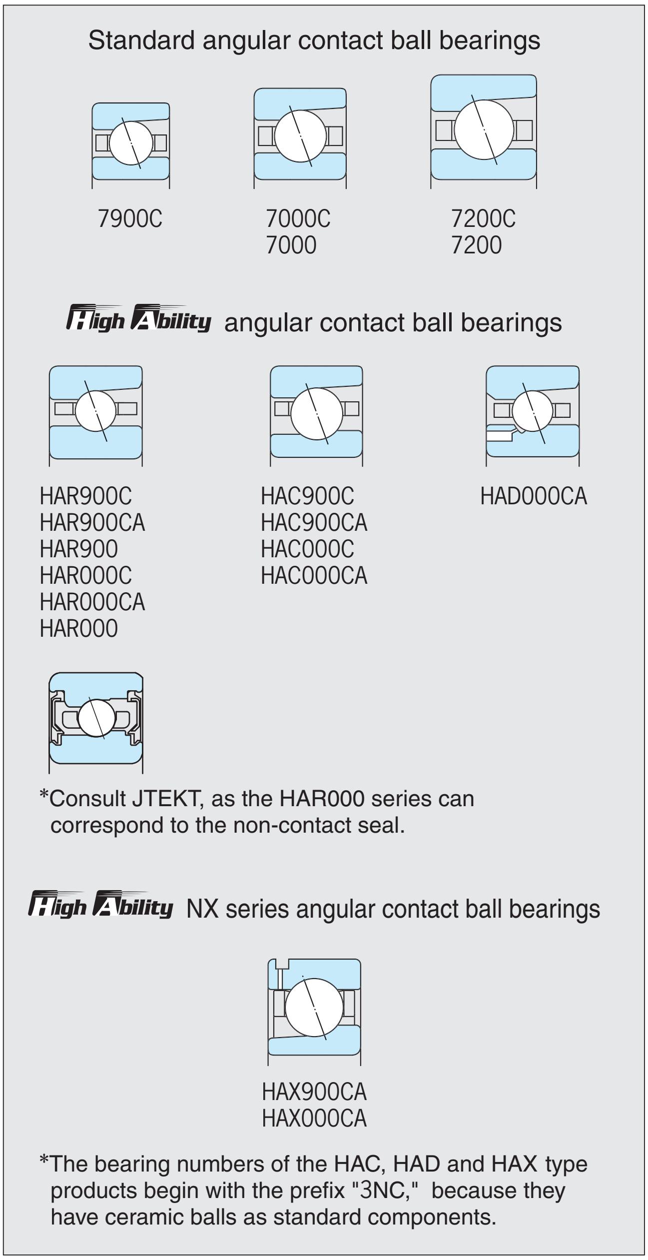


Fig. 1. 2 Types and series of angular contact ball bearings

1) Standard angular contact ball bearings

7900C
7000C, 7000 series
7200C, 7200

The standard cage is of the ball-guided type and is made from polyamide resin.

2) High Ability angular contact ball bearings

HAR900C, HAR900CA, HAR900 HAR000C, HAR000CA, HAR000	High-rigidity type
HAC000C, HAC000CA, HAC900C HAC900CA	High load-rating type
HAD000CA	Ultrahigh-speed type

- The High Ability angular contact ball bearings are optimized for use on high-speed machine tool spindles. They are available in three types: high-rigidity type, high load-rating type, and ultrahigh-speed type. (The ultrahigh-speed type is used with oil / air lubrication.)
- The standard contact angle of these bearings is 20°. The high-rigidity type products are also available with a contact angle of 15° and 30°. The high load-rating type products are also available with a contact angle of 15°.
- These bearings have ceramic balls and an outer ring-guided cage made from reinforced phenol resin as standard components.
  Steel-ball products and ball-guided cage products are also available to suit your needs.

3) High Ability NX series angular contact ball bearings

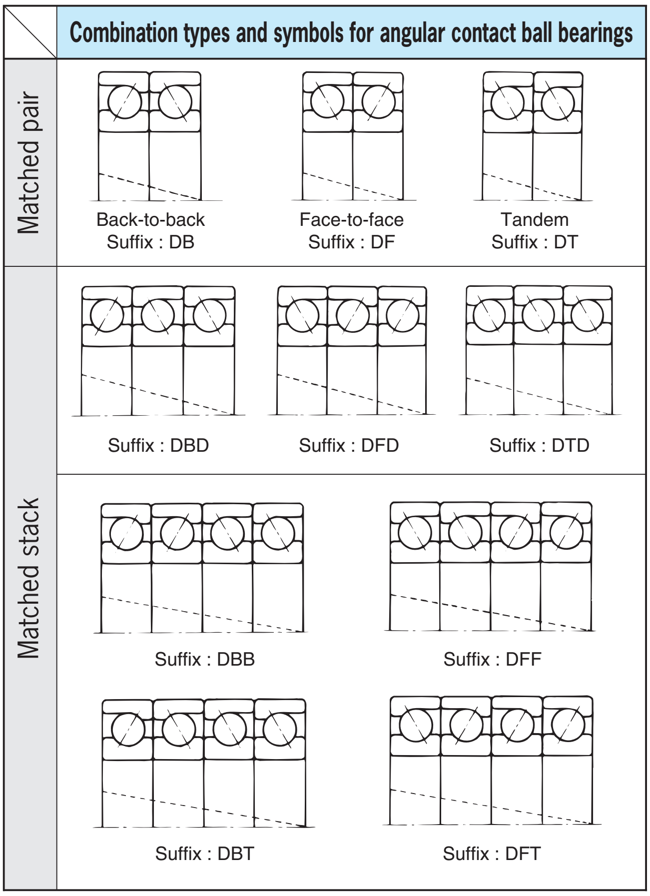
HAX000CA, HAX900CA	Extremely ultrahigh-speed type

- The High Ability NX Series angular contact ball produces less heat and has better high-speed performance than conventional High Ability Series products.
- The standard contact angle of these bearings is 20°. This type of bearing has ceramic balls and an outer ring-guided cage made from PEEK resin.

1. 2 Matched pair angular contact ball bearings

Angular contact ball bearings are used in matched pair, or in combinations of more than two bearings. **Table 1. 1** shows combination types and symbols for angular contact ball bearings.

Table 1. 1 Combination types and symbols for angular contact ball bearings



[Remark] - - - - - indicates the direction of the "V" mark.

Matched pair angular contact ball bearings are adjusted to a preset amount of preload and axial clearance.

The standard preloads are divided into 4 classes : slight preload (symbol : S), light preload (L), medium preload (M), and heavy preload (H). **Table 1. 4** (page 63) shows amounts of standard preloads.

Type G bearings

The type G bearing has both sides machined (flush-ground) to obtain the same stand-out between the inner and outer rings (see **Fig. 1. 3**).

This makes it possible to select any desired combination(s) from **Table 1. 1**.

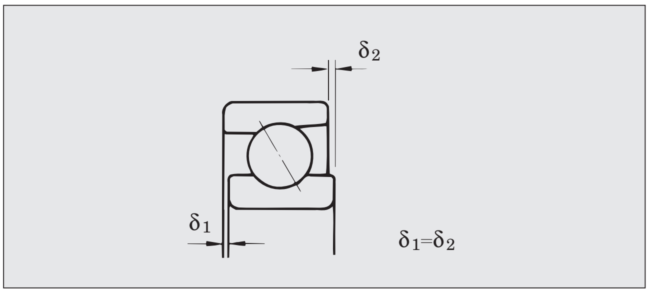


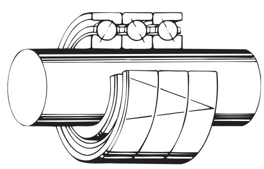
Fig. 1. 3 Flush-ground type G bearings

- Examples of identification numbers of type G bearings

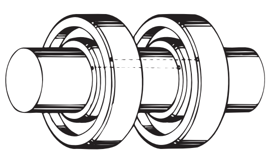
7010GL : Adjustment is made so that any combination of two or more bearings presents light preload (preload symbol : L).

7010GL×2 : Adjustment is made so that any combination of this set of two bearings presents light preload (preload symbol : L).

Cautions for assembly



(Combination mark)



(Mark indicating position of maximum eccentricity)

① A "V" mark is put on the outside surfaces of the outer rings of matched pair or matched stack angular contact ball bearings, to indicate their combination mode. Combine them in such a way that the marks on the outer ring form a "V".

② Chamfered edges of the inner and outer rings are marked with a circle "◯", which shows the position of maximum eccentricity.

Mount bearings so that the "◯" marks on the inner and outer rings are opposite (180°) to the position of maximum eccentricity of the shaft or housing. By doing so, maximum running accuracy is obtained.

1. 3 Composition of bearing numbers (angular contact ball bearings)

7018C–5K5DBL /27AFTP5

3NCHAC018C–5K5DBCS5/27AFGP4

Ceramic bearing

Bearing type symbols
- 7 : angular contact ball bearing
- HAR, HAC, HAD : High Ability angular contact ball bearings
- HAX : High Ability NX series angular contact ball bearings

Dimension series symbols
- 9 : dimension series 19
- 0 : dimension series 10
- 2 : dimension series 02

Bore diameter number
- 18 : nominal bore diameter : 90 mm
  (bore diameter number × 5 equals nominal bore diameter.)

Contact angle symbols
- A : nominal contact angle : 30° (A is to be omitted.)
- C : nominal contact angle : 15°
- CA : nominal contact angle : 20°

Cage guiding system symbols
- No specified : outer ring-guiding
- –5 : ball-guiding

Special permissible dimensional deviation symbols
- K5 : **JTEKT**'s special permissible dimensional deviations are used for the bore diameter of the inner ring and the outside diameter of the outer ring.
- No specified : If standard permissible dimensional deviations are used.

Matched pair or stack symbols
- DB : back-to-back
- DF : face-to-face
- DT : tandem
  For suffixes that denote bearings which consist of three or four bearings, see **Table 1. 1** (page 59).
- G : Type G bearing (flush-ground bearing)

Preload symbol* or clearance symbols
(*In some cases, a symbol denoting the specific preload is used.)
- S : slight preload
- L : light preload
- M : medium preload
- H : heavy preload
- CS : clearance
- CY : negative clearance (preload)
  (CS5 : The mean value of the clearance is 5µm.)

(For amount of preload, see **Table 1. 4** (page 63).)

Spacer number/symbols
- No specified : If no spacer is provided.
- /27 : spacer with lubrication hole, 27 mm in nominal width
- A : spacer not provided with lubrication hole (symbol A is not used if the spacer has a lubrication hole.)

Cage symbols
- FG : molded cage made of polyamide resin
- FT : machined cage made of reinforced phenolic
- FY : machined cage made of copper alloy
- PG : PEEK resin cage

Tolerance class symbols
- P5 : JIS class 5
- P4 : JIS class 4
- P2 : JIS class 2

1. 4 Tolerance of bearings

The tolerance of the precision angular contact ball bearing is compliant with permissible dimensional deviations and limits of classes 5, 4, and 2 as specified in JIS B 1514 for radial bearings (tapered roller bearings not included).

Permissible dimensional deviations and limits of radial bearings are shown in **Table 1. 2**.

Table 1. 3 (page 62) shows **JTEKT**'s special permissible dimensional deviations (K5) used to facilitate multi-row combinations (K5 is used for the bore diameter of the inner ring and the outside diameter of the outer ring).

Table 1. 2(1) Permissible dimensional deviations and limits of angular contact ball and cylindrical roller bearings

(1) Inner ring

Unit : μm

Nominal bore diameter d (mm)		Single plane mean bore diameter deviation Δ_{dmp}						Single bore diameter deviation Δ_{ds} [1)]				Single plane bore diameter variation V_{dsp}					Mean bore diameter variation V_{dmp}		
												Diameter series 7, 8, 9		Diameter series 0, 1, 2, 3, 4		–			
		Class 5		Class 4		Class 2		Class 4		Class 2		Class 5	Class 4	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2
over	up to	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	max.		max.		max.	max.		
10	**18**	0	– 5	0	– 4	0	–2.5	0	– 4	0	–2.5	5	4	4	3	2.5	3	2	1.5
18	**30**	0	– 6	0	– 5	0	–2.5	0	– 5	0	–2.5	6	5	5	4	2.5	3	2.5	1.5
30	**50**	0	– 8	0	– 6	0	–2.5	0	– 6	0	–2.5	8	6	6	5	2.5	4	3	1.5
50	**80**	0	– 9	0	– 7	0	–4	0	– 7	0	–4	9	7	7	5	4	5	3.5	2
80	**120**	0	–10	0	– 8	0	–5	0	– 8	0	–5	10	8	8	6	5	5	4	2.5
120	**150**	0	–13	0	–10	0	–7	0	–10	0	–7	13	10	10	8	7	7	5	3.5
150	**180**	0	–13	0	–10	0	–7	0	–10	0	–7	13	10	10	8	7	7	5	3.5
180	**250**	0	–15	0	–12	0	–8	0	–12	0	–8	15	12	12	9	8	8	6	4
250	**315**	0	–18	*0*	*–15*	–	–	*0*	*–15*	–	–	18	*15*	14	*11*	–	9	*8*	–
315	**400**	0	–23	*0*	*–18*	–	–	*0*	*–18*	–	–	23	*18*	18	*14*	–	12	*9*	–

Nominal bore diameter d (mm)		Radial runout of assembled bearing inner ring K_{ia}			S_d			S_{ia} [2)]			Single inner ring width deviation Δ_{Bs}				Single inner ring width deviation Δ_{Bs} [3)]		Inner ring width variation V_{Bs}		
		Class 5	Class 4	Class 2	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2	Classes 5, 4		Class 2		Classes 5, 4		Class 5	Class 4	Class 2
over	up to	max.			max.			max.			upper	lower	upper	lower	upper	lower	max.		
10	**18**	4	2.5	1.5	7	3	1.5	7	3	1.5	0	– 80	0	– 80	0	–250	5	2.5	1.5
18	**30**	4	3	2.5	8	4	1.5	8	4	2.5	0	–120	0	–120	0	–250	5	2.5	1.5
30	**50**	5	4	2.5	8	4	1.5	8	4	2.5	0	–120	0	–120	0	–250	5	3	1.5
50	**80**	5	4	2.5	8	5	1.5	8	5	2.5	0	–150	0	–150	0	–250	6	4	1.5
80	**120**	6	5	2.5	9	5	2.5	9	5	2.5	0	–200	0	–200	0	–380	7	4	2.5
120	**150**	8	6	2.5	10	6	2.5	10	7	2.5	0	–250	0	–250	0	–380	8	5	2.5
150	**180**	8	6	5	10	6	4	10	7	5	0	–250	0	–250	0	–380	8	5	4
180	**250**	10	8	5	11	7	5	13	8	5	0	–300	0	–300	0	–500	10	6	5
250	**315**	13	*10*	–	13	*8*	–	15	*9*	–	0	–350 [4)]	–	–	0	–500 [4)]	13	*8*	–
315	**400**	15	*13*	–	15	*9*	–	20	*12*	–	0	–400 [4)]	–	–	0	–630 [4)]	15	*9*	–

S_d : Perpendicularity of inner ring face with respect to the bore

S_{ia} : Axial runout of assembled bearing inner ring

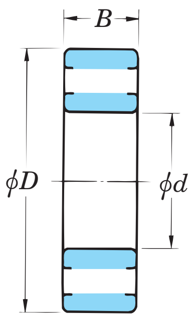
[Notes] 1) Tolerance class 4 is applied to bearings of diameter series 0, 1, 2, 3, and 4.

2) Applied to angular contact ball bearings.

3) Applied to individual bearing rings manufactured for matched pair or stack bearings.

4) Class 5 tolerance complies with JIS; class 4 tolerance is **JTEKT** standard.

[Remark] Values in italics comply with **JTEKT** standards.



d : nominal bore diameter

D : nominal outside diameter

B : nominal bearing width

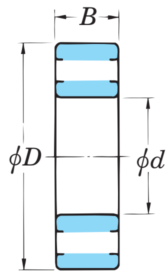
Table 1. 2(2) Permissible dimensional deviations and limits of angular contact ball and cylindrical roller bearings

(2) Outer ring

Unit : μm

Nominal outside diameter D (mm)		Single plane mean outside diameter deviation Δ_{Dmp}						Single outside diameter deviation Δ_{Ds} [1]				Single plane outside diameter variation V_{Dsp}					Mean outside diameter variation V_{Dmp}		
		Class 5		Class 4		Class 2		Class 4		Class 2		Diameter series 7, 8, 9		Diameter series 0, 1, 2, 3, 4		–			
												Class 5	Class 4	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2
over	up to	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	max.		max.		max.	max.		
18	**30**	0	–6	0	–5	0	–4	0	–5	0	–4	6	5	5	4	4	3	2.5	2
30	**50**	0	–7	0	–6	0	–4	0	–6	0	–4	7	6	5	5	4	4	3	2
50	**80**	0	–9	0	–7	0	–4	0	–7	0	–4	9	7	7	5	4	5	3.5	2
80	**120**	0	–10	0	–8	0	–5	0	–8	0	–5	10	8	8	6	5	5	4	2.5
120	**150**	0	–11	0	–9	0	–5	0	–9	0	–5	11	9	8	7	5	6	5	2.5
150	**180**	0	–13	0	–10	0	–7	0	–10	0	–7	13	10	10	8	7	7	5	3.5
180	**250**	0	–15	0	–11	0	–8	0	–11	0	–8	15	11	11	8	8	8	6	4
250	**315**	0	–18	0	–13	0	–8	0	–13	0	–8	18	13	14	10	8	9	7	4
315	**400**	0	–20	0	–15	0	–10	0	–15	0	–10	20	15	15	11	10	10	8	5
400	**500**	0	–23	*0*	*–17*	–	–	*0*	*–17*	–	–	23	*17*	17	*13*	–	12	*9*	–
500	**630**	0	–28	*0*	*–20*	–	–	*0*	*–20*	–	–	28	*20*	21	*15*	–	14	*10*	–

Nominal outside diameter D (mm)		Radial runout of assembled bearing outer ring K_{ea}			Perpendicularity of outer ring outside surface with respect to the face S_D			Axial runout of assembled bearing outer ring S_{ea} [2]			Deviation of a single outer ring width Δ_{Cs}		Ring width variation V_{Cs}		
		Class 5	Class 4	Class 2	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2	Classes 5, 4, 2		Class 5	Class 4	Class 2
over	up to	max.			max.			max.			upper	lower	max.		
18	**30**	6	4	2.5	8	4	1.5	8	5	2.5	Same as tolerance Δ_{Bs}, d being that of the same bearing.		5	2.5	1.5
30	**50**	7	5	2.5	8	4	1.5	8	5	2.5			5	2.5	1.5
50	**80**	8	5	4	8	4	1.5	10	5	4			6	3	1.5
80	**120**	10	6	5	9	5	2.5	11	6	5			8	4	2.5
120	**150**	11	7	5	10	5	2.5	13	7	5			8	5	2.5
150	**180**	13	8	5	10	5	2.5	14	8	5			8	5	2.5
180	**250**	15	10	7	11	7	4	15	10	7			10	7	4
250	**315**	18	11	7	13	8	5	18	10	7			11	7	5
315	**400**	20	13	8	13	10	7	20	13	8			13	8	7
400	**500**	23	*15*	–	15	*12*	–	23	*15*	–			15	*9*	–
500	**630**	25	*18*	–	18	*13*	–	25	*18*	–			18	*11*	–



d : nominal bore diameter
D : nominal outside diameter
B : nominal bearing width

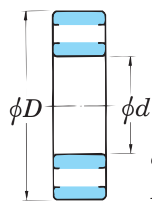
[Notes] 1) Tolerance class 4 is applied to bearings of diameter series 0, 1, 2, 3, and 4.
2) Applied to angular contact ball bearings.

[Remark] Values in italics comply with **JTEKT** standards.

Table 1. 3 JTEKT's specific tolerances of angular contact ball bearings (K5)[1]

Unit : μm

Nominal bore diameterd d (mm)		Single plane mean bore or outside diameter deviation Δ_{dmp}, Δ_{Dmp}			
		Class 5		Class 4	
over	up to	upper	lower	upper	lower
–	**50**	–1	–4	–1	–3
50	**80**	–1	–5	–1	–4
80	**120**	–1	–5	–1	–4
120	**150**	–1	–5	–1	–4
150	**180**	–1	–5	–1	–4
180	**250**	–1	–5	–1	–4



d : nominal bore diameter
D : nominal outside diameter

[Note] 1) K5 denotes specially formulated **JTEKT** standards for the purpose of minimizing individual differences in performance, which may occur as a result of fitting stack-mounted to bearings.

1. 5 Standard preloads for matched pair angular contact ball bearings

Back-to-back and face-to-face matched pair bearings are often used under a preload.
By applying a preload to a bearing, the following effects are realized.

1) The rigidity of a bearing can be improved.
2) Running accuracy is improved.
3) Abnormal noise caused by vibration and resonance is prevented.

A greater preload results in higher bearing rigidity. However, such preload also influences other parameters of the bearing : service life, temperature, frictional torque, etc.
Therefore, it is important to select an adequate preload, taking into consideration the rotational speed and lubrication conditions.

JTEKT offers 4 types of preset preloads, slight preload (S), light preload (L), medium preload (M), and heavy preload (H). This will enable the user to select any desired preload suitable for individual applications (see **Table 1. 4**).

As a guide for selecting the preload, light or medium preload is used for spindles of grinding machines, while medium or heavy preloads are used for spindle of lathes and milling machines.

Table 1. 4(1) Standard preloads for matched pair angular contact ball bearings

(S : slight preload; L : light preload; M : medium preload; H : heavy preload) Unit : N

Bore dia. No.	Bore dia. (mm)	7900C			7000C				7000		
		S	L	M	S	L	M	H	L	M	H
00	10	5	15	30	6	20	50	100	30	80	145
01	12	7	20	40	6	20	50	100	30	80	145
02	15	8	25	50	10	30	80	145	50	145	245
03	17	8	25	50	15	40	100	195	60	145	295
04	20	15	40	80	15	40	100	245	60	145	295
05	25	15	50	100	20	60	145	295	100	245	490
06	30	15	50	100	25	80	195	390	145	295	635
07	35	25	70	140	35	100	245	490	145	390	785
08	40	25	80	155	35	100	295	590	145	390	785
09	45	35	100	195	50	145	345	635	245	540	980
10	50	35	100	195	50	145	390	735	245	635	1 180
11	55	40	120	235	65	195	440	880	295	785	1 370
12	60	40	120	235	65	195	490	980	390	880	1 570
13	65	50	145	295	85	245	540	1 090	440	980	1 770
14	70	65	195	390	85	245	635	1 270	490	1 080	2 060
15	75	65	195	390	100	295	685	1 370	590	1 180	2 150
16	80	65	195	390	100	295	735	1 470	635	1 370	2 350
17	85	85	245	490	130	390	880	1 770	735	1 570	2 550
18	90	100	295	590	145	440	980	1 960	785	1 670	2 840
19	95	100	295	590	160	490	1 080	2 060	880	1 770	3 140
20	100	100	345	685	175	540	1 180	2 150	880	1 960	3 530
21	105	100	345	685	195	590	1 270	2 350	980	2 150	3 920
22	110	145	390	785	210	635	1 470	2 550	1 080	2 350	4 410
24	120	145	490	980	225	685	1 670	2 840	1 180	2 650	4 900
26	130	195	590	1 180	245	735	1 770	3 140	1 370	3 140	5 390
28	140	195	635	1 270	260	785	1 960	3 920	1 470	3 430	5 880
30	150	245	735	1 470	275	835	2 150	4 410	1 770	3 920	6 860
32	160	245	785	1 570	290	880	2 350	4 900	2 150	4 410	7 840
34	170	345	880	1 810	325	980	2 450	5 390	2 450	4 900	8 820
36	180	345	1 130	2 250	440	1 180	2 600	5 880	2 790	5 590	9 120
38	190	345	1 170	2 400	490	1 320	2 790	6 370	3 140	6 180	9 410
40	200	440	1 620	3 090	590	1 470	2 940	6 860	3 430	6 860	9 800

* Table 1.4 shows the standard preloads for matched pairs (DB, DF).
The standard preloads for matched triplicates (DBD, DFD) are obtained by multiplying the preloads in this table by 1.359.

Table 1. 4(2) Standard preloads for matched pair angular contact ball bearings

(S : slight preload; L : light preload; M : medium preload; H : heavy preload) Unit : N

Bore dia. No.	Bore dia. (mm)	7200C				7200		
		S	L	M	H	L	M	H
00	10	10	30	80	145	50	145	245
01	12	15	40	100	195	60	145	295
02	15	15	50	145	245	80	245	390
03	17	25	70	145	345	100	245	540
04	20	25	80	195	390	145	295	635
05	25	35	100	245	490	145	390	785
06	30	35	100	295	590	145	590	930
07	35	50	145	390	785	245	785	1 270
08	40	65	195	440	880	390	880	1 570
09	45	85	245	540	1 080	490	1 080	1 770
10	50	85	245	590	1 180	540	1 180	2 060
11	55	100	295	735	1 470	635	1 370	2 450
12	60	115	345	785	1 670	785	1 470	2 940
13	65	130	390	930	1 860	835	1 670	3 330
14	70	160	490	980	2 060	930	1 860	3 720
15	75	195	590	1 180	2 350	980	2 150	3 920
16	80	225	685	1 370	2 750	1 080	2 450	4 310
17	85	260	785	1 570	2 940	1 270	2 940	4 900
18	90	260	785	1 770	3 430	1 470	3 230	5 390
19	95	290	880	1 960	3 920	1 670	3 430	5 880
20	100	325	980	2 150	4 410	1 860	3 920	6 370
21	105	360	1 080	2 350	4 900	2 060	4 310	7 060
22	110	385	1 180	2 450	5 290	2 250	4 900	7 840
24	120	420	1 270	2 840	5 490	2 450	5 390	8 820
26	130	485	1 470	3 140	5 880	2 750	5 880	9 310
28	140	520	1 570	3 430	6 370	2 940	6 370	9 800
30	150	585	1 770	3 720	6 860	3 330	6 860	10 300
32	160	645	1 960	4 120	7 840	3 630	7 350	10 800
34	170	645	2 150	4 410	8 330	3 920	7 840	11 800
36	180	685	2 300	4 710	8 830	4 220	8 340	12 500
38	190	735	2 450	5 000	9 320	4 510	8 830	13 100
40	200	785	2 650	5 300	9 810	4 810	9 320	13 400

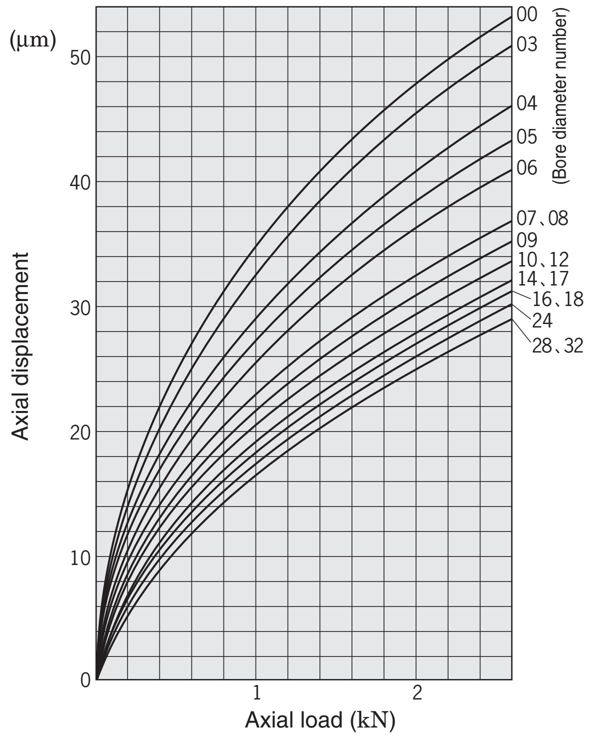
1. 6 Axial load and displacement (angular contact ball bearings)

Fig. 1. 4 shows relationships between axial load and displacement of **KOYO** angular contact ball bearings.

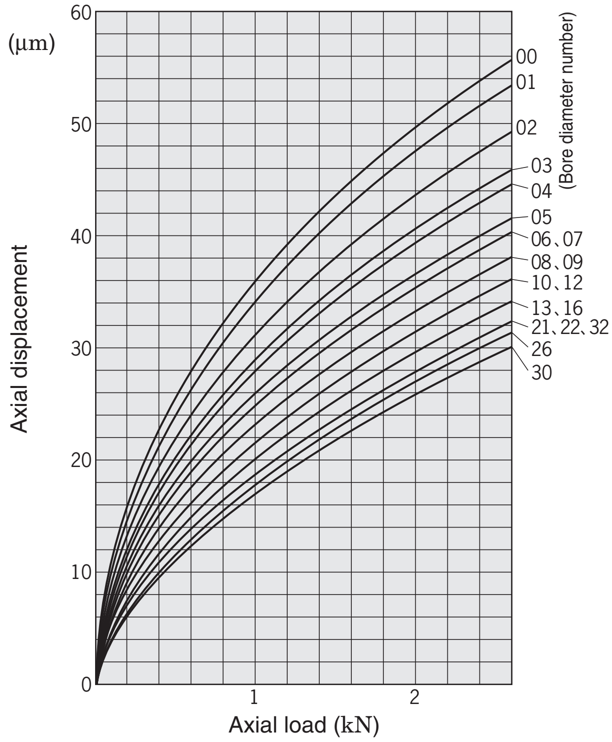
The graphs indicate that the greater the contact angle of a bearing, the smaller the axial displacement (high rigidity).

The displacement curve of duplex bearings under a given preload is determined by the method shown in **Fig. 6. 1** on page 30.

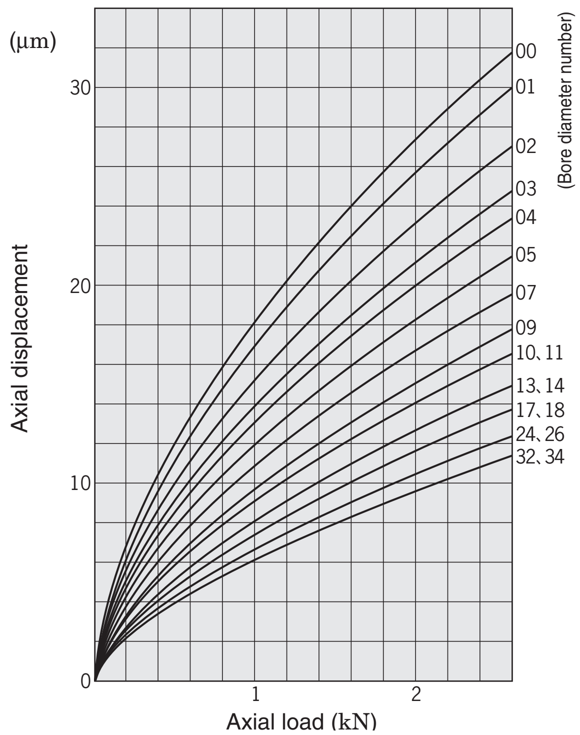
(1) 7900C series (contact angle : 15°)



(2) 7000C series (contact angle : 15°)



(3) 7000 series (contact angle : 30°)



(4) 7200C series (contact angle : 15°)

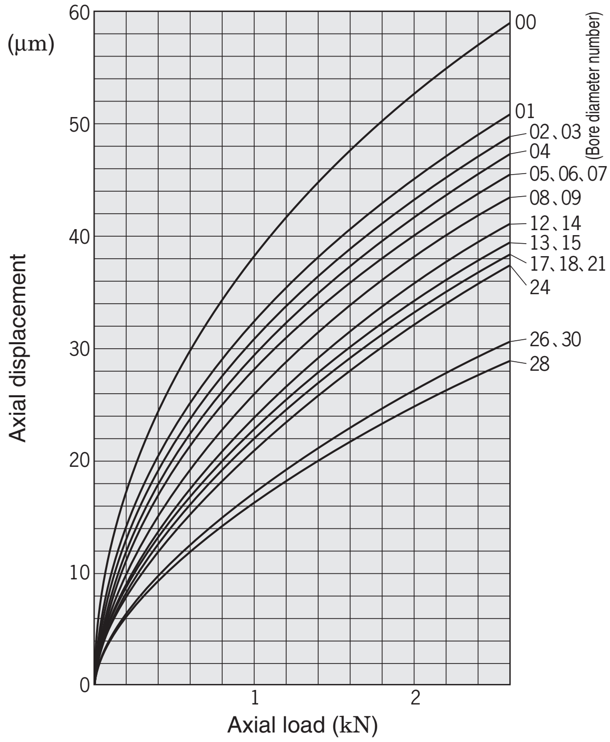
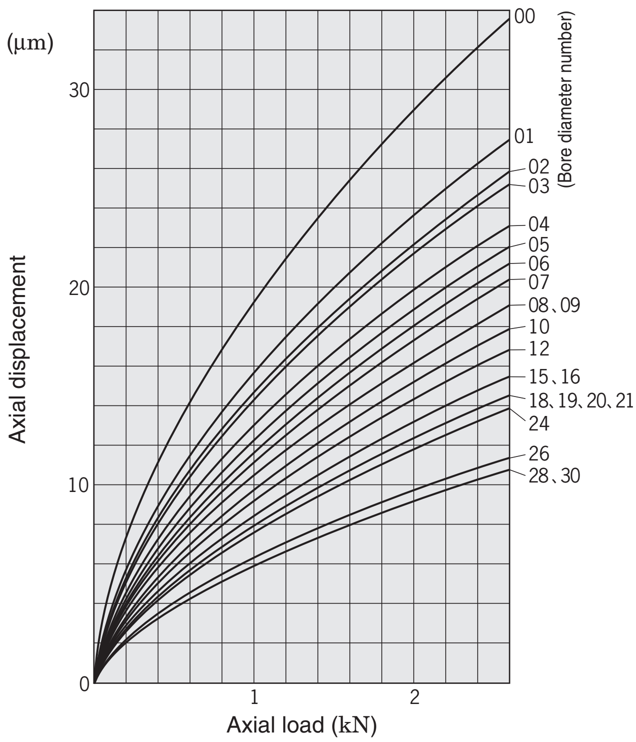


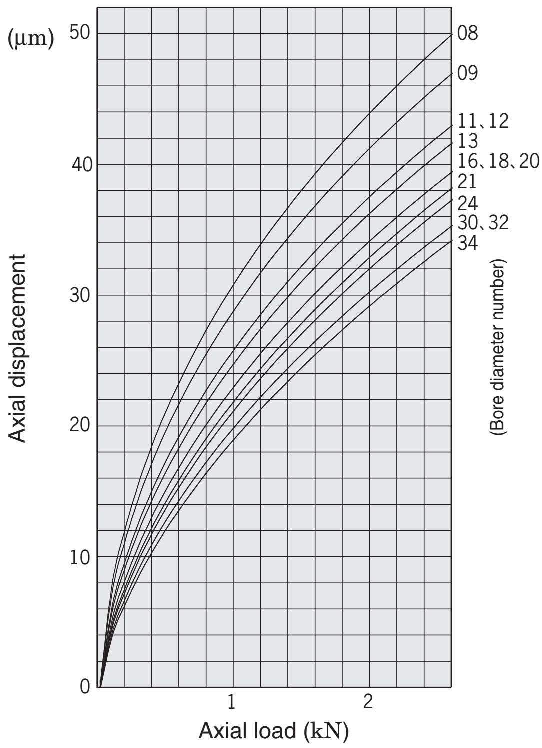
Fig. 1. 4 (1) Relationships between axial load and displacement (angular contact ball bearings)

*The axial displacements shown above are values of the single-row bearings not preloaded.

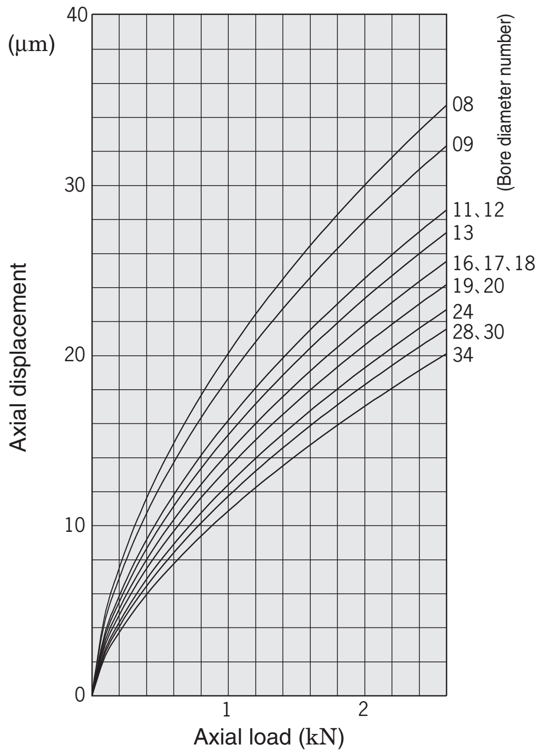
(5) 7200 series (contact angle : 30°)



(6) HAR900C series (contact angle : 15°)



(7) HAR900CA series (contact angle : 20°)



(8) HAR900 series (contact angle : 30°)

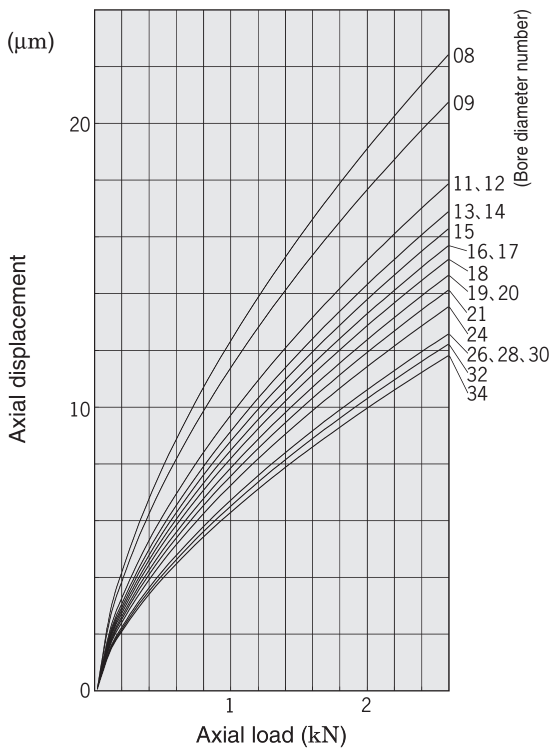
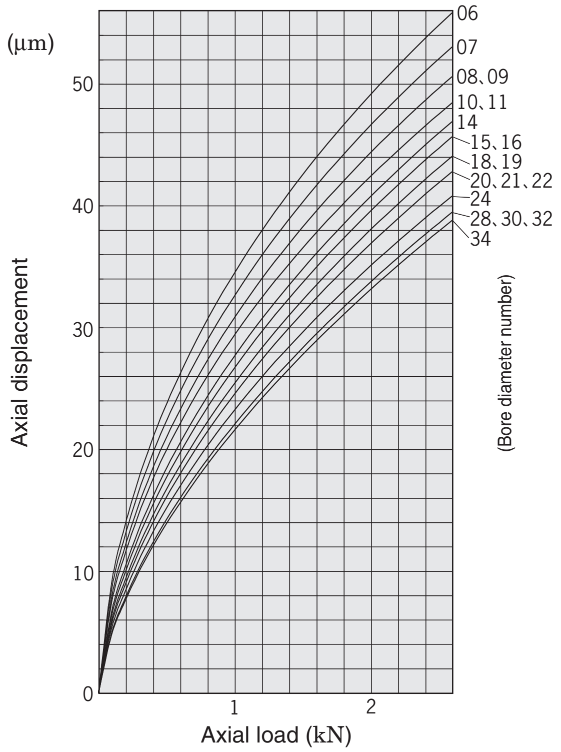


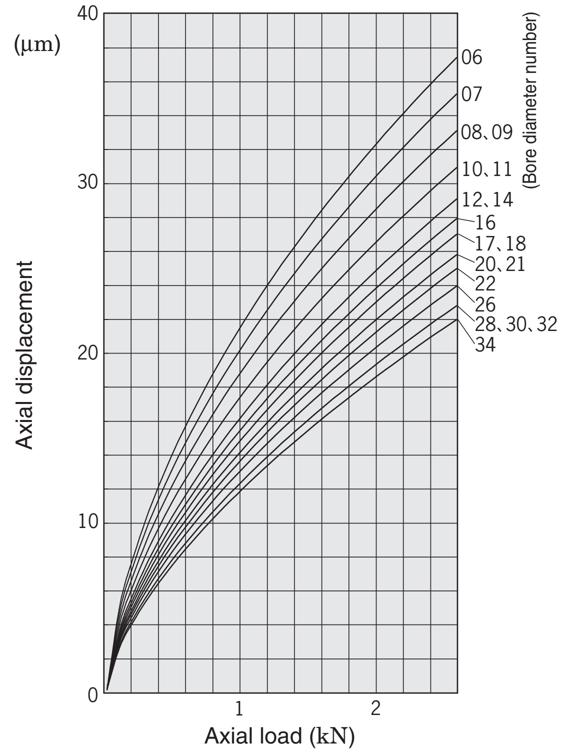
Fig. 1. 4 (2) Relationships between axial load and displacement (angular contact ball bearings)

*The axial displacements shown above are values of the single-row bearings not preloaded.

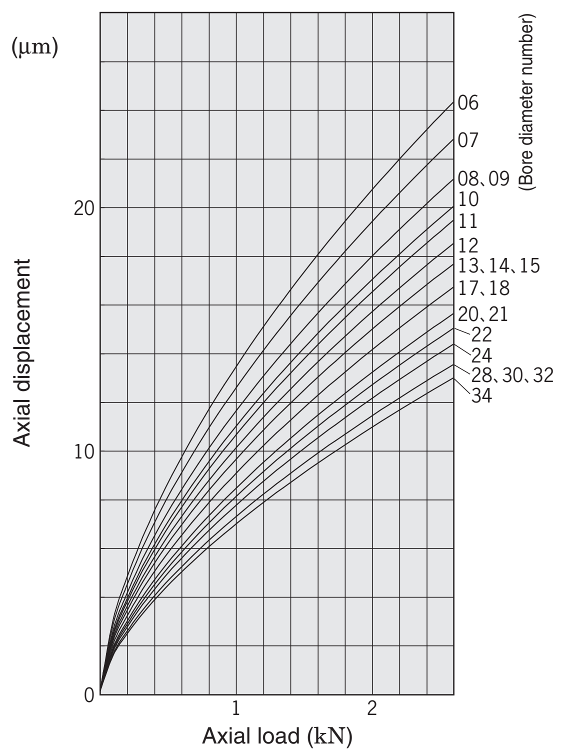
(9) HAR000C series (contact angle : 15°)



(10) HAR000CA series (contact angle : 20°)



(11) HAR000 series (contact angle : 30°)



(12) 3NCHAR900C series (contact angle : 15°)

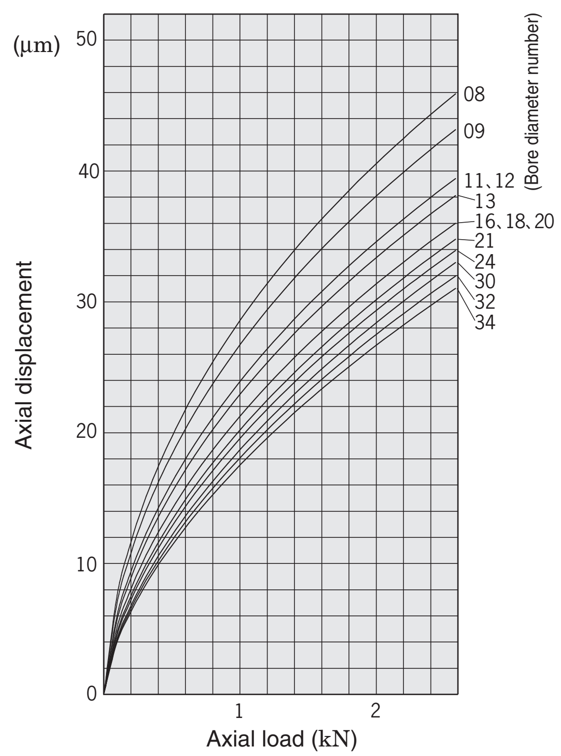
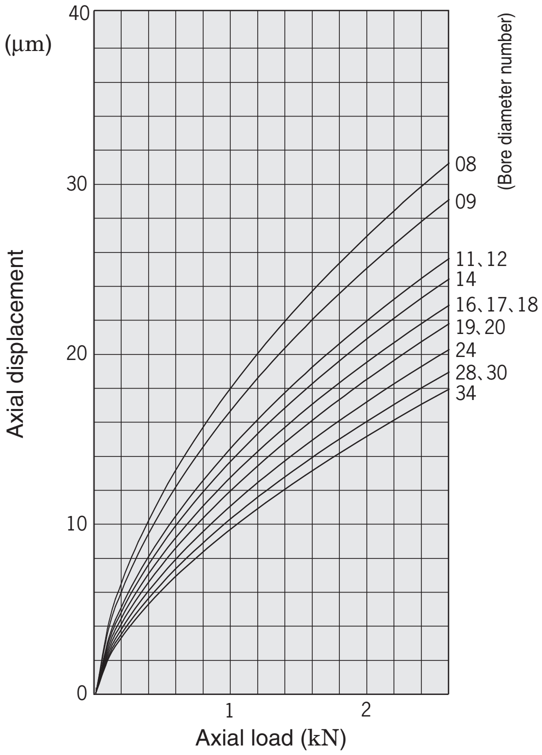


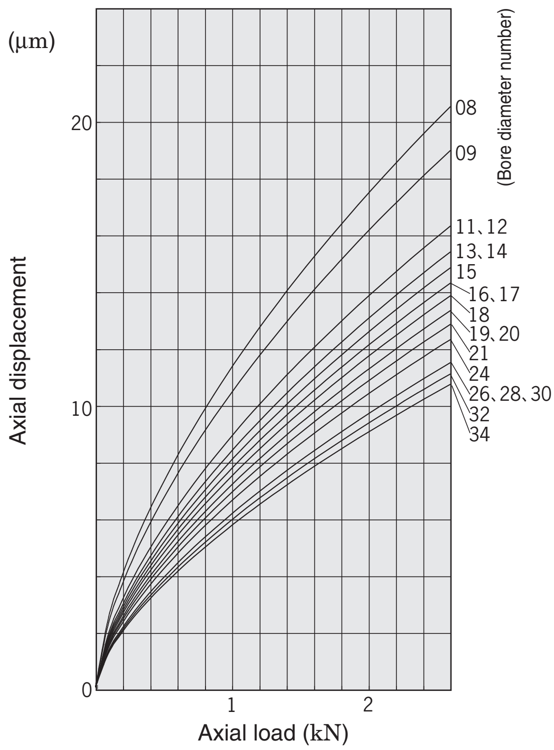
Fig. 1. 4 (3) Relationships between axial load and displacement (angular contact ball bearings)

*The axial displacements shown above are values of the single-row bearings not preloaded.

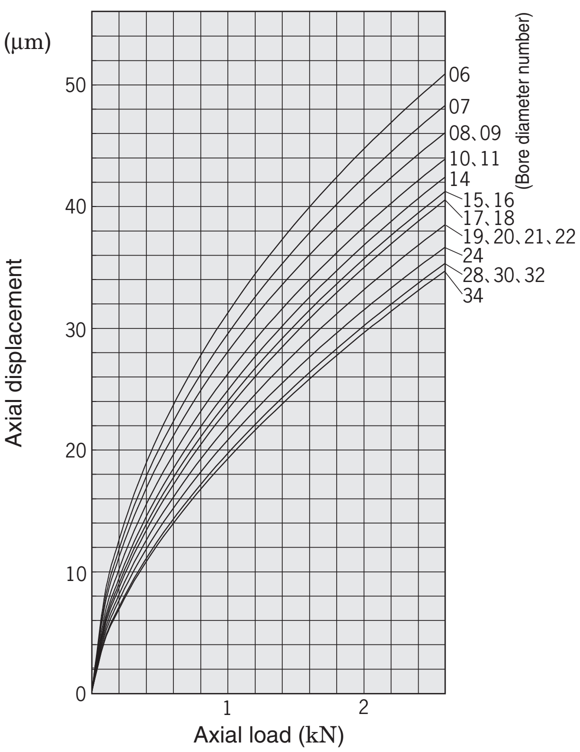
(13) 3NCHAR900CA series (contact angle : 20°)



(14) 3NCHAR900 series (contact angle : 30°)



(15) 3NCHAR000C series (contact angle : 15°)



(16) 3NCHAR000CA series (contact angle : 20°)

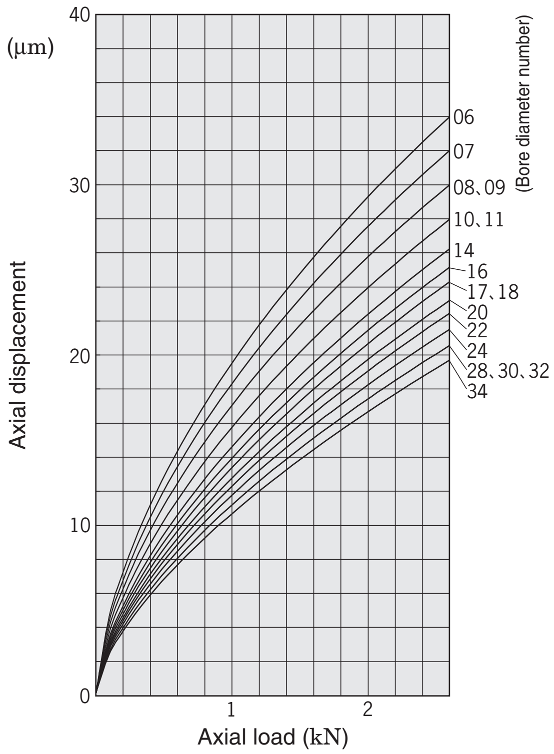


Fig. 1. 4 (4) Relationships between axial load and displacement (angular contact ball bearings)

*The axial displacements shown above are values of the single-row bearings not preloaded.

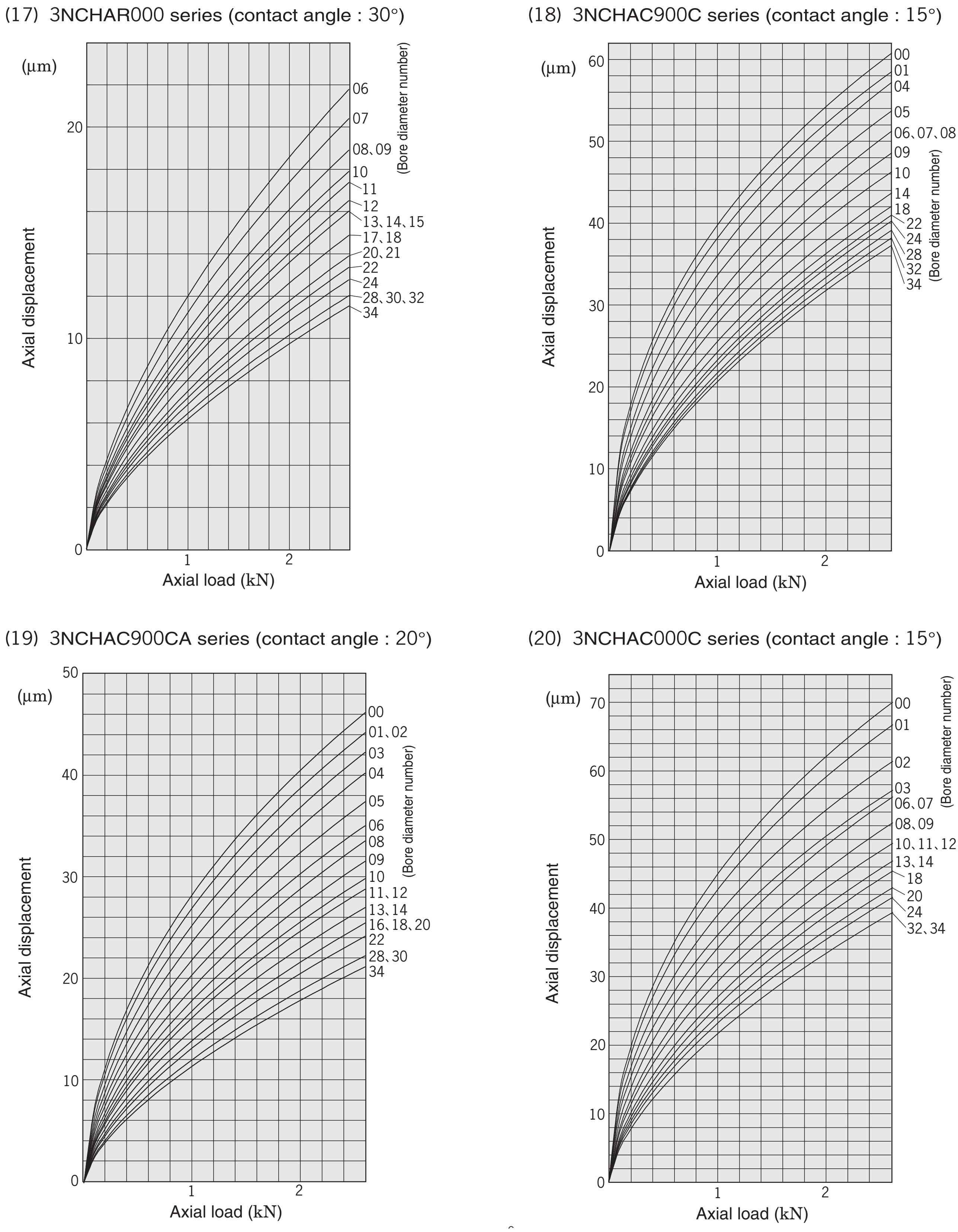
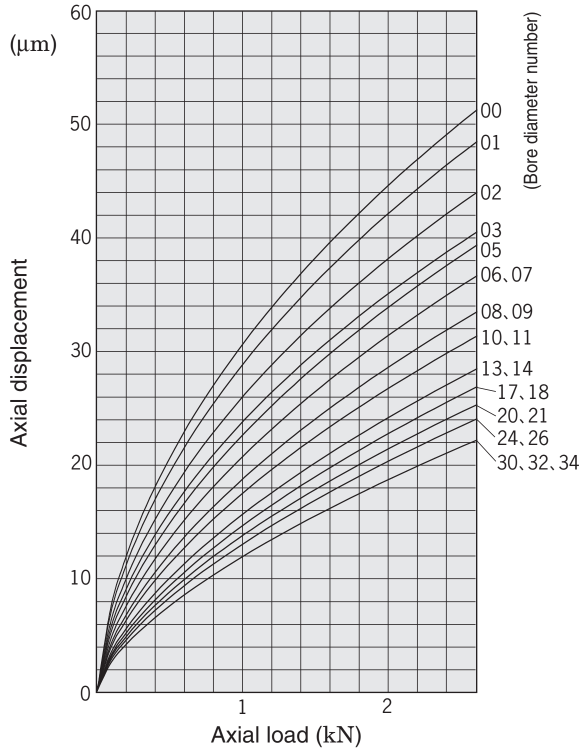


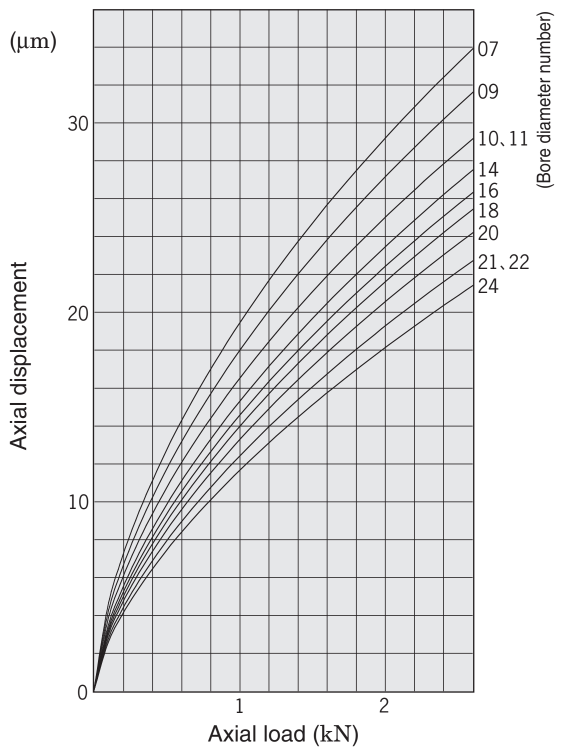
Fig. 1. 4 (5) Relationships between axial load and displacement (angular contact ball bearings)

*The axial displacements shown above are values of the single-row bearings not preloaded.

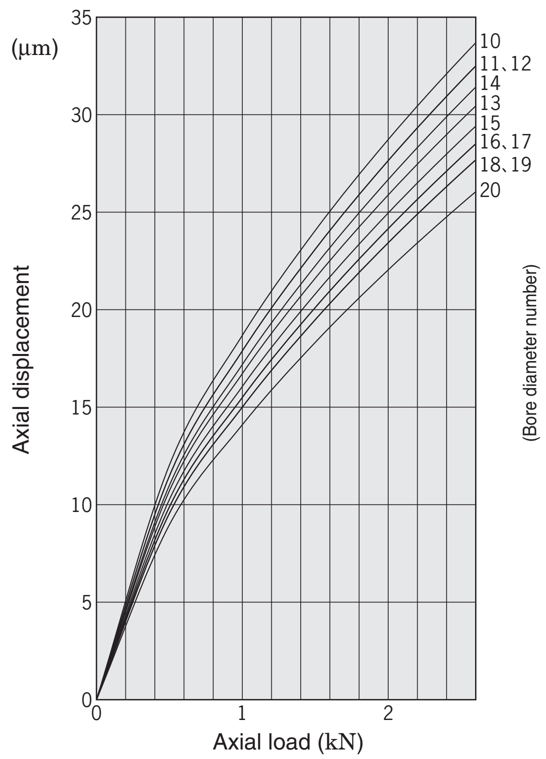
(21) 3NCHAC000CA series (contact angle : 20°)



(22) 3NCHAD000CA series (contact angle : 20°)



(23) 3NCHAX000CA series (contact angle : 20°)



(24) 3NCHAX900CA series (contact angle : 20°)

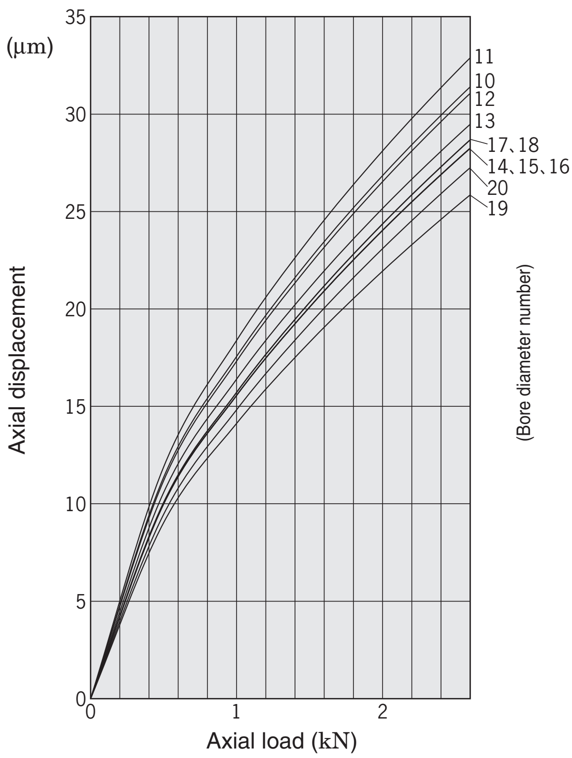
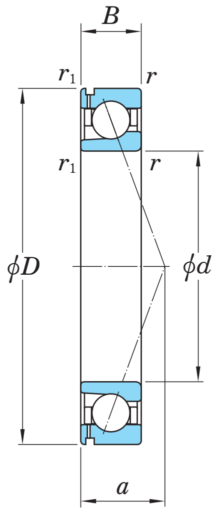


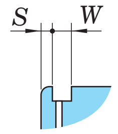
Fig. 1. 4 (6) Relationships between axial load and displacement (angular contact ball bearings)

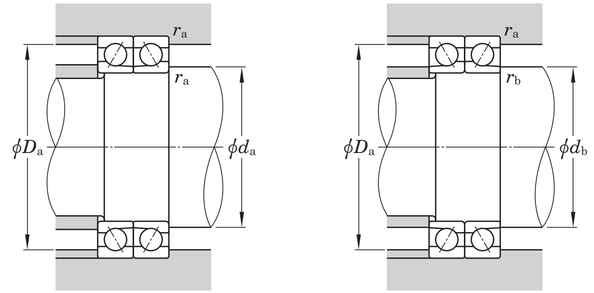
*The axial displacements shown above are values of the single-row bearings not preloaded.

High Ability NX series

3NCHAX000CA series
3NCHAX900CA series







We recommend that recesses be added at r_a and r_b.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
20°	0.5	0.42	1	0.84

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ [1)]	e	Single row/Tandem				Back-to-back/Face-to-face			
			$\frac{F_a}{F_r}\leq e$		$\frac{F_a}{F_r}>e$		$\frac{F_a}{F_r}\leq e$		$\frac{F_a}{F_r}>e$	
			X	Y	X	Y	X	Y	X	Y
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63

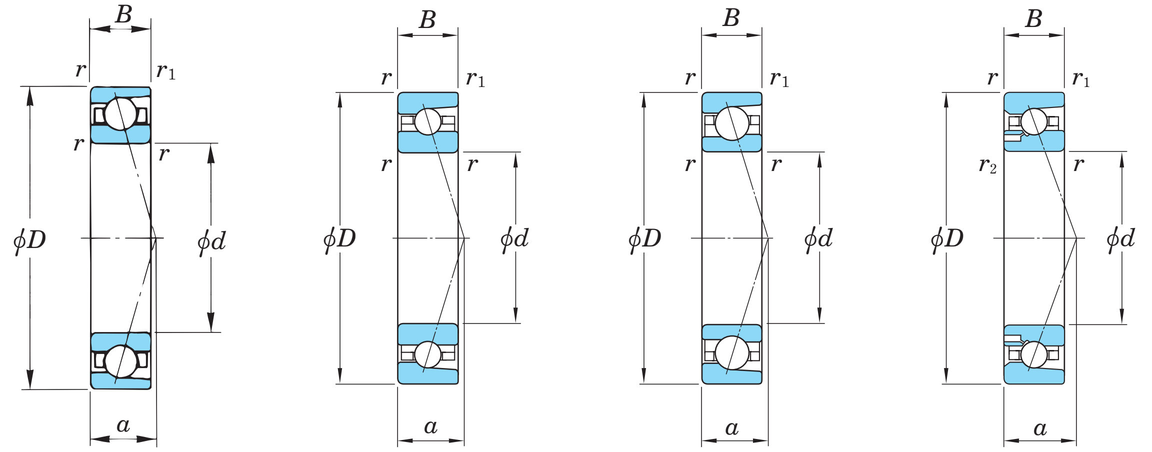
1) For i, use 2 for DB & DF and 1 for single & DT.

Boundary dimensions (mm)					Bearing No.	Basic load ratings (kN)		Fatigue load limit (kN)	Limiting speeds (min⁻¹)	Load center (mm)	(Refer.) Mass (kg/row)	Permissible axial load (kN)	Dimensions of lubrication groove (mm)		Mounting dimensions (mm)					Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
d	D	B	r min.	r_1 min.		C_r	C_{0r}	C_u	Oil lub.	a		(static)	S	W	d_a min.	d_b min.	D_a max.	r_a max.	r_b max.			
50	72	12	0.6	0.3	3NCHAX910CA	13.5	6.50	0.240	65 000	17.1	0.109	6.32	1.5	2.0	54.50	52.5	67.50	0.6	0.3	6 000	0.01~0.02	3NCHAX910CA
	80	16	1	0.6	3NCHAX010CA	19.2	8.65	0.450	61 000	19.9	0.219	8.37	2.0	2.0	55.50	54.5	74.50	1.0	0.6	10 000	0.01~0.02	3NCHAX010CA
55	80	13	0.6	0.3	3NCHAX911CA	14.0	6.70	0.240	59 000	18.8	0.154	6.48	1.5	2.0	60.50	59.5	74.50	0.6	0.3	6 000	0.01~0.02	3NCHAX911CA
	90	18	1.1	0.6	3NCHAX011CA	26.0	11.9	0.620	55 000	22.2	0.327	11.5	2.2	2.0	62.00	59.5	83.00	1.0	0.6	12 000	0.01~0.02	3NCHAX011CA
60	85	13	0.6	0.3	3NCHAX912CA	14.7	7.45	0.270	55 000	19.8	0.160	7.21	1.5	2.0	65.50	64.5	79.50	0.6	0.3	8 000	0.01~0.02	3NCHAX912CA
	95	18	1.1	0.6	3NCHAX012CA	25.9	12.1	0.630	51 000	23.1	0.344	11.7	2.2	2.0	67.00	64.5	88.00	1.0	0.6	12 000	0.01~0.02	3NCHAX012CA
65	90	13	0.6	0.3	3NCHAX913CA	15.5	8.15	0.300	51 000	20.6	0.178	7.93	1.5	2.0	70.50	69.5	84.50	0.6	0.3	8 000	0.01~0.02	3NCHAX913CA
	100	18	1.1	0.6	3NCHAX013CA	27.6	13.6	0.700	48 000	24.1	0.387	13.1	2.2	2.0	72.00	69.5	93.00	1.0	0.6	15 000	0.01~0.02	3NCHAX013CA
70	100	16	1	0.6	3NCHAX914CA	22.6	12.0	0.440	47 000	23.5	0.307	11.6	2.0	2.5	75.50	74.5	94.50	1.0	0.6	10 000	0.01~0.02	3NCHAX914CA
	110	20	1.1	0.6	3NCHAX014CA	33.5	16.1	0.930	44 000	26.4	0.512	15.6	2.2	2.5	77.00	74.5	103.0	1.0	0.6	15 000	0.01~0.02	3NCHAX014CA
75	105	16	1	0.6	3NCHAX915CA	22.4	12.1	0.440	44 000	24.4	0.309	11.7	2.0	2.5	80.50	79.5	99.50	1.0	0.6	10 000	0.01~0.02	3NCHAX915CA
	115	20	1.1	0.6	3NCHAX015CA	35.8	18.1	0.930	42 000	27.3	0.546	17.5	2.2	2.5	82.00	79.5	108.0	1.0	0.6	15 000	0.01~0.02	3NCHAX015CA
80	110	16	1	0.6	3NCHAX916CA	22.2	12.2	0.440	42 000	25.3	0.321	11.8	2.0	2.5	85.50	84.5	104.5	1.0	0.6	10 000	0.01~0.02	3NCHAX916CA
	125	22	1.1	0.6	3NCHAX016CA	45.0	23.0	1.20	39 000	29.7	0.723	22.3	2.2	2.5	87.00	84.5	118.0	1.0	0.6	15 000	0.01~0.02	3NCHAX016CA
85	120	18	1.1	0.6	3NCHAX917CA	28.7	15.5	0.560	39 000	27.6	0.448	14.9	2.2	3.0	92.00	89.5	113.0	1.0	0.6	12 000	0.01~0.02	3NCHAX917CA
	130	22	1.1	0.6	3NCHAX017CA	44.8	23.2	1.20	37 000	30.7	0.748	22.5	2.2	2.5	92.00	89.5	123.0	1.0	0.6	18 000	0.01~0.02	3NCHAX017CA
90	125	18	1.1	0.6	3NCHAX918CA	28.5	15.5	0.550	37 000	28.6	0.470	15.0	2.2	3.0	97.00	94.5	118.0	1.0	0.6	12 000	0.01~0.02	3NCHAX918CA
	140	24	1.5	1	3NCHAX018CA	55.0	28.8	1.40	34 000	32.9	0.986	27.8	2.5	3.0	98.50	95.5	131.5	1.5	1.0	18 000	0.01~0.02	3NCHAX018CA
95	130	18	1.1	0.6	3NCHAX919CA	31.6	18.5	0.630	35 000	29.5	0.499	17.9	2.2	3.0	102.0	99.5	123.0	1.0	0.6	12 000	0.01~0.02	3NCHAX919CA
	145	24	1.5	1	3NCHAX019CA	54.8	29.0	1.40	33 000	34.2	0.994	28.1	2.5	3.0	103.5	100.5	136.5	1.5	1.0	18 000	0.01~0.02	3NCHAX019CA
100	140	20	1.1	0.6	3NCHAX920CA	42.0	23.2	0.770	33 000	31.8	0.643	22.5	2.2	3.0	107.0	104.5	133.0	1.0	0.6	15 000	0.01~0.02	3NCHAX920CA
	150	24	1.5	1	3NCHAX020CA	58.1	32.1	1.50	32 000	34.7	1.07	31.1	2.5	3.0	108.5	105.5	141.5	1.5	1.0	20 000	0.01~0.02	3NCHAX020CA

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. CA in the bearing number indicates a nominal contact angle of 20°.

Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

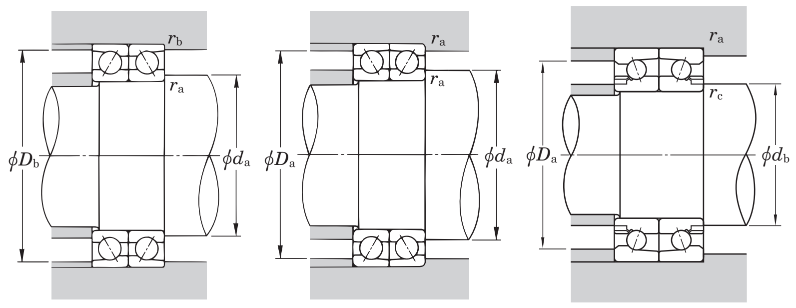


7000
7900
7200

HAR

3NCHAC

3NCHAD



We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ 1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$		Single row/Tandem $\frac{F_a}{F_r}>e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}>e$	
			X	Y	X	Y	X	Y	X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d 10 ~ (17)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No.	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
10	22	6	0.3	0.15	—	**7900C-5**	3.75	1.50	0.060	14.2	78 000	120 000	5.1	0.44	0.008	1.1	—	—	12.5	—	19.5	20.8	0.3	0.15	—	1 500	0.01~0.02	**7900C-5**
	22	6	0.3	0.15	—	**3NCHAC900C**	2.55	0.750	0.040	7.20	130 000	210 000	5.1	0.43	0.008	0.62	—	—	12.5	—	19.5	20.8	0.3	0.15	—	1 500	0.01~0.02	**3NCHAC900C**
	22	6	0.3	0.15	—	**3NCHAC900CA**	2.50	0.750	0.040	—	120 000	200 000	5.9	0.43	0.008	0.76	—	—	12.5	—	19.5	20.8	0.3	0.15	—	1 500	0.01~0.02	**3NCHAC900CA**
	26	8	0.3	0.15	—	**7000C-5**	6.60	2.45	0.130	12.5	67 000	100 000	6.4	0.89	0.021	1.9	—	—	12.5	—	23.5	24.8	0.3	0.15	—	2 000	0.01~0.02	**7000C-5**
	26	8	0.3	0.15	—	**7000-5**	6.25	2.35	0.120	—	51 000	67 000	9.1	0.86	0.021	0.7	—	—	12.5	—	23.5	24.8	0.3	0.15	—	2 000	0.01~0.02	**7000-5**
	26	8	0.3	0.15	—	**3NCHAC000C**	4.40	1.25	0.070	6.40	110 000	190 000	6.4	0.92	0.016	0.99	—	—	12.5	—	23.5	24.8	0.3	0.15	—	2 000	0.01~0.02	**3NCHAC000C**
	26	8	0.3	0.15	—	**3NCHAC000CA**	4.35	1.25	0.060	—	110 000	180 000	7.2	0.92	0.016	1.24	—	—	12.5	—	23.5	24.8	0.3	0.15	—	2 000	0.01~0.02	**3NCHAC000CA**
	30	9	0.6	0.3	—	**7200C-5**	6.25	2.35	0.120	13.4	57 000	92 000	7.2	1.3	0.031	2.22	—	—	14.5	—	25.5	27.5	0.6	0.3	—	3 000	0.01~0.02	**7200C-5**
	30	9	0.6	0.3	—	**7200-5**	5.85	2.20	0.110	—	44 000	57 000	10.4	1.3	0.031	1	—	—	14.5	—	25.5	27.5	0.6	0.3	—	3 000	0.01~0.02	**7200-5**
12	24	6	0.3	0.15	—	**7901C-5**	4.00	1.70	0.070	14.7	70 000	100 000	5.4	0.49	0.010	1.2	—	—	14.5	—	21.5	22.8	0.3	0.15	—	2 000	0.01~0.02	**7901C-5**
	24	6	0.3	0.15	—	**3NCHAC901C**	2.70	0.850	0.050	7.10	110 000	190 000	5.4	0.48	0.009	0.7	—	—	14.5	—	21.5	22.8	0.3	0.15	—	2 000	0.01~0.02	**3NCHAC901C**
	24	6	0.3	0.15	—	**3NCHAC901CA**	2.65	0.850	0.040	—	100 000	180 000	6.3	0.48	0.009	0.86	—	—	14.5	—	21.5	22.8	0.3	0.15	—	2 000	0.01~0.02	**3NCHAC901CA**
	28	8	0.3	0.15	—	**7001C-5**	7.25	2.95	0.150	13.4	57 000	92 000	6.7	1.1	0.024	1.97	—	—	14.5	—	25.5	26.8	0.3	0.15	—	2 000	0.01~0.02	**7001C-5**
	28	8	0.3	0.15	—	**7001-5**	6.75	2.75	0.140	—	44 000	57 000	9.9	1.1	0.024	0.74	—	—	14.5	—	25.5	26.8	0.3	0.15	—	2 000	0.01~0.02	**7001-5**
	28	8	0.3	0.15	—	**3NCHAC001C**	4.85	1.50	0.080	6.80	100 000	170 000	6.7	1.1	0.017	1.18	—	—	14.5	—	25.5	26.8	0.3	0.15	—	2 000	0.01~0.02	**3NCHAC001C**
	28	8	0.3	0.15	—	**3NCHAC001CA**	4.80	1.45	0.080	—	95 000	160 000	7.7	1.1	0.017	1.46	—	—	14.5	—	25.5	26.8	0.3	0.15	—	2 000	0.01~0.02	**3NCHAC001CA**
	32	10	0.6	0.3	—	**7201C-5**	9.90	3.85	0.300	12.5	54 000	85 000	7.9	1.7	0.038	2.28	—	—	16.5	—	27.5	29.5	0.6	0.3	—	3 000	0.01~0.02	**7201C-5**
	32	10	0.6	0.3	—	**7201-5**	9.30	3.65	0.280	—	42 000	54 000	11.4	1.7	0.038	1.05	—	—	16.5	—	27.5	29.5	0.6	0.3	—	3 000	0.01~0.02	**7201-5**
15	28	7	0.3	0.15	—	**7902C-5**	5.15	2.65	0.110	14.5	58 000	91 000	6.4	0.68	0.015	2.86	—	—	17.5	—	25.5	26.8	0.3	0.15	—	2 000	0.01~0.02	**7902C-5**
	28	7	0.3	0.15	—	**3NCHAC902C**	4.05	1.35	0.070	7.40	98 000	160 000	6.4	0.65	0.014	1.07	—	—	17.5	—	25.5	26.8	0.3	0.15	—	2 000	0.01~0.02	**3NCHAC902C**
	28	7	0.3	0.15	—	**3NCHAC902CA**	3.95	1.30	0.070	—	91 000	150 000	7.4	0.65	0.014	1.32	—	—	17.5	—	25.5	26.8	0.3	0.15	—	2 000	0.01~0.02	**3NCHAC902CA**
	32	9	0.3	0.15	—	**7002C-5**	8.25	3.70	0.190	14.1	50 000	79 000	7.6	1.3	0.035	2.84	—	—	17.5	—	29.5	30.8	0.3	0.15	—	3 000	0.01~0.02	**7002C-5**
	32	9	0.3	0.15	—	**7002-5**	7.65	3.45	0.180	—	39 000	50 000	11.3	1.3	0.035	1	—	—	17.5	—	29.5	30.8	0.3	0.15	—	3 000	0.01~0.02	**7002-5**
	32	9	0.3	0.15	—	**3NCHAC002C**	5.55	1.90	0.100	7.20	89 000	140 000	7.6	1.4	0.026	1.5	—	—	17.5	—	29.5	30.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC002C**
	32	9	0.3	0.15	—	**3NCHAC002CA**	5.50	1.85	0.100	—	84 000	140 000	8.8	1.4	0.026	1.85	—	—	17.5	—	29.5	30.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC002CA**
	35	11	0.6	0.3	—	**7202C-5**	10.8	4.55	0.340	13.3	46 000	74 000	8.9	2.3	0.048	2.33	—	—	19.5	—	30.5	32.5	0.6	0.3	—	5 000	0.01~0.02	**7202C-5**
	35	11	0.6	0.3	—	**7202-5**	10.1	4.25	0.300	—	35 000	46 000	12.9	2.3	0.048	1.1	—	—	19.5	—	30.5	32.5	0.6	0.3	—	5 000	0.01~0.02	**7202-5**
17	30	7	0.3	0.15	—	**7903C-5**	6.25	2.95	0.120	14.9	51 000	81 000	6.7	0.68	0.016	2.86	—	—	19.5	—	27.5	28.8	0.3	0.15	—	3 000	0.01~0.02	**7903C-5**
	30	7	0.3	0.15	—	**3NCHAC903C**	4.25	1.50	0.080	7.60	88 000	140 000	6.7	0.88	0.014	1.2	—	—	19.5	—	27.5	28.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC903C**
	30	7	0.3	0.15	—	**3NCHAC903CA**	4.15	1.45	0.080	—	81 000	130 000	7.9	0.88	0.014	1.47	—	—	19.5	—	27.5	28.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC903CA**

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

Basic load ratings in case of multiple-row combination bearing

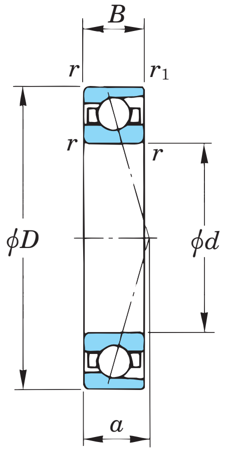
	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting Preload S	Preload L	Preload M	Preload H
∅ ⃠	DB	0.85	0.80	0.65	0.55
∅∅ ⃠⃠	DBB	0.80	0.75	0.60	0.45
∅∅ ⃠	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.

Koyo



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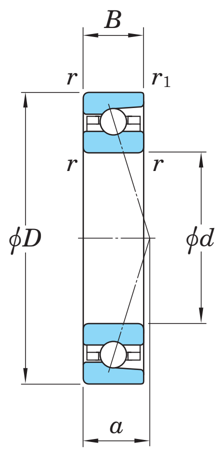

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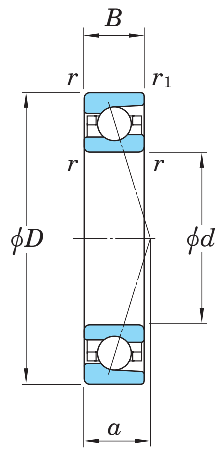

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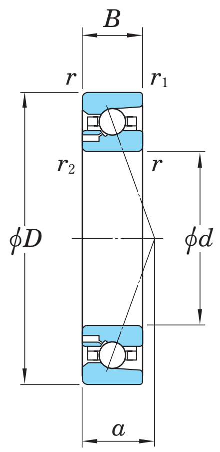

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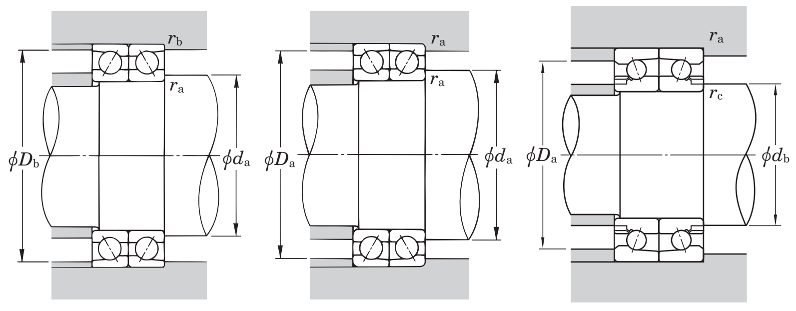


We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0 = X_0F_r + Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P = XF_r + YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ [1]	e	Single row/Tandem $\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$		Back-to-back/Face-to-face $\frac{F_a}{F_r} \leqq e$		$\frac{F_a}{F_r} > e$	
			X	Y	X	Y	X	Y	X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (17) ~ (30)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No.	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
17	35	10	0.3	0.15	—	**7003C-5**	9.15	4.45	0.230	14.6	44 000	71 000	8.6	1.8	0.045	2.9	—	—	19.5	—	32.5	33.8	0.3	0.15	—	3 000	0.01~0.02	**7003C-5**
	35	10	0.3	0.15	—	**7003-5**	8.40	4.15	0.210	—	35 000	44 000	12.7	1.6	0.045	1.03	—	—	19.5	—	32.5	33.8	0.3	0.15	—	3 000	0.01~0.02	**7003-5**
	35	10	0.3	0.15	—	**3NCHAC003C**	6.20	2.30	0.120	7.40	79 000	130 000	8.6	1.7	0.035	1.82	—	—	19.5	—	32.5	33.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC003C**
	35	10	0.3	0.15	—	**3NCHAC003CA**	6.10	2.25	0.120	—	74 000	120 000	9.8	1.7	0.035	2.14	—	—	19.5	—	32.5	33.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC003CA**
	40	12	0.6	0.3	—	**7203C-5**	13.6	5.90	0.440	13.4	40 000	65 000	9.9	3.2	0.070	3.6	—	—	21.5	—	35.5	37.5	0.6	0.3	—	5 000	0.01~0.02	**7203C-5**
	40	12	0.6	0.3	—	**7203-5**	12.7	5.50	0.380	—	30 000	40 000	14.4	3.1	0.070	1.86	—	—	21.5	—	35.5	37.5	0.6	0.3	—	5 000	0.01~0.02	**7203-5**
20	37	9	0.3	0.15	—	**7904C-5**	9.10	4.55	0.240	14.9	44 000	68 000	8.3	1.5	0.035	2.9	—	—	22.5	—	34.5	35.8	0.3	0.15	—	3 000	0.01~0.02	**7904C-5**
	37	9	0.3	0.15	—	**3NCHAC904C**	6.20	2.35	0.120	7.60	74 000	120 000	8.3	1.7	0.031	1.86	—	—	22.5	—	34.5	35.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC904C**
	37	9	0.3	0.15	—	**3NCHAC904CA**	6.10	2.30	0.120	—	68 000	110 000	9.7	1.7	0.031	2.14	—	—	22.5	—	34.5	35.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC904CA**
	42	12	0.6	0.3	—	**7004C-5**	13.9	6.60	0.450	14.1	37 000	60 000	10.2	3.2	0.079	3.4	—	—	24.5	—	37.5	39.5	0.6	0.3	—	5 000	0.01~0.02	**7004C-5**
	42	12	0.6	0.3	—	**7004-5**	12.9	6.10	0.390	—	29 000	37 000	15.1	3.2	0.079	1.65	—	—	24.5	—	37.5	39.5	0.6	0.3	—	5 000	0.01~0.02	**7004-5**
	42	12	0.6	0.3	—	**3NCHAC004C**	9.35	3.35	0.170	7.20	67 000	110 000	10.2	3.4	0.056	2.67	—	—	24.5	—	37.5	39.5	0.6	0.3	—	5 000	0.01~0.02	**3NCHAC004C**
	42	12	0.6	0.3	—	**3NCHAC004CA**	9.20	3.30	0.170	—	61 000	100 000	11.7	3.4	0.056	3.29	—	—	24.5	—	37.5	39.5	0.6	0.3	—	5 000	0.01~0.02	**3NCHAC004CA**
	47	14	1	0.6	—	**7204C-5**	19.4	9.00	0.670	13.4	35 000	54 000	11.6	5.3	0.112	4.8	—	—	25.5	—	41.5	42.5	1	0.6	—	5 000	0.01~0.02	**7204C-5**
	47	14	1	0.6	—	**7204-5**	18.1	8.40	0.580	—	26 000	35 000	17	5.2	0.112	2.34	—	—	25.5	—	41.5	42.5	1	0.6	—	5 000	0.01~0.02	**7204-5**
25	42	9	0.3	0.15	—	**7905C-5**	9.75	5.45	0.280	15.5	36 000	57 000	9.1	1.9	0.041	3	—	—	27.5	—	39.5	40.8	0.3	0.15	—	3 000	0.01~0.02	**7905C-5**
	42	9	0.3	0.15	—	**3NCHAC905C**	6.75	2.75	0.140	7.90	61 000	100 000	9.1	1.9	0.037	2.23	—	—	27.5	—	39.5	40.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC905C**
	42	9	0.3	0.15	—	**3NCHAC905CA**	6.60	2.70	0.140	—	57 000	96 000	10.7	1.9	0.037	2.72	—	—	27.5	—	39.5	40.8	0.3	0.15	—	3 000	0.01~0.02	**3NCHAC905CA**
	47	12	0.6	0.3	—	**7005C-5**	15.4	8.00	0.510	14.7	33 000	51 000	10.8	3.6	0.091	3.98	—	—	29.5	—	42.5	44.5	0.6	0.3	—	5 000	0.01~0.02	**7005C-5**
	47	12	0.6	0.3	—	**7005-5**	14.1	7.40	0.450	—	25 000	33 000	16.4	3.6	0.091	1.94	—	—	29.5	—	42.5	44.5	0.6	0.3	—	5 000	0.01~0.02	**7005-5**
	47	12	0.6	0.3	—	**3NCHAC005C**	10.4	4.10	0.210	7.50	58 000	96 000	10.8	3.8	0.066	3.26	—	—	29.5	—	42.5	44.5	0.6	0.3	—	5 000	0.01~0.02	**3NCHAC005C**
	47	12	0.6	0.3	—	**3NCHAC005CA**	10.2	4.00	0.210	—	54 000	91 000	12.6	3.8	0.066	4	—	—	29.5	—	42.5	44.5	0.6	0.3	—	5 000	0.01~0.02	**3NCHAC005CA**
	52	15	1	0.6	—	**7205C-5**	20.7	10.2	0.710	14.0	30 000	49 000	12.7	6.6	0.135	5.26	—	—	30.5	—	46.5	47.5	1	0.6	—	8 000	0.01~0.02	**7205C-5**
	52	15	1	0.6	—	**7205-5**	19.2	9.50	0.620	—	23 000	30 000	18.8	6.5	0.135	2.56	—	—	30.5	—	46.5	47.5	1	0.6	—	8 000	0.01~0.02	**7205-5**
30	47	9	0.3	0.15	—	**7906C-5**	10.4	6.25	0.320	15.9	32 000	50 000	9.7	2.2	0.046	3.04	—	—	32.5	—	44.5	45.8	0.3	0.15	—	5 000	0.01~0.02	**7906C-5**
	47	9	0.3	0.15	—	**3NCHAC906C**	7.20	3.20	0.160	8.10	54 000	91 000	9.7	2.3	0.041	2.57	—	—	32.5	—	44.5	45.8	0.3	0.15	—	5 000	0.01~0.02	**3NCHAC906C**
	47	9	0.3	0.15	—	**3NCHAC906CA**	7.05	3.10	0.160	—	50 000	85 000	11.5	2.3	0.041	3.13	—	—	32.5	—	44.5	45.8	0.3	0.15	—	5 000	0.01~0.02	**3NCHAC906CA**
	55	13	1	0.6	—	**7006C-5**	19.8	11.0	0.690	14.9	28 000	44 000	12.2	4.9	0.133	5.34	—	—	35.5	—	49.5	50.5	1	0.6	—	5 000	0.01~0.02	**7006C-5**
	55	13	1	0.6	—	**7006-5**	18.2	10.1	0.610	—	21 000	28 000	18.8	4.9	0.133	2.6	—	—	35.5	—	49.5	50.5	1	0.6	—	5 000	0.01~0.02	**7006-5**
	55	13	1	0.6	—	**HAR006C**	10.9	4.85	0.250	7.90	36 000	56 000	12.2	4.4	0.116	6.14	—	—	35.5	—	49.5	50.5	1	0.6	—	5 000	0.01~0.02	**HAR006C**

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

Basic load ratings in case of multiple-row combination bearing

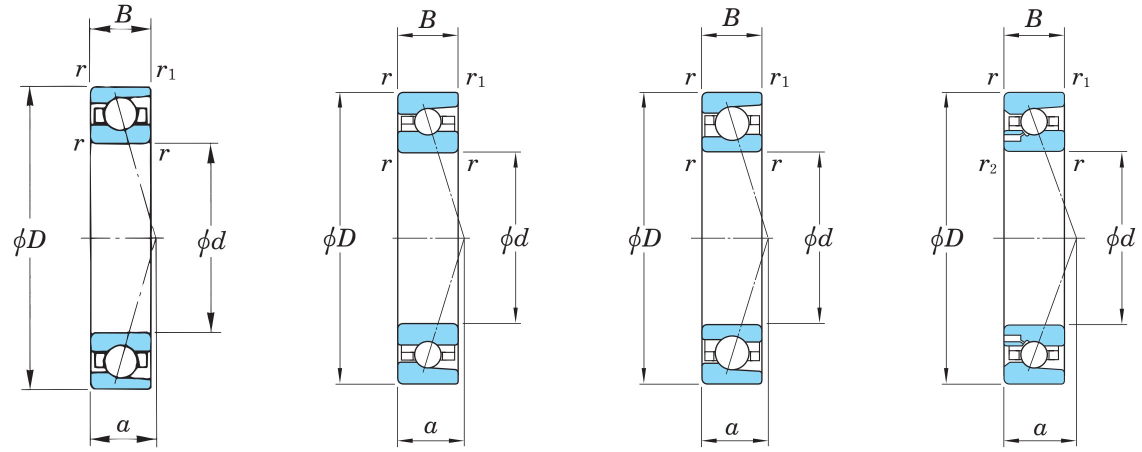
	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting Preload S	Preload L	Preload M	Preload H
	DB	0.85	0.80	0.65	0.55
	DBB	0.80	0.75	0.60	0.45
	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.

Koyo

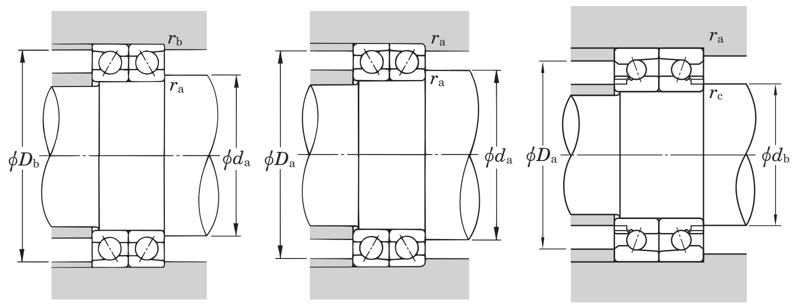


7000
7900
7200

HAR

3NCHAC

3NCHAD



We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ [1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$	
			X	Y	X	Y	X	Y	X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (30) ~ (40)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. [1)	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min^{-1}) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
30	55	13	1	0.6	—	**HAR006CA**	10.7	4.75	0.250	—	35 000	53 000	14.2	4.4	0.116	7.25	—	—	35.5	—	49.5	50.5	1	0.6	—	5 000	0.01~0.02	**HAR006CA**
	55	13	1	0.6	—	**HAR006**	10.0	4.45	0.230	—	25 000	33 000	18.8	4.4	0.116	6.37	—	—	35.5	—	49.5	50.5	1	0.6	—	5 000	0.01~0.02	**HAR006**
	55	13	1	0.6	—	**3NCHAC006C**	13.5	5.60	0.290	7.60	49 000	82 000	12.2	5.4	0.097	4.48	—	—	35.5	—	49.5	50.5	1	0.6	—	5 000	0.01~0.02	**3NCHAC006C**
	55	13	1	0.6	—	**3NCHAC006CA**	13.2	5.50	0.280	—	46 000	77 000	14.2	5.4	0.097	5.49	—	—	35.5	—	49.5	50.5	1	0.6	—	5 000	0.01~0.02	**3NCHAC006CA**
	62	16	1	0.6	—	**7206C-5**	28.8	14.7	1.00	14.0	25 000	40 000	14.3	9.3	0.208	7.61	—	—	35.5	—	56.5	57.5	1	0.6	—	8 000	0.01~0.02	**7206C-5**
	62	16	1	0.6	—	**7206-5**	26.7	13.7	0.890	—	19 000	25 000	21.5	9.3	0.208	3.7	—	—	35.5	—	56.5	57.5	1	0.6	—	8 000	0.01~0.02	**7206-5**
35	55	10	0.6	0.3	—	**7907C-5**	15.7	9.70	0.550	15.7	28 000	43 000	11	3	0.074	5.2	—	—	39.5	—	50.5	52.5	0.6	0.3	—	5 000	0.01~0.02	**7907C-5**
	55	10	0.6	0.3	—	**3NCHAC907C**	10.8	4.90	0.250	8.00	46 000	78 000	11	3.5	0.063	3.96	—	—	39.5	—	50.5	52.5	0.6	0.3	—	5 000	0.01~0.02	**3NCHAC907C**
	55	10	0.6	0.3	—	**3NCHAC907CA**	10.6	4.80	0.250	—	43 000	72 000	13.2	3.5	0.063	4.83	—	—	39.5	—	50.5	52.5	0.6	0.3	—	5 000	0.01~0.02	**3NCHAC907CA**
	62	14	1	0.6	—	**7007C-5**	23.9	13.7	0.840	15.0	23 000	39 000	13.5	7	0.170	6.63	—	—	40.5	—	56.5	57.5	1	0.6	—	8 000	0.01~0.02	**7007C-5**
	62	14	1	0.6	—	**7007-5**	21.9	12.6	0.740	—	18 000	23 000	21.2	6.9	0.170	3.22	—	—	40.5	—	56.5	57.5	1	0.6	—	8 000	0.01~0.02	**7007-5**
	62	14	1	0.6	—	**HAR007C**	11.6	5.55	0.290	8.10	32 000	49 000	13.5	5.5	0.158	7.02	—	—	40.5	—	56.5	57.5	1	0.6	—	8 000	0.01~0.02	**HAR007C**
	62	14	1	0.6	—	**HAR007CA**	11.3	5.40	0.280	—	30 000	46 000	15.8	5.5	0.158	7.44	—	—	40.5	—	56.5	57.5	1	0.6	—	8 000	0.01~0.02	**HAR007CA**
	62	14	1	0.6	—	**HAR007**	10.6	5.05	0.260	—	21 000	29 000	21	5.5	0.158	6.58	—	—	40.5	—	56.5	57.5	1	0.6	—	8 000	0.01~0.02	**HAR007**
	62	14	1	0.6	—	**3NCHAC007C**	16.3	7.00	0.360	7.60	43 000	71 000	13.6	7.1	0.129	5.59	—	—	40.5	—	56.5	57.5	1	0.6	—	8 000	0.01~0.02	**3NCHAC007C**
	62	14	1	0.6	—	**3NCHAC007CA**	16.0	6.85	0.350	—	40 000	67 000	15.9	7.1	0.129	6.85	—	—	40.5	—	56.5	57.5	1	0.6	—	8 000	0.01~0.02	**3NCHAC007CA**
	62	14	1	0.6	0.3	**3NCHAD007CA**	10.5	4.90	0.250	—	—	72 000	15.8	—	0.157	4.9	—	—	40.5	38.5	56.5	57.5	1	0.6	0.3	8 000	0.01~0.02	**3NCHAD007CA**
	72	17	1.1	0.6	—	**7207C-5**	38.0	20.1	1.40	14.0	22 000	35 000	15.8	13	0.295	10.8	—	—	42	—	65	67.5	1	0.6	—	8 000	0.01~0.02	**7207C-5**
	72	17	1.1	0.6	—	**7207-5**	35.2	18.6	1.20	—	16 000	22 000	24.2	13	0.295	5.43	—	—	42	—	65	67.5	1	0.6	—	8 000	0.01~0.02	**7207-5**
40	62	12	0.6	0.3	—	**7908C-5**	19.7	12.4	0.710	15.7	25 000	37 000	12.8	5.2	0.107	6.59	—	—	44.5	—	57.5	59.5	0.6	0.3	—	5 000	0.01~0.02	**7908C-5**
	62	12	0.6	0.3	—	**HAR908C**	7.95	4.05	0.210	8.40	30 000	46 000	12.8	4.1	0.115	5.18	—	—	44.5	—	57.5	59.5	0.6	0.3	—	5 000	0.01~0.02	**HAR908C**
	62	12	0.6	0.3	—	**HAR908CA**	7.75	3.95	0.210	—	29 000	43 000	15.3	4.1	0.115	6.08	—	—	44.5	—	57.5	59.5	0.6	0.3	—	5 000	0.01~0.02	**HAR908CA**
	62	12	0.6	0.3	—	**HAR908**	7.20	3.70	0.190	—	21 000	28 000	20.7	4.1	0.115	4.79	—	—	44.5	—	57.5	59.5	0.6	0.3	—	5 000	0.01~0.02	**HAR908**
	62	12	0.6	0.3	—	**3NCHAC908C**	13.6	6.30	0.330	8.00	40 000	68 000	12.8	5.4	0.093	5.1	—	—	44.5	—	57.5	59.5	0.6	0.3	—	5 000	0.01~0.02	**3NCHAC908C**
	62	12	0.6	0.3	—	**3NCHAC908CA**	13.3	6.20	0.320	—	37 000	64 000	15.3	5.4	0.093	6.22	—	—	44.5	—	57.5	59.5	0.6	0.3	—	5 000	0.01~0.02	**3NCHAC908CA**
	68	15	1	0.6	—	**7008C-5**	25.7	15.9	0.940	15.4	22 000	35 000	14.8	8.8	0.210	7.53	—	—	45.5	—	62.5	63.5	1	0.6	—	8 000	0.01~0.02	**7008C-5**
	68	15	1	0.6	—	**7008-5**	23.4	14.6	0.830	—	16 000	22 000	23.2	8.7	0.210	3.66	—	—	45.5	—	62.5	63.5	1	0.6	—	8 000	0.01~0.02	**7008-5**
	68	15	1	0.6	—	**HAR008C**	12.2	6.20	0.320	8.20	28 000	43 000	14.7	6.6	0.200	7.88	—	—	45.5	—	62.5	63.5	1	0.6	—	8 000	0.01~0.02	**HAR008C**
	68	15	1	0.6	—	**HAR008CA**	11.9	6.05	0.310	—	26 000	42 000	17.3	6.6	0.200	9.27	—	—	45.5	—	62.5	63.5	1	0.6	—	8 000	0.01~0.02	**HAR008CA**
	68	15	1	0.6	—	**HAR008**	11.1	5.65	0.290	—	19 000	26 000	23.1	6.6	0.200	7.75	—	—	45.5	—	62.5	63.5	1	0.6	—	8 000	0.01~0.02	**HAR008**

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.

2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.

3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

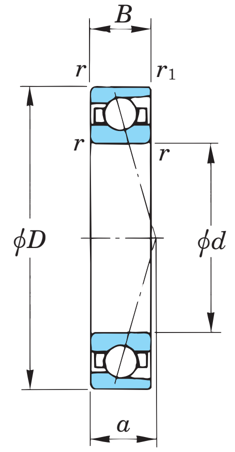
Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	$C_r\times1.62$	$C_{0r}\times2$
3-row	$C_r\times2.16$	$C_{0r}\times3$
4-row	$C_r\times2.64$	$C_{0r}\times4$

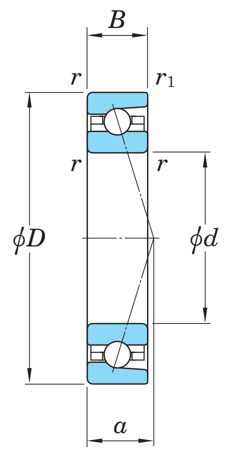
Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting: Preload S	Preload L	Preload M	Preload H
∅ ⃠	DB	0.85	0.80	0.65	0.55
∅∅ ⃠⃠	DBB	0.80	0.75	0.60	0.45
∅∅ ⃠	DBD	0.75	0.70	0.55	0.40

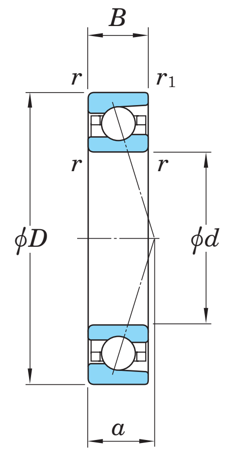
*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.



7000
7900
7200



HAR



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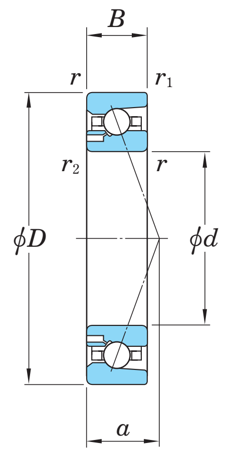

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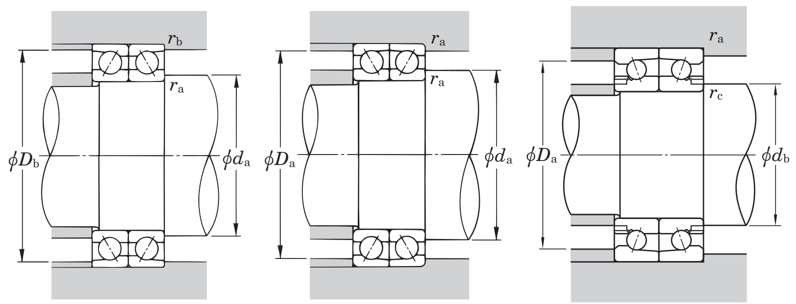


We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/Tandem X_0	Single row/Tandem Y_0	Back-to-back/Face-to-face X_0	Back-to-back/Face-to-face Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ 1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$ X	Y	$\frac{F_a}{F_r}>e$ X	Y	Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$ X	Y	$\frac{F_a}{F_r}>e$ X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (40) ~ (50)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. 1)	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)
40	68	15	1	0.6	—	3NCHAC008C	17.7	8.10	0.420	7.80	39 000	64 000	14.7	8.7
	68	15	1	0.6	—	3NCHAC008CA	17.3	7.90	0.410	—	36 000	61 000	17.3	8.7
	68	15	1	0.6	0.3	3NCHAD008CA	11.1	5.50	0.280	—	—	64 000	17.3	—
	80	18	1.1	0.6	—	7208C-5	45.4	25.2	1.70	14.2	19 000	30 000	17	15
	80	18	1.1	0.6	—	7208-5	42.0	23.3	1.50	—	15 000	19 000	26.3	15
45	68	12	0.6	0.3	—	7909C-5	20.8	14.1	0.770	16.0	22 000	35 000	13.6	5.7
	68	12	0.6	0.3	—	HAR909C	8.50	4.70	0.240	8.50	26 000	42 000	13.6	4.6
	68	12	0.6	0.3	—	HAR909CA	8.30	4.55	0.240	—	26 000	39 000	16.3	4.6
	68	12	0.6	0.3	—	HAR909	7.70	4.25	0.220	—	18 000	25 000	22.3	4.6
	68	12	0.6	0.3	—	3NCHAC909C	14.4	7.15	0.370	8.10	37 000	61 000	13.6	6.2
	68	12	0.6	0.3	—	3NCHAC909CA	14.1	7.00	0.360	—	35 000	58 000	16.3	6.2
	75	16	1	0.6	—	7009C-5	30.5	19.3	1.15	15.4	19 000	30 000	16	11
	75	16	1	0.6	—	7009-5	27.8	17.7	1.00	—	15 000	19 000	25.3	11
	75	16	1	0.6	—	HAR009C	13.6	7.10	0.370	8.30	25 000	39 000	16	8.4
	75	16	1	0.6	—	HAR009CA	13.3	6.95	0.360	—	25 000	37 000	18.9	8.4
	75	16	1	0.6	—	HAR009	12.4	6.45	0.330	—	18 000	23 000	25.3	8.4
	75	16	1	0.6	—	3NCHAC009C	20.9	9.80	0.510	7.80	35 000	58 000	16	11
	75	16	1	0.6	—	3NCHAC009CA	20.5	9.60	0.500	—	32 000	54 000	18.9	11
	75	16	1	0.6	0.3	3NCHAD009CA	12.4	6.30	0.330	—	—	58 000	18.9	—
	85	19	1.1	0.6	—	7209C-5	51.0	28.7	1.95	14.2	18 000	29 000	18.1	18
	85	19	1.1	0.6	—	7209-5	47.2	26.6	1.70	—	14 000	18 000	28	18
50	72	12	0.6	0.3	—	7910C-5	21.8	15.7	0.840	16.2	21 000	32 000	14.2	6.2
	72	12	0.6	0.3	—	HAR910C	11.4	6.30	0.330	8.50	25 000	39 000	14.2	5.6
	72	12	0.6	0.3	—	HAR910CA	11.1	6.15	0.320	—	23 000	36 000	17.1	5.6
	72	12	0.6	0.3	—	HAR910	10.3	5.75	0.300	—	16 000	22 000	23.6	5.6
	72	12	0.6	0.3	—	3NCHAC910C	15.2	7.95	0.410	8.20	35 000	57 000	14.2	6.5
	72	12	0.6	0.3	—	3NCHAC910CA	14.9	7.95	0.400	—	32 000	54 000	17.1	6.5
	80	16	1	0.6	—	7010C-5	32.5	21.9	1.25	15.7	18 000	29 000	16.8	12
	80	16	1	0.6	—	7010-5	29.5	20.1	1.10	—	13 000	18 000	26.9	12
	80	16	1	0.6	—	HAR010C	14.2	7.85	0.410	8.40	23 000	36 000	16.7	10

(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
0.161	6.5	—	—	45.5	—	62.5	63.5	1	0.6	—	8 000	0.01~0.02	3NCHAC008C
0.161	7.95	—	—	45.5	—	62.5	63.5	1	0.6	—	8 000	0.01~0.02	3NCHAC008CA
0.197	5.55	—	—	45.5	43.5	62.5	63.5	1	0.6	0.3	8 000	0.01~0.02	3NCHAD008CA
0.382	15.5	—	—	47	—	73	75.5	1	0.6	—	10 000	0.01~0.02	7208C-5
0.382	8.31	—	—	47	—	73	75.5	1	0.6	—	10 000	0.01~0.02	7208-5
0.127	6.84	—	—	49.5	—	63.5	65.5	0.6	0.3	—	6 000	0.01~0.02	7909C-5
0.136	5.97	—	—	49.5	—	63.5	65.5	0.6	0.3	—	6 000	0.01~0.02	HAR909C
0.136	7	—	—	49.5	—	63.5	65.5	0.6	0.3	—	6 000	0.01~0.02	HAR909CA
0.136	5.14	—	—	49.5	—	63.5	65.5	0.6	0.3	—	6 000	0.01~0.02	HAR909
0.109	5.78	—	—	49.5	—	63.5	65.5	0.6	0.3	—	6 000	0.01~0.02	3NCHAC909C
0.109	7.04	—	—	49.5	—	63.5	65.5	0.6	0.3	—	6 000	0.01~0.02	3NCHAC909CA
0.260	9.14	—	—	50.5	—	69.5	70.5	1	0.6	—	10 000	0.01~0.02	7009C-5
0.260	4.44	—	—	50.5	—	69.5	70.5	1	0.6	—	10 000	0.01~0.02	7009-5
0.251	9.03	—	—	50.5	—	69.5	70.5	1	0.6	—	10 000	0.01~0.02	HAR009C
0.251	10.6	—	—	50.5	—	69.5	70.5	1	0.6	—	10 000	0.01~0.02	HAR009CA
0.251	9.56	—	—	50.5	—	69.5	70.5	1	0.6	—	10 000	0.01~0.02	HAR009
0.205	7.89	—	—	50.5	—	69.5	70.5	1	0.6	—	10 000	0.01~0.02	3NCHAC009C
0.205	9.64	—	—	50.5	—	69.5	70.5	1	0.6	—	10 000	0.01~0.02	3NCHAC009CA
0.249	6.36	—	—	50.5	48.5	69.5	70.5	1	0.6	0.3	10 000	0.01~0.02	3NCHAD009CA
0.430	16.8	—	—	52	—	78	80.5	1	0.6	—	10 000	0.01~0.02	7209C-5
0.430	8.74	—	—	52	—	78	80.5	1	0.6	—	10 000	0.01~0.02	7209-5
0.128	7.42	—	—	54.5	—	67.5	69.5	0.6	0.3	—	6 000	0.01~0.02	7910C-5
0.131	8.06	—	—	54.5	—	67.5	69.5	0.6	0.3	—	6 000	0.01~0.02	HAR910C
0.131	9.13	—	—	54.5	—	67.5	69.5	0.6	0.3	—	6 000	0.01~0.02	HAR910CA
0.131	5.16	—	—	54.5	—	67.5	69.5	0.6	0.3	—	6 000	0.01~0.02	HAR910
0.109	6.45	—	—	54.5	—	67.5	69.5	0.6	0.3	—	6 000	0.01~0.02	3NCHAC910C
0.109	7.85	—	—	54.5	—	67.5	69.5	0.6	0.3	—	6 000	0.01~0.02	3NCHAC910CA
0.290	10.2	—	—	55.5	—	74.5	75.5	1	0.6	—	10 000	0.01~0.02	7010C-5
0.290	4.97	—	—	55.5	—	74.5	75.5	1	0.6	—	10 000	0.01~0.02	7010-5
0.273	9.98	—	—	55.5	—	74.5	75.5	1	0.6	—	10 000	0.01~0.02	HAR010C

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

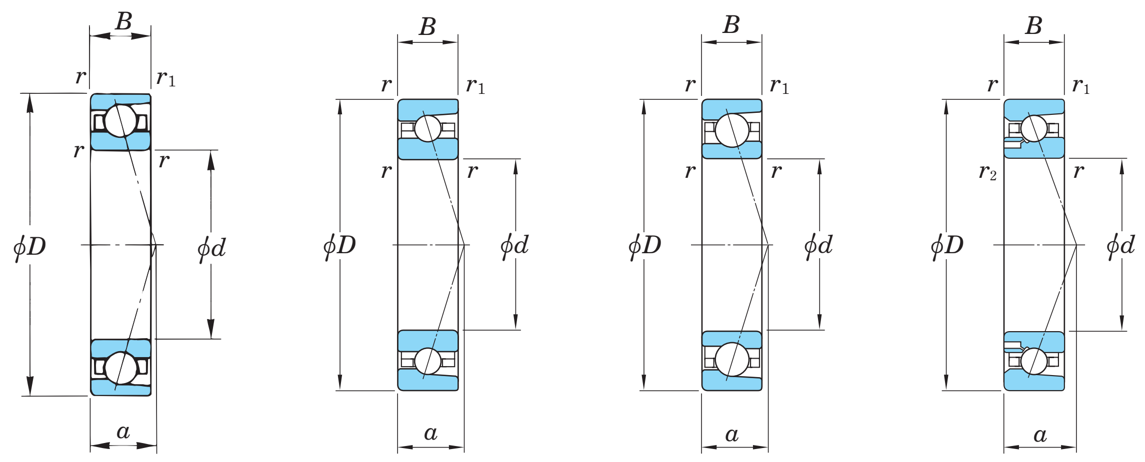
Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting: Preload S	Preload L	Preload M	Preload H
∅ ⃠	DB	0.85	0.80	0.65	0.55
∅∅ ⃠⃠	DBB	0.80	0.75	0.60	0.45
∅∅ ⃠	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.

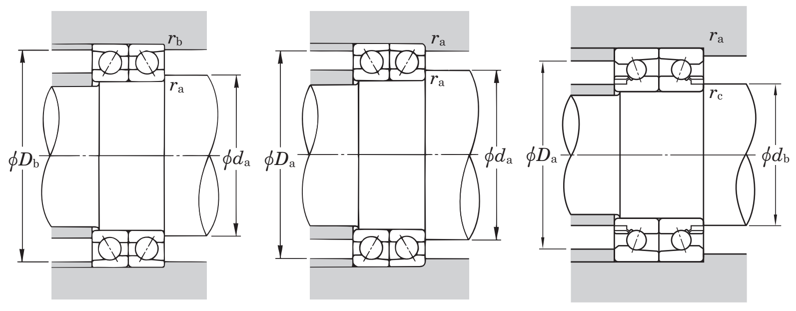


7000
7900
7200

HAR

3NCHAC

3NCHAD



We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ 1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$	
			X	Y	X	Y	X	Y	X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (50) ~ (60)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. 1)	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)
50	80	16	1	0.6	—	HAR010CA	13.9	7.65	0.400	—	22 000	35 000	19.8	10
	80	16	1	0.6	—	HAR010	12.9	7.15	0.370	—	16 000	21 000	26.8	10
	80	16	1	0.6	—	3NCHAC010C	22.4	11.2	0.580	8.00	32 000	53 000	16.8	12
	80	16	1	0.6	—	3NCHAC010CA	21.9	10.9	0.560	—	29 000	50 000	19.9	12
	80	16	1	0.6	0.3	3NCHAD010CA	13.5	7.35	0.380	—	—	53 000	19.8	—
	90	20	1.1	0.6	—	7210C-5	53.5	31.8	2.05	14.6	16 000	26 000	19.4	23
	90	20	1.1	0.6	—	7210-5	49.2	29.4	1.80	—	12 000	16 000	30.4	22
55	80	13	1	0.6	—	7911C-5	24.6	18.5	0.980	16.3	18 000	29 000	15.5	8.1
	80	13	1	0.6	—	HAR911C	12.6	7.65	0.400	8.60	22 000	35 000	15.5	6.5
	80	13	1	0.6	—	HAR911CA	12.3	7.50	0.390	—	22 000	33 000	18.8	6.5
	80	13	1	0.6	—	HAR911	11.4	6.95	0.360	—	15 000	21 000	26	6.5
	80	13	1	0.6	—	3NCHAC911C	17.3	9.40	0.490	8.30	30 000	51 000	15.5	8.3
	80	13	1	0.6	—	3NCHAC911CA	16.9	9.20	0.470	—	29 000	49 000	18.8	8.3
	90	18	1.1	0.6	—	7011C-5	42.6	28.6	1.65	15.5	16 000	26 000	18.7	17
	90	18	1.1	0.6	—	7011-5	38.9	26.3	1.50	—	12 000	16 000	29.9	17
	90	18	1.1	0.6	—	HAR011C	17.6	9.90	0.510	8.40	21 000	32 000	18.7	13
	90	18	1.1	0.6	—	HAR011CA	17.2	9.70	0.500	—	19 000	30 000	22.2	13
	90	18	1.1	0.6	—	HAR011	16.0	9.00	0.470	—	14 000	19 000	29.9	13
	90	18	1.1	0.6	—	3NCHAC011C	29.4	14.6	0.750	7.90	29 000	47 000	18.7	17
	90	18	1.1	0.6	—	3NCHAC011CA	28.7	14.3	0.740	—	26 000	44 000	22.2	17
	90	18	1.1	0.6	0.3	3NCHAD011CA	16.2	8.90	0.460	—	—	47 000	22.2	—
	100	21	1.5	1	—	7211C-5	66.1	40.2	2.60	14.6	15 000	23 000	21.1	29
	100	21	1.5	1	—	7211-5	60.9	37.1	2.30	—	11 000	15 000	33.3	29
60	85	13	1	0.6	—	7912C-5	29.0	21.8	1.15	16.3	16 000	26 000	16.3	8.8
	85	13	1	0.6	—	HAR912C	12.4	7.75	0.400	8.60	21 000	32 000	16.2	7
	85	13	1	0.6	—	HAR912CA	12.1	7.55	0.390	—	19 000	30 000	19.7	7
	85	13	1	0.6	—	HAR912	11.3	7.00	0.360	—	14 000	19 000	27.4	7
	85	13	1	0.6	—	3NCHAC912C	20.4	11.1	0.570	8.30	29 000	47 000	16.3	9.5
	85	13	1	0.6	—	3NCHAC912CA	19.9	10.8	0.560	—	26 000	44 000	19.8	9.5

(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
0.273	11.7	—	—	55.5	—	74.5	75.5	1	0.6	—	10 000	0.01~0.02	HAR010CA
0.273	10.4	—	—	55.5	—	74.5	75.5	1	0.6	—	10 000	0.01~0.02	HAR010
0.219	9	—	—	55.5	—	74.5	75.5	1	0.6	—	10 000	0.01~0.02	3NCHAC010C
0.219	10.9	—	—	55.5	—	74.5	75.5	1	0.6	—	10 000	0.01~0.02	3NCHAC010CA
0.269	7.4	—	—	55.5	53.5	74.5	75.5	1	0.6	0.3	10 000	0.01~0.02	3NCHAD010CA
0.485	18.1	—	—	57	—	83	85.5	1	0.6	—	12 000	0.01~0.02	7210C-5
0.485	9.44	—	—	57	—	83	85.5	1	0.6	—	12 000	0.01~0.02	7210-5
0.178	8.27	—	—	60.5	—	74.5	75.5	1	0.6	—	6 000	0.01~0.02	7911C-5
0.189	9.8	—	—	60.5	—	74.5	75.5	1	0.6	—	6 000	0.01~0.02	HAR911C
0.189	10.7	—	—	60.5	—	74.5	75.5	1	0.6	—	6 000	0.01~0.02	HAR911CA
0.189	8.84	—	—	60.5	—	74.5	75.5	1	0.6	—	6 000	0.01~0.02	HAR911
0.154	7.61	—	—	60.5	—	74.5	75.5	1	0.6	—	6 000	0.01~0.02	3NCHAC911C
0.154	9.25	—	—	60.5	—	74.5	75.5	1	0.6	—	6 000	0.01~0.02	3NCHAC911CA
0.420	13.3	—	—	62	—	83	85.5	1	0.6	—	12 000	0.01~0.02	7011C-5
0.420	6.35	—	—	62	—	83	85.5	1	0.6	—	12 000	0.01~0.02	7011-5
0.403	12.6	—	—	62	—	83	85.5	1	0.6	—	12 000	0.01~0.02	HAR011C
0.403	14.8	—	—	62	—	83	85.5	1	0.6	—	12 000	0.01~0.02	HAR011CA
0.403	12.8	—	—	62	—	83	85.5	1	0.6	—	12 000	0.01~0.02	HAR011
0.319	11.7	—	—	62	—	83	85.5	1	0.6	—	12 000	0.01~0.02	3NCHAC011C
0.319	14.3	—	—	62	—	83	85.5	1	0.6	—	12 000	0.01~0.02	3NCHAC011CA
0.395	8.94	—	—	62	58.5	83	85.5	1	0.6	0.3	12 000	0.01~0.02	3NCHAD011CA
0.635	23.5	—	—	63.5	—	91.5	94.5	1.5	1	—	12 000	0.01~0.02	7211C-5
0.635	12.4	—	—	63.5	—	91.5	94.5	1.5	1	—	12 000	0.01~0.02	7211-5
0.187	11.3	—	—	65.5	—	79.5	80.5	1	0.6	—	8 000	0.01~0.02	7912C-5
0.202	9.89	—	—	65.5	—	79.5	80.5	1	0.6	—	8 000	0.01~0.02	HAR912C
0.202	11.5	—	—	65.5	—	79.5	80.5	1	0.6	—	8 000	0.01~0.02	HAR912CA
0.202	9.95	—	—	65.5	—	79.5	80.5	1	0.6	—	8 000	0.01~0.02	HAR912
0.156	8.95	—	—	65.5	—	79.5	80.5	1	0.6	—	8 000	0.01~0.02	3NCHAC912C
0.156	10.8	—	—	65.5	—	79.5	80.5	1	0.6	—	8 000	0.01~0.02	3NCHAC912CA

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

Basic load ratings in case of multiple-row combination bearing

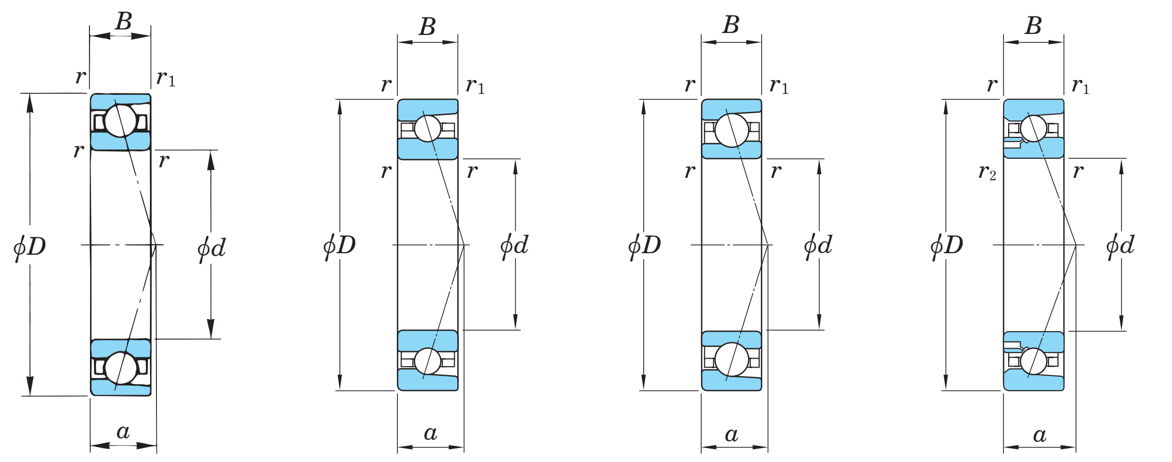
	Basic dynamic load ratings	Basic static load ratings
2-row	$C_r\times1.62$	$C_{0r}\times2$
3-row	$C_r\times2.16$	$C_{0r}\times3$
4-row	$C_r\times2.64$	$C_{0r}\times4$

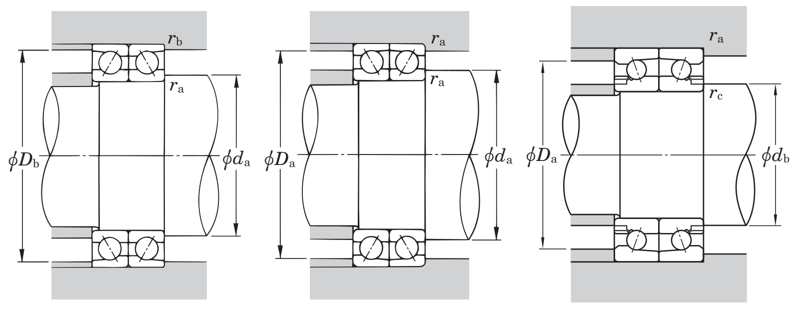
Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting Preload S	Preload L	Preload M	Preload H
∅ ⃠	DB	0.85	0.80	0.65	0.55
∅∅ ⃠⃠	DBB	0.80	0.75	0.60	0.45
∅∅ ⃠	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.

Koyo





We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/Tandem X_0	Single row/Tandem Y_0	Back-to-back/Face-to-face X_0	Back-to-back/Face-to-face Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ [1]	e	Single row/Tandem $\frac{F_a}{F_r}\leq e$ X	Y	Single row/Tandem $\frac{F_a}{F_r}>e$ X	Y	Back-to-back/Face-to-face $\frac{F_a}{F_r}\leq e$ X	Y	Back-to-back/Face-to-face $\frac{F_a}{F_r}>e$ X	Y
15°	0.178	0.38				1.47		1.65		2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47	1	0	0.44	1.19	1	1.34	0.72	1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (60) ~ (70)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. [1]	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
60	95	18	1.1	0.6	—	7012C-5	43.8	30.6	1.75	15.7	15 000	23 000	19.4	19	0.450	13.5	—	—	67	—	88	90.5	1	0.6	—	12 000	0.01~0.02	7012C-5
	95	18	1.1	0.6	—	7012-5	39.9	28.1	1.55	—	11 000	15 000	31.4	19	0.450	6.37	—	—	67	—	88	90.5	1	0.6	—	12 000	0.01~0.02	7012-5
	95	18	1.1	0.6	—	HAR012C	18.4	10.8	0.560	8.50	19 000	30 000	19.4	15	0.433	13.8	—	—	67	—	88	90.5	1	0.6	—	12 000	0.01~0.02	HAR012C
	95	18	1.1	0.6	—	HAR012CA	17.9	10.6	0.550	—	19 000	29 000	23.1	15	0.433	16.1	—	—	67	—	88	90.5	1	0.6	—	12 000	0.01~0.02	HAR012CA
	95	18	1.1	0.6	—	HAR012	16.7	9.85	0.510	—	13 000	18 000	31.4	15	0.433	13.9	—	—	67	—	88	90.5	1	0.6	—	12 000	0.01~0.02	HAR012
	95	18	1.1	0.6	—	3NCHAC012C	30.3	15.6	0.810	8.00	26 000	44 000	19.4	19	0.340	12.5	—	—	67	—	88	90.5	1	0.6	—	12 000	0.01~0.02	3NCHAC012C
	95	18	1.1	0.6	—	3NCHAC012CA	29.6	15.3	0.790	—	25 000	42 000	23.1	19	0.340	15.3	—	—	67	—	88	90.5	1	0.6	—	12 000	0.01~0.02	3NCHAC012CA
	95	18	1.1	0.6	0.3	3NCHAD012CA	17.0	9.75	0.500	—	—	44 000	23.1	—	0.427	9.84	—	—	67	63.5	88	90.5	1	0.6	0.3	12 000	0.01~0.02	3NCHAD012CA
	110	22	1.5	1	—	7212C-5	80.0	49.5	3.20	14.5	13 000	21 000	22.7	36	0.820	29.5	—	—	68.5	—	101.5	104.5	1.5	1	—	15 000	0.01~0.02	7212C-5
	110	22	1.5	1	—	7212-5	73.7	45.7	2.85	—	10 000	13 000	36.1	36	0.820	15.7	—	—	68.5	—	101.5	104.5	1.5	1	—	15 000	0.01~0.02	7212-5
65	90	13	1	0.6	—	7913C-5	25.9	21.2	1.10	16.5	16 000	25 000	16.9	9.4	0.205	9.52	—	—	70.5	—	84.5	85.5	1	0.6	—	8 000	0.01~0.02	7913C-5
	90	13	1	0.6	—	HAR913C	14.7	9.45	0.490	8.60	19 000	30 000	16.9	7.9	0.212	12	—	—	70.5	—	84.5	85.5	1	0.6	—	8 000	0.01~0.02	HAR913C
	90	13	1	0.6	—	HAR913CA	14.3	9.25	0.480	—	19 000	29 000	20.6	7.9	0.212	14.1	—	—	70.5	—	84.5	85.5	1	0.6	—	8 000	0.01~0.02	HAR913CA
	90	13	1	0.6	—	HAR913	13.3	8.55	0.440	—	13 000	18 000	28.9	7.9	0.212	11.2	—	—	70.5	—	84.5	85.5	1	0.6	—	8 000	0.01~0.02	HAR913
	90	13	1	0.6	—	3NCHAC913C	18.4	10.8	0.560	8.30	26 000	44 000	16.9	9.2	0.181	8.79	—	—	70.5	—	84.5	85.5	1	0.6	—	8 000	0.01~0.02	3NCHAC913C
	90	13	1	0.6	—	3NCHAC913CA	17.9	10.6	0.550	—	25 000	42 000	20.6	9.2	0.181	10.6	—	—	70.5	—	84.5	85.5	1	0.6	—	8 000	0.01~0.02	3NCHAC913CA
	100	18	1.1	0.6	—	7013C-5	46.3	34.3	1.90	15.9	14 000	22 000	20.1	19	0.470	18.7	—	—	72	—	93	95.5	1	0.6	—	15 000	0.01~0.02	7013C-5
	100	18	1.1	0.6	—	7013-5	42.1	31.4	1.70	—	10 000	14 000	33	19	0.470	9.89	—	—	72	—	93	95.5	1	0.6	—	15 000	0.01~0.02	7013-5
	100	18	1.1	0.6	—	HAR013C	19.1	11.8	0.610	8.50	18 000	29 000	20.1	16	0.462	14.9	—	—	72	—	93	95.5	1	0.6	—	15 000	0.01~0.02	HAR013C
	100	18	1.1	0.6	—	HAR013CA	18.6	11.5	0.590	—	18 000	26 000	24	16	0.462	17.5	—	—	72	—	93	95.5	1	0.6	—	15 000	0.01~0.02	HAR013CA
	100	18	1.1	0.6	—	HAR013	17.3	10.7	0.550	—	12 000	16 000	32.8	16	0.462	14.9	—	—	72	—	93	95.5	1	0.6	—	15 000	0.01~0.02	HAR013
	100	18	1.1	0.6	—	3NCHAC013C	32.2	17.5	0.900	8.10	25 000	42 000	20.1	20	0.365	14	—	—	72	—	93	95.5	1	0.6	—	15 000	0.01~0.02	3NCHAC013C
	100	18	1.1	0.6	—	3NCHAC013CA	31.5	17.1	0.880	—	23 000	39 000	24.1	20	0.365	17.1	—	—	72	—	93	95.5	1	0.6	—	15 000	0.01~0.02	3NCHAC013CA
	100	18	1.1	0.6	0.3	3NCHAD013CA	17.7	10.7	0.550	—	—	42 000	24	—	0.456	10.7	—	—	72	68.5	93	95.5	1	0.6	0.3	15 000	0.01~0.02	3NCHAD013CA
	120	23	1.5	1	—	7213C-5	91.4	58.7	3.80	14.6	12 000	19 000	23.9	41	1.02	34.6	—	—	73.5	—	111.5	114.5	1.5	1	—	15 000	0.01~0.02	7213C-5
	120	23	1.5	1	—	7213-5	84.1	54.2	3.35	—	9 800	12 000	38.2	40	1.02	18.3	—	—	73.5	—	111.5	114.5	1.5	1	—	15 000	0.01~0.02	7213-5
70	100	16	1	0.6	—	7914C-5	36.2	29.0	1.55	16.4	15 000	22 000	19.4	16	0.332	12.9	—	—	75.5	—	94.5	95.5	1	0.6	—	10 000	0.01~0.02	7914C-5
	100	16	1	0.6	—	HAR914C	16.1	10.5	0.540	8.70	18 000	28 000	19.4	12	0.356	13.3	—	—	75.5	—	94.5	95.5	1	0.6	—	10 000	0.01~0.02	HAR914C
	100	16	1	0.6	—	HAR914CA	15.7	10.2	0.530	—	16 000	26 000	23.5	12	0.356	15.6	—	—	75.5	—	94.5	95.5	1	0.6	—	10 000	0.01~0.02	HAR914CA

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

Basic load ratings in case of multiple-row combination bearing

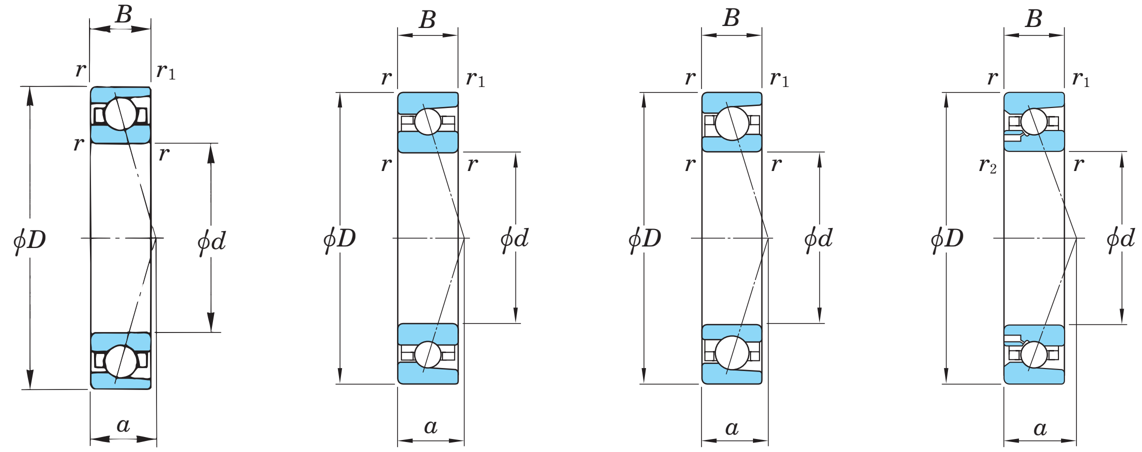
	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting: Preload S	Preload L	Preload M	Preload H
⊘ ⦸	DB	0.85	0.80	0.65	0.55
⊘⊘ ⦸⦸	DBB	0.80	0.75	0.60	0.45
⊘⊘ ⦸	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.

Koyo

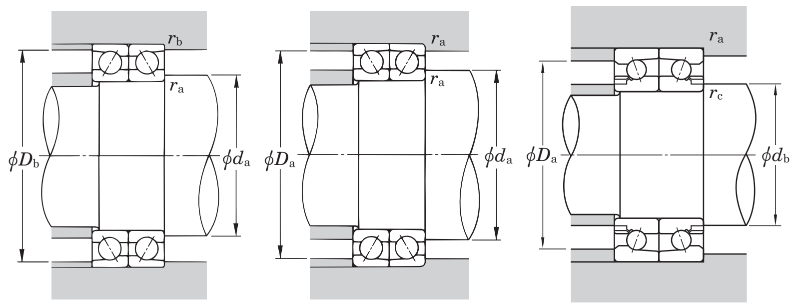


7000
7900
7200

HAR

3NCHAC

3NCHAD



We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ 1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$		Single row/Tandem $\frac{F_a}{F_r}>e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}>e$	
			X	Y	X	Y	X	Y	X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (70) ~ 75

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. 1)	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
70	100	16	1	0.6	—	**HAR914**	14.6	9.45	0.490	—	12 000	16 000	32.5	12	0.356	12.9	—	—	75.5	—	94.5	95.5	1	0.6	—	10 000	0.01~0.02	**HAR914**
	100	16	1	0.6	—	**3NCHAC914C**	25.4	14.7	0.760	8.30	25 000	40 000	19.4	15	0.291	11.9	—	—	75.5	—	94.5	95.5	1	0.6	—	10 000	0.01~0.02	**3NCHAC914C**
	100	16	1	0.6	—	**3NCHAC914CA**	24.8	14.4	0.740	—	22 000	39 000	23.5	15	0.291	14.5	—	—	75.5	—	94.5	95.5	1	0.6	—	10 000	0.01~0.02	**3NCHAC914CA**
	110	20	1.1	0.6	—	**7014C-5**	58.6	43.0	2.45	15.7	13 000	21 000	22.1	27	0.660	21	—	—	77	—	103	105.5	1	0.6	—	15 000	0.01~0.02	**7014C-5**
	110	20	1.1	0.6	—	**7014-5**	53.3	39.4	2.15	—	10 000	13 000	36	27	0.660	10.4	—	—	77	—	103	105.5	1	0.6	—	15 000	0.01~0.02	**7014-5**
	110	20	1.1	0.6	—	**HAR014C**	25.9	15.5	0.800	8.40	16 000	26 000	22.1	23	0.629	19.7	—	—	77	—	103	105.5	1	0.6	—	15 000	0.01~0.02	**HAR014C**
	110	20	1.1	0.6	—	**HAR014CA**	25.3	15.1	0.780	—	16 000	25 000	26.4	23	0.629	23.1	—	—	77	—	103	105.5	1	0.6	—	15 000	0.01~0.02	**HAR014CA**
	110	20	1.1	0.6	—	**HAR014**	23.6	14.1	0.730	—	11 000	15 000	36	23	0.629	20.3	—	—	77	—	103	105.5	1	0.6	—	15 000	0.01~0.02	**HAR014**
	110	20	1.1	0.6	—	**3NCHAC014C**	40.5	21.9	1.15	8.00	23 000	39 000	22.1	28	0.500	17.6	—	—	77	—	103	105.5	1	0.6	—	15 000	0.01~0.02	**3NCHAC014C**
	110	20	1.1	0.6	—	**3NCHAC014CA**	39.6	21.4	1.10	—	22 000	36 000	26.4	28	0.500	21.5	—	—	77	—	103	105.5	1	0.6	—	15 000	0.01~0.02	**3NCHAC014CA**
	110	20	1.1	0.6	0.3	**3NCHAD014CA**	23.9	13.9	0.720	—	—	39 000	26.4	—	0.635	14	—	—	77	73.5	103	105.5	1	0.6	0.3	15 000	0.01~0.02	**3NCHAD014CA**
	125	24	1.5	1	—	**7214C-5**	94.9	60.2	3.90	14.6	12 000	19 000	25.1	48	1.12	35.3	—	—	78.5	—	116.5	119.5	1.5	1	—	15 000	0.01~0.02	**7214C-5**
	125	24	1.5	1	—	**7214-5**	87.3	55.6	3.40	—	9 200	12 000	40.2	48	1.12	18.6	—	—	78.5	—	116.5	119.5	1.5	1	—	15 000	0.01~0.02	**7214-5**
75	105	16	1	0.6	—	**7915C-5**	36.7	30.5	1.60	16.5	13 000	21 000	20.1	17	0.350	13.5	—	—	80.5	—	99.5	100.5	1	0.6	—	10 000	0.01~0.02	**7915C-5**
	105	16	1	0.6	—	**HAR915C**	16.6	11.2	0.580	8.70	16 000	26 000	20.1	12	0.370	14.3	—	—	80.5	—	99.5	100.5	1	0.6	—	10 000	0.01~0.02	**HAR915C**
	105	16	1	0.6	—	**HAR915CA**	16.2	10.9	0.560	—	16 000	25 000	24.4	12	0.370	16.7	—	—	80.5	—	99.5	100.5	1	0.6	—	10 000	0.01~0.02	**HAR915CA**
	105	16	1	0.6	—	**HAR915**	15.0	10.1	0.520	—	11 000	15 000	34	12	0.370	13.8	—	—	80.5	—	99.5	100.5	1	0.6	—	10 000	0.01~0.02	**HAR915**
	105	16	1	0.6	—	**3NCHAC915C**	25.9	15.5	0.800	8.40	23 000	39 000	20.1	16	0.311	12.5	—	—	80.5	—	99.5	100.5	1	0.6	—	10 000	0.01~0.02	**3NCHAC915C**
	105	16	1	0.6	—	**3NCHAC915CA**	25.3	15.1	0.780	—	22 000	36 000	24.4	16	0.311	15.2	—	—	80.5	—	99.5	100.5	1	0.6	—	10 000	0.01~0.02	**3NCHAC915CA**
	115	20	1.1	0.6	—	**7015C-5**	60.1	45.6	2.55	15.9	12 000	19 000	22.7	29	0.690	22	—	—	82	—	108	110.5	1	0.6	—	15 000	0.01~0.02	**7015C-5**
	115	20	1.1	0.6	—	**7015-5**	54.6	41.7	2.25	—	9 500	12 000	37.4	28	0.690	10.6	—	—	82	—	108	110.5	1	0.6	—	15 000	0.01~0.02	**7015-5**
	115	20	1.1	0.6	—	**HAR015C**	26.4	16.2	0.840	8.50	16 000	25 000	22.7	25	0.665	20.6	—	—	82	—	108	110.5	1	0.6	—	15 000	0.01~0.02	**HAR015C**
	115	20	1.1	0.6	—	**HAR015CA**	25.7	15.8	0.820	—	15 000	23 000	27.3	25	0.665	24.2	—	—	82	—	108	110.5	1	0.6	—	15 000	0.01~0.02	**HAR015CA**
	115	20	1.1	0.6	—	**HAR015**	24.0	14.7	0.760	—	11 000	15 000	37.4	25	0.665	21	—	—	82	—	108	110.5	1	0.6	—	15 000	0.01~0.02	**HAR015**
	115	20	1.1	0.6	—	**3NCHAC015C**	41.7	23.2	1.20	8.10	22 000	36 000	22.7	28	0.539	18.7	—	—	82	—	108	110.5	1	0.6	—	15 000	0.01~0.02	**3NCHAC015C**
	115	20	1.1	0.6	—	**3NCHAC015CA**	40.7	22.7	1.15	—	21 000	35 000	27.3	28	0.539	22.8	—	—	82	—	108	110.5	1	0.6	—	15 000	0.01~0.02	**3NCHAC015CA**
	115	20	1.1	0.6	0.3	**3NCHAD015CA**	24.4	14.6	0.750	—	—	36 000	27.3	—	0.657	14.7	—	—	82	78.5	108	110.5	1	0.6	0.3	15 000	0.01~0.02	**3NCHAD015CA**
	130	25	1.5	1	—	**7215C-5**	108	70.6	4.50	14.6	11 000	18 000	26.2	54	1.23	41.1	—	—	83.5	—	121.5	124.5	1.5	1	—	15 000	0.01~0.02	**7215C-5**
	130	25	1.5	1	—	**7215-5**	99.0	65.2	3.95	—	8 800	11 000	42.1	53	1.23	21.6	—	—	83.5	—	121.5	124.5	1.5	1	—	15 000	0.01~0.02	**7215-5**

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting: Preload S	Preload L	Preload M	Preload H
⊘ ⦸	DB	0.85	0.80	0.65	0.55
⊘⊘ ⦸⦸	DBB	0.80	0.75	0.60	0.45
⊘⊘ ⦸	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.

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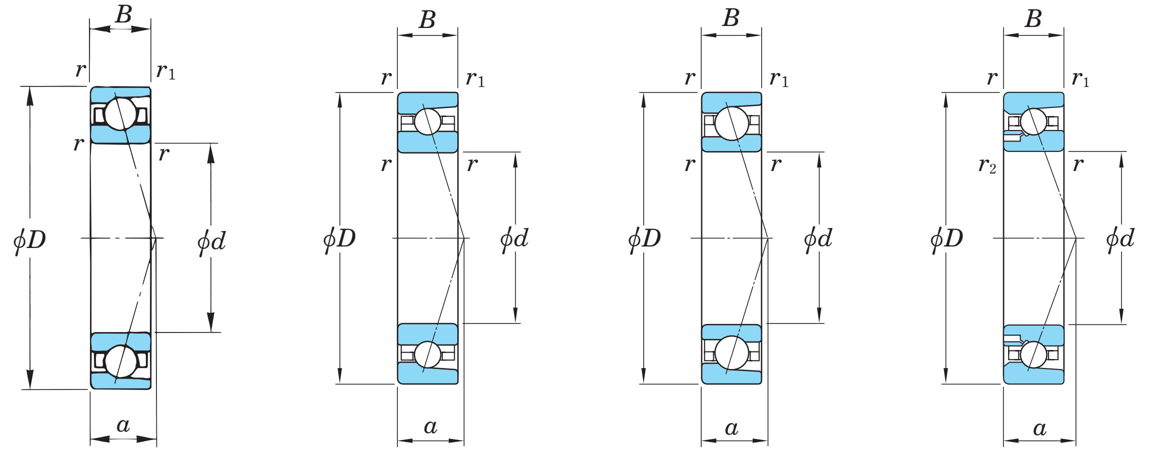

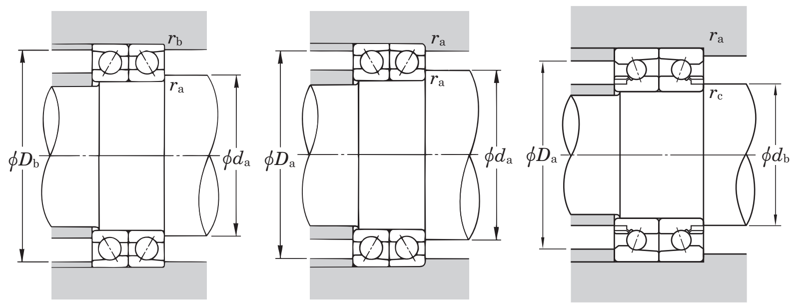

We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem X_0	Y_0	Back-to-back/ Face-to-face X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ [1]	e	Single row/Tandem $\frac{F_a}{F_r}\le e$ X	Y	$\frac{F_a}{F_r}>e$ X	Y	Back-to-back/Face-to-face $\frac{F_a}{F_r}\le e$ X	Y	$\frac{F_a}{F_r}>e$ X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d **80 ~ (85)**

d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. [1]	C_r (kN)	C_{0r} (kN)	Fatigue load limit C_u (kN)	Factor f_0	Limiting speeds Grease lub. (min⁻¹)	Oil lub. (min⁻¹)	Load center a (mm)	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Lubrication groove S (mm)	W	d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
80	110	16	1	0.6	—	7916C-5	37.3	31.6	1.65	16.5	13 000	21 000	20.7	18	0.368	14	—	—	85.5	—	104.5	105.5	1	0.6	—	10 000	0.01~0.02	7916C-5
	110	16	1	0.6	—	HAR916C	17.0	11.9	0.620	8.80	16 000	25 000	20.7	13	0.398	15.2	—	—	85.5	—	104.5	105.5	1	0.6	—	10 000	0.01~0.02	HAR916C
	110	16	1	0.6	—	HAR916CA	16.6	11.6	0.600	—	15 000	23 000	25.3	13	0.398	17.8	—	—	85.5	—	104.5	105.5	1	0.6	—	10 000	0.01~0.02	HAR916CA
	110	16	1	0.6	—	HAR916	15.4	10.8	0.560	—	11 000	15 000	35.4	13	0.398	14.6	—	—	85.5	—	104.5	105.5	1	0.6	—	10 000	0.01~0.02	HAR916
	110	16	1	0.6	—	3NCHAC916C	26.4	16.2	0.840	8.50	22 000	36 000	20.7	17	0.325	13.1	—	—	85.5	—	104.5	105.5	1	0.6	—	10 000	0.01~0.02	3NCHAC916C
	110	16	1	0.6	—	3NCHAC916CA	25.7	15.8	0.820	—	21 000	35 000	25.3	17	0.325	15.9	—	—	85.5	—	104.5	105.5	1	0.6	—	10 000	0.01~0.02	3NCHAC916CA
	125	22	1.1	0.6	—	7016C-5	73.3	55.3	3.10	15.7	11 000	18 000	24.7	37	0.930	23.5	—	—	87	—	118	120.5	1	0.6	—	15 000	0.01~0.02	7016C-5
	125	22	1.1	0.6	—	7016-5	66.7	50.6	2.75	—	8 800	11 000	40.6	37	0.930	10.8	—	—	87	—	118	120.5	1	0.6	—	15 000	0.01~0.02	7016-5
	125	22	1.1	0.6	—	HAR016C	30.9	19.2	0.980	8.40	14 000	22 000	24.7	31	0.903	24.5	—	—	87	—	118	120.5	1	0.6	—	15 000	0.01~0.02	HAR016C
	125	22	1.1	0.6	—	HAR016CA	30.1	18.8	0.960	—	13 000	21 000	29.7	31	0.903	28.7	—	—	87	—	118	120.5	1	0.6	—	15 000	0.01~0.02	HAR016CA
	125	22	1.1	0.6	—	HAR016	28.1	17.5	0.890	—	9 800	13 000	40.6	31	0.903	24.6	—	—	87	—	118	120.5	1	0.6	—	15 000	0.01~0.02	HAR016
	125	22	1.1	0.6	—	3NCHAC016C	50.7	28.1	1.45	8.00	19 000	32 000	24.7	38	0.714	22.6	—	—	87	—	118	120.5	1	0.6	—	15 000	0.01~0.02	3NCHAC016C
	125	22	1.1	0.6	—	3NCHAC016CA	49.6	27.5	1.40	—	18 000	30 000	29.7	38	0.714	27.6	—	—	87	—	118	120.5	1	0.6	—	15 000	0.01~0.02	3NCHAC016CA
	125	22	1.1	0.6	0.3	3NCHAD016CA	28.6	17.3	0.890	—	—	32 000	29.7	—	0.885	17.5	—	—	87	83.5	118	120.5	1	0.6	0.3	15 000	0.01~0.02	3NCHAD016CA
	140	26	2	1	—	7216C-5	116	77.5	4.70	14.7	10 000	16 000	27.7	63	1.50	44.5	—	—	90	—	130	134.5	2	1	—	18 000	0.01~0.02	7216C-5
	140	26	2	1	—	7216-5	107	71.5	4.10	—	8 100	10 000	44.8	63	1.50	23.3	—	—	90	—	130	134.5	2	1	—	18 000	0.01~0.02	7216-5
85	120	18	1.1	0.6	—	7917C-5	48.6	40.6	2.10	16.5	12 000	19 000	22.7	25	0.523	19.5	—	—	92	—	113	115.5	1	0.6	—	12 000	0.01~0.02	7917C-5
	120	18	1.1	0.6	—	HAR917C	20.4	14.2	0.720	8.70	14 000	22 000	22.7	18	0.570	18.1	—	—	92	—	113	115.5	1	0.6	—	12 000	0.01~0.02	HAR917C
	120	18	1.1	0.6	—	HAR917CA	19.9	13.8	0.710	—	13 000	21 000	27.7	18	0.570	21.2	—	—	92	—	113	115.5	1	0.6	—	12 000	0.01~0.02	HAR917CA
	120	18	1.1	0.6	—	HAR917	18.5	12.8	0.650	—	9 800	13 000	38.6	18	0.570	17	—	—	92	—	113	115.5	1	0.6	—	12 000	0.01~0.02	HAR917
	120	18	1.1	0.6	—	3NCHAC917C	34.2	20.6	1.05	8.40	19 000	32 000	22.7	24	0.473	16.7	—	—	92	—	113	115.5	1	0.6	—	12 000	0.01~0.02	3NCHAC917C
	120	18	1.1	0.6	—	3NCHAC917CA	33.4	20.1	1.05	—	18 000	30 000	27.6	24	0.473	20.3	—	—	92	—	113	115.5	1	0.6	—	12 000	0.01~0.02	3NCHAC917CA
	130	22	1.1	0.6	—	7017C-5	75.1	58.7	3.15	15.9	10 000	16 000	25.5	39	0.970	28.2	—	—	92	—	123	125.5	1	0.6	—	18 000	0.01~0.02	7017C-5
	130	22	1.1	0.6	—	7017-5	68.2	53.7	2.75	—	8 200	10 000	42.3	39	0.970	14	—	—	92	—	123	125.5	1	0.6	—	18 000	0.01~0.02	7017-5
	130	22	1.1	0.6	—	HAR017C	31.4	20.1	1.00	8.50	13 000	21 000	25.4	33	0.947	25.6	—	—	92	—	123	125.5	1	0.6	—	18 000	0.01~0.02	HAR017C
	130	22	1.1	0.6	—	HAR017CA	30.7	19.6	0.980	—	13 000	19 000	30.6	33	0.947	30	—	—	92	—	123	125.5	1	0.6	—	18 000	0.01~0.02	HAR017CA
	130	22	1.1	0.6	—	HAR017	28.5	18.3	0.910	—	9 200	12 000	42	33	0.947	26.3	—	—	92	—	123	125.5	1	0.6	—	18 000	0.01~0.02	HAR017
	130	22	1.1	0.6	—	3NCHAC017C	52.1	29.8	1.50	8.10	18 000	30 000	25.5	40	0.741	24	—	—	92	—	123	125.5	1	0.6	—	18 000	0.01~0.02	3NCHAC017C
	130	22	1.1	0.6	—	3NCHAC017CA	51.0	29.2	1.45	—	16 000	29 000	30.7	40	0.741	29.3	—	—	92	—	123	125.5	1	0.6	—	18 000	0.01~0.02	3NCHAC017CA
	130	22	1.1	0.6	0.3	3NCHAD017CA	29.1	18.2	0.910	—	—	30 000	30.6	—	0.924	18.3	—	—	92	88.5	123	125.5	1	0.6	0.3	18 000	0.01~0.02	3NCHAD017CA

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload S	Preload L	Preload M	Preload H
⊘ ⦸	DB	0.85	0.80	0.65	0.55
⊘⊘ ⦸⦸	DBB	0.80	0.75	0.60	0.45
⊘⊘ ⦸	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.

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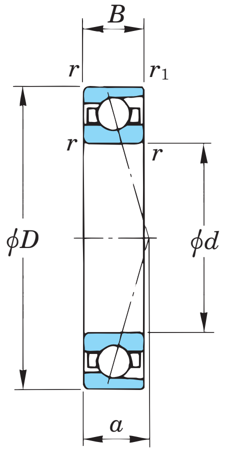

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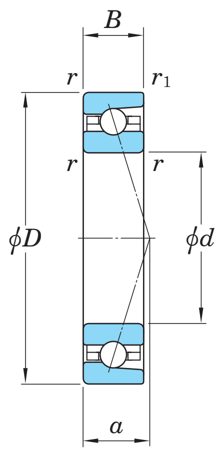

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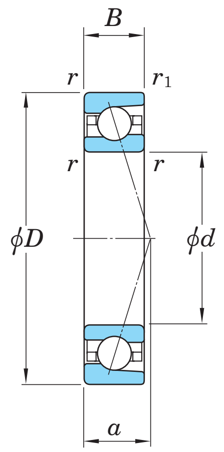

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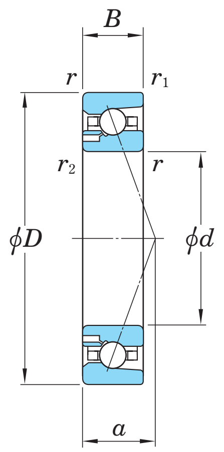

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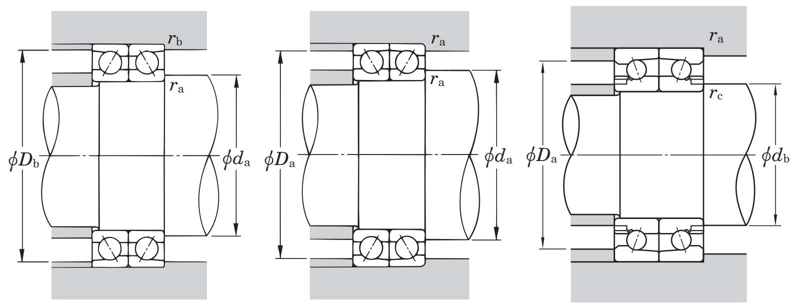


We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem X_0	Single row/ Tandem Y_0	Back-to-back/ Face-to-face X_0	Back-to-back/ Face-to-face Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	if_0F_a/C_{0r} [1]	e	Single row/Tandem $F_a/F_r\leq e$ X	Y	Single row/Tandem $F_a/F_r>e$ X	Y	Back-to-back/Face-to-face $F_a/F_r\leq e$ X	Y	Back-to-back/Face-to-face $F_a/F_r>e$ X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (85) ~ (95)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. [1]	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
85	150	28	2	1	—	7217C-5	134	90.6	5.35	14.7	9 900	15 000	29.7	76	1.87	52.9	—	—	95	—	140	144.5	2	1	—	18 000	0.01~0.02	7217C-5
	150	28	2	1	—	7217-5	123	83.6	4.70	—	7 500	9 900	47.9	75	1.87	27.9	—	—	95	—	140	144.5	2	1	—	18 000	0.01~0.02	7217-5
90	125	18	1.1	0.6	—	7918C-5	49.5	42.6	2.15	16.6	11 000	18 000	23.4	26	0.551	20.4	—	—	97	—	118	120.5	1	0.6	—	12 000	0.01~0.02	7918C-5
	125	18	1.1	0.6	—	HAR918C	21.1	15.1	0.750	8.80	13 000	21 000	23.4	19	0.598	19.3	—	—	97	—	118	120.5	1	0.6	—	12 000	0.01~0.02	HAR918C
	125	18	1.1	0.6	—	HAR918CA	20.5	14.7	0.730	—	13 000	19 000	28.6	19	0.598	22.6	—	—	97	—	118	120.5	1	0.6	—	12 000	0.01~0.02	HAR918CA
	125	18	1.1	0.6	—	HAR918	19.0	13.7	0.680	—	9 200	12 000	40	19	0.598	18	—	—	97	—	118	120.5	1	0.6	—	12 000	0.01~0.02	HAR918
	125	18	1.1	0.6	—	3NCHAC918C	34.9	21.6	1.10	8.40	18 000	30 000	23.4	27	0.465	17.5	—	—	97	—	118	120.5	1	0.6	—	12 000	0.01~0.02	3NCHAC918C
	125	18	1.1	0.6	—	3NCHAC918CA	34.1	21.1	1.05	—	16 000	29 000	28.6	27	0.465	21.2	—	—	97	—	118	120.5	1	0.6	—	12 000	0.01~0.02	3NCHAC918CA
	140	24	1.5	1	—	7018C-5	89.6	69.1	3.65	15.7	10 000	16 000	27.4	47	1.26	37.3	—	—	98.5	—	131.5	134.5	1.5	1	—	18 000	0.01~0.02	7018C-5
	140	24	1.5	1	—	7018-5	81.5	63.3	3.25	—	7 800	10 000	45.2	47	1.26	19	—	—	98.5	—	131.5	134.5	1.5	1	—	18 000	0.01~0.02	7018-5
	140	24	1.5	1	—	HAR018C	41.0	26.1	1.25	8.40	12 000	19 000	27.4	43	1.21	33.1	—	—	98.5	—	131.5	134.5	1.5	1	—	18 000	0.01~0.02	HAR018C
	140	24	1.5	1	—	HAR018CA	40.0	25.4	1.25	—	12 000	18 000	32.9	43	1.21	38.9	—	—	98.5	—	131.5	134.5	1.5	1	—	18 000	0.01~0.02	HAR018CA
	140	24	1.5	1	—	HAR018	37.3	23.7	1.15	—	8 600	11 000	45.2	43	1.21	33.4	—	—	98.5	—	131.5	134.5	1.5	1	—	18 000	0.01~0.02	HAR018
	140	24	1.5	1	—	3NCHAC018C	62.0	35.2	1.70	8.00	16 000	29 000	27.4	51	0.943	28.3	—	—	98.5	—	131.5	134.5	1.5	1	—	18 000	0.01~0.02	3NCHAC018C
	140	24	1.5	1	—	3NCHAC018CA	60.6	34.4	1.65	—	16 000	26 000	32.9	51	0.943	34.5	—	—	98.5	—	131.5	134.5	1.5	1	—	18 000	0.01~0.02	3NCHAC018CA
	140	24	1.5	1	0.3	3NCHAD018CA	38.0	23.5	1.15	—	—	29 000	32.9	—	1.15	23.6	—	—	98.5	94	131.5	134.5	1.5	1	0.3	18 000	0.01~0.02	3NCHAD018CA
	160	30	2	1	—	7218C-5	153	105	6.00	14.6	9 300	15 000	31.7	93	2.30	62.3	—	—	100	—	150	154.5	2	1	—	20 000	0.01~0.02	7218C-5
	160	30	2	1	—	7218-5	141	96.7	5.30	—	7 100	9 300	51.1	92	2.30	33	—	—	100	—	150	154.5	2	1	—	20 000	0.01~0.02	7218-5
95	130	18	1.1	0.6	—	7919C-5	50.3	44.1	2.15	16.5	11 000	16 000	24.1	27	0.574	20.9	—	—	102	—	123	125.5	1	0.6	—	12 000	0.01~0.02	7919C-5
	130	18	1.1	0.6	—	HAR919C	21.6	16.0	0.780	8.80	13 000	19 000	24.1	19	0.626	20.5	—	—	102	—	123	125.5	1	0.6	—	12 000	0.01~0.02	HAR919C
	130	18	1.1	0.6	—	HAR919CA	21.1	15.6	0.760	—	12 000	19 000	29.5	19	0.626	23.9	—	—	102	—	123	125.5	1	0.6	—	12 000	0.01~0.02	HAR919CA
	130	18	1.1	0.6	—	HAR919	19.6	14.5	0.710	—	8 800	11 000	41.5	19	0.626	19	—	—	102	—	123	125.5	1	0.6	—	12 000	0.01~0.02	HAR919
	130	18	1.1	0.6	—	3NCHAC919C	35.6	22.6	1.10	8.50	18 000	29 000	24.1	26	0.491	18.3	—	—	102	—	123	125.5	1	0.6	—	12 000	0.01~0.02	3NCHAC919C
	130	18	1.1	0.6	—	3NCHAC919CA	34.7	22.1	1.10	—	16 000	28 000	29.5	26	0.491	22.2	—	—	102	—	123	125.5	1	0.6	—	12 000	0.01~0.02	3NCHAC919CA
	145	24	1.5	1	—	7019C-5	91.7	73.4	3.70	15.9	9 600	15 000	28.3	50	1.32	37.8	—	—	103.5	—	136.5	139.5	1.5	1	—	18 000	0.01~0.02	7019C-5
	145	24	1.5	1	—	7019-5	83.3	67.1	3.25	—	7 200	9 600	47.2	50	1.32	19.1	—	—	103.5	—	136.5	139.5	1.5	1	—	18 000	0.01~0.02	7019-5
	145	24	1.5	1	—	HAR019C	41.8	27.2	1.30	8.50	12 000	18 000	28.1	45	1.28	34.6	—	—	103.5	—	136.5	139.5	1.5	1	—	18 000	0.01~0.02	HAR019C
	145	24	1.5	1	—	HAR019CA	40.8	26.6	1.25	—	11 000	18 000	33.8	45	1.28	40.6	—	—	103.5	—	136.5	139.5	1.5	1	—	18 000	0.01~0.02	HAR019CA
	145	24	1.5	1	—	HAR019	38.0	24.7	1.15	—	8 200	11 000	46.6	45	1.28	33.5	—	—	103.5	—	136.5	139.5	1.5	1	—	18 000	0.01~0.02	HAR019
	145	24	1.5	1	—	3NCHAC019C	63.7	37.3	1.75	8.10	16 000	26 000	28.3	55	0.960	30.1	—	—	103.5	—	136.5	139.5	1.5	1	—	18 000	0.01~0.02	3NCHAC019C

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

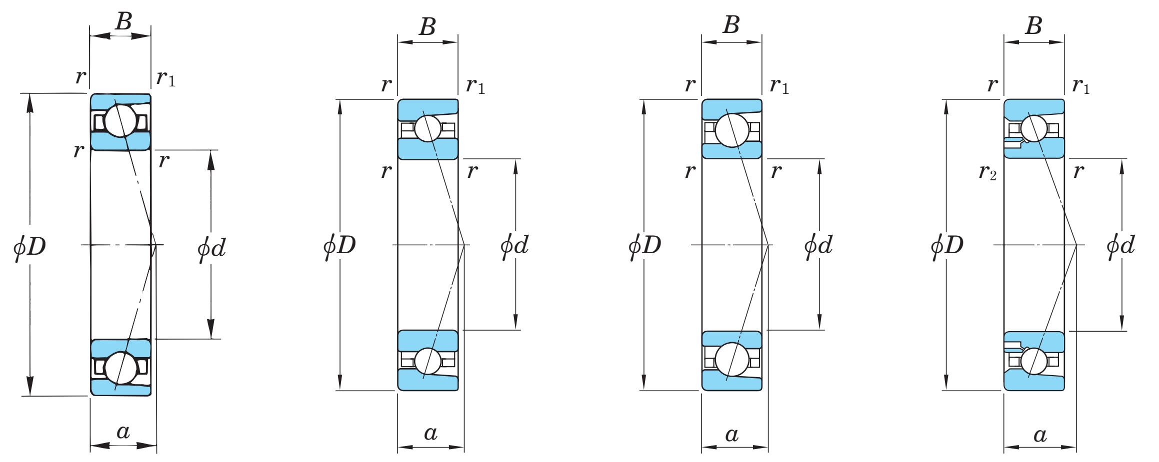
Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting: Preload S	Preload L	Preload M	Preload H
⊘ ⦸	DB	0.85	0.80	0.65	0.55
⊘⊘ ⦸⦸	DBB	0.80	0.75	0.60	0.45
⊘⊘ ⦸	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.

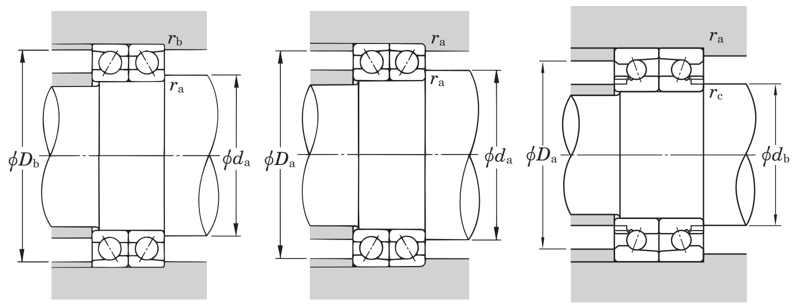


7000
7900
7200

HAR

3NCHAC

3NCHAD



We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ 1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$	
			X	Y	X	Y	X	Y	X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (95) ~ (105)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. 1)	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
95	145	24	1.5	1	—	3NCHAC019CA	62.3	36.5	1.70	—	15 000	25 000	34.2	55	0.960	36.7	—	—	103.5	—	136.5	139.5	1.5	1	—	18 000	0.01~0.02	3NCHAC019CA
	145	24	1.5	1	0.3	3NCHAD019CA	38.7	24.6	1.15	—	—	28 000	33.8	—	1.25	24.8	—	—	103.5	99	136.5	139.5	1.5	1	0.3	18 000	0.01~0.02	3NCHAD019CA
	170	32	2.1	1.1	—	7219C-5	166	112	6.30	14.6	8 800	14 000	33.8	116	2.78	65.9	—	—	107	—	158	163	2	1	—	20 000	0.01~0.02	7219C-5
	170	32	2.1	1.1	—	7219-5	153	103	5.50	—	6 700	8 800	54.3	115	2.78	34.8	—	—	107	—	158	163	2	1	—	20 000	0.01~0.02	7219-5
100	140	20	1.1	0.6	—	7920C-5	69.4	58.5	2.85	16.3	10 000	15 000	26.1	35	0.773	31.9	—	—	107	—	133	135.5	1	0.6	—	15 000	0.01~0.02	7920C-5
	140	20	1.1	0.6	—	HAR920C	30.2	21.7	1.05	8.70	12 000	18 000	26.1	28	0.839	27.8	—	—	107	—	133	135.5	1	0.6	—	15 000	0.01~0.02	HAR920C
	140	20	1.1	0.6	—	HAR920CA	29.4	21.2	1.00	—	11 000	18 000	31.8	28	0.839	32.5	—	—	107	—	133	135.5	1	0.6	—	15 000	0.01~0.02	HAR920CA
	140	20	1.1	0.6	—	HAR920	27.3	19.7	0.930	—	8 200	11 000	44.6	28	0.839	27.5	—	—	107	—	133	135.5	1	0.6	—	15 000	0.01~0.02	HAR920
	140	20	1.1	0.6	—	3NCHAC920C	48.7	29.7	1.40	8.30	16 000	28 000	26.1	38	0.632	24	—	—	107	—	133	135.5	1	0.6	—	15 000	0.01~0.02	3NCHAC920C
	140	20	1.1	0.6	—	3NCHAC920CA	47.6	29.0	1.35	—	15 000	26 000	31.8	38	0.632	29.2	—	—	107	—	133	135.5	1	0.6	—	15 000	0.01~0.02	3NCHAC920CA
	150	24	1.5	1	—	7020C-5	94.2	77.2	3.80	16.0	9 300	15 000	28.7	51	1.37	38.1	—	—	108.5	—	141.5	144.5	1.5	1	—	20 000	0.01~0.02	7020C-5
	150	24	1.5	1	—	7020-5	85.5	70.6	3.35	—	7 100	9 300	48.1	51	1.37	19.2	—	—	108.5	—	141.5	144.5	1.5	1	—	20 000	0.01~0.02	7020-5
	150	24	1.5	1	—	HAR020C	42.5	28.4	1.30	8.50	11 000	18 000	28.7	47	1.32	36.1	—	—	108.5	—	141.5	144.5	1.5	1	—	20 000	0.01~0.02	HAR020C
	150	24	1.5	1	—	HAR020CA	41.5	27.7	1.30	—	11 000	16 000	34.7	47	1.32	42.4	—	—	108.5	—	141.5	144.5	1.5	1	—	20 000	0.01~0.02	HAR020CA
	150	24	1.5	1	—	HAR020	38.6	25.8	1.20	—	7 900	10 000	48.1	47	1.32	37.4	—	—	108.5	—	141.5	144.5	1.5	1	—	20 000	0.01~0.02	HAR020
	150	24	1.5	1	—	3NCHAC020C	65.5	39.3	1.80	8.10	15 000	26 000	28.7	56	1.03	31.7	—	—	108.5	—	141.5	144.5	1.5	1	—	20 000	0.01~0.02	3NCHAC020C
	150	24	1.5	1	—	3NCHAC020CA	64.0	38.4	1.75	—	15 000	25 000	34.7	56	1.03	38.6	—	—	108.5	—	141.5	144.5	1.5	1	—	20 000	0.01~0.02	3NCHAC020CA
	150	24	1.5	1	0.3	3NCHAD020CA	39.5	25.7	1.20	—	—	26 000	34.7	—	1.28	25.9	—	—	108.5	104	141.5	144.5	1.5	1	0.3	20 000	0.01~0.02	3NCHAD020CA
	180	34	2.1	1.1	—	7220C-5	186	127	6.95	14.6	8 200	13 000	35.9	140	3.32	74.2	—	—	112	—	168	173	2	1	—	25 000	0.01~0.02	7220C-5
	180	34	2.1	1.1	—	7220-5	171	117	6.10	—	6 300	8 200	57.7	139	3.32	39	—	—	112	—	168	173	2	1	—	25 000	0.01~0.02	7220-5
105	145	20	1.1	0.6	—	7921C-5	70.8	61.5	2.90	16.4	9 900	15 000	26.7	37	0.810	34	—	—	112	—	138	140.5	1	0.6	—	15 000	0.02~0.04	7921C-5
	145	20	1.1	0.6	—	HAR921C	31.1	23.1	1.05	8.70	11 000	18 000	26.7	29	0.874	29.6	—	—	112	—	138	140.5	1	0.6	—	15 000	0.02~0.04	HAR921C
	145	20	1.1	0.6	—	HAR921CA	30.3	22.5	1.05	—	11 000	16 000	32.7	29	0.874	34.6	—	—	112	—	138	140.5	1	0.6	—	15 000	0.02~0.04	HAR921CA
	145	20	1.1	0.6	—	HAR921	28.2	20.9	0.970	—	7 900	10 000	46.1	29	0.874	29.1	—	—	112	—	138	140.5	1	0.6	—	15 000	0.02~0.04	HAR921
	145	20	1.1	0.6	—	3NCHAC921C	49.8	31.2	1.45	8.30	15 000	26 000	26.7	40	0.658	25.3	—	—	112	—	138	140.5	1	0.6	—	15 000	0.02~0.04	3NCHAC921C
	145	20	1.1	0.6	—	3NCHAC921CA	48.7	30.5	1.40	—	15 000	25 000	32.7	40	0.658	30.7	—	—	112	—	138	140.5	1	0.6	—	15 000	0.02~0.04	3NCHAC921CA
	160	26	2	1	—	7021C-5	110	89.6	4.30	15.9	8 600	13 000	31	68	1.73	48.9	—	—	115	—	150	154.5	2	1	—	20 000	0.02~0.04	7021C-5
	160	26	2	1	—	7021-5	99.7	81.9	3.80	—	6 500	8 600	51.8	68	1.73	25	—	—	115	—	150	154.5	2	1	—	20 000	0.02~0.04	7021-5
	160	26	2	1	—	HAR021C	48.2	32.5	1.45	8.50	11 000	16 000	30.8	57	1.68	41.4	—	—	115	—	150	154.5	2	1	—	20 000	0.02~0.04	HAR021C

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

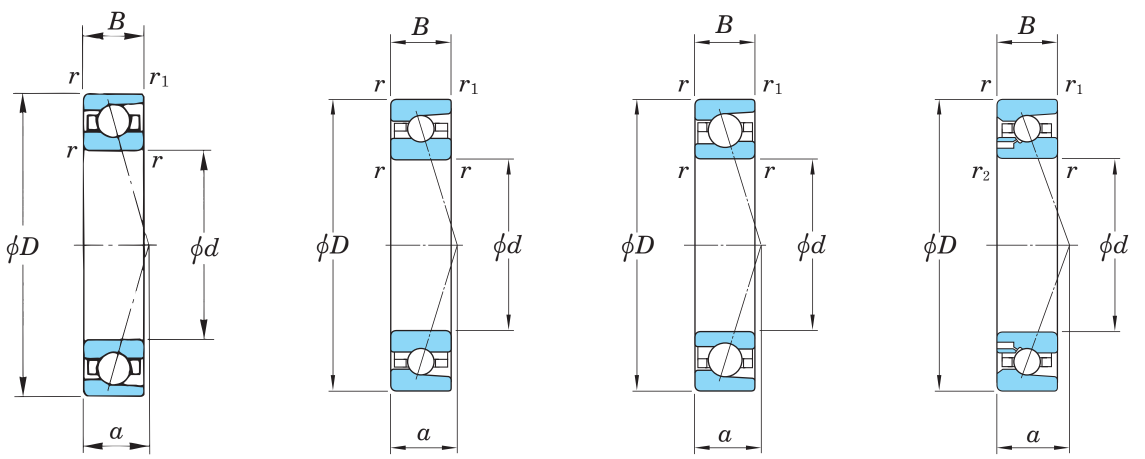
Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting Preload S	Preload L	Preload M	Preload H
⌀ ⦸	DB	0.85	0.80	0.65	0.55
⌀⌀ ⦸⦸	DBB	0.80	0.75	0.60	0.45
⌀⌀ ⦸	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.

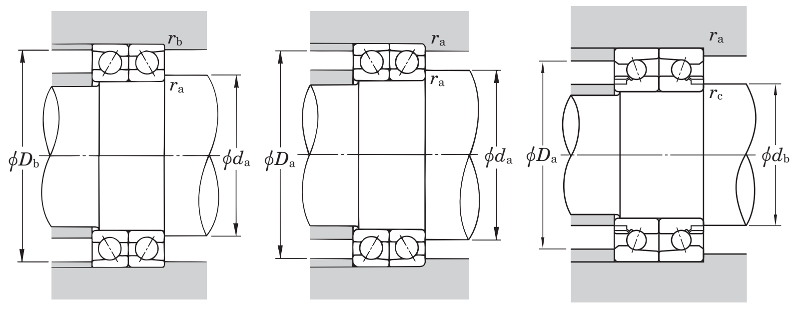


7000
7900
7200

HAR

3NCHAC

3NCHAD



We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ 1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$ X	Y	$\frac{F_a}{F_r}>e$ X	Y	Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$ X	Y	$\frac{F_a}{F_r}>e$ X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (105) ~ (120)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. 1)	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
105	160	26	2	1	—	HAR021CA	47.1	31.7	1.45	—	10 000	15 000	37.1	57	1.68	48.6	—	—	115	—	150	154.5	2	1	—	20 000	0.02–0.04	HAR021CA
	160	26	2	1	—	HAR021	43.8	29.5	1.35	—	7 500	10 000	51.2	57	1.68	42	—	—	115	—	150	154.5	2	1	—	20 000	0.02–0.04	HAR021
	160	26	2	1	—	3NCHAC021C	76.2	45.6	2.05	8.10	15 000	25 000	31	71	1.28	36.7	—	—	115	—	150	154.5	2	1	—	20 000	0.02–0.04	3NCHAC021C
	160	26	2	1	—	3NCHAC021CA	74.6	44.6	2.00	—	13 000	23 000	37.5	71	1.28	44.8	—	—	115	—	150	154.5	2	1	—	20 000	0.02–0.04	3NCHAC021CA
	160	26	2	1	0.6	3NCHAD021CA	47.1	31.8	1.45	—	—	25 000	37.1	—	1.65	32	—	—	115	110	150	154.5	2	1	0.6	20 000	0.02–0.04	3NCHAD021CA
	190	36	2.1	1.1	—	7221C-5	203	143	7.60	14.6	7 700	12 000	38	171	3.95	84.8	—	—	117	—	178	183	2	1	—	30 000	0.02–0.04	7221C-5
	190	36	2.1	1.1	—	7221-5	187	132	6.70	—	5 800	7 700	61	171	3.95	44.8	—	—	117	—	178	183	2	1	—	30 000	0.02–0.04	7221-5
110	150	20	1.1	0.6	—	7922C-5	72.2	64.4	2.95	16.5	9 500	15 000	27.4	40	0.840	34.2	—	—	117	—	143	145.5	1	0.6	—	15 000	0.02–0.04	7922C-5
	150	20	1.1	0.6	—	HAR922C	31.4	23.8	1.10	8.70	11 000	16 000	27.4	30	0.909	30.5	—	—	117	—	143	145.5	1	0.6	—	15 000	0.02–0.04	HAR922C
	150	20	1.1	0.6	—	HAR922CA	30.6	23.2	1.05	—	10 000	16 000	33.7	30	0.909	35.7	—	—	117	—	143	145.5	1	0.6	—	15 000	0.02–0.04	HAR922CA
	150	20	1.1	0.6	—	HAR922	28.4	21.6	0.980	—	7 700	10 000	47.5	30	0.909	29.9	—	—	117	—	143	145.5	1	0.6	—	15 000	0.02–0.04	HAR922
	150	20	1.1	0.6	—	3NCHAC922C	50.9	32.7	1.50	8.40	15 000	25 000	27.4	41	0.687	26.5	—	—	117	—	143	145.5	1	0.6	—	15 000	0.02–0.04	3NCHAC922C
	150	20	1.1	0.6	—	3NCHAC922CA	49.7	31.9	1.45	—	14 000	23 000	33.7	41	0.687	32.1	—	—	117	—	143	145.5	1	0.6	—	15 000	0.02–0.04	3NCHAC922CA
	170	28	2	1	—	7022C-5	126	101	4.85	15.7	8 200	13 000	32.8	80	2.14	50.3	—	—	120	—	160	164.5	2	1	—	20 000	0.02–0.04	7022C-5
	170	28	2	1	—	7022-5	115	92.8	4.30	—	6 300	8 200	54.4	80	2.14	25.2	—	—	120	—	160	164.5	2	1	—	20 000	0.02–0.04	7022-5
	170	28	2	1	—	HAR022C	54.2	37.0	1.60	8.50	10 000	16 000	32.8	68	2.11	47.1	—	—	120	—	160	164.5	2	1	—	20 000	0.02–0.04	HAR022C
	170	28	2	1	—	HAR022CA	52.9	36.1	1.60	—	9 900	15 000	39.5	68	2.11	55.2	—	—	120	—	160	164.5	2	1	—	20 000	0.02–0.04	HAR022CA
	170	28	2	1	—	HAR022	49.3	33.6	1.45	—	7 100	9 500	54.4	68	2.11	47	—	—	120	—	160	164.5	2	1	—	20 000	0.02–0.04	HAR022
	170	28	2	1	—	3NCHAC022C	87.4	51.6	2.25	8.00	14 000	23 000	32.8	89	1.60	41.6	—	—	120	—	160	164.5	2	1	—	20 000	0.02–0.04	3NCHAC022C
	170	28	2	1	—	3NCHAC022CA	85.5	50.4	2.20	—	13 000	22 000	39.5	89	1.60	50.7	—	—	120	—	160	164.5	2	1	—	20 000	0.02–0.04	3NCHAC022CA
	170	28	2	1	0.6	3NCHAD022CA	52.9	36.1	1.60	—	—	23 000	39.5	—	2.06	36.4	—	—	120	115	160	164.5	2	1	0.6	20 000	0.02–0.04	3NCHAD022CA
	200	38	2.1	1.1	—	7222C-5	220	160	8.35	14.5	7 200	11 000	40	202	4.65	95.9	—	—	122	—	188	193	2	1	—	30 000	0.02–0.04	7222C-5
	200	38	2.1	1.1	—	7222-5	202	148	7.30	—	5 600	7 200	64.3	202	4.65	50.9	—	—	122	—	188	193	2	1	—	30 000	0.02–0.04	7222-5
120	165	22	1.1	0.6	—	7924C-5	89.7	81.2	3.55	16.5	8 600	13 000	30.1	57	1.15	44.9	—	—	127	—	158	160.5	1	0.6	—	15 000	0.02–0.04	7924C-5
	165	22	1.1	0.6	—	HAR924C	36.7	28.4	1.25	8.80	10 000	15 000	30.1	40	1.25	36.3	—	—	127	—	158	160.5	1	0.6	—	15 000	0.02–0.04	HAR924C
	165	22	1.1	0.6	—	HAR924CA	35.8	27.7	1.20	—	9 800	15 000	36.9	40	1.25	42.4	—	—	127	—	158	160.5	1	0.6	—	15 000	0.02–0.04	HAR924CA
	165	22	1.1	0.6	—	HAR924	33.2	25.7	1.10	—	7 000	9 300	52.1	40	1.25	34.8	—	—	127	—	158	160.5	1	0.6	—	15 000	0.02–0.04	HAR924
	165	22	1.1	0.6	—	3NCHAC924C	63.2	41.2	1.80	8.40	14 000	23 000	30.1	55	0.934	33.4	—	—	127	—	158	160.5	1	0.6	—	15 000	0.02–0.04	3NCHAC924C
	165	22	1.1	0.6	—	3NCHAC924CA	61.7	40.3	1.75	—	13 000	22 000	36.9	55	0.934	40.5	—	—	127	—	158	160.5	1	0.6	—	15 000	0.02–0.04	3NCHAC924CA

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

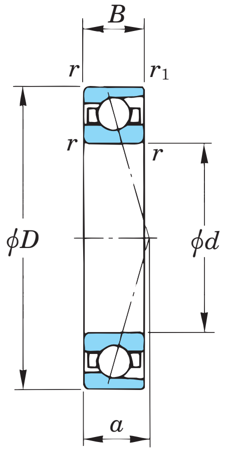
Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting Preload S	Preload L	Preload M	Preload H
⊘ ⦸	DB	0.85	0.80	0.65	0.55
⊘⊘ ⦸⦸	DBB	0.80	0.75	0.60	0.45
⊘⊘ ⦸	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.



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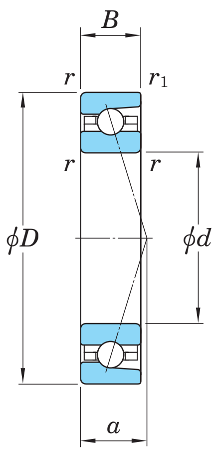

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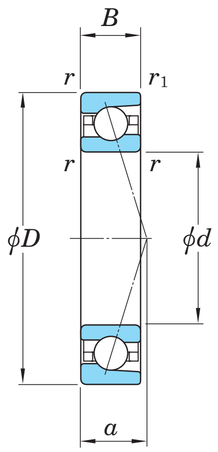

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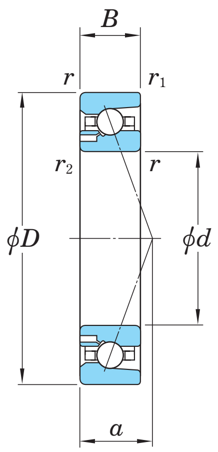

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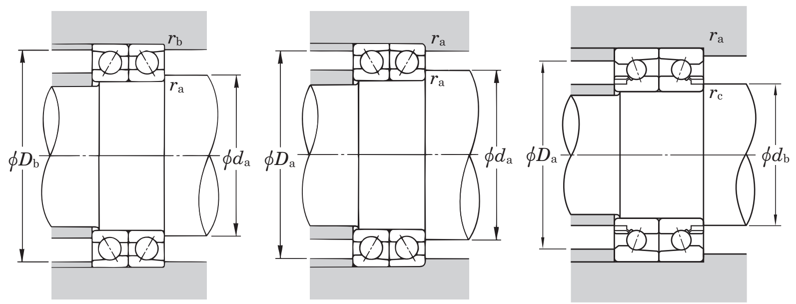


We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ 1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$	
			X	Y	X	Y	X	Y	X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (120) ~ (140)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. 1)	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
120	180	28	2	1	—	**7024C-5**	133	113	5.10	16.0	7 700	12 000	34.1	85	2.27	60.8	—	—	130	—	170	174.5	2	1	—	20 000	0.02~0.04	**7024C-5**
	180	28	2	1	—	**7024-5**	121	103	4.50	—	5 800	7 700	57.3	78	2.27	31.9	—	—	130	—	170	174.5	2	1	—	20 000	0.02~0.04	**7024-5**
	180	28	2	1	—	**HAR024C**	56.1	39.9	1.70	8.50	9 800	15 000	34.1	73	2.26	50.9	—	—	130	—	170	174.5	2	1	—	20 000	0.02~0.04	**HAR024C**
	180	28	2	1	—	**HAR024CA**	54.8	39.0	1.65	—	9 300	14 000	41.3	73	2.26	59.7	—	—	130	—	170	174.5	2	1	—	20 000	0.02~0.04	**HAR024CA**
	180	28	2	1	—	**HAR024**	50.9	36.2	1.55	—	6 700	8 800	57.3	73	2.26	50.3	—	—	130	—	170	174.5	2	1	—	20 000	0.02~0.04	**HAR024**
	180	28	2	1	—	**3NCHAC024C**	92.5	57.5	2.40	8.10	13 000	22 000	34.1	95	1.72	46.4	—	—	130	—	170	174.5	2	1	—	20 000	0.02~0.04	**3NCHAC024C**
	180	28	2	1	—	**3NCHAC024CA**	90.4	56.2	2.35	—	12 000	21 000	41.3	95	1.72	56.5	—	—	130	—	170	174.5	2	1	—	20 000	0.02~0.04	**3NCHAC024CA**
	180	28	2	1	0.6	**3NCHAD024CA**	54.8	39.0	1.65	—	—	22 000	41.3	—	2.21	39.3	—	—	130	125	170	174.5	2	1	0.6	20 000	0.02~0.04	**3NCHAD024CA**
	215	40	2.1	1.1	—	**7224C-5**	237	180	8.95	14.6	6 800	10 000	42.5	241	5.49	108	—	—	132	—	203	208	2	1	—	30 000	0.02~0.04	**7224C-5**
	215	40	2.1	1.1	—	**7224-5**	218	166	7.85	—	5 100	6 800	68.5	240	5.49	57.5	—	—	132	—	203	208	2	1	—	30 000	0.02~0.04	**7224-5**
130	180	24	1.5	1	—	**7926C-5**	109	99.9	4.20	16.4	7 800	12 000	32.8	61	1.50	53.4	—	—	138.5	—	171.5	174.5	1.5	1	—	20 000	0.02~0.04	**7926C-5**
	180	24	1.5	1	—	**HAR926C**	43.9	35.1	1.45	8.80	9 300	14 000	32.8	51	1.66	44.9	—	—	138.5	—	171.5	174.5	1.5	1	—	20 000	0.02~0.04	**HAR926C**
	180	24	1.5	1	—	**HAR926CA**	42.8	34.3	1.40	—	8 900	13 000	40.2	51	1.66	52.5	—	—	138.5	—	171.5	174.5	1.5	1	—	20 000	0.02~0.04	**HAR926CA**
	180	24	1.5	1	—	**HAR926**	39.7	31.8	1.30	—	6 400	8 500	56.7	51	1.66	42.3	—	—	138.5	—	171.5	174.5	1.5	1	—	20 000	0.02~0.04	**HAR926**
	180	24	1.5	1	—	**3NCHAC926C**	76.6	50.8	2.10	8.30	12 000	21 000	32.8	72	1.23	41.1	—	—	138.5	—	171.5	174.5	1.5	1	—	20 000	0.02~0.04	**3NCHAC926C**
	180	24	1.5	1	—	**3NCHAC926CA**	74.8	49.6	2.05	—	12 000	19 000	40.3	72	1.23	49.9	—	—	138.5	—	171.5	174.5	1.5	1	—	20 000	0.02~0.04	**3NCHAC926CA**
	200	33	2	1	—	**7026C-5**	161	137	5.95	15.9	7 000	11 000	38.6	130	3.43	74.7	—	—	140	—	190	194.5	2	1	—	20 000	0.02~0.04	**7026C-5**
	200	33	2	1	—	**7026-5**	147	125	5.25	—	5 300	7 000	64.1	129	3.43	39.4	—	—	140	—	190	194.5	2	1	—	20 000	0.02~0.04	**7026-5**
	200	33	2	1	—	**HAR026C**	70.4	48.4	1.95	8.50	8 800	13 000	38.6	115	3.38	61.6	—	—	140	—	190	194.5	2	1	—	20 000	0.02~0.04	**HAR026C**
	200	33	2	1	—	**HAR026CA**	68.7	47.2	1.90	—	8 400	12 000	46.5	115	3.38	72.2	—	—	140	—	190	194.5	2	1	—	20 000	0.02~0.04	**HAR026CA**
	200	33	2	1	—	**HAR026**	64.0	43.9	1.75	—	6 000	8 100	64.1	115	3.38	62.3	—	—	140	—	190	194.5	2	1	—	20 000	0.02~0.04	**HAR026**
	200	33	2	1	—	**3NCHAC026C**	112	69.7	2.80	8.10	12 000	19 000	38.6	139	2.68	56.3	—	—	140	—	190	194.5	2	1	—	20 000	0.02~0.04	**3NCHAC026C**
	200	33	2	1	—	**3NCHAC026CA**	110	68.2	2.75	—	11 000	19 000	46.5	139	2.68	68.6	—	—	140	—	190	194.5	2	1	—	20 000	0.02~0.04	**3NCHAC026CA**
	200	33	2	1	0.6	**3NCHAD026CA**	68.7	47.2	1.90	—	—	19 000	46.5	—	3.30	47.6	—	—	140	135	190	194.5	2	1	0.6	20 000	0.02~0.04	**3NCHAD026CA**
	230	40	3	1.1	—	**7226C-5**	266	214	8.25	14.7	6 300	10 000	44.1	258	6.21	116	—	—	144	—	216	223	2.5	1	—	30 000	0.02~0.04	**7226C-5**
	230	40	3	1.1	—	**7226-5**	245	198	7.60	—	4 700	6 300	72	257	6.21	62.1	—	—	144	—	216	223	2.5	1	—	30 000	0.02~0.04	**7226-5**
140	190	24	1.5	1	—	**7928C-5**	110	105	4.20	16.6	7 400	11 000	34.1	66	1.59	55.6	—	—	148.5	—	181.5	184.5	1.5	1	—	20 000	0.02~0.04	**7928C-5**
	190	24	1.5	1	—	**HAR928C**	44.0	36.2	1.45	8.80	8 800	13 000	34.1	57	1.76	46.3	—	—	148.5	—	181.5	184.5	1.5	1	—	20 000	0.02~0.04	**HAR928C**
	190	24	1.5	1	—	**HAR928CA**	42.9	35.3	1.40	—	8 400	12 000	42	57	1.76	54.2	—	—	148.5	—	181.5	184.5	1.5	1	—	20 000	0.02~0.04	**HAR928CA**

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

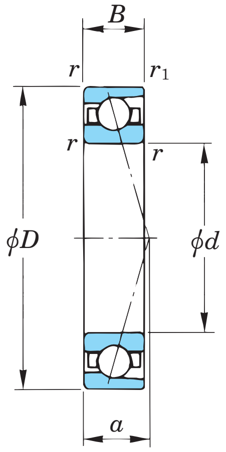
Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting: Preload S	Preload L	Preload M	Preload H
∅ ⦸	DB	0.85	0.80	0.65	0.55
∅∅ ⦸⦸	DBB	0.80	0.75	0.60	0.45
∅∅ ⦸	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.



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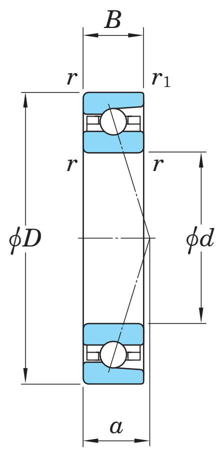

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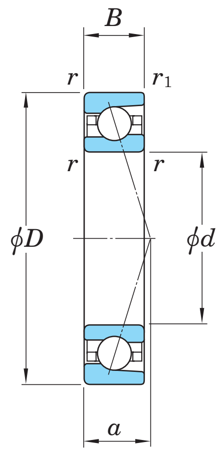
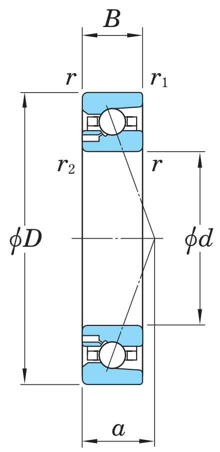
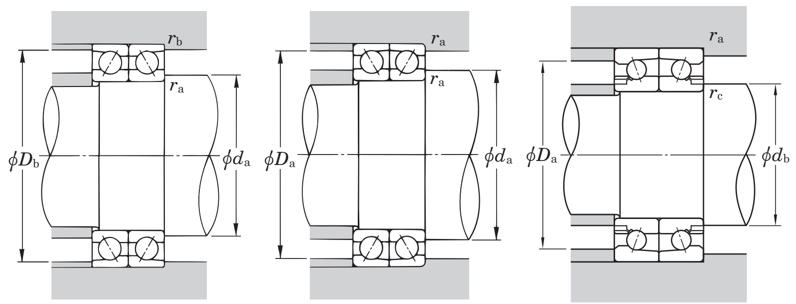


3NCHAC



3NCHAD



We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ 1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$		Single row/Tandem $\frac{F_a}{F_r}>e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}>e$	
			X	Y	X	Y	X	Y	X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (140) ~ (160)

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No. 1)	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
140	190	24	1.5	1	—	HAR928	39.8	32.8	1.30	—	6 000	8 100	59.6	57	1.76	43.3	—	—	148.5	—	181.5	184.5	1.5	1	—	20 000	0.02~0.04	HAR928
	190	24	1.5	1	—	3NCHAC928C	77.9	53.2	2.15	8.40	12 000	19 000	34.1	77	1.31	43.2	—	—	148.5	—	181.5	184.5	1.5	1	—	20 000	0.02~0.04	3NCHAC928C
	190	24	1.5	1	—	3NCHAC928CA	76.0	52.0	2.10	—	11 000	19 000	42	77	1.31	52.4	—	—	148.5	—	181.5	184.5	1.5	1	—	20 000	0.02~0.04	3NCHAC928CA
	210	33	2	1	—	7028C-5	165	145	6.00	16.0	6 500	10 000	39.9	137	3.64	78.3	—	—	150	—	200	204.5	2	1	—	25 000	0.02~0.04	7028C-5
	210	33	2	1	—	7028-5	150	133	5.30	—	5 000	6 400	67	136	3.64	41.3	—	—	150	—	200	204.5	2	1	—	25 000	0.02~0.04	7028-5
	210	33	2	1	—	HAR028C	76.7	56.2	2.20	8.50	8 400	12 000	39.9	120	3.62	71.6	—	—	150	—	200	204.5	2	1	—	25 000	0.02~0.04	HAR028C
	210	33	2	1	—	HAR028CA	74.8	54.8	2.15	—	7 900	12 000	48.3	120	3.62	84	—	—	150	—	200	204.5	2	1	—	25 000	0.02~0.04	HAR028CA
	210	33	2	1	—	HAR028	69.6	51.0	2.00	—	5 700	7 500	67	120	3.62	71.9	—	—	150	—	200	204.5	2	1	—	25 000	0.02~0.04	HAR028
	210	33	2	1	—	3NCHAC028C	115	73.8	2.90	8.20	11 000	19 000	40	146	2.84	59.6	—	—	150	—	200	204.5	2	1	—	25 000	0.02~0.04	3NCHAC028C
	210	33	2	1	—	3NCHAC028CA	112	72.1	2.80	—	10 000	18 000	48.4	146	2.84	72.6	—	—	150	—	200	204.5	2	1	—	25 000	0.02~0.04	3NCHAC028CA
	250	42	3	1.1	—	7228C-5	297	254	9.40	14.8	5 700	9 100	47.1	301	7.76	136	—	—	154	—	236	243	2.5	1	—	35 000	0.02~0.04	7228C-5
	250	42	3	1.1	—	7228-5	273	234	8.65	—	4 300	5 700	77.3	300	7.76	72.8	—	—	154	—	236	243	2.5	1	—	35 000	0.02~0.04	7228-5
150	210	28	2	1	—	7930C-5	148	132	5.45	16.3	6 700	10 000	38.1	117	2.47	69	—	—	160	—	200	204.5	2	1	—	20 000	0.02~0.04	7930C-5
	210	28	2	1	—	HAR930C	61.2	48.9	1.90	8.70	8 100	12 000	38.1	85	2.68	62.5	—	—	160	—	200	204.5	2	1	—	20 000	0.02~0.04	HAR930C
	210	28	2	1	—	HAR930CA	59.7	47.6	1.85	—	7 700	11 000	46.8	85	2.68	73.1	—	—	160	—	200	204.5	2	1	—	20 000	0.02~0.04	HAR930CA
	210	28	2	1	—	HAR930	55.4	44.2	1.70	—	5 600	7 400	66	85	2.68	60.3	—	—	160	—	200	204.5	2	1	—	20 000	0.02~0.04	HAR930
	210	28	2	1	—	3NCHAC930C	104	69.8	2.70	8.30	10 000	16 000	38.1	118	2.00	56.5	—	—	160	—	200	204.5	2	1	—	20 000	0.02~0.04	3NCHAC930C
	210	28	2	1	—	3NCHAC930CA	102	68.2	2.65	—	9 800	16 000	46.8	118	2.00	68.7	—	—	160	—	200	204.5	2	1	—	20 000	0.02~0.04	3NCHAC930CA
	225	35	2.1	1.1	—	7030C-5	188	169	6.70	16.1	6 000	9 500	42.8	169	4.43	89.9	—	—	162	—	213	218	2	1	—	25 000	0.02~0.04	7030C-5
	225	35	2.1	1.1	—	7030-5	171	154	5.95	—	4 600	6 000	72.1	168	4.43	47.1	—	—	162	—	213	218	2	1	—	25 000	0.02~0.04	7030-5
	225	35	2	1	—	HAR030C	90.3	66.1	2.50	8.50	7 400	11 000	42.6	150	4.36	84.2	—	—	160	—	215	219.5	2	1	—	25 000	0.02~0.04	HAR030C
	225	35	2	1	—	HAR030CA	88.1	64.5	2.45	—	7 000	10 000	51.6	150	4.36	98.8	—	—	160	—	215	219.5	2	1	—	25 000	0.02~0.04	HAR030CA
	225	35	2	1	—	HAR030	82.0	60.0	2.25	—	5 000	6 700	71.6	150	4.36	82.9	—	—	160	—	215	219.5	2	1	—	25 000	0.02~0.04	HAR030
	225	35	2.1	1.1	—	3NCHAC030C	131	85.7	3.20	8.20	9 900	16 000	42.8	176	3.44	69.2	—	—	162	—	213	218	2	1	—	25 000	0.02~0.04	3NCHAC030C
	225	35	2.1	1.1	—	3NCHAC030CA	128	83.7	3.15	—	9 300	15 000	51.9	176	3.44	84.2	—	—	162	—	213	218	2	1	—	25 000	0.02~0.04	3NCHAC030CA
160	220	28	2	1	—	7932C-5	151	144	5.45	16.5	6 300	9 800	39.5	116	2.60	75.1	—	—	170	—	210	214.5	2	1	—	25 000	0.02~0.04	7932C-5
	220	28	2	1	—	HAR932C	62.7	51.8	1.95	8.80	7 200	11 000	39.5	90	2.83	66.3	—	—	170	—	210	214.5	2	1	—	25 000	0.02~0.04	HAR932C
	220	28	2	1	—	HAR932CA	61.2	50.5	1.90	—	7 000	10 000	48.6	90	2.83	77.5	—	—	170	—	210	214.5	2	1	—	25 000	0.02~0.04	HAR932CA
	220	28	2	1	—	HAR932	56.7	46.9	1.75	—	5 000	6 500	68.8	90	2.83	63.6	—	—	170	—	210	214.5	2	1	—	25 000	0.02~0.04	HAR932
	220	28	2	1	—	3NCHAC932C	106	73.3	2.75	8.40	9 900	16 000	39.5	124	2.11	59.4	—	—	170	—	210	214.5	2	1	—	25 000	0.02~0.04	3NCHAC932C

[Note] 1) The blue bearing numbers indicate recommended products.

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.

2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.

3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

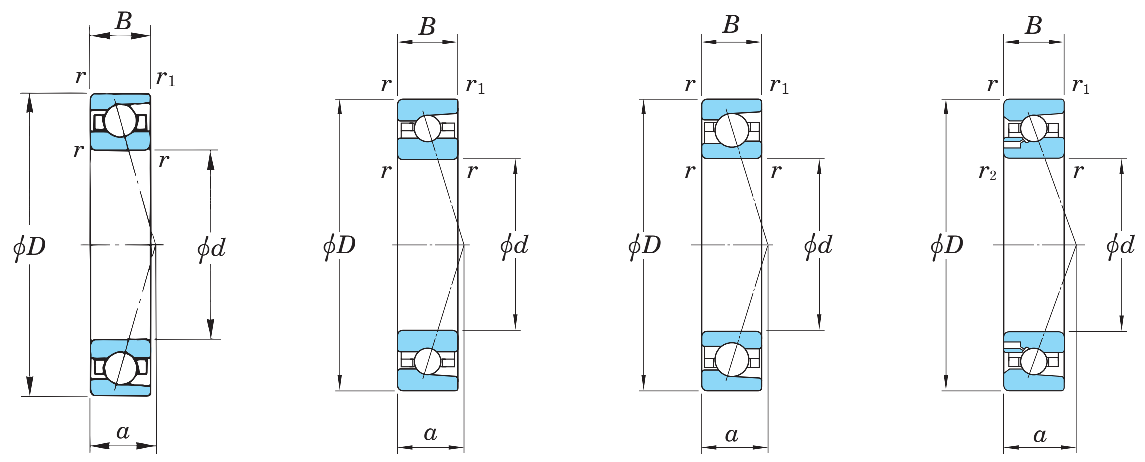
Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	$C_r\times1.62$	$C_{0r}\times2$
3-row	$C_r\times2.16$	$C_{0r}\times3$
4-row	$C_r\times2.64$	$C_{0r}\times4$

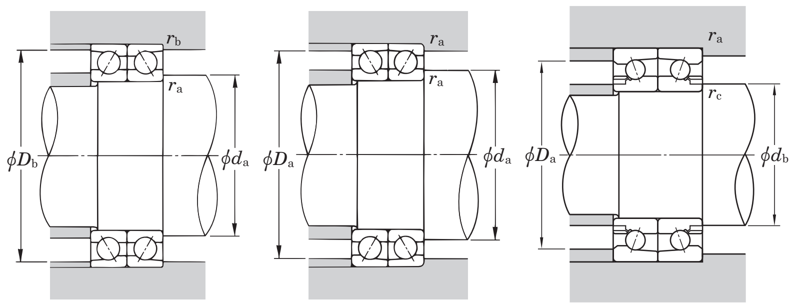
Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting: Preload S	Preload L	Preload M	Preload H
∅ ⃠	DB	0.85	0.80	0.65	0.55
∅∅ ⃠⃠	DBB	0.80	0.75	0.60	0.45
∅∅ ⃠	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.



7000 7900 7200 | HAR | 3NCHAC | 3NCHAD



We recommend that recesses be added at r_a, r_b, and r_c.

Static equivalent load $P_0=X_0F_r+Y_0F_a$

Contact angle	Single row/ Tandem		Back-to-back/ Face-to-face	
	X_0	Y_0	X_0	Y_0
15°	0.5	0.46	1	0.92
20°	0.5	0.42	1	0.84
30°	0.5	0.33	1	0.66

Note that in the case of single row or tandem, assume $P_0=F_r$ if $P_0<F_r$.

Dynamic equivalent load $P=XF_r+YF_a$

Contact angle	$\frac{if_0F_a}{C_{0r}}$ [1)	e	Single row/Tandem $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$		Back-to-back/Face-to-face $\frac{F_a}{F_r}\leqq e$		$\frac{F_a}{F_r}>e$	
			X	Y	X	Y	X	Y	X	Y
15°	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.07	0.46				1.23		1.38		2.00
	1.43	0.47				1.19		1.34		1.93
	2.14	0.50				1.12		1.26		1.82
	3.57	0.55				1.02		1.14		1.66
	5.35	0.56				1.00		1.12		1.63
	7.14	0.56				1.00		1.12		1.63
20°		0.57	1	0	0.43	1	1	1.09	0.70	1.63
30°		0.80	1	0	0.39	0.76	1	0.78	0.63	1.24

1) For i, use 2 for DB & DF and 1 for single & DT.

d (160) ~ 190

Boundary dimensions (mm) d	D	B	r min.	r_1 min.	r_2 min.	Bearing No.	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Factor f_0	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Load center (mm) a	Interspace volume (cm³/row)	(Refer.) Mass (kg/row)	Permissible axial load (kN) (static)	Dimensions of lubrication groove (mm) S	W	Mounting dimensions (mm) d_a min.	d_b min.	D_a max.	D_b max.	r_a max.	r_b max.	r_c max.	Nut axial tension (N)	Interference of retaining plate (mm)	Bearing No.
160	220	28	2	1	—	**3NCHAC932CA**	104	71.6	2.70	—	9 200	15 000	48.6	124	2.11	72.1	—	—	170	—	210	214.5	2	1	—	25 000	0.02~0.04	**3NCHAC932CA**
	240	38	2.1	1.1	—	**7032C-5**	214	193	7.50	16.0	5 600	8 900	45.8	232	5.45	111	—	—	172	—	228	233	2	1	—	30 000	0.02~0.04	**7032C-5**
	240	38	2.1	1.1	—	**7032-5**	194	176	6.65	—	4 300	5 600	76.8	232	5.45	60.7	—	—	172	—	228	233	2	1	—	30 000	0.02~0.04	**7032-5**
	240	38	2.1	1.1	—	**HAR032C**	97.8	72.7	2.65	8.50	7 000	10 000	45.8	186	5.40	92.7	—	—	172	—	228	233	2	1	—	30 000	0.02~0.04	**HAR032C**
	240	38	2.1	1.1	—	**HAR032CA**	95.5	71.0	2.60	—	6 500	10 000	55.4	186	5.40	108	—	—	172	—	228	233	2	1	—	30 000	0.02~0.04	**HAR032CA**
	240	38	2.1	1.1	—	**HAR032**	88.8	66.0	2.40	—	4 700	6 300	76.7	186	5.40	90	—	—	172	—	228	233	2	1	—	30 000	0.02~0.04	**HAR032**
	240	38	2.1	1.1	—	**3NCHAC032C**	149	98.1	3.60	8.10	9 300	15 000	45.8	223	4.23	79.3	—	—	172	—	228	233	2	1	—	30 000	0.02~0.04	**3NCHAC032C**
	240	38	2.1	1.1	—	**3NCHAC032CA**	145	95.9	3.50	—	8 800	15 000	55.4	223	4.23	96.5	—	—	172	—	228	233	2	1	—	30 000	0.02~0.04	**3NCHAC032CA**
170	230	28	2	1	—	**7934C-5**	153	151	5.50	16.6	5 800	9 200	40.8	115	3.21	78.1	—	—	180	—	220	224.5	2	1	—	25 000	0.02~0.04	**7934C-5**
	230	28	2	1	—	**HAR934C**	64.2	54.8	2.00	8.80	7 000	10 000	40.8	94	2.97	70.2	—	—	180	—	220	224.5	2	1	—	25 000	0.02~0.04	**HAR934C**
	230	28	2	1	—	**HAR934CA**	62.6	53.4	1.95	—	6 500	10 000	50.4	94	2.97	82	—	—	180	—	220	224.5	2	1	—	25 000	0.02~0.04	**HAR934CA**
	230	28	2	1	—	**HAR934**	58.0	49.6	1.80	—	4 700	6 300	71.7	94	2.97	66.9	—	—	180	—	220	224.5	2	1	—	25 000	0.02~0.04	**HAR934**
	230	28	2	1	—	**3NCHAC934C**	108	76.7	2.80	8.40	9 300	15 000	40.8	148	3.07	62.3	—	—	180	—	220	224.5	2	1	—	25 000	0.02~0.04	**3NCHAC934C**
	230	28	2	1	—	**3NCHAC934CA**	105	74.9	2.75	—	8 800	15 000	50.4	148	3.07	75.6	—	—	180	—	220	224.5	2	1	—	25 000	0.02~0.04	**3NCHAC934CA**
	260	42	2.1	1.1	—	**7034C-5**	256	234	8.95	15.9	5 100	8 100	49.8	301	7.57	128	—	—	182	—	248	253	2	1	—	30 000	0.02~0.04	**7034C-5**
	260	42	2.1	1.1	—	**7034-5**	232	214	7.90	—	3 900	5 100	83.1	301	7.58	67.8	—	—	182	—	248	253	2	1	—	30 000	0.02~0.04	**7034-5**
	260	42	2.1	1.1	—	**HAR034C**	115	86.4	3.05	8.50	6 400	9 900	49.8	236	7.32	110	—	—	182	—	248	253	2	1	—	30 000	0.02~0.04	**HAR034C**
	260	42	2.1	1.1	—	**HAR034CA**	112	84.3	2.95	—	6 100	9 300	60.1	236	7.32	129	—	—	182	—	248	253	2	1	—	30 000	0.02~0.04	**HAR034CA**
	260	42	2.1	1.1	—	**HAR034**	104	78.4	2.75	—	4 300	5 800	83.1	236	7.32	109	—	—	182	—	248	253	2	1	—	30 000	0.02~0.04	**HAR034**
	260	42	2.1	1.1	—	**3NCHAC034C**	177	119	4.20	8.10	8 800	14 000	49.8	299	5.76	96.2	—	—	182	—	248	253	2	1	—	30 000	0.02~0.04	**3NCHAC034C**
	260	42	2.1	1.1	—	**3NCHAC034CA**	173	117	4.10	—	8 200	13 000	60.1	299	5.76	117	—	—	182	—	248	253	2	1	—	30 000	0.02~0.04	**3NCHAC034CA**
180	250	33	2	1	—	**7936C-5**	200	188	7.05	16.4	5 400	8 500	45.3	178	4.68	100	—	—	190	—	240	244.5	2	1	—	25 000	0.02~0.04	**7936C-5**
190	260	33	2	1	—	**7938C-5**	198	197	6.85	16.5	5 100	7 900	46.6	195	4.83	113	—	—	200	—	250	254.5	2	1	—	25 000	0.02~0.04	**7938C-5**

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4** on page 41 to 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.
3. C, CA, and no character string in the bearing number indicate nominal contact angles of 15°, 20°, and 30°, respectively.

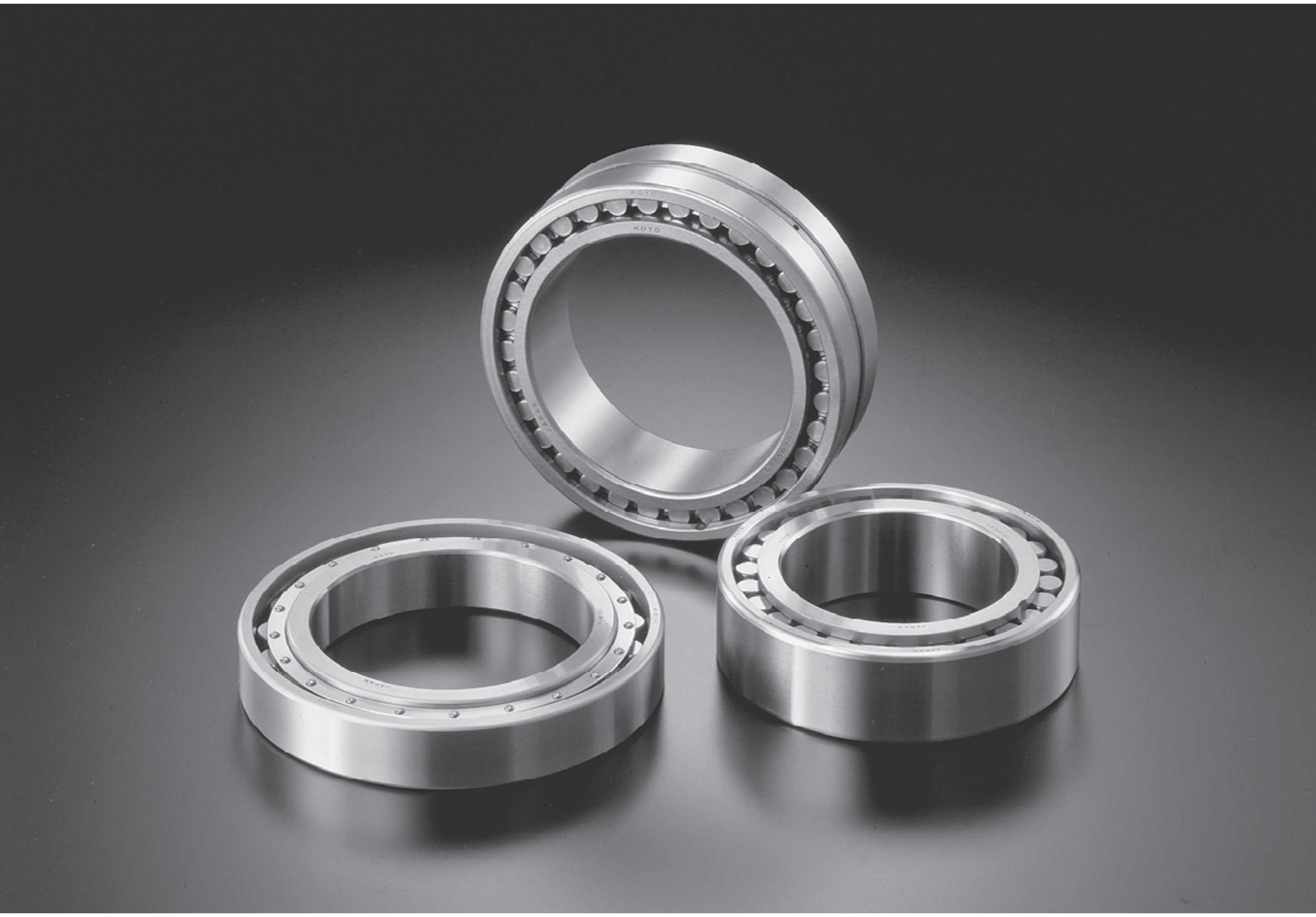
Basic load ratings in case of multiple-row combination bearing

	Basic dynamic load ratings	Basic static load ratings
2-row	C_r×1.62	C_{0r}×2
3-row	C_r×2.16	C_{0r}×3
4-row	C_r×2.64	C_{0r}×4

Speed coefficients in case of multiple-row combination bearing

Combination types	Combination symbols	Preload when mounting Preload S	Preload L	Preload M	Preload H
∅ ⃠	DB	0.85	0.80	0.65	0.55
∅∅ ⃠⃠	DBB	0.80	0.75	0.60	0.45
∅∅ ⃠	DBD	0.75	0.70	0.55	0.40

*Speed coefficients also vary depending on the distance of bearings.
*Consult JTEKT for information on High Ability bearings.



2. Cylindrical Roller Bearings

Contents

2. Cylindrical roller bearings

The cylindrical roller bearing has high radial rigidity and is suitable for high-speed rotation through an arrangement of many rollers and a line contact which is made between the rollers and raceways.

The bores of cylindrical roller bearings are either cylindrical or tapered. With a bearing having a tapered bore, its radial internal clearance can be set with ease to a given value by adjusting the extent to which the bearing is pushed onto the shaft.

2. 1 Types and features of cylindrical roller bearings

The cylindrical roller bearing is divided into two types: double row and single row bearings. Both having outer ring which is separable from the inner to facilitate mounting and dismounting from shaft and housing (see **Fig. 2. 1**).

1) Double row cylindrical roller bearings

The double row cylindrical roller bearing is classified into the NN30 and NNU49 series.

Some of these bearings have a lubrication groove and holes provided at the center of the outside surface of the outer rings in order to attain a sufficient supply of lubricant to the inside of the bearing (the suffix W is added).

2) Single row cylindrical roller bearings

Single row cylindrical roller bearings for the spindles of machine tools are often selected from the N10 series.

The bore and outside diameters of the N10 series are the same as those of the NN30: double row cylindrical roller bearing series.

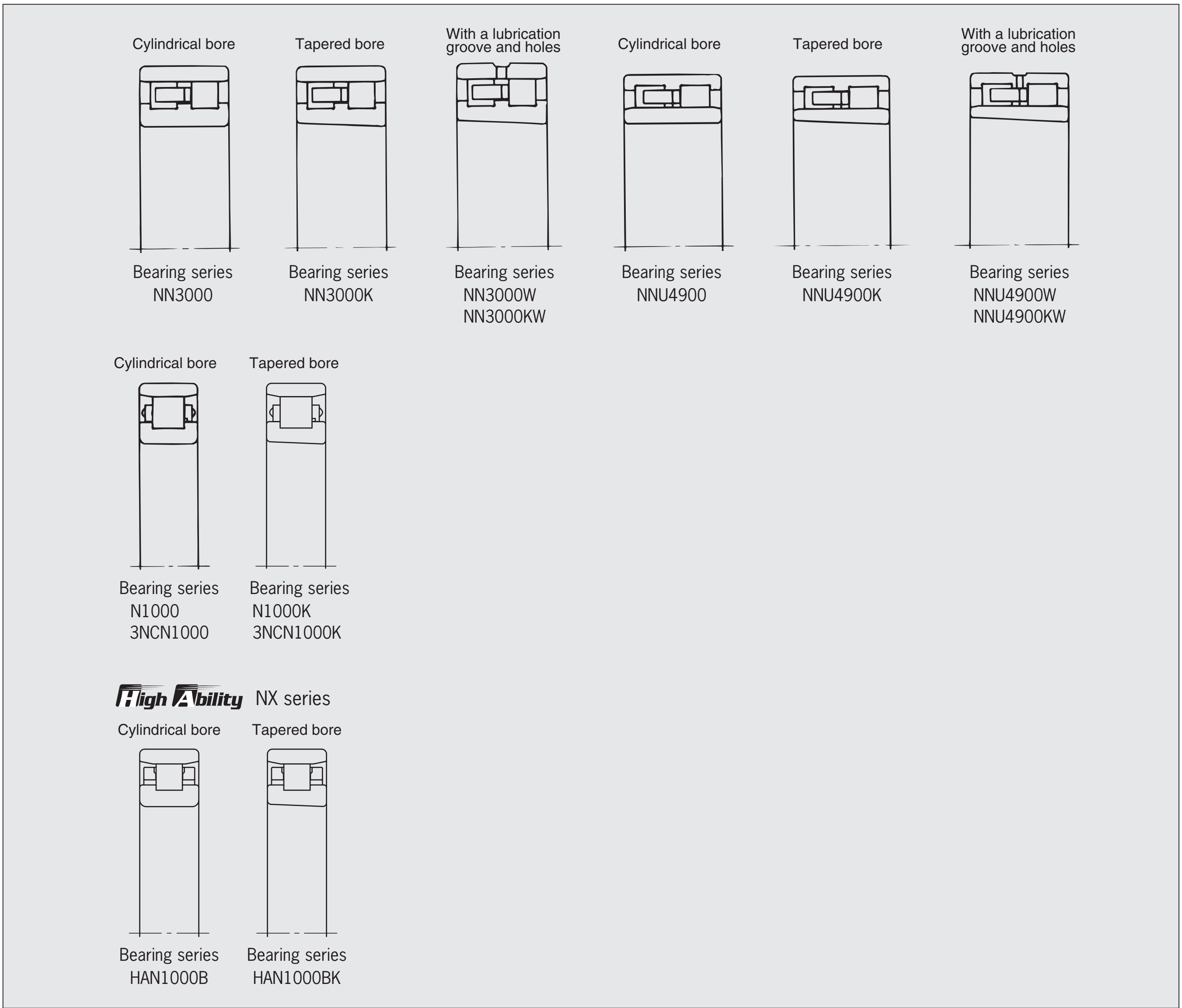


Fig. 2. 1 Types and series of cylindrical roller bearings for machine tool spindles

2. 2 Composition of bearing numbers (cylindrical roller bearings)

N N 3 0 0 9 K W C 1 N A F W P 4
N 1 0 0 9 C 1 N A F Y P 4
H A N 1 0 0 9 B K C 1 N A P G P 4

Bearing type symbols
- NN : double row/ inner ring with rib
- NNU : double row/ outer ring with rib
- N : single row/ inner ring with rib
- HAN : High Ability NX series single row/ inner ring with rib Ultrahigh-speed type

Dimension series symbols
- 30 : dimension series 30
- 49 : dimension series 49
- 10 : dimension series 10

Bore diameter number
- 09 : nominal bore diameter : 45 mm (Bore diameter number × 5 equals nominal bore diameter.)

Internal design code

Ring shape symbols
- K : bearing with tapered bore (1/12 taper)
- W : outer ring with a lubrication groove and holes

Tolerance class symbols
- P5 : JIS class 5
- P4 : JIS class 4
- P2 : JIS class 2

Cage symbols
- FW: separable machined cage made of copper alloy
- FY : integrated machined cage made of copper alloy (Double row bearing) Machined cage made of copper alloy with rivets (single row bearing)
- FG : molded cage made of polyamide resin (Consult **JTEKT** for detailed information about the available types.)
- PG : PEEK resin cage

Internal clearance symbols
- C9NA ~C3NA : radial internal clearance of non-interchangeable bearings

(For values of radial internal clearances, see **Table 2. 2** (page 107).)

For ceramic bearings

3 N C N 1 0 0 9 C 1 N A F Y P 4

3NC — Ceramic bearing

2. 3 Tolerance of cylindrical roller bearings

1) Boundary dimension and running accuracies

The tolerance of precision cylindrical roller bearings is compliant with permissible dimensional deviations and limits of classes 5, 4, and 2 as specified in JIS B 1514 for radial bearings (tapered roller bearings not included).

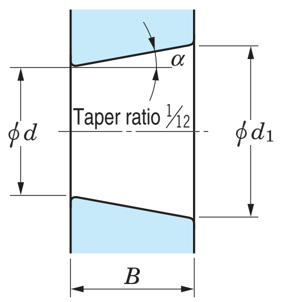
Permissible dimensional deviations and limits to boundary dimension and running accuracies are shown in **Table 1. 2** on page 61.

2) Permissible dimensional deviations and limits for tapered bores

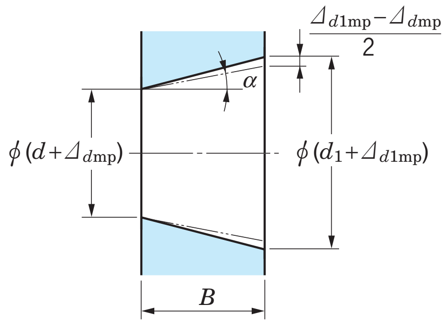
The dimensional deviations and limits for tapered bores of radial bearings of class 0 only are specified in JIS B 1514.

JTEKT has formulated special standards for dimensional deviations and limits for tapered bores of radial bearings of classes 5, 4, and 2 (see **Table 2. 1**).

Table 2. 1 Dimensional deviations and limits for tapered bores of radial bearings (classes 5, 4, and 2)



Theoretical tapered bore



Tapered bore with single plane mean bore diameter deviation

Unit : μm

Nominal bore diameter d (mm)		Δ_{dmp}				$\Delta_{d1mp}-\Delta_{dmp}$ 1)		V_{dsp} 2)				
								Diameter series 9		Diameter series 0		—
		Class 5		Classes 4, 2		Classes 5, 4, 2		Class 5	Class 4	Class 5	Class 4	Class 2
over	up to	upper	lower	upper	lower	upper	lower	max.		max.		max.
18	**30**	+10	0	+ 6	0	+ 3	0	6	5	5	4	2.5
30	**50**	+12	0	+ 8	0	+ 3	0	8	6	6	5	2.5
50	**80**	+15	0	+ 9	0	+ 5	0	9	7	7	5	4
80	**120**	+20	0	+10	0	+ 6	0	10	8	8	6	5
120	**180**	+25	0	+13	0	+ 8	0	13	10	10	8	7
180	**250**	+30	0	+15	0	+ 9	0	15	12	12	9	8
250	**315**	+35	0	+18	0	+10	0	18	15	14	11	—
315	**400**	+40	0	+23	0	+12	0	23	18	18	14	—

[Notes] 1) Permissible dimensional deviation for the taper angle is $4°46'18.8''^{+26''}_{0}$

2) Applied to all radial planes of tapered bores.

[Remarks] 1. **Scope** These values are applied to the tapered bores with a reference taper ratio of 1/12.

2. **Symbols for quantities**

d_1 : reference diameter at theoretical large end of tapered bore $d_1 = d + \frac{1}{12}B$

Δ_{dmp} : single plane mean bore diameter deviation at theoretical small end of tapered bore

Δ_{d1mp} : single plane mean bore diameter deviation at theoretical large end of tapered bore

V_{dsp} : single plane bore diameter variation

B : nominal inner ring width

α : $\frac{1}{2}$ of the nominal taper angle of tapered bore

$\alpha = 2°23'9.4''$

$= 2.385\ 94°$

$= 0.041\ 643$ rad

2. 4 Radial internal clearances of cylindrical roller bearings

In order to minimize variations in the running accuracy of machine tool spindles, the values of the radial internal clearance should be same as those of special radial internal clearance of non-interchangeable bearings.

Table 2. 2 shows values of non-interchangeable radial internal clearances for cylindrical roller bearings.

Since the inner and outer rings of cylindrical roller bearings for spindles of machine tools are not interchangeable, care should be taken when using them.

Table 2. 2 Values of radial internal clearances for cylindrical roller bearings

(1) Bearings with cylindrical bores

Unit : μm

Nominal bore diameter *d* (mm)		Values of non-interchangeable clearances of bearings with cylindrical bores							
		C1NA		C2NA		CNNA		C3NA	
over	up to	min.	max.	min.	max.	min.	max.	min.	max.
24	**30**	5	10	10	25	25	35	40	50
30	**40**	5	12	12	25	25	40	45	55
40	**50**	5	15	15	30	30	45	50	65
50	**65**	5	15	15	35	35	50	55	75
65	**80**	10	20	20	40	40	60	70	90
80	**100**	10	25	25	45	45	70	80	105
100	**120**	10	25	25	50	50	80	95	120
120	**140**	15	30	30	60	60	90	105	135
140	**160**	15	35	35	65	65	100	115	150
160	**180**	15	35	35	75	75	110	125	165
180	**200**	20	40	40	80	80	120	140	180
200	**225**	20	45	45	90	90	135	155	200
225	**250**	25	50	50	100	100	150	170	215
250	**280**	25	55	55	110	110	165	185	240
280	**315**	30	60	60	120	120	180	205	265
315	**355**	30	65	65	135	135	200	225	295
355	**400**	35	75	75	150	150	225	255	330

(2) Bearings with tapered bores

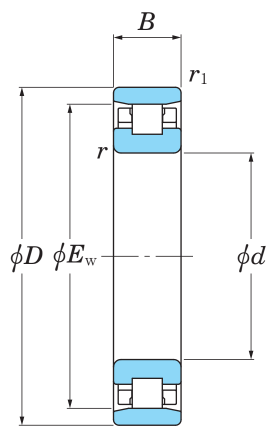
Unit : μm

Nominal bore diameter *d* (mm)		Values of non-interchangeable clearances of bearings with tapered bores											
		C9NA[1]		C0NA		C1NA		C2NA		CNNA		C3NA	
over	up to	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
24	**30**	5	10	10	20	10	25	25	35	40	50	50	60
30	**40**	5	12	10	20	12	25	25	40	45	55	55	70
40	**50**	5	15	10	20	15	30	30	45	50	65	65	80
50	**65**	5	15	10	20	15	35	35	50	55	75	75	90
65	**80**	10	20	15	30	20	40	40	60	70	90	90	110
80	**100**	10	25	20	35	25	45	45	70	80	105	105	125
100	**120**	10	25	20	35	25	50	50	80	95	120	120	145
120	**140**	15	30	25	40	30	60	60	90	105	135	135	160
140	**160**	15	35	30	45	35	65	65	100	115	150	150	180
160	**180**	15	35	30	45	35	75	75	110	125	165	165	200
180	**200**	20	40	30	50	40	80	80	120	140	180	180	220
200	**225**	20	45	35	55	45	90	90	135	155	200	200	240
225	**250**	25	50	40	65	50	100	100	150	170	215	215	265
250	**280**	25	55	40	65	55	110	110	165	185	240	240	295
280	**315**	30	60	45	75	60	120	120	180	205	265	265	325
315	**355**	30	65	45	75	65	135	135	200	225	295	295	360
355	**400**	35	75	50	90	75	150	150	225	255	330	330	405

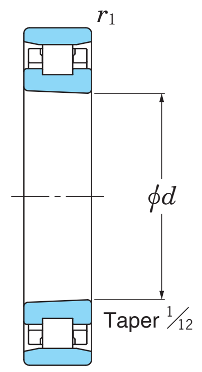
[Note] 1) The clearance C9NA is applied to cylindrical roller bearings with tapered bores made to JIS tolerance classes 5 and 4.

High Ability NX series

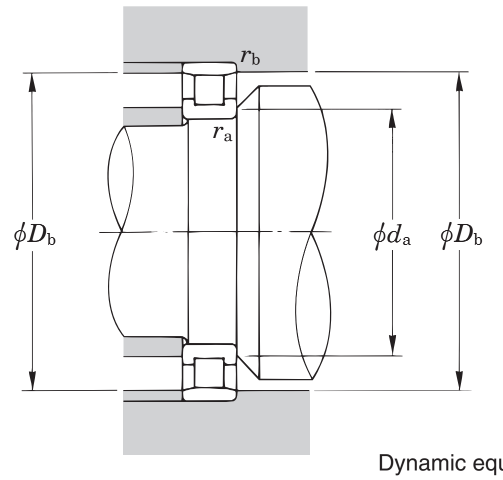
HAN1000B/BK series



Cylindrical bore



Tapered bore



Dynamic equivalent load $P_r = F_r$

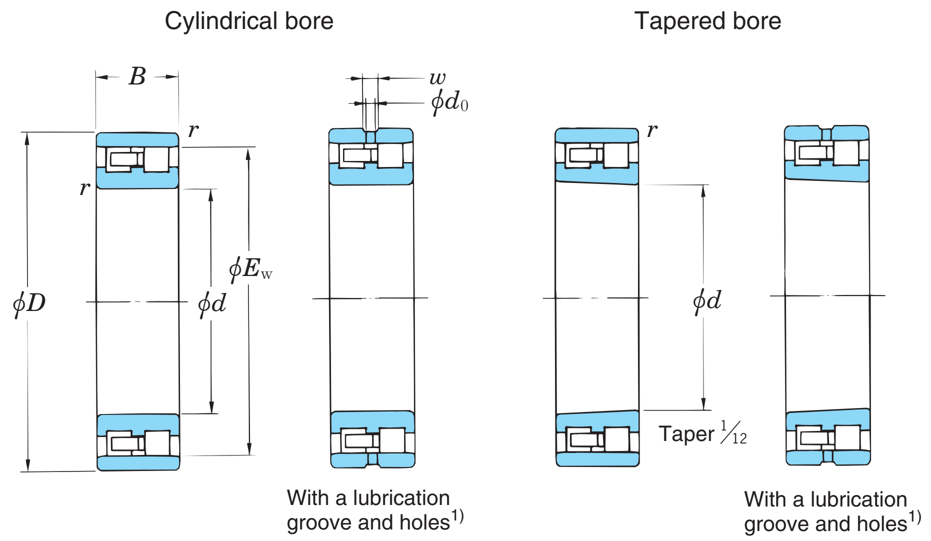
Static equivalent load $P_{0r} = F_r$

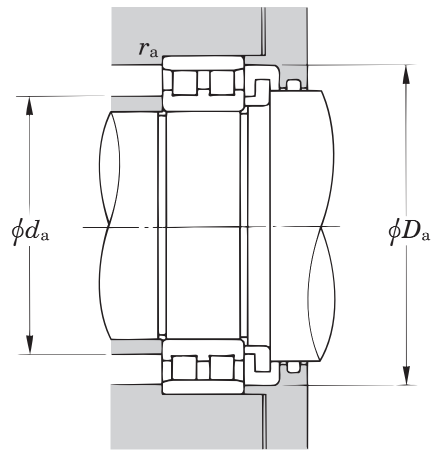
Boundary dimensions (mm)						Bearing No.		Basic load ratings (kN)		Fatigue load limit (kN)	Limiting speeds (min^{-1})	Mounting dimensions (mm)					(Refer.) Mass (kg)	
d	D	B	r min.	r_1 min.	E_W	Cylindrical bore	Tapered bore	C_r	C_{0r}	C_u	Oil lub.	d_a min.	D_b max.	D_b min.	r_a max.	r_b max.	Cylindrical bore	Tapered bore
45	75	16	1	0.6	67.5	**HAN1009B**	**HAN1009BK**	36.9	29.9	3.90	40 000	50	70	68.5	1	0.6	0.224	0.219
50	80	16	1	0.6	72.5	**HAN1010B**	**HAN1010BK**	40.4	34.5	4.50	37 000	55	75	73.5	1	0.6	0.257	0.251
55	90	18	1.1	1	81.0	**HAN1011B**	**HAN1011BK**	43.5	39.5	5.20	33 000	61.5	83.5	82	1	1	0.380	0.373
60	95	18	1.1	1	86.1	**HAN1012B**	**HAN1012BK**	44.8	42.0	5.50	31 000	66.5	88.5	87	1	1	0.407	0.400
65	100	18	1.1	1	91.0	**HAN1013B**	**HAN1013BK**	46.2	44.5	5.90	29 000	71.5	93.5	92	1	1	0.442	0.433
70	110	20	1.1	1	100	**HAN1014B**	**HAN1014BK**	72.9	70.4	9.10	27 000	76.5	103.5	101	1	1	0.599	0.586
75	115	20	1.1	1	105	**HAN1015B**	**HAN1015BK**	66.8	63.8	9.20	25 000	81.5	108.5	106	1	1	0.655	0.640
80	125	22	1.1	1	113	**HAN1016B**	**HAN1016BK**	71.4	71.5	10.2	23 000	86.5	118.5	114	1	1	0.886	0.869
85	130	22	1.1	1	118	**HAN1017B**	**HAN1017BK**	70.9	71.9	10.1	22 000	91.5	123	119	1	1	0.879	0.861
90	140	24	1.5	1.1	127	**HAN1018B**	**HAN1018BK**	103	104	11.3	21 000	98	132	129	1.5	1	1.13	1.11
95	145	24	1.5	1.1	132	**HAN1019B**	**HAN1019BK**	111	110	12.3	20 000	103	137	134	1.5	1	1.20	1.18
100	150	24	1.5	1.1	137	**HAN1020B**	**HAN1020BK**	120	123	12.2	19 000	108	142	139	1.5	1	1.29	1.27

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4(5)** on page 45.

2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.

NN3000(K) series





Dynamic equivalent load $P_r = F_r$
Static equivalent load $P_{0r} = F_r$

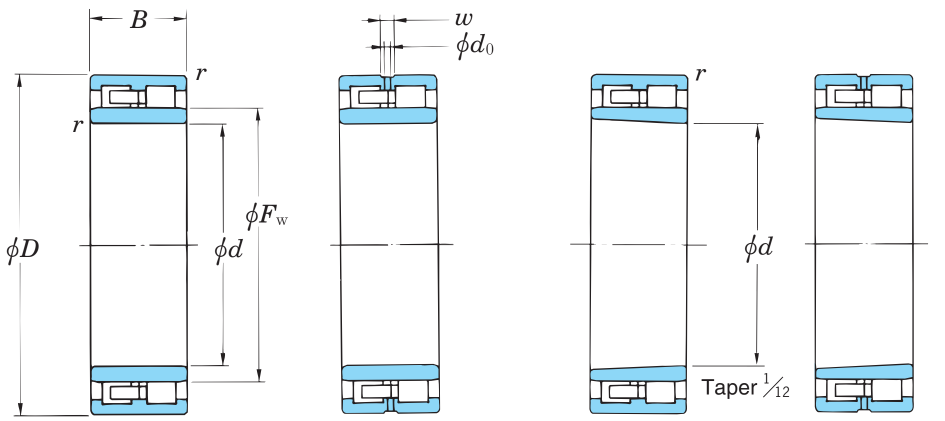
Boundary dimensions (mm) d	D	B	r min.	E_W	Bearing No.[1)2)] Cylindrical bore	Tapered bore	Basic load ratings (kN) C_r	C_{0r}	Fatigue load limit (kN) C_u	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Dimensions of lubrication groove and holes (mm) d_0	w	Mounting dimensions (mm) d_a min.	D_a max.	D_a min.	r_a max.	Interspace volume (cm³)	(Refer.) Mass (kg) Cylindrical bore	Tapered bore
25	47	16	0.6	41.3	**NN3005**	**NN3005K**	32.2	30.0	5.20	19 000	23 000	2	4	29	43	42	0.6	3.5	0.127	0.123
30	55	19	1	48.5	**NN3006**	**NN3006K**	46.0	44.1	4.95	16 000	20 000	2	4	35	50	49	1	6	0.198	0.192
35	62	20	1	55	**NN3007**	**NN3007K**	49.1	50.0	5.65	14 000	17 000	2	4	40	57	56	1	8	0.253	0.246
40	68	21	1	61	**NN3008**	**NN3008K**	52.0	55.9	6.35	13 000	15 000	2	4	45	63	62	1	10	0.307	0.298
45	75	23	1	67.5	**NN3009**	**NN3009K**	67.1	71.9	8.75	12 000	14 000	3	6	50	70	69	1	13	0.404	0.382
50	80	23	1	72.5	**NN3010**	**NN3010K**	66.4	72.6	8.85	11 000	13 000	3	6	55	75	74	1	14	0.429	0.415
55	90	26	1.1	81	**NN3011**	**NN3011K**	89.6	101	13.2	9 600	12 000	3	6	61.5	83.5	82	1	20	0.637	0.618
60	95	26	1.1	86.1	**NN3012**	**NN3012K**	91.6	106	13.9	9 000	11 000	3	6	66.5	88.5	87	1	22	0.685	0.664
65	100	26	1.1	91	**NN3013**	**NN3013K**	93.6	111	14.6	8 400	10 000	3	6	71.5	93.5	92	1	23	0.728	0.705
70	110	30	1.1	100	**NN3014**	**NN3014K**	122	148	20.6	7 600	9 200	3	6	76.5	103.5	101	1	33	1.04	1.02
75	115	30	1.1	105	**NN3015**	**NN3015K**	124	155	21.5	7 200	8 700	3	6	81.5	108.5	106	1	35	1.11	1.08
80	125	34	1.1	113	**NN3016**	**NN3016K**	149	186	26.6	6 700	8 100	4	7	86.5	118.5	114	1	48	1.55	1.50
85	130	34	1.1	118	**NN3017**	**NN3017K**	152	194	27.3	6 400	7 700	4	7	91.5	123.5	119	1	50	1.63	1.58
90	140	37	1.5	127	**NN3018**	**NN3018K**	179	228	29.3	5 900	7 100	4	7	98	132	129	1.5	65	2.07	2.01
95	145	37	1.5	132	**NN3019**	**NN3019K**	188	246	31.3	5 700	6 800	4	7	103	137	134	1.5	67	2.17	2.10
100	150	37	1.5	137	**NN3020**	**NN3020K**	191	256	32.1	5 500	6 500	4	7	108	142	139	1.5	68	2.28	2.21
105	160	41	2	146	**NN3021**	**NN3021K**	247	322	42.5	5 200	6 200	4	7	114	151	148	2	94	2.88	2.81
110	170	45	2	155	**NN3022**	**NN3022K**	278	361	47.9	4 800	5 800	4	7	119	161	157	2	117	3.65	3.56
120	180	46	2	165	**NN3024**	**NN3024K**	291	392	51.1	4 500	5 400	4	7	129	171	167	2	127	4.00	3.87
130	200	52	2	182	**NN3026**	**NN3026K**	356	476	57.7	4 100	4 900	5	8.5	139	191	183	2	185	5.94	5.76
140	210	53	2	192	**NN3028**	**NN3028K**	372	516	61.5	3 800	4 600	6	10	149	201	194	2	193	6.41	6.21
150	225	56	2.1	206	**NN3030**	**NN3030K**	418	587	70.1	3 500	4 200	6	10	161	214	208	2	239	7.74	7.50
160	240	60	2.1	219	**NN3032**	**NN3032K**	499	695	79.6	3 300	4 000	6	10	171	229	221	2	281	9.38	9.08
170	260	67	2.1	236	**NN3034**	**NN3034K**	592	824	105	3 000	3 600	6	10	181	249	238	2	371	12.8	12.4

[Note] 1) The symbol W is added to the end of bearing numbers to denote bearings whose outer ring has a lubrication groove and holes.
2) The blue bearing numbers indicate recommended products.

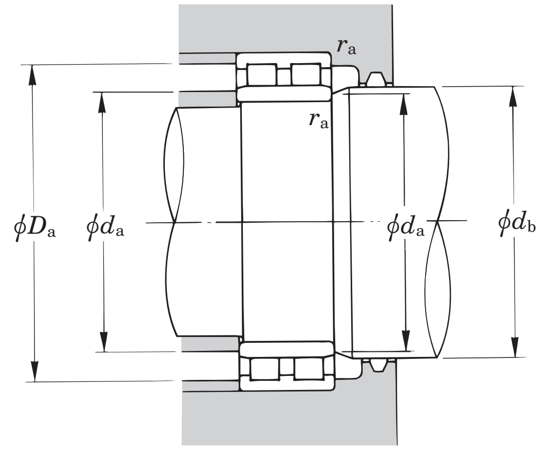
[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4(5)** on page 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.

NNU4900(K) series

Cylindrical bore　　　Tapered bore



With a lubrication groove and holes[1)]　　With a lubrication groove and holes[1)]

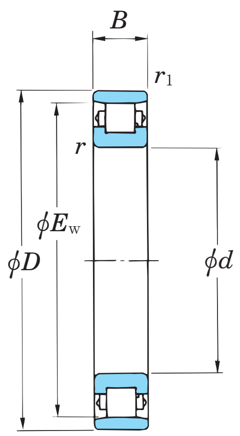


Dynamic equivalent load $P_r = F_r$
Static equivalent load $P_{0r} = F_r$

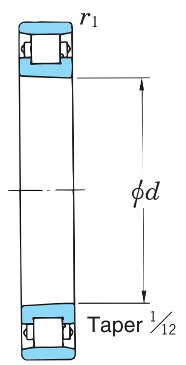
Boundary dimensions (mm)					Bearing No.[1)]		Basic load ratings (kN)		Fatigue load limit (kN)	Limiting speeds (min^{-1})		Dimensions of lubrication groove and holes (mm)		Mounting dimensions (mm)					Interspace volume (cm^3)	(Refer.) Mass (kg)	
d	D	B	r min.	F_W	Cylindrical bore	Tapered bore	C_r	C_{0r}	C_u	Grease lub.	Oil lub.	d_0	w	d_a min.	d_a max.	d_b min.	D_a max.	r_a max.		Cylindrical bore	Tapered bore
100	140	40	1.1	113	**NNU4920**	**NNU4920K**	173	258	32.9	5 600	6 800	2.5	6	106.5	111	115	133.5	1	61	1.95	1.87
105	145	40	1.1	118	**NNU4921**	**NNU4921K**	196	306	40.2	5 400	6 500	2.5	6	111.5	116	120	138.5	1	61	2.00	1.91
110	150	40	1.1	123	**NNU4922**	**NNU4922K**	204	326	42.4	5 200	6 200	2.5	6	116.5	121	125	143.5	1	60	2.10	2.01
120	165	45	1.1	134.5	**NNU4924**	**NNU4924K**	234	373	47.6	4 700	5 700	3	7	126.5	132	137	158.5	1	84	2.90	2.77
130	180	50	1.5	146	**NNU4926**	**NNU4926K**	269	428	50.2	4 300	5 200	3	7	138	143.5	148	172	1.5	116	3.90	3.73
140	190	50	1.5	156	**NNU4928**	**NNU4928K**	277	456	52.5	4 000	4 800	3	7	148	153.5	158	182	1.5	125	4.15	3.97
150	210	60	2	168.5	**NNU4930**	**NNU4930K**	430	692	80.7	3 700	4 400	4	7	159	166	171	201	2	192	6.50	6.22
160	220	60	2	178.5	**NNU4932**	**NNU4932K**	425	695	79.8	3 400	4 100	4	7	169	176	182	211	2	186	6.95	6.65
170	230	60	2	188.5	**NNU4934**	**NNU4934K**	451	763	86.4	3 200	3 900	4	7	179	186	192	221	2	216	7.20	6.88
180	250	69	2	202	**NNU4936**	**NNU4936K**	572	964	117	3 000	3 600	4	7	189	199.5	205	241	2	297	10.5	10.1
190	260	69	2	210	**NNU4938**	**NNU4938K**	581	996	119	2 900	3 400	5	8.5	199	207	215	251	2	313	11.0	10.5

[Note] 1) The symbol W is added to the end of bearing numbers to denote bearings whose outer ring has a lubrication groove and holes.

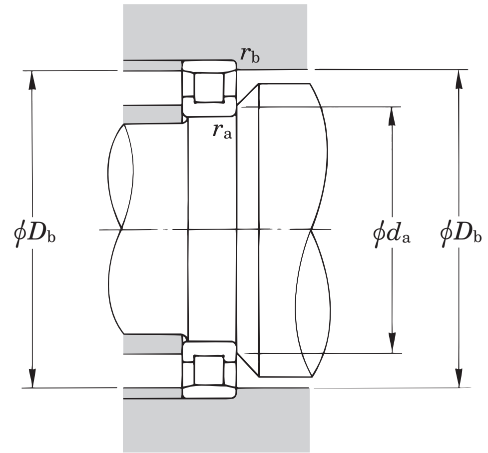
N1000(K) series



Cylindrical bore



Tapered bore



Dynamic equivalent load $P_r = F_r$
Static equivalent load $P_{0r} = F_r$

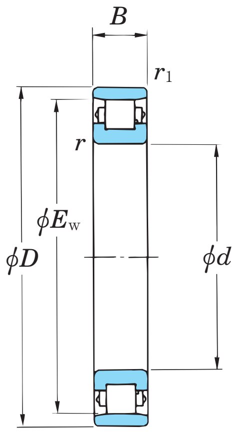
Boundary dimensions (mm)						Bearing No.[1]		Basic load ratings (kN)		Fatigue load limit (kN)	Limiting speeds (min⁻¹)		Mounting dimensions (mm)					Interspace volume	(Refer.) Mass (kg)	
d	D	B	r min.	r_1 min.	E_W	Cylindrical bore	Tapered bore	C_r	C_{0r}	C_u	Grease lub.	Oil lub.	d_a min.	D_b max.	D_b min.	r_a max.	r_b max.	(cm³)	Cylindrical bore	Tapered bore
30	55	13	1	0.6	48.5	**N1006**	**N1006K**	23.4	18.4	2.05	18 000	21 000	35	50	49.5	1	0.6	4.8	0.138	0.135
35	62	14	1	0.6	55	**N1007**	**N1007K**	25.3	21.3	2.40	15 000	18 000	40	57	56	1	0.6	6.4	0.176	0.173
40	68	15	1	0.6	61	**N1008**	**N1008K**	28.2	25.4	2.90	14 000	16 000	45	63	62	1	0.6	8.3	0.215	0.210
45	75	16	1	0.6	68.5	**N1009**	**N1009K**	40.7	34.2	4.45	13 000	15 000	50	70	68.5	1	0.6	11	0.268	0.262
50	80	16	1	0.6	72.5	**N1010**	**N1010K**	44.1	38.9	5.10	11 000	13 000	55	75	73.5	1	0.6	12	0.292	0.285
55	90	18	1.1	1	81	**N1011**	**N1011K**	47.1	43.9	5.75	10 000	12 000	61.5	83.5	82	1	1	17	0.429	0.420
60	95	18	1.1	1	86.1	**N1012**	**N1012K**	48.3	46.4	6.10	9 600	11 000	66.5	88.5	87	1	1	18	0.458	0.448
65	100	18	1.1	1	91.5	**N1013**	**N1013K**	51.3	51.2	6.75	9 000	11 000	71.5	93.5	92	1	1	20	0.486	0.475
70	110	20	1.1	1	100	**N1014**	**N1014K**	72.9	70.4	10.1	8 300	9 700	76.5	103.5	101	1	1	27	0.676	0.662
75	115	20	1.1	1	106	**N1015**	**N1015K**	68.4	74.5	9.95	7 800	9 100	81.5	108.5	106	1	1	29	0.711	0.696
80	125	22	1.1	1	113	**N1016**	**N1016K**	79.3	82.2	11.7	7 200	8 500	86.5	118.5	114	1	1	36	0.957	0.937
85	130	22	1.1	1	118	**N1017**	**N1017K**	81.3	86.2	12.2	6 900	8 100	91.5	123	119	1	1	39	1.01	0.989
90	140	24	1.5	1.1	129	**N1018**	**N1018K**	121	122	16.7	6 400	7 500	98	132	129	1.5	1	52	1.30	1.27
95	145	24	1.5	1.1	133	**N1019**	**N1019K**	125	129	17.5	6 200	7 200	103	137	134	1.5	1	53	1.36	1.34
100	150	24	1.5	1.1	139	**N1020**	**N1020K**	99.8	129	13.9	5 900	6 900	108	142	139	1.5	1	56	1.42	1.39
105	160	26	2	1.1	146	**N1021**	**N1021K**	136	149	19.6	5 500	6 500	114	151	148	2	1	66	1.82	1.78
110	170	28	2	1.1	157	**N1022**	**N1022K**	147	171	21.1	5 200	6 100	119	161	157	2	1	84	2.24	2.20
120	180	28	2	1.1	167	**N1024**	**N1024K**	173	181	22.6	4 800	5 700	129	171	167	2	1	92	2.40	2.35
130	200	33	2	1.1	182	**N1026**	**N1026K**	215	238	29.5	4 400	5 100	139	191	184	2	1	135	3.64	3.57
140	210	33	2	1.1	192	**N1028**	**N1028K**	220	250	30.5	4 100	4 800	149	201	194	2	1	140	3.88	3.80
150	225	35	2.1	1.5	207.5	**N1030**	**N1030K**	252	281	32.8	3 800	4 400	161	214	208	2	1.5	177	4.68	4.58
160	240	38	2.1	1.5	219	**N1032**	**N1032K**	297	330	42.8	3 500	4 100	171	229	221	2	1.5	191	5.80	5.68

[Note] 1) The blue bearing numbers indicate recommended products.

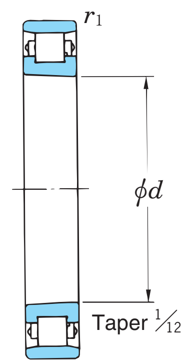
[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4(5)** on page 45.

2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.

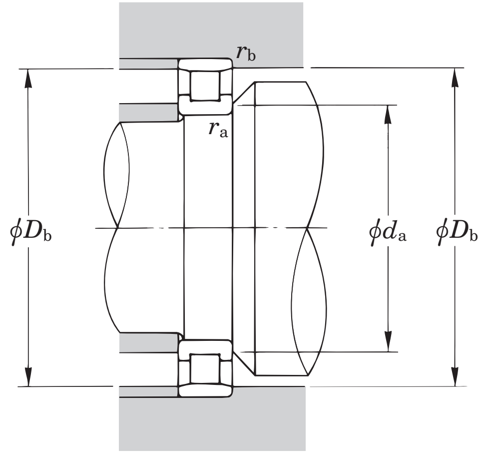
3NCN1000(K) series Ceramic bearings



Cylindrical bore



Tapered bore



Dynamic equivalent load $P_r = F_r$

Static equivalent load $P_{0r} = F_r$

Boundary dimensions (mm)						Bearing No.		Basic load ratings (kN)		Fatigue load limit (kN)	Limiting speeds (min^{-1})		Mounting dimensions (mm)					Interspace volume (cm^3)	(Refer.) Mass (kg)	
d	D	B	r min.	r_1 min.	E_W	Cylindrical bore	Tapered bore	C_r	C_{0r}	C_u	Grease lub.	Oil lub.	d_a min.	max.	D_b min.	r_a max.	r_b max.		Cylindrical bore	Tapered bore
30	55	13	1	0.6	48.5	**3NCN1006**	**3NCN1006K**	23.4	18.4	2.05	23 000	27 000	35	50	49.5	1	0.6	4.8	0.126	0.123
35	62	14	1	0.6	55	**3NCN1007**	**3NCN1007K**	25.3	21.3	2.40	20 000	23 000	40	57	56	1	0.6	6.4	0.163	0.160
40	68	15	1	0.6	61	**3NCN1008**	**3NCN1008K**	28.2	25.4	2.90	18 000	21 000	45	63	62	1	0.6	8.3	0.199	0.194
45	75	16	1	0.6	68.5	**3NCN1009**	**3NCN1009K**	40.7	34.2	4.45	17 000	20 000	50	70	68.5	1	0.6	11	0.238	0.232
50	80	16	1	0.6	72.5	**3NCN1010**	**3NCN1010K**	44.1	38.9	5.10	14 000	17 000	55	75	73.5	1	0.6	12	0.259	0.252
55	90	18	1.1	1	81	**3NCN1011**	**3NCN1011K**	47.1	43.9	5.75	13 000	16 000	61.5	83.5	82	1	1	17	0.392	0.383
60	95	18	1.1	1	86.1	**3NCN1012**	**3NCN1012K**	48.3	46.4	6.10	12 000	14 000	66.5	88.5	87	1	1	18	0.419	0.409
65	100	18	1.1	1	91.5	**3NCN1013**	**3NCN1013K**	51.3	51.2	6.75	12 000	14 000	71.5	93.5	92	1	1	20	0.445	0.434
70	110	20	1.1	1	100	**3NCN1014**	**3NCN1014K**	72.9	70.4	10.1	11 000	13 000	76.5	103.5	101	1	1	27	0.618	0.604
75	115	20	1.1	1	106	**3NCN1015**	**3NCN1015K**	68.4	74.5	9.95	10 000	12 000	81.5	108.5	106	1	1	29	0.635	0.620
80	125	22	1.1	1	113	**3NCN1016**	**3NCN1016K**	79.3	82.2	11.7	9 400	11 000	86.5	118.5	114	1	1	36	0.874	0.854
85	130	22	1.1	1	118	**3NCN1017**	**3NCN1017K**	81.3	86.2	12.2	9 000	11 000	91.5	123	119	1	1	39	0.923	0.902
90	140	24	1.5	1.1	129	**3NCN1018**	**3NCN1018K**	121	122	16.7	8 300	9 800	98	132	129	1.5	1	52	1.14	1.11
95	145	24	1.5	1.1	133	**3NCN1019**	**3NCN1019K**	125	129	17.5	8 100	9 400	103	137	134	1.5	1	53	1.19	1.17
100	150	24	1.5	1.1	139	**3NCN1020**	**3NCN1020K**	99.8	129	13.9	7 700	9 000	108	142	139	1.5	1	56	1.25	1.22
105	160	26	2	1.1	146	**3NCN1021**	**3NCN1021K**	136	149	19.6	7 200	8 500	114	151	148	2	1	66	1.64	1.60
110	170	28	2	1.1	157	**3NCN1022**	**3NCN1022K**	147	171	21.1	6 800	7 900	119	161	157	2	1	84	2.02	1.98
120	180	28	2	1.1	167	**3NCN1024**	**3NCN1024K**	173	181	22.6	6 200	7 400	129	171	167	2	1	92	2.10	2.05
130	200	33	2	1.1	182	**3NCN1026**	**3NCN1026K**	215	238	29.5	5 700	6 600	139	191	184	2	1	135	3.23	3.16
140	210	33	2	1.1	192	**3NCN1028**	**3NCN1028K**	220	250	30.5	5 300	6 200	149	201	194	2	1	140	3.45	3.37
150	225	35	2.1	1.5	207.5	**3NCN1030**	**3NCN1030K**	252	281	32.8	4 900	5 700	161	214	208	2	1.5	177	4.14	4.04
160	240	38	2.1	1.5	219	**3NCN1032**	**3NCN1032K**	297	330	42.8	4 600	5 300	171	229	221	2	1.5	191	5.13	5.01

[Remarks] 1. For the dimensions of the spacers for oil / air lubrication, refer to **Table 9. 4(5)** on page 45.
2. For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.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3. Angular Contact Ball Bearings for Axial Load

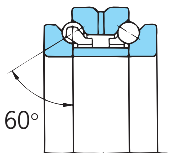
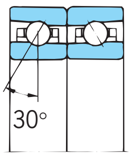
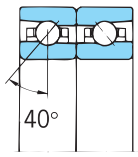
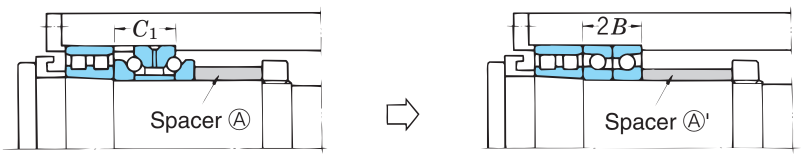
Contents

3. Angular contact ball bearings for axial load

JTEKT produces double direction angular contact thrust and high-speed matched pair angular contact ball bearings to receive the axial loads from spindles of machine tools.

3. 1 Types and features of angular contact ball bearings for axial load

Table 3. 1 Types and features of angular contact ball bearings for axial load

Type / Diameter series	Double direction angular contact thrust ball bearings	High-speed matched pair angular contact ball bearings		To combine with double row cylindrical roller bearings
				Remark: These bearings are used primarily in combination with double row cylindrical roller bearings for radial load. Combinations are as shown below.
0	2344 B	ACT 0 DB	ACT 0 BDB	Placed next to the small tapered bore diameter side of NN30K, or used in tandem with NN30 (cylindrical bore).
	2347 B	—	—	Placed next to the large tapered bore diameter side of NN30K.
9	2394 B	—	—	Placed next to the small tapered bore diameter side of NNU49K, or used in tandem with NNU49 (cylindrical bore).
	2397 B	—	—	Placed next to the large tapered-bore diameter side of NNU49K.
Features	● Axial load can be applied in both directions, and the rigidity in the axial direction is high. ● Bearings having greater contact angles are more suitable where rigidity is a priority, and those having smaller contact angles are more appropriate where high-speed performance is a priority.	● Negative tolerances on the outside diameters are used to permit axial load only. ● Having small contact angles, these are suitable for high-speed rotations. ● These bearings are interchangeable with 2344 B series.		—
Interchangeability	 Example of mounting in tandem with 2344 B — Example of mounting in tandem with ACT 0 DB or ACT 0 BDB Since the combined width "$2B$" of ACT 0 DB and ACT 0 BDB is equal to dimension "C_1" of 2344 B, it is not necessary to change shaft and housing dimensions. Changing the width of spacer Ⓐ is sufficient.			

3. 2 Composition of bearing numbers (angular contact ball bearings for axial load)

Double direction angular contact thrust ball bearings

2 3 4 4 18 B FY P4

- **2** — **Double direction angular contact thrust ball bearings**
- **3** — **Contact angle symbols**
  - 3 : nominal contact angle 60°
- **4** — **Diameter series symbols**
  - 4 : diameter series 0
  - 9 : diameter series 9
- **4** — **Bearing bore diameter classification symbols**
  - 4 : small bore diameter type
  - 7 : large bore diameter type
- **18** — **Bore diameter number**
  - 18 : nominal bore diameter 90 mm (Bore diameter number × 5 equals nominal bore diameter.)
- **B** — **Outer ring configuration symbols**
  - B : integrated outer ring type
- **FY** — **Cage symbols**
  - FY : machined cage made of copper alloy
- **P4** — **Tolerance class symbols**
  - P5 : equivalent of JIS class 5
  - P4 : equivalent of JIS class 4

High-speed matched pair angular contact ball bearings

ACT 0 18 B DB M FT P4

- **ACT** — **High-speed matched pair angular contact ball bearings**
- **0** — **Diameter series 0**
- **18** — **Bore diameter number**
  - 18 : nominal bore diameter 90 mm (Bore diameter number × 5 equals nominal bore diameter.)
- **B** — **Contact angle symbols**
  - A (to be omitted) : nominal contact angle 30°
  - B : nominal contact angle 40°
- **DB** — **Back-to-back symbols**
- **M** — **Preload symbols**
  - L : light preload
  - M : medium preload
  - (See **Table 3. 4** (page 125) for preload values.)
- **FT** — **Cage symbols**
  - FG : molded cage made of polyamide resin (ball-guiding type)
  - FT : machined cage made of reinforced phenolic resin (outer ring-guiding type)
  - FY : machined cage made of copper alloy (outer ring-guiding type)
- **P4** — **Tolerance class symbols**
  - P5 : equivalent of JIS class 5
  - P4 : equivalent of JIS class 4

3. 3 Tolerance of angular contact ball bearings for axial load

The tolerance of double direction angular contact thrust ball bearings is shown in **Table 3. 2**.
The tolerance of high-speed matched pair angular contact ball bearings is shown in **Table 3. 3** (page 123 and 124).

The tolerance of these bearings complies with **JTEKT** standards Classes 5 and 4 (equivalent of JIS Classes 5 and 4).

Table 3. 2 Permissible dimensional deviations and limits to double direction angular contact thrust ball bearings (JTEKT standards)

(1) Inner ring and assembled bearing width

Unit : μm

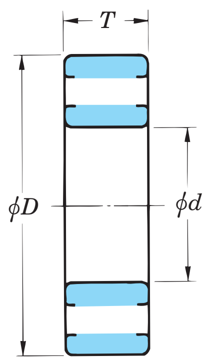
Nominal bore diameter d (mm)		Δ_{dmp} or Δ_{ds} 1)				Actual bearing width deviation Δ_{Ts}		Inner ring width variation V_{Bs}		Perpendicularity of inner ring face with respect to the bore S_d		Axial runout of assembled bearing inner ring S_{ia}	
		Class 5		Class 4		Classes 5, 4		Class 5	Class 4	Class 5	Class 4	Class 5	Class 4
over	up to	upper	lower	upper	lower	upper	lower	max.		max.		max.	
18	**30**	0	– 6	0	– 5	0	– 300	5	2.5	8	4	5	3
30	**50**	0	– 8	0	– 6	0	– 400	5	3	8	4	5	3
50	**80**	0	– 9	0	– 7	0	– 500	6	4	8	4	6	5
80	**120**	0	–10	0	– 8	0	– 600	7	4	9	5	6	5
120	**180**	0	–13	0	–10	0	– 700	8	5	10	6	8	6
180	**250**	0	–15	0	–12	0	– 800	10	6	11	7	8	6
250	**315**	0	–18	0	–15	0	– 900	13	7	13	8	10	8
315	**400**	0	–23	0	–18	0	–1 000	15	9	15	9	13	10

(2) Outer ring

Unit : μm

Nominal outside diameter D (mm)		Δ_{Dmp} or Δ_{Ds} 2)		Outer ring width variation V_{Cs}		Perpendicularity of outer ring outside surface with respect to the face S_D		Axial runout of assembled bearing outer ring S_{ea}
		Classes 5, 4		Class 5	Class 4	Class 5	Class 4	Classes 5, 4
over	up to	upper	lower	max.		max.		max.
30	**50**	– 30	– 40	5	2.5	8	4	Same as permissible values S_{ia}, d being that of the same bearing.
50	**80**	– 40	– 50	6	3	8	4	
80	**120**	– 50	– 60	8	4	9	5	
120	**150**	– 60	– 75	8	5	10	5	
150	**180**	– 60	– 75	8	5	10	5	
180	**250**	– 75	– 90	10	7	11	7	
250	**315**	– 90	–105	11	7	13	8	
315	**400**	–110	–125	13	8	13	10	
400	**500**	–120	–140	15	10	15	13	

[Notes] 1) Single plane mean bore diameter deviation or single bore diameter deviation
2) Single plane mean outside diameter deviation or single outside diameter deviation



d : nominal bore diameter
D : nominal outside diameter
T : nominal bearing width

Table 3. 3(1) Permissible dimensional deviations and limits of high-speed matched pair angular contact ball bearings (JTEKT standards)

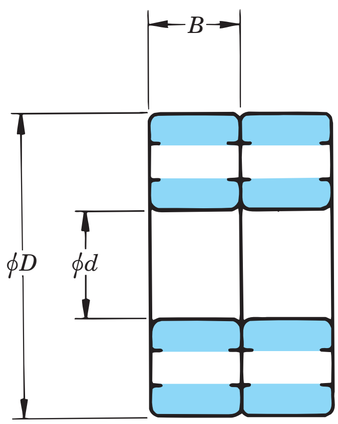
(1) Inner ring

Unit : µm

Nominal bore diameter d (mm)		Single plane mean bore diameter deviation Δ_{dmp}				Single bore diameter deviation Δ_{ds} 1)		Single plane bore diameter variation V_{dsp} Diameter series 9, 0		Mean bore diameter variation V_{dmp}	
		Class 5		Class 4		Class 4		Class 5	Class 4	Class 5	Class 4
over	up to	upper	lower	upper	lower	upper	lower	max.		max.	
18	30	0	− 6	0	− 5	0	− 5	6	5	3	2.5
30	50	0	− 8	0	− 6	0	− 6	8	6	4	3
50	80	0	− 9	0	− 7	0	− 7	9	7	5	3.5
80	120	0	−10	0	− 8	0	− 8	10	8	5	4
120	150	0	−13	0	−10	0	−10	13	10	7	5
150	180	0	−13	0	−10	0	−10	13	10	7	5
180	250	0	−15	0	−12	0	−12	15	12	8	6
250	315	0	−18	0	−15	0	−15	18	15	9	8
315	400	0	−23	0	−18	0	−18	23	18	12	9

Nominal bore diameter d (mm)		Radial runout of assembled bearing inner ring K_{ia}		Perpendicularity of inner ring face with respect to the bore S_d		Axial runout of assembled bearing inner ring S_{ia}		Single inner ring width deviation Δ_{Bs}		Single inner ring width deviation Δ_{Bs} 2)		Inner ring width variation V_{Bs}	
		Class 5	Class 4	Class 5	Class 4	Class 5	Class 4	Classes 5, 4		Classes 5, 4		Class 5	Class 4
over	up to	max.		max.		max.		upper	lower	upper	lower	max.	
18	30	4	3	8	4	8	4	0	−120	0	−250	5	2.5
30	50	5	4	8	4	8	4	0	−120	0	−250	5	3
50	80	5	4	8	5	8	5	0	−150	0	−250	6	4
80	120	6	5	9	5	9	5	0	−200	0	−380	7	4
120	150	8	6	10	6	10	7	0	−250	0	−380	8	5
150	180	8	6	10	6	10	7	0	−250	0	−380	8	5
180	250	10	8	11	7	13	8	0	−300	0	−500	10	6
250	315	13	10	13	8	15	9	0	−350	0	−500	13	8
315	400	15	13	15	9	20	12	0	−400	0	−630	15	9

[Notes] 1) Tolerance class 4 is applied to bearings of diameter series 0.
2) Applied to individual bearing rings manufactured for matched pair or stack bearings.



d : nominal bore diameter
D : nominal outside diameter
B : nominal bearing width

Table 3. 3(2) Permissible dimensional deviations and limits for high-speed matched pair angular contact ball bearings (JTEKT standards)

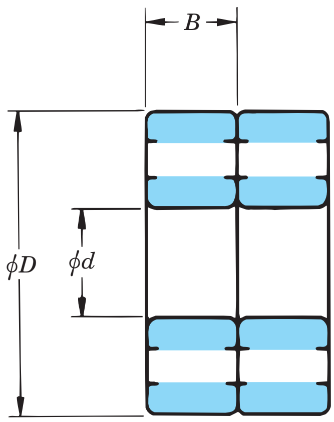
(2) Outer ring

Unit : μm

Nominal outside diameter D (mm)		Δ_{Dmp} or Δ_{Ds} 1), 2)		Single plane outside diameter variation V_{Dsp} Diameter series 9, 0		Mean outside diameter variation V_{Dmp}	
		Classes 5, 4		Class 5	Class 4	Class 5	Class 4
over	up to	upper	lower	max.		max.	
50	**80**	–32	– 47	9	7	5	3.5
80	**120**	–39	– 56	10	8	5	4
120	**150**	–44	– 66	11	9	6	5
150	**180**	–44	– 68	13	10	7	5
180	**250**	–51	– 79	15	11	8	6
250	**315**	–56	– 89	18	13	9	7
315	**400**	–63	– 99	20	15	10	8
400	**500**	–71	–111	23	17	12	9

Nominal outside diameter D (mm)		Radial runout of assembled bearing outer ring K_{ea}		Perpendicularity of outer ring out side surface with respect to the face S_D		Axial runout of assembled bearing outer ring S_{ea}		Deviation of a single outer ring width Δ_{Cs}		Ring width variation V_{Cs}	
		Class 5	Class 4	Class 5	Class 4	Class 5	Class 4	Classes 5, 4		Class 5	Class 4
over	up to	max.		max.		max.		upper	lower	max.	
50	**80**	8	5	8	4	10	5	Same as tolerance Δ_{Bs}, d being that of the same bearing.		6	3
80	**120**	10	6	9	5	11	6			8	4
120	**150**	11	7	10	5	13	7			8	5
150	**180**	13	8	10	5	14	8			8	5
180	**250**	15	10	11	7	15	10			10	7
250	**315**	18	11	13	8	18	10			11	7
315	**400**	20	13	13	10	20	13			13	8
400	**500**	23	15	15	12	23	15			15	9

[Notes] 1) Single plane mean outside diameter deviation or single outside diameter deviation
2) Dimensional tolerance for outside diameter of class 4 is applied to bearings of diameter series 0.



d : nominal bore diameter
D : nominal outside diameter
B : nominal bearing width

3. 4 Standard preloads for high-speed matched pair angular contact ball bearings

Table 3. 4 shows standard preloads for high-speed matched pair angular contact ball bearings.

Table 3. 4 Standard preloads for high-speed matched pair angular contact ball bearings

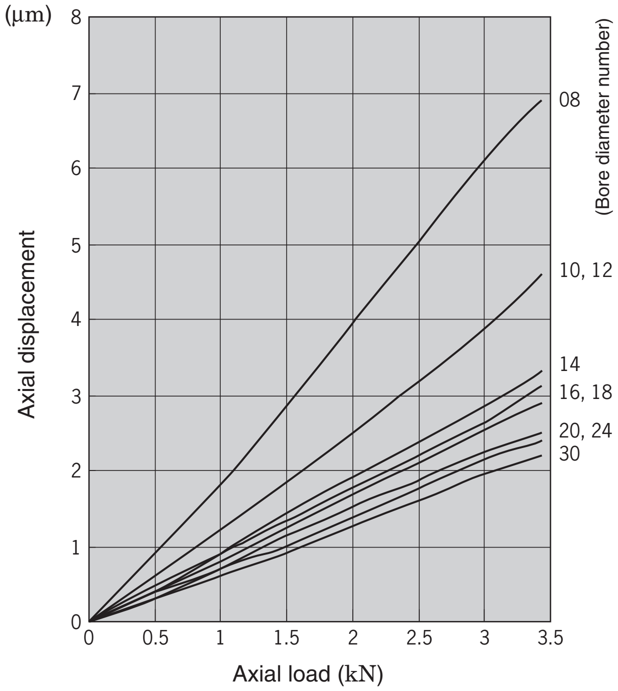
(L : light preload; M : medium preload) Unit : N

Bore diameter number	ACT 000		ACT 000 B	
	L	M	L	M
06	195	345	295	685
07	195	390	390	735
08	245	440	440	835
09	245	490	490	930
10	295	540	540	1 030
11	390	685	685	1 270
12	390	735	735	1 420
13	440	835	785	1 520
14	590	1 130	1 030	2 010
15	590	1 130	1 080	2 110
16	685	1 370	1 270	2 500
17	735	1 420	1 320	2 600
18	980	1 860	1 770	3 380
19	980	1 960	1 860	3 530
20	1 030	2 010	1 910	3 680
21	1 180	2 250	2 150	3 770
22	1 320	2 600	2 450	4 760
24	1 420	2 800	2 550	5 100
26	1 770	3 380	3 230	6 230
28	2 010	3 920	3 720	7 210
30	2 400	4 610	4 410	8 480
32	2 500	4 850	4 660	8 920
34	3 090	6 030	5 730	9 320
36	3 530	6 860	6 570	10 500
38	3 780	7 160	6 960	10 800
40	4 410	8 530	8 040	13 000
44	5 200	9 710	8 430	15 300
48	5 540	10 000	8 680	15 800
52	6 620	12 400	10 800	19 600
56	6 820	12 700	11 100	20 200
60	7 700	14 400	12 700	23 000
64	7 750	14 500	12 700	23 000

3. 5 Axial load and displacement (angular contact ball bearings for axial load)

Fig. 3. 1 show relationships between axial load and displacement respectively for double direction angular contact thrust and high-speed matched pair angular contact ball bearings when a standard preload is applied.

(1) 234400B and 234700B series (contact angle : 60°)



(2) 239400B and 239700B series (contact angle : 60°)

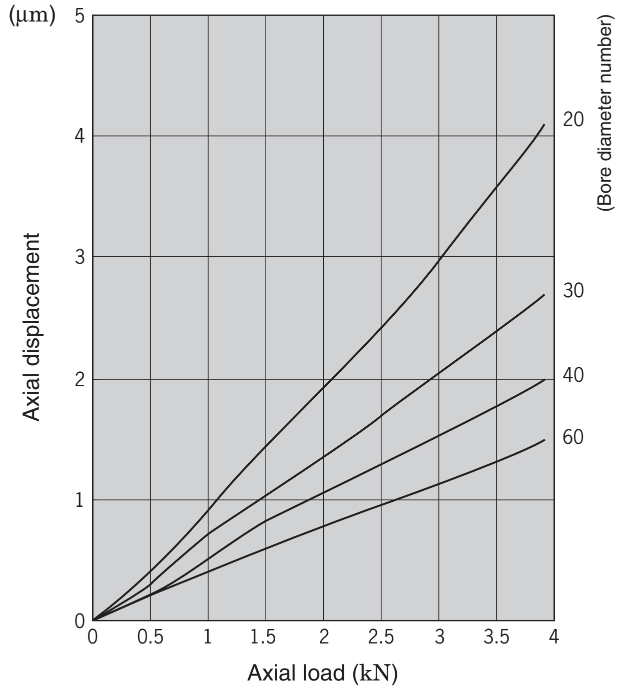
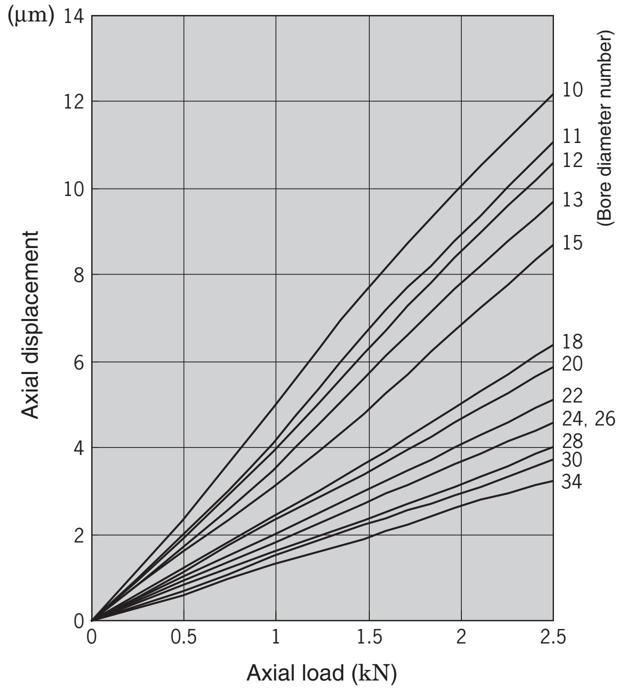


Fig. 3. 1(1) Relationships between axial load and displacement (double direction angular contact thrust ball bearings)

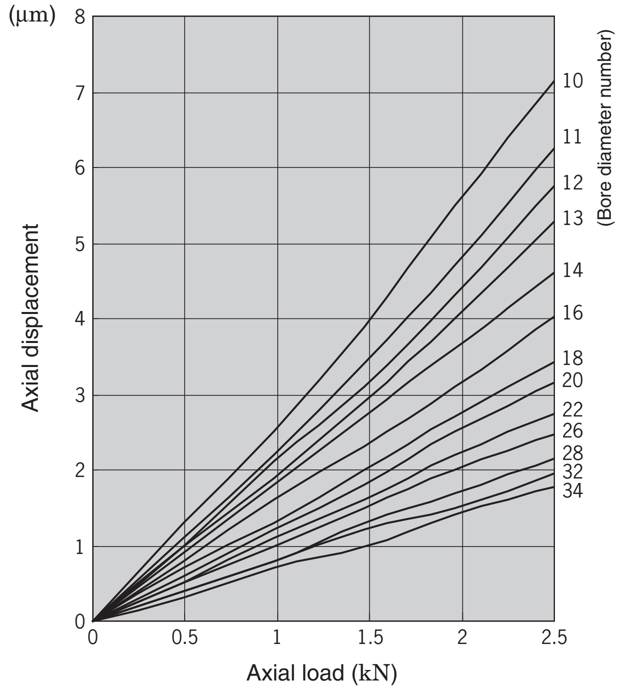
(3) ACT000 series (contact angle 30°)

a) When preload L is applied

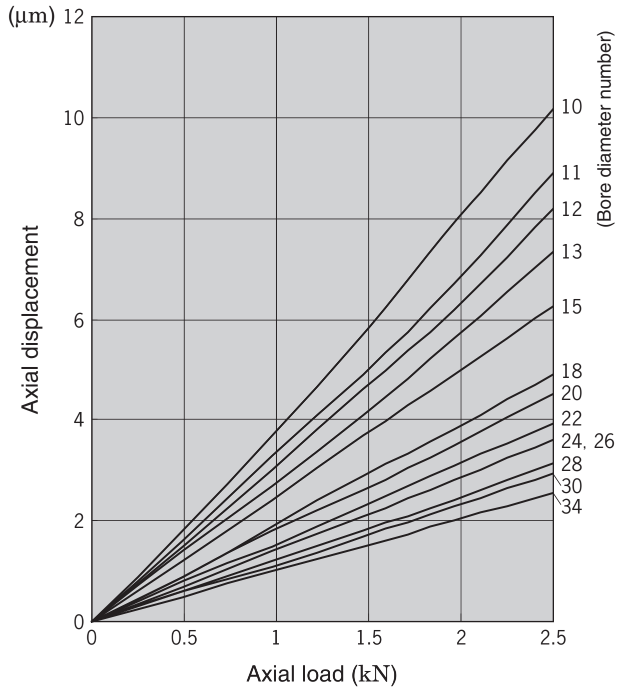


(4) ACT000B series (contact angle 40°)

a) When preload L is applied



b) When preload M is applied



b) When preload M is applied

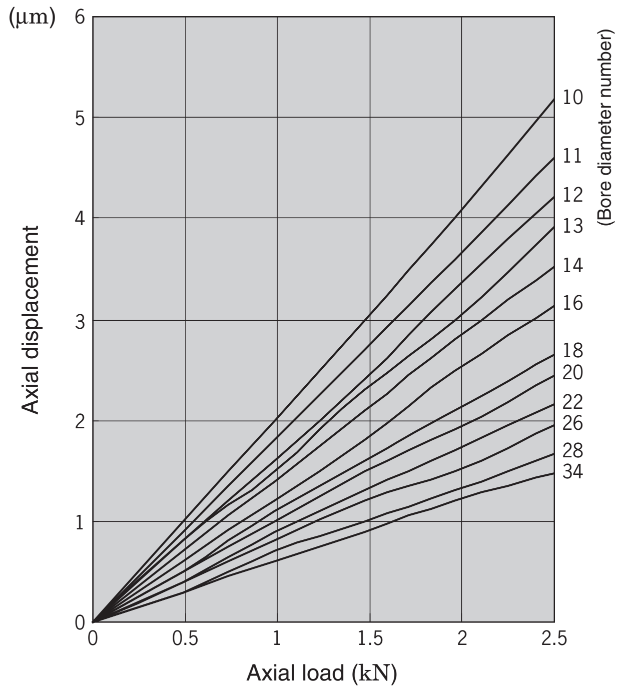
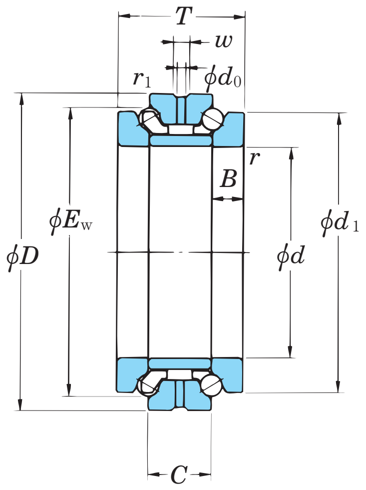


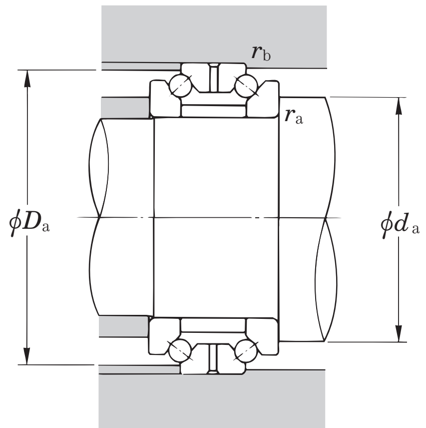
Fig. 3. 1(2) Relationships between axial load and displacement (high-speed matched pair angular contact ball bearings)

Koyo

234400B series
234700B series

Contact angle 60°





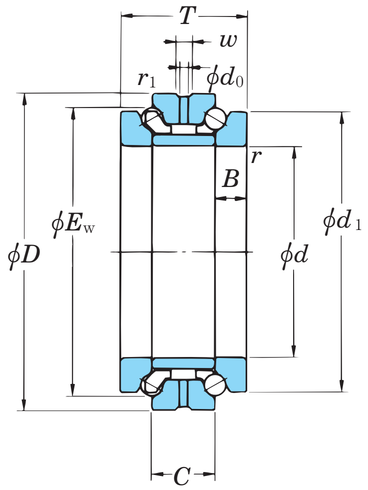
Dynamic equivalent load $P_a = F_a$
Static equivalent load $P_{0a} = F_a$

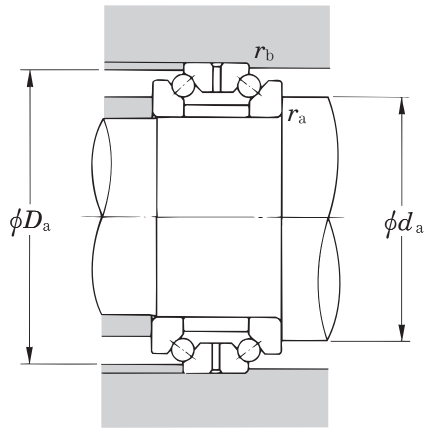
Boundary dimensions (mm)							Bearing No.[1)]		Basic load ratings (kN)		Limiting speeds (min^{-1})		Dimensions (mm)					Mounting dimensions (mm)				Amount of grease fill (cm^3/row)	(Refer.) Mass (kg)	
d Small bore dia. type	d Large bore dia. type	D	T	C	r min.	r_1 min.	Small bore dia. type	Large bore dia. type	C_a	C_{0a}	Grease lub.	Oil lub.	E_w[2)]	d_1	B	d_0	w	d_a min.	D_a max.	r_a max.	r_b max.		Small bore dia. type	Large bore dia. type
25	—	47	28	14	0.6	0.3	**234405B**	—	16.5	19.9	7 700	11 000	41.3	40	7	2	4.5	33	44	0.6	0.3	0.18~0.26	0.194	—
30	32	55	32	16	1	0.6	**234406B**	**234706B**	17.5	23.6	6 700	9 500	48.5	47	8	2	4.5	40	50.5	1	0.6	0.3~0.45	0.296	0.272
35	37	62	34	17	1	0.6	**234407B**	**234707B**	26.0	34.8	6 100	8 700	55	53	8.5	2	4.5	45.5	57.5	1	0.6	0.4~0.6	0.388	0.367
40	42	68	36	18	1	0.6	**234408B**	**234708B**	29.9	41.7	5 700	8 100	61	58.5	9	2	4.5	50	63.5	1	0.6	0.5~0.75	0.475	0.437
45	47	75	38	19	1	0.6	**234409B**	**234709B**	32.5	50.1	5 200	7 500	67.5	65	9.5	2	4.5	56.5	70.5	1	0.6	0.65~0.98	0.602	0.554
50	52	80	38	19	1	0.6	**234410B**	**234710B**	33.5	54.4	5 100	7 300	72.5	70	9.5	2	4.5	61.5	75.5	1	0.6	0.7~1.1	0.654	0.602
55	57	90	44	22	1.1	0.6	**234411B**	**234711B**	46.5	71.7	4 400	6 400	81	78	11	4	8	67.5	84	1	0.6	1~1.5	0.978	0.900
60	62	95	44	22	1.1	0.6	**234412B**	**234712B**	47.0	75.2	4 300	6 200	86.1	83	11	4	8	72.5	89	1	0.6	1.1~1.7	1.04	0.957
65	67	100	44	22	1.1	0.6	**234413B**	**234713B**	48.8	81.8	4 200	6 000	91	88	11	4	8	77.5	94	1	0.6	1.2~1.7	1.11	1.02
70	73	110	48	24	1.1	0.6	**234414B**	**234714B**	59.4	103	3 800	5 500	100	97	12	4	8	85	104	1	0.6	1.7~2.5	1.52	1.40
75	78	115	48	24	1.1	0.6	**234415B**	**234715B**	61.4	111	3 700	5 300	105	102	12	4	8	90	109	1	0.6	1.8~2.6	1.62	1.49
80	83	125	54	27	1.1	0.6	**234416B**	**234716B**	72.0	132	3 400	4 800	113	110	13.5	4	8	96.5	119	1	0.6	2.4~3.6	2.19	2.03
85	88	130	54	27	1.1	0.6	**234417B**	**234717B**	72.8	137	3 300	4 700	118	115	13.5	4	8	102	124	1	0.6	2.5~3.8	2.30	2.12
90	93	140	60	30	1.5	1	**234418B**	**234718B**	84.3	160	3 000	4 300	127	123	15	4	8	109	133.5	1.5	1	3.3~4.9	3.03	2.79
95	98	145	60	30	1.5	1	**234419B**	**234719B**	85.0	166	3 000	4 200	132	128	15	4	8	114	138.5	1.5	1	3.4~5	3.17	2.92
100	103	150	60	30	1.5	1	**234420B**	**234720B**	85.9	172	2 900	4 100	137	133	15	4	8	119	143.5	1.5	1	3.4~5.1	3.33	3.06
105	109	160	66	33	2	1	**234421B**	**234721B**	98.5	199	2 700	3 800	146	142	16.5	6	12	127	152	2	1	4.7~7.1	4.15	3.82
110	114	170	72	36	2	1	**234422B**	**234722B**	120	235	2 500	3 500	155	150	18	6	12	133	162	2	1	5.9~8.8	5.38	4.95
120	124	180	72	36	2	1	**234424B**	**234724B**	123	252	2 400	3 400	165	160	18	6	12	143	172	2	1	6.4~9.5	5.77	5.31
130	135	200	84	42	2	1	**234426B**	**234726B**	174	340	2 100	3 000	182	177	21	6	12	155	192	2	1	9.3~13.9	8.63	7.94
140	145	210	84	42	2	1	**234428B**	**234728B**	180	366	2 000	2 900	192	187	21	6	12	165	202	2	1	9.7~14.5	9.18	8.44
150	155	225	90	45	2.1	1.1	**234430B**	**234730B**	184	394	1 900	2 700	206	200	22.5	6	14	178	215	2	1	12~17.9	11.3	10.4
160	165	240	96	48	2.1	1.1	**234432B**	**234732B**	216	460	1 700	2 500	219	212	24	6	14	189	230	2	1	14.1~21.1	13.3	12.2
170	176	260	108	54	2.1	1.1	**234434B**	**234734B**	254	547	1 600	2 200	236	230	27	6	14	203	250	2	1	18.6~27.8	18.1	16.6

[Notes] 1) The small bore diameter type bearing is placed next to the small tapered-bore diameter side of the NN30K, or used in tandem with NN30.
The large bore diameter type bearing is placed next to the large tapered-bore diameter side of NN30K.
2) The dimension E_w is used as a reference for the ball set outside diameter.

239400B series
239700B series

Contact angle 60°





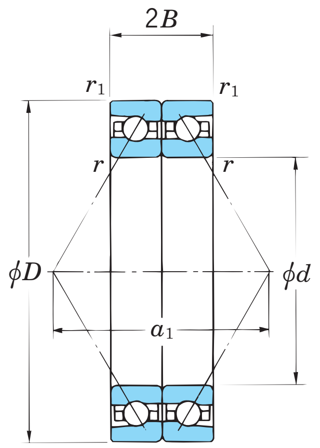
Dynamic equivalent load $P_a = F_a$
Static equivalent load $P_{0a} = F_a$

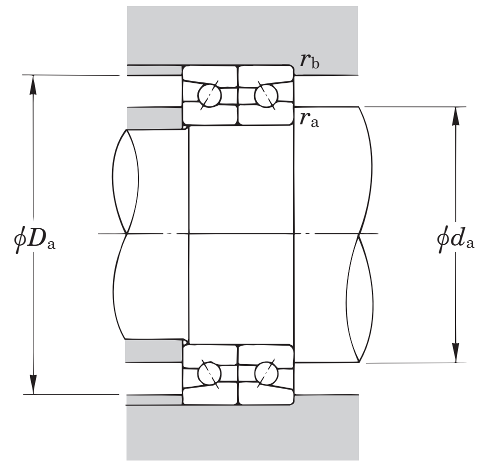
Boundary dimensions (mm)							Bearing No.[1]		Basic load ratings (kN)		Limiting speeds (min⁻¹)		Dimensions (mm)					Mounting dimensions (mm)				Amount of grease fill (cm³/row)	(Refer.) Mass (kg)	
d Small bore dia. type	d Large bore dia. type	D	T	C	r min.	r_1 min.	Small bore dia. type	Large bore dia. type	C_a	C_{0a}	Grease lub.	Oil lub.	E_w[2]	d_1	B	d_0	w	d_a min.	D_a max.	r_a max.	r_b max.		Small bore dia. type	Large bore dia. type
100	—	140	48	24	1.1	0.6	**239420B**	—	65.3	135	2 800	3 800	131	126	12	4	8	114	134	1	0.6	3.1~4.6	2.08	—
105	—	145	48	24	1.1	0.6	**239421B**	—	67.0	143	2 700	3 800	136	131	12	4	8	119	139	1	0.6	3.1~4.6	2.16	—
110	—	150	48	24	1.1	0.6	**239422B**	—	67.4	148	2 700	3 700	141	136	12	4	8	124	144	1	0.6	3~4.5	2.25	—
120	124	165	54	27	1.1	0.6	**239424B**	**239724B**	81.1	185	2 400	3 300	154.5	150	13.5	4	8	138	160	1	0.6	4.2~6.3	3.12	2.81
130	134	180	60	30	1.5	1	**239426B**	**239726B**	93.8	217	2 100	3 000	168	163	15	4	8	150	172	1.5	1	5.8~8.7	4.19	3.77
140	144	190	60	30	1.5	1	**239428B**	**239728B**	94.9	229	2 100	2 900	178	173	15	4	8	160	182	1.5	1	6.3~9.4	4.47	4.03
150	155	210	72	36	2	1	**239430B**	**239730B**	134	312	1 800	2 500	196.5	190	18	4	8	174	200	2	1	9.6~14.4	7.01	6.31
160	165	220	72	36	2	1	**239432B**	**239732B**	136	329	1 700	2 400	206.5	200	18	4	8	184	210	2	1	9.3~14	7.40	6.66
170	175	230	72	36	2	1	**239434B**	**239734B**	139	346	1 700	2 300	216.5	210	18	4	8	194	220	2	1	10.8~16.2	7.79	7.01
180	186	250	84	42	2	1	**239436B**	**239736B**	196	460	1 500	2 100	234	227	21	4	8	207	240	2	1	14.9~22.3	11.3	10.2
190	196	260	84	42	2	1	**239438B**	**239738B**	196	474	1 400	2 000	242	237	21	4	8	217	250	2	1	15.7~23.5	11.9	10.7

[Notes] 1) The small bore diameter type bearing is placed next to the small tapered-bore diameter side of the NNU49K, or used in tandem with NNU49.
The large bore diameter type bearing is placed next to the large tapered-bore diameter side of NNU49K.
2) The dimension E_w is used as a reference for the ball set outside diameter.

Koyo

ACT000DB/BDB series





Dynamic equivalent load $P_a = F_a$
Static equivalent load $P_{0a} = F_a$

d 30 ~ 95

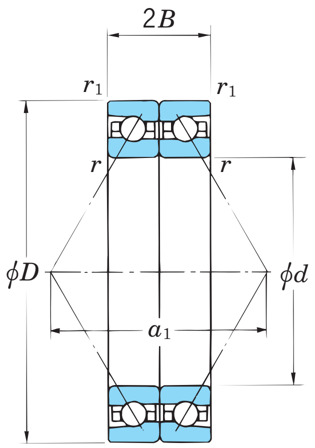
Boundary dimensions (mm) *d*	*D*	2*B*	*r* min.	r_1 min.	Bearing No.[1]	Basic load ratings (kN) C_a	C_{0a}	Limiting speeds (min⁻¹) Grease lub.	Oil lub.	Permissible axial load (kN) (static)	Load center spread (mm) a_1	Mounting dimensions (mm) d_a min.	D_a max.	r_a max.	r_b max.	Interspace volume (cm^3/row)	(Refer.) Mass (kg/row)
30	55	24	1	0.6	ACT006DB	18.9	26.6	15 000	20 000	2.92	48.5	41	50	1	0.6	3	0.235
	55	24	1	0.6	ACT006BDB	22.6	30.5	13 000	18 000	9.86	59.6	41	50	1	0.6	3	0.235
35	62	25.5	1	0.6	ACT007DB	19.8	30.2	13 000	17 000	3.25	53.5	46	57	1	0.6	4.2	0.312
	62	25.5	1	0.6	ACT007BDB	23.6	34.5	12 000	15 000	10.9	66.2	46	57	1	0.6	4.2	0.312
40	68	27	1	0.6	ACT008DB	20.6	33.8	12 000	15 000	3.58	58.2	51	63	1	0.6	5	0.391
	68	27	1	0.6	ACT008BDB	24.5	37.7	11 000	14 000	12.1	72.3	51	63	1	0.6	5	0.391
45	75	28.5	1	0.6	ACT009DB	23.0	38.6	11 000	14 000	3.84	63.1	56	70	1	0.6	5.7	0.536
	75	28.5	1	0.6	ACT009BDB	27.3	42.7	9 500	13 000	13.2	78.8	56	70	1	0.6	5.7	0.536
50	80	28.5	1	0.6	ACT010DB	23.9	41.7	9 700	13 000	4.2	51.8	61	75	1	0.6	8	0.551
	80	28.5	1	0.6	ACT010BDB	28.4	46.3	8 800	12 000	14.5	83	61	75	1	0.6	8	0.551
55	90	33	1.1	0.6	ACT011DB	29.6	52.8	8 700	11 000	5.63	58.4	68	84	1	0.6	12	0.831
	90	33	1.1	0.6	ACT011BDB	35.1	58.6	7 900	10 000	19	89.3	68	84	1	0.6	12	0.831
60	95	33	1.1	0.6	ACT012DB	30.7	56.9	8 100	11 000	6.11	61.2	73	89	1	0.6	13	0.887
	95	33	1.1	0.6	ACT012BDB	36.4	63.1	7 400	9 700	20.6	93.5	73	89	1	0.6	13	0.887
65	100	33	1.1	0.6	ACT013DB	31.8	60.9	7 600	10 000	6.59	64.1	78	94	1	0.6	14	0.943
	100	33	1.1	0.6	ACT013BDB	37.7	67.6	6 900	9 000	22.2	85.8	78	94	1	0.6	14	0.945
70	110	36	1.1	0.6	ACT014DB	43.5	82.1	7 000	9 200	8.39	70	85	104	1	0.6	16	1.33
	110	36	1.1	0.6	ACT014BDB	51.7	91.1	6 300	8 300	28.8	93.5	85	104	1	0.6	16	1.33
75	115	36	1.1	0.6	ACT015DB	44.1	84.9	6 600	8 700	8.74	72.8	90	109	1	0.6	20	1.35
	115	36	1.1	0.6	ACT015BDB	52.3	94.2	6 000	7 800	30	97.7	90	109	1	0.6	20	1.35
80	125	40.5	1.1	0.6	ACT016DB	51.7	101	6 100	8 000	10.8	79.4	97	118	1	0.6	27	1.86
	125	40.5	1.1	0.6	ACT016BDB	61.3	112	5 500	7 200	36.6	106.3	97	118	1	0.6	27	1.86
85	130	40.5	1.1	0.6	ACT017DB	52.4	105	5 800	7 600	11.2	82.3	102	123	1	0.6	29	1.94
	130	40.5	1.1	0.6	ACT017BDB	62.1	116	5 200	6 900	38	110.5	102	123	1	0.6	29	1.94
90	140	45	1.5	1	ACT018DB	68.8	138	5 400	7 100	14.2	88.9	109	132	1.5	1	39	2.55
	140	45	1.5	1	ACT018BDB	81.7	153	4 900	6 400	48.7	119	109	132	1.5	1	39	2.55
95	145	45	1.5	1	ACT019DB	69.8	143	5 200	6 800	14.8	91.8	114	137	1.5	1	40	2.62
	145	45	1.5	1	ACT019BDB	82.8	159	4 700	6 200	50.6	123.2	114	137	1.5	1	40	2.62

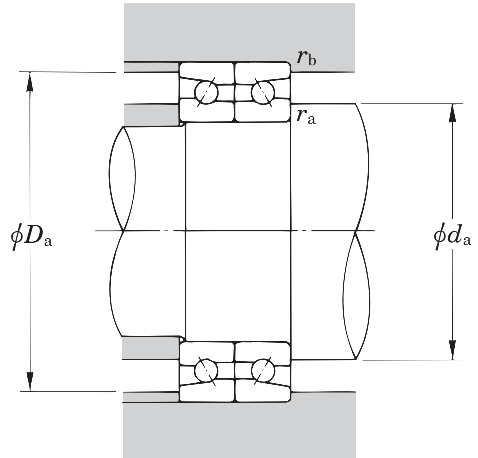
[Note] 1) The blue bearing numbers indicate recommended products.

[Remark] 1) This bearing is interchangeable with 234400B as their bore and outside diameters are the same.

Koyo

ACT000DB/BDB series





d 100 ~ 170

Dynamic equivalent load $P_a = F_a$
Static equivalent load $P_{0a} = F_a$

Boundary dimensions (mm)					Bearing No.[1]	Basic load ratings (kN)		Limiting speeds (min⁻¹)		Permissible axial load (kN)	Load center spread (mm)	Mounting dimensions (mm)				Interspace volume	(Refer.) Mass
d	D	$2B$	r min.	r_1 min.		C_a	C_{0a}	Grease lub.	Oil lub.	(static)	a_1	d_a min.	D_a max.	r_a max.	r_b max.	(cm^3/row)	(kg/row)
100	150	45	1.5	1	ACT020DB	70.8	148	5 000	6 500	15.3	94.7	119	143	1.5	1	42	2.77
	150	45	1.5	1	ACT020BDB	84.0	164	4 500	5 900	52.5	127.4	119	143	1.5	1	42	2.77
105	160	49.5	2	1	ACT021DB	80.5	170	4 700	6 100	18.2	101.2	125	151	2	1	50	3.61
	160	49.5	2	1	ACT021BDB	95.5	188	4 200	5 500	63.2	135.9	125	151	2	1	50	3.61
110	170	54	2	1	ACT022DB	90.6	193	4 400	5 800	19.6	107.8	132	160	2	1	64	4.52
	170	54	2	1	ACT022BDB	107	214	4 000	5 200	71.3	144.5	132	160	2	1	64	4.52
120	180	54	2	1	ACT024DB	93.2	206	4 100	5 400	21	113.6	142	170	2	1	69	4.83
	180	54	2	1	ACT024BDB	111	228	3 700	4 900	76.4	152.9	142	170	2	1	69	4.83
130	200	63	2	1	ACT026DB	118	253	3 700	4 800	25.9	126.8	156	188	2	1	106	7.21
	200	63	2	1	ACT026BDB	140	281	3 300	4 400	93	170	156	188	2	1	106	7.21
140	210	63	2	1	ACT028DB	128	290	3 400	4 500	29.9	132.5	166	198	2	1	110	7.69
	210	63	2	1	ACT028BDB	151	323	3 100	4 100	107	178.3	166	198	2	1	110	7.65
150	225	67.5	2.1	1.1	ACT030DB	150	344	3 200	4 200	34.7	142	178	213	2	1	138	9.39
	225	67.5	2.1	1.1	ACT030BDB	179	382	2 900	3 800	125	191.1	178	213	2	1	138	9.39
160	240	72	2.1	1.1	ACT032DB	163	377	3 000	3 900	39.1	151.5	190	227	2	1	167	11.4
	240	72	2.1	1.1	ACT032BDB	193	419	2 700	3 500	139	203.8	190	227	2	1	167	11.4
170	260	81	2.1	1.1	ACT034DB	191	449	2 700	3 600	45.7	164.6	204	245	2	1	221	15.7
	260	81	2.1	1.1	ACT034BDB	227	499	2 500	3 200	163	221	204	245	2	1	221	15.7

[Note] 1) The blue bearing numbers indicate recommended products.

[Remark] 1) This bearing is interchangeable with 234400B as their bore and outside diameters are the same.

4. Tapered Roller Bearings

Contents

4. Tapered roller bearings

The tapered roller bearing is a bearing in which tapered rollers (truncated conical rollers) are inserted between the outer ring and inner ring. The rollers are guided by the inner ring back face rib (see **Fig. 4. 1**).

A radial load and an axial load can be simultaneously applied to the tapered roller bearing. This bearing has high rigidity.

In addition, tapered roller bearings allow easy adjustments of preload.

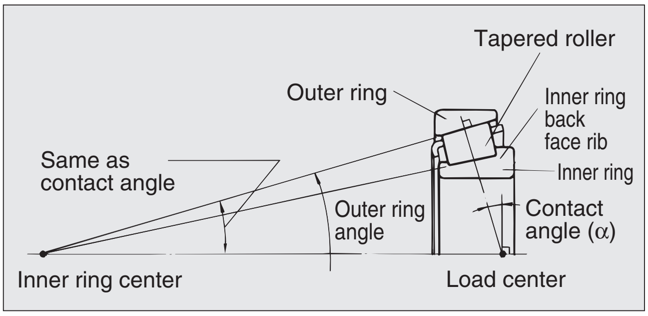


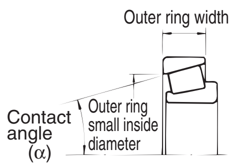
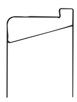
Fig. 4. 1 Structure of tapered roller bearing

Since the single row tapered roller bearing can receive only a unidirectional axial load, a pair of single row bearings are mounted apart and facing each other, or they are often used in a face-to-face or back-to-back arrangement.

4. 1 Types and features of tapered roller bearings

Two types of tapered roller bearings are available for machine tools: the single row tapered roller bearing (auxiliary symbol: JR) and the tapered roller bearing with flanged outer ring (auxiliary symbol: B) (see **Table 4. 1**).

Table 4. 1 Types and features of tapered roller bearings for machine tools

Types	Features
Tapered roller bearing with J designation  ISO sub-unit specifications	Bearings whose basic numbers are followed by "J" are made to the ISO sub-unit specifications. Consequently, inner ring assembles and outer rings, if given the same bearing number, are interchangeable on an international level. Reference: The symbol R denotes high load capacity bearings.
Tapered roller bearing with flanged outer ring 	This bearing allows easy positioning in axial direction using a simple housing structure.

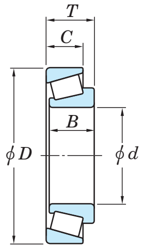
4. 2 Composition of bearing numbers (metric series tapered roller bearings)

3 02 15 J R B P5

- **Tapered roller bearing** (3)
- **Dimension series symbols** (02)
  - 29 : dimension series 29
  - 20 : dimension series 20
  - 02 : dimension series 02
  - 22 : dimension series 22
- **Bore diameter number** (15)
  - 15 : nominal bore diameter 75 mm
    (Bore diameter number × 5 equals nominal bore diameter.)
- **Designed to ISO sub-unit** (J)
- **High load capacity bearing** (R)
- **Outer ring shape symbols** (B)
  - B : flanged outer ring
  - No specified : standard type
- **Tolerance class symbols** (P5)
  - P5 : JIS class 5
  - P4 : JIS class 4

4. 3　Tolerance of tapered roller bearings

The tolerance of the tapered roller bearing is compliant with permissible dimensional deviations and limits of classes 5 and 4 as specified in JIS B 1514 for tapered roller bearings.
Permissible dimensional deviations and limits to tapered roller bearings are shown in **Table 4. 2**.



d : nominal bore diameter
D : nominal outside diameter
B : nominal inner ring width
C : nominal outer ring width
T : nominal bearing width

Table 4. 2 Permissible dimensional deviations and limits to metric tapered roller bearings

(1)　Inner ring

Unit : μm

Nominal bore diameter d (mm)		Single plane mean bore diameter deviation Δ_{dmp}				Single bore diameter deviation Δ_{ds}		Single plane bore diameter variation V_{dsp}		Mean bore diameter variation V_{dmp}	
		Class 5		Class 4		Class 4		Class 5	Class 4	Class 5	Class 4
over	up to	upper	lower	upper	lower	upper	lower	max.		max.	
10	**18**	0	– 7	0	– 5	0	– 5	5	4	5	4
18	**30**	0	– 8	0	– 6	0	– 6	6	5	5	4
30	**50**	0	–10	0	– 8	0	– 8	8	6	5	5
50	**80**	0	–12	0	– 9	0	– 9	9	7	6	5
80	**120**	0	–15	0	–10	0	–10	11	8	8	5
120	**180**	0	–18	0	–13	0	–13	14	10	9	7

Nominal bore diameter d (mm)		Radial runout of assembled bearing inner ring K_{ia}		Face runout with bore S_d		Assembled bearing inner ring back face runout with raceway S_{ia}	Single inner ring width deviation Δ_{Bs}		Actual bearing width deviation Δ_{Ts}	
		Class 5	Class 4	Class 5	Class 4	Class 4	Classes 5, 4		Classes 5, 4	
over	up to	max.		max.		max.	upper	lower	upper	lower
10	**18**	5	3	7	3	3	0	–200	+200	–200
18	**30**	5	3	8	4	4	0	–200	+200	–200
30	**50**	6	4	8	4	4	0	–240	+200	–200
50	**80**	7	4	8	5	4	0	–300	+200	–200
80	**120**	8	5	9	5	5	0	–400	+200	–200
120	**180**	11	6	10	6	7	0	–500	+350	–250

(2)　Outer ring

Unit : μm

Nominal outside diameter D (mm)		Single plane mean outside diameter deviation Δ_{Dmp}				Single outside diameter deviation Δ_{Ds}		Single radial plane outside diameter variation V_{Dsp}		Mean outside diameter variation V_{Dmp}		Radial runout of assembled bearing outer ring K_{ea}		Variation of outside surface generatrix inclination with face S_D		Assembled bearing outer ring back face runout with raceway S_{ea}	Single outer ring width deviation Δ_{Cs}	
		Class 5		Class 4		Class 4		Class 5	Class 4	Class 5	Class 4	Class 5	Class 4	Class 5	Class 4	Class 4	Classes 5, 4	
over	up to	upper	lower	upper	lower	upper	lower	max.		max.		max.		max.		max.	upper	lower
18	**30**	0	– 8	0	– 6	0	– 6	6	5	5	4	6	4	8	4	5	Same as tolerance Δ_{Bs}, d being that of the same bearing.	
30	**50**	0	– 9	0	– 7	0	– 7	7	5	5	5	7	5	8	4	5		
50	**80**	0	–11	0	– 9	0	– 9	8	7	6	5	8	5	8	4	5		
80	**120**	0	–13	0	–10	0	–10	10	8	7	5	10	6	9	5	6		
120	**150**	0	–15	0	–11	0	–11	11	8	8	6	11	7	10	5	7		
150	**180**	0	–18	0	–13	0	–13	14	10	9	7	13	8	10	5	8		
180	**250**	0	–20	0	–15	0	–15	15	11	10	8	15	10	11	7	10		
250	**315**	0	–25	0	–18	0	–18	19	14	13	9	18	11	13	8	10		

4. 4 Axial load and displacement (tapered roller bearings)

Fig 4. 2 shows relationships between axial load and displacement of **KOYO** tapered roller bearings.

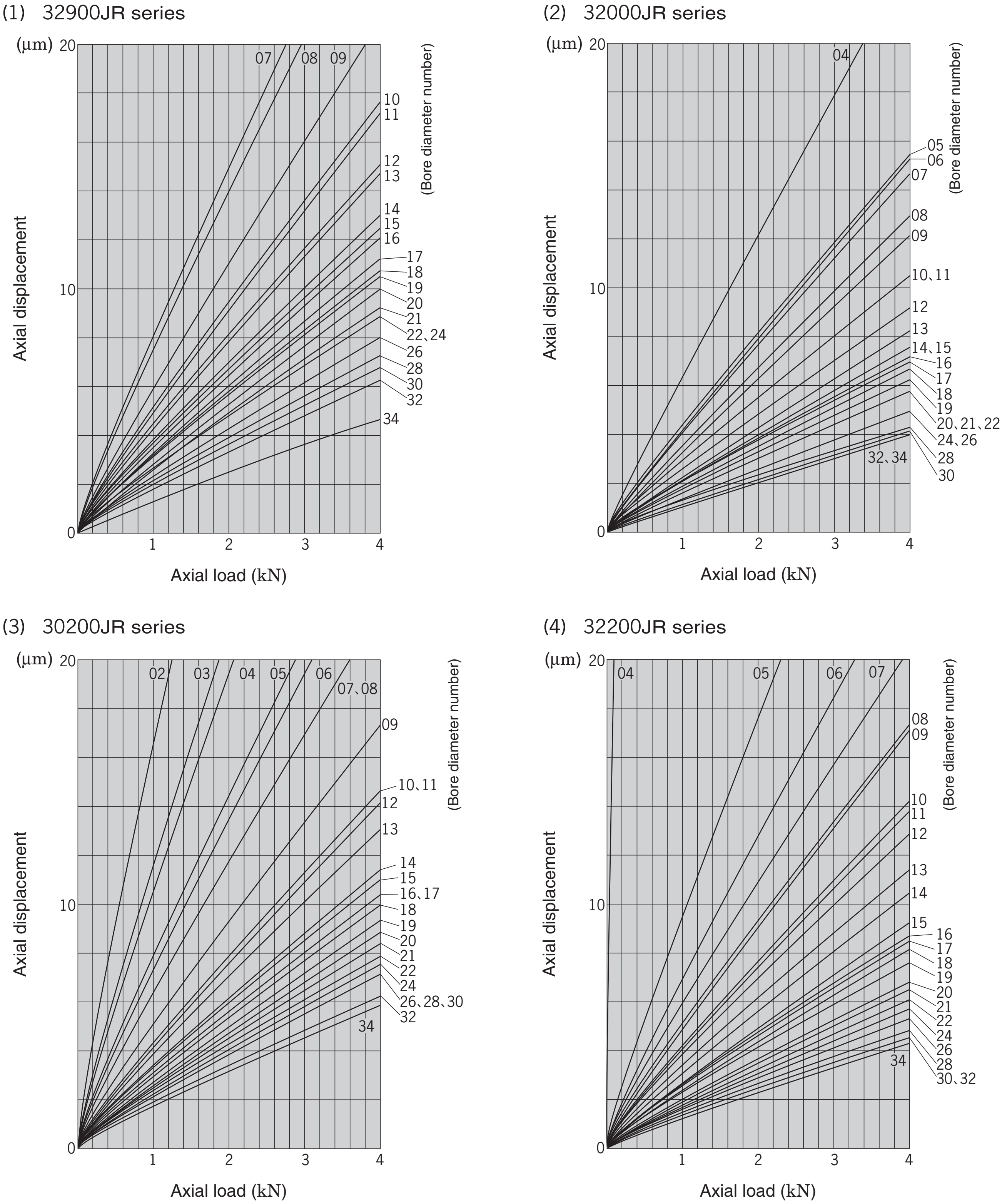
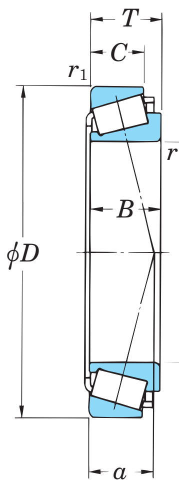


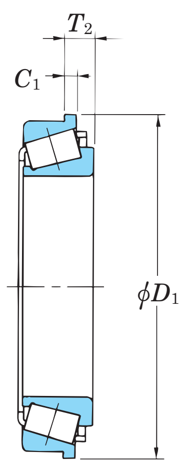
Fig. 4. 2 Relationships between axial load and displacement (tapered roller bearings)

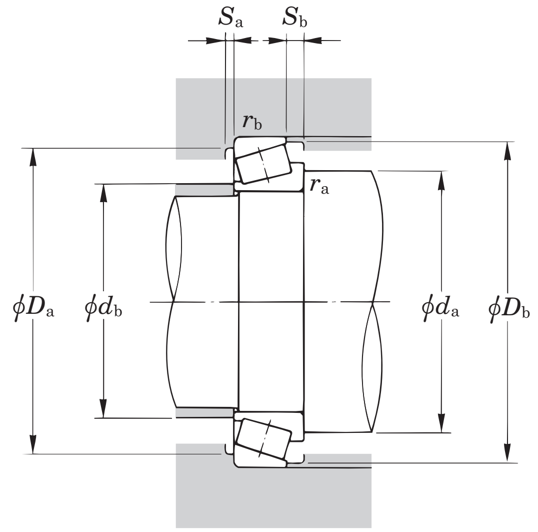
*The axial displacements shown above are values of the single-row bearings not preloaded.

32000JR



32000JRB





Dynamic equivalent load $P=XF_r+YF_a$

$\frac{F_a}{F_r} \leq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	0	0.4	Y_1

Static equivalent load $P_0=0.5F_r+Y_0F_a$

Note that if $P_0<F_r$, it is assumed that $P_0=F_r$.

For e, Y_1, and Y_0, use values given in the table.

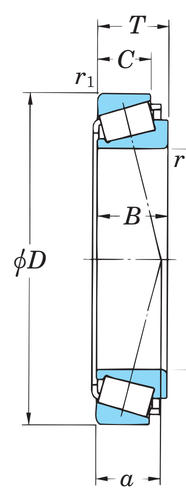
d 17 ~ 55

Boundary dimensions (mm)							Bearing No. [1]	Basic load ratings (kN)		Fatigue load limit (kN)	Limiting speeds (min⁻¹)		Load center (mm)	Flange dimensions (mm)			Mounting dimensions (mm)									Constant	Axial load coefficients		(Refer.) Mass (kg)
d	D	T	B	C	r min.	r_1 min.		C_r	C_{0r}	C_u	Grease lub.	Oil lub.	a	D_1	C_1	T_2	d_a min.	d_b max.	D_a max.	D_a min.	D_b max.	S_a min.	S_b min.	r_a max.	r_b max.	e	Y_1	Y_0	
17	40	13.25	12	11	1	1	**30203JR**	26.0	20.7	2.85	10 000	14 000	10.1	44	3	5.25	22.5	23	34.5	33	37	2	2	1	1	0.35	1.74	0.96	0.081
20	42	15	15	12	0.6	0.6	**32004JR**	34.1	31.5	4.35	9 700	13 000	10.5	46	3	6	24.5	25	37.5	35	39	3	3	0.6	0.6	0.37	1.6	0.88	0.102
	47	15.25	14	12	1	1	**30204JR**	33.8	27.2	3.80	8 700	12 000	11.8	51	3	6.25	25.5	27	41.5	39	44	2	3	1	1	0.35	1.74	0.96	0.127
	47	19.25	18	15	1	1	**32204JR**	41.4	34.7	4.90	8 900	12 000	12.5	51	3	7.25	25.5	27	41.5	39	43	2	4	1	1	0.33	1.81	1	0.159
25	47	15	15	11.5	0.6	0.6	**32005JR**	37.8	37.7	5.20	8 300	11 000	11.8	51	3	6.5	29.5	30	42.5	40	44	3	3.5	0.6	0.6	0.43	1.39	0.77	0.118
	52	16.25	15	13	1	1	**30205JR**	39.3	33.7	4.75	7 800	10 000	12.9	57	3.5	6.75	30.5	31	46.5	44	48	2	3	1	1	0.37	1.6	0.88	0.156
	52	19.25	18	16	1	1	**32205JR**	49.7	44.8	6.35	7 900	11 000	13.5	57	3.5	6.75	30.5	31	46.5	43	48	2	4	1	1	0.36	1.67	0.92	0.188
30	55	17	17	13	1	1	**32006JR**	47.9	48.0	6.75	7 000	9 400	13.6	59	3	7	35.5	35	49.5	47	52	3	4	1	1	0.43	1.39	0.77	0.177
	62	17.25	16	14	1	1	**30206JR**	51.8	44.8	6.45	6 500	8 700	14.1	67	3.5	6.75	35.5	37	56.5	53	57	2	3	1	1	0.37	1.6	0.88	0.236
	62	21.25	20	17	1	1	**32206JR**	63.3	57.9	8.40	6 500	8 700	15.9	67	4	8.25	35.5	37	56.5	52	58	2	4	1	1	0.37	1.6	0.88	0.292
35	55	14	14	11.5	0.6	0.6	**32907JR-2**	32.8	36.5	5.10	6 600	8 800	10.9	59	3	5.5	39.5	40	50.5	49	52	2.5	2.5	0.6	0.6	0.29	2.06	1.13	0.120
	62	18	18	14	1	1	**32007JR**	57.0	59.4	8.40	6 200	8 200	15.1	66	3	7	40.5	40	56.5	54	59	4	4	1	1	0.45	1.32	0.73	0.231
	72	18.25	17	15	1.5	1.5	**30207JR**	68.8	60.9	8.95	5 600	7 400	15.3	77	4	7.25	43.5	44	63.5	62	67	3	3	1.5	1.5	0.37	1.6	0.88	0.344
	72	24.25	23	19	1.5	1.5	**32207JR**	86.9	82.4	12.2	5 600	7 500	18.2	77	4.5	9.75	43.5	43	63.5	61	67	3	5	1.5	1.5	0.37	1.6	0.88	0.453
40	62	15	15	12	0.6	0.6	**32908JR**	42.1	48.5	6.90	5 900	7 800	11.9	66	3	6	44.5	45	57.5	55	59	3	3	0.6	0.6	0.29	2.07	1.14	0.164
	68	19	19	14.5	1	1	**32008JR**	67.2	71.4	10.3	5 600	7 400	15.1	72	3.5	8	45.5	46	62.5	60	65	4	4.5	1	1	0.38	1.58	0.87	0.282
	80	19.75	18	16	1.5	1.5	**30208JR**	78.4	69.2	10.3	5 000	6 700	17	85	4	7.75	48.5	49	71.5	69	75	3	3.5	1.5	1.5	0.37	1.6	0.88	0.434
	80	24.75	23	19	1.5	1.5	**32208JR**	97.0	90.8	13.6	5 000	6 600	19.4	85	4.5	10.25	48.5	48	71.5	68	75	3	5.5	1.5	1.5	0.37	1.6	0.88	0.554
45	68	15	15	12	0.6	0.6	**32909JR**	43.5	52.4	7.45	5 300	7 100	12.5	73	3	6	49.5	50	63.5	61	64	3	3	0.6	0.6	0.32	1.88	1.04	0.190
	75	20	20	15.5	1	1	**32009JR**	78.8	86.5	12.6	5 000	6 600	16.5	79	3.5	8	50.5	51	69.5	67	72	4	4.5	1	1	0.39	1.53	0.84	0.354
	85	20.75	19	16	1.5	1.5	**30209JR**	83.9	77.4	11.6	4 600	6 100	18.9	90	4	8.75	53.5	54	76.5	74	80	3	4.5	1.5	1.5	0.4	1.48	0.81	0.502
	85	24.75	23	19	1.5	1.5	**32209JR-1**	105	104	15.6	4 600	6 100	20.3	90	4.5	10.25	53.5	53	76.5	73	81	3	5.5	1.5	1.5	0.4	1.48	0.81	0.597
50	72	15	15	12	0.6	0.6	**32910JR**	45.0	56.3	8.00	4 900	6 600	13.7	77	3	6	54.5	55	67.5	65	69	3	3	0.6	0.6	0.34	1.76	0.97	0.195
	80	20	20	15.5	1	1	**32010JR**	82.7	94.5	13.8	4 600	6 100	17.7	84	3.5	8	55.5	56	74.5	72	77	4	4.5	1	1	0.42	1.42	0.78	0.389
	90	21.75	20	17	1.5	1.5	**30210JR**	95.6	91.7	13.8	4 300	5 700	20.1	95	4	8.75	58.5	58	81.5	79	85	3	4.5	1.5	1.5	0.42	1.43	0.79	0.566
	90	24.75	23	19	1.5	1.5	**32210JR**	106	105	15.9	4 300	5 700	20.6	95	4.5	10.25	58.5	58	81.5	78	85	3	5.5	1.5	1.5	0.42	1.43	0.79	0.643
55	80	17	17	14	1	1	**32911JR**	55.8	73.3	10.6	4 400	5 900	14.5	85	3	6	61	61	74	72	76	3	3	1	1	0.31	1.94	1.07	0.285
	90	23	23	17.5	1.5	1.5	**32011JR**	106	121	18.2	4 100	5 500	19.8	94	4	9.5	63.5	63	81.5	81	86	4	5.5	1.5	1.5	0.41	1.48	0.81	0.569
	100	22.75	21	18	2	1.5	**30211JR**	118	113	17.3	3 900	5 200	20.7	106	4.5	9.25	65	64	90	88	94	4	4.5	2	1.5	0.4	1.48	0.81	0.732
	100	26.75	25	21	2	1.5	**32211JR-1**	134	133	20.5	3 900	5 200	23	106	5	10.75	65	63	90	87	95	4	5.5	2	1.5	0.4	1.48	0.81	0.863

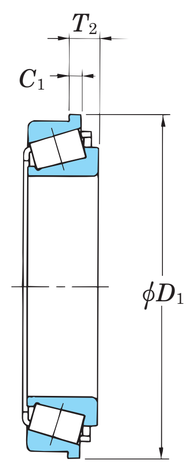
[Note] 1) The bearing number of a tapered roller bearing with a flanged outer ring contains the auxiliary symbol B.
Example 30203JRB

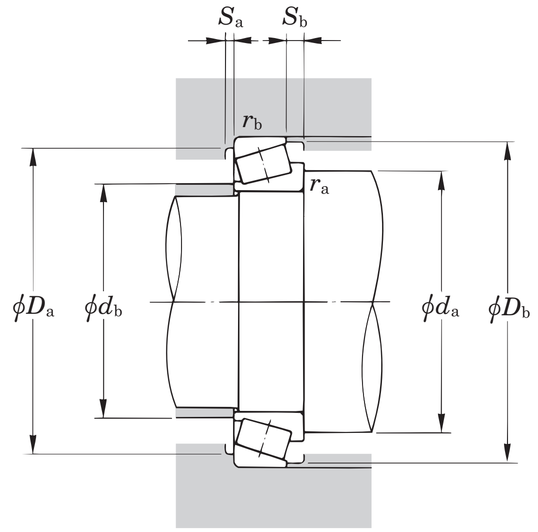
Koyo

32000JR



32000JRB





Dynamic equivalent load $P = XF_r + YF_a$

$\frac{F_a}{F_r} \leq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	0	0.4	Y_1

Static equivalent load $P_0 = 0.5F_r + Y_0F_a$

Note that if $P_0 < F_r$, it is assumed that $P_0 = F_r$.

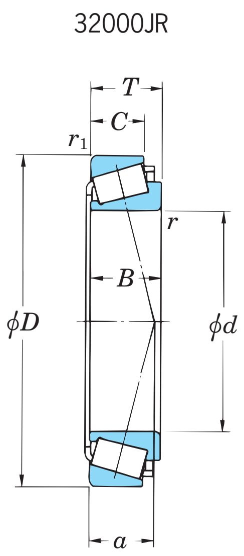
For e, Y_1, and Y_0, use values given in the table.

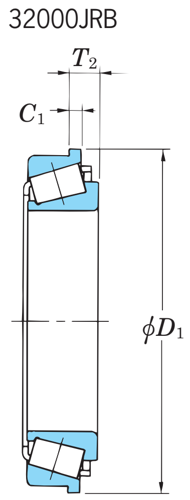
d 60 ~ (95)

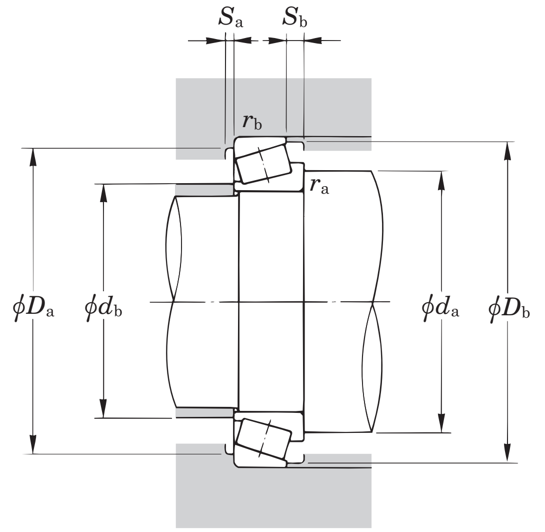
Boundary dimensions (mm)							Bearing No. 1)	Basic load ratings (kN)		Fatigue load limit (kN)	Limiting speeds (min⁻¹)		Load center (mm)	Flange dimensions (mm)			Mounting dimensions (mm)									Constant	Axial load coefficients		(Refer.) Mass (kg)
d	D	T	B	C	r min.	r_1 min.		C_r	C_{0r}	C_u	Grease lub.	Oil lub.	a	D_1	C_1	T_2	d_a min.	d_b max.	D_a max.	D_a min.	D_b max.	S_a min.	S_b min.	r_a max.	r_b max.	e	Y_1	Y_0	
60	85	17	17	14	1	1	**32912JR**	57.6	78.2	11.3	4 100	5 500	15.6	90	3	6	65.5	66	79.5	77	81	3	3	1	1	0.33	1.81	1	0.306
	95	23	23	17.5	1.5	1.5	**32012JR**	108	127	19.0	3 900	5 200	21	99	4	9.5	68.5	67	86.5	85	91	4	5.5	1.5	1.5	0.43	1.39	0.77	0.621
	110	23.75	22	19	2	1.5	**30212JR**	133	127	19.7	3 500	4 700	21.9	116	4.5	9.25	70	70	100	96	103	4	4.5	2	1.5	0.4	1.48	0.81	0.945
	110	29.75	28	24	2	1.5	**32212JR**	164	167	25.9	3 500	4 700	25.1	116	5	10.75	70	69	100	95	104	4	5.5	2	1.5	0.4	1.48	0.81	1.19
65	90	17	17	14	1	1	**32913JR**	59.2	83.1	12.0	3 900	5 200	16.8	95	3	6	70.5	70	84.5	81	86	3	3	1	1	0.35	1.7	0.93	0.327
	100	23	23	17.5	1.5	1.5	**32013JR**	113	137	20.6	3 600	4 800	22.5	104	4	9.5	73.5	72	91.5	90	97	4	5.5	1.5	1.5	0.46	1.31	0.72	0.664
	120	24.75	23	20	2	1.5	**30213JR**	160	156	24.3	3 200	4 300	24.2	127	4.5	9.25	75	77	110	106	113	4	4.5	2	1.5	0.4	1.48	0.81	1.18
	120	32.75	31	27	2	1.5	**32213JR**	196	203	31.7	3 200	4 300	26.6	127	6	11.75	75	76	110	104	115	4	5.5	2	1.5	0.4	1.48	0.81	1.58
70	100	20	20	16	1	1	**32914JR**	89.0	115	17.2	3 500	4 700	17.8	105	3	7	75.5	77	94.5	91	96	4	4	1	1	0.32	1.9	1.05	0.496
	110	25	25	19	1.5	1.5	**32014JR**	136	163	24.8	3 300	4 400	23.6	116	4.5	10.5	78.5	78	101.5	98	105	5	6	1.5	1.5	0.43	1.38	0.76	0.884
	125	26.25	24	21	2	1.5	**30214JR**	173	173	27.1	3 100	4 100	25.9	132	5	10.25	80	81	116.5	110	118	4	5	2	1.5	0.42	1.43	0.79	1.32
	125	33.25	31	27	2	1.5	**32214JR**	212	225	35.2	3 100	4 100	29.2	132	6	12.25	80	80	116.5	108	119	4	6	2	1.5	0.42	1.43	0.79	1.71
75	105	20	20	16	1	1	**32915JR**	92.2	123	18.4	3 300	4 400	18.9	111	3	7	80.5	81	99.5	96	101	4	4	1	1	0.33	1.8	0.99	0.526
	115	25	25	19	1.5	1.5	**32015JR**	139	169	25.8	3 100	4 200	25.1	121	4.5	10.5	83.5	83	106.5	103	110	5	6	1.5	1.5	0.46	1.31	0.72	0.930
	130	27.25	25	22	2	1.5	**30215JR**	178	181	28.2	2 900	3 900	27.6	137	5	10.25	85	86	121.5	115	124	4	5	2	1.5	0.44	1.38	0.76	1.42
	130	33.25	31	27	2	1.5	**32215JR**	218	234	36.4	2 900	3 900	30.2	137	6	12.25	85	85	121.5	114	125	4	6	2	1.5	0.44	1.38	0.76	1.77
80	110	20	20	16	1	1	**32916JR**	95.1	131	19.5	3 100	4 200	20.1	116	3	7	85.5	86	104.5	101	106	4	4	1	1	0.35	1.71	0.94	0.556
	125	29	29	22	1.5	1.5	**32016JR**	185	225	34.6	2 900	3 900	26.7	131	5	12	88.5	89	116.5	112	120	6	7	1.5	1.5	0.42	1.42	0.78	1.32
	140	28.25	26	22	2.5	2	**30216JR**	202	202	31.2	2 700	3 600	28.6	147	5	11.25	92	91	130	124	132	4	6	2	2	0.42	1.43	0.79	1.72
	140	35.25	33	28	2.5	2	**32216JR**	253	271	41.5	2 700	3 600	31.7	147	6	13.25	92	90	130	122	134	4	7	2	2	0.42	1.43	0.79	2.17
85	120	23	23	18	1.5	1.5	**32917JR**	122	165	25.0	2 900	3 900	21.2	126	3	8	93.5	93	111.5	109	115	5	5	1.5	1.5	0.33	1.83	1.01	0.794
	130	29	29	22	1.5	1.5	**32017JR**	189	234	35.5	2 800	3 700	28	136	5	12	93.5	94	121.5	117	125	6	7	1.5	1.5	0.44	1.36	0.75	1.38
	150	30.5	28	24	2.5	2	**30217JR**	228	231	35.1	2 500	3 400	30.4	158	5	11.5	97	97	140	132	141	5	6.5	2	2	0.42	1.43	0.79	2.17
	150	38.5	36	30	2.5	2	**32217JR**	290	315	47.5	2 500	3 400	34.2	158	7	15.5	97	96	140	130	142	5	8.5	2	2	0.42	1.43	0.79	2.80
90	125	23	23	18	1.5	1.5	**32918JR**	126	175	26.2	2 800	3 700	22.3	131	3	8	98.5	97	116.5	114	120	5	5	1.5	1.5	0.34	1.75	0.96	0.834
	140	32	32	24	2	1.5	**32018JR**	224	276	41.5	2 600	3 500	29.8	146	5.5	13.5	100	100	131.5	125	134	6	8	2	1.5	0.42	1.42	0.78	1.80
	160	32.5	30	26	2.5	2	**30218JR**	255	261	39.0	2 400	3 200	32.6	168	6	12.5	102	103	150	140	150	5	6.5	2	2	0.42	1.43	0.79	2.65
	160	42.5	40	34	2.5	2	**32218JR**	329	362	53.7	2 400	3 200	37	168	8	16.5	102	102	150	138	152	5	8.5	2	2	0.42	1.43	0.79	3.47
95	130	23	23	18	1.5	1.5	**32919JR**	130	186	27.4	2 600	3 500	23.5	133	3	8	103.5	102	121.5	119	125	5	5	1.5	1.5	0.36	1.68	0.92	0.876
	145	32	32	24	2	1.5	**32019JR**	229	287	42.6	2 500	3 300	31.2	151	5.5	13.5	105	105	136.5	130	140	6	8	2	1.5	0.44	1.36	0.75	1.88

[Note] 1) The bearing number of a tapered roller bearing with a flanged outer ring contains the auxiliary symbol B.
Example 32912JRB

Koyo







Dynamic equivalent load $P=XF_r+YF_a$

$\frac{F_a}{F_r} \leq e$		$\frac{F_a}{F_r} > e$	
X	Y	X	Y
1	0	0.4	Y_1

Static equivalent load $P_0=0.5F_r+Y_0F_a$

Note that if $P_0<F_r$, it is assumed that $P_0=F_r$.

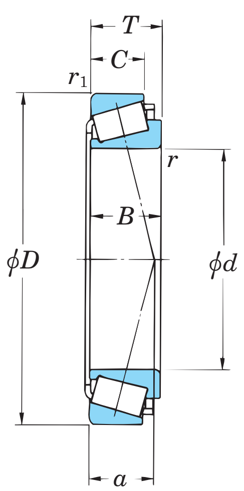
For e, Y_1, and Y_0, use values given in the table.

d (95) ~ 150

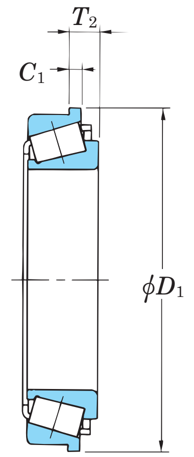
Boundary dimensions (mm)							Bearing No. [1]	Basic load ratings (kN)		Fatigue load limit (kN)	Limiting speeds (min^{-1})		Load center (mm)	Flange dimensions (mm)			Mounting dimensions (mm)									Constant	Axial load coefficients		(Refer.) Mass (kg)
d	D	T	B	C	r min.	r_1 min.		C_r	C_{0r}	C_u	Grease lub.	Oil lub.	a	D_1	C_1	T_2	d_a min.	d_b max.	D_a max.	D_a min.	D_b max.	S_a min.	S_b min.	r_a max.	r_b max.	e	Y_1	Y_0	
95	170	34.5	32	27	3	2.5	**30219JR**	289	299	44.0	2 200	3 000	34.9	179	6.5	14	109	110	158	149	159	5	7.5	2.5	2	0.42	1.43	0.79	3.20
	170	45.5	43	37	3	2.5	**32219JR**	389	439	64.1	2 200	3 000	38.9	179	8	16.5	109	108	158	145	161	5	8.5	2.5	2	0.42	1.43	0.79	4.34
100	140	25	25	20	1.5	1.5	**32920JR**	158	217	32.0	2 400	3 300	24	147	4	9	108.5	108	131.5	128	135	5	5	1.5	1.5	0.33	1.82	1	1.19
	150	32	32	24	2	1.5	**32020JR**	233	298	43.8	2 400	3 200	32.6	156	5.5	13.5	110	109	141.5	134	144	6	8	2	1.5	0.46	1.31	0.72	1.95
	180	37	34	29	3	2.5	**30220JR**	323	338	49.1	2 100	2 800	36.8	190	7	15	114	116	168	157	168	5	8	2.5	2	0.42	1.43	0.79	3.83
	180	49	46	39	3	2.5	**32220JR**	435	495	63.9	2 100	2 800	42.1	190	8	18	114	114	168	154	171	5	10	2.5	2	0.42	1.43	0.79	5.21
105	145	25	25	20	1.5	1.5	**32921JR**	160	224	32.6	2 400	3 100	25.1	152	4	9	113.5	113	136.5	133	140	5	5	1.5	1.5	0.34	1.75	0.96	1.23
	160	35	35	26	2.5	2	**32021JR**	270	344	49.9	2 200	3 000	34.5	168	6.5	15.5	117	116	150	143	154	6	9	2	2	0.44	1.35	0.74	2.45
	190	39	36	30	3	2.5	**30221JR**	360	380	52.3	2 000	2 600	39	200	7	16	119	122	178	165	178	6	9	2.5	2	0.42	1.43	0.79	4.49
	190	53	50	43	3	2.5	**32221JR**	490	567	73.0	2 000	2 700	44.8	200	9	19	119	120	178	161	180	6	10	2.5	2	0.42	1.43	0.79	6.37
110	150	25	25	20	1.5	1.5	**32922JR**	162	231	33.3	2 300	3 000	26.3	157	4	9	118.5	118	141.5	138	145	5	5	1.5	1.5	0.36	1.69	0.93	1.28
	170	38	38	29	2.5	2	**32022JR**	312	395	56.7	2 100	2 800	36.1	178	6.5	15.5	122	122	160	152	163	7	9	2	2	0.43	1.39	0.77	3.12
	200	41	38	32	3	2.5	**30222JR**	405	434	58.1	1 900	2 500	40.8	210	7	16	124	129	188	174	188	6	9	2.5	2	0.42	1.43	0.79	5.33
	200	56	53	46	3	2.5	**32222JR**	547	640	80.4	1 900	2 500	46.7	210	10	20	124	126	188	170	190	6	10	2.5	2	0.42	1.43	0.79	7.45
120	165	29	29	23	1.5	1.5	**32924JR**	215	298	42.5	2 100	2 700	29.4	172	5	11	128.5	128	156.5	152	160	6	6	1.5	1.5	0.35	1.72	0.95	1.77
	180	38	38	29	2.5	2	**32024JR**	325	427	60.0	2 000	2 600	38.8	188	6.5	15.5	132	131	170	161	173	7	9	2	2	0.46	1.31	0.72	3.34
	215	43.5	40	34	3	2.5	**30224JR**	435	473	61.7	1 700	2 300	44.2	225	8	17.5	134	140	203	187	203	6	9.5	2.5	2	0.44	1.38	0.76	6.36
	215	61.5	58	50	3	2.5	**32224JR**	589	691	84.0	1 700	2 300	51.6	225	11	22.5	134	136	203	181	204	7	11.5	2.5	2	0.44	1.38	0.76	9.04
130	180	32	32	25	2	1.5	**32926JR**	251	368	51.2	1 900	2 500	31.4	187	5	12	140	141	171.5	165	174	6	7	2	1.5	0.34	1.77	0.97	2.42
	200	45	45	34	2.5	2	**32026JR**	428	563	77.4	1 800	2 300	42.9	208	8	19	142	144	190	178	192	8	11	2	2	0.43	1.38	0.76	5.04
	230	43.75	40	34	4	3	**30226JR**	472	511	65.7	1 600	2 100	46.2	241	8	17.75	148	152	216	203	218	7	9.5	3	2.5	0.44	1.38	0.76	7.24
	230	67.75	64	54	4	3	**32226JR**	693	830	99.9	1 600	2 200	56	241	11	24.75	148	146	216	193	219	7	13.5	3	2.5	0.44	1.38	0.76	11.5
140	190	32	32	25	2	1.5	**32928JR**	258	390	53.2	1 800	2 300	33.6	197	5	12	150	150	181.5	174	184	6	7	2	1.5	0.36	1.67	0.92	2.57
	210	45	45	34	2.5	2	**32028JR**	435	585	79.2	1 700	2 200	45.6	218	8	19	152	153	200	187	202	8	11	2	2	0.46	1.31	0.72	5.28
	250	45.75	42	36	4	3	**30228JR**	526	570	71.8	1 500	1 900	49.4	261	9	18.75	158	163	236	219	237	9	9.5	3	2.5	0.44	1.38	0.76	8.97
	250	71.75	68	58	4	3	**32228JR**	796	961	112	1 500	2 000	60	261	12	25.75	158	158	236	210	238	9	13.5	3	2.5	0.44	1.38	0.76	14.7
150	210	38	38	30	2.5	2	**32930JR**	358	536	72.1	1 600	2 100	36.1	218	6	14	162	163	200	194	202	7	8	2	2	0.33	1.83	1.01	3.96
	225	48	48	36	3	2.5	**32030JR**	492	668	79.6	1 500	2 000	48.8	233	8.5	20.5	164	164	213	200	216	8	12	2.5	2	0.46	1.31	0.72	6.41
	270	49	45	38	4	3	**30230JR**	604	664	80.9	1 300	1 800	52.4	282	9	20	168	175	256	234	255	9	11	3	2.5	0.44	1.38	0.76	11.6
	270	77	73	60	4	3	**32230JR**	881	1070	122	1 300	1 800	65.2	282	12	29	168	170	256	226	254	8	17	3	2.5	0.44	1.38	0.76	18.2

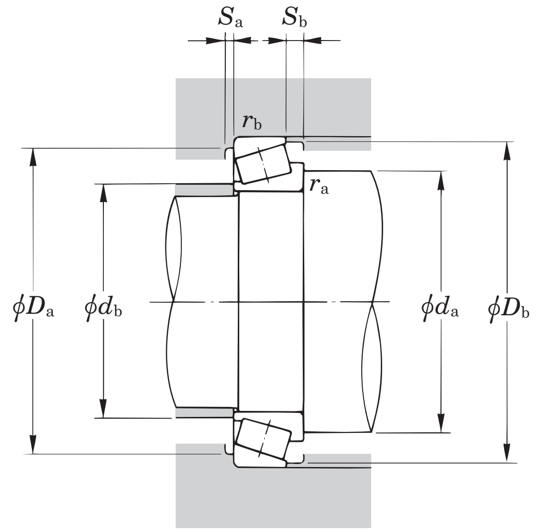
[Note] 1) The bearing number of a tapered roller bearing with a flanged outer ring contains the auxiliary symbol B.
Example 30219JRB

32000JR



32000JRB





Dynamic equivalent load $P=XF_r+YF_a$

$\frac{F_a}{F_r}\leq e$		$\frac{F_a}{F_r}>e$	
X	Y	X	Y
1	0	0.4	Y_1

Static equivalent load $P_0=0.5F_r+Y_0F_a$

Note that if $P_0<F_r$, it is assumed that $P_0=F_r$.

For e, Y_1, and Y_0, use values given in the table.

d 160 ~ 170

Boundary dimensions (mm)							Bearing No. [1]	Basic load ratings (kN)		Fatigue load limit (kN)	Limiting speeds (min⁻¹)		Load center (mm)	Flange dimensions (mm)			Mounting dimensions (mm)									Constant	Axial load coefficients		(Refer.) Mass (kg)
d	D	T	B	C	r min.	r_1 min.		C_r	C_{0r}	C_u	Grease lub.	Oil lub.	a	D_1	C_1	T_2	d_a min.	d_b max.	D_a max.	D_a min.	D_b max.	S_a min.	S_b min.	r_a max.	r_b max.	e	Y_1	Y_0	
160	220	38	38	30	2.5	2	**32932JR**	368	568	75.2	1 500	2 000	38.4	228	6	14	172	173	210	204	212	7	8	2	2	0.35	1.73	0.95	4.19
	240	51	51	38	3	2.5	**32032JR**	553	758	90.3	1 400	1 900	52.1	248	9	22	174	175	228	213	231	8	13	2.5	2	0.46	1.31	0.72	7.75
	290	52	48	40	4	3	**30232JR**	679	750	89.3	1 200	1 600	56.3	302	11	23	178	189	276	252	269	8	12	3	2.5	0.44	1.38	0.76	14.1
	290	84	80	67	4	3	**32232JR**	994	1210	137	1 200	1 700	70.3	304	14	31	178	182	276	242	274	10	17	3	2.5	0.44	1.38	0.76	23.2
170	230	38	38	30	2.5	2	**32934JR**	370	606	78.8	1 400	1 900	42	238	6	14	182	183	220	213	222	7	8	2	2	0.38	1.57	0.86	4.49
	260	57	57	43	3	2.5	**32034JR**	661	905	105	1 300	1 700	55.8	268	10	24	184	187	248	230	249	10	14	2.5	2	0.44	1.35	0.74	10.5
	310	57	52	43	5	4	**30234JR**	776	867	103	1 100	1 500	61.2	322	11	25	192	202	292	269	288	8	14	4	3	0.44	1.38	0.76	17.8
	310	91	86	71	5	4	**32234JR**	1120	1380	152	1 100	1 500	76.2	324	14	34	192	195	292	259	294	10	20	4	3	0.44	1.38	0.76	28.9

[Note] 1) The bearing number of a tapered roller bearing with a flanged outer ring contains the auxiliary symbol B.
Example 32932JRB

5. Support Bearings and Support Bearing Units for Precision Ball Screws

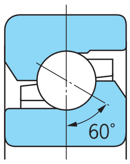
Contents

5. Support bearings and support bearing units for precision ball screws

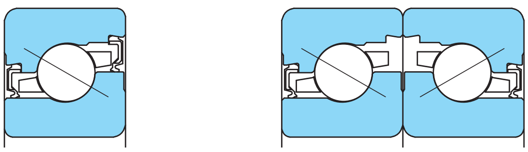
5. 1 Structure and features

Support bearings for precision ball screws

The SAC type support bearings are angular contact thrust ball bearings specifically for supporting the screw shafts of precision ball screws (see **Fig. 5. 1**).



The bearings supporting the precision ball screws correspond to the type with contact seal.
Consult **JTEKT** for details about the type with contact seal and the pair patterns.



Both-side sealed type   Matching example of one-side sealed type

Fig. 5. 1 Structure of support bearings for precision ball screws

These bearings have many, small-diameter balls and thick section inner and outer rings.
The contact angle of these bearings is 60° enabling a high axial load and a certain degree of radial load to be applied simultaneously.

1) Features of support bearings for precision ball screws

· High rigidity
Has higher rigidity against axial load than conventional standard bearings (see **Fig. 5. 2**).

· Compact and lightweight
Since this bearing eliminates the need for an additional radial bearing or thrust bearing, it allows a compact surrounding design, thereby contributing to a reduction in the weight of the total system.

· High precision
A high-precision bearing suitable for precision ball screws.

· Preload adjustments not required
Preload is preadjusted to ensure an adequate preload after mounting. As a result, complicated adjustments are not required during mounting.

· Low torque
Requires lower friction torque than the tapered roller bearing or thrust roller bearing.

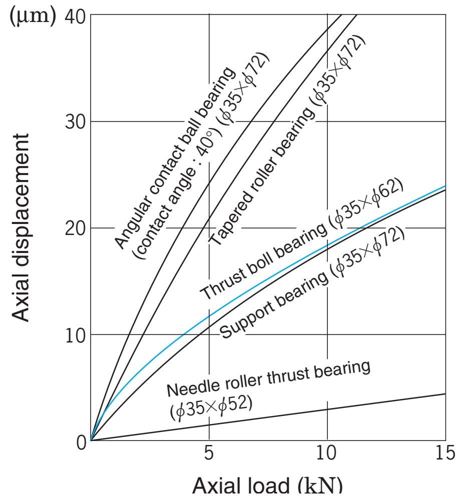
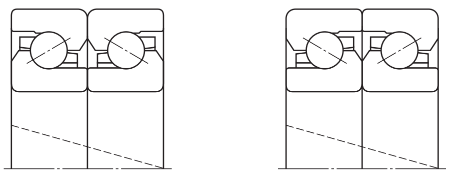
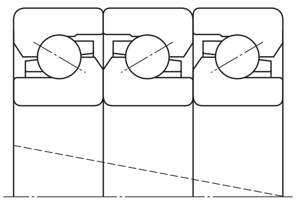
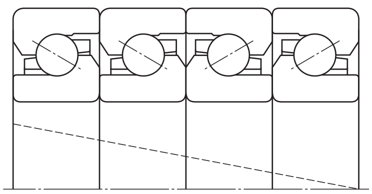


Fig. 5. 2 Relationship between axial load and displacement (comparison between support bearings and other bearings)

*The axial displacements shown above are values of the single-row bearings not preloaded.

2) Matched pair or stack support bearings

Table 5. 1 Types and suffixes of support bearings

	Type and suffix of support bearing
Combination of two	 Suffix DB Suffix DF
Combination of three	 Suffix DFD
Combination of four	 Suffix DFF

[Remarks] 1. A "V" mark is put on the outside surfaces of the outer rings of matched pair and stack bearings to indicate their combination type. For handling precautions of the type G bearing, refer to the bearing dimension table "**1. 2 Matched pair angular contact ball bearings.**"
2. Type G bearings are also manufactured, which enable any desired combinations. For descriptions of the type G bearing, refer to the bearing dimension table "**1. 2 Matched pair angular contact ball bearings.**"

Support bearing units for precision ball screws

The support bearing unit for precision ball screws is a unit product combining the SAC type support bearing and a housing machined to a high precision.

Std. series : BSU0000   T series : BSU0000-T

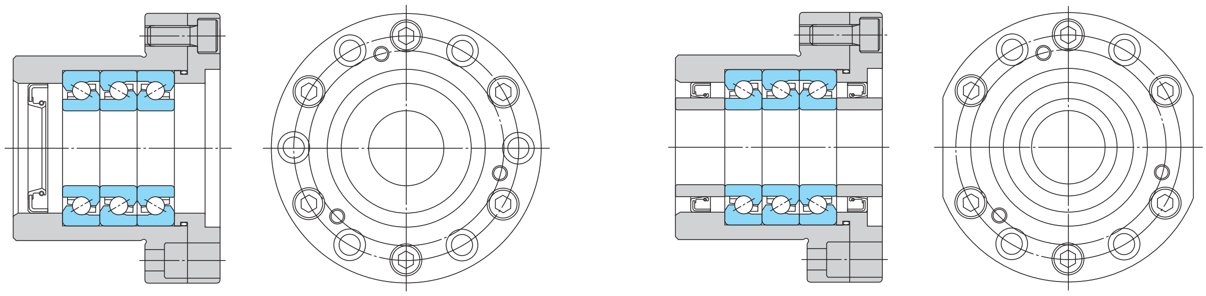
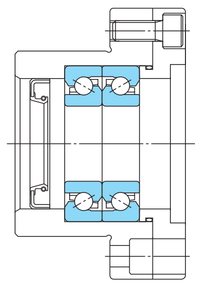
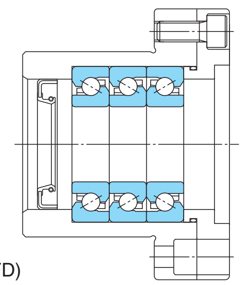
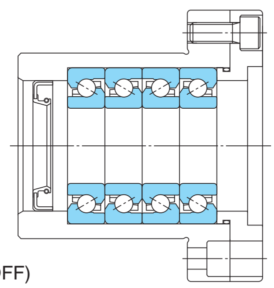


Fig. 5. 3 Series and structures of support bearing units for precision ball screws

1) Types of matched pair or stack bearing

Table 5. 2 Types of matched pair or stack bearing

	Type and symbol
Combination of two bearings	 (Suffix : DF)
Combination of three bearings	 (Suffix : DFD)
Combination of four bearings	 (Suffix : DFF)

2) Features of support bearing units for precision ball screws

· Simple mounting work

This is a unit product consisting of a bearing where the preload is adjusted and an adequate quantity of grease is sealed within the bearing, and is mounted in a compact housing.

Thus the support bearing unit can be easily mounted on a machine.

· Excellent dust-proof performance

Having a high-performance built in oil seal the support bearing unit, with low torque operation, is excellent in dust-proof performance.

· Capability of coping with any desired design

In addition to the standard products listed in the dimension tables, **JTEKT** manufactures support bearing units to meet the support structures of various ball screws.

Consult **JTEKT** for more information.

5. 2 Composition of identification numbers (support bearings and support bearing units for precision ball screws)

Support bearings for precision ball screws

S A C 2 0 4 7 B D B M G 4 Z

- **SAC** — **Support bearing for precision ball screws**
- **20** — **Nominal bore diameter**
  20 : 20 mm
- **47** — **Nominal outside diameter**
  47 : 47 mm
- **B** — **Internal design code**
- **DB** — **Matched pair or stack symbols**
  DB : back-to-back
  DF : face-to-face
  DFD : three bearings making up face-to-face + tandem
  DFF : four bearings making up face-to-face + tandem
- **MG** — **Cage symbols**
  MG : molded cage made of polyamide resin
- **4Z** — **Tolerance class symbols**
  4Z : **JTEKT** standards class 4 (Equivalent of JIS class 4)
  5Z : **JTEKT** standards class 5 (Equivalent of JIS class 5)

[Remark]
Amount of preload is standardized for each matched pair type.

Support bearing units for precision ball screws

B S U 3 0 6 2 B D F D –T

- **BSU** — **Support bearing unit for precision ball screws**
- **30** — **Nominal bore diameter**
  30 : 30 mm
- **62** — **Nominal outside diameter**
  62 : 62 mm
- **B** — **Internal design code**
- **DFD** — **Matched pair or stack symbols**
  DF : face-to-face
  DFD : three bearings making up face-to-face + tandem
  DFF : four bearings making up face-to-face + tandem
- **–T** — **Series code**
  no code : std. series
  –T : T series

5. 3 Tolerance of support bearings for precision ball screws

The support bearings for precision ball screws are manufactured to specific **JTEKT** standards suitable for the requirements of precision ball screws (see **Table 5. 3**).

Table 5. 3 Permissible dimensional deviations and limits of support bearings for precision ball screws

(1) Inner ring

Unit : μm

Nominal bore diameter d (mm)		Single plane mean bore diameter deviation Δ_{dmp}				Single bore diameter deviation Δ_{ds}				Single inner ring width deviation Δ_{Bs}		Inner ring width variation V_{Bs}		K_{ia}		Perpendicularity of inner ring face with respect to the bore S_d		S_{ia}	
		Class 5Z		Class 4Z		Class 5Z		Class 4Z		Classes 5Z, 4Z		Class 5Z	Class 4Z	Class 5Z	Class 4Z	Class 5Z	Class 4Z	Class 5Z	Class 4Z
over	up to	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	max.		max.		max.		max.	
10	**18**	0	− 5	0	− 4	0	− 5	0	− 4	0	− 80	5	2.5	4	2.5	7	3	5	3
18	**30**	0	− 6	0	− 5	0	− 6	0	− 5	0	− 120	5	2.5	4	3	8	4	5	3
30	**50**	0	− 8	0	− 6	0	− 8	0	− 6	0	− 120	5	3	5	4	8	4	6	3
50	**80**	0	− 9	0	− 7	0	− 9	0	− 7	0	− 150	6	4	5	4	8	5	7	4

K_{ia} : Radial runout of assembled bearing inner ring
S_{ia} : Axial runout of assembled bearing inner ring

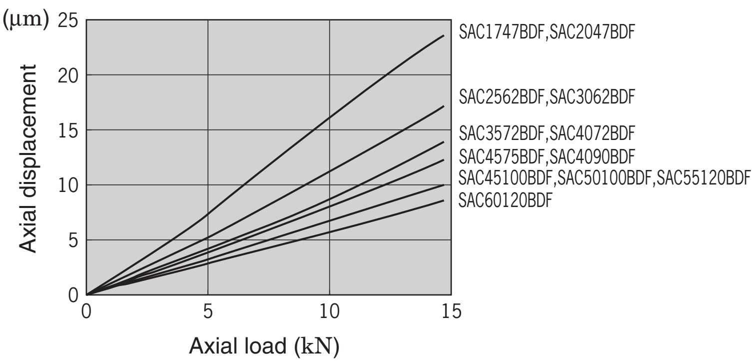
(2) Outer ring

Unit : μm

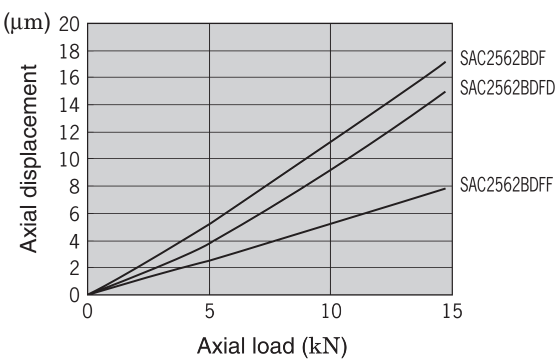
Nominal outside diameter D (mm)		Single plane mean outside diameter deviation Δ_{Dmp}				Single outside diameter deviation Δ_{Ds}				Deviation of a single outer ring width Δ_{Cs}		Ring width variation V_{Cs}		K_{ea}		S_D		S_{ea}	
		Class 5Z		Class 4Z		Class 5Z		Class 4Z		Classes 5Z, 4Z		Class 5Z	Class 4Z	Class 5Z	Class 4Z	Class 5Z	Class 4Z	Class 5Z	Class 4Z
over	up to	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	max.		max.		max.		max.	
30	**50**	0	− 7	0	− 6	0	− 7	0	− 6	Same as tolerance Δ_{Bs}, d being that of the same bearing.		5	2.5	7	5	8	4	Same as tolerance S_{ia}, d being that of the same bearing.	
50	**80**	0	− 9	0	− 7	0	− 9	0	− 7			6	3	8	5	8	4		
80	**120**	0	− 10	0	− 8	0	− 10	0	− 8			8	4	10	6	9	5		

K_{ea} : Radial runout of assembled bearing outer ring
S_D : Perpendicularity of outer ring surface with respect to the face
S_{ea} : Axial runout of assembled bearing outer ring

5. 4 Axial load and displacement (support bearings for precision ball screws)



(Matched pair, standard preload)

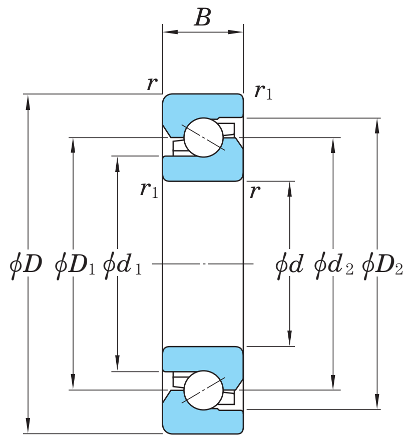


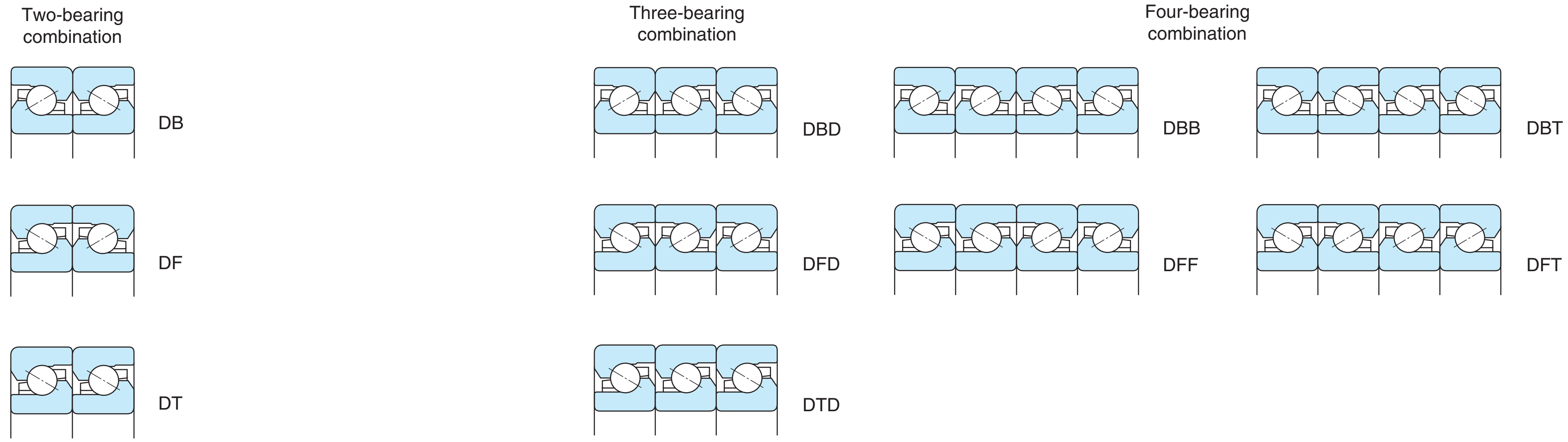
(Comparison of number of bearing rows)

Fig. 5. 4 Relationship between axial load and displacement (support bearings for precision ball screws)

SAC0000B, SAC00000B series

Contact angle 60°





Boundary dimensions (mm)					Basic dynamic load rating[1)] (kN)	Max. axial loads (kN)			Limiting speeds (min^{-1})		Bearing[2)] No.	Interspace volume (cm^3/row)	Dimensions (mm)				Standard preloads (kN)			Starting torques (mN·m)			Axial spring constants (N/μm)			(Refer.) Mass (kg/row)
d	D	B	r min.	r_1 min.	C_a	Single row	Double row	Triple row	Grease lub.	Oil lub.			d_1	d_2	D_1	D_2	Two bearings	Three bearings	Four bearings	Two bearings	Three bearings	Four bearings	Two bearings	Three bearings	Four bearings	
17	47	15	1	0.6	32.5	34.3	68.6	103	6 300	8 000	**SAC1747B**	3.7	25.5	33.7	33.5	41	2.15	2.92	4.3	140	180	280	695	1 030	1 390	0.130
20	47	15	1	0.6	32.5	34.3	68.6	103	6 300	8 000	**SAC2047B**	3.7	26.8	33.7	33.5	41	2.15	2.92	4.3	140	180	280	695	1 030	1 390	0.120
25	62	15	1	0.6	37.8	48.1	96.2	144	4 600	6 000	**SAC2562B**	4.9	38	46.2	46	53.5	3.04	4.13	6.08	200	260	400	970	1 440	1 940	0.240
30	62	15	1	0.6	37.8	48.1	96.2	144	4 600	6 000	**SAC3062B**	4.9	38	46.2	46	53.5	3.04	4.13	6.08	200	260	400	970	1 440	1 940	0.210
35	72	15	1	0.6	41.0	58.8	118	176	3 700	5 000	**SAC3572B**	6.2	48	56.3	55.9	63.5	3.73	5.07	7.46	240	320	480	1 180	1 760	2 360	0.290
40	72	15	1	0.6	41.0	58.8	118	176	3 700	4 800	**SAC4072B**	6.2	48	56.3	55.9	63.5	3.73	5.07	7.46	240	320	480	1 180	1 760	2 360	0.260
	90	20	1	0.6	81.8	122	244	366	3 100	4 000	**SAC4090B**	15	54.5	67.5	66.8	78.5	5	6.8	10	440	610	880	1 270	1 890	2 540	0.620
45	75	15	1	0.6	42.5	64.4	129	193	3 400	4 300	**SAC4575B**	6.9	54	61.7	61.5	69	3.89	5.29	7.78	250	330	500	1 270	1 890	2 540	0.250
	100	20	1	0.6	86.0	137	274	411	2 800	3 600	**SAC45100B**	16	61.5	74.2	74	85.5	5.95	8.09	11.9	540	730	1 080	1 450	2 150	2 900	0.790
50	100	20	1	0.6	87.9	144	288	432	2 700	3 400	**SAC50100B**	17	65.8	78.2	78	89.5	6	8.15	12	540	730	1 080	1 500	2 230	3 000	0.650
55	100	20	1	0.6	87.9	144	288	432	2 700	3 400	**SAC55100B**	17	65.8	78.2	78	89.5	6	8.15	12	540	730	1 080	1 500	2 230	3 000	0.650
	120	20	1	0.6	92.4	166	332	498	2 300	3 000	**SAC55120B**	20	79.5	92.2	92	103.6	7.08	9.62	14.2	640	860	1 280	1 740	2 590	3 480	1.15
60	120	20	1	0.6	92.4	166	332	498	2 300	3 000	**SAC60120B**	20	78.3	92.2	92	103.6	7.08	9.62	14.2	640	860	1 280	1 740	2 590	3 480	1.15

[Notes] 1) The value of the basic dynamic load rating of a single bearing is shown. For those of matched pair and stack bearings, see table below.
2) The identification of a matched bearing is composed of the bearing number of a single row bearing followed by the suffix (DB, DF, etc.).

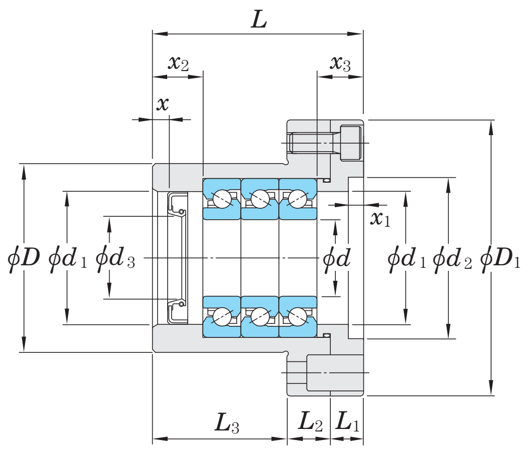
[Remarks] 1. We recommend a nut axial tension of two to three times the bearing preload.
2. We recommend a retaining plate holding allowance of 0.01 to 0.03 mm.

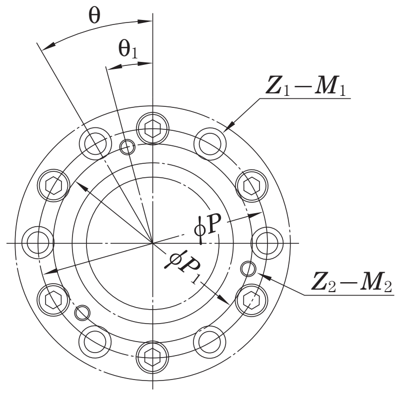
Number of rows to receive axial load	Basic dynamic load rating	Sample combination (arrow indicates direction of load.)			
Single row	C_a	→ DB	→ DF	→ DBD	DFD ←
Double row	C_a×1.625	DT ←	DBD ← →	DFD	→ DFF
Triple row	C_a×2.16	DTD ←	DBT ←	→ DFT	

Dynamic equivalent load $P_a = XF_r + YF_a$

Sample combination		Two bearings		Three bearings			Four bearings		
		DB DF	DT	DBD DFD		DTD	DBT DFT	DBB DFF	DBT DFT
Number of rows to receive axial load		Single row	Double row	Single row	Double row	Triple row	Single row	Double row	Triple row
$\frac{F_a}{F_r} \leq 2.17$	X	1.9	—	1.43	2.33	—	1.17	2.33	2.53
	Y	0.54	—	0.77	0.35	—	0.89	0.35	0.26
$\frac{F_a}{F_r} > 2.17$	X	0.92							
	Y	1							

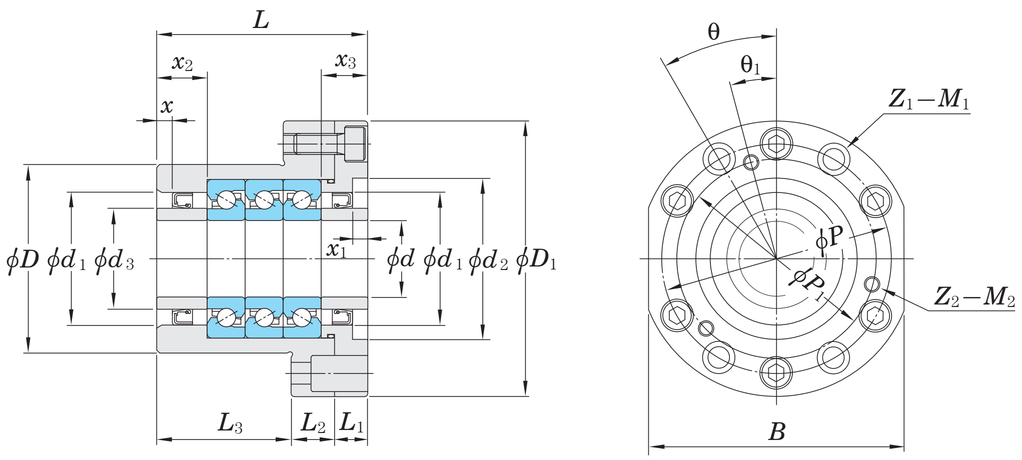
BSU0000BDF(DFD, DFF) series





Dimensions (mm) d	D	D_1	L	L_1	L_2	L_3	d_1	d_2	x	x_1	x_2	x_3	Applicable shaft dia. d_3 (mm)	Unit identification number	Quantity of bearing	Mounting hole of housing P (mm)	θ (°)	Z_1-M_1 (No. of holes–threads)	Tapped hole for Dust-proof cover/Damper P_1 (mm)	θ_1 (°)	Z_2-M_2 (No. of holes–threads)	Standard preload (kN)	Starting torque (mN·m)	(Refer.) Mass (kg)
17	60	90	65	15	15	35	38	47	6	6	15	20	28	**BSU1747BDF**	2	75	45	4-M6	75	22.5	4-M6	2.15	140	1.72
20	60	90	65	15	15	35	38	47	6	6	15	20	28	**BSU2047BDF**	2	75	45	4-M6	75	22.5	4-M6	2.15	140	1.70
25	74	108	68	13	17	38	52	63	6	6	20	18	32	**BSU2562BDF**	2	90	30	6-M8	78	15	3-M6	3.04	200	2.45
	74	108	83	13	17	53	52	63	6	6	20	18	32	**BSU2562BDFD**	3	90	30	6-M8	78	15	3-M6	4.13	260	2.85
30	74	108	68	13	17	38	52	63	6	6	20	18	40	**BSU3062BDF**	2	90	30	6-M8	78	15	3-M6	3.04	200	2.38
	74	108	83	13	17	53	52	63	6	6	20	18	40	**BSU3062BDFD**	3	90	30	6-M8	78	15	3-M6	4.13	260	2.74
35	84	118	68	13	17	38	60	73	6	6	20	18	45	**BSU3572BDF**	2	100	30	6-M8	88	15	3-M6	3.73	240	2.81
	84	118	83	13	17	53	60	73	6	6	20	18	45	**BSU3572BDFD**	3	100	30	6-M8	88	15	3-M6	5.07	320	3.28
	84	118	98	13	17	68	60	73	6	6	20	18	45	**BSU3572BDFF**	4	100	30	6-M8	88	15	3-M6	7.46	480	3.74
40	84	118	68	13	17	38	60	73	6	6	20	18	50	**BSU4072BDF**	2	100	30	6-M8	88	15	3-M6	3.73	240	2.77
	84	118	83	13	17	53	60	73	6	6	20	18	50	**BSU4072BDFD**	3	100	30	6-M8	88	15	3-M6	5.07	320	3.20
	84	118	98	13	17	68	60	73	6	6	20	18	50	**BSU4072BDFF**	4	100	30	6-M8	88	15	3-M6	7.46	480	3.64

BSU0000BDF(DFD, DFF) - T series



Dimensions (mm) d	D	D_1	B	L	L_1	L_2	L_3	d_1	d_2	d_3	x	x_1	x_2	x_3	Unit identification number	Quantity of bearing	Mounting hole of housing P (mm)	θ (°)	Z_1−M_1 (No. of holes−threads)	Tapped hole for Dust-proof cover/Damper P_1 (mm)	θ_1 (°)	Z_2−M_2 (No. of holes−threads)	Standard preload (kN)	Starting torque (mN·m)	(Refer.) Mass (kg)
17	60	90	80	65	15	15	35	38	47	28	6	6	15	20	**BSU1747BDF - T**	2	75	22.5	6-M6	57	10	4-M6	2.15	140	1.36
20	60	90	80	65	15	15	35	38	47	28	6	6	15	20	**BSU2047BDF - T**	2	75	22.5	6-M6	57	10	4-M6	2.15	140	1.32
25	74	108	100	68	13	17	38	52	63	32	6	6	20	18	**BSU2562BDF - T**	2	90	30	4-M8	78	15	3-M6	3.04	200	1.46
	74	108	100	83	13	17	53	52	63	32	6	6	20	18	**BSU2562BDFD - T**	3	90	30	4-M8	78	15	3-M6	4.13	260	2.44
30	74	108	100	68	13	17	38	52	63	40	6	6	20	18	**BSU3062BDF - T**	2	90	30	4-M8	78	15	3-M6	3.04	200	1.40
	74	108	100	83	13	17	53	52	63	40	6	6	20	18	**BSU3062BDFD - T**	3	90	30	4-M8	78	15	3-M6	4.13	260	2.47
35	84	118	105	68	13	17	38	60	73	45	6	6	20	18	**BSU3572BDF - T**	2	100	30	4-M8	88	15	3-M6	3.73	240	1.29
	84	118	105	83	13	17	53	60	73	45	6	6	20	18	**BSU3572BDFD - T**	3	100	30	4-M8	88	15	3-M6	5.07	320	2.68
	84	118	105	98	13	17	68	60	73	45	6	6	20	18	**BSU3572BDFF - T**	4	100	30	4-M8	88	15	3-M6	7.46	480	3.62
40	84	118	105	68	13	17	38	60	73	50	6	6	20	18	**BSU4072BDF - T**	2	100	30	4-M8	88	15	3-M6	3.73	240	1.24
	84	118	105	83	13	17	53	60	73	50	6	6	20	18	**BSU4072BDFD - T**	3	100	30	4-M8	88	15	3- M6	5.07	320	2.72
	84	118	105	98	13	17	68	60	73	50	6	6	20	18	**BSU4072BDFF - T**	4	100	30	4-M8	88	15	3-M6	7.46	480	3.64

Ⅱ. Oil / Air Lubrication System

Contents

Page

1. Oil / air lubricator

1. 1 Oil / air lubrication

Oil / air is a new method of lubrication, which was developed to prevent atmospheric contamination caused by oil mist leakage, a phenomenon caused by the high speed of the spindles of machine tools combined with oil mist lubrication.

In oil / air lubrication, an extremely small quantity of oil is supplied and sprayed by air pressure directly into the bearings.

JTEKT has produced an oil / air lubricator and an air cleaning unit, for use as a lubrication system.

1) Features of oil / air lubrication

① Ensures a low level of temperature increase and power loss of bearing and enables a high rotation speed.
Supplies the necessary quantity of oil to each bearing in a reliable manner.

② High reliability.
Since new oil is constantly supplied to bearings, the user does not need to be concerned about the service life of the lubrication oil.
Furthermore, compressed air, which increases the internal pressure of the spindle, is effective in preventing dust or cutting fluid from entering from outside.

③ No atmospheric contamination.
A small quantity of oil flows on the surfaces of piping walls controlled by compressed air. This mechanism eliminates atmospheric contamination caused by oil mist leakage from oil mist lubrication.

2) System diagram of oil / air lubrication

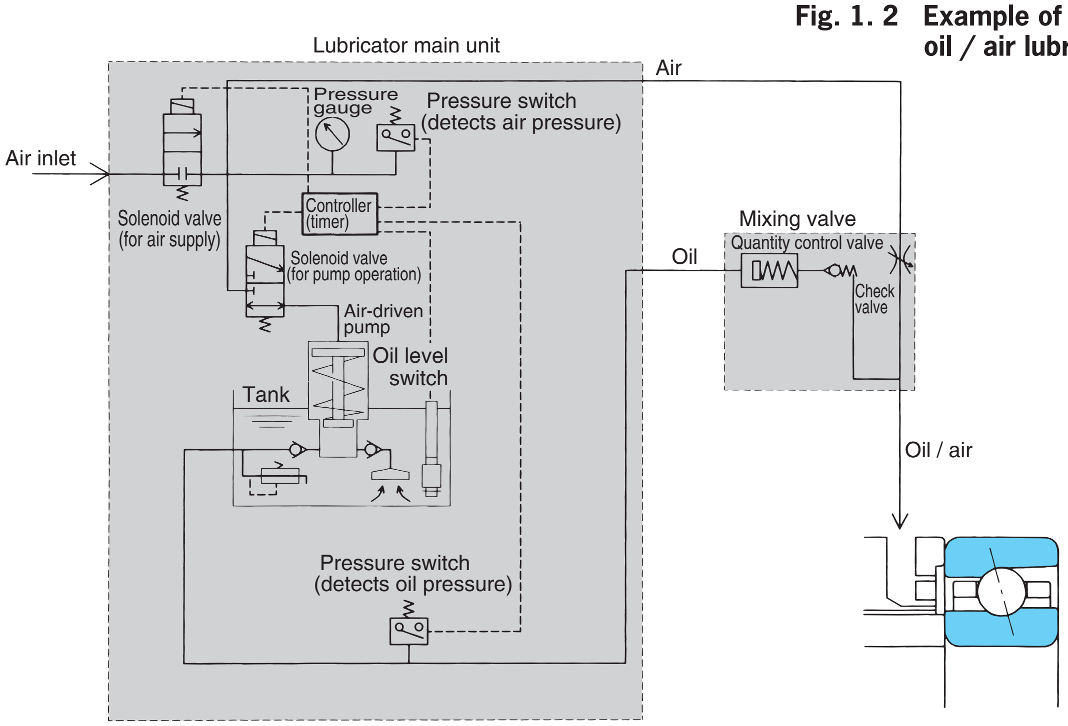


Fig. 1. 1 System diagram of oil / air lubrication

3) Example of connections of oil / air lubrication system

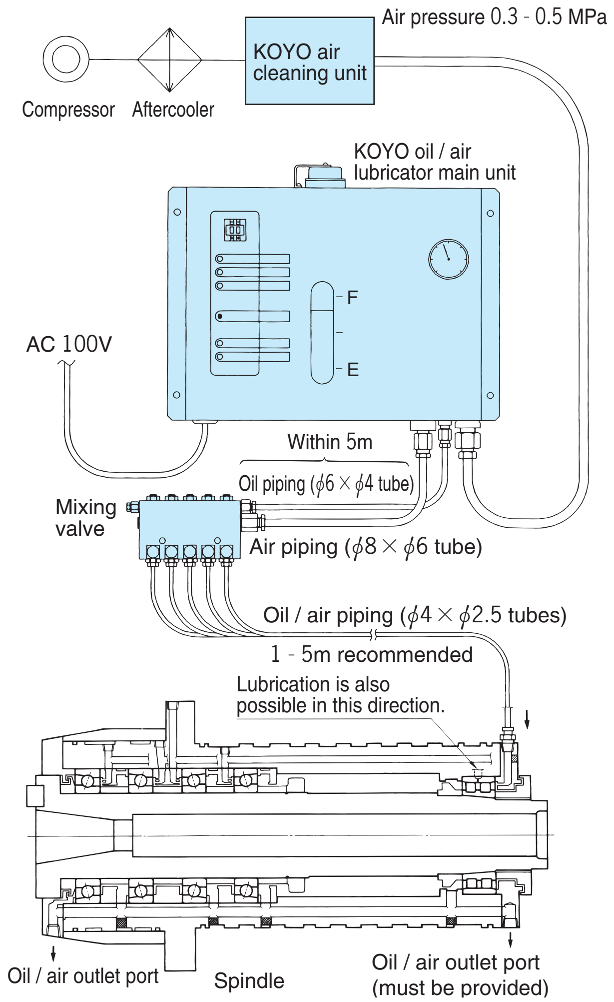


Fig. 1. 2 Example of connections of oil / air lubrication systems

1. 2 Oil / air lubricator

1) Features of KOYO oil / air lubricator

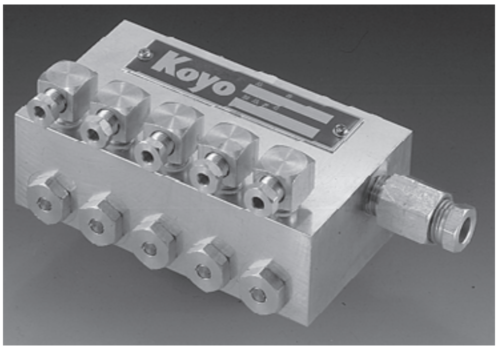
① Lubrication (discharge) intervals can be set to desired values.
The lubricator allows adjustment of lubrication (discharge) intervals from 1 to 99 minutes so that optimum settings for lubrication (discharge) intervals can be selected.
A lock mechanism is provided.

② A solenoid valve used to stop air flow is fitted.
It is included with the standard accessories.
The valve stops air flow when the machine body stops. This eliminates the need for valve operation when shutting down the machine when not in use.

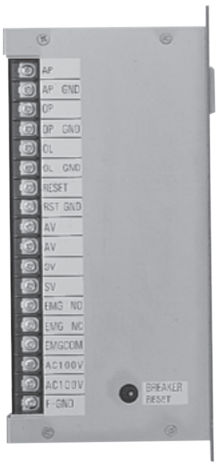
③ Oil can be discharged continuously by manual operation.
Before starting oil / air lubricator, the air in the piping must be discharged (air bleed).
The lubricator has a circuit built in that allows a single or a successive 11 round oil discharge by manual operation.

④ A unique safety device is built in.
A level switch is attached to the oil tank, and pressure switches are attached to main oil and air pipes.
In the event of failure of the lubricator, the location of the failure is indicated by a lamp. In addition, an abnormality signal can be output from the abnormality signal contact points (EMG NO-EMGCOM and EMG NC-EMGCOM terminals on the side of the controller).

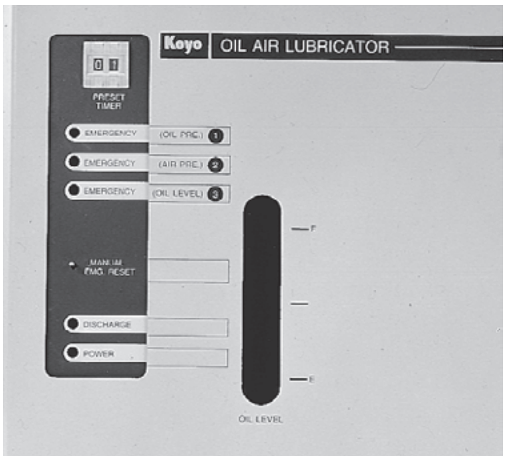
■ **KOYO** oil / air lubricator



■ **KOYO** mixing valve
(Discharges a small quantity of oil at a fixed rate into the compressed air flow for oil / air lubrication.)



■ Controller side view



■ Controller front view

2) Model number of oil / air lubricator (including mixing valve)

Model number **L A S 1 A 4 B - 1**

- KOYO oil / air lubricator (LAS)
- Mixing valve model number (1)
  - □□ (4B): Oil discharge quantity symbol (see **Table 1. 1**); Number of discharge ports*1) 4 : four B ports
  - □□ (1A): Oil discharge quantity symbol (see **Table 1. 1**); Number of discharge ports*1) 1 : one A port

*1) The standard number of oil discharge ports is 5. As it is changeable, specify according to need. The number of maximum available ports is 8 per block.

Table 1. 1 Symbols of mixing valves and oil discharge quantity

Symbol of mixing valve	Oil discharge quantity (mL/stroke)
A	0.01
B	0.03
C	0.05
D	0.10

For the discharge intervals of the oil / air, refer to **Supplementary table 6** on page 203.

3) Outline drawing and specifications of oil / air lubricator

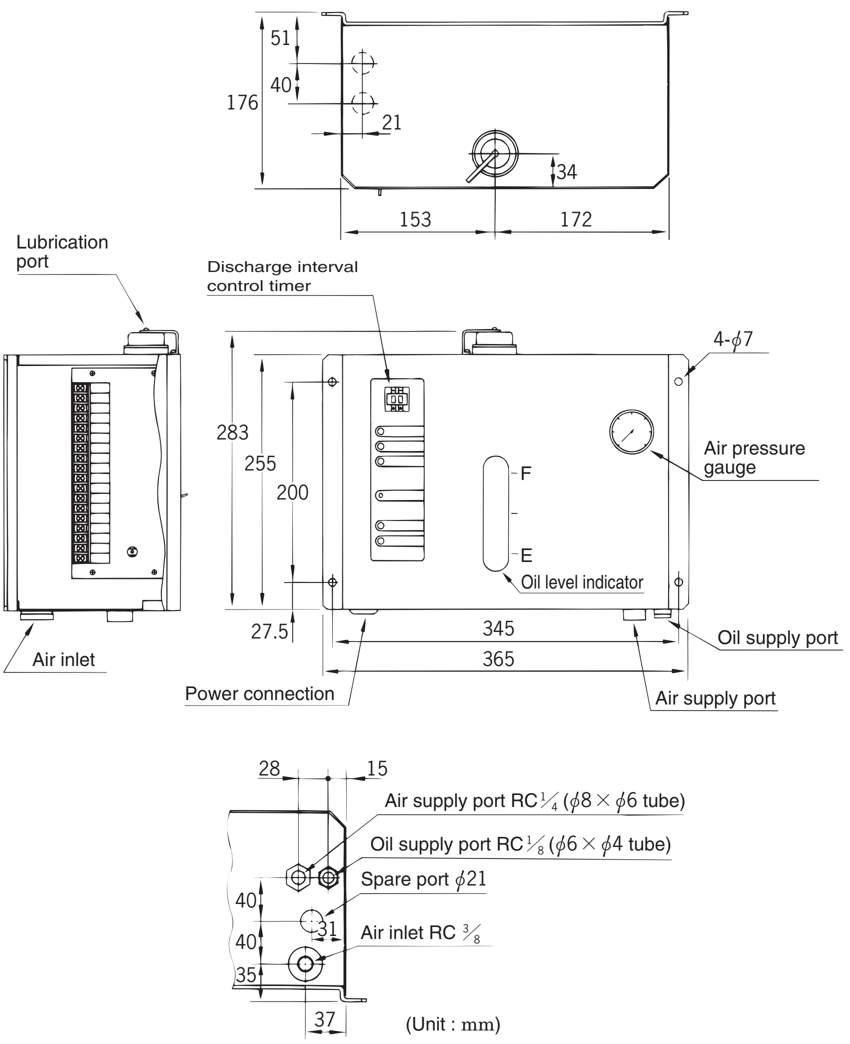


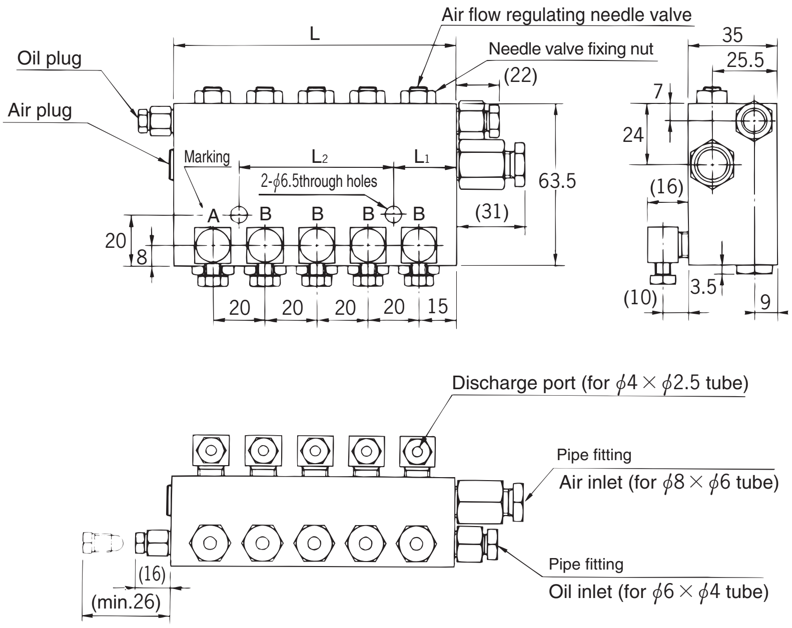
Fig. 1. 3 Outline drawing and specifications of oil / air lubricator

Table 1. 2 Specifications

Item	Specification
Supply voltage	AC100V, 50 / 60Hz
Power consumption	With pump in operation : approx. 20W Pump not in operation : approx. 12W
Service air pressure	0.3-0.5 MPa
Viscosity of oil used	10-100mm²/s
Lubrication (discharge) intervals	Any desired value between 1 and 99 minutes in one-minute intervals
Tank capacity	1.8L (effective oil quantity : 1.4L)
Capacity of abnormality signal contact points	Contact point a : (EMG NO) 250V AC, 5A; 30V DC, 5A Contact point b : (EMG NC) 250V AC, 2A; 30V DC, 3A
Mass (refer.)	15 kg

[Note] AC200V is also available. Consult JTEKT.

4) Outline drawing and specifications of mixing valve



(Unit : mm)

Specifications

・The standard number of oil discharge ports is 5. As it is changeable, specify according to need (8 ports per block at maximum).

No. of ports	2	3	4	5	6	7	8
L	50	70	90	110	130	150	170
L_1	5	5	25	25	25	25	25
L_2	40	60	40	60	80	100	120

Fig. 1. 4 Outline drawing of KOYO mixing valve (example of 1A4B-1)

2. Air cleaning unit

Clean, dry air is required for oil / air lubrication, pneumatic bearings, etc.

JTEKT has developed and commercialized the air cleaning unit KAU05, a compact unit consisting of filters, an air dryer, mist separators, and other parts.

This unit efficiently and effectively removes moisture, oil, dust, etc. contained in compressed air.

(Front) (Rear)

■ **KOYO** air cleaning unit KAU05

1) Features of KOYO air cleaning units

① Removes moisture efficiently by refrigerated air dryer.

② Its micro-mist separator removes oil content 99.999 9% and solid foreign matter 0.01μm or greater in particle size.

③ Contains a differential pressure detection switch, which indicates clogging of filter.

In addition, an output signal is obtained from terminals attached on the differential pressure detection switch.

2) Piping system diagram

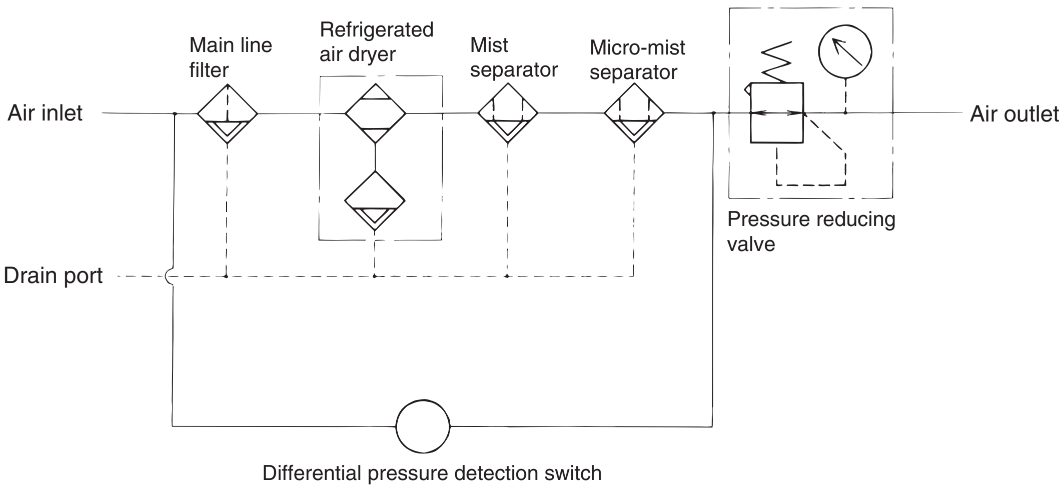


Fig. 2. 1 Piping system diagram of air cleaning unit

3) Outline drawing and specifications of air cleaning unit

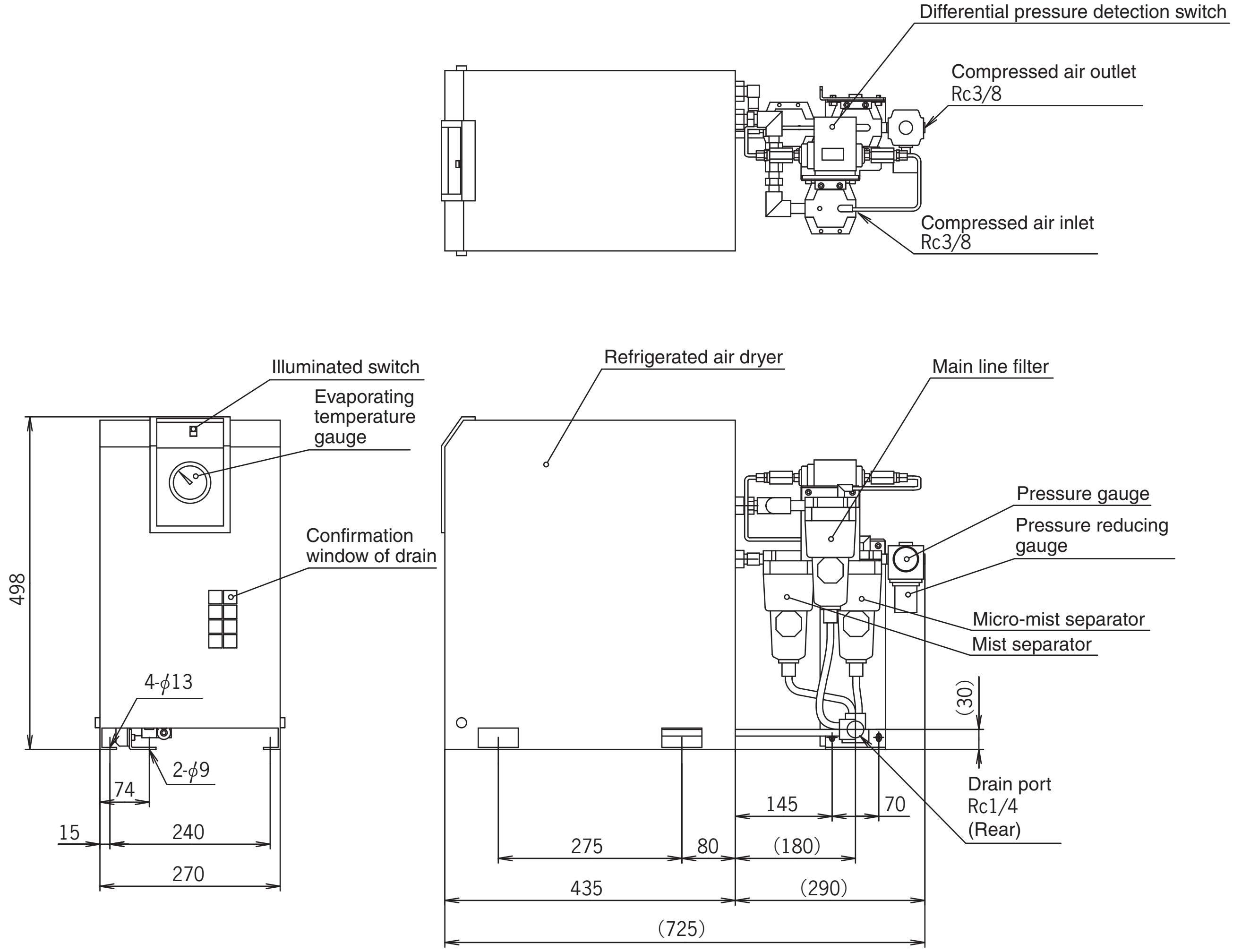


Fig. 2. 2 Outline drawing of KOYO air cleaning unit

Table 2. 1 Specifications of KOYO air cleaning unit KAU05

Item	Specification
Treatment air flow rate	0.52/0.57 m^3/min
Inlet air pressure	0.7 MPa
Maximum temperature of inlet air	50 ℃
Main line filter	3 to 50 μm (95%-arresting particle size)
Mist separator	0.3 μm (95%-arresting particle size)
Micro-mist separator	0.01 μm (95%-arresting particle size)
Oil content separation efficiency	99.999 9%
Solid substance separation efficiency	100% if 0.01 μm or greater
Supply voltage	Single-phase 100 V AC (50/60 Hz)*
Power consumption	180/202 W (50/60 Hz) (at 100 V)
Mass (refer.)	26 kg

*AC 200V is also avilable.

Ⅲ. Handling of Bearings

Contents

1. Handling and mounting of bearings

1. 1 Handling precautions of bearings

1. 1. 1 Handling of bearings

Since ball & roller bearings are made to a higher precision than general mechanical parts, they should be handled carefully.

① Maintain bearings and their surroundings in a clean condition.
② Handle with care.
A severe shock to a bearing by rough handling may result in damage such as flaws, nicks and chipping.
③ Use correct handling tools.
④ Exercise care for rust prevention of bearings.
Avoid handling and storing them in a highly humid atmosphere.
⑤ Bearing should be handled by an experienced person.
⑥ Standard operating procedure for handling bearings should be established.
- Storage of bearings
- Cleaning of bearings and their peripheral parts
- Inspection of dimensions and finish of peripheral parts of bearings
- Mounting
- Dismounting
- Inspection after mounting
- Maintenance and inspection
- Replenishment of lubricant

1. 1. 2 Storage of bearings

Bearings are shipped after a high-quality anticorrosive oil is applied to them followed by a suitable wrapping and packing.

Their quality is guaranteed as long as the wrapping and packing are not damaged.

Bearing, if they are to be stored for a long time, should be stored on a shelf at least 30cm from the ground at 65% or less humidity at a temperature of around 20℃. Avoid direct exposure to sunlight. Keep bearings at a distance from walls.

1. 2 Mounting of bearings

The mounting condition of the bearings affects the accuracy, performance and life of machines.

To optimize the performance of the bearings, it is necessary to strictly follow the procedure and instructions to mount them.

The procedure for mounting the bearings is shown in **Fig. 1. 1**.

In this section, a general procedure for mounting the bearings is described in accordance with the workflow shown in **Fig. 1. 1**.

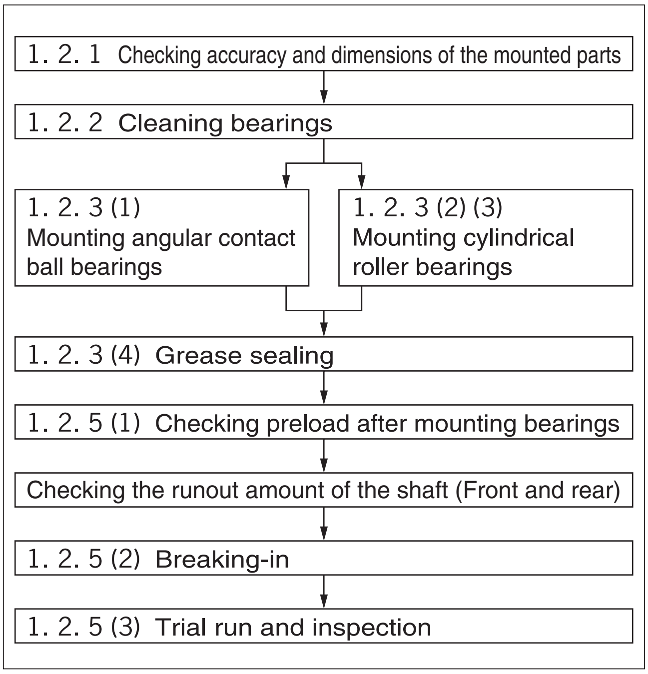


Fig. 1. 1 Mounting workflow

1. 2. 1 Checking dimensions of peripheral parts of bearings

Before mounting the bearing, clean the shaft, housing, spacer, etc. Ensure that the inside of the housing is absolutely free from any residual wrapping material (SiC, Al_2O_3, etc.), molding sand, or chips.

Next, inspect other parts. Check that the dimensions, shapes and roughness are as shown in the drawing, and there is no flaw, burr or barb. Measure the bearing diameter and the bore diameter of the housing at several positions as shown in **Figs. 1. 2** and **1. 3**, and confirm that the fitting is made correctly.

Record the measured values of these parts along with the inspection number of the bearing to be mounted.

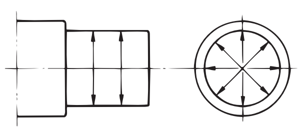


Fig. 1. 2 Measuring positions of shaft diameter

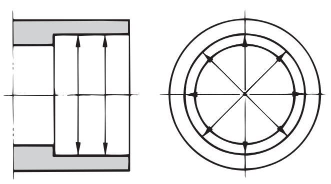


Fig. 1. 3 Measuring positions of housing bore diameter

Besides, pay attention to the fillet radii and the squareness of the shoulders of the shaft and housing. (See **Fig. 1. 4**.)

For the tolerances for the shaft diameters and the bore diameters of the housing, refer to **Tables 6. 2** and **6. 3** (on pages 32 and 33) of "**6. Rigidity and preload of bearings**".

Also, for the accuracy of the shaft and housing as well as the fillet radii, refer to "**9. Designing peripheral parts of bearings**" (on page 39).

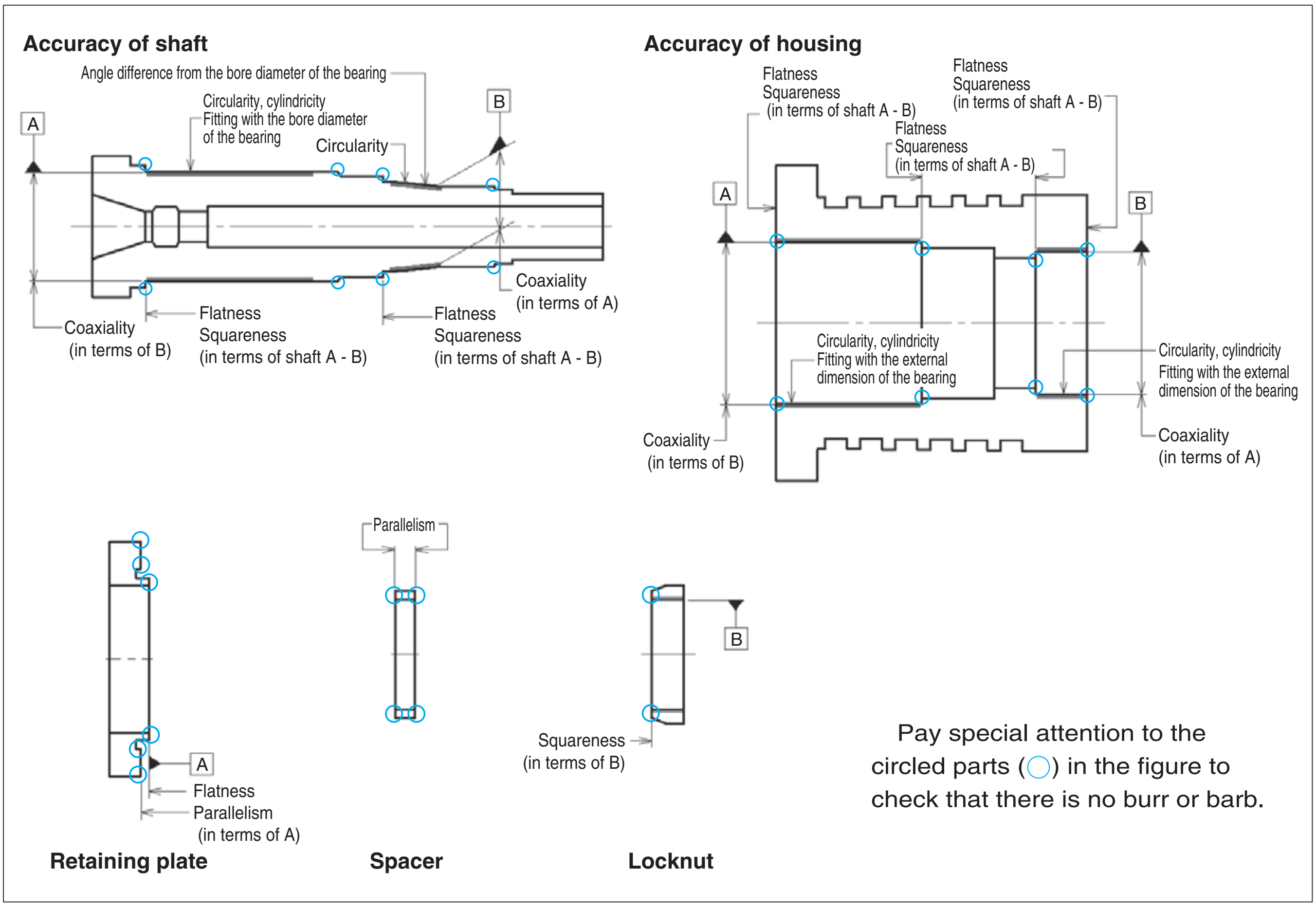


Fig. 1. 4 Points for checking the accuracy

1. 2. 2 Cleaning bearings

After preparing the parts necessary for mounting the bearings, unwrap the bearings just before starting to mount them.

Anticorrosive oil is applied to the bearings to prevent corrosion. After unwrapping the bearings, clean them to remove the anticorrosive oil following the procedure shown in **Fig. 1. 5**.

After cleaning, degrease and dry the bearings. Then, seal grease (in case of grease lubrication) and mount the bearings.

Point

- Be especially careful when cleaning the oil / air lubrication supply and discharge piping, air purge piping, and similar piping.
- After cleaning, ensure that no foreign matter adheres to the piping and store the piping in a clean environment.

<Workflow>

Unwrap the bearings

↓

Cleaning: Rough cleaning → Final cleaning

Caution ⇒

- In general, white kerosene is used to clean the bearings.
- Be careful not to contact the impurities in the cleaning bath with the bearings due to raised bottom.
- Carry out the rough cleaning only to roughly remove the anticorrosive oil. Refrain from cleaning the bearings by rotating them.
- Always use the new cleaning oil to clean the bearings perfectly in the final cleaning.
- In the final cleaning, rotate the bearings in the cleaning oil to remove the anticorrosive oil from the inside of the bearings.

↓

Degreasing (drying)

Caution ⇒

- After the cleaning, handle the bearings in a clean environment. When handling them, wear gloves to prevent rust due to sebum.
- Never rotate the bearings after degreasing.

Point

- Ensure that the bearings are cleaned directly before assembly.
- Never rotate bearings that have been degreased (dried).
- After cleaning, to prevent foreign matter from getting into the bearings, ensure that the bearings are handled in a clean environment.

Fig. 1. 5 Cleaning workflow

1. 2. 3　Mounting bearings

The preparation before mounting the bearings varies depending on the bearing types and lubrication as shown in **Fig. 1. 6**.

For details, see **Fig. 1. 6** to mount the bearings.

In case of the angular contact ball bearings, the fitting mark is indicated on the outside surface of the bearing (see page 59). Mount the bearing in the correct direction referring to the fitting mark.

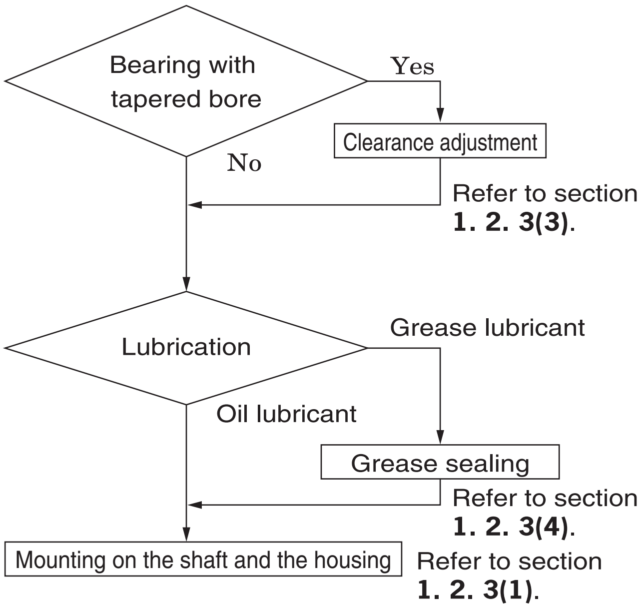


Fig. 1. 6　Preparation before mounting

1. 2. 3(1)　Mounting on shaft and housing

① Bearing mounting

Mounting method of the bearings differs depending on types and fitting conditions.

In case of the bearings for machine tool spindles, the inner ring is usually rotated. Therefore, the interference fit is applied for the inner rings, and the clearance fit is applied for the outer rings.

As a method of interference fit, the shrinkage fit is usually applied for the cylindrical bore bearings. In case of the bearings with tapered bore, the inner ring is press fitted in the taper shaft. In this case, the bearing internal clearance needs to be adjusted as described in section **1.2.3(3)** beforehand, because it is necessary to control the radial internal clearance after fitting.

The clearance fit is used to fit the outer ring in the housing. To facilitate the mounting, the housing is heated to expand the bore diameter before mounting the bearing.

The bearing before mounting, which is used for oil lubrication, is very susceptible to flaws, because it is cleaned and degreased and is in metallic contact with a rolling element and raceway. To protect the raceway during the mounting, it is recommended to apply a small quantity of oil used for the machine to be mounted inside the bearing.

●Shrinkage fit

Heat the bearing assembly or inner ring on an induction heater or hot plate to induce expansion before mounting it onto a shaft.

If this method is used, no force is applied to the bearing and operation is carried out in a short time.

When a hot plate is used to heat up a bearing assembly, the use of a jig as shown in **Fig. 1. 7** enables efficient heating of the inner ring.

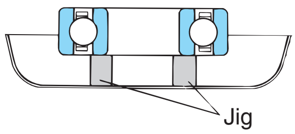


Fig. 1. 7　Inner ring heating jig

Specify the heating temperature of the bearing in accordance with the size and the required expansion, referring to **Fig. 1. 8**. Specify the temperature about 20 to 30℃ higher than the required temperature, taking into consideration the temperature to be reduced during the operation.

However, never heat the bearing up to 120℃ or more.

After mounting the bearing, shrinkage will occur in the width as the bearing cools off. Therefore, fit the inner ring and the shoulder firmly using a locknut to prevent clearance between them.

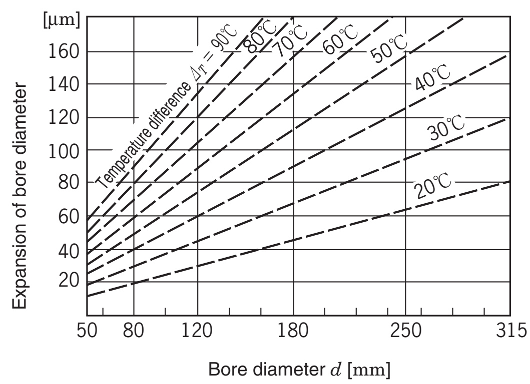


Fig. 1. 8　Heating temperature and expansion of inner rings

●Press fit

Be sure to use the specific jig to mount the inner ring to the shaft and the outer ring to the housing. When press fitting the inner ring and the outer ring, hold only the inner ring and the outer ring, respectively, and apply gently uniform pressure to the whole circumference surface.

Never mount the rings using hammer.

To facilitate the mounting, it is recommended to apply a small quantity of lubricant to the shaft or housing before press fitting.

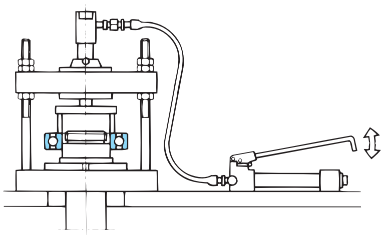


Fig. 1. 9 Press fitting by pressing machine

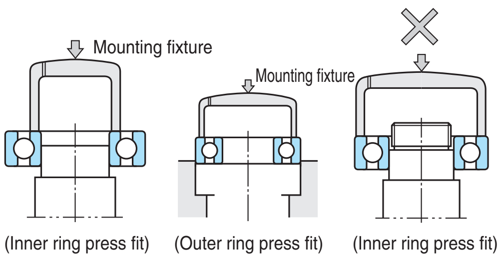
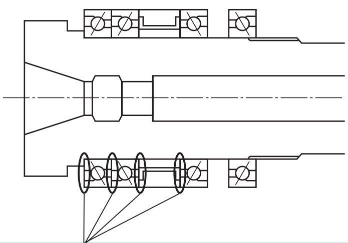


Fig. 1. 10 Example of press fitting jig



Point

- Ensure that contact is made for each mating surface.
- Take special care to ensure that no foreign matter or the like has been introduced.

Fig. 1. 11 Cautions for bearing assembly

[Reference] Force is necessary to press fit or remove bearings

The force necessary to press fit or remove inner rings of bearings differs depending on the finish of shafts and how much interference the bearings allow. The standard values can be obtained by using the following equations.

(In the case of solid shafts)

$$K_a = 9.8\, f_k \cdot \Delta_{deff} \cdot B \left(1 - \frac{d^2}{D_i^2}\right) \times 10^3 \quad \cdots\cdots\cdots\cdots (1.\ 1)$$

(In the case of hollow shafts)

$$K_a = 9.8\, f_k \cdot \Delta_{deff} \cdot B \frac{\left(1 - \frac{d^2}{D_i^2}\right)\left(1 - \frac{d_0^2}{d^2}\right)}{\left(1 - \frac{d_0^2}{D_i^2}\right)} \times 10^3 \quad \cdots\cdots\cdots\cdots (1.\ 2)$$

Where:

- K_a : force necessary for press fit or removal N
- Δ_{deff} : effective interference mm
- f_k : resistance coefficient
  (Coefficient taking into consideration friction between shafts and inner rings ... refer to the table below.)
- B : nominal inner ring width mm
- d : nominal inner ring bore diameter mm
- D_i : average outside diameter of inner ring mm
- d_0 : hollow shaft bore diameter mm

Value of resistance coefficient f_k

Conditions	f_k
· Press fitting bearings on to cylindrical shafts	4
· Removing bearings from cylindrical shafts	6
· Press fitting bearings on to tapered shafts or tapered sleeves	5.5
· Removing bearings from tapered shafts or tapered sleeves	4.5
· Press fitting tapered sleeves between shafts and bearings	10
· Removing tapered sleeves from the space between shafts and bearings	11

② Tightening of bearings

●Tightening of inner ring

As a way of fixing the inner ring to a shaft, a locknut is usually used. **Fig. 1. 12** shows an example of fixing an inner ring using a locknut.

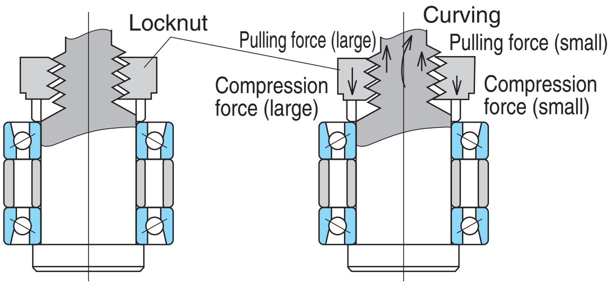


Fig. 1. 12 Example of fixing on inner ring using a locknut

As a clearance is present between thread of the locknut and that of the shaft, fixing the inner ring by using a locknut results in the center of the locknut deviating from the center of the shaft. This deviation in turn causes inclination of the inner ring or bending of the shaft.

As a result, the running accuracy of the shaft is decreased or an abnomal temperature increase is experienced due to the high load applied to the bearing (see **Fig. 1. 13**).

To settle this problem, positioning (centering) of the locknut is necessary after tightening.

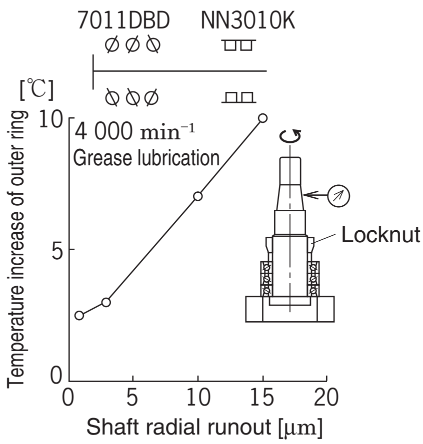


Fig. 1. 13 Relationship between shaft radial runout and temperature increase of the outer ring caused by the faulty positioning of the inner ring

Furthermore, the axial force generated by tightening the locknut leads to compressive strain of the inner ring and inner ring spacer, which in the case of position preloading, influence the amount of preload applied to the bearing.

For those applications which are considerably affected by preload, such as a high-speed spindle, this compressive strain should be taken into consideration. Consideration to other types of bearing supports are the inclination of inner rings, bending of shafts, and axial forces. In cases where a interference fit sleeve is used to fix a bearing, the tolerance of the sleeve is of vital importance since positioning becomes difficult once the bearing is fitted.

Tightening forces (shaft forces) of the locknuts or sleeves used to fix the inner rings are indicated as standard values in the bearing dimension table.

Note that if the interference of inner ring is large and the number of bearing rows is large, the press fitting force also becomes large.

●Tightening of outer rings

Outer rings are fixed to the housing usually by means of a retaining plate.

The retaining plate is fastened to the housing with several bolts. Inadvertent fastening of the retaining plate, however, may result in an inclination and / or deformation of the outer ring.

If inclination and / or deformation occurs in the outer ring, the rolling elements and the cage cannot rotate properly, possibly causing unusual noise generation.

In order to prevent this, it is necessary to tighten the retaining plate fastening bolts with an even torque in diagonal sequence. The fastening bolts should not be fastened individually to the final torque, but in a step-by-step sequence (see **Fig. 1. 14**).

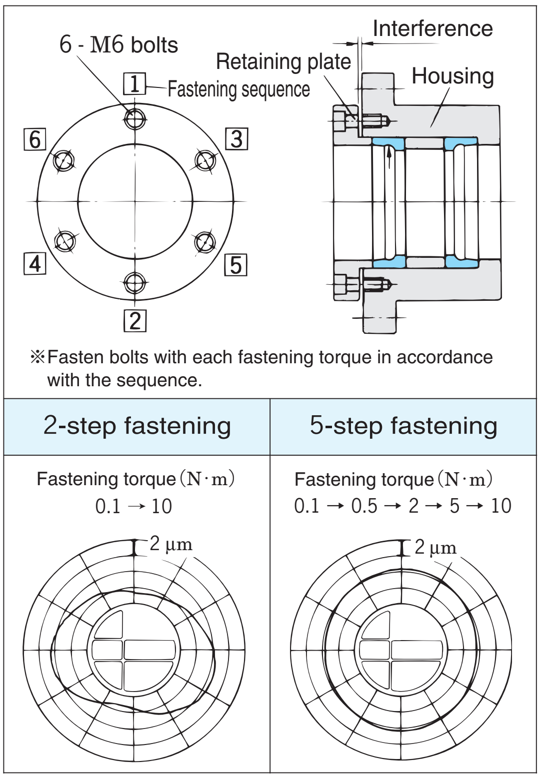


Fig. 1. 14 Raceway roundness variations with respect to the various fastening method

A slight interference is provided between the housing and retaining plate to hold the outer ring firmly.

If variations on the interference exist on the circumference due to poor tolerance of the retaining plate or housing, fastening the retaining plate may cause inclination of the outer ring.

When securing the outer ring using the retaining plate, if the interference is excessive, the preload will become less than the set value, increasing the likelihood of the pressing force becoming uneven. In addition, if the interference is insufficient, the preload will become more than the set value, causing the pressing force to be insufficient, thus leading to creeping of the outer ring.

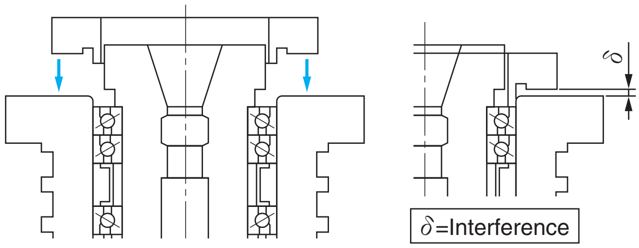


Fig. 1. 15 Interference of retaining plate

Therefore, sufficient care should be taken to ensure tolerance of the retaining plate and housing.

For the interference between the housing and retaining plate, refer to the dimension table for each bearing.

1. 2. 3(2) Management of spindle taper angle

When using cylindrical roller bearings with a tapered bore, the angle of the spindle taper and the angle of the bearing taper must be managed. Managing the taper angles ensures the high precision of the spindle.

To manage the taper angle, apply a thin coating of blue paste to the bearing bore and check the contact locations with the spindle.

A large difference in the angle between the spindle and the bearing bore will result in an increased difference in the circumscribed roller diameter between two rollers. This may lead to a failure.

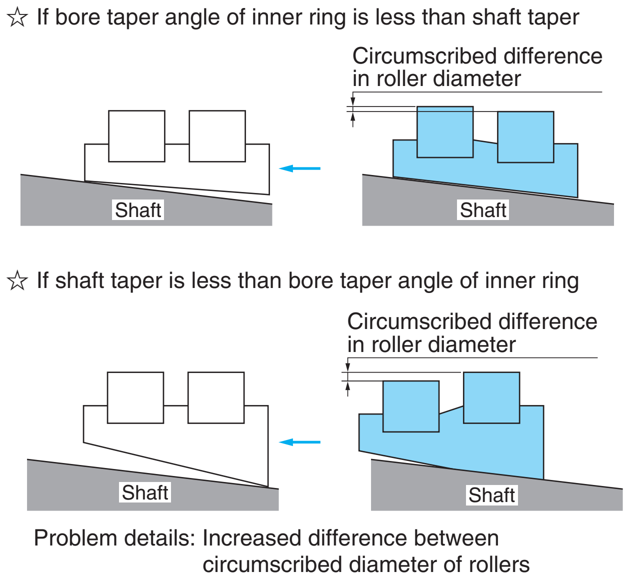


Fig. 1. 16 Example of poor accuracy for tapered hole

1. 2. 3(3) Adjusting of clearance

In case of the cylindrical roller bearing with tapered bore, it is necessary to adjust the dimension of the spacer to adjust the radial clearance of the bearing.

The adjustment is made as follows.

(1) Lightly apply low-viscosity oil (kerosene, etc.) to the taper part of the shaft and fit slightly the inner ring of the cylindrical roller bearing into the shaft (**Fig. 1. 17**).

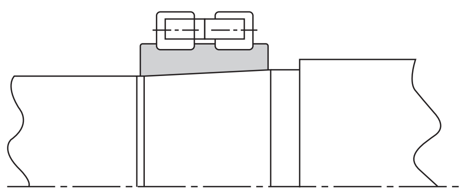


Fig. 1. 17 Temporary mounting of inner ring

(2) Using a block gauge, measure the distance between the end face of the inner ring and that of the shoulder (**Fig. 1. 18**).

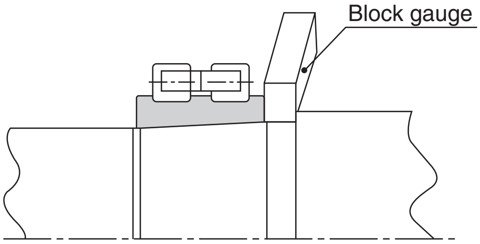


Fig. 1. 18 Width of spacer

(3) Temporarily adjust the width of the spacer.
Adjust the width of the spacer to the distance between the end face of the inner ring and that of the shoulder as measured in step (2). It is recommendable to make the outside diameter of the spacer larger than the diameter of the shaft shoulder to facilitate the pulling-out (Useful when pulling out the inner ring).

Point

- After machining, the parallelism of the lateral spacer sides must be 0.001 mm or less.
- Designing a spacer outer diameter larger than the diameter of the shaft shoulder will facilitate later work.

(4) After degreasing the outside surface and the bore, fit the temporarily adjusted spacer and mount the inner ring onto the shaft.
Be careful not to make clearance between the end face of the spacer and that of the inner ring and clearance between the end face of the spacer and that of the shaft shoulder (**Fig. 1. 19**).

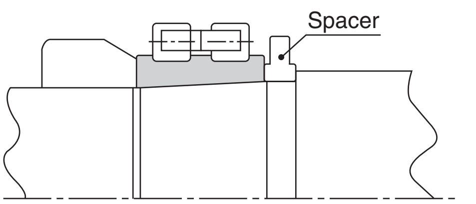


Fig. 1. 19 Mounting of spacer

(5) Place the dial gauge on the outside surface of the outer ring, and move the outer ring upward and downward on the axial line of the dial gauge needle to measure the residual radial internal clearance (**Fig. 1. 20**).

(6) After measurement, pull the bearing and the spacer out of the shaft.
Never hit the bearing to pull it out (Hit gently the end face of the spacer of large outside diameter).

(7) Based on the radial internal clearance measured in step (5), use the equation shown below to calculate the adjustment value of the inner ring to obtain the desired residual radial internal clearance.

In case of taper 1/12,
Adjustment value $\varDelta_A = (R_{sa} - R_{sb} - R_{sc}) \times 12/K$

Where:
R_{sa}: measured radial internal clearance ...... the value measured in step (5)
R_{sb}: desired radial internal clearance
R_{sc}: contraction of the outer ring raceway due to fitting (0 in case of clearance fit)
K : expansion coefficient of the inner ring raceway due to press fitting

Formula to calculate R_{sc}

$$R_{sc} = \varDelta_{Deff} \frac{D_e}{D} \cdot \frac{\left(1 - \frac{D^2}{D_h^2}\right)}{\left(1 - \frac{D_e^2}{D_h^2}\right)}$$

Formula to calculate K

$$K = \frac{d}{D_i} \cdot \frac{\left(1 - \frac{d_0^2}{d^2}\right)}{\left(1 - \frac{d_0^2}{D_i^2}\right)}$$

Where:
$\varDelta_{Deff}$: effective interference of outer ring
D_h : outside diameter of housing
D_e : outer ring raceway contact diameter
ball bearing······$D_e \fallingdotseq 0.2\ (4D + d)$
roller bearing ···$D_e \fallingdotseq 0.25\ (3D + d)$
D : nominal outer ring outside diameter
d : nominal inner ring bore diameter (shaft diameter)
d_0 : bore diameter of hollow shaft
D_i : inner ring raceway contact diameter
ball bearing······$D_i \fallingdotseq 0.2\ (D + 4d)$
roller bearing ···$D_i \fallingdotseq 0.25\ (D + 3d)$

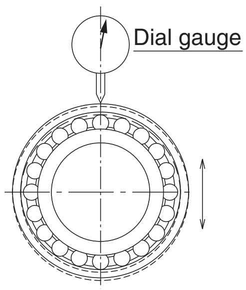


Fig. 1. 20 Measurement of residual radial clearance

Point

- Gently tap the spacer when pulling out the inner ring. Never tap the bearing under any circumstances!

(8) Adjust the width of the spacer.
The width of the spacer must be the value temporarily adjusted minus the adjustment value calculated in step (7).

Point

- After machining, the parallelism of the lateral spacer sides must be 0.001 mm or less.
- After machining, be sure to clean the spacer sufficiently.

(9) After cleaning, mount the bearing and the spacer onto the shaft.
Push inner ring sufficiently so that the end face of the spacer and that of the inner ring as well as the end face of the spacer and that of the shaft shoulder contact each other completely (**Fig. 1. 21**).

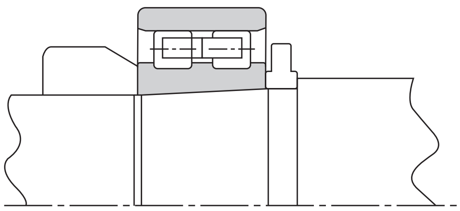


Fig. 1. 21 Mounting of bearing

(10) As in step (5), check the residual radial internal clearance of the bearing.
If the desired value of the radial internal clearance is not obtained, return to step (7) and make adjustment again.

(11) After checking that the desired value of the radial internal clearance in obtained in step (10), pull the bearing and spacer out of the shaft temporarily to clean and degrease them. In case of grease lubrication, seal them with the specified amount of grease, and then reassemble them.

Point

- Make sure that no temperature differences exist between components.
- Ensure proper fitting between the shaft and the bearing bore and between the housing and the bearing outer diameter.
- When using cylindrical roller bearings with a tapered bore, take note of the difference in taper angles of the shaft and the bearing bore.
- Be cautious of burrs and barbs on surfaces in contact with the bearing.

✻Pay special attention to accuracy upon reinstallation following a seizure.

1. 2. 3(4) Grease sealing

If the sealed amount of grease or the sealing method is not appropriate, overheating or instability (**Fig. 1. 22**) may result during breaking-in, and an extended time of breaking-in may become necessary.

Therefore, be sure to seal the bearing with an appropriate amount of grease in correct manner.

Sealing method of grease is described below.

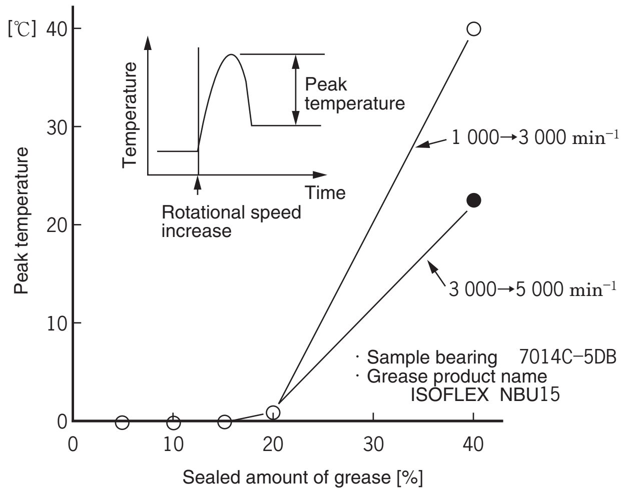


Fig. 1. 22 Relationship between sealed amount of grease and peak temperature

① Preparation before sealing

- Clean and degrease the bearing. And check that there is no stain of anticorrosive oil or foreign matter on the interspace and outer surfaces of the bearing.
- An appropriate amount of grease must be applied uniformly to the specified locations in the bearing.
  To apply grease, it is recommended to use a specific tool with measuring gauge, which has a nozzle tip.
- The tool used to apply grease also has to be cleaned off and degreased.
- Before applying grease, check the amount of grease to be sealed. The amount should be 10 to 15% of the space capacity of the bearing.
  (The space capacity of each bearing and the sealed amount of grease are shown in the bearing dimension table.)

② Method for grease sealing

Grease must be applied uniformly to the bearing raceway surface and the retainer guide as shown in **Fig. 1. 23**.

After applying grease, manually rotate the bearing to let the grease spread all over the inside of the bearing.

Also, after applying grease, be careful to prevent foreign matter and dust from adhering to the bearing.

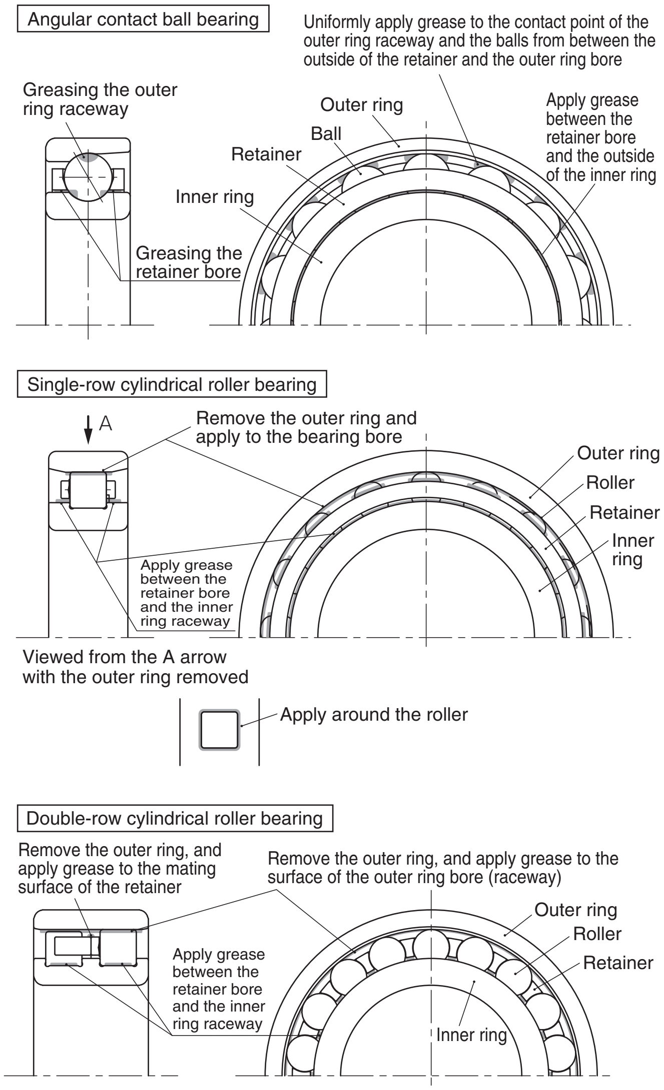


Fig. 1. 23 Grease sealing points

Point

- To apply grease, a tool with a nozzle-like tip similar to a syringe will facilitate work.
- Clean and dry the grease application tool before performing the work.
- Control the amount of grease according to capacity or amount.
- After applying grease, handle the bearing carefully as foreign matter will easily adhere to the bearing.
- Apply the grease evenly and little by little.

1. 2. 4 Mounting of ball screw support bearings

The methods for cleaning parts and applying grease are the same as for spindle bearings. Refer to sections **1. 2. 1 Checking dimensions of peripheral parts of bearings**, **1. 2. 2 Cleaning bearings**, and **1. 2. 3(4) Grease sealing** in **1. Handling and mounting of bearings**.

To use the ball screw support bearings, first create a housing assembly (unit) with the bearings already mounted in the housing.

Refer to “Tightening of outer rings” under **1. 2. 3(1) Mounting on shaft and housing** for how to mount the support bearing to the housing.

Be sure to wash the support bearing assembly part of the ball screw shaft.

The following section describes the procedure using a unit component as an example.

1. 2. 4(1) Mounting on shaft

The fitting of the inner ring of the ball screw support bearing is what’s referred to as a “transition fit.” Begin by heating the inner ring beforehand (**Fig. 1. 24**).

The inner ring can be heated by inserting a provisional shaft that has been heated into the bore of the inner ring or by directly heating the inner ring using a jig heated using a heater or the like.

When heating the inner ring directly, make sure the unit’s oil seal lip does not touch the heating jig.

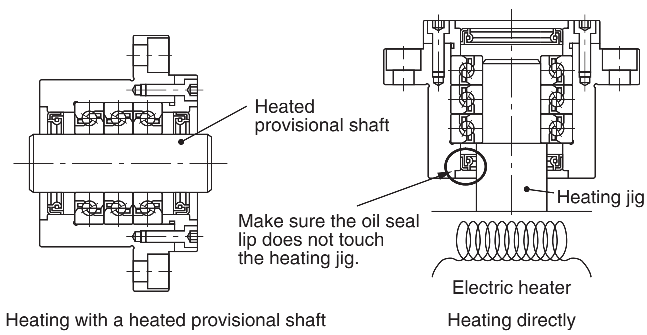


Fig. 1. 24 Heating the inner ring

1. 2. 4(2) Mounting on the machine body

Once the inner ring has been heated, mount the unit on the ball screw shaft as shown in **Fig. 1. 25**.

Make sure the ball screw shaft has been passed through the machine body beforehand.

To mount the unit, insert the inner collar onto the shaft with a clearance fit, and then insert the unit with a heated inner ring onto the shaft.

After inserting the unit onto the shaft, insert the other inner collar onto the shaft with a clearance fit.

Next, tighten the inner ring and the shaft with the shaft nut, and tighten the housing onto the machine body with the bolt.

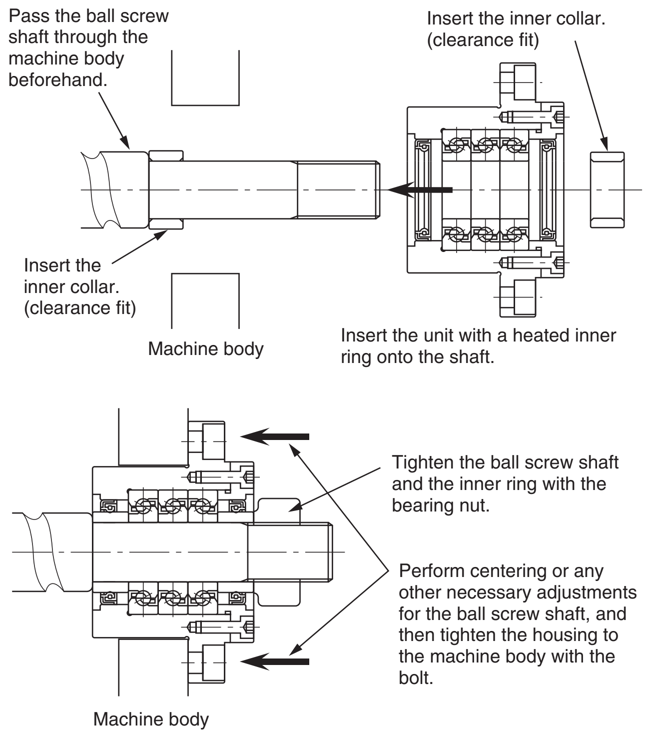


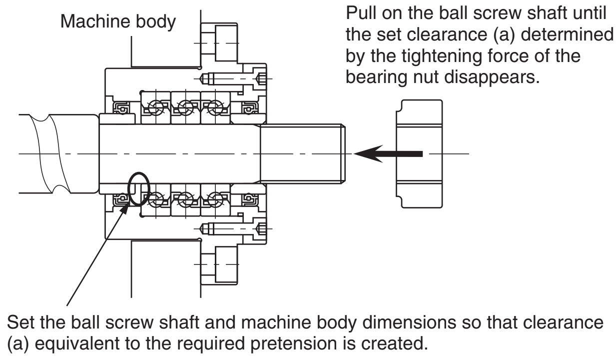
Fig. 1. 25 Mounting of the ball screw support unit

1. 2. 4(3) Applying pretension

The ball screw shaft can be used with pretension applied beforehand.

Fig. 1. 26 shows an example of this method.

After tightening one end of the ball screw, insert the unit at the other end onto the shaft. Set the dimensions of the ball screw and machine body in advance so that an axial clearance equivalent to the necessary pretension is created. When the inner ring and ball screw shaft are tightened using the shaft nut, the set clearance will disappear. The required pretension can be applied to the ball screw shaft by eliminating the clearance.



Point

· After tightening, make sure no residual clearance exists between the shaft shoulder and the inner collar and between the inner collar and the inner ring.

Fig. 1. 26 Applying pretension

1. 2. 5 Check after mounting bearings

1. 2. 5(1) Checking of preload

Preload of the bearing affects its rigidity and heat generation. If the preload is inadequate, not only the standard performance is not obtained, but also the life span is shortened and seizure results.

Therefore, it is important to check that the specified preload is applied to the bearing after completing the mounting of the bearing.

In this section, the following methods for checking the preload, which are generally used, are described.

① Check using the starting torque

If the preload of the bearing becomes large, the starting torque also tends to increases. Therefore, the preload can be checked by measuring the starting torque value.

Wind the thread on the shaft or the outer ring and fix it. By pulling the thread tangentially, measure the tension of the thread when the bearing starts to rotate using a tension gauge, etc. After obtaining the starting torque, the preload can be presumed referring to the correlation between the starting torque and the preload (**Fig. 1.27**).

The starting torque can be measured easily. However, in case of the bearings used with low preload (e.g. angular contact ball bearing used as a spindle), the measurement error can be large because the starting torque is small. This method is recommendable when using the ball screw support bearings by applying heavy preload to them.

Note that it is necessary to standardize the sampling and measurement conditions because the condition of the lubricant and pulling speed affect the measurement result.

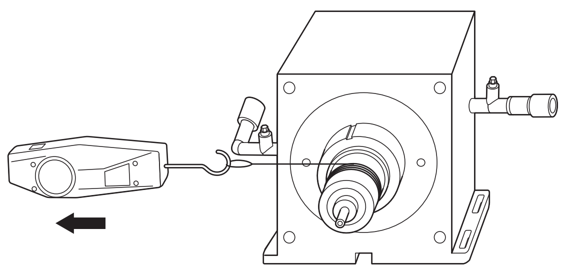


Fig. 1. 27 Measuring starting torque

② Check using the axial rigidity

The preload is confirmed referring to the correlation between the shaft end axial deviation measured by applying the axial load to the shaft end, and the axial rigidity and the preload (**Fig. 1.28**).

This method is not recommendable when using a main shaft of high rigidity because the deviation is very small.

To use this method, a large-sized facility such as a load applying device is necessary. Also, it is necessary to standardize the sampling and measurement conditions because the parts other than the bearing have elastic deformability.

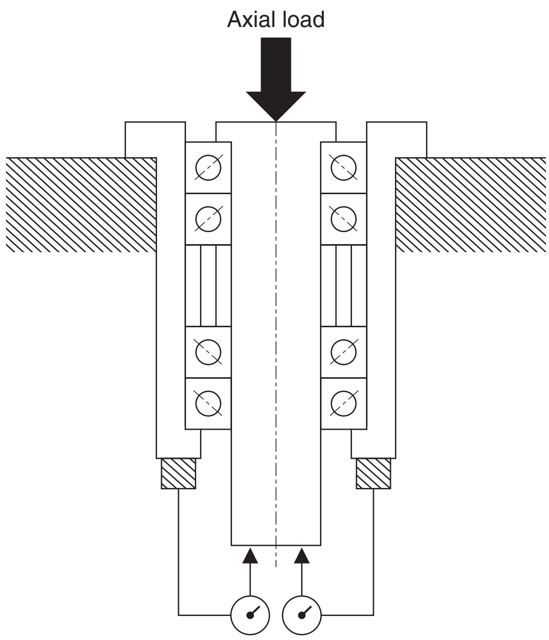


Fig. 1. 28 Measuring axial rigidity

③ Check using the proper vibrations

The preload is confirmed referring to the correlation between the spring constant of the bearing and the preload (**Fig. 1.29**).

This method guarantees accuracy and repeatability of measured values.

However, the fixing method has to be meticulously inspected and standardized because the results are affected by the fixing method.

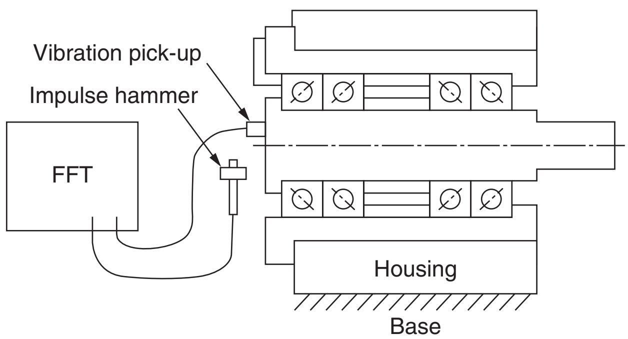


Fig. 1. 29 Measuring eigenfrequency

1. 2. 5(2) Breaking-in

In case of the bearings for grease lubrication, after installation of a bearing, problems are likely to occur due to rapid temperature rise caused by the immediate application of the maximum specified rotational speed. Therefore, breaking-in of the bearing is recommended, in which rotational speed is increased gradually.

Specifically, roller bearings require adequate breaking-in.

Fig. 1. 30 shows an example of breaking-in.

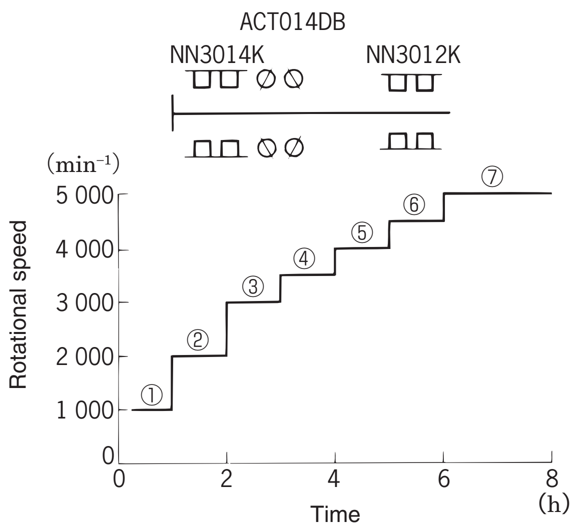


Fig. 1. 30 Example of breaking-in (In case of 5 000 min^{-1} max. speed)

If carrying out the break-in, after increasing the rotational speed, wait until the temperature of the bearing stops to increase or starts to decrease. Then, increase the rotational speed further. (Refer to **Fig.1.31**.)

Never increase the rotational speed when the temperature of the bearing is increasing.

The higher the temperature of the bearing becomes, the faster the grease deteriorates. Therefore, it is important to monitor the temperature during the breaking-in. When the temperature reaches a certain level, stop the operation temporarily. After the bearing cools off, resume the break-in starting from the rotational speed at which the operation was stopped or lower.

If the temperature is measured on the outside surface of the housing or retaining plate, the temperature at which the operation should be stopped is the room temperature plus 30 to 40℃ (Supposing that the room temperature is 15 to 25℃).

The break-in is not required for the bearings lubricated with oil. However, if the bearings are used for the first time or after stored for an extended period of time, it is recommended to carry out the break-in because an abrupt increase of temperature may be expected due to the oil remaining in the lubrication duct and the inside of the bearing (excessive oil quantity).

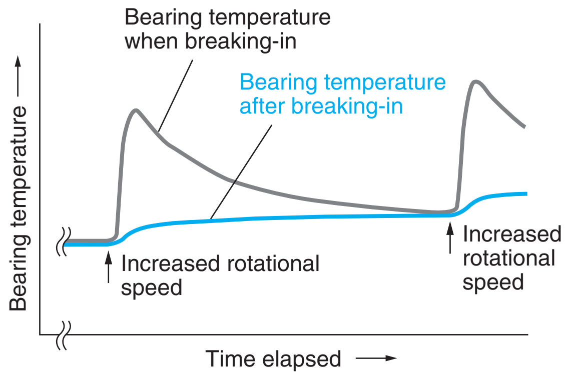


Fig. 1. 31 Bearing temperature increase before and after breaking-in

Point

- The breaking-in pattern should be based on a pattern of increased rotational speed ⇒ temperature equilibration ⇒ increased rotational speed.
- Set the amount of the rotational speed increase to be smaller than the maximum rotational speed of the vicinity.
- Even oil lubrication is affected by initial lubrication. Therefore, we recommend that you perform breaking-in.

1. 2. 5(3) Trial run and inspection

A trial run and inspection are carried out when bearings have been mounted, in order to check whether the mounting is adequate.

In the case of a small spindle, the rotation condition is examined initially by rotating it manually. After confirming that the below conditions do not exist, a further inspection is carried out by a powered run.

- Unsmoothness·········Possible causes include the inserfion of foreign matter and flaws on the rolling surfaces. Grease used in grease lubrication may cause a phenomenon of unsmoothness at the initial stage. In such cases, unsmoothness disappears after breaking-in.
- Excessive torque (heavy)······Possible causes are friction in the sealing device, insufficient clearance, etc.
- Uneven rotational torque·····Possible causes are difective mounting, and / or errors in mounting dimensions.

In the case of a large spindle that cannot be rotated manually, start it under unloaded condition and immediately after starting, turn the power off and allow to coast.

After verifying that the shaft is free of abnormal vibration or noise and rotates smoothly, proceed to powered run.

Powered run should be started with no load applied and at a low speed, before being increased gradually to a given condition.

Noise, temperature increase, and vibration are principal judging factors in powered run and inspection. If a faulty condition such as shown in **Tables 1. 1** and **1. 2** occurs, conduct a further inspection immediately.

In some cases, it is necessary to remove the bearing for inspection.

Table 1. 1 Bearing noises, causes, and countermeasures

Noise types		Causes	Countermeasures
Cyclic	Flaw noise (similar to noise when punching a rivet[1)]) Brinelling noise (unclear siren-line noise[1)])	Flaw on raceway Brinelling on raceway	Improve mounting procedure, cleaning method and rust preventive method. Replace bearing.
	Flaking noise (similar to a large hammering noise[1)])	Flaking on raceway	Replace bearing.
Not cyclic	Dirt noise (an irregular sandy noise[1)])	Insertion of foreign matter	Improve cleaning method, sealing device. Use clean lubricant. Replace bearing.
	Flaw noise, flaking noise	Flaws and flaking on rolling elements	Replace bearing.
	Squeak noise (often heard in cylindrical roller bearing with grease lubrication, especially in winter or at low temperature)	If noise is caused by improper lubrication, a proper lubricant should be selected. In general, however, serious damage will not be caused by an improper lubricant if used continuously.	
Others	Abnormally large metallic sound	Abnormal load Incorrect mounting Insufficient amount of or improper lubricant	Review fitting, clearance. Adjust preload. Improve accuracy in processing and mounting shafts and housings. Improve sealing device. Refill lubricant. Select proper lubricant.

[Note] 1) In case of slow or medium rotation.

Table 1. 2 Causes and countermeasures for abnormal temperature rise

Causes	Countermeasures
Too much lubricant	Reduce lubricant amount
Insufficient lubricant	Refill lubricant
Improper lubricant	Select proper lubricant
Abnormal load	Review fitting and clearance conditions and adjust preload
Improper mounting (excessive friction)	Improve accuracy in processing and mounting shaft and housing. Review fitting. Improve sealing device.

Normally, listening rods are employed for bearing noise inspections. The device, which detects abnormalities through sound vibration, and the system, which utilizes acoustic emission for abnormality detection, are useful for more precise inspection.

In general, bearing temperature can be estimated from housing temperature, but the most accurate method is to measure the temperature of outer rings directly via lubrication holes.

Normally, bearing temperature begins to rise gradually when operation is just starting; and, unless the bearing has some abnormality, the temperature stabilizes within one or two hours.

Therefore, a rapid rise in temperature or unusually high temperature indicates some abnormality.

1. 2. 6 Dismounting of bearings

Dismounting a bearing for reuse or identification of causes of failure should be carried out in a careful manner similar to that of when mounted. Care should be taken to avoid damage to the bearing and other parts.

Specifically, when dismounting a bearing involving an interference, the dismounting process of the bearing should be taken into consideration at the designing stage of the shaft and housing.

It is recommended to make a jig for dismounting where appropriate.

Ⅳ. Examples of Bearing Failures

Contents Page

1. Bearing failures, causes and countermeasures

It is necessary to carry out the maintenance and inspection to use the machine equipment always in stable conditions.

The bearing is an important part of the machine installation. If the bearing is damaged, the machine may become nonoperating and other inadvertent effects may occur.

Rotation noise, vibrations, temperature and torque are important phenomena to determine the status of the bearing. If any abnormality is perceived in such phenomena, it is necessary to immediately find the cause of the problem and take appropriate measures.

In **Table 1. 1**, bearing failures, possible causes and countermeasures are shown.

Table 1. 1 Bearing failures, causes and countermeasures

Phenomena		Causes	Countermeasures	Notes
Temperature rise	Excessive	Excessively small quantity of lubricant	Check the quantity of the enclosed grease and the oil / air blow. Check that there is no leakage in the oil / air pipe.	Usually this phenomenon is accompanied by metallic noise. Grease may be deteriorated or leaking if this phenomenon occurs during normal operation in case of grease lubrication.
		Excessively large quantity of lubricant	Check the quantity of the enclosed grease and the oil / air blow.	In case of grease lubrication, the breaking-in may be insufficient.
		Angular contact ball bearing: excessive preload Cylindrical roller bearing: excessive negative clearance	Check the bearing axial clearance and mounting conditions.	Refer to case ① (page 189).
		Inadequate mounting precision	Check that there is no misalignment.	If reinstalling the bearing, it is necessary to check the precision of the parts after dismounting it.
		Insufficient cooling	Check the availability of the cooling capacity required.	
		External factors	Check that the belt tension is not excessive, the built-in motor is not heated excessively, and the coupling core is precisely placed.	
		Deterioration of bearing	Replace the bearing.	Usually this phenomenon is accompanied by torque rise.
	Instable	Oil / air lubrication: bad exhaust Grease lubrication: insufficient breaking-in	Check the oil / air exhaust route.	In case of oil / air lubrication, if the oil blows intermittently (irregularly) from the exhaust port, the exhaust (oil drainage) is not carried out correctly.
Noise	Metallic noise	Excessively small quantity of lubricant	Check the quantity of the enclosed grease and the oil / air blow. Check that there is no leakage in the oil / air pipe.	This phenomenon is accompanied by excessive temperature rise. Grease may be deteriorated or leaking if this phenomenon occurs during normal operation in case of grease lubrication.
	Continuous noise	Contact and interference between all rotating parts and all non-rotating parts	Check the conditions of the mounted parts, including the labyrinth.	If this phenomenon occurs during normal operation, it may be the secondary phenomenon of a temporal failure.
		Unbalanced shaft and imprecise rotation	Adjust the shaft balance. Readjust the rotational accuracy.	This phenomenon is accompanied by buzzing noise. If this phenomenon occurs during normal operation, it may be the secondary phenomenon of a temporal failure.
		Rough surface and brinelling of raceway	Replace the bearing in the case of entry of foreign matter, flaking, or excessive load.	Refer to cases ② and ③ (page 189 and 190). If there is no measure taken, this phenomenon may occur repeatedly.
	Intermittent noise	Noise of cages, and slippage because of preload leakage	If the preload is excessively small, check the axial clearance and mounting conditions of the bearing.	
Vibrations		Unbalanced shaft	Adjust the shaft balance. Readjust the rotational accuracy.	
		Excessive radial clearance of cylindrical roller bearing	Check the radial clearance of the bearing. Check the mounting conditions.	In case of the bearing with tapered bore, the shaft nut may be loose. Also, the wear may have worsened.
		Rough surface and brinelling of raceway	Replace the bearing in the case of entry of foreign matter, flaking, or excessive load.	Refer to cases ② and ③ (page 189 and 190).

Case ① Excessive bearing preload

Causes

1) Inadequate fitting

· Excessively large interference fitting of the inner ring

⇒Due to the increase of interference of the inner ring and the shaft, the diameter of the raceway expands and the preload increases.

· Excessively small clearance fitting of the outer ring

⇒If a temperature difference is generated between the outer ring and the housing, the outer ring is compressed and the diameter of the raceway shrinks, resulting in an increase in preload.

2) Inadequate tightening force of the bearing

· If the tightening force of the inner ring (nut shaft force etc.) is excessively large, the inner ring is deformed in axial direction and the preload increases.

3) Excessive cooling of the housing

· If the outer surface of the housing is excessively cooled, the phenomenon described in item **1)** is generated and the preload increases.

4) Failure in constant-pressure preloading and variable preloading system

· If the outer ring cannot be moved smoothly by the constant-pressure preloading and the preload variable spindle, the same phenomenon as in the case of the position preloading is generated, and an excessive preload is applied to the bearing.

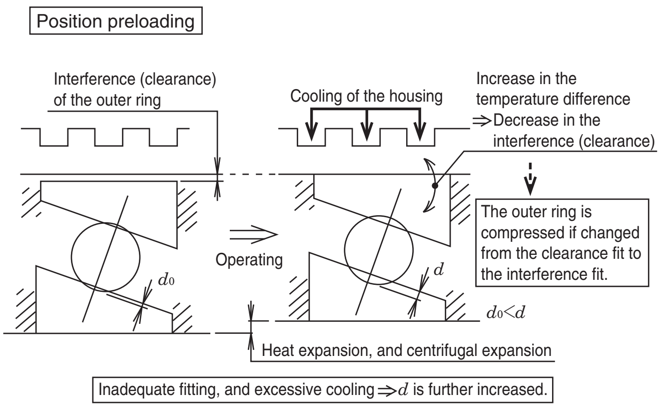


Fig. 1. 1 Cause of increase in preload

Case ② Entry of foreign matter

Major types of foreign matter are as follows.

· Coolant
· Chippings
· Iron chips (housing material)

Causes

1) Poor sealing performance

If the labyrinth is not adequately configured for use conditions, the sufficient sealing effect is not obtained, and foreign matter including coolant, may be trapped in the bearing.

2) Part not cleaned sufficiently

If the parts are not cleaned sufficiently, foreign matter such as small burrs and barbs may exist. This foreign matter may fall into the inside of the bearing during the operation.

3) Dirty lubricant

If the oil lubricant is not completely washed out of the pipe, or if the environment for the enclosing grease is not adequate, foreign matter may be trapped in the lubricant and the bearing may be damaged.

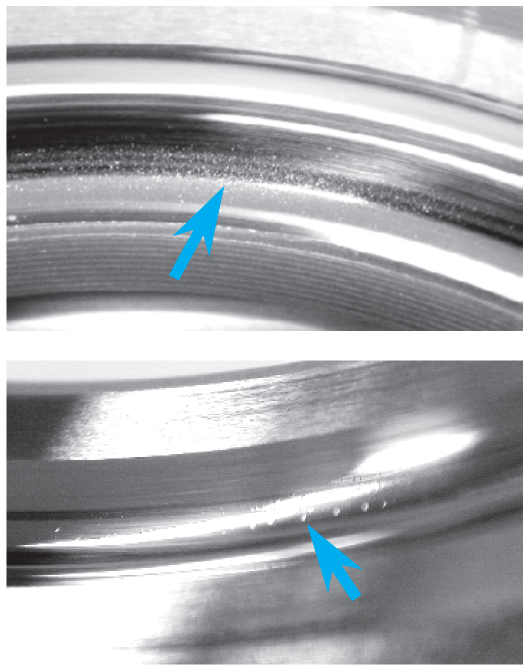


Fig. 1. 2 Example of biting flaws formed in raceway because of entry of foreign matter

Case ③ Damage on the raceway surface (nick and flaking)

Causes

1) Nick

Nick may be produced on the raceway surface if the main shaft is hit, any excessive load is applied to the bearing because of the clamping and unclamping of the tool, or the bearing is not properly handled.

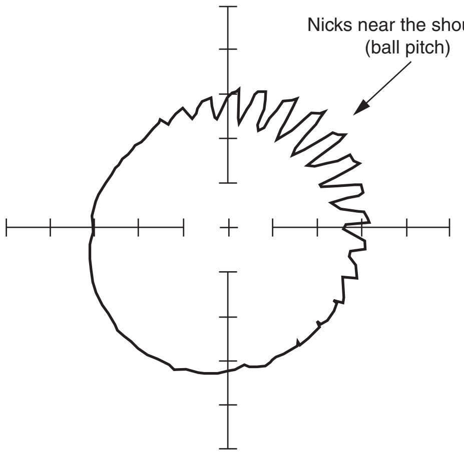


Fig. 1. 3 Example of nicks

2) Flaking

As the bearing becomes old, the flaking occurs if the load is applied repeatedly to the raceway surface.

However, even in case of a new bearing, the flaking may occur if an excessive load is applied to the bearing or the oil film is formed insufficiently.

Also, the flaking may be generated by the brinelling (nicks).

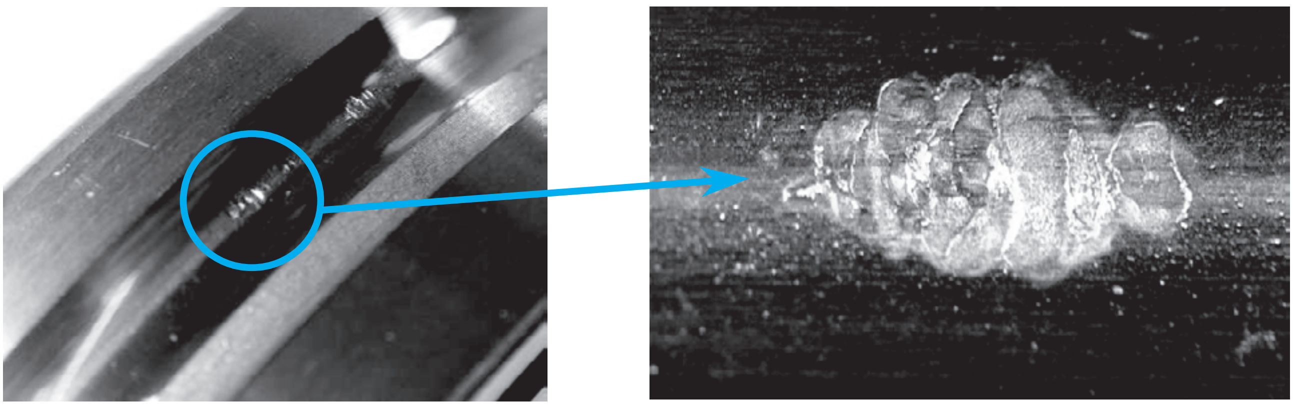


Fig. 1. 4 Example of flaking

Ⅴ. Supplementary Tables

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Supplementary table 1 Shaft tolerances (deviation from nominal dimensions)

Unit : μm

Nominal shaft dia. (mm) over	up to	g4	g5	g6	h4	h5	h6	h7	js3	js4	js5	js6	js7	j5	j6	j7
3	6	−4 −8	−4 −9	−4 −12	0 −4	0 −5	0 −8	0 −12	±1.2	±2	±2.5	±4	±6	+3 −2	+6 −2	+8 −4
6	10	−5 −9	−5 −11	−5 −14	0 −4	0 −6	0 −9	0 −15	±1.2	±2	±3	±4.5	±7.5	+4 −2	+7 −2	+10 −5
10	18	−6 −11	−6 −14	−6 −17	0 −5	0 −8	0 −11	0 −18	±1.5	±2.5	±4	±5.5	±9	+5 −3	+8 −3	+12 −6
18	30	−7 −13	−7 −16	−7 −20	0 −6	0 −9	0 −13	0 −21	±2	±3	±4.5	±6.5	±10.5	+5 −4	+9 −4	+13 −8
30	50	−9 −16	−9 −20	−9 −25	0 −7	0 −11	0 −16	0 −25	±2	±3.5	±5.5	±8	±12.5	+6 −5	+11 −5	+15 −10
50	80	−10 −18	−10 −23	−10 −29	0 −8	0 −13	0 −19	0 −30	±2.5	±4	±6.5	±9.5	±15	+6 −7	+12 −7	+18 −12
80	120	−12 −22	−12 −27	−12 −34	0 −10	0 −15	0 −22	0 −35	±3	±5	±7.5	±11	±17.5	+6 −9	+13 −9	+20 −15
120	180	−14 −26	−14 −32	−14 −39	0 −12	0 −18	0 −25	0 −40	±4	±6	±9	±12.5	±20	+7 −11	+14 −11	+22 −18
180	250	−15 −29	−15 −35	−15 −44	0 −14	0 −20	0 −29	0 −46	±5	±7	±10	±14.5	±23	+7 −13	+16 −13	+25 −21
250	315	−17 −33	−17 −40	−17 −49	0 −16	0 −23	0 −32	0 −52	±6	±8	±11.5	±16	±26	+7 −16	±16	±26
315	400	−18 −36	−18 −43	−18 −54	0 −18	0 −25	0 −36	0 −57	±6.5	±9	±12.5	±18	±28.5	+7 −18	±18	+29 −28
400	500	−20 −40	−20 −47	−20 −60	0 −20	0 −27	0 −40	0 −63	±7.5	±10	±13.5	±20	±31.5	+7 −20	±20	+31 −32
500	630	−22 −44	−22 −54	−22 −66	0 −22	0 −32	0 −44	0 −70	±8	±11	±16	±22	±35	—	—	—
630	800	−24 −49	−24 −60	−24 −74	0 −25	0 −36	0 −50	0 −80	±9	±12.5	±18	±25	±40	—	—	—
800	1 000	−26 −54	−26 −66	−26 −82	0 −28	0 −40	0 −56	0 −90	±10.5	±14	±20	±28	±45	—	—	—

Nominal shaft dia. (mm) over	up to	k3	k4	k5	k6	k7	m4	m5	m6	m7	n4	n5	n6	p6
3	6	+2.5 0	+5 +1	+6 +1	+9 +1	+13 +1	+8 +4	+9 +4	+12 +4	+16 +4	+12 +8	+13 +8	+16 +8	+20 +12
6	10	+2.5 0	+5 +1	+7 +1	+10 +1	+16 +1	+10 +6	+12 +6	+15 +6	+21 +6	+14 +10	+16 +10	+19 +10	+24 +15
10	18	+3 0	+6 +1	+9 +1	+12 +1	+19 +1	+12 +7	+15 +7	+18 +7	+25 +7	+17 +12	+20 +12	+23 +12	+29 +18
18	30	+4 0	+8 +2	+11 +2	+15 +2	+23 +2	+14 +8	+17 +8	+21 +8	+29 +8	+21 +15	+24 +15	+28 +15	+35 +22
30	50	+4 0	+9 +2	+13 +2	+18 +2	+27 +2	+16 +9	+20 +9	+25 +9	+34 +9	+24 +17	+28 +17	+33 +17	+42 +26
50	80	+5 0	+10 +2	+15 +2	+21 +2	+32 +2	+19 +11	+24 +11	+30 +11	+41 +11	+28 +20	+33 +20	+39 +20	+51 +32
80	120	+6 0	+13 +3	+18 +3	+25 +3	+38 +3	+23 +13	+28 +13	+35 +13	+48 +13	+33 +23	+38 +23	+45 +23	+59 +37
120	180	+8 0	+15 +3	+21 +3	+28 +3	+43 +3	+27 +15	+33 +15	+40 +15	+55 +15	+39 +27	+45 +27	+52 +27	+68 +43
180	250	+10 0	+18 +4	+24 +4	+33 +4	+50 +4	+31 +17	+37 +17	+46 +17	+63 +17	+45 +31	+51 +31	+60 +31	+79 +50
250	315	+12 0	+20 +4	+27 +4	+36 +4	+56 +4	+36 +20	+43 +20	+52 +20	+72 +20	+50 +34	+57 +34	+66 +34	+88 +56
315	400	+13 0	+22 +4	+29 +4	+40 +4	+61 +4	+39 +21	+46 +21	+57 +21	+78 +21	+55 +37	+62 +37	+73 +37	+98 +62
400	500	+15 0	+25 +5	+32 +5	+45 +5	+68 +5	+43 +23	+50 +23	+63 +23	+86 +23	+60 +40	+67 +40	+80 +40	+108 +68
500	630	+16 0	+22 0	+32 0	+44 0	+70 0	+48 +26	+58 +26	+70 +26	+96 +26	+66 +44	+76 +44	+88 +44	+122 +78
630	800	+18 0	+25 0	+36 0	+50 0	+80 0	+55 +30	+66 +30	+80 +30	+110 +30	+75 +50	+86 +50	+100 +50	+138 +88
800	1 000	+21 0	+28 0	+40 0	+56 0	+90 0	+62 +34	+74 +34	+90 +34	+124 +34	+84 +56	+96 +56	+112 +56	+156 +100

r5	r6	r7	Nominal shaft dia. (mm) over	up to
+20 +15	+23 +15	+27 +15	3	6
+25 +19	+28 +19	+34 +19	6	10
+31 +23	+34 +23	+41 +23	10	18
+37 +28	+41 +28	+49 +28	18	30
+45 +34	+50 +34	+59 +34	30	50
+54 +41	+60 +41	+71 +41	50	65
+56 +43	+62 +43	+73 +43	65	80
+66 +51	+73 +51	+86 +51	80	100
+69 +54	+76 +54	+89 +54	100	120
+81 +63	+88 +63	+103 +63	120	140
+83 +65	+90 +65	+105 +65	140	160
+86 +68	+93 +68	+108 +68	160	180
+97 +77	+106 +77	+123 +77	180	200
+100 +80	+109 +80	+126 +80	200	225
+104 +84	+113 +84	+130 +84	225	250
+117 +94	+126 +94	+146 +94	250	280
+121 +98	+130 +98	+150 +98	280	315
+133 +108	+144 +108	+165 +108	315	355
+139 +114	+150 +114	+171 +114	355	400
+153 +126	+166 +126	+189 +126	400	450
+159 +132	+172 +132	+195 +132	450	500
+182 +150	+194 +150	+220 +150	500	560
+187 +155	+199 +155	+225 +155	560	630
+211 +175	+225 +175	+255 +175	630	710
+221 +185	+235 +185	+265 +185	710	800
+250 +210	+266 +210	+300 +210	800	900
+260 +220	+276 +220	+310 +220	900	1 000

Supplementary table 2 Housing bore tolerances (deviation from nominal dimensions)

Unit : μm

Nominal bore dia. (mm) over	up to	G5	G6	G7	H4	H5	H6	H7	H8	JS4	JS5	JS6	JS7	J6	J7
10	18	+14 +6	+17 +6	+24 +6	+5 0	+8 0	+11 0	+18 0	+27 0	±2.5	±4	±5.5	±9	+6 −5	+10 −8
18	30	+16 +7	+20 +7	+28 +7	+6 0	+9 0	+13 0	+21 0	+33 0	±3	±4.5	±6.5	±10.5	+8 −5	+12 −9
30	50	+20 +9	+25 +9	+34 +9	+7 0	+11 0	+16 0	+25 0	+39 0	±3.5	±5.5	±8	±12.5	+10 −6	+14 −11
50	80	+23 +10	+29 +10	+40 +10	+8 0	+13 0	+19 0	+30 0	+46 0	±4	±6.5	±9.5	±15	+13 −6	+18 −12
80	120	+27 +12	+34 +12	+47 +12	+10 0	+15 0	+22 0	+35 0	+54 0	±5	±7.5	±11	±17.5	+16 −6	+22 −13
120	180	+32 +14	+39 +14	+54 +14	+12 0	+18 0	+25 0	+40 0	+63 0	±6	±9	±12.5	±20	+18 −7	+26 −14
180	250	+35 +15	+44 +15	+61 +15	+14 0	+20 0	+29 0	+46 0	+72 0	±7	±10	±14.5	±23	+22 −7	+30 −16
250	315	+40 +17	+49 +17	+69 +17	+16 0	+23 0	+32 0	+52 0	+81 0	±8	±11.5	±16	±26	+25 −7	+36 −16
315	400	+43 +18	+54 +18	+75 +18	+18 0	+25 0	+36 0	+57 0	+89 0	±9	±12.5	±18	±28.5	+29 −7	+39 −18
400	500	+47 +20	+60 +20	+83 +20	+20 0	+27 0	+40 0	+63 0	+97 0	±10	±13.5	±20	±31.5	+33 −7	+43 −20
500	630	+54 +22	+66 +22	+92 +22	+22 0	+32 0	+44 0	+70 0	+110 0	±11	±16	±22	±35	—	—
630	800	+60 +24	+74 +24	+104 +24	+25 0	+36 0	+50 0	+80 0	+125 0	±12.5	±18	±25	±40	—	—
800	1 000	+66 +26	+82 +26	+116 +26	+28 0	+40 0	+56 0	+90 0	+140 0	±14	±20	±28	±45	—	—
1 000	1 250	+75 +28	+94 +28	+133 +28	+33 0	+47 0	+66 0	+105 0	+165 0	±16.5	±23.5	±33	±52.5	—	—

K4	K5	K6	K7	M4	M5	M6	M7	N4	N5	N6	N7	P5	P6	P7	Nominal bore dia. (mm) over	up to
+1 −4	+2 −6	+2 −9	+6 −12	−5 −10	−4 −12	−4 −15	0 −18	−10 −15	−9 −17	−9 −20	−5 −23	−15 −23	−15 −26	−11 −29	10	18
0 −6	+1 −8	+2 −11	+6 −15	−6 −12	−5 −14	−4 −17	0 −21	−13 −19	−12 −21	−11 −24	−7 −28	−19 −28	−18 −31	−14 −35	18	30
+1 −6	+2 −9	+3 −13	+7 −18	−6 −13	−5 −16	−4 −20	0 −25	−14 −21	−13 −24	−12 −28	−8 −33	−22 −33	−21 −37	−17 −42	30	50
+1 −7	+3 −10	+4 −15	+9 −21	−8 −16	−6 −19	−5 −24	0 −30	−17 −25	−15 −28	−14 −33	−9 −39	−27 −40	−26 −45	−21 −51	50 65	65 80
+1 −9	+2 −13	+4 −18	+10 −25	−9 −19	−8 −23	−6 −28	0 −35	−19 −29	−18 −33	−16 −38	−10 −45	−32 −47	−30 −52	−24 −59	80 100	100 120
+1 −11	+3 −15	+4 −21	+12 −28	−11 −23	−9 −27	−8 −33	0 −40	−23 −35	−21 −39	−20 −45	−12 −52	−37 −55	−36 −61	−28 −68	120 140 160	140 160 180
0 −14	+2 −18	+5 −24	+13 −33	−13 −27	−11 −31	−8 −37	0 −46	−27 −41	−25 −45	−22 −51	−14 −60	−44 −64	−41 −70	−33 −79	180 200 225	200 225 250
0 −16	+3 −20	+5 −27	+16 −36	−16 −32	−13 −36	−9 −41	0 −52	−30 −46	−27 −50	−25 −57	−14 −66	−49 −72	−47 −79	−36 −88	250 280	280 315
+1 −17	+3 −22	+7 −29	+17 −40	−16 −34	−14 −39	−10 −46	0 −57	−32 −50	−30 −55	−26 −62	−16 −73	−55 −80	−51 −87	−41 −98	315 355	355 400
0 −20	+2 −25	+8 −32	+18 −45	−18 −38	−16 −43	−10 −50	0 −63	−35 −55	−33 −60	−27 −67	−17 −80	−61 −88	−55 −95	−45 −108	400 450	450 500
0 −22	0 −32	0 −44	0 −70	−26 −48	−26 −58	−26 −70	−26 −96	−44 −66	−44 −76	−44 −88	−44 −114	−78 −110	−78 −122	−78 −148	500 560	560 630
0 −25	0 −36	0 −50	0 −80	−30 −55	−30 −66	−30 −80	−30 −110	−50 −75	−50 −86	−50 −100	−50 −130	−88 −124	−88 −138	−88 −168	630 710	710 800
0 −28	0 −40	0 −56	0 −90	−34 −62	−34 −74	−34 −90	−34 −124	−56 −84	−56 −96	−56 −112	−56 −146	−100 −140	−100 −156	−100 −190	800 900	900 1 000
0 −33	0 −47	0 −66	0 −105	−40 −73	−40 −87	−40 −106	−40 −145	−66 −99	−66 −113	−66 −132	−66 −171	−120 −167	−120 −186	−120 −225	1 000 1 120	1 120 1 250

Supplementary table 3 Numerical values for standard tolerance grades IT (ISO 286-1)

Basic size (mm)		Standard tolerance grades (IT)																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14[1]	15[1]	16[1]	17[1]	18[1]
over	up to	Tolerances (µm)											Tolerances (mm)						
—	3	0.8	1.2	2	3	4	6	10	14	25	40	60	0.10	0.14	0.26	0.40	0.60	1.00	1.40
3	6	1	1.5	2.5	4	5	8	12	18	30	48	75	0.12	0.18	0.30	0.48	0.75	1.20	1.80
6	10	1	1.5	2.5	4	6	9	15	22	36	58	90	0.15	0.22	0.36	0.58	0.90	1.50	2.20
10	18	1.2	2	3	5	8	11	18	27	43	70	110	0.18	0.27	0.43	0.70	1.10	1.80	2.70
18	30	1.5	2.5	4	6	9	13	21	33	52	84	130	0.21	0.33	0.52	0.84	1.30	2.10	3.30
30	50	1.5	2.5	4	7	11	16	25	39	62	100	160	0.25	0.39	0.62	1.00	1.60	2.50	3.90
50	80	2	3	5	8	13	19	30	46	74	120	190	0.30	0.46	0.74	1.20	1.90	3.00	4.60
80	120	2.5	4	6	10	15	22	35	54	87	140	220	0.35	0.54	0.87	1.40	2.20	3.50	5.40
120	180	3.5	5	8	12	18	25	40	63	100	160	250	0.40	0.63	1.00	1.60	2.50	4.00	6.30
180	250	4.5	7	10	14	20	29	46	72	115	185	290	0.46	0.72	1.15	1.85	2.90	4.60	7.20
250	315	6	8	12	16	23	32	52	81	130	210	320	0.52	0.81	1.30	2.10	3.20	5.20	8.10
315	400	7	9	13	18	25	36	57	89	140	230	360	0.57	0.89	1.40	2.30	3.60	5.70	8.90
400	500	8	10	15	20	27	40	63	97	155	250	400	0.63	0.97	1.55	2.50	4.00	6.30	9.70
500	630	—	—	—	—	—	44	70	110	175	280	440	0.70	1.10	1.75	2.80	4.40	7.00	11.00
630	800	—	—	—	—	—	50	80	125	200	320	500	0.80	1.25	2.00	3.20	5.00	8.00	12.50
800	1 000	—	—	—	—	—	56	90	140	230	360	560	0.90	1.40	2.30	3.60	5.60	9.00	14.00
1 000	1 250	—	—	—	—	—	66	105	165	260	420	660	1.05	1.65	2.60	4.20	6.60	10.50	16.50
1 250	1 600	—	—	—	—	—	78	125	195	310	500	780	1.25	1.95	3.10	5.00	7.80	12.50	19.50
1 600	2 000	—	—	—	—	—	92	150	230	370	600	920	1.50	2.30	3.70	6.00	9.20	15.00	23.00
2 000	2 500	—	—	—	—	—	110	175	280	440	700	1 100	1.75	2.80	4.40	7.00	11.00	17.50	28.00
2 500	3 150	—	—	—	—	—	135	210	330	540	860	1 350	2.10	3.30	5.40	8.60	13.50	21.00	33.00

[Note] 1) Standard tolerance grades IT 14 to IT 18 (incl.) shall not be used for basic sizes less than or equal to 1 mm.

Supplementary table 4　Steel hardness conversion

Rockwell C-scale 1 471.0 N(150 kgf)	Vicker's	Brinell Standard ball	Brinell Tungsten carbide ball	Rockwell A-scale 588.4 N(60 kgf)	Rockwell B-scale 980.7 N(100 kgf)	Shore
68	940			85.6		97
67	900			85.0		95
66	865			84.5		92
65	832		739	83.9		91
64	800		722	83.4		88
63	772		705	82.8		87
62	746		688	82.3		85
61	720		670	81.8		83
60	697		654	81.2		81
59	674		634	80.7		80
58	653		615	80.1		78
57	633		595	79.6		76
56	613		577	79.0		75
55	595	—	560	78.5		74
54	577	—	543	78.0		72
53	560	—	525	77.4		71
52	544	500	512	76.8		69
51	528	487	496	76.3		68
50	513	475	481	75.9		67
49	498	464	469	75.2		66
48	484	451	455	74.7		64
47	471	442	443	74.1		63
46	458	432		73.6		62
45	446	421		73.1		60
44	434	409		72.5		58
43	423	400		72.0		57
42	412	390		71.5		56
41	402	381		70.9		55
40	392	371		70.4	—	54
39	382	362		69.9	—	52
38	372	353		69.4	—	51
37	363	344		68.9	—	50
36	354	336		68.4	(109.0)	49
35	345	327		67.9	(108.5)	48
34	336	319		67.4	(108.0)	47
33	327	311		66.8	(107.5)	46
32	318	301		66.3	(107.0)	44
31	310	294		65.8	(106.0)	43
30	302	286		65.3	(105.5)	42
29	294	279		64.7	(104.5)	41
28	286	271		64.3	(104.0)	41
27	279	264		63.8	(103.0)	40
26	272	258		63.3	(102.5)	38
25	266	253		62.8	(101.5)	38
24	260	247		62.4	(101.0)	37
23	254	243		62.0	100.0	36
22	248	237		61.5	99.0	35
21	243	231		61.0	98.5	35
20	238	226		60.5	97.8	34
(18)	230	219		—	96.7	33
(16)	222	212		—	95.5	32
(14)	213	203		—	93.9	31
(12)	204	194		—	92.3	29
(10)	196	187			90.7	28
(8)	188	179			89.5	27
(6)	180	171			87.1	26
(4)	173	165			85.5	25
(2)	166	158			83.5	24
(0)	160	152			81.7	24

Supplementary table 5(1) SI units and conversion factors

Mass	SI units	Other units [1]	Conversion into SI units	Conversion from SI units
Angle	rad [radian(s)]	° [degree(s)] * ' [minute(s)] * " [second(s)] *	1° = π /180 rad 1' = π /10 800 rad 1" = π /648 000 rad	1 rad = 57.295 78°
Length	m [meter(s)]	Å [Angstrom unit] μ [micron(s)] in [inch(es)] ft [foot(feet)] yd [yard(s)] mile [mile(s)]	1Å = 10^{-10}m = 0.1 nm = 100 pm 1μ = 1 μm 1in = 25.4 mm 1ft = 12 in = 0.304 8 m 1yd = 3 ft = 0.914 4 m 1mile = 5 280 ft = 1 609.344 m	1m = 10^{10}Å 1m = 39.37 in 1m = 3.280 8 ft 1m = 1.093 6 yd 1km = 0.621 4 mile
Area	m^2	a [are(s)] ha [hectare(s)] acre [acre(s)]	1a = 100 m^2 1ha = 10^4 m^2 1acre = 4 840 yd^2 = 4 046.86 m^2	 1km^2 = 247.1 acre
Volume	m^3	ℓ, L [liter(s)] * cc [cubic centimeters] gal(US) [gallon(s)] floz(US) [fluid ounce(s)] barrel(US) [barrels(US)]	1 ℓ = 1 dm^3 = 10^{-3} m^3 1cc = 1 cm^3 = 10^{-6} m^3 1gal(US) = 231 in^3 = 3.785 41dm^3 1floz(US) = 29.573 5 cm^3 1barrel(US) = 158.987 dm^3	1m^3 = 10^3 ℓ 1m^3 = 10^6 cc 1m^3 = 264.17 gal 1m^3 = 33 814 floz 1m^3 = 6.289 8 barrel
Time	s [second(s)]	min [minute(s)] * h [hour(s)] * d [day(s)] *		
Angular velocity	rad / s			
Velocity	m / s	kn [knot(s)] m / h *	1kn = 1 852 m / h	1km / h = 0.539 96 kn
Acceleration	m / s^2	G	1G = 9.806 65 m / s^2	1m / s^2 = 0.101 97 G
Frequency	Hz [hertz]	c / s [cycle(s)/second]	1c / s = 1s^{-1} = 1 Hz	
Rotational frequency	s^{-1}	rpm [revolutions per minute] min^{-1} * r / min	1rpm = 1 / 60 s^{-1}	1s^{-1} = 60 rpm
Mass	kg [kilogram(s)]	t [ton(s)] * lb [pound(s)] gr [grain(s)] oz [ounce(s)] ton (UK) [ton(s) (UK)] ton (US) [ton(s) (US)] car [carat(s)]	1t = 10^3 kg 1lb = 0.453 592 37 kg 1gr = 64.798 91 mg 1oz = 1/16 lb = 28.349 5 g 1ton(UK) = 1 016.05 kg 1ton(US) = 907.185 kg 1car = 200 mg	 1kg = 2.204 6 lb 1g = 15.432 4 gr 1kg = 35.274 0 oz 1t = 0.984 2 ton (UK) 1t = 1.102 3 ton (US) 1g = 5 car

[Notes] 1) * : Unit can be used as an SI unit.
No asterisk : Unit cannot be used.

Supplementary table 5(2) SI units and conversion factors

Mass	SI units	Other units [1)]	Conversion into SI units	Conversion from SI units
Density	kg / m³			
Linear density	kg / m			
Momentum	kg·m / s			
Moment of momentum, angular momentum	kg·m² / s			
Moment of inertia	kg·m²			
Force	N [newton(s)]	dyn [dyne(s)] kgf [kilogram-force] gf [gram-force] tf [ton-force] lbf [pound-force]	1dyn = 10^{-5} N 1kgf = 9.806 65 N 1gf = 9.806 65×10^{-3} N 1tf = 9.806 65×10^{3} N 1lbf = 4.448 22N	1N = 10^{5} dyn 1N = 0.101 97 kgf 1N = 0.224 809 lbf
Moment of force	N·m [Newton meter(s)]	gf·cm kgf·cm kgf·m tf·m lbf·ft	1gf·cm = 9.806 65×10^{-5} N·m 1kgf·cm = 9.806 65×10^{-2} N·m 1kgf·m = 9.806 65 N·m 1tf·m = 9.806 65×10^{3} N·m 1lbf·ft = 1.355 82 N·m	 1N·m = 0.101 97 kgf·m 1N·m = 0.737 56 lbf·ft
Pressure, Normal stress	Pa [Pascal(s)] or N / m² {1 Pa = 1 N / m²}	gf / cm² kgf / mm² kgf / m² lbf / in² bar [bar(s)] at [engineering air pressure] mH_2O, mAq [meter water column] atm [atmosphere] mHg [meter merury column] Torr [torr]	1gf / cm² = 9.806 65×10 Pa 1kgf / mm² = 9.806 65×10^{6} Pa 1kgf / m² = 9.806 65 Pa 1lbf / in² = 6 894.76 Pa 1bar = 10^{5} Pa 1at = 1kgf / cm² = 9.806 65×10^{4} Pa 1mH_2O = 9.806 65×10^{3} Pa 1atm = 101 325 Pa 1mHg = $\frac{101\ 325}{0.76}$ Pa 1Torr = 1 mmHg = 133.322 Pa	 1MPa = 0.101 97 kgf / mm² 1Pa = 0.101 97 kgf / m² 1Pa = 0.145×10^{-3} lbf / in² 1Pa = 10^{-2} mbar 1Pa = 7.500 6×10^{-3} Torr
Viscosity	Pa·s [pascal second]	P [poise] kgf·s / m²	10^{-2} P = 1 cP = 1 mPa·s 1kgf·s / m² = 9.806 65 Pa·s	 1Pa·s = 0.101 97 kgf·s / m²
Kinematic viscosity	m² / s	St [stokes]	10^{-2} St = 1 cSt = 1 mm² / s	
Surface tension	N / m			

Supplementary table 5(3) SI units and conversion factors

Mass	SI units	Other units [1)]	Conversion into SI units	Conversion from SI units
Work, energy	J [joule(s)] {1 J = 1 N·m}	eV [electron volt(s)] * erg [erg(s)] kgf·m lbf·ft	1eV = (1.602 189 2±0.000 004 6)×10^{-19} J 1 erg = 10^{-7} J 1kgf·m = 9.806 65 J 1 lbf·ft = 1.355 82 J	1 J = 10^{7} erg 1 J = 0.101 97 kgf·m 1 J = 0.737 56 lbf·ft
Power	W [watt(s)]	erg / s [ergs per second] kgf·m / s PS [French horse-power] HP [horse-power (British)] lbf·ft / s	1 erg / s = 10^{-7} W 1 kgf·m / s = 9.806 65 W 1 PS = 75 kgf·m / s = 735.5 W 1 HP = 550 lbf·ft / s = 745.7 W 1 lbf·ft / s = 1.355 82 W	1 W = 0.101 97 kgf·m / s 1 W = 0.001 36 PS 1 W = 0.001 34 HP
Thermo-dynamic temperature	K [kelvin(s)]			
Celsius temperature	℃ [Celsius(s)] {t℃ = (t+273.15)K}	℉ [degree(s) Fahrenheit]	t ℉ = $\frac{5}{9}$(t−32)℃	t ℃ = ($\frac{9}{5}$t+32)℉
Linear expansion coefficient	K^{-1}	$℃^{-1}$ [per degree]		
Heat	J [joule(s)] {1 J = 1 N·m}	erg [erg(s)] kgf·m cal_{IT} [I. T. calories]	1 erg = 10^{-7} J 1 cal_{IT} = 4.186 8 J 1 $Mcal_{IT}$ = 1.163 kW·h	1 J = 10^{7} erg 1 J = 0.238 85 cal_{IT} 1 kW·h = 0.86×10^{6} cal_{IT}
Thermal conductivity	W / (m·K)	W / (m·℃) cal / (s·m·℃)	1 W / (m·℃) = 1 W / (m·K) 1 cal / (s·m·℃) = 4.186 05 W / (m·K)	
Coefficient of heat transfer	W / (m^2·K)	W / (m^2·℃) cal / (s·m^2·℃)	1 W / (m^2·℃) = 1 W / (m^2·K) 1 cal / (s·m^2·℃) = 4.186 05 W / (m^2·K)	
Heat capacity	J / K	J / ℃	1 J / ℃ = 1 J / K	
Massic heat capacity	J / (kg·K)	J / (kg·℃)		

[Notes] 1) * : Unit can be used as an SI unit.
No asterisk : Unit cannot be used.

Supplementary table 5(4) SI units and conversion factors

Mass	SI units	Other units [1]	Conversion into SI units	Conversion from SI units
Electric current	A [ampere(s)]			
Electric charge, quantity of electricity	C [coulomb(s)] {1 C = 1 A·s}	A·h *	1 A·h = 3.6 kC	
Tension, electric potential	V [volt(s)] {1 V = 1 W / A}			
Capacitance	F [farad(s)] {1 F = 1 C / V}			
Magnetic field strength	A / m	Oe [oersted(s)]	$1\ Oe = \frac{10^3}{4\pi}\ A/m$	$1\ A/m = 4\pi \times 10^{-3}\ Oe$
Magnetic flux density	T [tesla(s)] {1 T = 1 N/(A·m) = 1 Wb/m² = 1 V·s/m²}	Gs [gauss(es)] γ [gamma(s)]	$1\ Gs = 10^{-4}\ T$ $1\ \gamma = 10^{-9}\ T$	$1\ T = 10^{4}\ Gs$ $1\ T = 10^{9}\ \gamma$
Magnetic flux	Wb [weber(s)] {1 Wb = 1 V·s}	Mx [maxwell(s)]	$1\ Mx = 10^{-8}\ Wb$	$1\ Wb = 10^{8}\ Mx$
Self inductance	H [henry(-ries)] {1 H = 1 Wb / A}			
Resistance (to direct current)	Ω [ohm(s)] {1 Ω = 1 V / A}			
Conductance (to direct current)	S [siemens] {1 S = 1 A / V}			
Active power	W {1 W = 1 J / s = 1 A·V}			

[Refer.] Principal units conversion table

Force

N	dyn	kgf
1	1×10^{5}	$1.019\ 72\times10^{-1}$
1×10^{-5}	1	$1.019\ 72\times10^{-6}$
9.806 65	$9.806\ 65\times10^{5}$	1

Torque

N·m	mN·m	μN·m	kgf·m	kgf·cm	gf·cm
1	1×10^{3}	1×10^{6}	$1.019\ 72\times10^{-1}$	$1.019\ 72\times10$	$1.019\ 72\times10^{4}$
1×10^{-3}	1	1×10^{3}	$1.019\ 72\times10^{-4}$	$1.019\ 72\times10^{-2}$	$1.019\ 72\times10$
1×10^{-6}	1×10^{-3}	1	$1.019\ 72\times10^{-7}$	$1.019\ 72\times10^{-5}$	$1.019\ 72\times10^{-2}$
9.806 65	$9.806\ 65\times10^{3}$	$9.806\ 65\times10^{6}$	1	1×10^{2}	1×10^{5}
$9.806\ 65\times10^{-2}$	$9.806\ 65\times10$	$9.806\ 65\times10^{4}$	1×10^{-2}	1	1×10^{3}
$9.806\ 65\times10^{-5}$	$9.806\ 65\times10^{-2}$	$9.806\ 65\times10$	1×10^{-5}	1×10^{-3}	1

Stress

Pa or N/m²	MPa or N/mm²	kgf/mm²	kgf/cm²
1	1×10^{-6}	$1.019\ 72\times10^{-7}$	$1.019\ 72\times10^{-5}$
1×10^{6}	1	$1.019\ 72\times10^{-1}$	$1.019\ 72\times10$
$9.806\ 65\times10^{6}$	9.806 65	1	1×10^{2}
$9.806\ 65\times10^{4}$	$9.806\ 65\times10^{-2}$	1×10^{-2}	1

[Note] 1 Pa=1 N/m², 1 MPa=1 N/mm²

Pressure

Pa	kPa	MPa	bar	kgf/cm²	atm	mmH_2O	mmHg or Torr
1	1×10^{-3}	1×10^{-6}	1×10^{-5}	$1.019\ 72\times10^{-5}$	$9.869\ 23\times10^{-6}$	$1.019\ 72\times10^{-1}$	$7.500\ 62\times10^{-3}$
1×10^{3}	1	1×10^{-3}	1×10^{-2}	$1.019\ 72\times10^{-2}$	$9.869\ 23\times10^{-3}$	$1.019\ 72\times10^{2}$	7.500 62
1×10^{6}	1×10^{3}	1	1×10	$1.019\ 72\times10$	9.869 23	$1.019\ 72\times10^{5}$	$7.500\ 62\times10^{3}$
1×10^{5}	1×10^{2}	1×10^{-1}	1	1.019 72	$9.869\ 23\times10^{-1}$	$1.019\ 72\times10^{4}$	$7.500\ 62\times10^{2}$
$9.806\ 65\times10^{4}$	$9.806\ 65\times10$	$9.806\ 65\times10^{-2}$	$9.806\ 65\times10^{-1}$	1	$9.678\ 41\times10^{-1}$	1×10^{4}	$7.355\ 59\times10^{2}$
$1.013\ 25\times10^{5}$	$1.013\ 25\times10^{2}$	$1.013\ 25\times10^{-1}$	1.013 25	1.033 23	1	$1.033\ 23\times10^{4}$	$7.600\ 00\times10^{2}$
9.806 65	$9.806\ 65\times10^{-3}$	$9.806\ 65\times10^{-6}$	$9.806\ 65\times10^{-5}$	1×10^{-4}	$9.678\ 41\times10^{-5}$	1	$7.355\ 59\times10^{-2}$
$1.333\ 22\times10^{2}$	$1.333\ 22\times10^{-1}$	$1.333\ 22\times10^{-4}$	$1.333\ 22\times10^{-3}$	$1.359\ 51\times10^{-3}$	$1.315\ 79\times10^{-3}$	$1.359\ 51\times10$	1

[Note] 1 Pa=1 N/m²

Kinematic viscosity

m²/s	cSt	St
1	1×10^{6}	1×10^{4}
1×10^{-6}	1	1×10^{-2}
1×10^{-4}	1×10^{2}	1

[Note] 1 cSt=1 mm²/s, 1 St=1 cm²/s

Supplementary table 6 Lubrication (discharge) intervals of the oil / air

<table>
<tr><th rowspan="3">Preloading method</th><th rowspan="3">Material of rolling element</th><th rowspan="3">Oil viscosity</th><th colspan="11">$d_m n$ value (×10^4)</th></tr>
<tr><th>over</th><th>—</th><th>70</th><th>85</th><th>100</th><th>125</th><th>150</th><th>175</th><th>200</th><th>225</th><th>250</th></tr>
<tr><th>up to</th><th>70</th><th>85</th><th>100</th><th>125</th><th>150</th><th>175</th><th>200</th><th>225</th><th>250</th><th></th></tr>
<tr><td rowspan="12">Position preloading</td><td rowspan="6">Bearing steel (SUJ2)</td><td rowspan="2">ISO VG10</td><td>Standard</td><td>5-10 Minute</td><td colspan="2">3-8 Minute</td><td>2-6 Minute</td><td colspan="6">Consult JTEKT.</td></tr>
<tr><td>High Ability</td><td colspan="2">5-10 Minute</td><td colspan="2">3-8 Minute</td><td>2-6 Minute</td><td colspan="5"></td></tr>
<tr><td rowspan="2">ISO VG22</td><td>Standard</td><td>6-12 Minute</td><td colspan="2">4-10 Minute</td><td>3-6 Minute</td><td colspan="6"></td></tr>
<tr><td>High Ability</td><td colspan="2">6-12 Minute</td><td colspan="2">4-10 Minute</td><td>3-6 Minute</td><td colspan="5"></td></tr>
<tr><td rowspan="2">ISO VG32</td><td>Standard</td><td>10-18 Minute</td><td colspan="2">6-15 Minute</td><td>4-12 Minute</td><td colspan="6"></td></tr>
<tr><td>High Ability</td><td colspan="2">10-18 Minute</td><td colspan="2">6-15 Minute</td><td>4-12 Minute</td><td colspan="5"></td></tr>
<tr><td rowspan="6">Ceramics (Si_3N_4)</td><td rowspan="2">ISO VG10</td><td>Standard</td><td colspan="2">4-10 Minute</td><td colspan="2">2-8 Minute</td><td>1-5 Minute</td><td colspan="5">Consult JTEKT.</td></tr>
<tr><td>High Ability</td><td colspan="3">4-10 Minute</td><td colspan="2">2-8 Minute</td><td>1-5 Minute</td><td colspan="4"></td></tr>
<tr><td rowspan="2">ISO VG22</td><td>Standard</td><td colspan="2">6-12 Minute</td><td colspan="2">4-10 Minute</td><td>3-6 Minute</td><td colspan="5"></td></tr>
<tr><td>High Ability</td><td colspan="3">6-12 Minute</td><td colspan="2">4-10 Minute</td><td>3-6 Minute</td><td colspan="4"></td></tr>
<tr><td rowspan="2">ISO VG32</td><td>Standard</td><td colspan="2">10-18 Minute</td><td colspan="2">6-15 Minute</td><td>4-12 Minute</td><td colspan="5"></td></tr>
<tr><td>High Ability</td><td colspan="3">10-18 Minute</td><td colspan="2">6-15 Minute</td><td>4-12 Minute</td><td colspan="4"></td></tr>
<tr><td rowspan="12">Constant-pressure preloading</td><td rowspan="6">Bearing steel (SUJ2)</td><td rowspan="2">ISO VG10</td><td>Standard</td><td colspan="3">4-10 Minute</td><td colspan="2">2-8 Minute</td><td colspan="5">Consult JTEKT.</td></tr>
<tr><td>High Ability</td><td colspan="4">4-10 Minute</td><td colspan="2">2-8 Minute</td><td colspan="4"></td></tr>
<tr><td rowspan="2">ISO VG22</td><td>Standard</td><td colspan="3">6-12 Minute</td><td colspan="2">3-10 Minute</td><td colspan="5"></td></tr>
<tr><td>High Ability</td><td colspan="4">6-12 Minute</td><td colspan="2">3-10 Minute</td><td colspan="4"></td></tr>
<tr><td rowspan="2">ISO VG32</td><td>Standard</td><td colspan="3">10-18 Minute</td><td colspan="2">6-15 Minute</td><td colspan="5"></td></tr>
<tr><td>High Ability</td><td colspan="4">10-18 Minute</td><td colspan="2">6-15 Minute</td><td colspan="4"></td></tr>
<tr><td rowspan="6">Ceramics (Si_3N_4)</td><td rowspan="2">ISO VG10</td><td>Standard</td><td colspan="4">4-10 Minute</td><td colspan="2">2-8 Minute</td><td>1-5 Minute</td><td>1-3 Minute</td><td colspan="2"></td></tr>
<tr><td>High Ability</td><td colspan="5">4-10 Minute</td><td colspan="2">2-8 Minute</td><td>1-5 Minute</td><td>1-3 Minute</td><td rowspan="2">Consult JTEKT.</td></tr>
<tr><td rowspan="2">ISO VG22</td><td>Standard</td><td colspan="4">6-12 Minute</td><td colspan="2">3-10 Minute</td><td>2-6 Minute</td><td>2-4 Minute</td><td>1-3 Minute</td></tr>
<tr><td>High Ability</td><td colspan="5">6-12 Minute</td><td colspan="2">3-10 Minute</td><td>2-6 Minute</td><td>2-4 Minute</td><td>1-3 Minute</td></tr>
<tr><td rowspan="2">ISO VG32</td><td>Standard</td><td colspan="4">10-18 Minute</td><td colspan="2">6-15 Minute</td><td>3-10 Minute</td><td>2-6 Minute</td><td>2-5 Minute</td><td></td></tr>
<tr><td>High Ability</td><td colspan="5">10-18 Minute</td><td colspan="2">6-15 Minute</td><td>3-10 Minute</td><td>2-6 Minute</td><td>2-5 Minute</td></tr>
</table>

[Remarks]
1. The discharge intervals indicated are reference values supposing that the oil quantity of one discharge is 0.03ml in case of the angular contact ball bearing.
2. If the cylindrical roller bearing is used, suppose that the discharge interval is the same, and the oil quantity of one discharge is 0.01ml.
3. Select the optimal value of the required oil quantity by carrying out the test on the machine referring to the table above, because the optimal value varies depending on the type of the bearing, environment and use conditions.
4. ISO VG22 or VG32 is recommended in case of the main shaft driven by the built-in motor.

Supplementary table 7 Specification report of bearing for main shaft of machine tool

Examination certificate No.

Please fill in the space provided ☐.

＊Please attach the drawings, which show the configuration of the main shaft, dimensions, external load and loading position and direction.

No	Item		Details
1	Machine used ☐Newly developed ☐Improved ☐Existing ☐Additional machine consideration	Name	
		Type	☐Machining center ☐Lathe ☐Sanding machine ☐Others ( )
		Mounting direction of main shaft	☐Horizontal ☐Vertical upward ☐Vertical downward ☐Others ( )
		Weight of rotating part	① Other than the built-in type　Weight of rotating part : N ② The built-in type　Rotating unit weight (Not including rotor) : N Rotor weight : N
2	Bearing used	Bearing number	Bearing ① Bearing ② Bearing ③ Bearing ④
		Matching	(DB, DF etc...)
		Spacer	☐Not available ☐Available Dimension and location: (____The number of row is counted from the left.) Row No. -Row No. : mm Row No. -Row No. : mm Row No. -Row No. : mm Row No. -Row No. : mm Row No. -Row No. : mm Row No. -Row No. : mm Manufacture: ☐Manufactured by JTEKT ☐Supplied ☐Manufactured by you (JTEKT supplies only the bearings.) ☐Others Shape: ☐Standard design by JTEKT ☐Specified by you (Description must be attached.)
3	Maximum velocity		min^{-1}
4	Main shaft bore		① mm ② mm (Main shaft bore in the mounting part of the bearing)
5	Lubrication method		☐Grease ☐Oil / air ☐Oil mist ☐Jet ☐Others ( )
6	Preloading method ＊After examination, other methods may be recommended.		☐Position preloading ☐Constant-pressure preloading ☐Preload change (position preloading ←→ position preloading) Change rotation velocity min^{-1} ☐Preload change (position preloading ←→ constant-pressure preloading) Change rotation velocity min^{-1} ☐Others ( ) (Desired preload amount N/ min^{-1}hour)
7	Driving method		☐Built-in motor ☐Coupling ☐Others ( ) ☐Gear ☐Belt ＊When consideration of the gear and belt loads is necessary, please contact us with the load and position.
8	Cooling		☐Not available ☐Available　Cooled part : ☐Housing (including bearing outer cylinder) ☐Housing (no cooling of the bearing outer cylinder) ☐Shaft ☐Others ( )
9	Requirements		☐None ☐Available ☐Service life ☐Max. rotation with no load ☐Machining load: hours ＊For machining load, machining cycle, and other detailed conditions, contact us. ☐Rigidity: ☐Rotational frequency : ☐At mounting ☐ At ( ) min^{-1} ☐Spindle orientation : ☐Horizontal ☐Vertical downward ☐Vertical downward ☐Bearing stiffness ＊Contact us for single row or total value specifications. ☐Single row ☐Total value ☐Shaft head rigidity ＊Contact us for specific loads. ☐Axial rigidity : N/μm (When the Axial load = N) ☐Ra rigidity : N/μm (When the Ra load = N) ☐Tool unclamp force (when using a machining center) kN
10	Examination item		
11	Remarks ＊Other requests or comments		

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