کالا صنعتی

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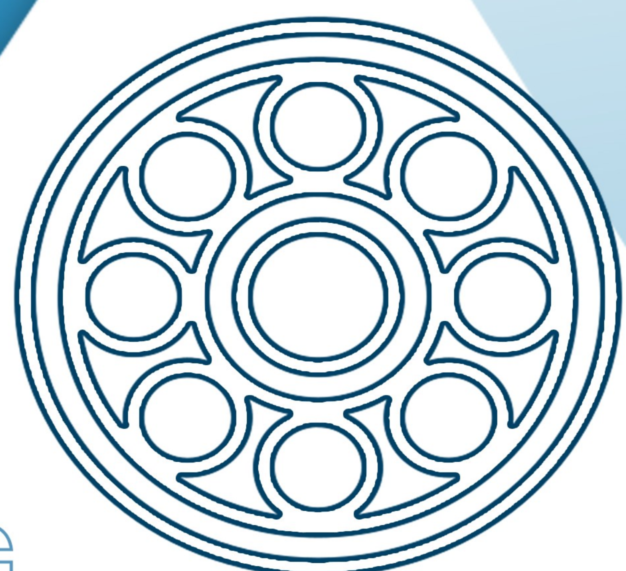
Catalog 2021



BULL BEARING

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Ball bearing

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Technical Information

1. Types and Features of Bearings

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1. Types and Features of bearings

1.1 Classification and Types of Rolling Contact Bearings

In general, rolling contact bearings may be classified as radial or thrust bearings according to bearing design or they may be classified as ball or roller bearings according to the type of rolling element.
Radial bearings are mainly designed for supporting a load perpendicular to a shaft axis, whereas thrust bearings accept loads parallel to the shaft axis.
Using the BALL and ROLLER classification ROLLER bearings may be further divided according to the shape of the roller into the sub-classes; Cylindrical roller, Tapered roller, Spherical roller, or Needle roller bearings. BALL bearings can be further divided according to the number of rows into either single-row or double-row (for Thrust Ball bearings, single-direction and double-direction.) BALL Bearing may be still further sub-divided into smaller segments according to the relationship between the bearing rings and rolling elements; the shape of bearing rings; and use of accessories.
Bearings are also classified by specific application, such as Clutch-release ball bearings for automotive applications.
Table 1.1 indicates the principal types of radial and thrust bearings and a summary of their design. Table 1.2 summarizes the designs and features of rolling contact bearings.

Table 1.1 Classification and Types of Rolling Contact Bearings

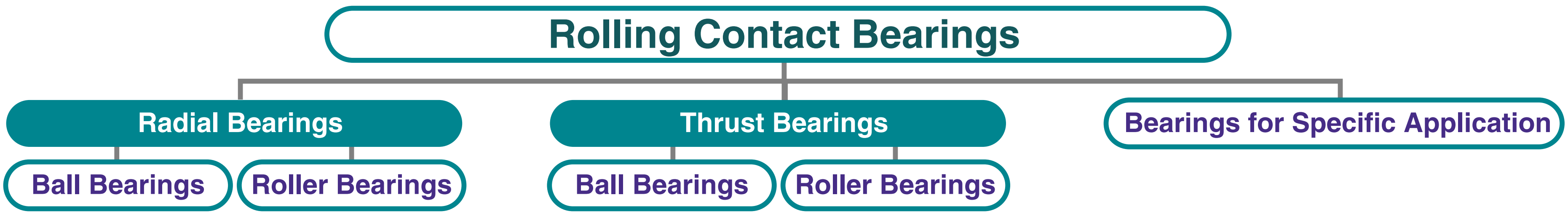

Table 1.2 Types and Features of Rolling Contact Bearings

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Table 1.1 Classification and Types of Rolling Contact Bearings
Radial Bearings > Ball Bearings

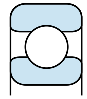
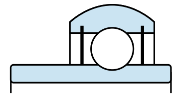
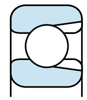
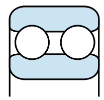
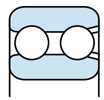
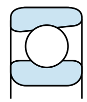
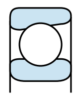
Bearing Types			Cross Sections	Bearing Series Symbols	
				JIS	Others
Deep Groove Ball Bearings	Single row	Without filling slot (JIS B 1521)		67 68 69 60 62 63	00B60 RLS RMS 16000
		Without filling slot [for unit ;JIS B 1558]		UC UWE UNE UM UK	U B KH
		With filling slot		-	
	Double row	Without filling slot		-	
		With filling slot		-	42 43
Counter-Bored Bearings	Single row	Non-Separable		-	
		Separable (JIS B 1538)		E EN	BM

Table 1.1 Classification and Types of Rolling Contact Bearings
Radial Bearings > Ball Bearings

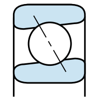
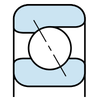
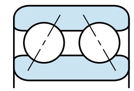
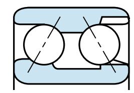
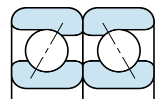
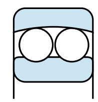
Bearing Types			Cross Sections	Bearing Series Symbols	
				JIS	Others
Angular Contact Ball Bearings	Single row	Non-Separable (JIS B 1522)		79 72 70 73	
		Separable		-	
	Double row	Without filling slot		-	52 53
		With filling slot		-	32 33
	Duplex mounting	DB mounting DF mounting DT mounting		-	
Self-Aligning Ball Bearings	Double row	Outer ring raceway : spherical		12 22 13 23	

Table 1.1 Classification and Types of Rolling Contact Bearings
Radial Bearings > Roller Bearings

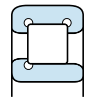
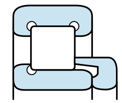
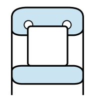
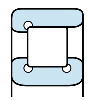
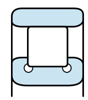
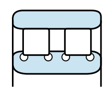
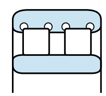
<table>
<tr><th colspan="5" rowspan="2">Bearing Types</th><th rowspan="2">Cross Sections</th><th colspan="2">Bearing Series Symbols</th></tr>
<tr><th>JIS</th><th>Others</th></tr>
<tr><td rowspan="7">Cylindrical Roller Bearings</td><td rowspan="5">Single row</td><td rowspan="2">Inner ring with a rib</td><td>Without loose rib</td><td rowspan="3">Outer ring with ribs on both sides [JIS B 1533]</td><td></td><td>NJ2 NJ23
NJ22 NJ4
NJ3</td><td></td></tr>
<tr><td>With loose rib</td><td></td><td>NH2 NH23
NH22 NH4
NH3</td><td></td></tr>
<tr><td colspan="2">Inner ring without rib</td><td></td><td>NU10 NU3
NU2 NU23
NU22 NU4</td><td></td></tr>
<tr><td colspan="2" rowspan="2">Inner ring with ribs on both sides</td><td>Outer ring with a rib [JIS B 1533]</td><td></td><td>NF2
NF3
NF4</td><td></td></tr>
<tr><td>Outer ring without rib</td><td></td><td>N2
N3
N4</td><td>N10</td></tr>
<tr><td rowspan="2">Double row</td><td colspan="2">Inner ring with ribs on both sides</td><td>Outer ring without rib</td><td></td><td>NN30</td><td></td></tr>
<tr><td colspan="2">Inner ring without rib</td><td>Outer ring with ribs on both sides</td><td></td><td>NNU49</td><td></td></tr>
</table>

Table 1.1 Classification and Types of Rolling Contact Bearings
Radial Bearings > Roller Bearings

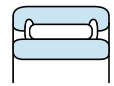
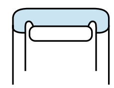
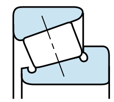
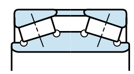
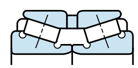
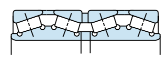
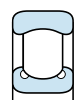
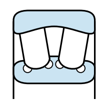
Bearing Types				Cross Sections	Bearing Series Symbols	
					JIS	Others
Needle Roller Bearings	Single row	Inner ring without rib	Outer ring with ribs on both sides		NA48 NA49	
		Without inner ring			RNA48 RNA49	
Tapered Roller Bearings	Single row	Separable (JIS B 1534)			320 303 302 303D 322 323	329 331 330 313 332
	Double row	Separable (Inward)			-	KBD
		Separable (Outward)			-	KBE KDE
	Four row	Separable			-	
Spherical Roller Bearings	Single row	Outer ring raceway : spherical			-	
	Double row	Outer ring raceway : spherical			239 231 232 230 241 213 240 222 223	

Table 1.1 Classification and Types of Rolling Contact Bearings
Thrust Bearings > Ball Bearings

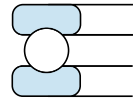
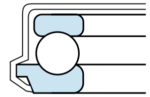
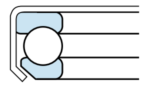
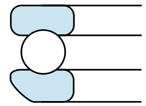
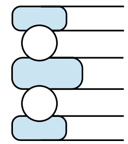
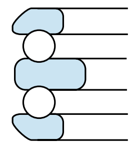
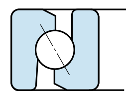
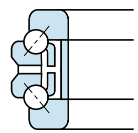
Bearing Types			Cross Sections	Bearing Series Symbols	
				JIS	Others
Thrust Ball Bearings	Single direction	Flat back face (JIS B 1532)		511 513 512 514	29 39 9 0
		Flat back face		-	TMN
		Flat back face		-	TG
		Spherical back face		-	532(U) 7(U) 533(U) 37(U) 534(U) OOT6(U)
	Double direction	Flat back face (JIS B 1532)		522 523 524	19
		Spherical back face		-	542(U) 543(U) 544(U)
Thrust Angular Contact Ball Bearings	Single direction	Non-Separable (DB, DF, DT)		-	TAB
	Double direction	Separable		-	TAD

Table 1.1 Classification and Types of Rolling Contact Bearings
Thrust Bearings > Roller Bearings

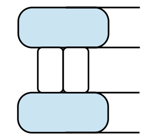
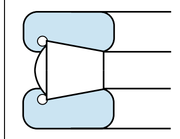
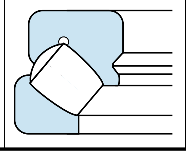
Bearing Types			Cross Sections	Bearing Series Symbols	
				JIS	Others
Thrust Cylindrical Roller Bearings	Single direction	Flat back face		-	TMP
Thrust Tapered Roller Bearings	Single direction	Flat back face		-	
Spherical Roller Thrust Bearings	Single direction	Outer ring raceway : spherical		292 293 294	

Table 1.1 Classification and Types of Rolling Contact Bearings
Bearings for Specific Application

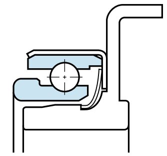
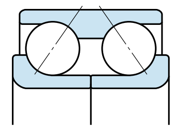
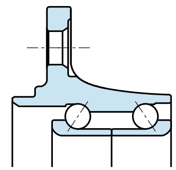
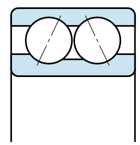
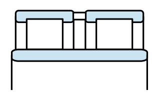
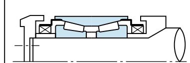
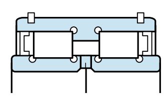
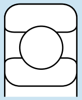
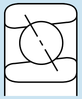
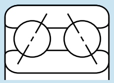
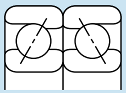
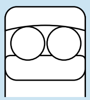
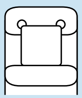
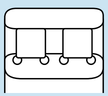
Bearing Types		Cross Sections	Bearing Series Symbols	
			JIS	Others
Automotive Bearings	Self-Aligning Clutch-Release Ball Bearings		-	SCRN
	Ball Bearings for Wheel (1st type)		-	BVV
	Ball Bearings for Wheel (2nd type)		-	F BVV
	Ball Bearings for Air Conditioner Clutch		-	BG
Journal Bearings for Rolling Stocks			-	FCD JC AP
			-	JT
Sheave Bearings			-	E50 RB48 RC48

Table 1.2 Classification and Types of Rolling Contact Bearings

Features / Bearing Type		Load carring capacity	High speed rotation	Accuracy	Low noise • Low torque	Permissible aligning of inner ring • outer ring	Rigidity	Aligning action	Separable inner ring • outer ring	Applicable to "fix side"	Applicable to "free side" only	Inner ring with tapered bore
Deep Groove Ball Bearings		⬆ ← →	●●●●	●●●	●●●	●●	●			○	□	○
Angular Contact Ball Bearings		↑ ⬅	●●●●	●●●	●●●	●	●					
Double Row Angular Contact Ball Bearings		⬆ ⬅ ➡	●●●	●	●	●	●			○	□	
Duplex Mounting Angular Contact Ball Bearings		⬆ ⬅ ➡	●●●	●●●	●●	●	●●			○	□	
Self-Aligning Ball Bearing		↑ ← →	●●	●	●	●●●	●	○			□	○
Cylindrical Roller Bearings		⬆	●●●	●●●	●●	●	●●		○		○	○
Double Row Cylindrical Roller Bearings		⬆	●●●	●●●	●●	●	●●●		○		○	○

Remarks

(1) ⬆ and ← → show radial load and axial load respectively ← and ← → mean single direction and double directions respectively.

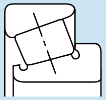
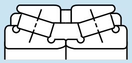
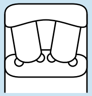
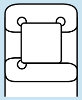
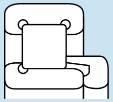
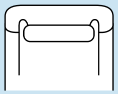
(2) Mark " ● " shows possibility for getting the characteristics. More number of "●" means much easier than less number.
"X" mean "not applicable".

(3) " ○ " means "applicable". " □ " means "can be applicable", but shaft thermal expansion must be absorbed.

(4) Thrust Ball/Roller Bearings can sustain axial loads ONLY.

(5) This table is for reference only. Bearings should be selected for specific applications.

Table 1.2 Classification and Types of Rolling Contact Bearings

Features / Bearing Type	Load carring capacity	High speed rotation	Accuracy	Low noise • Low torque	Permissible aligning of inner ring • outer ring	Rigidity	Aligning action	Separable inner ring • outer ring	Applicable to "fix side"	Applicable to "free side" only	Inner ring with tapered bore
Tapered Roller Bearings 	↑ ←	●●	●●●	●	●	●●		○			
Double-row Multi-row Tapered Roller Bearings 	↑ ← →	●●	●	●	●	●●●●		○	○	□	
Spherical Roller Bearings 	↑ ← →	●●	●	●	●●●	●●●	○		○	□	○
Cylindrical Roller Bearings With One Rib Inner Ring 	↑ →	●●●	●●	●●	●	●●		○			
Cylindrical Roller Bearings With L-shaped Thrust Collar 	↑ ← →	●●●	●●	●●	●	●●		○	○		
Needle Roller Bearings 	↑	●●	●	●	●	●●		○		○	

Remarks
(1) ↑ and ← → show radial load and axial load respectively ← and ← → mean single direction and double directions respectively.
(2) Mark " ● " shows possibility for getting the characteristics. More number of " ● " means much easier than less number.
"X" mean "not applicable".
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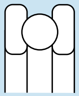
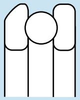
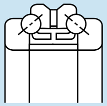
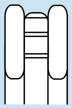
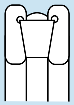
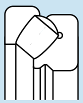
Single Direction Thrust Ball Bearings With Flat Back Face 	←	●	●	●●	×	●		○			
Single Direction Thrust Ball Bearings With Spherical Flat Back Face 	←	●	●	●●	●●●	●	○	○			
Double-row Thrust Angular Contact Ball Bearings 	← →	●●●	●●●	●●	×	●●		○			
Thrust Cylindrical Roller Bearings 	←	●	●	●	×	●●●		○			
Thrust Tapered Roller Bearings 	←	●	●	●	×	●●●		○			
Spherical Roller Thrust Bearings 	↑ ←	●	●	●	●●●	●●●	○	○			

Remarks

(1) ⬆ and ← → show radial load and axial load respectively ← and ← → mean single direction and double directions respectively.

(2) Mark " ● " shows possibility for getting the characteristics. More number of "●" means much easier than less number.
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(4) Thrust Ball/Roller Bearings can sustain axial loads ONLY.

(5) This table is for reference only. Bearings should be selected for specific applications.

1.2 Rolling Contact Bearing Designs and Features

Rolling Contact Bearings usually consist of an inner ring, outer ring, and rolling elements (balls or rollers), and a cage which positions the rolling elements at fixed intervals between the ring raceways. (See Figure 1).

Standard materials for inner and outer rings, and for the rolling elements, are high carbon chromium bearing steel or case hardening steel. The steel is heat-treated to an appropriate hardness to attain optimum resistance to rolling fatigue. Bearing surfaces are ground to a very high accuracy using special machine tools.

While each of the various types of rolling contact bearings has special features, the following features are common to most rolling contact bearing types:

- Rolling contact bearings have relatively low starting resistance. There is little difference between the starting and running resistance of rolling contact bearings.
- Dimensions and accuracy are standardized. Ready-made products of high quality are easy to obtain.
- Compared to “sliding” bearings, rolling contact bearings are less prone to wear and help to maintain the accuracy of the machine in which they are used.
- Rolling contact bearings consume small amounts of lubricant and are far less costly to maintain than sliding-type bearings.
- While not common to all rolling contact bearings, many types can sustain both axial and radial loads.

To get optimum performance from a selected bearing, it is necessary to understand the design and features of the various bearing types and to then select bearings optimal to individual machine performance.

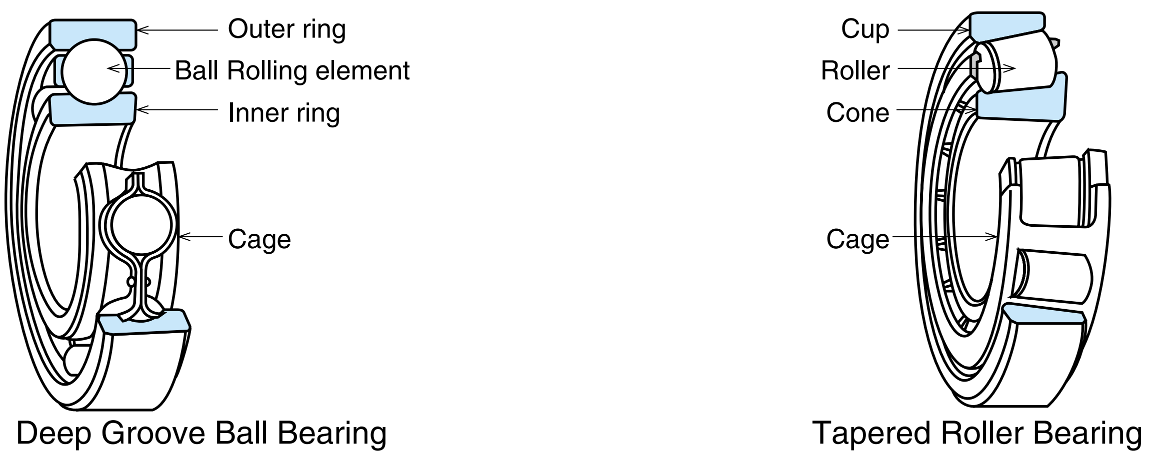


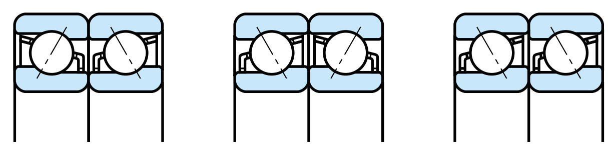
Fig 1. Rolling Contact Bearing Designes

1.2.1 Deep Groove Ball Bearings

Deep Groove ball bearings are the most popular of all the ball bearing types because they are available in a wide variety of seal, shield and snap-ring arrangements.
The bearing ring grooves are circular arcs made slightly larger than the radius of the ball. The balls make point contact with the raceways (elliptical contact when loaded). The inner ring shoulders are of equal height (as the outer ring shoulders).
Deep Groove ball bearings can sustain radial, axial, or composite loads and because of simple design, this bearing type can be produced to provide both high-running accuracy and high-speed operation.
Deep Groove ball bearings having an outside diameter less than 9 mm are known as Miniature ball bearings. Deep Groove ball bearings having an outside diameter => 9 mm and a bore diameter < 10 mm are known as Extra-small ball bearings.
Standard ball retainers (cages) are made from pressed steel. Machined cages are used in bearing operating at very high speed or for large diameter bearings.
Deep groove ball bearings with seals or shields are standardized. They contain proper amount of grease in advance.

1.2.2 Single-row Angular Contact Ball Bearings

The raceways of both the inner and outer rings of this bearing type are made with a set contact angle. These bearings are non-separable. Since the balls are inserted utilizing counter-bore construction, a larger number of balls can be installed than in the case of Deep-groove ball bearings.
Standard cage materials may be pressed steel, high-strength brass, or synthetic resin. Cage material is dependent on the bearing series and or service condition.
Single-row Angular Contact ball bearings can sustain radial, axial or composite loads, however, any axial load must be in one direction.
This bearing type is generally used in pairs to handle the induced load resulting from the internal axial force generated by the applied radial load. When mounting two single bearings in adjacent positions, NACHI provides these combination parts (pairs) with preadjusted clearance. Paired combination bearings are matched sets. Combination or paired bearings can be arranged BACK-TO-BACK (DB), FACE-TO-FACE (DF), or in TANDEM (DT). DB or DF sets can sustain bidirectional axial loads.



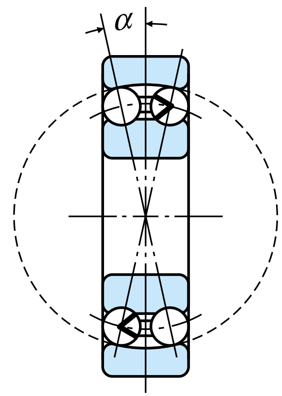
DB (Back-to-back) DF (Face-to-face) DT (Tandem)

1.2.3 Double-row Angular Contact Ball Bearings

The construction of this type ball bearing is similar to the adjacent, BACK-TO-BACK mounting of two Single-row Angular Contact ball bearings. Because fewer balls can be inserted per row compared to Single-row Angular Contact ball bearings, a Double-row Angular Contact ball bearing will have less load capacity than an equivalent size/series BACK-TO-BACK set of two Single-row Angular Contact ball bearings.
This bearing type can sustain radial, moment and bi-directional axial loads.

1.2.4 Self-aligning Ball Bearings

This type is constructed with the inner ring and ball assembly contained within an outer ring which has a spherical raceway. Due to the construction, this bearing type will tolerate a small angular misalignment from deflection or mounting error.
Self-aligning Ball bearings are suitable for long shafts where accurate positioning of housing bores is difficult. This type is often used in conjunction with pillow blocks. Cages are made from pressed steel or polyamide resin.
This bearing should only be used in light axial load applications due to the small axial support of the rolling elements by the outer ring raceway.



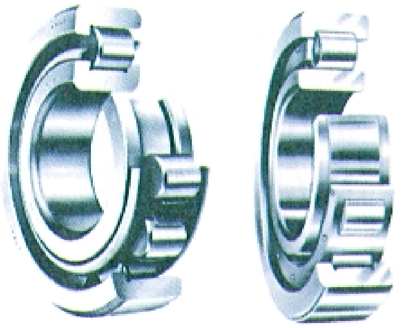
1.2.5 Cylindrical Roller Bearings

Construction of this roller bearing type is the simplest of all radial roller bearings. This bearing type is often used in high-speed applications.
Because the inner ring, outer ring, and rollers are in line contact, this bearing type has a large radial load capacity. Various Cylindrical roller bearing configurations are:

N,NJ,NF,NU,RNU	: integral ribs (flanges)
NH,NP,NUP,NUH	: integral and loose ribs
NN,NNU	: double-row bearings

[→Continue]

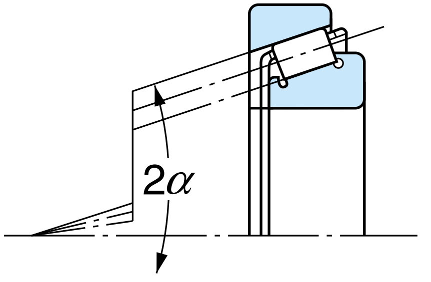
(See the Cylindrical roller bearing dimensional data section for description of configuration design).
Configurations having integral flanges or loose ribs on both the inner and outer rings can sustain a small amount of axial load. Since this bearing type supports axial loads as sliding action between the end of the rollers and flange faces, axial loading is limited.
Double-row Cylindrical roller bearings are used for high-speed, high-accuracy applications such as; main spindle support for lathes, milling machines, and machining centers. Radial clearance of tapered-bore bearings can be adjusted during mounting of the bearing(s) onto the mating journal.
Standard cages are pressed steel or polyamide resin. Machined cages of high-strength brass are used for bearings of large dimension or for high-speed applications.



1.2.6 Tapered Roller Bearings

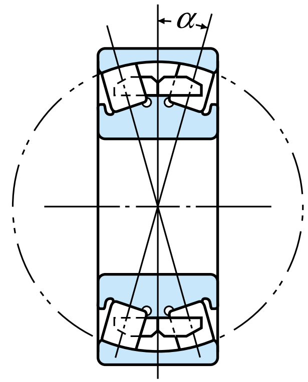
The inner and outer ring raceways and rollers of this type of bearing are made with a taper so that the planes of the surfaces of the raceways and roller axis meet at a point. The rollers are guided by the cone (inner ring) back-face rib.
A single-row Tapered roller bearing can support a combined radial and axial load. If either a radial load or bi-directional axial load is to be carried, a pair of bearings must be used in a "face-to-face" or "back-to-back" position.
Tapered roller bearings are separable into the components: outer ring, inner ring and roller assembly. The non-separable inner ring and roller assembly is called the "cone", and the outer ring is called the "cup". Internal clearance is established during mounting by the axial positioning of the cone relative to the cup.
This bearing type can be used in a preload situation to obtain higher rigidity and better running accuracy of the shaft.

Double-row and four-row Tapered roller bearings are designed to carry radial, and bi-directional axial loads. Four-row Tapered roller bearings are used for the roll necks of rolling machines and for other applications where heavy or impact loads are present.
Multi-row Tapered roller bearings have the serial number and the combination symbol stamped on the faces of the rings for clearance adjustment and must be assembled according to this number and symbol.
Pressed steel cages are used for small bore bearings and machined, high-strength brass or mild-steel cages are used for bearings with larger bores. Heavy-duty pin-type cages are used for some large-bore bearings.



1.2.7 Spherical Roller Bearings

NACHI double-row Spherical roller bearings are available in bore sizes from 25 mm to over 1000 mm.
The raceways in the outer ring of this type bearing are designed with a spherical surface whose center coincides with the bearing center.
NACHI Spherical roller bearings are of an improved design having a modified line contact between the raceways and rollers. This construction enables very high radial and impact-load capacity.
This bearing type can carry a moderately-high level of bi-directional axial load and is self-aligning. This type is used extensively for large machines where shaft deflection or mounting error may occur.
Spherical roller bearings are used for paper mill equipment, rolling machines, rolling stock, shaker screens and general industrial machinery. The mounting and dismounting of Spherical roller bearings is facilitated through the use of tapered-bore bearings in conjunction with tapered journals, or adapters or withdrawal sleeves. Internal clearance can also be precisely set using a tapered-bore bearing.
Pressed steel cages are used for small-bore bearings and machined, high-strength brass or mild-steel cages are used for bearings with larger bores.

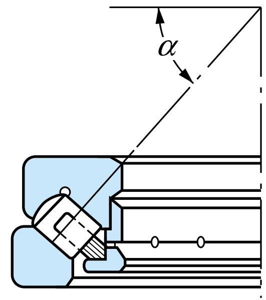


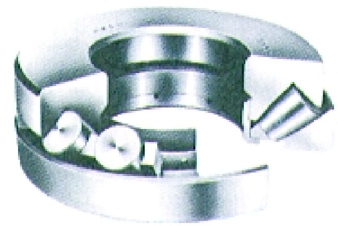
1.2.8 Thrust Ball Bearings

Thrust ball bearings can handle axial loads only. Bearing rings mounted on the shaft are called shaft washers, and those mounted in the bearing housing are called housing washers. Both washers contain grooves for the balls.
Thrust Ball bearings are of two types: single type which can support axial loads in only one direction and double type that can support bi-directional loads. The central washer of double type thrust ball bearing is located in an axial direction by a shaft shoulder and sleeve.
Thrust Ball bearings are not suitable for high-speed rotation since lubricant is expelled by centrifugal force. When used on a horizontal shaft, a minimum axial load must be applied.
Pressed steel plate, polyamide resin, machined high-strength brass or mild steel are used for cages.
Care must be taken in handling to prevent damage to the separable rings and ball assembly.

1.2.9 Spherical Roller Thrust Bearings

The raceway of housing washer of this bearing type is spherical with the center of the radius located on the bearing axis. The design provides self-alignment capability to the bearing. The contact angle (see sketch below) is approximately 45° enabling the bearing to support axial load and a small to moderate amount of radial load.
NACHI Spherical Roller Thrust bearings can sustain high loads at low-to-moderate speeds.
Because of the large load capacity and self-aligning characteristics, this bearing type is often used for injection molding machines, crane hooks and other large machines.
Cages are made from machined, high-strength brass or pressed steel.





2. Selection of Bearings

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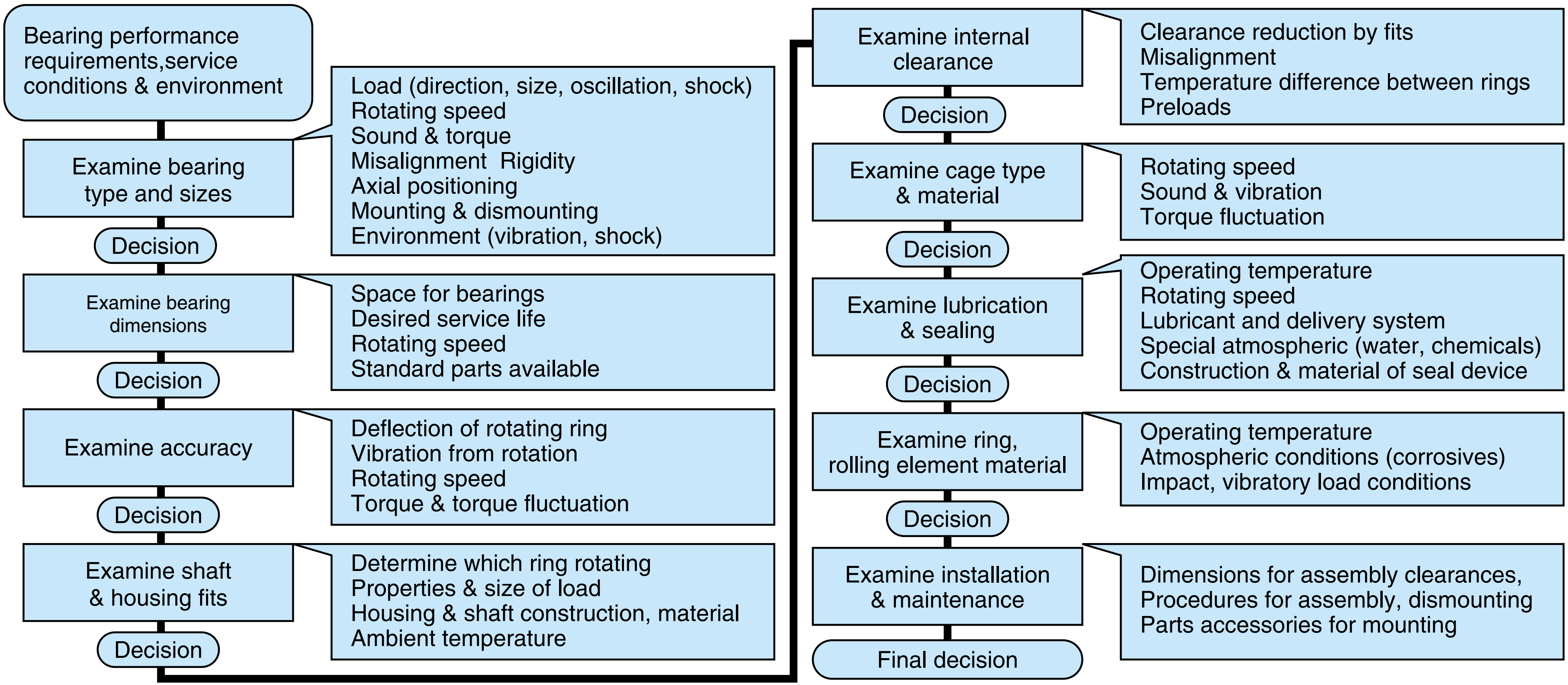
2. Selection of Rolling Contact Bearings

Rolling contact bearings are important, often critical, components of machinery. To meet the demands of a large variety of applications, rolling contact bearings are manufactured in a wide variety of types, sizes, and configurations. While machine performance and service life depend on which bearings are selected, it is often difficult to select the optimal bearing from among the many available variations.
While there is no "best" procedure for selecting the optimal bearing, Figure 2.1 provides an example of a procedure based on the establishment of priorities for the required bearing characteristics.

Fig. 2.1 Bearing Selection Procedure



2.1 Bearing Type Selection Considerations

2.1.1 Load

Bearing types are selected according to the types of load (radial, axial, moment) and the magnitude of these loads on the bearing. Table 2.1 outlines the types of load and applicable bearing types. In bearings of identical dimensional series, a roller bearing will have a greater load rating capacity than a ball bearing.

Table 2.1 Applicable Bearings vs Load Type

Bearing type	Load type						
	Radial	●		●	●		●
	Axial		●	●		●	●
	Moment				●	●	●
Ball bearings:	Single-row Deep Groove	○	△	○	○	△	○
	Single-row Angular Contact		○	○			
	Paired Angular Contact	○	○	○	○	○	○
	Double-row Angular Contact	○	△	○	○	△	○
Roller bearings:	Cylindrical	○		△			
	Single-row Tapered		○	○			
	Paired Tapered	○	○	○	○	○	○
	Multi-row Tapered	○	○	○	○	○	○
	Spherical radial	○		△			
	Spherical thrust		○			△	

Remarks: ○ Bearing type can meet the load type.
△ Bearing can meet the load type conditionally. (Contact NACHI for more information.)

2.1.2 Rotating Speed

Limiting speed of bearings is determined by bearing type, bearing dimensions, accuracy of work, construction of cages, load, lubricating system, and seal type and design. The bearing dimension tables show the rotating speed limits of standard rolling contact bearings as a criterion of bearing type selection.

Bearings used at high rotating speeds should generally have high accuracy. In applications over the limiting speed, please consult NACHI for assistance.

2.1.3 Noise and Torque

All NACHI rolling contact bearings are designed and manufactured to operate with low noise and torque levels. Of the many types of ball and roller bearings, single-row deep-groove ball bearings will tend to operate with the lowest noise and torque levels.

2.1.4 Alignment

If the accuracy of alignment of the shaft and bearing housing is poor or the shaft is deflected due to load, the inner and outer rings of the bearings will be misaligned.

Non-self-aligning rolling contact bearings are capable of tolerating only that amount of misalignment which can be handled by the assembled internal clearance. If inclination is expected to occur between the inner and outer rings, the choice of bearings should be from types such as thrust ball bearings with self-aligning washer, Self-aligning ball bearings, or Spherical roller bearings.

The permissible angle of inclination of bearings differs by bearing type, internal clearance, and load conditions. Table 2.2 outlines the permissible angles of mis-alignment by bearing type.

Internal bearing damage can occur if misalignment in the bearing is greater than the permissible angle. Please contact NACHI for assistance.

Table 2.2 Permissible Misalignment of Bearing Types

Bearing type	Permissible angle of misalignment
Single-row deep groove ball bearings	1/300
Single-row angular contact ball bearings	1/1000
Cylindrical roller bearings	1/1000
Tapered roller bearings	1/800
Thrust ball bearings	1/2000

2.1.5 Rigidity

When rolling contact bearings are loaded, the contact section between the bearing rings and rolling elements will elastically deform. The magnitude of this elastic deformation will differ depending on load, bearing type, and bearing dimensions.
If bearings of identical dimension series are compared, roller bearings will have a much higher level of rigidity than ball bearings, and if bearings of identical type are compared, bearings of larger dimensions will have higher rigidity than those of smaller dimensions. (Pre-loading combinations of units of two or more bearings will increase rigidity.)

2.1.6 Mounting, Dismounting

Rolling contact bearings can be divided into bearing types classed as separable or non-separable. Mounting and dismounting is facilitated if a separable bearing type is used.
Use of tapered-bore bearings and sleeves or hydraulic assist also makes bearing mounting and dismounting easier.
There is a possibility that noise and shortening of life occur due to poor mounting of bearings. When bearings are mounted, the following items should be noticed.

-Keep the bearings clean
-Rust prevention
-Protect bearings from external damage

2.1.7 Axial Location; Bearing Arrangement

Generally the shaft is supported by two units (or the equivalent to two units) of bearings. Generally, one of the bearings acts to hold (or fix) the axial position of the assembly and the other bearing acts to allow linear expansion.
The fixed side bearings must be firmly seated against both housing and shaft.
Table 2.3 shows representative examples of actual bearing arrangements according to service conditions.

Table 2.3 Examples of Bearing Arrangements

2.1.8 Bearing Environment

If there is a comparatively large source of vibration near the bearing mount, or if the bearing is to handle impact loading, the use of Spherical roller bearings or Spherical roller thrust bearings is recommended.
Standard bearings will be not suitable to be operated under severe condition (load, rotating speed, operating temperature, lubrication amount, vibrating environment).

Table 2.3 Examples of Bearing Arrangements

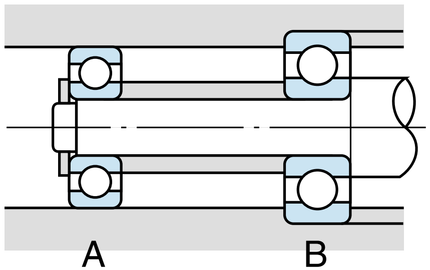
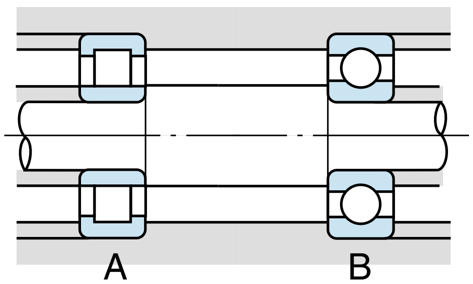
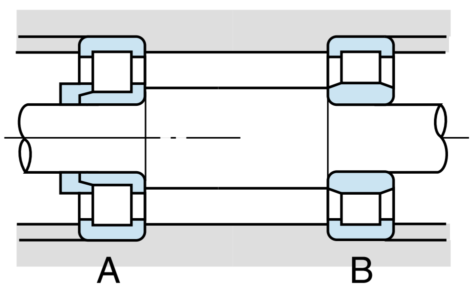
No.	Mounting examples	Applicable bearings A	Applicable bearings B	Application & design considerations
①		Deep Groove Ball Spherical Roller	Deep Groove Ball Spherical Roller	Popular mounting. Ball bearings can support light-to-moderate axial loads. Spherical roller bearings are good for heavy radial loads and light axial loads. One of the bearing outer ring must be free to move axially to handle thermal expansion.
②		Cylindrical Roller; N, NU configuration	Deep Groove Ball	Popular mounting. Axial expansion of shaft taken by inner ring of Cylindrical roller bearing. Use a Cylindrical roller bearing for the heavy load position. The Deep groove ball bearing carries the axial load. Not recommended for handling angular misalignment.
③		Cylindrical Roller; NH configuration	Cylindrical Roller; N, NU configuration	Easy mounting arrangement where interference fit is required for both inner and outer rings. Not recommended for handling angular misalignment. Thermal expansion taken internally. Suitable for light axial load applications.

Table 2.3 Examples of Bearing Arrangements

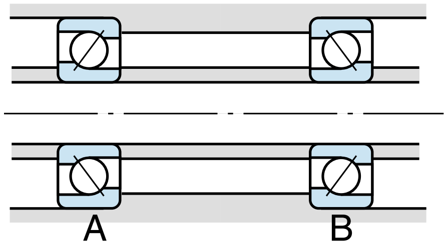
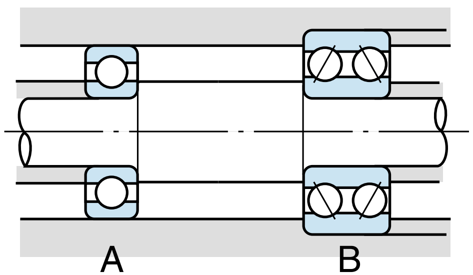
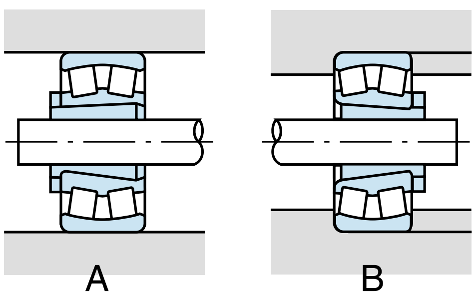
<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Mounting examples</th><th colspan="2">Applicable bearings</th><th rowspan="2">Application & design considerations</th></tr>
<tr><th>A</th><th>B</th></tr>
<tr><td rowspan="2">④</td><td rowspan="2"></td><td>Deep Groove Ball</td><td>Deep Groove Ball</td><td rowspan="2">Preloading allows good rigidity.
Care must be taken in design of preload amount.
Angular contact ball bearings are better than Deep groove ball bearings for moderate axial laods and preload.</td></tr>
<tr><td>Angular Contact Ball</td><td>Angular Contact Ball</td></tr>
<tr><td rowspan="2">⑤</td><td rowspan="2"></td><td>Deep Groove Ball</td><td>Double-Row Angular Contact Ball</td><td rowspan="2">Good for moderate, bidirectional axial loads.
When using Deep groove ball bearings in position <A>, and double-row bearings in position <B>, the outer ring of one of the parts must be free to move axially for thermal expansion. If an N, or NU configuration bearing is used in position <A>, thermal expansion can be taken internally and a much greater radial load can taken on side <A>.</td></tr>
<tr><td>Cylindrical Roller; N, NU configuration</td><td>Double-Row Angular Contact Ball</td></tr>
<tr><td rowspan="2">⑥</td><td rowspan="2"></td><td>Self-Aligning Ball</td><td>Self-Aligning Ball</td><td rowspan="2">Good for small angular misalignment.
Use with adapter for long shafts which eliminates costly, shaft-weakening shaft shoulders and threading.
Outer ring of one bearing must be free to move to compensate for thermal expansion or mouting error.
Axial load capacity is light for ball bearing and moderate for Spherical roller bearing.
Check with NACHI if Fa/Fr ratio is greater than 0.6 for Spherical roller bearings.</td></tr>
<tr><td>Spherical Roller</td><td>Spherical Roller</td></tr>
</table>

Table 2.3 Examples of Bearing Arrangements

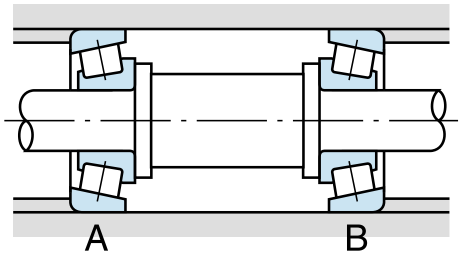
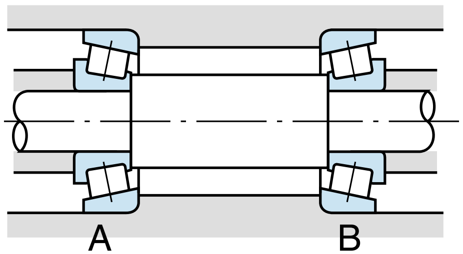
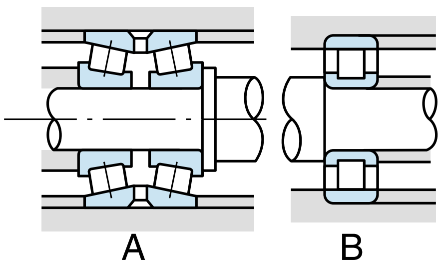
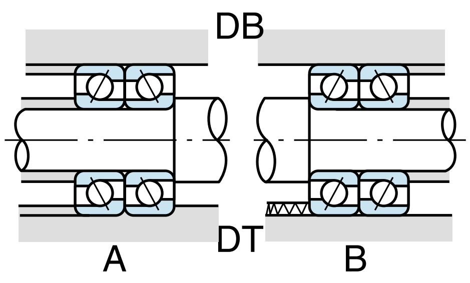
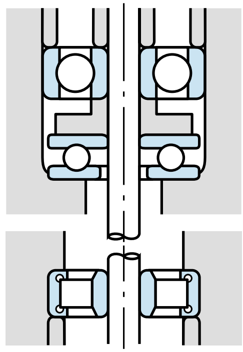
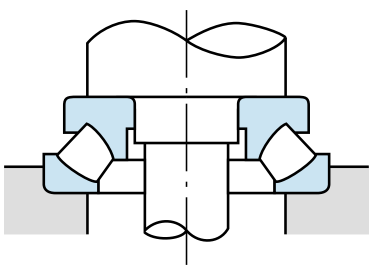
No.	Mounting examples	Applicable bearings A	Applicable bearings B	Application & design considerations
⑦		Tapered Roller	Tapered Roller	General application, direct mounting ("face-to-face"). Good for heavy axial loads. Clearance easily adjustable. Assembly is convenient where one or both inner ring are interference-fit to shaft.
⑧		Tapered Roller	Tapered Roller	Indirect mounting ("back-to-back"). Good shaft rigidity. Good for moment loading. Good for large axial and radial loads. Use care in establishing preload or clearance.
		Angular Contact Ball	Angular Contact Ball	
⑨		Tapered Roller	Cylindrical Roller; N, NU configuration	Good for heavy loads and radial and axial rigidity. Clearance on side <A> easy to adjust. Thermal expansion can be taken by Cylindrical roller bearing. Alignment must be accurate.

Table 2.3 Examples of Bearing Arrangements

No.	Mounting examples	Applicable bearings		Application & design considerations
		A	B	
⑩		Paired Angular Contact Ball	Paired Angular Contact Ball	Good for very accurate rotation and light loads. Two bearings are used in pairs with preload. Good shaft rigidity. Alignment must be accurate. Mounting example above the shaft center line is DB ("back-to-back") mount; below line is DT ("tandem") mount.
⑪		Deep Groove Ball & Thrust Ball	Cylindrical Roller	Thrust bearing should be close to radial bearing to reduce shaft deflection. When using Thrust ball bearing on a horizontal shaft, it is important to keep a load on the thrust bearing at all times. If there is shaft deflection at the thrust bearing location, use of a Thrust ball bearing with aligning washer arrangement is recommended.
		Cylindrical Roller & Thrust Ball	Cylindrical Roller	
⑫		Spherical Roller Thrust	Various Radial Types	Spherical roller thrust bearings are applicable if radial load is 55% or less than that of axial load. Suitable for heavy axial load. Good where there is shaft deflection and housing accuracy error. Axial load must be continuous. Used in conjunction with radial bearings at low-to-moderate speed.

3. Load Capacity and Life of Bearings

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3. Load Capacity and Life of Rolling Contact Bearings

3.1 Basic Dynamic Load Rating and Rating Life

Although requirements of rolling contact bearings vary somewhat with the individual application the principal requirements are:

- High load capabilities
- Smooth and quiet rotation
- High rigidity
- Low friction
- High accuracy
- Reliability

The reliability or durability requirement sets the time frame over which all other requirements are to be maintained. The reliability requirement (life in the broad sense) includes grease and acoustic life, as well as fatigue life. Reliability is reduced by various types of damage and degradation.
Improper handling, mounting, lubrication, and fits are the major causes of problems leading to lower-than-calculated bearing life. Regardless of how well they are maintained or mounted or handled, dynamic bearings will eventually fail from rolling fatigue generated by the repetitive stress of bearing load.
The service life of a bearing can be examined from two perspectives: 1)If, from inspection, a trace of fatigue becomes noticeable, the bearing should be deemed not suitable for further use; or 2) length of bearing life in hours or revolutions can be predefined as a limit beyond which the bearing is automatically replaced.
Since calculated fatigue life will vary with the size and type of bearings used under identical load conditions, great care must be taken in the analysis of the load conditions and the final choice of bearings to satisfy the application requirements.
Fatigue lives of individual bearing are dispersed. When a group of identical bearings operate under the same conditions, the statistical phenomenon of dispersion will appear. Use of average life is not an adequate criterion for selecting rolling contact bearings. Instead, it is more appropriate to consider a limit (hours or numbers of revolutions) which a large percentage of the operating bearings can attain.
Accordingly, the rating life and basic dynamic load rating Cr or Ca are defined using the following definition:

- Basic rating life is defined as the total number of revolutions (or total operating hours at some given constant speed) that 90% of a group of identical bearings operated individually under equal conditions can complete without suffering material damage from rolling fatigue.
- Basic dynamic load rating (Cr or Ca) is defined as a bearing load of constant direction and size that ends the bearing life after a million revolutions.

Constant-direction radial or thrust loads (for radial and thrust bearings, respectively) are used as the basis of the ratings.
The rating life of bearings is calculated by formulas (3.1) and (3.2):

$$L = \left(\frac{C}{P}\right)^p \quad \cdots\cdots (3.1)$$

$$Lh = \left(\frac{C}{P}\right)^p \cdot \frac{10^6}{60\ n} \quad \cdots\cdots (3.2)$$

Where:
- L : Basic rating life (10^6 rev.)
- Lh : Basic rating life in hours
- C : Basic dynamic load rating (N). (Cr for radial bearings and Ca for thrust bearings)
- P : Bearing load (dynamic equivalent load) (N) Pr for radial, and, Pa for thrust bearings
- p : 3 for ball, 10/3 for roller bearings
- n : Rotating speed (rpm)

The relationship of fh, the bearing life factor and fn, the speed factor, is outlined in Table 3.1.
Formula (3.3) may be used to determine the basic dynamic load rating, C, of bearings given the bearing equivalent load, P, and the operating speed, n, in revolutions-per-minute.
The lives of automobile wheel bearings may be defined in kilometers using the formula (3.4).
Table 3.2 shows values for the life factor, fh, by application and machine type.
If a bearing is used with vibrating or impact loads or low speed including no rotation, additional study with basic static load rating is required.

Table 3.1 Bearing Basic Rating Life; Life and Speed Factors

	Ball Bearings	Roller Bearings
Basic Rating Life	$Lh = 500fh^3$	$Lh = 500fh^{\frac{10}{3}}$
Life Factor	$fh = fn\frac{C}{P}$	$fh = fn\frac{C}{P}$
Speed Factor	$fn = \left(\frac{10^6}{500 \times 60n}\right)^{\frac{1}{3}}$	$fn = \left(\frac{10^6}{500 \times 60n}\right)^{\frac{3}{10}}$

$$C = \frac{P}{fn} \cdot \left(\frac{Lh}{500}\right)^{1/p} \quad \cdots\cdots (3.3)$$

$$Ls = \frac{\pi \cdot D}{1000} \cdot L \quad \cdots\cdots (3.4)$$

Where:
- Ls : Kilometer traveled (10^6 km)
- D : Outside diameter of wheel (m)
- L : Life in revolutions

Table 3.2 Life Factors (fh)

Table 3.2 Life Factors (fh)

Application conditions	Application example	Life Factor (fh)
Infrequent use	Hinges	to 1.5
Short period or Intermittent use	Hand tools Agricultural equipment Household apparatus Casting plant cranes	2 ~ 3
Intermittent, critical use	Power plant auxiliary machines Assembly line conveyers General crane applications Motors for home air conditioning	3 ~ 4
8 hour per day, intermittent	General gearing applications General industrial motors	3 ~ 5
8 hour per day, continuous	Cranes in continuous use Air blowers Mechanical power transmission General industrial machinery Industrdal wood-working machines	4 ~ 5
24 hour per day, continuous	Compressors Mine hoists Marine propeller shafts Rolling machine tables	5 ~ 8
24 hour per, critical	Paper manufacturing Power plants Water supply equipment Mine water pumps, air blowers	6-up

3.2 Basic Rating Life Calculation Guide

• Determine the bearing life normal to the application by using Table 3.2 to define the life factor, fh.
• Use rating life charts (nomograms) to calculate life. The nomogram for ball bearings is shown in Fig. 3.4. The nomogram for roller bearings is shown in Fig. 3.5. These nomograms are based on formulas (3.1) and (3.2).
• Where operating temperatures are to be in excess of 150°c, a correction factor must be applied to the bearing basic dynamic load rating. (See Item 3.3.1).
• If the bearings are to operate with vibration or impact loading, or where a bearing mounting or manufacturing error exists, the actual load may be greater than the calculated load. In this case, the calculated load must be multiplied by a safety coefficient to obtain an approximation of the actual load. For safety coefficients in actual application, refer to the machine and drive factors. (See Item 3.4.1 and 3.4.2)
• Bearings do not always operate under a constant load. When the bearing operates with a fluctuation load, the load must be converted to a constant size reflecting the effect of the fluctuating load. Conversion may be done using weighted average mean loading (See Item 3.4.4).
• By definition, bearing load Pr (net radial load) or Pa (net axial load) is a load with constant direction and size. When a composite load of radial and axial loads occurs on a radial bearing, these loads must be converted to a radial load reflecting the effect of the composite load. This effective load is called the DYNAMIC EQUIVALENT LOAD. (See Item 3.5).
• When calculating bearing load using the loads on a position on the shaft, it is necessary to calculate center distance between the load application point of the bearings. Many bearing types have load center points at the center line of the width as shown in Fig. 3.1. Single-row Angular Contact ball bearings and single-row Tapered roller bearings, have load center points off-center to the center line of the bearing width (See Fig. 3.2 and 3.3 respectively). Refer to the dimension tables for the value of the off-set.
• The axial load limit for Cylindrical roller bearings is a function of the lubrication conditions and speed of rotation. This limit differs from a rating load as determined by fatigue life. (See Item 3.7).

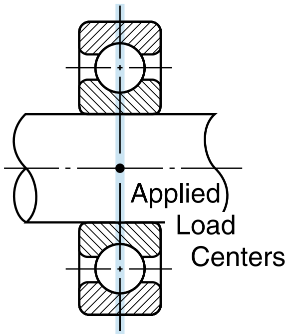


Fig 3.1

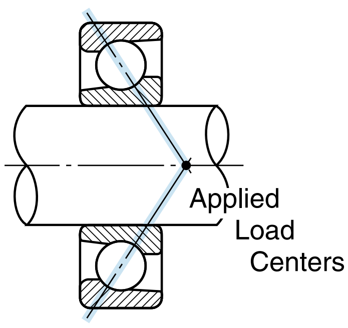


Fig 3.2

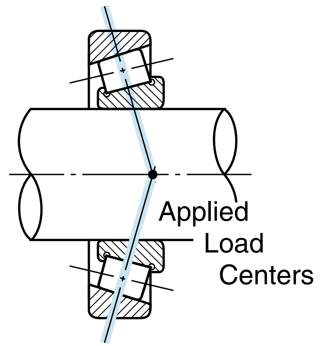


Fig 3.3

[→Continue]

Calculation example : 1

Suppose that an application has selection parameters as follows :
Bore : 50 mm or smaller
Outside diameter : 100 mm or smaller
Width : 20 mm or smaller
Radial load (Fr) : 4000 N (Newtons)
Rotating speed (n) : 1800rpm
Life factor (fh) : 2 or greater
Bearing type : Single-row deep groove ball bearing

From Table 3.1 the speed factor, fn is obtained as follows:

$$fn = \left(\frac{10^6}{500 \times 60 \times 1800} \right)^{1/3} = 0.265$$

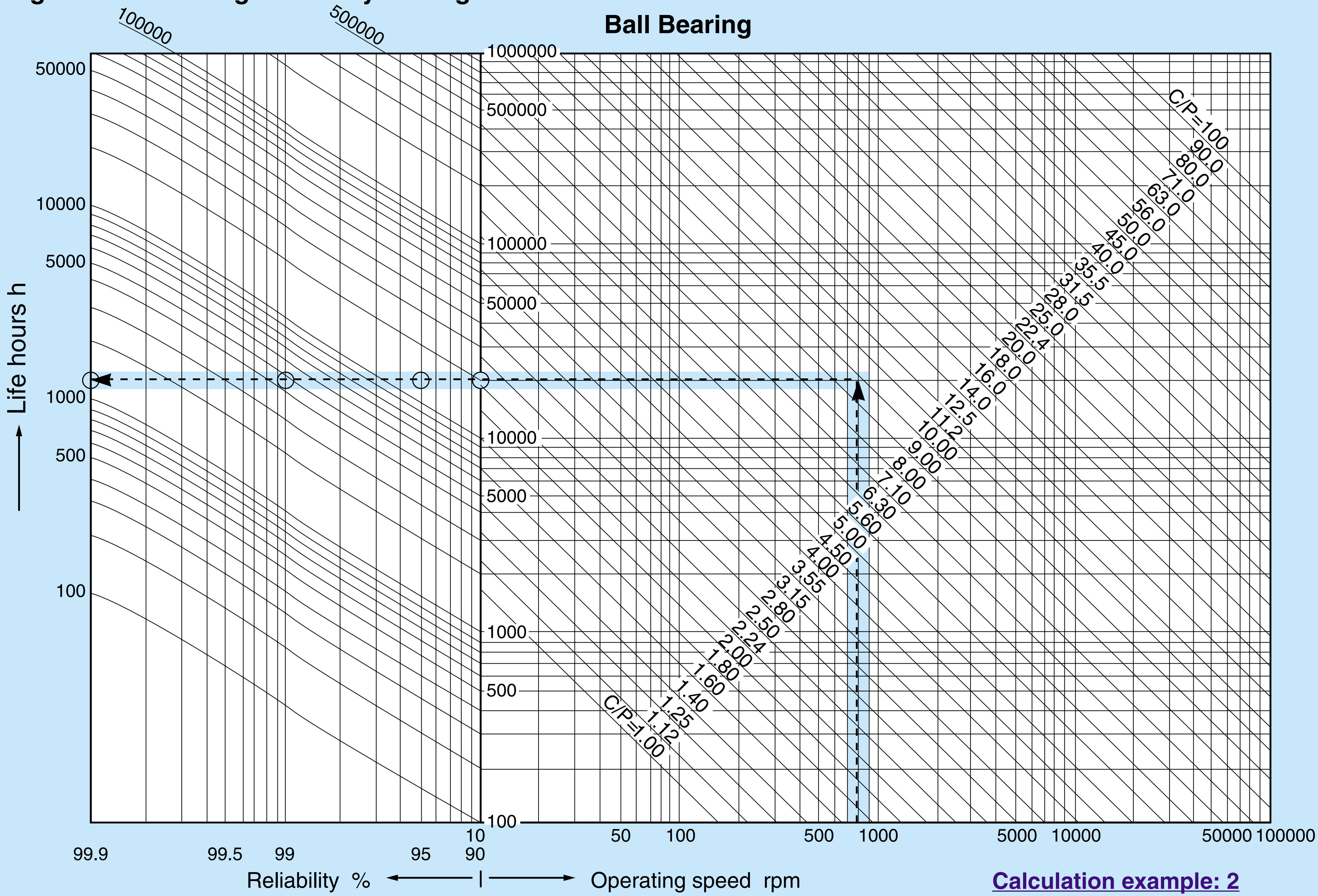
From Table 3.1,

$$Cr = \frac{fh \cdot P}{fn} = \frac{2 \times 4000}{0.265} = 30188N$$

Bearings having the required basic dynamic load rating are selected from the bearing dimension table(s). Of the two sizes meeting the load and diameter constraints, only bearing 6209 will satisfy the width constraint. Given the above parameters, bearing part 6209 would be the selection.

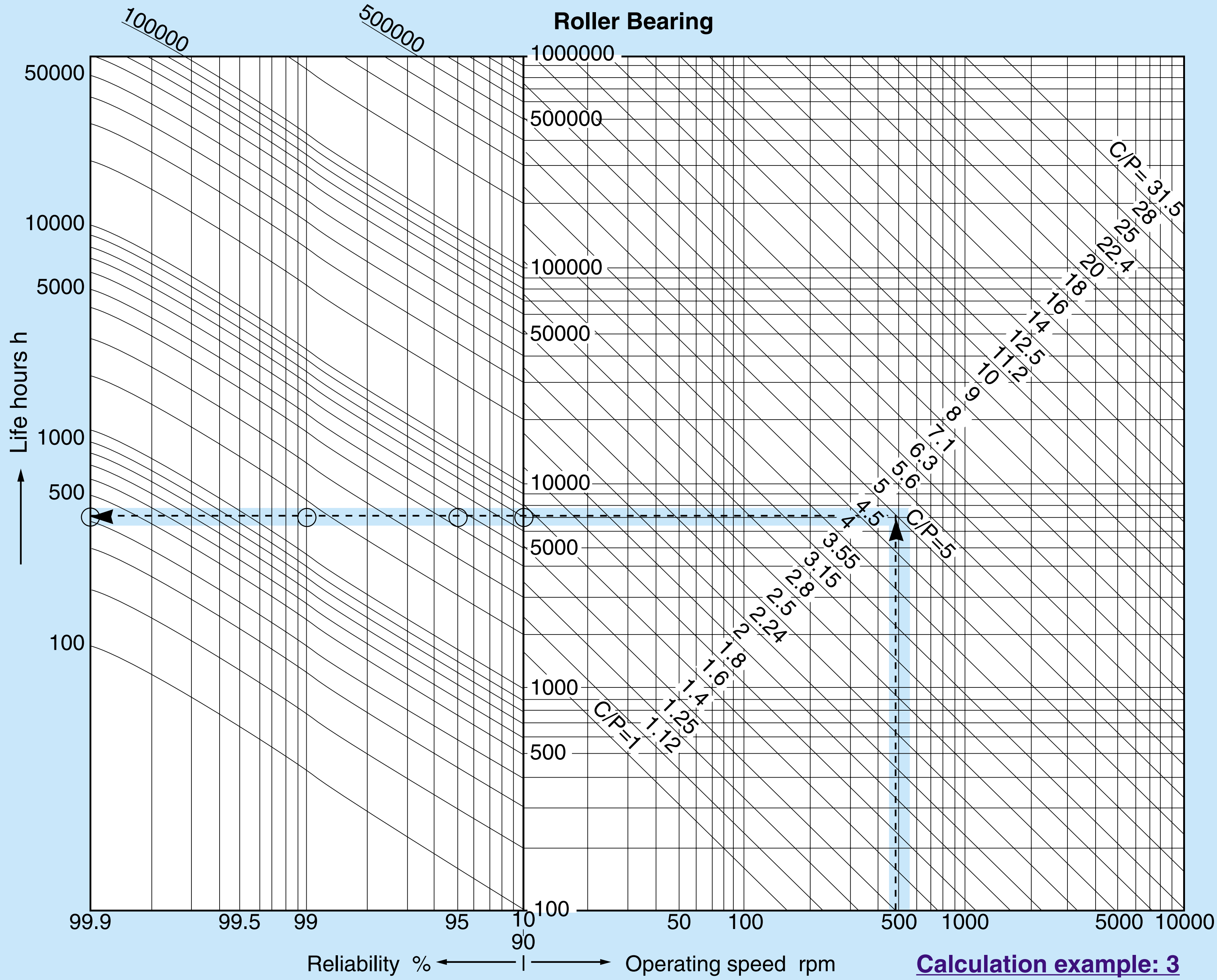
Bearing No.	Bore Dia. (mm)	Outside Dia. (mm)	Width (mm)	Basic Dynamic Load Rating (N)
6209	45	85	19	32500
6307	35	80	21	33500

Fig 3.4 Ball Bearing Reliability Nomogram



Calculation example: 2

Fig 3.5
Roller Bearing
Reliability Nomogram



Calculation example: 3

Fig 3.4 Ball Bearing Reliability Nomogram

Calculation example: 2

Bearing Number 6012 is loaded with an dynamic equivalent radial load Pr = 2950N.
Object is to obtain the life at various levels of reliability when the bearing is rotated at n = 800 rpm.
The basic dynamic load rating Cr is taken form the dimension table.

Cr = 29400N
Cr/Pr = 10

(*) For reliabilities, see Item 3. 3. 2.

By tracing the dotted lines, rating lives are obtained as follows:

Reliability (*)	Life hours
90%	20000
95%	15000
99%	4500
99.9%	1200

Fig 3.5 Roller Bearing Reliability Nomogram

Calculation example: 3

Bearing Number 22222EX is loaded with dynamic equivalent radial load Pr = 98000N.
Object is to obtain the life at various levels of reliability when the bearing is rotated at n = 500 rpm.
The basic dynamic load rating Cr is taken from the dimension table.

Cr = 490000N
Cr/Pr = 5

By tracing the dotted lines, rating lives are obtained as follows:

Reliability (*)	Life hours
90%	7000
95%	4400
99%	1500
99.9%	400

(*) For reliabilities, see Item 3. 3. 2.

3.3 Rating Life and Operating Temperature

3.3.1 Temperature-Related Decrease in Basic Dynamic Load Rating

Bearing ring diameters grow slightly with an increase in temperature. If the operating temperature does not exceed about 120°c , the bearing rings will return to their original dimensions at normal temperature. If the operating temperature exceeds this level (approximately 120°c), the bearing rings and rolling elements can undergo small, permanent changes in size.
To prevent these permanent changes in size, special heat-stabilization treatment can be used (see Table 3.3).

Table 3.3 Heat - Stabilization Treatment

Max. Operating temperature	Heat stabilization treatment symbol
~ 150°C	S26
~ 200°C	S28

The S26 heat-treated bearings will resist dimensional change through a maximum temperature of 150°c. Bearings with the S26 heat-treated steel will suffer decreases to their rating life and will have dimensional changes if they are used at temperatures in excess of 150°c.
The S28 heat-treated bearings will resist dimensional change and have a temperature factor of 0.90 through a maximum temperature of 200°c.
Bearings with the S28 heat-treated steel will suffer further decreases to their rating life and will have dimensional changes if they are used at temperatures in excess of 200°c.
Operation at temperatures exceed the limit of the heat-stabilization should be avoided to prevent bad effects of these dimensional changes.

If bearings are operated at temperatures exceeding the limit of the heat-stabilization, hardness of the bearing steel will be reduced. In calculating the life of such bearings, the basic dynamic load rating must be multiplied by the temperature factor as shown in Table 3.4. The temperature factor for standard bearings operating at a temperature under 120°c is 1 and these bearings will show no dimensional change. Standard bearings run at an operating temperature exceeding 120°c, will experience dimensional changes and are subject to the basic dynamic load rating decreases as shown in Table 3.4.

Table 3.4 Temperature Factor

Bearing Temperature	~ 150°C	175°C	200°C
Temperature Factor	1	0.95	0.90

3.3.2 Life Calculation Factors

Rating Life Formula, L=(C/P)p....... (3.1), is used when applying rolling contact bearings for normal use.
To provide for utilization of lubrication theory, and advances in bearing material and bearing manufacturing technology, the ISO and JIS have adopted the following life calculation formula.

$$L_{na} = a_1 \cdot a_2 \cdot a_3 \cdot \left(\frac{C}{P}\right)^p \quad \cdots\cdots\cdot (3.5)$$

where:

Lna	: Adjusted rating life (106 rev.)
a_1	: Reliability factor
a_2	: Material factor
a_3	: Application conditions factor

Formula (3.5) is applicable only when all bearing loads are considered and operating conditions are clearly defined.
Generally, reliability of 90% is used, and material and operating conditions may be considered as a_1, a_2, a_3=1, coinciding with formula (3.1).

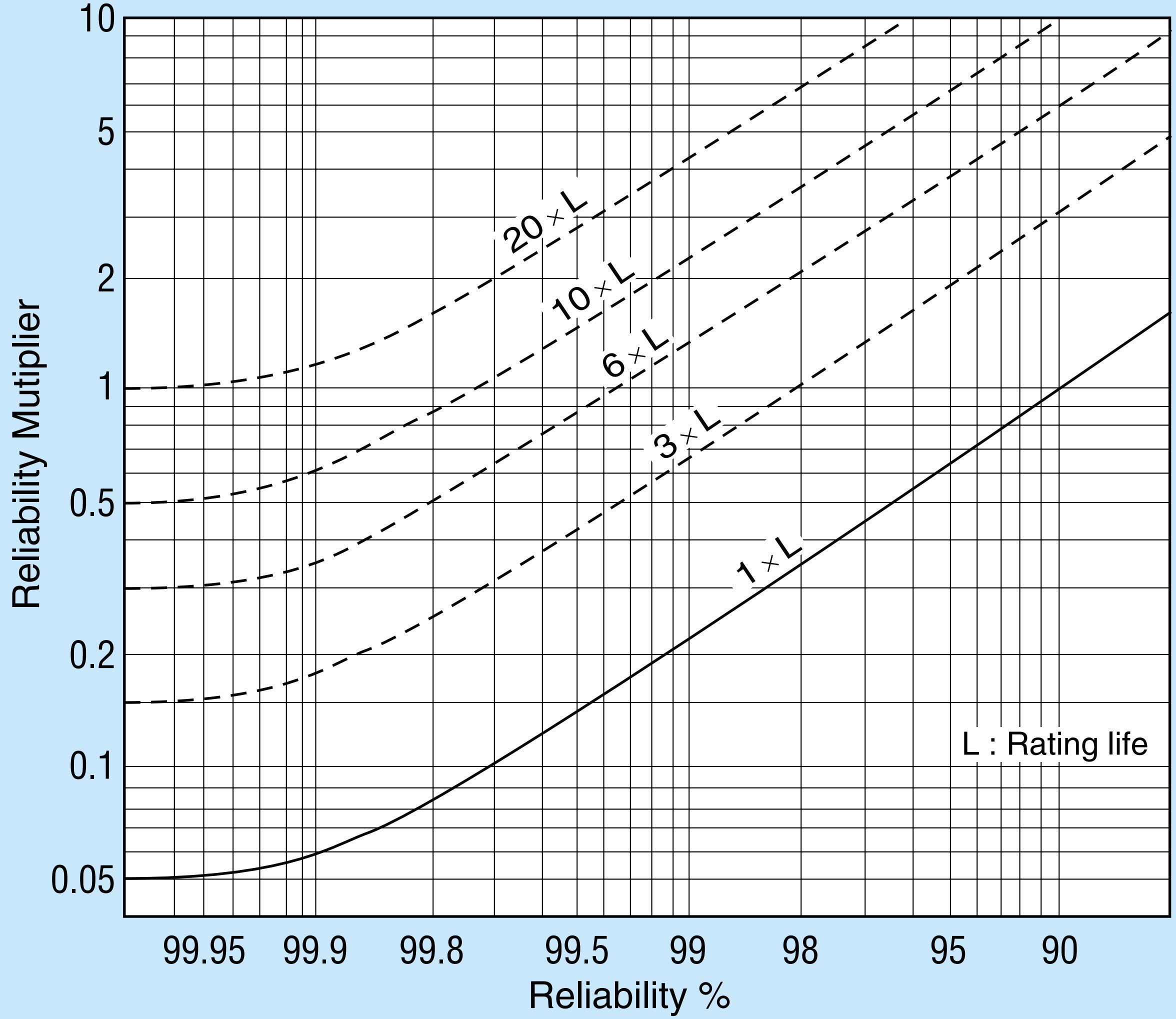
1) Reliability Factor, a_1

Reliability Factor, a1, becomes 1 if 90% of a group of identical bearings operated individually under the same conditions can complete the calculated life without exhibiting material damage from rolling fatigue. Reliability is then set as 90 %, and for reliability over 90%; a1 takes a value from Table 3.5.
As observed from Table 3.5, the calculated bearing life decreases in proportion to a higher level of bearing reliabilities.
Fig. 3.6 shows the improved reliabilities when bearings having rating lives of 3, 6, 10 and 20 times are used in comparison with the 90% reliability (life-multiplying factor being 1) of a bearing having a given rating life.

Table 3.5 Reliability Factor a_1

Reliability %	99	98	97	96	95	90
a_1 factor	0.21	0.33	0.44	0.53	0.62	1

Fig 3.6 Reliability Multiplier



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Calculation example: 4

Bearing Number 6209 is used to support a radial load of 3160N. Object is to define the life and select a bearing which will have a reliability of 99.4%.

The life corresponding to the reliability of 90% is obtained as follows by reading the basic dynamic load rating, Cr=32500N from the dimension table and using formula (3.1):

$$\left(\frac{32500}{3160}\right)^3 \times 10^6 = 1088 \times 10^6 \text{rev.}$$

Reading Fig. 3.6, it can be seen that a bearing having a life -multiplying factor of 6 is required to attain 99.4% reliability. Applying this multiplier to the basic dynamic load rating, Cr as obtained from formula (3.1), will calculate as:

$$\left(\frac{Cr}{3160}\right)^3 \times 10^6 = 6 \times 1088 \times 10^6 \text{rev.}$$

From the above equation, obtain;

$$\begin{aligned} Cr &= (6)^{1/3} \times 32500 = 1.817 \times 32500 \\ &= 59000\text{N} \end{aligned}$$

The bearing meeting this basic dynamic load rating (in the same diameter series) is bearing number 6214.

[→Continue]

2) Material factor, a_2

Material factor, a_2, is the adjustment factor applied as an increase to rating life for type and quality of material, special manufacturing process and/or special design.

The basic dynamic load rating, Cr (or Ca), listed in the bearing dimension tables reflects both the use of vacuum-degassed, high-carbon chrome bearing steel for all NACHI rolling contact bearings as well as improvements in manufacturing technology. The a_2-factor has a base value of 1 for NACHI standard parts.

Unless specialty steels are utilized, a_2 is defined as 1 when calculating the life using the formula (3.5).

3) Application condition factor, a_3

The application condition factor, a_3, is used to consider bearing load conditions, lubricating conditions, and temperature conditions.

Factor a_3 is set as 1 if the rolling elements and raceway surfaces are separated (good lubricating condition). When lubricating conditions are poor (as in the following cases), a_3 is less than 1:

• When the operating speed is <dm · n of 10,000. (Where dm · n=rolling element pitch diameter in millimeters times the speed in revolutions-per-minute).

• When lubricant will tend to deteriorate rapidly.

At present, it is difficult to quantify the application condition factor because of the many variables involved.

Because factors a_2 and a_3 have interactive effects on each other, these two factors are treated as one value (a_2) (a_3). When lubrication and application conditions are good, the value (a_2) (a_3) can be set as equal to 1.

In case of poor lubrication such as when lubricant viscosity is considerably low, please consult NACHI.

3.4 Calculation of Bearing Load

Generally, the load that is applied to the bearings is composed of loads generated by machine operation, drive components, and dead weight of the shaft and components mounted to and on the shaft. These loads can be precisely calculated. The above loads are usually accompanied by vibration and impact. With the exception of very special cases, it is impractical to calculate and add the specific effects of vibration and impact loading on each component in a machine. To facilitate the calculation and analysis of loading in a machine system, loading factors (based on empirical experience) have been developed as multipliers to the driving and static loads.

$$F = f_s \cdot F_c \qquad \cdots\cdots (3.6)$$

where:

F : Bearing load (N)
fs : Machine factor (Table 3.6)
Fc : Calculated load (N)

When a load fluctuates in size, an average load must be calculated which reflects the effects of the fluctuating load.
When a composite load of radial and axial load occurs on a radial bearing, the loads must be converted to an effective radial load by use of the dynamic equivalent load formula for the specific bearing type. This value, P, is used in the basic rating life formula (3.1).

Table 3.6 Machine Factors, (f_s)

Type of Machine	f_s
Smooth running machinery (no impact) ; motors, conveyors, turbo compressor, paper manufacturing machinery	1 ~ 1.2
Machine with low impact; reciprocating pumps, internal combustion engine, hoists, cranes	1.2 ~ 1.5
Machines with high impact; shears, crushers, rolling mill equipment	1.5 ~ 3.0

Table 3.7 Belt Drive Factors, (f_1)

Type of drive	f_1
Flat leather belt (with tension pulley)	1.75 ~ 2.5
Flat leather belt (without tension pulley) Silk Rubber Balata	2.25 ~ 3.5
V-belt	1.5 ~ 2
Steel strip belt	4 ~ 6
Cotton belt / Hemp belt	2 ~ 6

Notes : 1. For low speed, use top value

Table 3.8 Gear Precisiion Factors, (f_z)

Type of gear	f_z
Precision (Pitch and form errors ≤ 0.02mm)	1 ~ 1.1
Normal (Pitch and form errors 0.02 ~ 0.1mm)	1.1 ~ 1.3

3.4.1 Belt Drives

Transferring of power through belt drives requires on initial belt tension. Radial load, K, that occurs from this tension can be calculated as follows:

$$M = 955000 \cdot \frac{H}{n} \quad \cdots\cdots (3.7)$$

$$Kt = \frac{M}{r} \quad \cdots\cdots (3.8)$$

where:
M : Rotating moment of pulley (N • cm)
Kt : Effective transfer power of belt (N)
(tension side minus slack side)
H : Transfer power (kW)
n : Rotating speed of pulley (rpm)
r : Radius of pulley (cm)

Load that works on the shaft through the pulley is calculated by multiplying the effective transfer power, Kt, by the belt drive factors, f_1, from Table 3.7.
Generally,

$$K = f_1 \cdot Kt \quad \cdots\cdots (3.9)$$

where:
K : Radial load (N) applied to the pulley transferred by the belt
f_1 : Belt drive factor (Table 3.7)

3.4.2 Gear Drives

Shaft load from gear drives are calculated using the transfer power and type of gear.
Helical, bevel and worm gears transmit radial loads and create an axial load component, while spur gears transmit only radial loads.
Gear load formulas described below refer to spur gears.

$$M = 955000 \cdot \frac{H}{n} \quad \cdots\cdots (3.10)$$

$$Kt = \frac{M}{r} \quad \cdots\cdots (3.11)$$

$$Ks = Kt \cdot \tan\alpha \quad \cdots\cdots (3.12)$$

$$Kg = \sqrt{Kt^2 + Ks^2} = Kt \cdot \sec\alpha \quad \cdots (3.13)$$

where:
M : Rotating gear moment (N • cm)
Kt : Tangential component of force (N)
Ks : Radial component of force (N)
Kg : Total gear load (N)
H : Transfer power (kW)
n : Rotating speed (rpm)
r : Drive gear pitch radius (cm)
α : Pressure angle of gear (°)

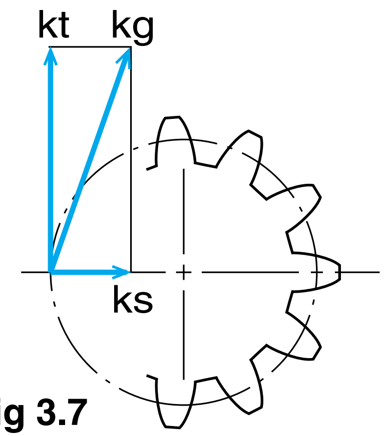


Fig 3.7

[→Continue]

Kg, the total theoretical gear load, must be multiplied by both the gear precision factor and the machine factor (the latter of which takes into account impact and other forces dependent on machinery type).

$$K = f_z \cdot f_s \cdot K_g \qquad \cdots\cdots\; (3.14)$$

where:
K : Gear load transmitted to shaft (N)
fz : Gear precision factor (Table 3.8)
fs : Machine factor (Table 3.6)

3.4.3 Load Distribution to Bearings

Load applied to a point on the shaft is distributed to the bearings supporting the shaft.
Reference Fig. 3.8,

$$Fr_{\mathrm{I}} = \frac{\ell + m}{\ell} K + \frac{x}{x+y} W \qquad \cdots\cdots\; (3.15)$$

$$Fr_{\mathrm{II}} = \frac{m}{\ell} K - \frac{y}{x+y} W \qquad \cdots\cdots\; (3.16)$$

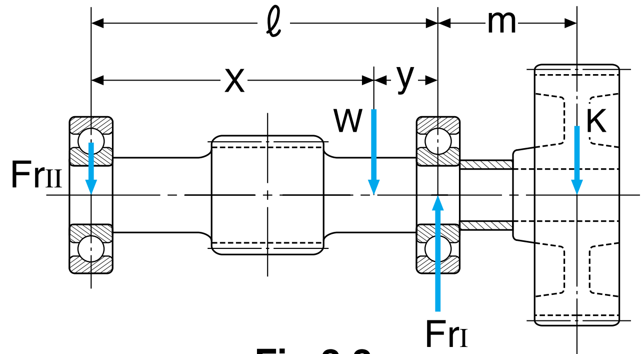


Fig 3.8

where:
Fr_{I} : Load working on bearing I (N)
Fr_{II} : Load working on bearing II (N)
K : Gear load transmitted to shaft (N)
W : Shaft Weight (N)
ℓ,m,x,y : Relative positions of the points of applied force

3.4.4 Averaging Fluctuating Loads

A large load will have an emphasized effect on bearing life even if it is applied only for a very short duration of the total life-span of the bearing.
When the size of bearing load fluctuates with a defined cycle, bearing life may be calculated by deriving an average load simulating the affects of the fluctuating load.

(1) Step Type Load Fluctuation

$$F_m = \sqrt[p]{\frac{F_1^{\,p} n_1 + F_2^{\,p} n_2 \cdots + F_n^{\,p} n_n}{n_1 + n_2 + \cdots\cdots + n_n}} \quad \cdots\cdots (3.17)$$

where:
F_m : Average of fluctuating load (N)
n_1 : Total number of revolutions at load F_1 (rev.)
n_2 : Total number of revolutions at load F_2 (rev.)
n_n : Total number of revolutions at load F_n (rev.)
p : 3 for ball; 10/3 for roller bearings

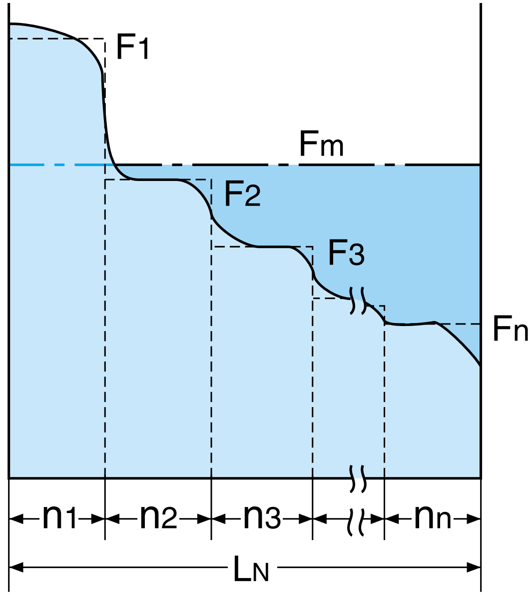


Fig 3.9

In formula (3.17), if rotating speed is constant, and ($n_1 + n_2 + \dots\dots\dots + n_n$) is referenced as applied time, then n_1, n_2 and n_n , can be replaced by time periods t_1, t_2, ... t_n respectively, in the formula.

(2) Linear Load Fluctuation
When the load fluctuates almost linearly (see Fig. 3.10), the following formula is used to obtain the average load.

$$F_m \fallingdotseq \frac{1}{3} F_{min} + \frac{2}{3} F_{max} \quad \cdots\cdots (3.18)$$

where:
F_m : Average load (N)
F_{min} : Minimum load (N)
F_{max} : Maximum load (N)

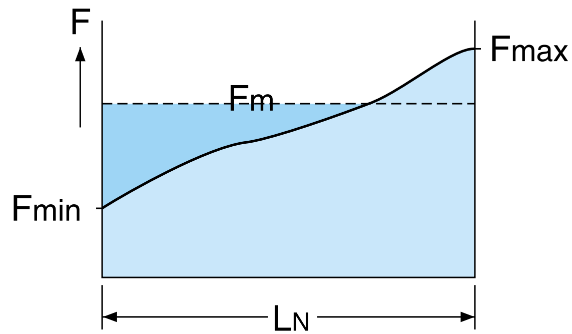


Fig 3.10

[→Continue]

(3) Dynamic plus static load fluctuation

Where load F_1 of a constant size and direction, is combined with a constantly revolving load F_2 caused by an unbalanced load on the bearing (see Fig. 3.11), the average load is calculated using formula 3.19.

$$F_m \fallingdotseq AF_1 + F_2 \qquad \cdots\cdots (3.19)$$

Value of A is taken from Fig. 3.12.

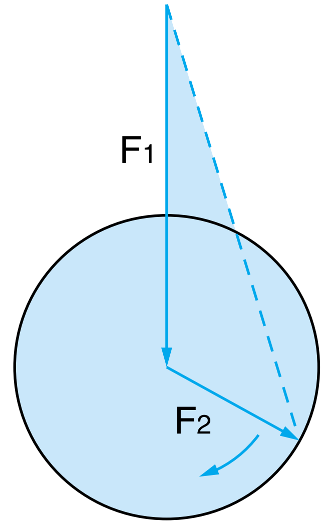


Fig 3.11

Calculation example: 5

A Single-row Deep-groove ball bearing is loaded with the fluctuating radial loads shown below.

Object: to obtain an average radial load on the bearing.

F_1=100N: 800 rpm for 6 sec
F_2= 50N: 1800 rpm for 20 sec
F_3=200N: 3600 rpm for 12 sec

Numbers of revolution for the individual loads F_1, F_2 and F_3 are derived for the formula as follows.

$$n_1 = \frac{6}{60} \times 800 = 80 \text{ rev.} \quad n_2 = \frac{20}{60} \times 1800 = 600 \text{ rev.} \quad n_3 = \frac{12}{60} \times 3600 = 720 \text{ rev.}$$

Therefore,

$$n = n_1 + n_2 + n_3 = 1400 \text{ rev.}$$

From formula (3.17),

$$F_m = \sqrt[3]{\frac{100^3 \times 80 + 50^3 \times 600 + 200^3 \times 720}{1400}}$$

$$= 162 \text{ N}$$

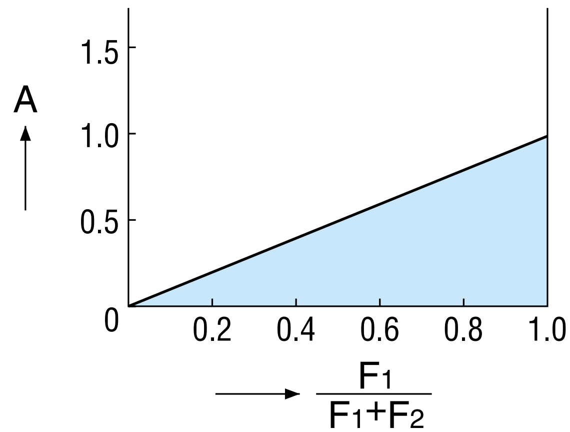


Fig 3.12

3.5 Dynamic Equivalent Load

Dynamic equivalent load refers to a load having constant direction and size such that theoretical calculations of bearing life using this load will simulate actual bearing life. This load is called dynamic equivalent radial load when calculated for radial bearings and dynamic equivalent axial load when calculated for thrust bearings.
In formula (3.1) expressing the relation between the bearing load and bearing life, bearing load, P, is either radial or axial load. Since radial and axial loads often occur simultaneously, the radial and axial loads must be converted to composite load within the dynamic equivalent load formula.

3.5.1 Dynamic Equivalent Radial Load

Dynamic equivalent radial load for radial bearings is calculated using the formula:

$$Pr = XFr + YFa \qquad \cdots\cdots (3.20)$$

where:

Pr : Dynamic equivalent radial load (N)
Fr : Radial load (N)
Fa : Axial load (N)
X : Radial load factor (from dimensional tables)
Y : Axial load factor (from dimensional tables)

In the above formula, if the axial load to radial load ratio, Fa/Fr, is less than or equal to e (a value determined by the bearing size and load as shown in the dimension tables), X, Y, and Pr will be as follows:

X = 1
Y = 0
Pr = Fr

3.5.2 Dynamic Equivalent Axial Load

While most thrust bearings are incapable of supporting any radial load, Spherical roller thrust bearings will support some radial load. For Spherical roller thrust bearings, the dynamic equivalent axial load is derived using the formula:

$$Pa = Fa + 1.2Fr \qquad \cdots\cdots (3.21)$$

where:

Pa : Dynamic equivalent axial load (N)
Fa : Axial load (N)
Fr : Radial load (N)
Fr / Fa must be ≤ 0.55

3.5.3 Dynamic Equivalent Load for Oscillating Loads

The dynamic equivalent load of radial bearings sustaining oscillating movements is derived using the formula:

$$Pr = \left(\frac{\Psi}{90^\circ}\right)^{1/p}(XFr + YFa) \quad \bullet\bullet\bullet\bullet\bullet\bullet\bullet (3.22)$$

where:

- Pr : Dynamic equivalent load (N)
- Ψ : Angle of oscillation (Ψ must be $\geq 90^\circ/Z$)
- p : 3 for ball, 10/3 for roller bearings
- Fr : Radial load (N)
- Fa : Axial load (N)
- X : Radial load factor (from dimensional tables)
- Y : Axial load factor (from dimensional tables)
- Z : Number of rolling elements in row

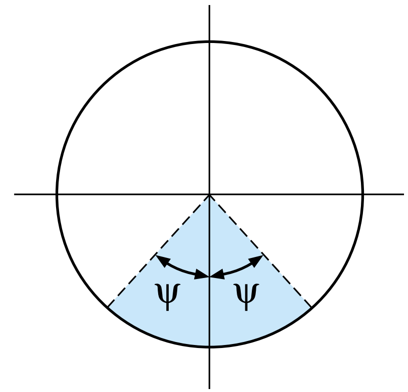


Fig 3.13

If the value of $\Psi<90^\circ/Z$, the above formula may not accurately predict bearing life since localized wear may be generated in the raceways. (Oil lubrication may be tried to prevent the wear (false brinelling) associated with low-amplitude operation in this type application).

3.5.4 Angular Contact Ball; Tapered Roller Bearing Loads

For single-row Angular Contact ball and single-row Tapered roller bearings, the load center dimensions from the bearing tables must be used when determining the relative load positions. The load-center positions of these bearings are off-set from the midpoint of the width of these bearings as shown in Fig 3.14 and 3.15).

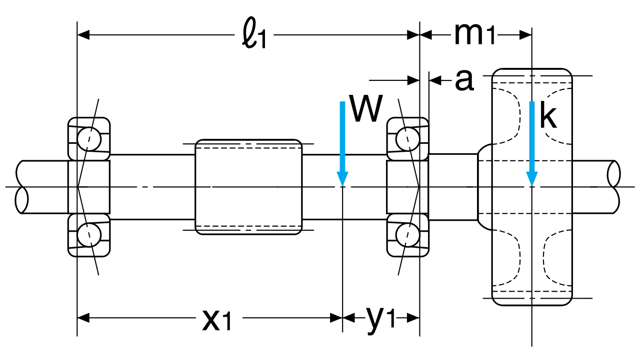


Fig 3.14

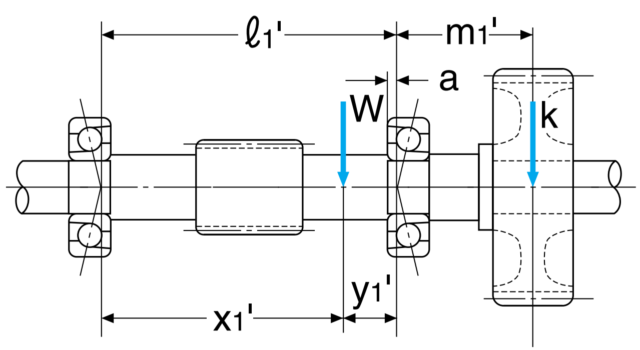


Fig 3.15

[→Continue]

The off-set dimension for Angular Contact ball and Tapered roller bearings is shown as the value "a" in the dimensional tables to indicate the load-center position. If moment loading is to be considered in a bearing system, location of load-center is of particular importance.
Where ℓ_1 , m_1 , x_1 or ℓ'_1 , m'_1 , x'_1 , and y'_1 are applied to formulas (3.15) and (3.16) as effective intervals instead of r, m, x, and y previously used in formulas (3.15) and (3.16). If the radial load is applied to two units of Tapered roller bearings used in pairs and induced axial load will be produced. The magnitude of this induced axial force Fa' is calculated using the formula:

$$Fa' = \frac{Fr}{2Y_1} \qquad \cdots\cdots\cdots (3.23)$$

where:

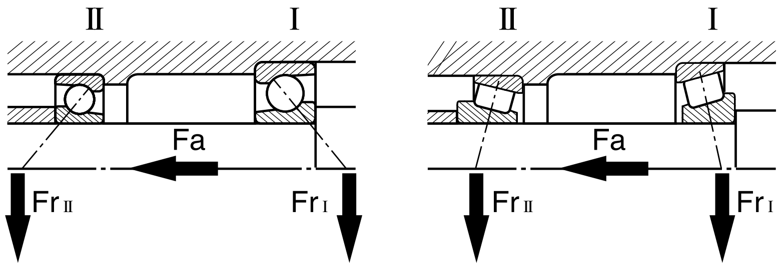
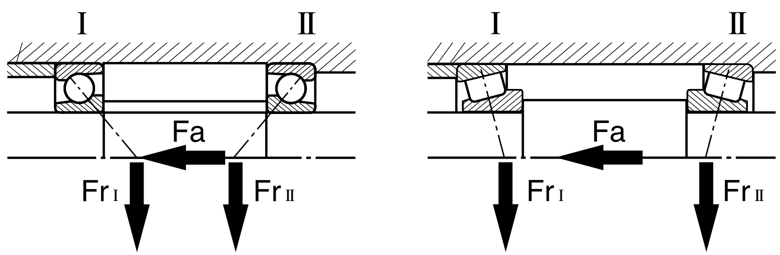
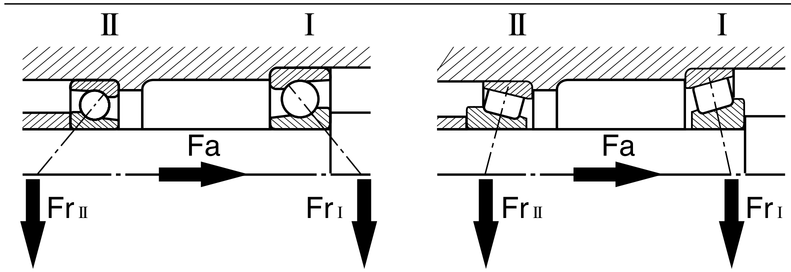
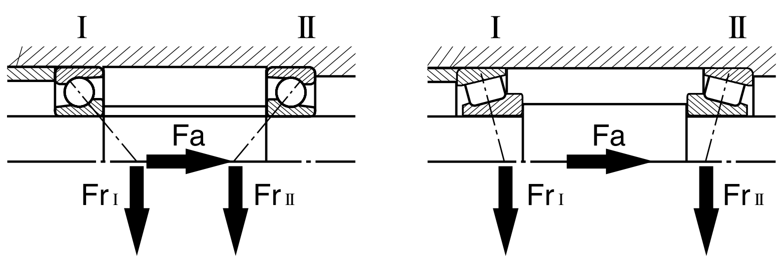
Y_1	: Axial load factor (from dimension tables)
Fa'	: External axial load (N)
Fr	: Radial load (N)

Axial and equivalent radial load on bearing calculated using formulas in Tables 3.9.

Table 3.9 Axial and Equivalent Load of Angular Contact Ball and Tapered Roller Bearings

Fr1,Fr2 : Radial load applied to bearings1and2(N)
Fa : External axial load (N) direction shown by Table 3.9
Fa1,Fa2 : Axial load on bearings1and2(N)
Pr1,Pr2 : Dynamic equivalent radial load on bearings1and2(N)
X1,X2 : Radial Load Factor for bearings1and2from dimension tables
Y1,Y2 : Axial Load Factor for bearings1and2from dimension tables
(Use Y1 for Tapered roller bearings)

Table 3.9 Axial and Equivalent Load of Angular Contact Ball and Tapered Roller Bearings

Bearing arrangement	Load conditions	Axial load	Dynamic equivalent radial load
	$Fa \geq 0.5\left(\frac{Fr_{\mathrm{I}}}{Y_{\mathrm{I}}} - \frac{Fr_{\mathrm{II}}}{Y_{\mathrm{II}}}\right)$	$Fa_{\mathrm{I}}=Fa_{\mathrm{II}}+Fa$ $Fa_{\mathrm{II}}=0.5\frac{Fr_{\mathrm{II}}}{Y_{\mathrm{II}}}$	$Pr_{\mathrm{I}}=X_{\mathrm{I}}Fr_{\mathrm{I}}+Y_{\mathrm{I}}(Fa_{\mathrm{II}}+Fa)$ $Pr_{\mathrm{II}}=Fr_{\mathrm{II}}$
	$Fa < 0.5\left(\frac{Fr_{\mathrm{I}}}{Y_{\mathrm{I}}} - \frac{Fr_{\mathrm{II}}}{Y_{\mathrm{II}}}\right)$	$Fa_{\mathrm{I}}=0.5\frac{Fr_{\mathrm{I}}}{Y_{\mathrm{I}}}$ $Fa_{\mathrm{II}}=Fa_{\mathrm{I}}-Fa$	$Pr_{\mathrm{I}}=Fr_{\mathrm{I}}$ $Pr_{\mathrm{II}}=X_{\mathrm{II}}Fr_{\mathrm{II}}+Y_{\mathrm{II}}(Fa_{\mathrm{I}}-Fa)$
	$Fa \geq 0.5\left(\frac{Fr_{\mathrm{II}}}{Y_{\mathrm{II}}} - \frac{Fr_{\mathrm{I}}}{Y_{\mathrm{I}}}\right)$	$Fa_{\mathrm{I}}=0.5\frac{Fr_{\mathrm{I}}}{Y_{\mathrm{I}}}$ $Fa_{\mathrm{II}}=Fa_{\mathrm{I}}+Fa$	$Pr_{\mathrm{I}}=Fr_{\mathrm{I}}$ $Pr_{\mathrm{II}}=X_{\mathrm{II}}Fr_{\mathrm{II}}+Y_{\mathrm{II}}(Fa_{\mathrm{I}}+Fa)$
	$Fa < 0.5\left(\frac{Fr_{\mathrm{II}}}{Y_{\mathrm{II}}} - \frac{Fr_{\mathrm{I}}}{Y_{\mathrm{I}}}\right)$	$Fa_{\mathrm{I}}=Fa_{\mathrm{II}}-Fa$ $Fa_{\mathrm{II}}=0.5\frac{Fr_{\mathrm{II}}}{Y_{\mathrm{II}}}$	$Pr_{\mathrm{I}}=X_{\mathrm{I}}Fr_{\mathrm{I}}+Y_{\mathrm{I}}(Fa_{\mathrm{II}}-Fa)$ $Pr_{\mathrm{II}}=Fr_{\mathrm{II}}$

Notes : 1. Equalities apply when the bearing clearance and preload are 0.
2. Radial load applied in reverse direction to the arrows above will be also treated as positive values.

3.6 Basic Static Load Rating and Static Equivalent Load

3.6.1 Basic Static Load Rating

Load applied to stationary bearings can create permanent indentations in the load surfaces. While some level of deformation can be tolerated, a level of deformation will be reached where noise and vibration during operation of the bearing, will make the bearing unusable.

The term "Basic static load rating" refers to the maximum contact stress value of the static load where the rolling element and raceways contact. The ratings are:

- Self-aligning ball bearing • • • 4600MPa
- Other ball bearings • • • 4200MPa
- Roller bearings • • • 4000 MPa

With these contact stresses, the sum of deformations (ball/roller and raceway) is approximately 1/10000 of the diameter of the rolling element.

Basic static load ratings are shown in the dimension tables for each bearing number. The symbol Cor is for radial bearings and the symbol Coa is for thrust bearings.

3.6.2 Static Equivalent Load

Static equivalent load is the static load that reflects the actual load conditions to the contact section of the rolling elements and raceway receiving the maximum stress. For radial bearings, radial load of a constant direction and size is called the static equivalent radial load, and for thrust bearings, axial load of a constant direction and size is called the static equivalent axial load.

1) Static equivalent radial load

To calculate the static equivalent radial load of a radial bearing supporting simultaneous radial and axial loads, the larger of the values obtained from formulas (3.24) and (3.25) are to be used

$$Por=XoFr+YoFa \quad \cdots\cdots (3.24)$$

$$Por=Fr \quad \cdots\cdots (3.25)$$

where:

Por : Static equivalent radial load (N)

Fr : Radial load (N)

Fa : Axial load (N)

Xo & Yo: Static radial and axial load factors from dimension tables

[→Continue]

2) Static equivalent axial load

Static equivalent axial load for Spherical Thrust bearings is calculated using formula (3.26)

$$Poa = Fa + 2.7Fr \quad \cdots\cdots \ (3.26)$$

where:

Poa : Static equivalent axial load (N)

Fa : Axial load (N)

Fr : Radial load (N)

Fr/Fa must be ≤ 0.55

3.6.3 Safety Factor

The basic static load rating is considered as the limiting load for general applications. In terms of a safety factor, this means that, by definition, a safety factor, So, is set as a base of 1. An application may require a larger or allow a smaller safety factor. Table 3.10 provides a guide for selection of the safety factor, So, to be used with formula (3.27) for calculation of the maximum (weighted) static equivalent load.

$$Co = So \cdot Pomax \quad \cdots\cdots \ (3.27)$$

where:

Co: Basic static load rating (N)

(Cor for radial; Coa for thrust bearings)

So: Safety factor

(select from Table 3.10)

Pomax: Static equivalent load (N)

Table 3.10 Static Safety Factor (So)

Application condition	So	
	Ball Bearings	Roller Bearings
High rotating accuracy is needed	2	3
Vibration and/or impact present	1.5	2
Normal operating conditions	1	1.5
Small amount of permanent deformation is tolerable	0.7	1

Note : So > 4 for spherical roller thrust bearings

3.7 Axial Load Capacity of Cylindrical Roller Bearings

Cylindrical roller bearings are generally used for supporting radial loads only. Bearings having flanges or loose ribs on both the inner and outer rings (such as on configurations NJ, NF, and NUP), however, are capable of supporting some amount of axial load. Since any axial loading on a cylindrical roller bearing is supported by a "sliding" action between the roller ends and flanges, allowable axial load is based on the limiting values of heat, seizure, and wear caused by this "sliding" contact.
Permissible axial loading (no consideration of bearing life as a radial bearing) on Cylindrical roller bearings is calculated using the following formula.

$$F_a = (pv)\frac{\lambda}{n} \quad \cdots\cdots \text{Allowable axial load (N)}$$

pv : Application factor from Table 3.11.1
λ : Bearing type factor from Table 3.11.2
n : Rotating speed (rpm)

However, there is another limits shown by the following formula because Fa exceeding the limits cause abnormal roller movement

Allowable axial load $\leq$ K1 · Fr

Bearing series	K1
1000, 200, 200E 300, 300E, 400	0.2
2200, 2200E, 2300, 2300E	0.4

When cylindrical roller bearings are applied axial load, additional considerations are required as follows;

- Apply sufficient radial load to overcome axial load
- Supply sufficient lubricant between roller ends and flanges
- Use lubricant which has good film strength (pressure resistant) properties
- Practice good bearing mounting accuracy (see section 8.3)
- Allow sufficient running-in
- Minimize radial bearing clearance

Table 3.11.1 Application Factor (pv)

Operating conditions (Load and lubrication)	(pv)
Intermittent axial load, Good heat conduction and Good cooling or Very large amount of lubricant	5400 ~ 6900
Intermittent axial load, Good heat conduction and Large amount of lubricant	2600 ~ 3200
Oil lubrication, Good heat conduction or Good cooling	1900 ~ 2200
Continuous axial load and Oil lubrication or Intermittent axial load and Grease lubrication	1300 ~ 1600
Continuous axial load and Grease lubrication	690 ~ 780

Table 3.11.2 Bearing Type Factor λ

Diameter Series	λ
0	19d
2	32d
3	45d
4	60d

d=Bearing bore (mm)

4. Boundary Dimensions and Nomenclature

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4.1 Boundary Dimensions

4.2 Radial Bearings(Except Tapered Roller Bearings)

Table 4.2.1
- Diameter series 7
- Diameter series 8
- Diameter series 9
- Diameter series 0

Table 4.2.2
- Diameter series 1
- Diameter series 2
- Diameter series 3
- Diameter series 4

4.3 Boundary Dimensions of Tapered Roller Bearings

Table 4.3.1
- Diameter series 9
- Diameter series 1
- Diameter series 0

Table 4.3.2
- Diameter series 2
- Diameter series 3

4.4 Boundary Dimensions of Thrust Bearings with Flat Back Face

Table 4.4.1
- Diameter series 0
- Diameter series 1

Table 4.4.2
- Diameter series 2

Table 4.4.3
- Diameter series 3

Table 4.4.4
- Diameter series 4
- Diameter series 5

4.5 Dimensions of Snap Ring Grooves and Snap Rings

- Table 4.5.1 Dimensions of Snap Ring Grooves for Bearing Dimension Series 18 and 19
- Table 4.5.2 Snap Ring Dimensions for Bearing Dimension Series 18 and 19
- Table 4.5.3 Dimensions of Snap Ring Grooves for Bearing Diameter Series 0, 2, 3 and 4
- Table 4.5.4 Snap Ring Dimensions for Bearing Diameter Series 0, 2, 3 and 4

4.6 NACHI Bearing Numbers

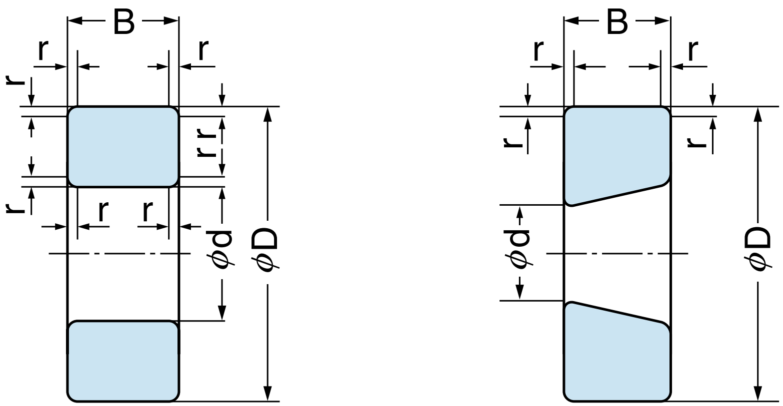
4. Boundary Dimensions and Bearing Numbers of Rolling Contact Bearings

4.1 Boundary Dimensions of Rolling Contact Bearings

Boundary dimensions have been established in a standard plan for metric rolling contact bearings to facilitate the selection process, improve availability, and to limit the necessity for use of high cost, non-standard parts.
Boundary dimensions standards include the bore diameter (d), outside diameter (D), width (B), assembly width (T) or height (H), and the chamfer dimension (r) of bearings.
Boundary dimensions are standardized by the International Organization for Standardization (ISO 15) and also Japanese Industrial Standard (JIS B 1512).
NACHI has adopted the ISO boundary dimension standards. Figures 4.6 and 4.7 show the relationship of the dimensions for radial and thrust rolling contact bearings (except for Tapered roller bearings).

Table 4.1 Boundary Dimensions Terminolory

Series	Definition	Remarks
Diameter series	The diameter series is a series of standard outside diameters with standard bore diameters. Several series of outside diameters are set in stages to the same bearing bore diameter. Diameter series are labeled by single digit numbers 7, 8, 9, 0, 1, 2, 3, and 4.	Diameter series is in ascending order by diameter size with number 7 the smallest and 4 the largest.
Width or Height series	Width or height series is a series of standard widths or heights with the same bore diameter within the same diameter series of bearings. These width or height series are labeled with single digit numbers. Width series 8, 0, 1, 2, 3, 4, 5, and 6 for radial bearings and height series 7, 9, 1, and 2 are for thrust bearings.	Each radial bearing diameter series has width series with numbers 8, 0, 1, 2, 3, 4, 5 and 6. Number 8 is the minimum width to the same bore and outside diameter. Number 6 is the maximum width
Dimension series	Dimension series = width or height series number + Diameter series. Dimension series are labeled with a two digit number by combining numbers for the width or height series to the numbers for the diameter series. The two digit number has the width or height series in the lead position.	Each thrust bearing diameter series has width series with number 7, 9, 1 and 2. Number 7 is the minimum width to the same bore and outside diameter. Number 2 is the maximum width



Cylindrical Bore

Tapered bore ($\frac{1}{12}$ or $\frac{1}{30}$ taper)

Fig 4.1 Radial Bearings (except Tapered Roller Baerings)

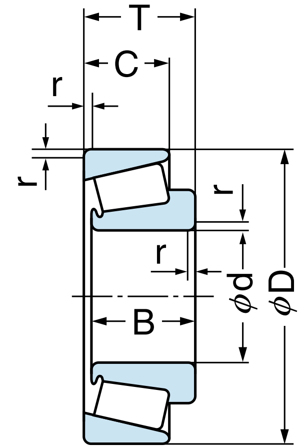


Fig 4.2 Tapered Roller Bearings

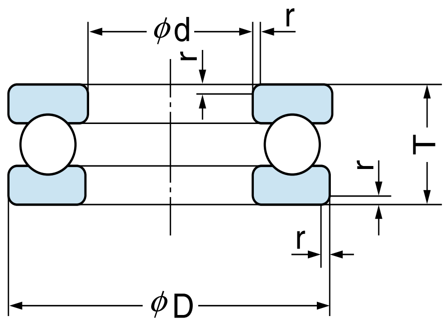


Fig 4.3
Single-direction Thrust Ball Bearings

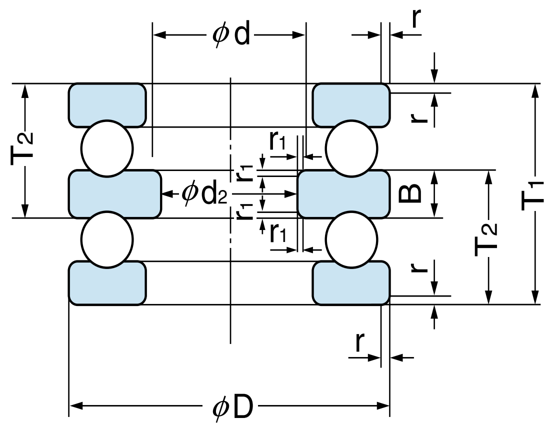


Fig 4.4
Double-direction Thrust Ball Bearings

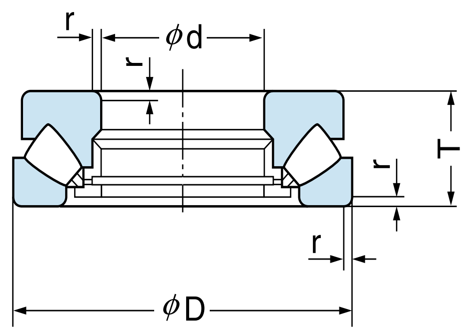


Fig 4.5
Spherical Roller Thrust Bearings

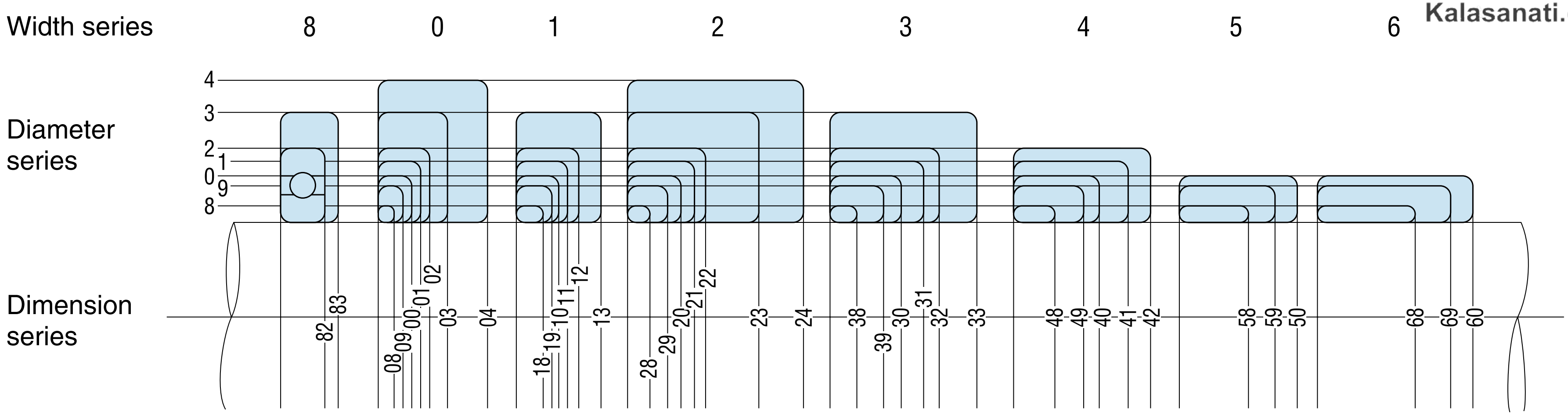


Fig 4.6 Graphical Representation of the Dimension series of Radial Bearings (except Tapered Roller Bearings)

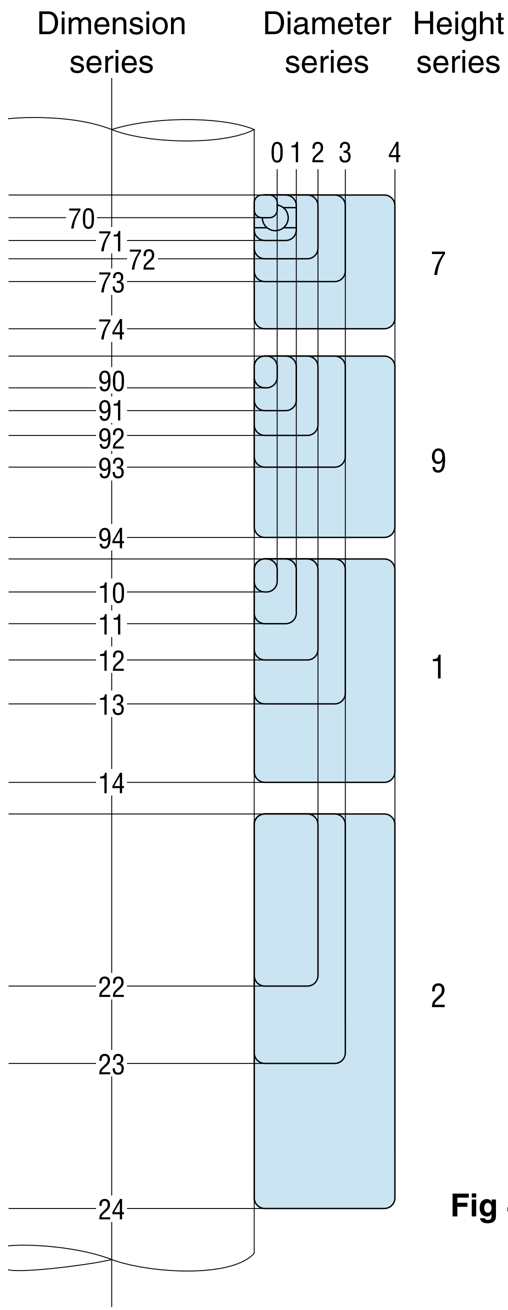


Fig 4.7 Graphical Indication of Dimension Series of Thrust Bearings

Table 4.2.1 Boundary Dimensions of Diameter Series 7, 8 (1/8)

Unit : mm

Single row, radial ball bearings			67						68							
Double row, radial ball bearings																
Cylindrical roller bearings																
Spherical roller bearings																
Bearing bore diameter Nominal		Diameter series 7					Diameter series 8									
		Bearing outside diameter D	Width series 1	Width series 2	Width series 3	Chamfer dimension	Bearing outside diameter D	Width series 0	Width series 1	Width series 2	Width series 3	Width series 4	Width series 5	Width series 6	Chamfer dimension	Chamfer dimension
			Dimension series 17	27	37	17 ~ 37		Dimension series 08	18	28	38	48	58	68	08	18 ~ 68
Bore No.	d		Width B			r_{min}		Width B							r_{min}	
/0.6	0.6	2	0.8	–	–	0.05	2.5	–	1	–	1.4	–	–	–	–	0.05
1	1	2.5	1	–	–	0.05	3	–	1	–	1.5	–	–	–	–	0.05
/1.5	1.5	3	1	–	1.8	0.05	4	–	1.2	–	2	–	–	–	–	0.05
2	2	4	1.2	–	2	0.05	5	–	1.5	–	2.3	–	–	–	–	0.08
/2.5	2.5	5	1.5	–	2.3	0.08	6	–	1.8	–	2.6	–	–	–	–	0.08
3	3	6	2	2.5	3	0.08	7	–	2	–	3	–	–	–	–	0.1
4	4	7	2	2.5	3	0.08	9	–	2.5	3.5	4	–	–	–	–	0.1
5	5	8	2	2.5	3	0.08	11	–	3	4	5	–	–	–	–	0.15
6	6	10	2.5	3	3.5	0.1	13	–	3.5	5	6	–	–	–	–	0.15
7	7	11	2.5	3	3.5	0.1	14	–	3.5	5	6	–	–	–	–	0.15
8	8	12	2.5	–	3.5	0.1	16	–	4	5	6	8	–	–	–	0.2
9	9	14	3	–	4.5	0.1	17	–	4	5	6	8	–	–	–	0.2

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 7, 8 (2/8) Unit : mm

Bearing bore diameter Nominal		Diameter series 7					Diameter series 8									
Single row, radial ball bearings			67						68							
Double row, radial ball bearings																
Cylindrical roller bearings																
Spherical roller bearings																
		Bearing outside diameter D	Width series 1	Width series 2	Width series 3	Chamfer dimension	Bearing outside diameter D	Width series 0	1	2	3	4	5	6	Chamfer dimension	
			Dimension series 17	27	37	17 ~ 37		Dimension series 08	18	28	38	48	58	68	08	18 ~ 68
Bore No.	d		Width B			r_{min}		Width B							r_{min}	
00	10	15	3	–	4.5	0.1	19	–	5	6	7	9	–	–	–	0.3
01	12	18	4	–	5	0.2	21	–	5	6	7	9	–	–	–	0.3
02	15	21	4	–	5	0.2	24	–	5	6	7	9	–	–	–	0.3
03	17	23	4	–	5	0.2	26	–	5	6	7	9	–	–	–	0.3
04	20	27	4	–	5	0.2	32	4	7	8	10	12	16	22	0.3	0.3
/22	22	–	–	–	–	–	34	4	7	–	10	–	16	22	0.3	0.3
05	25	32	4	–	5	0.2	37	4	7	8	10	12	16	22	0.3	0.3
/28	28	–	–	–	–	–	40	4	7	–	10	–	16	22	0.3	0.3
06	30	37	4	–	5	0.2	42	4	7	8	10	12	16	22	0.3	0.3
/32	32	–	–	–	–	–	44	4	7	–	10	–	16	22	0.3	0.3
07	35	–	–	–	–	–	47	4	7	8	10	12	16	22	0.3	0.3
08	40	–	–	–	–	–	52	4	7	8	10	12	16	22	0.3	0.3

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 7, 8 (3/8) Unit : mm

Single row, radial ball bearings			67						68							
Double row, radial ball bearings																
Cylindrical roller bearings																
Spherical roller bearings																
Bearing bore diameter Nominal		Diameter series 7					Diameter series 8									
		Bearing outside diameter D	Width series 1	Width series 2	Width series 3	Chamfer dimension	Bearing outside diameter D	Width series 0	Width series 1	Width series 2	Width series 3	Width series 4	Width series 5	Width series 6	Chamfer dimension	
			Dimension series 17	27	37	17 ~ 37		Dimension series 08	18	28	38	48	58	68	08	18 ~ 68
Bore No.	d		Width B			r_{min}		Width B							r_{min}	
09	45	–	–	–	–	–	58	4	7	8	10	13	18	23	0.3	0.3
10	50	–	–	–	–	–	65	5	7	10	12	15	20	27	0.3	0.3
11	55	–	–	–	–	–	72	7	9	11	13	17	23	30	0.3	0.3
12	60	–	–	–	–	–	78	7	10	12	14	18	24	32	0.3	0.3
13	65	–	–	–	–	–	85	7	10	13	15	20	27	36	0.3	0.6
14	70	–	–	–	–	–	90	8	10	13	15	20	27	36	0.3	0.6
15	75	–	–	–	–	–	95	8	10	13	15	20	27	36	0.3	0.6
16	80	–	–	–	–	–	100	8	10	13	15	20	27	36	0.3	0.6
17	85	–	–	–	–	–	110	9	13	16	19	25	34	45	0.3	1
18	90	–	–	–	–	–	115	9	13	16	19	25	34	45	0.3	1
19	95	–	–	–	–	–	120	9	13	16	19	25	34	45	0.3	1
20	100	–	–	–	–	–	125	9	13	16	19	25	34	45	0.3	1

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 7, 8 (4/8) Unit : mm

Bearing type															
Single row, radial ball bearings			67						68						
Double row, radial ball bearings															
Cylindrical roller bearings															
Spherical roller bearings															
		Diameter series 7					Diameter series 8								
Bearing bore diameter Nominal		Bearing outside diameter D	Width series 1	2	3	Chamfer dimension	Bearing outside diameter D	Width series 0	1	2	3	4	5	6	Chamfer dimension
			Dimension series 17	27	37	17 ~ 37		Dimension series 08	18	28	38	48	58	68	08 / 18 ~ 68
Bore No.	d		Width B			r_{min}		Width B							r_{min}
21	105	–	–	–	–	–	130	9	13	16	19	25	34	45	0.3 / 1
22	110	–	–	–	–	–	140	10	16	19	23	30	40	54	0.6 / 1
24	120	–	–	–	–	–	150	10	16	19	23	30	40	54	0.6 / 1
26	130	–	–	–	–	–	165	11	18	22	26	35	46	63	0.6 / 1.1
28	140	–	–	–	–	–	175	11	18	22	26	35	46	63	0.6 / 1.1
30	150	–	–	–	–	–	190	13	20	24	30	40	54	71	0.6 / 1.1
32	160	–	–	–	–	–	200	13	20	24	30	40	54	71	0.6 / 1.1
34	170	–	–	–	–	–	215	14	22	27	34	45	60	80	0.6 / 1.1
36	180	–	–	–	–	–	225	14	22	27	34	45	60	80	0.6 / 1.1
38	190	–	–	–	–	–	240	16	24	30	37	50	67	90	1 / 1.5
40	200	–	–	–	–	–	250	16	24	30	37	50	67	90	1 / 1.5
44	220	–	–	–	–	–	270	16	24	30	37	50	67	90	1 / 1.5

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 7, 8 (5/8)

Unit : mm

Bore No.	d	Diameter series 7: Bearing outside diameter D	Width series 1 / Dimension series 17: Width B	Width series 2 / Dimension series 27: Width B	Width series 3 / Dimension series 37: Width B	Chamfer dimension 17 ~ 37: r_{min}	Diameter series 8: Bearing outside diameter D	Width series 0 / Dimension series 08: Width B	Width series 1 / Dimension series 18: Width B	Width series 2 / Dimension series 28: Width B	Width series 3 / Dimension series 38: Width B	Width series 4 / Dimension series 48: Width B	Width series 5 / Dimension series 58: Width B	Width series 6 / Dimension series 68: Width B	Chamfer dimension 08: r_{min}	Chamfer dimension 18 ~ 68: r_{min}
Single row, radial ball bearings			67						68							
Double row, radial ball bearings																
Cylindrical roller bearings																
Spherical roller bearings																
48	240	–	–	–	–	–	300	19	28	36	45	60	80	109	1	2
52	260	–	–	–	–	–	320	19	28	36	45	60	80	109	1	2
56	280	–	–	–	–	–	350	22	33	42	52	69	95	125	1.1	2
60	300	–	–	–	–	–	380	25	38	48	60	80	109	145	1.5	2.1
64	320	–	–	–	–	–	400	25	38	48	60	80	109	145	1.5	2.1
68	340	–	–	–	–	–	420	25	38	48	60	80	109	145	1.5	2.1
72	360	–	–	–	–	–	440	25	38	48	60	80	109	145	1.5	2.1
76	380	–	–	–	–	–	480	31	46	60	75	100	136	180	2	2.1
80	400	–	–	–	–	–	500	31	46	60	75	100	136	180	2	2.1
84	420	–	–	–	–	–	520	31	46	60	75	100	136	180	2	2.1
88	440	–	–	–	–	–	540	31	46	60	75	100	136	180	2	2.1
92	460	–	–	–	–	–	580	37	56	72	90	118	160	218	2.1	3

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 7, 8 (6/8)

Unit : mm

Single row, radial ball bearings			67						68							
Double row, radial ball bearings																
Cylindrical roller bearings																
Spherical roller bearings																
Bearing bore diameter Nominal		Diameter series 7					Diameter series 8									
		Bearing outside diameter D	Width series 1	Width series 2	Width series 3	Chamfer dimension	Bearing outside diameter D	Width series 0	Width series 1	Width series 2	Width series 3	Width series 4	Width series 5	Width series 6	Chamfer dimension	
			Dimension series 17	27	37	17 ~ 37		Dimension series 08	18	28	38	48	58	68	08	18 ~ 68
Bore No.	d		Width B			r_{min}		Width B							r_{min}	
96	480	–	–	–	–	–	600	37	56	72	90	118	160	218	2.1	3
/500	500	–	–	–	–	–	620	37	56	72	90	118	160	218	2.1	3
/530	530	–	–	–	–	–	650	37	56	72	90	118	160	218	2.1	3
/560	560	–	–	–	–	–	680	37	56	72	90	118	160	218	2.1	3
/600	600	–	–	–	–	–	730	42	60	78	98	128	175	236	3	3
/630	630	–	–	–	–	–	780	48	69	88	112	150	200	272	3	4
/670	670	–	–	–	–	–	820	48	69	88	112	150	200	272	3	4
/710	710	–	–	–	–	–	870	50	74	95	118	160	218	290	4	4
/750	750	–	–	–	–	–	920	54	78	100	128	170	230	308	4	5
/800	800	–	–	–	–	–	980	57	82	106	136	180	243	325	4	5
/850	850	–	–	–	–	–	1030	57	82	106	136	180	243	325	4	5
/900	900	–	–	–	–	–	1090	60	85	112	140	190	258	345	5	5

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 7, 8 (7/8)

Unit : mm

Bearing type		Series 7: D	17	27	37	17~37	Series 8: D	08	18	28	38	48	58	68	08	18~68
Single row, radial ball bearings			67						68							
Double row, radial ball bearings																
Cylindrical roller bearings																
Spherical roller bearings																
Bearing bore diameter Nominal		Diameter series 7					Diameter series 8									
		Bearing outside diameter D	Width series 1	Width series 2	Width series 3	Chamfer dimension	Bearing outside diameter D	Width series 0	Width series 1	Width series 2	Width series 3	Width series 4	Width series 5	Width series 6	Chamfer dimension	
			Dimension series 17	27	37	17 ~ 37		Dimension series 08	18	28	38	48	58	68	08	18 ~ 68
Bore No.	d		Width B			r_{min}		Width B							r_{min}	
/950	950	–	–	–	–	–	1150	63	90	118	150	200	272	355	5	5
/1000	1000	–	–	–	–	–	1220	71	100	128	165	218	300	400	5	6
/1060	1060	–	–	–	–	–	1280	71	100	128	165	218	300	400	5	6
/1120	1120	–	–	–	–	–	1360	78	106	140	180	243	325	438	5	6
/1180	1180	–	–	–	–	–	1420	78	106	140	180	243	325	438	5	6
/1250	1250	–	–	–	–	–	1500	80	112	145	185	250	335	450	6	6
/1320	1320	–	–	–	–	–	1600	88	122	165	206	280	375	500	6	6
/1400	1400	–	–	–	–	–	1700	95	132	175	224	300	400	545	6	7.5
/1500	1500	–	–	–	–	–	1820	–	140	185	243	315	–	–	–	7.5

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 7, 8 (8/8) Unit : mm

Single row, radial ball bearings			67						68							
Double row, radial ball bearings																
Cylindrical roller bearings																
Spherical roller bearings																
Bearing bore diameter Nominal		Diameter series 7					Diameter series 8									
		Bearing outside diameter D	Width series			Chamfer dimension	Bearing outside diameter D	Width series							Chamfer dimension	
			1	2	3			0	1	2	3	4	5	6		
			Dimension series					Dimension series								
			17	27	37	17 ~ 37		08	18	28	38	48	58	68	08	18 ~ 68
Bore No.	d		Width B			r_{min}		Width B							r_{min}	
/1600	1600	–	–	–	–	–	1950	–	155	200	265	345	–	–	–	7.5
/1700	1700	–	–	–	–	–	2060	–	160	206	272	355	–	–	–	7.5
/1800	1800	–	–	–	–	–	2180	–	165	218	290	375	–	–	–	9.5
/1900	1900	–	–	–	–	–	2300	–	175	230	300	400	–	–	–	9.5
/2000	2000	–	–	–	–	–	2430	–	190	250	325	425	–	–	–	9.5

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 (1/8)

Unit : mm

Single row, radial ball bearings				69 79										160	60 70							
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49								N10		NN30					
Spherical roller bearings						239											230	240				
Bearing bore diameter Nominal		Diameter series 9											Diameter series 0									
		Bearing outside diameter D	Width series							Chamfer dimension			Bearing outside diameter D	Width series							Chamfer dimension	
			0	1	2	3	4	5	6					0	1	2	3	4	5	6		
			Dimension series											Dimension series								
			09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r_{min}				Width B							r_{min}	
/0.6	0.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1	1	4	–	1.6	–	2.3	–	–	–	–	0.1	–	–	–	–	–	–	–	–	–	–	–
/1.5	1.5	5	–	2	–	2.6	–	–	–	–	0.15	–	6	–	2.5	–	3	–	–	–	–	0.15
2	2	6	–	2.3	–	3	–	–	–	–	0.15	–	7	–	2.8	–	3.5	–	–	–	–	0.15
/2.5	2.5	7	–	2.5	–	3.5	–	–	–	–	0.15	–	8	–	2.8	–	4	–	–	–	–	0.15
3	3	8	–	3	–	4	–	–	–	–	0.15	–	9	–	3	–	5	–	–	–	–	0.15
4	4	11	–	4	–	5	–	–	–	–	0.15	–	12	–	4	–	6	–	–	–	–	0.2
5	5	13	–	4	–	6	10	–	–	–	0.2	0.15	14	–	5	–	7	–	–	–	–	0.2
6	6	15	–	5	–	7	10	–	–	–	0.2	0.15	17	–	6	–	9	–	–	–	–	0.3
7	7	17	–	5	–	7	10	–	–	–	0.3	0.15	19	–	6	8	10	–	–	–	–	0.3
8	8	19	–	6	–	9	11	–	–	–	0.3	0.2	22	–	7	9	11	14	19	25	–	0.3
9	9	20	–	6	–	9	11	–	–	–	0.3	0.3	24	–	7	10	12	15	20	27	–	0.3

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 (2/8) Unit : mm

Single row, radial ball bearings				69 79										160	60 70							
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49								N10		NN30					
Spherical roller bearings						239											230	240				
Bearing bore diameter Nominal		Diameter series 9											Diameter series 0									
		Bearing outside diameter D	Width series							Chamfer dimension			Bearing outside diameter D	Width series							Chamfer dimension	
			0	1	2	3	4	5	6					0	1	2	3	4	5	6		
			Dimension series											Dimension series								
			09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r_{min}				Width B							r_{min}	
00	10	22	–	6	8	10	13	16	22	–	0.3	0.3	26	–	8	10	12	16	21	29	–	0.3
01	12	24	–	6	8	10	13	16	22	–	0.3	0.3	28	7	8	10	12	16	21	29	0.3	0.3
02	15	28	–	7	8.5	10	13	18	23	–	0.3	0.3	32	8	9	11	13	17	23	30	0.3	0.3
03	17	30	–	7	8.5	10	13	18	23	–	0.3	0.3	35	8	10	12	14	18	24	32	0.3	0.3
04	20	37	7	9	11	13	17	23	30	0.3	0.3	0.3	42	8	12	14	16	22	30	40	0.3	0.6
/22	22	39	7	9	11	13	17	23	30	0.3	0.3	0.3	44	8	12	14	16	22	30	40	0.3	0.6
05	25	42	7	9	11	13	17	23	30	0.3	0.3	0.3	47	8	12	14	16	22	30	40	0.3	0.6
/28	28	45	7	9	11	13	17	23	30	0.3	0.3	0.3	52	8	12	15	18	24	32	43	0.3	0.6
06	30	47	7	9	11	13	17	23	30	0.3	0.3	0.3	55	9	13	16	19	25	34	45	0.3	1
/32	32	52	7	10	13	15	20	27	36	0.3	0.6	0.6	58	9	13	16	20	26	35	47	0.3	1
07	35	55	7	10	13	15	20	27	36	0.3	0.6	0.6	62	9	14	17	20	27	36	48	0.3	1
08	40	62	8	12	14	16	22	30	40	0.3	0.6	0.6	68	9	15	18	21	28	38	50	0.3	1

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 (3/8) Unit : mm

Single row, radial ball bearings				69 79										160	60 70							
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49								N10		NN30					
Spherical roller bearings						239											230	240				
Bearing bore diameter Nominal			Diameter series 9										Diameter series 0									
		Bearing outside diameter D	Width series							Chamfer dimension			Bearing outside diameter D	Width series							Chamfer dimension	
			0	1	2	3	4	5	6					0	1	2	3	4	5	6		
			Dimension series											Dimension series								
			09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r_{min}				Width B							r_{min}	
09	45	68	8	12	14	16	22	30	40	0.3	0.6	0.6	75	10	16	19	23	30	40	54	0.6	1
10	50	72	8	12	14	16	22	30	40	0.3	0.6	0.6	80	10	16	19	23	30	40	54	0.6	1
11	55	80	9	13	16	19	25	34	45	0.3	1	1	90	11	18	22	26	35	46	63	0.6	1.1
12	60	85	9	13	16	19	25	34	45	0.3	1	1	95	11	18	22	26	35	46	63	0.6	1.1
13	65	90	9	13	16	19	25	34	45	0.3	1	1	100	11	18	22	26	35	46	63	0.6	1.1
14	70	100	10	16	19	23	30	40	54	0.6	1	1	110	13	20	24	30	40	54	71	0.6	1.1
15	75	105	10	16	19	23	30	40	54	0.6	1	1	115	13	20	24	30	40	54	71	0.6	1.1
16	80	110	10	16	19	23	30	40	54	0.6	1	1	125	14	22	27	34	45	60	80	0.6	1.1
17	85	120	11	18	22	26	35	46	63	0.6	1.1	1.1	130	14	22	27	34	45	60	80	0.6	1.1
18	90	125	11	18	22	26	35	46	63	0.6	1.1	1.1	140	16	24	30	37	50	67	90	1	1.5
19	95	130	11	18	22	26	35	46	63	0.6	1.1	1.1	145	16	24	30	37	50	67	90	1	1.5
20	100	140	13	20	24	30	40	54	71	0.6	1.1	1.1	150	16	24	30	37	50	67	90	1	1.5

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 (4/8)

Unit : mm

Single row, radial ball bearings				69 79										160	60 70							
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49								N10		NN30					
Spherical roller bearings						239											230	240				
			Diameter series 9											Diameter series 0								
Bearing bore diameter Nominal		Bearing outside diameter D	Width series 0	1	2	3	4	5	6	Chamfer dimension			Bearing outside diameter D	Width series 0	1	2	3	4	5	6	Chamfer dimension	
			Dimension series 09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		Dimension series 00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r_{min}				Width B							r_{min}	
21	105	145	13	20	24	30	40	54	71	0.6	1.1	1.1	160	18	26	33	41	56	75	100	1	2
22	110	150	13	20	24	30	40	54	71	0.6	1.1	1.1	170	19	28	36	45	60	80	109	1	2
24	120	165	14	22	27	34	45	60	80	0.6	1.1	1.1	180	19	28	36	46	60	80	109	1	2
26	130	180	16	24	30	37	50	67	90	1	1.5	1.5	200	22	33	42	52	69	95	125	1.1	2
28	140	190	16	24	30	37	50	67	90	1	1.5	1.5	210	22	33	42	53	69	95	125	1.1	2
30	150	210	19	28	36	45	60	80	109	1	2	2	225	24	35	45	56	75	100	136	1.1	2.1
32	160	220	19	28	36	45	60	80	109	1	2	2	240	25	38	48	60	80	109	145	1.5	2.1
34	170	230	19	28	36	45	60	80	109	1	2	2	260	28	42	54	67	90	122	160	1.5	2.1
36	180	250	22	33	42	52	69	95	125	1.1	2	2	280	31	46	60	74	100	136	180	2	2.1
38	190	260	22	33	42	52	69	95	125	1.1	2	2	290	31	46	60	75	100	136	180	2	2.1
40	200	280	25	38	48	60	80	109	145	1.5	2.1	2.1	310	34	51	66	82	109	150	200	2	2.1
44	220	300	25	38	48	60	80	109	145	1.5	2.1	2.1	340	37	56	72	90	118	160	218	2.1	3

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 (5/8)

Unit : mm

Single row, radial ball bearings				69 79										160	60 70							
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49								N10		NN30					
Spherical roller bearings						239											230	240				
Bearing bore diameter Nominal		Diameter series 9											Diameter series 0									
		Bearing outside diameter D	Width series							Chamfer dimension			Bearing outside diameter D	Width series							Chamfer dimension	
			0	1	2	3	4	5	6					0	1	2	3	4	5	6		
			Dimension series											Dimension series								
			09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r min				Width B							r min	
48	240	320	25	38	48	60	80	109	145	1.5	2.1	2.1	360	37	56	72	92	118	160	218	2.1	3
52	260	360	31	46	60	75	100	136	180	2	2.1	2.1	400	44	65	82	104	140	190	250	3	4
56	280	380	31	46	60	75	100	136	180	2	2.1	2.1	420	44	65	82	106	140	190	250	3	4
60	300	420	37	56	72	90	118	160	218	2.1	3	3	460	50	74	95	118	160	218	290	4	4
64	320	440	37	56	72	90	118	160	218	2.1	3	3	480	50	74	95	121	160	218	290	4	4
68	340	460	37	56	72	90	118	160	218	2.1	3	3	520	57	82	106	133	180	243	325	4	5
72	360	480	37	56	72	90	118	160	218	2.1	3	3	540	57	82	106	134	180	243	325	4	5
76	380	520	44	65	82	106	140	190	250	3	4	4	560	57	82	106	135	180	243	325	4	5
80	400	540	44	65	82	106	140	190	250	3	4	4	600	63	90	118	148	200	272	355	5	5
84	420	560	44	65	82	106	140	190	250	3	4	4	620	63	90	118	150	200	272	355	5	5
88	440	600	50	74	95	118	160	218	290	4	4	4	650	67	94	122	157	212	280	375	5	6
92	460	620	50	74	95	118	160	218	290	4	4	4	680	71	100	128	163	218	300	400	5	6

Remarks: 1. r min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 **(6/8)** Unit : mm

Bearing type		Series 9: D	0	1	2	3	4	5	6	Chamfer			Series 0: D	0	1	2	3	4	5	6	Chamfer	
Single row, radial ball bearings				69 79										160	60 70							
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49								N10		NN30					
Spherical roller bearings						239											230	240				
Bearing bore diameter Nominal		Diameter series 9											Diameter series 0									
		Bearing outside diameter D	Width series							Chamfer dimension			Bearing outside diameter D	Width series							Chamfer dimension	
			0	1	2	3	4	5	6					0	1	2	3	4	5	6		
			Dimension series											Dimension series								
			09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r_{min}				Width B							r_{min}	
96	480	650	54	78	100	128	170	230	308	4	5	5	700	71	100	128	165	218	300	400	5	6
/500	500	670	54	78	100	128	170	230	308	4	5	5	720	71	100	128	167	218	300	400	5	6
/530	530	710	57	82	106	136	180	243	325	4	5	5	780	80	112	145	185	250	335	450	6	6
/560	560	750	60	85	112	140	190	258	345	5	5	5	820	82	115	150	195	258	355	462	6	6
/600	600	800	63	90	118	150	200	272	355	5	5	5	870	85	118	155	200	272	365	488	6	6
/630	630	850	71	100	128	165	218	300	400	5	6	6	920	92	128	170	212	290	388	515	6	7.5
/670	670	900	73	103	136	170	230	308	412	5	6	6	980	100	136	180	230	308	425	560	6	7.5
/710	710	950	78	106	140	180	243	325	438	5	6	6	1030	103	140	185	236	315	438	580	6	7.5
/750	750	1000	80	112	145	185	250	335	450	6	6	6	1090	109	150	195	250	335	462	615	7.5	7.5
/800	800	1060	82	115	150	195	258	355	462	6	6	6	1150	112	155	200	258	345	475	630	7.5	7.5
/850	850	1120	85	118	155	200	272	365	488	6	6	6	1220	118	165	212	272	365	500	670	7.5	7.5
/900	900	1180	88	122	165	206	280	375	500	6	6	6	1280	122	170	218	280	375	515	690	7.5	7.5

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 (7/8)

Unit : mm

Single row, radial ball bearings				69 79										160	60 70							
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49								N10		NN30					
Spherical roller bearings						239											230	240				
Bearing bore diameter Nominal		Diameter series 9											Diameter series 0									
		Bearing outside diameter D	Width series							Chamfer dimension			Bearing outside diameter D	Width series							Chamfer dimension	
			0	1	2	3	4	5	6					0	1	2	3	4	5	6		
			Dimension series											Dimension series								
			09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r_{min}				Width B							r_{min}	
/950	950	1250	95	132	175	224	300	400	545	6	7.5	7.5	1360	132	180	236	300	412	560	730	7.5	7.5
/1000	1000	1320	103	140	185	236	315	438	580	6	7.5	7.5	1420	136	185	243	308	412	560	750	7.5	7.5
/1060	1060	1400	109	150	195	250	335	462	615	7.5	7.5	7.5	1500	140	195	250	325	438	600	800	9.5	9.5
/1120	1120	1460	109	150	195	250	335	462	615	7.5	7.5	7.5	1580	145	200	265	345	462	615	825	9.5	9.5
/1180	1180	1540	115	160	206	272	355	488	650	7.5	7.5	7.5	1660	155	212	272	355	475	650	875	9.5	9.5
/1250	1250	1630	122	170	218	280	375	515	690	7.5	7.5	7.5	1750	–	218	290	375	500	–	–	–	9.5
/1320	1320	1720	128	175	230	300	400	545	710	7.5	7.5	7.5	1850	–	230	300	400	530	–	–	–	12
/1400	1400	1820	–	185	243	315	425	–	–	–	9.5	9.5	1950	–	243	315	412	545	–	–	–	12
/1500	1500	1950	–	195	258	335	450	–	–	–	9.5	9.5	2120	–	272	355	462	615	–	–	–	12

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 (8/8)

Unit : mm

Single row, radial ball bearings				69 79										160	60 70							
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49								N10		NN30					
Spherical roller bearings						239											230	240				
Bearing bore diameter Nominal		Diameter series 9											Diameter series 0									
		Bearing outside diameter D	Width series							Chamfer dimension			Bearing outside diameter D	Width series							Chamfer dimension	
			0	1	2	3	4	5	6					0	1	2	3	4	5	6		
			Dimension series											Dimension series								
			09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r_{min}				Width B							r_{min}	
/1600	1600	2060	–	200	265	345	462	–	–	–	9.5	9.5	2240	–	280	365	475	630	–	–	–	12
/1700	1700	2180	–	212	280	355	475	–	–	–	9.5	9.5	2360	–	290	375	500	650	–	–	–	15
/1800	1800	2300	–	218	290	375	500	–	–	–	12	12	2500	–	308	400	530	690	–	–	–	15
/1900	1900	2430	–	230	308	400	530	–	–	–	12	12	–	–	–	–	–	–	–	–	–	–
/2000	2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 1, 2 (1/8) Unit : mm

Single row, radial ball bearings												62 72						
Double row, radial ball bearings												12			32 52			
Cylindrical roller bearings												N2		N22				
Spherical roller bearings						231	241							222	232			
		Diameter series 1								Diameter series 2								
Bearing bore diameter Nominal		Bearing outside diameter D	Width series					Chamfer dimension		Bearing outside diameter D	Width series						Chamfer dimension	
			0	1	2	3	4				8	0	1	2	3	4		
			Dimension series								Dimension series							
			01	11	21	31	41	01	11 ~ 41		82	02	12	22	32	42	82	02 ~ 42
Bore No.	d		Width B					r_{min}			Width B						r_{min}	
/0.6	0.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
/1.5	1.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
/2.5	2.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3	3	–	–	–	–	–	–	–	–	10	2.5	4	–	–	5	–	0.1	0.15
4	4	–	–	–	–	–	–	–	–	13	3	5	–	–	7	–	0.15	0.2
5	5	–	–	–	–	–	–	–	–	16	3.5	5	–	–	8	–	0.15	0.3
6	6	–	–	–	–	–	–	–	–	19	4	6	–	–	10	–	0.2	0.3
7	7	–	–	–	–	–	–	–	–	22	5	7	–	–	11	–	0.3	0.3
8	8	–	–	–	–	–	–	–	–	24	5	8	–	–	12	–	0.3	0.3
9	9	–	–	–	–	–	–	–	–	26	6	8	–	–	13	–	0.3	0.3

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 1, 2 (2/8)

Unit : mm

Single row, radial ball bearings												62 72						
Double row, radial ball bearings												12			32 52			
Cylindrical roller bearings												N2		N22				
Spherical roller bearings						231	241							222	232			
Bearing bore diameter Nominal		Diameter series 1								Diameter series 2								
		Bearing outside diameter D	Width series					Chamfer dimension		Bearing outside diameter D	Width series						Chamfer dimension	
			0	1	2	3	4				8	0	1	2	3	4		
			Dimension series								Dimension series							
			01	11	21	31	41	01	11 ~ 41		82	02	12	22	32	42	82	02 ~ 42
Bore No.	d		Width B					r_{min}			Width B						r_{min}	
00	10	–	–	–	–	–	–	–	–	30	7	9	–	14	14.3	–	0.3	0.6
01	12	–	–	–	–	–	–	–	–	32	7	10	–	14	15.9	–	0.3	0.6
02	15	–	–	–	–	–	–	–	–	35	8	11	–	14	15.9	20	0.3	0.6
03	17	–	–	–	–	–	–	–	–	40	8	12	–	16	17.5	22	0.3	0.6
04	20	–	–	–	–	–	–	–	–	47	9	14	–	18	20.6	27	0.3	1
/22	22	–	–	–	–	–	–	–	–	50	9	14	–	18	20.6	27	0.3	1
05	25	–	–	–	–	–	–	–	–	52	10	15	–	18	20.6	27	0.3	1
/28	28	–	–	–	–	–	–	–	–	58	10	16	–	19	23	30	0.6	1
06	30	–	–	–	–	–	–	–	–	62	10	16	–	20	23.8	32	0.6	1
/32	32	–	–	–	–	–	–	–	–	65	11	17	–	21	25	33	0.6	1
07	35	–	–	–	–	–	–	–	–	72	12	17	–	23	27	37	0.6	1.1
08	40	–	–	–	–	–	–	–	–	80	13	18	–	23	30.2	40	0.6	1.1

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 1, 2 (3/8) Unit : mm

Single row, radial ball bearings												62 72						
Double row, radial ball bearings												12			32 52			
Cylindrical roller bearings												N2		N22				
Spherical roller bearings						231	241							222	232			
Bearing bore diameter Nominal		Diameter series 1								Diameter series 2								
		Bearing outside diameter D	Width series					Chamfer dimension		Bearing outside diameter D	Width series						Chamfer dimension	
			0	1	2	3	4				8	0	1	2	3	4		
			Dimension series								Dimension series							
			01	11	21	31	41	01	11 ~ 41		82	02	12	22	32	42	82	02 ~ 42
Bore No.	d		Width B					r_{min}			Width B						r_{min}	
09	45	–	–	–	–	–	–	–	–	85	13	19	–	23	30.2	40	0.6	1.1
10	50	–	–	–	–	–	–	–	–	90	13	20	–	23	30.2	40	0.6	1.1
11	55	–	–	–	–	–	–	–	–	100	14	21	–	25	33.3	45	0.6	1.5
12	60	–	–	–	–	–	–	–	–	110	16	22	–	28	36.5	50	1	1.5
13	65	–	–	–	–	–	–	–	–	120	18	23	–	31	38.1	56	1	1.5
14	70	–	–	–	–	–	–	–	–	125	18	24	–	31	39.7	56	1	1.5
15	75	–	–	–	–	–	–	–	–	130	18	25	–	31	41.3	56	1	1.5
16	80	–	–	–	–	–	–	–	–	140	19	26	–	33	44.4	60	1	2
17	85	–	–	–	–	–	–	–	–	150	21	28	–	36	49.2	65	1.1	2
18	90	150	–	–	–	–	60	–	2	160	22	30	–	40	52.4	69	1.1	2
19	95	160	–	–	–	–	65	–	2	170	24	32	–	43	55.6	75	1.1	2.1
20	100	165	21	30	39	52	65	1.1	2	180	25	34	–	46	60.3	80	1.5	2.1

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 1, 2 (4/8) Unit : mm

		Diameter series 1									Diameter series 2								
Single row, radial ball bearings													62 72						
Double row, radial ball bearings													12			32 52			
Cylindrical roller bearings													N2		N22				
Spherical roller bearings						231	241								222	232			
Bearing bore diameter Nominal		Bearing outside diameter D	Width series 0	1	2	3	4	Chamfer dimension		Bearing outside diameter D	Width series 8	0	1	2	3	4	Chamfer dimension	
			Dimension series 01	11	21	31	41	01	11 ~ 41		Dimension series 82	02	12	22	32	42	82	02 ~ 42
Bore No.	d		Width B					r_{min}			Width B						r_{min}	
21	105	175	22	33	42	56	69	1.1	2	190	27	36	–	50	65.1	85	1.5	2.1
22	110	180	22	33	42	56	69	1.1	2	200	28	38	–	53	69.8	90	1.5	2.1
24	120	200	25	38	48	62	80	1.5	2	215	–	40	42	58	76	95	–	2.1
26	130	210	25	38	48	64	80	1.5	2	230	–	40	46	64	80	100	–	3
28	140	225	27	40	50	68	85	1.5	2.1	250	–	42	50	68	88	109	–	3
30	150	250	31	46	60	80	100	2	2.1	270	–	45	54	73	96	118	–	3
32	160	270	34	51	66	86	109	2	2.1	290	–	48	58	80	104	128	–	3
34	170	280	34	51	66	88	109	2	2.1	310	–	52	62	86	110	140	–	4
36	180	300	37	56	72	96	118	2.1	3	320	–	52	62	86	112	140	–	4
38	190	320	42	60	78	104	128	3	3	340	–	55	65	92	120	150	–	4
40	200	340	44	65	82	112	140	3	3	360	–	58	70	98	128	160	–	4
44	220	370	48	69	88	120	150	3	4	400	–	65	78	108	144	180	–	4

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 1, 2 Unit : mm

Single row, radial ball bearings												62 72						
Double row, radial ball bearings												12			32 52			
Cylindrical roller bearings												N2		N22				
Spherical roller bearings					231	241								222	232			
Bearing bore diameter Nominal		Diameter series 1								Diameter series 2								
		Bearing outside diameter D	Width series					Chamfer dimension		Bearing outside diameter D	Width series						Chamfer dimension	
			0	1	2	3	4				8	0	1	2	3	4		
			Dimension series								Dimension series							
			01	11	21	31	41	01	11 ~ 41		82	02	12	22	32	42	82	02 ~ 42
Bore No.	d		Width B					r_{min}			Width B						r_{min}	
48	240	400	50	74	95	128	160	4	4	440	–	72	85	120	160	200	–	4
52	260	440	57	82	106	144	180	4	4	480	–	80	90	130	174	218	–	5
56	280	460	57	82	106	146	180	4	5	500	–	80	90	130	176	218	–	5
60	300	500	63	90	118	160	200	5	5	540	–	85	98	140	192	243	–	5
64	320	540	71	100	128	176	218	5	5	580	–	92	105	150	208	258	–	5
68	340	580	78	106	140	190	243	5	5	620	–	92	118	165	224	280	–	6
72	360	600	78	106	140	192	243	5	5	650	–	95	122	170	232	290	–	6
76	380	620	78	106	140	194	243	5	5	680	–	95	132	175	240	300	–	6
80	400	650	80	112	145	200	250	6	6	720	–	103	140	185	256	315	–	6
84	420	700	88	122	165	224	280	6	6	760	–	109	150	195	272	335	–	7.5
88	440	720	88	122	165	226	280	6	6	790	–	112	155	200	280	345	–	7.5
92	460	760	95	132	175	240	300	6	7.5	830	–	118	165	212	296	365	–	7.5

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 1, 2

Unit : mm

Single row, radial ball bearings												62 72						
Double row, radial ball bearings												12			32 52			
Cylindrical roller bearings												N2		N22				
Spherical roller bearings						231	241							222	232			
Bearing bore diameter Nominal		Diameter series 1								Diameter series 2								
		Bearing outside diameter D	Width series					Chamfer dimension		Bearing outside diameter D	Width series						Chamfer dimension	
			0	1	2	3	4				8	0	1	2	3	4		
			Dimension series								Dimension series							
			01	11	21	31	41	01	11 ~ 41		82	02	12	22	32	42	82	02 ~ 42
Bore No.	d		Width B					r_{min}			Width B						r_{min}	
96	480	790	100	136	180	248	308	6	7.5	870	–	125	170	224	310	388	–	7.5
/500	500	830	106	145	190	264	325	7.5	7.5	920	–	136	185	243	336	412	–	7.5
/530	530	870	109	150	195	272	335	7.5	7.5	980	–	145	200	258	355	450	–	9.5
/560	560	920	115	160	206	280	355	7.5	7.5	1030	–	150	206	272	365	475	–	9.5
/600	600	980	122	170	218	300	375	7.5	7.5	1090	–	155	212	280	388	488	–	9.5
/630	630	1030	128	175	230	315	400	7.5	7.5	1150	–	165	230	300	412	515	–	12
/670	670	1090	136	185	243	336	412	7.5	7.5	1220	–	175	243	315	438	545	–	12
/710	710	1150	140	195	250	345	438	9.5	9.5	1280	–	180	250	325	450	560	–	12
/750	750	1220	150	206	272	365	475	9.5	9.5	1360	–	195	265	345	475	615	–	15
/800	800	1280	155	212	272	375	475	9.5	9.5	1420	–	200	272	355	488	615	–	15
/850	850	1360	165	224	290	400	500	12	12	1500	–	206	280	375	515	650	–	15
/900	900	1420	165	230	300	412	515	12	12	1580	–	218	300	388	515	670	–	15

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 1, 2 (7/8)

Unit : mm

Single row, radial ball bearings												62 72						
Double row, radial ball bearings												12			32 52			
Cylindrical roller bearings												N2		N22				
Spherical roller bearings						231	241							222	232			
Bearing bore diameter Nominal		Diameter series 1								Diameter series 2								
		Bearing outside diameter D	Width series					Chamfer dimension		Bearing outside diameter D	Width series						Chamfer dimension	
			0	1	2	3	4				8	0	1	2	3	4		
			Dimension series								Dimension series							
			01	11	21	31	41	01	11 ~ 41		82	02	12	22	32	42	82	02 ~ 42
Bore No.	d		Width B					r_{min}			Width B						r_{min}	
/950	950	1500	175	243	315	438	545	12	12	1660	–	230	315	412	530	710	–	15
/1000	1000	1580	185	258	335	462	580	12	12	1750	–	243	330	425	560	750	–	15
/1060	1060	1660	190	265	345	475	600	12	15	–	–	–	–	–	–	–	–	–
/1120	1120	1750	–	280	365	475	630	–	15	–	–	–	–	–	–	–	–	–
/1180	1180	1850	–	290	388	500	670	–	15	–	–	–	–	–	–	–	–	–
/1250	1250	1950	–	308	400	530	710	–	15	–	–	–	–	–	–	–	–	–
/1320	1320	2060	–	325	425	560	750	–	15	–	–	–	–	–	–	–	–	–
/1400	1400	2180	–	345	450	580	775	–	19	–	–	–	–	–	–	–	–	–
/1500	1500	2300	–	355	462	600	800	–	19	–	–	–	–	–	–	–	–	–

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 7, 8 (8/8) Unit : mm

Single row, radial ball bearings													62 72						
Double row, radial ball bearings													12			32 52			
Cylindrical roller bearings													N2		N22				
Spherical roller bearings							231	241							222	232			
Bearing bore diameter Nominal		Diameter series 1									Diameter series 2								
		Bearing outside diameter D	Width series					Chamfer dimension		Bearing outside diameter D	Width series						Chamfer dimension	
			0	1	2	3	4				8	0	1	2	3	4		
			Dimension series								Dimension series							
			01	11	21	31	41	01	11 ~ 41		82	02	12	22	32	42	82	02 ~ 42
Bore No.	d		Width B					r_{min}			Width B						r_{min}	
/1600	1600	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
/1700	1700	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
/1800	1800	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
/1900	1900	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
/2000	2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 3, 4 (1/8)

Unit : mm

Single row, radial ball bearings				63 73									
Double row, radial ball bearings				13			33 53						
Cylindrical roller bearings				N3		N23					N4		
Spherical roller bearings				213		223							
		Diameter series 3								Diameter series 4			
Bearing bore diameter Nominal		Bearing outside diameter D	Width series					Chamfer dimension		Bearing outside diameter D	Width series		Chamfer dimension
			8	0	1	2	3				0	2	
			Dimension series								Dimension series		
			83	03	13	23	33	83	03 ~ 33		04	24	04 ~ 24
Bore No.	d		Width B					r_{min}			Width B		r_{min}
/0.6	0.6	–	–	–	–	–	–	–	–	–	–	–	–
1	1	–	–	–	–	–	–	–	–	–	–	–	–
/1.5	1.5	–	–	–	–	–	–	–	–	–	–	–	–
2	2	–	–	–	–	–	–	–	–	–	–	–	–
/2.5	2.5	–	–	–	–	–	–	–	–	–	–	–	–
3	3	13	–	5	–	–	7	–	0.2	–	–	–	–
4	4	16	–	5	–	–	9	–	0.3	–	–	–	–
5	5	19	–	6	–	–	10	–	0.3	–	–	–	–
6	6	22	–	7	–	11	13	–	0.3	–	–	–	–
7	7	26	–	9	–	13	15	–	0.3	–	–	–	–
8	8	28	–	9	–	13	15	–	0.3	30	10	14	0.6
9	9	30	–	10	–	14	16	–	0.6	32	11	15	0.6

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 3, 4 **(2/8)** Unit : mm

Single row, radial ball bearings				63 73									
Double row, radial ball bearings				13			33 53						
Cylindrical roller bearings				N3		N23					N4		
Spherical roller bearings				213		223							
		Diameter series 3								Diameter series 4			
Bearing bore diameter Nominal		Bearing outside diameter D	Width series 8	0	1	2	3	Chamfer dimension		Bearing outside diameter D	Width series 0	2	Chamfer dimension
			Dimension series 83	03	13	23	33	83	03 ~ 33		Dimension series 04	24	04 ~ 24
Bore No.	d		Width B					r_{min}			Width B		r_{min}
00	10	35	9	11	–	17	19	0.3	0.6	37	12	16	0.6
01	12	37	9	12	–	17	19	0.3	1	42	13	19	1
02	15	42	9	13	–	17	19	0.3	1	52	15	24	1.1
03	17	47	10	14	–	19	22.2	0.6	1	62	17	29	1.1
04	20	52	10	15	–	21	22.2	0.6	1.1	72	19	33	1.1
/22	22	56	11	16	–	21	25	0.6	1.1	–	–	–	–
05	25	62	12	17	–	24	25.4	0.6	1.1	80	21	36	1.5
/28	28	68	13	18	–	24	30	0.6	1.1	–	–	–	–
06	30	72	13	19	–	27	30.2	0.6	1.1	90	23	40	1.5
/32	32	75	14	20	–	28	32	0.6	1.1	–	–	–	–
07	35	80	14	21	–	31	34.9	0.6	1.5	100	25	43	1.5
08	40	90	16	23	–	33	36.5	1	1.5	110	27	46	2

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 3, 4 (3/8) Unit : mm

Bearing type		Diameter series 3: Bearing outside diameter D	Width series 8	Width series 0	Width series 1	Width series 2	Width series 3	Chamfer dimension		Diameter series 4: Bearing outside diameter D	Width series 0	Width series 2	Chamfer dimension
Single row, radial ball bearings				63 73									
Double row, radial ball bearings				13			33 53						
Cylindrical roller bearings				N3		N23					N4		
Spherical roller bearings				213		223							
Dimension series			83	03	13	23	33	83	03 ~ 33		04	24	04 ~ 24
Bearing bore diameter Nominal: Bore No.	d	D	Width B					r_{min}		D	Width B		r_{min}
09	45	100	17	25	–	36	39.7	1	1.5	120	29	50	2
10	50	110	19	27	–	40	44.4	1	2	130	31	53	2.1
11	55	120	21	29	–	43	49.2	1.1	2	140	33	57	2.1
12	60	130	22	31	–	46	54	1.1	2.1	150	35	60	2.1
13	65	140	24	33	–	48	58.7	1.1	2.1	160	37	64	2.1
14	70	150	25	35	–	51	63.5	1.5	2.1	180	42	74	3
15	75	160	27	37	–	55	68.3	1.5	2.1	190	45	77	3
16	80	170	28	39	–	58	68.3	1.5	2.1	200	48	80	3
17	85	180	30	41	–	60	73	2	3	210	52	86	4
18	90	190	30	43	–	64	73	2	3	225	54	90	4
19	95	200	33	45	–	67	77.8	2	3	240	55	95	4
20	100	215	36	47	51	73	82.6	2.1	3	250	58	98	4

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 3, 4 (4/8) Unit : mm

Single row, radial ball bearings				63 73									
Double row, radial ball bearings				13			33 53						
Cylindrical roller bearings				N3		N23					N4		
Spherical roller bearings				213		223							
		Diameter series 3								Diameter series 4			
Bearing bore diameter Nominal		Bearing outside diameter D	Width series 8	Width series 0	Width series 1	Width series 2	Width series 3	Chamfer dimension		Bearing outside diameter D	Width series 0	Width series 2	Chamfer dimension
			Dimension series 83	03	13	23	33	83	03 ~ 33		Dimension series 04	24	04 ~ 24
Bore No.	d		Width B					r_{min}			Width B		r_{min}
21	105	225	37	49	53	77	87.3	2.1	3	260	60	100	4
22	110	240	42	50	57	80	92.1	3	3	280	65	108	4
24	120	260	44	55	62	86	106	3	3	310	72	118	5
26	130	280	48	58	66	93	112	3	4	340	78	128	5
28	140	300	50	62	70	102	118	4	4	360	82	132	5
30	150	320	–	65	75	108	128	–	4	380	85	138	5
32	160	340	–	68	79	114	136	–	4	400	88	142	5
34	170	360	–	72	84	120	140	–	4	420	92	145	5
36	180	380	–	75	88	126	150	–	4	440	95	150	6
38	190	400	–	78	92	132	155	–	5	460	98	155	6
40	200	420	–	80	97	138	165	–	5	480	102	160	6
44	220	460	–	88	106	145	180	–	5	540	115	180	6

Remarks:
1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
   (1) the groove side of bearing rings with snap ring groove
   (2) the flangeless side of thin cylindrical roller bearing rings
   (3) the front face side of angular contact bearing
   (4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 3, 4 (5/8) Unit : mm

Single row, radial ball bearings				63 73									
Double row, radial ball bearings				13			33 53						
Cylindrical roller bearings				N3		N23					N4		
Spherical roller bearings				213		223							
		Diameter series 3								Diameter series 4			
Bearing bore diameter Nominal		Bearing outside diameter D	Width series 8	Width series 0	Width series 1	Width series 2	Width series 3	Chamfer dimension		Bearing outside diameter D	Width series 0	Width series 2	Chamfer dimension
			Dimension series 83	03	13	23	33	83	03 ~ 33		Dimension series 04	24	04 ~ 24
Bore No.	d		Width B					r_{min}			Width B		r_{min}
48	240	500	–	95	114	155	195	–	5	580	122	190	6
52	260	540	–	102	123	165	206	–	6	620	132	206	7.5
56	280	580	–	108	132	175	224	–	6	670	140	224	7.5
60	300	620	–	109	140	185	236	–	7.5	710	150	236	7.5
64	320	670	–	112	155	200	258	–	7.5	750	155	250	9.5
68	340	710	–	118	165	212	272	–	7.5	800	165	265	9.5
72	360	750	–	125	170	224	290	–	7.5	850	180	280	9.5
76	380	780	–	128	175	230	300	–	7.5	900	190	300	9.5
80	400	820	–	136	185	243	308	–	7.5	950	200	315	12
84	420	850	–	136	190	250	315	–	9.5	980	206	325	12
88	440	900	–	145	200	265	345	–	9.5	1030	212	335	12
92	460	950	–	155	212	280	365	–	9.5	1060	218	345	12

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 3, 4 (6/8)

Unit : mm

Single row, radial ball bearings				63 73									
Double row, radial ball bearings				13			33 53						
Cylindrical roller bearings				N3		N23					N4		
Spherical roller bearings				213		223							
		Diameter series 3								Diameter series 4			
Bearing bore diameter Nominal		Bearing outside diameter D	Width series 8	Width series 0	Width series 1	Width series 2	Width series 3	Chamfer dimension		Bearing outside diameter D	Width series 0	Width series 2	Chamfer dimension
			Dimension series 83	03	13	23	33	83	03 ~ 33		Dimension series 04	24	04 ~ 24
Bore No.	d		Width B					r_{min}			Width B		r_{min}
96	480	980	–	160	218	290	375	–	9.5	1120	230	365	15
/500	500	1030	–	170	230	300	388	–	12	1150	236	375	15
/530	530	1090	–	180	243	325	412	–	12	1220	250	400	15
/560	560	1150	–	190	258	335	438	–	12	1280	258	412	15
/600	600	1220	–	200	272	355	462	–	15	1360	272	438	15
/630	630	1280	–	206	280	375	488	–	15	1420	280	450	15
/670	670	1360	–	218	300	400	515	–	15	1500	290	475	15
/710	710	1420	–	224	308	412	530	–	15	–	–	–	–
/750	750	1500	–	236	325	438	560	–	15	–	–	–	–
/800	800	1600	–	258	355	462	600	–	15	–	–	–	–
/850	850	1700	–	272	375	488	630	–	19	–	–	–	–
/900	900	1780	–	280	388	500	650	–	19	–	–	–	–

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 3, 4 (7/8) Unit : mm

Single row, radial ball bearings				63 73									
Double row, radial ball bearings				13			33 53						
Cylindrical roller bearings				N3		N23					N4		
Spherical roller bearings				213		223							
		Diameter series 3								Diameter series 4			
Bearing bore diameter Nominal		Bearing outside diameter D	Width series 8	Width series 0	Width series 1	Width series 2	Width series 3	Chamfer dimension		Bearing outside diameter D	Width series 0	Width series 2	Chamfer dimension
			Dimension series 83	03	13	23	33	83	03 ~ 33		Dimension series 04	24	04 ~ 24
Bore No.	d		Width B					r_{min}			Width B		r_{min}
/950	950	1850	–	290	400	515	670	–	19	–	–	–	–
/1000	1000	1950	–	300	412	545	710	–	19	–	–	–	–
/1060	1060	–	–	–	–	–	–	–	–	–	–	–	–
/1120	1120	–	–	–	–	–	–	–	–	–	–	–	–
/1180	1180	–	–	–	–	–	–	–	–	–	–	–	–
/1250	1250	–	–	–	–	–	–	–	–	–	–	–	–
/1320	1320	–	–	–	–	–	–	–	–	–	–	–	–
/1400	1400	–	–	–	–	–	–	–	–	–	–	–	–
/1500	1500	–	–	–	–	–	–	–	–	–	–	–	–

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.2 Boundary Dimensions of Diameter Series 3, 4 (8/8)

Unit : mm

Bearing type													
Single row, radial ball bearings				63 73									
Double row, radial ball bearings				13			33 53						
Cylindrical roller bearings				N3		N23					N4		
Spherical roller bearings				213		223							
		Diameter series 3								Diameter series 4			
Bearing bore diameter Nominal		Bearing outside diameter D	Width series 8	Width series 0	Width series 1	Width series 2	Width series 3	Chamfer dimension		Bearing outside diameter D	Width series 0	Width series 2	Chamfer dimension
			Dimension series 83	03	13	23	33	83	03 ~ 33		04	24	04 ~ 24
Bore No.	d		Width B					r_{min}			Width B		r_{min}
/1600	1600	–	–	–	–	–	–	–	–	–	–	–	–
/1700	1700	–	–	–	–	–	–	–	–	–	–	–	–
/1800	1800	–	–	–	–	–	–	–	–	–	–	–	–
/1900	1900	–	–	–	–	–	–	–	–	–	–	–	–
/2000	2000	–	–	–	–	–	–	–	–	–	–	–	–

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.3.1 Boundary Dimensions of Tapered Roller Bearings (1/3) Unit : mm

Tapered roller bearing			329						320			330						331				
Bearing bore diameter Nominal		Diameter series 9						Diameter series 0									Diameter series 1					
		Outside diameter	Width series 2			Chamfer dimension		Outside diameter	Width series 2			Width series 3			Chamfer dimension		Outside diameter	Width series 3			Chamfer dimension	
						r_{min}									r_{min}						r_{min}	
Bore No.	d	D	B	C	T	Inner ring	Outer ring	D	B	C	T	B	C	T	Inner ring	Outer ring	D	B	C	T	Inner ring	Outer ring
02	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
03	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
04	20	37	12	9	12	0.3	0.3	42	15	12	15	–	–	–	0.6	0.6	–	–	–	–	–	–
/22	22	40	12	9	12	0.3	0.3	44	15	11.5	15	–	–	–	0.6	0.6	–	–	–	–	–	–
05	25	42	12	9	12	0.3	0.3	47	15	11.5	15	17	14	17	0.6	0.6	–	–	–	–	–	–
/28	28	45	12	9	12	0.3	0.3	52	16	12	16	–	–	–	1	1	–	–	–	–	–	–
06	30	47	12	9	12	0.3	0.3	55	17	13	17	20	16	20	1	1	–	–	–	–	–	–
/32	32	52	15	10	14	0.6	0.6	58	17	13	17	–	–	–	1	1	–	–	–	–	–	–
07	35	55	14	11.5	14	0.6	0.6	62	18	14	18	21	17	21	1	1	–	–	–	–	–	–
08	40	62	15	12	15	0.6	0.6	68	19	14.5	19	22	18	22	1	1	75	26	20.5	26	1.5	1.5
09	45	68	15	12	15	0.6	0.6	75	20	15.5	20	24	19	24	1	1	80	26	20.5	26	1.5	1.5
10	50	72	15	12	15	0.6	0.6	80	20	15.5	20	24	19	24	1	1	85	26	20	26	1.5	1.5
11	55	80	17	14	17	1	1	90	23	17.5	23	27	21	27	1.5	1.5	95	30	23	30	1.5	1.5
12	60	85	17	14	17	1	1	95	23	17.5	23	27	21	27	1.5	1.5	100	30	23	30	1.5	1.5
13	65	90	17	14	17	1	1	100	23	17.5	23	27	21	27	1.5	1.5	110	34	26.5	34	1.5	1.5

Remarks: 1. $r$min is the smallest chamfer dimension.

2. Dimensions B, C, T of 32000 and 32200 series bearings without prefix E and suffix J listed on the pages from D84 to D87 are differ from the above dimensions.

Note: (1) To be applied to 30300D series.

Table 4.3.1 Boundary Dimensions of Tapered Roller Bearings (2/3)

Unit : mm

Tapered roller bearing			329						320			330						331				
Bearing bore diameter Nominal		Diameter series 9						Diameter series 0									Diameter series 1					
		Outside diameter	Width series 2			Chamfer dimension r_{min}		Outside diameter	Width series 2			Width series 3			Chamfer dimension r_{min}		Outside diameter	Width series 3			Chamfer dimension r_{min}	
Bore No.	d	D	B	C	T	Inner ring	Outer ring	D	B	C	T	B	C	T	Inner ring	Outer ring	D	B	C	T	Inner ring	Outer ring
14	70	100	20	16	20	1	1	110	25	19	25	31	25.5	31	1.5	1.5	120	37	29	37	2	1.5
15	75	105	20	16	20	1	1	115	25	19	25	31	25.5	31	1.5	1.5	125	37	29	37	2	1.5
16	80	110	20	16	20	1	1	125	29	22	29	36	29.5	36	1.5	1.5	130	37	29	37	2	1.5
17	85	120	23	18	23	1.5	1.5	130	29	22	29	36	29.5	36	1.5	1.5	140	41	32	41	2.5	2
18	90	125	23	18	23	1.5	1.5	140	32	24	32	39	32.5	39	2	1.5	150	45	35	45	2.5	2
19	95	130	23	18	23	1.5	1.5	145	32	24	32	39	32.5	39	2	1.5	160	49	38	49	2.5	2
20	100	140	25	20	25	1.5	1.5	150	32	24	32	39	32.5	39	2	1.5	165	52	40	52	2.5	2
21	105	145	25	20	25	1.5	1.5	160	35	26	35	43	34	43	2.5	2	175	56	44	56	2.5	2
22	110	150	25	20	25	1.5	1.5	170	38	29	38	47	37	47	2.5	2	180	56	43	56	2.5	2
24	120	165	29	23	29	1.5	1.5	180	38	29	38	48	38	48	2.5	2	200	62	48	62	2.5	2
26	130	180	32	25	32	2	1.5	200	45	34	45	55	43	55	2.5	2	–	–	–	–	–	–
28	140	190	32	25	32	2	1.5	210	45	34	45	56	44	56	2.5	2	–	–	–	–	–	–
30	150	210	38	30	38	2.5	2	225	48	36	48	59	46	59	3	2.5	–	–	–	–	–	–
32	160	220	38	30	38	2.5	2	240	51	38	51	–	–	–	3	2.5	–	–	–	–	–	–
34	170	230	38	30	38	2.5	2	260	57	43	57	–	–	–	3	2.5	–	–	–	–	–	–

Remarks:
1. r_{min} is the smallest chamfer dimension.
2. Dimensions B, C, T of 32000 and 32200 series bearings without prefix E and suffix J listed on the pages from D84 to D87 are differ from the above dimensions.

Note: (1) To be applied to 30300D series.

Table 4.3.1 Boundary Dimensions of Tapered Roller Bearings (3/3)

Unit : mm

Tapered roller bearing			329						320			330						331				
Bearing bore diameter Nominal		Diameter series 9						Diameter series 0									Diameter series 1					
		Outside diameter	Width series 2			Chamfer dimension		Outside diameter	Width series 2			Width series 3			Chamfer dimension		Outside diameter	Width series 3			Chamfer dimension	
Bore No.	d	D	B	C	T	r_{min} Inner ring	r_{min} Outer ring	D	B	C	T	B	C	T	r_{min} Inner ring	r_{min} Outer ring	D	B	C	T	r_{min} Inner ring	r_{min} Outer ring
36	180	250	45	34	45	2.5	2	280	64	48	64	–	–	–	3	2.5	–	–	–	–	–	–
38	190	260	45	34	45	2.5	2	290	64	48	64	–	–	–	3	2.5	–	–	–	–	–	–
40	200	280	51	39	51	3	2.5	310	70	53	70	–	–	–	3	2.5	–	–	–	–	–	–
44	220	300	51	39	51	3	2.5	340	76	57	76	–	–	–	4	3	–	–	–	–	–	–
48	240	320	51	39	51	3	2.5	360	76	57	76	–	–	–	4	3	–	–	–	–	–	–
52	260	360	63.5	48	63.5	3	2.5	400	87	65	87	–	–	–	5	4	–	–	–	–	–	–
56	280	380	63.5	48	63.5	3	2.5	420	87	65	87	–	–	–	5	4	–	–	–	–	–	–
60	300	420	76	57	76	4	3	460	100	74	100	–	–	–	5	4	–	–	–	–	–	–
64	320	440	76	57	76	4	3	480	100	74	100	–	–	–	5	4	–	–	–	–	–	–
68	340	460	76	57	76	4	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
72	360	480	76	57	76	4	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Remarks:
1. $r$min is the smallest chamfer dimension.
2. Dimensions B, C, T of 32000 and 32200 series bearings without prefix E and suffix J listed on the pages from D84 to D87 are differ from the above dimensions.

Note: (1) To be applied to 30300D series.

Table 4.3.2 Boundary Dimensions of Tapered Roller Bearings (1/3) Unit : mm

Tapered roller bearing			302			322			332						303		303D		313			323				
Bearing bore diameter Nominal		Diameter series 2												Diameter series 3												
		Outside diameter	Width series 0			Width series 2			Width series 3			Chamfer dimension		Outside diameter	Width series 0				Width series 1			Width series 2			Chamfer dimension	
Bore No.	d	D	B	C	T	B	C	T	B	C	T	r_{min} Inner ring	r_{min} Outer ring	D	B	C	C(1)	T	B	C	T	B	C	T	r_{min} Inner ring	r_{min} Outer ring
02	15	–	–	–	–	–	–	–	–	–	–	–	–	42	13	11	–	14.25	–	–	–	–	–	–	1	1
03	17	40	12	11	13.25	16	14	17.25	–	–	–	1	1	47	14	12	–	15.25	–	–	–	19	16	20.25	1	1
04	20	47	14	12	15.25	18	15	19.25	–	–	–	1	1	52	15	13	–	16.25	–	–	–	21	18	22.25	1.5	1.5
/22	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
05	25	52	15	13	16.25	18	16	19.25	22	18	22	1	1	62	17	15	13	18.25	–	–	–	24	20	25.25	1.5	1.5
/28	28	58	–	–	–	19	16	20.25	24	19	24	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
06	30	62	16	14	17.25	20	17	21.25	25	19.5	25	1	1	72	19	16	14	20.75	–	–	–	27	23	28.75	1.5	1.5
/32	32	65	17	15	18.25	26.5	17	22	26	20.5	26	1	1	75	–	–	–	–	–	–	–	28	23	29.75	1.5	1.5
07	35	72	17	15	18.25	23	19	24.25	28	22	28	1.5	1.5	80	21	18	15	22.75	–	–	–	31	25	32.75	2	1.5
08	40	80	18	16	19.75	23	19	24.75	32	25	32	1.5	1.5	90	23	20	17	25.25	–	–	–	33	27	35.25	2	1.5
09	45	85	19	16	20.75	23	19	24.75	32	25	32	1.5	1.5	100	25	22	18	27.25	–	–	–	36	30	38.25	2	1.5
10	50	90	20	17	21.75	23	19	24.75	32	24.5	32	1.5	1.5	110	27	23	19	29.25	–	–	–	40	33	42.25	2.5	2
11	55	100	21	18	22.75	25	21	26.75	35	27	35	2	1.5	120	29	25	21	31.5	–	–	–	43	35	45.5	2.5	2
12	60	110	22	19	23.75	28	24	29.75	38	29	38	2	1.5	130	31	26	22	33.5	–	–	–	46	37	48.5	3	2.5
13	65	120	23	20	24.75	31	27	32.75	41	32	41	2	1.5	140	33	28	23	36	–	–	–	48	39	51	3	2.5

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. Dimensions B, C, T of 32000 and 32200 series bearings without prefix E and suffix J listed on the pages from D84 to D87 are differ from the above dimensions.

Note: (1) To be applied to 30300D series.

Table 4.3.2 Boundary Dimensions of Tapered Roller Bearings (2/3)

Unit : mm

Tapered roller bearing			302			322			332						303		303D		313			323				
Bearing bore diameter Nominal		Diameter series 2												Diameter series 3												
		Outside diameter	Width series 0			Width series 2			Width series 3			Chamfer dimension		Outside diameter	Width series 0				Width series 1			Width series 2			Chamfer dimension	
												r_{min}													r_{min}	
Bore No.	d	D	B	C	T	B	C	T	B	C	T	Inner ring	Outer ring	D	B	C	C(1)	T	B	C	T	B	C	T	Inner ring	Outer ring
14	70	125	24	21	26.25	31	27	33.25	41	32	41	2	1.5	150	35	30	25	38	–	–	–	51	42	54	3	2.5
15	75	130	25	22	27.25	31	27	33.25	41	31	41	2	1.5	160	37	31	26	40	–	–	–	55	45	58	3	2.5
16	80	140	26	22	28.25	33	28	35.25	46	35	46	2.5	2	170	39	33	27	42.5	–	–	–	58	48	61.5	3	2.5
17	85	150	28	24	30.5	36	30	38.5	49	37	49	2.5	2	180	41	34	28	44.5	–	–	–	60	49	63.5	4	3
18	90	160	30	26	32.5	40	34	42.5	55	42	55	2.5	2	190	43	36	30	46.5	–	–	–	64	53	67.5	4	3
19	95	170	32	27	34.5	43	37	45.5	58	44	58	3	2.5	200	45	38	32	49.5	–	–	–	67	55	71.5	4	3
20	100	180	34	29	37	46	39	49	63	48	63	3	2.5	215	47	39	–	51.5	51	35	56.5	73	60	77.5	4	3
21	105	190	36	30	39	50	43	53	68	52	68	3	2.5	225	49	41	–	53.5	53	36	58	77	63	81.5	4	3
22	110	200	38	32	41	53	46	56	–	–	–	3	2.5	240	50	42	–	54.5	57	38	63	80	65	84.5	4	3
24	120	215	40	34	43.5	58	50	61.5	–	–	–	3	2.5	260	55	46	–	59.5	62	42	68	86	69	90.5	4	3
26	130	230	40	34	43.75	64	54	67.75	–	–	–	4	3	280	58	49	–	63.75	66	44	72	–	–	–	5	4
28	140	250	42	36	45.75	68	58	71.75	–	–	–	4	3	300	62	53	–	67.75	70	47	77	–	–	–	5	4
30	150	270	45	38	49	73	60	77	–	–	–	4	3	320	65	55	–	72	75	50	82	–	–	–	5	4
32	160	290	48	40	52	80	67	84	–	–	–	4	3	340	68	58	–	75	–	–	–	–	–	–	5	4
34	170	310	52	43	57	86	71	91	–	–	–	5	4	360	72	62	–	80	–	–	–	–	–	–	5	4

Remarks:
1. r_{min} is the smallest chamfer dimension.
2. Dimensions B, C, T of 32000 and 32200 series bearings without prefix E and suffix J listed on the pages from D84 to D87 are differ from the above dimensions.

Note: (1) To be applied to 30300D series.

Table 4.3.2 Boundary Dimensions of Tapered Roller Bearings (3/3)

Unit : mm

Tapered roller bearing			302			322			332						303		303D		313			323				
Bearing bore diameter Nominal		Diameter series 2												Diameter series 3												
		Outside diameter	Width series 0			Width series 2			Width series 3			Chamfer dimension		Outside diameter	Width series 0				Width series 1			Width series 2			Chamfer dimension	
Bore No.	d	D	B	C	T	B	C	T	B	C	T	r_{min} Inner ring	r_{min} Outer ring	D	B	C	C(1)	T	B	C	T	B	C	T	r_{min} Inner ring	r_{min} Outer ring
36	180	320	52	43	57	86	71	91	–	–	–	5	4	–	–	–	–	–	–	–	–	–	–	–	–	–
38	190	340	55	46	60	92	75	97	–	–	–	5	4	–	–	–	–	–	–	–	–	–	–	–	–	–
40	200	360	58	48	64	98	82	104	–	–	–	5	4	–	–	–	–	–	–	–	–	–	–	–	–	–
44	220	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
48	240	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
52	260	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
56	280	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
60	300	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
64	320	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
68	340	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
72	360	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Remarks: 1. r_{min} is the smallest chamfer dimension.
2. Dimensions B, C, T of 32000 and 32200 series bearings without prefix E and suffix J listed on the pages from D84 to D87 are differ from the above dimensions.

Note: (1) To be applied to 30300D series.

Table 4.4.1 Boundary Dimensions of Thrust Bearings with Flat Back Face (1/4) Unit : mm

Single direction thrust ball bearings										511	
Double direction thrust ball bearings											
Spherical roller thrust bearings											
Bearing bore diameter Nominal		Diameter series 0					Diameter series 1				
		Bearing outside diameter Nominal D	Dimension series			Chamfer dimension r_{min}	Bearing outside diameter Nominal D	Dimension series			Chamfer dimension r_{min}
			70	90	10			71	91	11	
Bore No.	d		Height Nominal T					Height Nominal T			
4	4	12	4	–	6	0.3	–	–	–	–	–
6	6	16	5	–	7	0.3	–	–	–	–	–
8	8	18	5	–	7	0.3	–	–	–	–	–
00	10	20	5	–	7	0.3	24	6	–	9	0.3
01	12	22	5	–	7	0.3	26	6	–	9	0.3
02	15	26	5	–	7	0.3	28	6	–	9	0.3
03	17	28	5	–	7	0.3	30	6	–	9	0.3
04	20	32	6	–	8	0.3	35	7	–	10	0.3
05	25	37	6	–	8	0.3	42	8	–	11	0.6
06	30	42	6	–	8	0.3	47	8	–	11	0.6
07	35	47	6	–	8	0.3	52	8	–	12	0.6
08	40	52	6	–	9	0.3	60	9	–	13	0.6
09	45	60	7	–	10	0.3	65	9	–	14	0.6
10	50	65	7	–	10	0.3	70	9	–	14	0.6
11	55	70	7	–	10	0.3	78	10	–	16	0.6
12	60	75	7	–	10	0.3	85	11	–	17	1
13	65	80	7	–	10	0.3	90	11	–	18	1
14	70	85	7	–	10	0.3	95	11	–	18	1
15	75	90	7	–	10	0.3	100	11	–	19	1
16	80	95	7	–	10	0.3	105	11	–	19	1
17	85	100	7	–	10	0.3	110	11	–	19	1

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.1 Boundary Dimensions of Thrust Bearings with Flat Back Face (2/4)

Unit : mm

Single direction thrust ball bearings										511	
Double direction thrust ball bearings											
Spherical roller thrust bearings											
Bearing bore diameter Nominal		Diameter series 0					Diameter series 1				
		Bearing outside diameter Nominal	Dimension series			Chamfer dimension	Bearing outside diameter Nominal	Dimension series			Chamfer dimension
			70	90	10			71	91	11	
			Height Nominal T					Height Nominal T			
Bore No.	d	D				r_{min}	D				r_{min}
18	90	105	7	–	10	0.3	120	14	–	22	1
20	100	120	9	–	14	0.6	135	16	21	25	1
22	110	130	9	–	14	0.6	145	16	21	25	1
24	120	140	9	–	14	0.6	155	16	21	25	1
26	130	150	9	–	14	0.6	170	18	24	30	1
28	140	160	9	–	14	0.6	180	18	24	31	1
30	150	170	9	–	14	0.6	190	18	24	31	1
32	160	180	9	–	14	0.6	200	18	24	31	1
34	170	190	9	–	14	0.6	215	20	27	34	1.1
36	180	200	9	–	14	0.6	225	20	27	34	1.1
38	190	215	11	–	17	1	240	23	30	37	1.1
40	200	225	11	–	17	1	250	23	30	37	1.1
44	220	250	14	–	22	1	270	23	30	37	1.1
48	240	270	14	–	22	1	300	27	36	45	1.5
52	260	290	14	–	22	1	320	27	36	45	1.5
56	280	310	14	–	22	1	350	32	42	53	1.5
60	300	340	18	24	30	1	380	36	48	62	2
64	320	360	18	24	30	1	400	36	48	63	2
68	340	380	18	24	30	1	420	36	48	64	2
72	360	400	18	24	30	1	440	36	48	65	2
76	380	420	18	24	30	1	460	36	48	65	2

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.1 Boundary Dimensions of Thrust Bearings with Flat Back Face (3/4) Unit : mm

Single direction thrust ball bearings										511	
Double direction thrust ball bearings											
Spherical roller thrust bearings											
Bearing bore diameter Nominal		Diameter series 0					Diameter series 1				
		Bearing outside diameter Nominal D	Dimension series			Chamfer dimension	Bearing outside diameter Nominal D	Dimension series			Chamfer dimension
			70	90	10			71	91	11	
Bore No.	d		Height Nominal T			r_{min}		Height Nominal T			r_{min}
80	400	440	18	24	30	1	480	36	48	65	2
84	420	460	18	24	30	1	500	36	48	65	2
88	440	480	18	24	30	1	540	45	60	80	2.1
92	460	500	18	24	30	1	560	45	60	80	2.1
96	480	520	18	24	30	1	580	45	60	80	2.1
/500	500	540	18	24	30	1	600	45	60	80	2.1
/530	530	580	23	30	38	1.1	640	50	67	85	3
/560	560	610	23	30	38	1.1	670	50	67	85	3
/600	600	650	23	30	38	1.1	710	50	67	85	3
/630	630	680	23	30	38	1.1	750	54	73	95	3
/670	670	730	27	36	45	1.5	800	58	78	105	4
/710	710	780	32	42	53	1.5	850	63	85	112	4
/750	750	820	32	42	53	1.5	900	67	90	120	4
/800	800	870	32	42	53	1.5	950	67	90	120	4
/850	850	920	32	42	53	1.5	1000	67	90	120	4
/900	900	980	36	48	63	2	1060	73	95	130	5
/950	950	1030	36	48	63	2	1120	78	103	135	5
/1000	1000	1090	41	54	70	2.1	1180	82	109	140	5
/1060	1060	1150	41	54	70	2.1	1250	85	115	150	5
/1120	1120	1220	45	60	80	2.1	1320	90	122	160	5
/1180	1180	1280	45	60	80	2.1	1400	100	132	175	6

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.1 Boundary Dimensions of Thrust Bearings with Flat Back Face (4/4)

Unit : mm

Single direction thrust ball bearings										511	
Double direction thrust ball bearings											
Spherical roller thrust bearings											
Bearing bore diameter Nominal		Diameter series 0					Diameter series 1				
		Bearing outside diameter Nominal D	Dimension series			Chamfer dimension r_{min}	Bearing outside diameter Nominal D	Dimension series			Chamfer dimension r_{min}
			70	90	10			71	91	11	
Bore No.	d		Height Nominal T					Height Nominal T			
/1250	1250	1360	50	67	85	3	1460	–	–	175	6
/1320	1320	1440	–	–	95	3	1540	–	–	175	6
/1400	1400	1520	–	–	95	3	1630	–	–	180	6
/1500	1500	1630	–	–	105	4	1750	–	–	195	6
/1600	1600	1730	–	–	105	4	1850	–	–	195	6
/1700	1700	1840	–	–	112	4	1970	–	–	212	7.5
/1800	1800	1950	–	–	120	4	2080	–	–	220	7.5
/1900	1900	2060	–	–	130	5	2180	–	–	220	7.5
/2000	2000	2160	–	–	130	5	2300	–	–	236	7.5
/2120	2120	2300	–	–	140	5	2430	–	–	243	7.5
/2240	2240	2430	–	–	150	5	2570	–	–	258	9.5
/2360	2360	2550	–	–	150	5	2700	–	–	265	9.5
/2500	2500	2700	–	–	160	5	2850	–	–	272	9.5

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.2 Boundary Dimensions of Thrust Bearings with Flat Back Face (1/4) Unit : mm

Single direction thrust ball bearings					512					
Double direction thrust ball bearings						522				
Spherical roller thrust bearings				292						
Bearing bore diameter Nominal		Diameter series 2								
		Bearing outside diameter Nominal D	Dimension series						Chamfer dimension	
			72	92	12	22	22			
			Height Nominal T				Center washer			
Bore No.	d						Bore d_2	Height a	r_{min}	r_{1min}
4	4	16	6	–	8	–	–	–	0.3	–
6	6	20	6	–	9	–	–	–	0.3	–
8	8	22	6	–	9	–	–	–	0.3	–
00	10	26	7	–	11	–	–	–	0.6	–
01	12	28	7	–	11	–	–	–	0.6	–
02	15	32	8	–	12	22	10	5	0.6	0.3
03	17	35	8	–	12	–	–	–	0.6	–
04	20	40	9	–	14	26	15	6	0.6	0.3
05	25	47	10	–	15	28	20	7	0.6	0.3
06	30	52	10	–	16	29	25	7	0.6	0.3
07	35	62	12	–	18	34	30	8	1	0.3
08	40	68	13	–	19	36	30	9	1	0.6
09	45	73	13	–	20	37	35	9	1	0.6
10	50	78	13	–	22	39	40	9	1	0.6
11	55	90	16	21	25	45	45	10	1	0.6
12	60	95	16	21	26	46	50	10	1	0.6
13	65	100	16	21	27	47	55	10	1	0.6
14	70	105	16	21	27	47	55	10	1	1
15	75	110	16	21	27	47	60	10	1	1
16	80	115	16	21	28	48	65	10	1	1
17	85	125	18	24	31	55	70	12	1	1

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.2 Boundary Dimensions of Thrust Bearings with Flat Back Face (2/4)

Unit : mm

Single direction thrust ball bearings					512					
Double direction thrust ball bearings						522				
Spherical roller thrust bearings				292						
Bearing bore diameter Nominal		Diameter series 2								
		Bearing outside diameter Nominal	Dimension series						Chamfer dimension	
			72	92	12	22	22			
			Height Nominal T				Center washer			
Bore No.	d	D					Bore d_2	Height a	r_{min}	r_{1min}
18	90	135	20	27	35	62	75	14	1.1	1
20	100	150	23	30	38	67	85	15	1.1	1
22	110	160	23	30	38	67	95	15	1.1	1
24	120	170	23	30	39	68	100	15	1.1	1.1
26	130	190	27	36	45	80	110	18	1.5	1.1
28	140	200	27	36	46	81	120	18	1.5	1.1
30	150	215	29	39	50	89	130	20	1.5	1.1
32	160	225	29	39	51	90	140	20	1.5	1.1
34	170	240	32	42	55	97	150	21	1.5	1.1
36	180	250	32	42	56	98	150	21	1.5	2
38	190	270	36	48	62	109	160	24	2	2
40	200	280	36	48	62	109	170	24	2	2
44	220	300	36	48	63	110	190	24	2	2
48	240	340	45	60	78	–	–	–	2.1	–
52	260	360	45	60	79	–	–	–	2.1	–
56	280	380	45	60	80	–	–	–	2.1	–
60	300	420	54	73	95	–	–	–	3	–
64	320	440	54	73	95	–	–	–	3	–
68	340	460	54	73	96	–	–	–	3	–
72	360	500	63	85	110	–	–	–	4	–
76	380	520	63	85	112	–	–	–	4	–

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.1 Boundary Dimensions of Thrust Bearings with Flat Back Face (3/4) Unit : mm

Single direction thrust ball bearings					512					
Double direction thrust ball bearings						522				
Spherical roller thrust bearings				292						
Bearing bore diameter Nominal		Bearing outside diameter Nominal	Diameter series 2							
			Dimension series						Chamfer dimension	
			72	92	12	22	22			
			Height Nominal T				Center washer			
Bore No.	d	D					Bore d_2	Height a	r_{min}	r_{1min}
80	400	540	63	85	112	–	–	–	4	–
84	420	580	73	95	130	–	–	–	5	–
88	440	600	73	95	130	–	–	–	5	–
92	460	620	73	95	130	–	–	–	5	–
96	480	650	78	103	135	–	–	–	5	–
/500	500	670	78	103	135	–	–	–	5	–
/530	530	710	82	109	140	–	–	–	5	–
/560	560	750	85	115	150	–	–	–	5	–
/600	600	800	90	122	160	–	–	–	5	–
/630	630	850	100	132	175	–	–	–	6	–
/670	670	900	103	140	180	–	–	–	6	–
/710	710	950	109	145	190	–	–	–	6	–
/750	750	1000	112	150	195	–	–	–	6	–
/800	800	1060	118	155	205	–	–	–	7.5	–
/850	850	1120	122	160	212	–	–	–	7.5	–
/900	900	1180	125	170	220	–	–	–	7.5	–
/950	950	1250	136	180	236	–	–	–	7.5	–
/1000	1000	1320	145	190	250	–	–	–	9.5	–
/1060	1060	1400	155	206	265	–	–	–	9.5	–
/1120	1120	1460	–	206	–	–	–	–	9.5	–
/1180	1180	1520	–	206	–	–	–	–	9.5	–

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.2 Boundary Dimensions of Thrust Bearings with Flat Back Face (4/4) Unit : mm

Single direction thrust ball bearings					512					
Double direction thrust ball bearings						522				
Spherical roller thrust bearings				292						
Bearing bore diameter Nominal		Diameter series 2								
		Bearing outside diameter Nominal	Dimension series						Chamfer dimension	
			72	92	12	22	22			
			Height Nominal T				Center washer			
Bore No.	d	D					Bore d_2	Height a	r_{min}	r_{1min}
/1250	1250	1610	–	216	–	–	–	–	9.5	–
/1320	1320	1700	–	228	–	–	–	–	9.5	–
/1400	1400	1760	–	234	–	–	–	–	12	–
/1500	1500	1920	–	252	–	–	–	–	12	–
/1600	1600	2040	–	264	–	–	–	–	15	–
/1700	1700	2160	–	276	–	–	–	–	15	–
/1800	1800	2280	–	280	–	–	–	–	15	–
/1900	1900	–	–	–	–	–	–	–	–	–
/2000	2000	–	–	–	–	–	–	–	–	–
/2120	2120	–	–	–	–	–	–	–	–	–
/2240	2240	–	–	–	–	–	–	–	–	–
/2360	2360	–	–	–	–	–	–	–	–	–
/2500	2500	–	–	–	–	–	–	–	–	–

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.3 Boundary Dimensions of Thrust Bearings with Flat Back Face (1/4) Unit : mm

Single direction thrust ball bearings					513					
Double direction thrust ball bearings						523				
Spherical roller thrust bearings				293						
Bearing bore diameter Nominal		Diameter series 3								
		Bearing outside diameter Nominal D	Dimension series						Chamfer dimension	
			73	93	13	23	23			
Bore No.	d		Height Nominal T				Center washer		r_{min}	r_{1min}
							Bore d_2	Height a		
4	4	20	7	–	11	–	–	–	0.6	–
6	6	24	8	–	12	–	–	–	0.6	–
8	8	26	8	–	12	–	–	–	0.6	–
00	10	30	9	–	14	–	–	–	0.6	–
01	12	32	9	–	14	–	–	–	0.6	–
02	15	37	10	–	15	–	–	–	0.6	–
03	17	40	10	–	16	–	–	–	0.6	–
04	20	47	12	–	18	–	–	–	1	–
05	25	52	12	–	18	34	20	8	1	0.3
06	30	60	14	–	21	38	25	9	1	0.3
07	35	68	15	–	24	44	30	10	1	0.3
08	40	78	17	22	26	49	30	12	1	0.6
09	45	85	18	24	28	52	35	12	1	0.6
10	50	95	20	27	31	58	40	14	1.1	0.6
11	55	105	23	30	35	64	45	15	1.1	0.6
12	60	110	23	30	35	64	50	15	1.1	0.6
13	65	115	23	30	36	65	55	15	1.1	0.6
14	70	125	25	34	40	72	55	16	1.1	1
15	75	135	27	36	44	79	60	18	1.5	1
16	80	140	27	36	44	79	65	18	1.5	1
17	85	150	29	39	49	87	70	19	1.5	1

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.3 Boundary Dimensions of Thrust Bearings with Flat Back Face (2/4) Unit : mm

Single direction thrust ball bearings						513				
Double direction thrust ball bearings							523			
Spherical roller thrust bearings					293					
Bearing bore diameter Nominal		Diameter series 3								
		Bearing outside diameter Nominal	Dimension series						Chamfer dimension	
			73	93	13	23	23			
			Height Nominal T				Center washer			
Bore No.	d	D					Bore d_2	Height a	r_{min}	r_{1min}
18	90	155	29	39	50	88	75	19	1.5	1
20	100	170	32	42	55	97	85	21	1.5	1
22	110	190	36	48	63	110	95	24	2	1
24	120	210	41	54	70	123	100	27	2.1	1.1
26	130	225	42	58	75	130	110	30	2.1	1.1
28	140	240	45	60	80	140	120	31	2.1	1.1
30	150	250	45	60	80	140	130	31	2.1	1.1
32	160	270	50	67	87	153	140	33	3	1.1
34	170	280	50	67	87	153	150	33	3	1.1
36	180	300	54	73	95	165	150	37	3	2
38	190	320	58	78	105	183	160	40	4	2
40	200	340	63	85	110	192	170	42	4	2
44	220	360	63	85	112	–	–	–	4	–
48	240	380	63	85	112	–	–	–	4	–
52	260	420	73	95	130	–	–	–	5	–
56	280	440	73	95	130	–	–	–	5	–
60	300	480	82	109	140	–	–	–	5	–
64	320	500	82	109	140	–	–	–	5	–
68	340	540	90	122	160	–	–	–	5	–
72	360	560	90	122	160	–	–	–	5	–
76	380	600	100	132	175	–	–	–	6	–

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.3 Boundary Dimensions of Thrust Bearings with Flat Back Face (3/4) Unit : mm

Single direction thrust ball bearings					513					
Double direction thrust ball bearings						523				
Spherical roller thrust bearings				293						
Bearing bore diameter Nominal		Diameter series 3								
		Bearing outside diameter Nominal D	Dimension series						Chamfer dimension	
			73	93	13	23	23			
Bore No.	d		Height Nominal T				Center washer Bore d_2	Center washer Height a	r_{min}	r_{1min}
80	400	620	100	132	175	–	–	–	6	–
84	420	650	103	140	180	–	–	–	6	–
88	440	680	109	145	190	–	–	–	6	–
92	460	710	112	150	195	–	–	–	6	–
96	480	730	112	150	195	–	–	–	6	–
/500	500	750	112	150	195	–	–	–	6	–
/530	530	800	122	160	212	–	–	–	7.5	–
/560	560	850	132	175	224	–	–	–	7.5	–
/600	600	900	136	180	236	–	–	–	7.5	–
/630	630	950	145	190	250	–	–	–	9.5	–
/670	670	1000	150	200	258	–	–	–	9.5	–
/710	710	1060	160	212	272	–	–	–	9.5	–
/750	750	1120	165	224	290	–	–	–	9.5	–
/800	800	1180	170	230	300	–	–	–	9.5	–
/850	850	1250	180	243	315	–	–	–	12	–
/900	900	1320	190	250	335	–	–	–	12	–
/950	950	1400	200	272	355	–	–	–	12	–
/1000	1000	1460	–	276	–	–	–	–	12	–
/1060	1060	1540	–	288	–	–	–	–	15	–
/1120	1120	1630	–	306	–	–	–	–	15	–
/1180	1180	1710	–	318	–	–	–	–	15	–

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.3 Boundary Dimensions of Thrust Bearings with Flat Back Face (4/4)

Unit : mm

Single direction thrust ball bearings					513					
Double direction thrust ball bearings						523				
Spherical roller thrust bearings				293						
Bearing bore diameter Nominal		Diameter series 3								
		Bearing outside diameter Nominal D	Dimension series						Chamfer dimension	
			73	93	13	23	23			
			Height Nominal T				Center washer			
Bore No.	d						Bore d_2	Height a	r_{min}	r_{1min}
/1250	1250	1800	–	330	–	–	–	–	15	–
/1320	1320	1900	–	348	–	–	–	–	19	–
/1400	1400	2000	–	360	–	–	–	–	19	–
/1500	1500	2140	–	384	–	–	–	–	19	–
/1600	1600	2270	–	402	–	–	–	–	19	–
/1700	1700	–	–	–	–	–	–	–	–	–
/1800	1800	–	–	–	–	–	–	–	–	–
/1900	1900	–	–	–	–	–	–	–	–	–
/2000	2000	–	–	–	–	–	–	–	–	–
/2120	2120	–	–	–	–	–	–	–	–	–
/2240	2240	–	–	–	–	–	–	–	–	–
/2360	2360	–	–	–	–	–	–	–	–	–
/2500	2500	–	–	–	–	–	–	–	–	–

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.4 Boundary Dimensions of Thrust Bearings with Flat Back Face (1/4)

Unit : mm

Single direction thrust ball bearings					514								
Double direction thrust ball bearings						524							
Spherical roller thrust bearings				294									
Bearing bore diameter Nominal		Diameter series 4									Diameter series 5		
		Bearing outside diameter Nominal D	Dimension series						Chamfer dimension		Bearing outside diameter Nominal D	Dimension series	Chamfer dimension
			74	94	14	24	24					95	
			Height Nominal T				Center washer		r_{min}	r_{1min}		Height Nominal T	r_{min}
Bore No.	d						Bore d_2	Height a					
4	4	–	–	–	–	–	–	–	–	–	–	–	–
6	6	–	–	–	–	–	–	–	–	–	–	–	–
8	8	–	–	–	–	–	–	–	–	–	–	–	–
00	10	–	–	–	–	–	–	–	–	–	–	–	–
01	12	–	–	–	–	–	–	–	–	–	–	–	–
02	15	–	–	–	–	–	–	–	–	–	–	–	–
03	17	–	–	–	–	–	–	–	–	–	52	21	1
04	20	–	–	–	–	–	–	–	–	–	60	24	1
05	25	60	16	21	24	45	15	11	1	0.6	73	29	1.1
06	30	70	18	24	28	52	20	12	1	0.6	85	34	1.1
07	35	80	20	27	32	59	25	14	1.1	0.6	100	39	1.1
08	40	90	23	30	36	65	30	15	1.1	0.6	110	42	1.5
09	45	100	25	34	39	72	35	17	1.1	0.6	120	45	2
10	50	110	27	36	43	78	40	18	1.5	0.6	135	51	2
11	55	120	29	39	48	87	45	20	1.5	0.6	150	58	2.1
12	60	130	32	42	51	93	50	21	1.5	0.6	160	60	2.1
13	65	140	34	45	56	101	50	23	2	1	170	63	2.1
14	70	150	36	48	60	107	55	24	2	1	180	67	3
15	75	160	38	51	65	115	60	26	2	1	190	69	3
16	80	170	41	54	68	120	65	27	2.1	1	200	73	3
17	85	180	42	58	72	128	65	29	2.1	1.1	215	78	4

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.4 Boundary Dimensions of Thrust Bearings with Flat Back Face (2/4)

Unit : mm

Single direction thrust ball bearings					514								
Double direction thrust ball bearings						524							
Spherical roller thrust bearings				294									
Bearing bore diameter Nominal		Diameter series 4									Diameter series 5		
		Bearing outside diameter Nominal D	Dimension series						Chamfer dimension		Bearing outside diameter Nominal D	Dimension series	Chamfer dimension
			74	94	14	24	24					95	
			Height Nominal T				Center washer					Height Nominal T	
Bore No.	d						Bore d_2	Height a	r_{min}	r_{1min}			r_{min}
18	90	190	45	60	77	135	70	30	2.1	1.1	225	82	4
20	100	210	50	67	85	150	80	33	3	1.1	250	90	4
22	110	230	54	73	95	166	90	37	3	1.1	270	95	5
24	120	250	58	78	102	177	95	40	4	1.5	300	109	5
26	130	270	63	85	110	192	100	42	4	2	320	115	5
28	140	280	63	85	112	196	110	44	4	2	340	122	5
30	150	300	67	90	120	209	120	46	4	2	360	125	6
32	160	320	73	95	130	226	130	50	5	2	380	132	6
34	170	340	78	103	135	236	135	50	5	2.1	400	140	6
36	180	360	82	109	140	245	140	52	5	3	420	145	6
38	190	380	85	115	150	–	–	–	5	–	440	150	6
40	200	400	90	122	155	–	–	–	5	–	460	155	7.5
44	220	420	90	122	160	–	–	–	6	–	500	170	7.5
48	240	440	90	122	160	–	–	–	6	–	540	180	7.5
52	260	480	100	132	175	–	–	–	6	–	580	190	9.5
56	280	520	109	145	190	–	–	–	6	–	620	206	9.5
60	300	540	109	145	190	–	–	–	6	–	670	224	9.5
64	320	580	118	155	205	–	–	–	7.5	–	710	236	9.5
68	340	620	125	170	220	–	–	–	7.5	–	750	243	12
72	360	640	125	170	220	–	–	–	7.5	–	780	250	12
76	380	670	132	175	224	–	–	–	7.5	–	820	265	12

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.4 Boundary Dimensions of Thrust Bearings with Flat Back Face (3/4) Unit : mm

Single direction thrust ball bearings					514								
Double direction thrust ball bearings						524							
Spherical roller thrust bearings				294									
Bearing bore diameter Nominal		Diameter series 4									Diameter series 5		
		Bearing outside diameter Nominal D	Dimension series						Chamfer dimension		Bearing outside diameter Nominal D	Dimension series	Chamfer dimension
			74	94	14	24	24					95	
			Height Nominal T				Center washer					Height Nominal T	
Bore No.	d						Bore d_2	Height a	r_{min}	r_{1min}			r_{min}
80	400	710	140	185	243	–	–	–	7.5	–	850	272	12
84	420	730	140	185	243	–	–	–	7.5	–	900	290	15
88	440	780	155	206	265	–	–	–	9.5	–	950	308	15
92	460	800	155	206	265	–	–	–	9.5	–	980	315	15
96	480	850	165	224	290	–	–	–	9.5	–	1000	315	15
/500	500	870	165	224	290	–	–	–	9.5	–	1060	335	15
/530	530	920	175	236	308	–	–	–	9.5	–	1090	335	15
/560	560	980	190	250	335	–	–	–	12	–	1150	355	15
/600	600	1030	195	258	335	–	–	–	12	–	1220	375	15
/630	630	1090	206	280	365	–	–	–	12	–	1280	388	15
/670	670	1150	218	290	375	–	–	–	15	–	1320	388	15
/710	710	1220	230	308	400	–	–	–	15	–	1400	412	15
/750	750	1280	236	315	412	–	–	–	15	–	–	–	–
/800	800	1360	250	335	438	–	–	–	15	–	–	–	–
/850	850	1440	–	354	–	–	–	–	15	–	–	–	–
/900	900	1520	–	372	–	–	–	–	15	–	–	–	–
/950	950	1600	–	390	–	–	–	–	15	–	–	–	–
/1000	1000	1670	–	402	–	–	–	–	15	–	–	–	–
/1060	1060	1770	–	426	–	–	–	–	15	–	–	–	–
/1120	1120	1860	–	444	–	–	–	–	15	–	–	–	–
/1180	1180	1950	–	462	–	–	–	–	19	–	–	–	–

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.4.4 Boundary Dimensions of Thrust Bearings with Flat Back Face (4/4)

Unit : mm

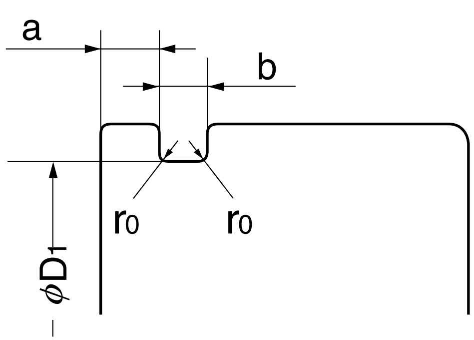
Single direction thrust ball bearings					514								
Double direction thrust ball bearings						524							
Spherical roller thrust bearings				294									
Bearing bore diameter Nominal		Diameter series 4									Diameter series 5		
		Bearing outside diameter Nominal D	Dimension series						Chamfer dimension		Bearing outside diameter Nominal D	Dimension series	Chamfer dimension
			74	94	14	24	24					95	
			Height Nominal T				Center washer					Height Nominal T	
Bore No.	d						Bore d_2	Height a	r_{min}	r_{1min}			r_{min}
/1250	1250	2050	–	480	–	–	–	–	19	–	–	–	–
/1320	1320	2160	–	505	–	–	–	–	19	–	–	–	–
/1400	1400	2280	–	530	–	–	–	–	19	–	–	–	–
/1500	1500	–	–	–	–	–	–	–	–	–	–	–	–
/1600	1600	–	–	–	–	–	–	–	–	–	–	–	–
/1700	1700	–	–	–	–	–	–	–	–	–	–	–	–
/1800	1800	–	–	–	–	–	–	–	–	–	–	–	–
/1900	1900	–	–	–	–	–	–	–	–	–	–	–	–
/2000	2000	–	–	–	–	–	–	–	–	–	–	–	–
/2120	2120	–	–	–	–	–	–	–	–	–	–	–	–
/2240	2240	–	–	–	–	–	–	–	–	–	–	–	–
/2360	2360	–	–	–	–	–	–	–	–	–	–	–	–
/2500	2500	–	–	–	–	–	–	–	–	–	–	–	–

Remarks: r_{min} is the smallest chamfer dimension.

Table 4.5.1 Dimensions of Snap Ring Grooves for Bearing Dimension Series 18 and 19 (1/3)

Unit: mm

Bearing outside diameter Nominal D	Snap ring groove diameter D_1		Snap ring groove location a: Dimension series 18		Snap ring groove location a: Dimension series 19		Snap ring groove width b		Fillet radius at snap ring groove bottom r_0	Applicable snap ring
	Max	Min	Max	Min	Max	Min	Max	Min	Max	
22	20.8	20.5	–	–	1.05	0.9	1.05	0.8	0.2	NR1022
24	22.8	22.5	–	–	1.05	0.9	1.05	0.8	0.2	NR1024
28	26.7	26.4	–	–	1.3	1.15	1.2	0.95	0.25	NR1028
30	28.7	28.4	–	–	1.3	1.15	1.2	0.95	0.25	NR1030
32	30.7	30.4	1.3	1.15	–	–	1.2	0.95	0.25	NR1032
34	32.7	32.4	1.3	1.15	–	–	1.2	0.95	0.25	NR1034
37	35.7	35.4	1.3	1.15	1.7	1.55	1.2	0.95	0.25	NR1037
39	37.7	37.4	–	–	1.7	1.55	1.2	0.95	0.25	NR1039
40	38.7	38.4	1.3	1.15	–	–	1.2	0.95	0.25	NR1040
42	40.7	40.4	1.3	1.15	1.7	1.55	1.2	0.95	0.25	NR1042
44	42.7	42.4	1.3	1.15	–	–	1.2	0.95	0.25	NR1044
45	43.7	43.4	–	–	1.7	1.55	1.2	0.95	0.25	NR1045
47	45.7	45.4	1.3	1.15	1.7	1.55	1.2	0.95	0.25	NR1047
52	50.7	50.4	1.3	1.15	1.7	1.55	1.2	0.95	0.25	NR1052
55	53.7	53.4	–	–	1.7	1.55	1.2	0.95	0.25	NR1055



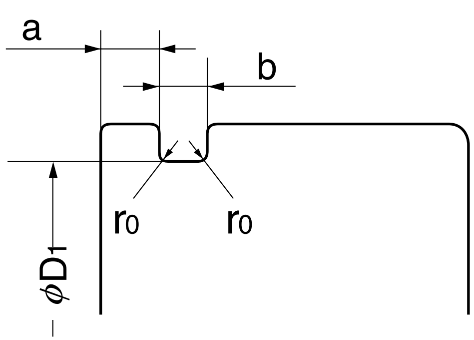
Remarks:

Chamfer at groove side of outer ring clears a fillet radius of:
0.3 mm in dimension series 18 up to and including D = 78 mm and
in dimension series 19 up to and including D = 47 mm;
0.5 mm in dimension series 18 over D = 78 mm and
in dimension series 19 over D = 47 mm

Table 4.5.1 Dimensions of Snap Ring Grooves for Bearing Dimension Series 18 and 19 (2/3)

Unit: mm

Bearing outside diameter Nominal D	Snap ring groove diameter D_1		Snap ring groove location a				Snap ring groove width b		Fillet radius at snap ring groove bottom r_0	Applicable snap ring
			Dimension series 18		Dimension series 19					
	Max	Min	Max	Min	Max	Min	Max	Min	Max	
58	56.7	56.4	1.3	1.15	–	–	1.2	0.95	0.25	NR1058
62	60.7	60.3	–	–	1.7	1.55	1.2	0.95	0.25	NR1062
65	63.7	63.3	1.3	1.15	–	–	1.2	0.95	0.25	NR1065
68	66.7	66.3	–	–	1.7	1.55	1.2	0.95	0.25	NR1068
72	70.7	70.3	1.7	1.55	1.7	1.55	1.2	0.95	0.25	NR1072
78	76.2	75.8	1.7	1.55	–	–	1.6	1.3	0.4	NR1078
80	77.9	77.5	–	–	2.1	1.9	1.6	1.3	0.4	NR1080
85	82.9	82.5	1.7	1.55	2.1	1.9	1.6	1.3	0.4	NR1085
90	87.9	87.5	1.7	1.55	2.1	1.9	1.6	1.3	0.4	NR1090
95	92.9	92.5	1.7	1.55	–	–	1.6	1.3	0.4	NR1095
100	97.9	97.5	1.7	1.55	2.5	2.3	1.6	1.3	0.4	NR1100
105	102.6	102.1	–	–	2.5	2.3	1.6	1.3	0.4	NR1105



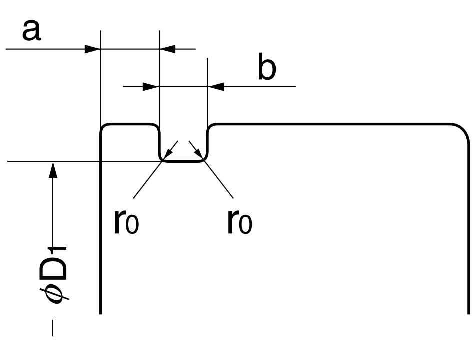
Remarks:

Chamfer at groove side of outer ring clears a fillet radius of:
0.3 mm in dimension series 18 up to and including D = 78 mm and
in dimension series 19 up to and including D = 47 mm;
0.5 mm in dimension series 18 over D = 78 mm and
in dimension series 19 over D = 47 mm

Table 4.5.1 Dimensions of Snap Ring Grooves for Bearing Dimension Series 18 and 19 (3/3)

Unit: mm

Bearing outside diameter Nominal D	Snap ring groove diameter D_1		Snap ring groove location a				Snap ring groove width b		Fillet radius at snap ring groove bottom r_0	Applicable snap ring
			Dimension series 18		Dimension series 19					
	Max	Min	Max	Min	Max	Min	Max	Min	Max	
110	107.6	107.1	2.1	1.9	2.5	2.3	1.6	1.3	0.4	NR1110
115	112.6	112.1	2.1	1.9	–	–	1.6	1.3	0.4	NR1115
120	117.6	117.1	2.1	1.9	3.3	3.1	1.6	1.3	0.4	NR1120
125	122.6	122.1	2.1	1.9	3.3	3.1	1.6	1.3	0.4	NR1125
130	127.6	127.1	2.1	1.9	3.3	3.1	1.6	1.3	0.4	NR1130
140	137.6	137.1	2.5	2.3	3.3	3.1	2.2	1.9	0.6	NR1140
145	142.6	142.1	–	–	3.3	3.1	2.2	1.9	0.6	NR1145
150	147.6	147.1	2.5	2.3	3.3	3.1	2.2	1.9	0.6	NR1150
165	161.8	161.3	3.3	3.1	3.7	3.5	2.2	1.9	0.6	NR1165
175	171.8	171.3	3.3	3.1	–	–	2.2	1.9	0.6	NR1175
180	176.8	176.3	–	–	3.7	3.5	2.2	1.9	0.6	NR1180
190	186.8	186.3	3.3	3.1	3.7	3.5	2.2	1.9	0.6	NR1190
200	196.8	196.3	3.3	3.1	–	–	2.2	1.9	0.6	NR1200



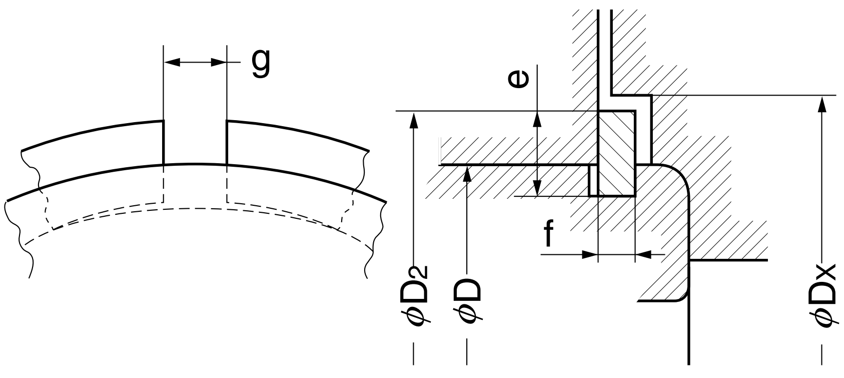
Remarks:

Chamfer at groove side of outer ring clears a fillet radius of:
0.3 mm in dimension series 18 up to and including D = 78 mm and
in dimension series 19 up to and including D = 47 mm;
0.5 mm in dimension series 18 over D = 78 mm and
in dimension series 19 over D = 47 mm

Table 4.5.2 Snap Ring Dimensions for Bearing Dimension Series 18 and 19 (1/3)

Unit: mm

Snap ring No.	Snap ring dimensions: Section height e Max	Section height e Min	Thickness f Max	Thickness f Min	After snap ring mounting: Gap g	Outside diameter of snap ring D_2 (Max)	Applicable bearing: Bearing outside diameter Nominal D	Dimension series 18: Bearing bore diameter d	Dimension series 19: Bearing bore diameter d	Diameter of end cover bore D_X
NR1022	2.0	1.85	0.7	0.6	2	24.8	22	–	10	25.5
NR1024	2.0	1.85	0.7	0.6	2	26.8	24	–	12	27.5
NR1028	2.05	1.9	0.85	0.75	3	30.8	28	–	15	31.5
NR1030	2.05	1.9	0.85	0.75	3	32.8	30	–	17	33.5
NR1032	2.05	1.9	0.85	0.75	3	34.8	32	20	–	35.5
NR1034	2.05	1.9	0.85	0.75	3	36.8	34	22	–	37.5
NR1037	2.05	1.9	0.85	0.75	3	39.8	37	25	20	40.5
NR1039	2.05	1.9	0.85	0.75	3	41.8	39	–	22	42.5
NR1040	2.05	1.9	0.85	0.75	3	42.8	40	28	–	43.5
NR1042	2.05	1.9	0.85	0.75	3	44.8	42	30	25	45.5
NR1044	2.05	1.9	0.85	0.75	4	46.8	44	32	–	47.5
NR1045	2.05	1.9	0.85	0.75	4	47.8	45	–	28	48.5
NR1047	2.05	1.9	0.85	0.75	4	49.8	47	35	30	50.5
NR1052	2.05	1.9	0.85	0.75	4	54.8	52	40	32	55.5
NR1055	2.05	1.9	0.85	0.75	4	57.8	55	–	35	58.5



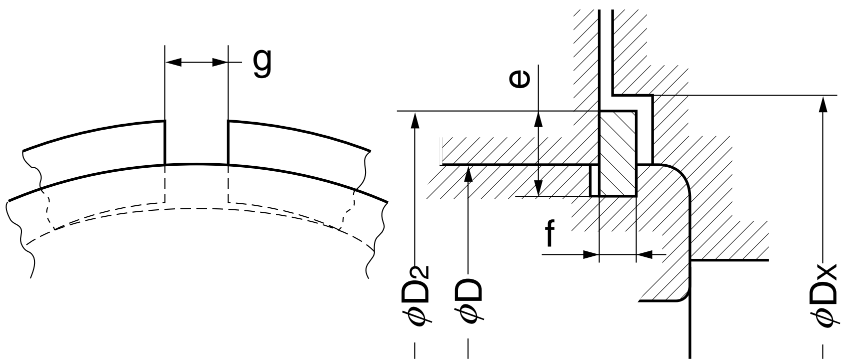
Remarks:

Chamfer at groove side of outer ring clears a fillet radius of:
0.3 mm in dimension series 18 up to and including D = 78 mm and
in dimension series 19 up to and including D = 47 mm;
0.5 mm in dimension series 18 over D = 78 mm and
in dimension series 19 over D = 47 mm

Table 4.5.2 Snap Ring Dimensions for Bearing Dimension Series 18 and 19 (2/3)

Unit: mm

Snap ring No.	Snap ring dimensions: Section height e, Max	Section height e, Min	Thickness f, Max	Thickness f, Min	After snap ring mounting: Gap g	After snap ring mounting: Outside diameter of snap ring D_2 (Max)	Applicable bearing: Bearing outside diameter Nominal D	Dimension series 18: Bearing bore diameter d	Dimension series 19: Bearing bore diameter d	Diameter of end cover bore D_X
NR1058	2.05	1.9	0.85	0.75	4	60.8	58	45	–	61.5
NR1062	2.05	1.9	0.85	0.75	4	64.8	62	–	40	65.5
NR1065	2.05	1.9	0.85	0.75	4	67.8	65	50	–	68.5
NR1068	2.05	1.9	0.85	0.75	5	70.8	68	–	45	72
NR1072	2.05	1.9	0.85	0.75	5	74.8	72	55	50	76
NR1078	3.25	3.1	1.12	1.02	5	82.7	78	60	–	84
NR1080	3.25	3.1	1.12	1.02	5	84.4	80	–	55	86
NR1085	3.25	3.1	1.12	1.02	5	89.4	85	65	60	91
NR1090	3.25	3.1	1.12	1.02	5	94.4	90	70	65	96
NR1095	3.25	3.1	1.12	1.02	5	99.4	95	75	–	101
NR1100	3.25	3.1	1.12	1.02	5	104.4	100	80	70	106
NR1105	4.04	3.89	1.12	1.02	5	110.7	105	–	75	112



Remarks:

Chamfer at groove side of outer ring clears a fillet radius of:

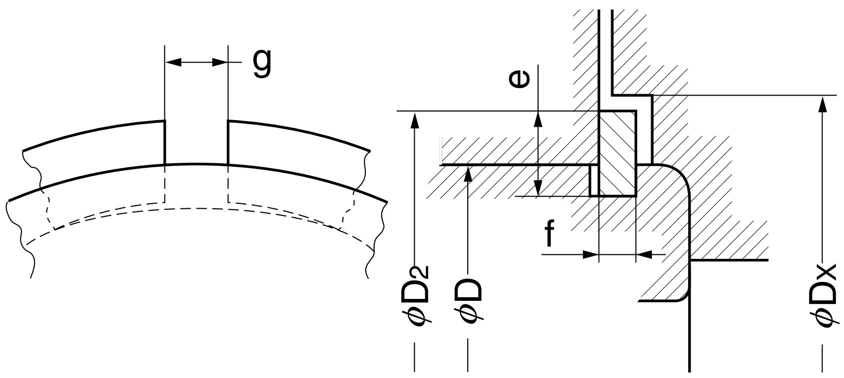
0.3 mm in dimension series 18 up to and including D = 78 mm and
in dimension series 19 up to and including D = 47 mm;

0.5 mm in dimension series 18 over D = 78 mm and
in dimension series 19 over D = 47 mm

Table 4.5.2 Snap Ring Dimensions for Bearing Dimension Series 18 and 19 (3/3)

Unit: mm

Snap ring No.	Snap ring dimensions: Section height e Max	Section height e Min	Thickness f Max	Thickness f Min	After snap ring mounting: Gap g	Outside diameter of snap ring D_2 (Max)	Applicable bearing: Bearing outside diameter Nominal D	Dimension series 18: Bearing bore diameter d	Dimension series 19: Bearing bore diameter d	Diameter of end cover bore D_X
NR1110	4.04	3.89	1.12	1.02	5	115.7	110	85	80	117
NR1115	4.04	3.89	1.12	1.02	5	120.7	115	90	–	122
NR1120	4.04	3.89	1.12	1.02	7	125.7	120	95	85	127
NR1125	4.04	3.89	1.12	1.02	7	130.7	125	100	90	132
NR1130	4.04	3.89	1.12	1.02	7	135.7	130	105	95	137
NR1140	4.04	3.89	1.7	1.6	7	145.7	140	110	100	147
NR1145	4.04	3.89	1.7	1.6	7	150.7	145	–	105	152
NR1150	4.04	3.89	1.7	1.6	7	155.7	150	120	110	157
NR1165	4.85	4.7	1.7	1.6	7	171.5	165	130	120	173
NR1175	4.85	4.7	1.7	1.6	10	181.5	175	140	–	183
NR1180	4.85	4.7	1.7	1.6	10	186.5	180	–	130	188
NR1190	4.85	4.7	1.7	1.6	10	196.5	190	150	140	198
NR1200	4.85	4.7	1.7	1.6	10	206.5	200	160	–	208



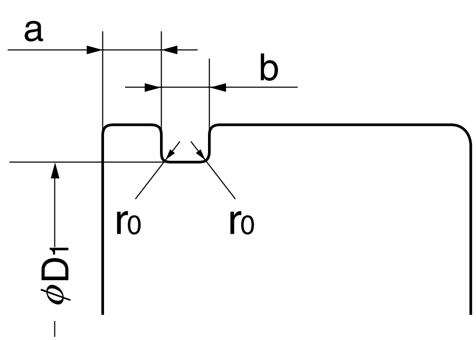
Remarks:

Chamfer at groove side of outer ring clears a fillet radius of:
0.3 mm in dimension series 18 up to and including D = 78 mm and
in dimension series 19 up to and including D = 47 mm;
0.5 mm in dimension series 18 over D = 78 mm and
in dimension series 19 over D = 47 mm

Table 4.5.3 Dimensions of Snap Ring Grooves for Bearing Diameter Series 0, 2, 3 and 4 **(1/4)**

Unit: mm

Bearing outside diameter Nominal D	Snap ring groove diameter D_1		Snap ring groove location a				Snap ring groove width b		Fillet radius at snap ring groove bottom r_0	Applicable snap ring
			Diameter series 0		Diameter series 2, 3, 4					
	Max	Min	Max	Min	Max	Min	Max	Min	Max	
13	12.04	11.91	–	–	1.1	0.95	1.05	0.8	0.2	NR 13
16	15.16	15.04	–	–	1.2	1.05	1.05	0.8	0.2	NR 16
19	18.25	18.1	1.73	1.55	1.73	1.55	1.05	0.8	0.2	NR 19
22	21.11	20.95	1.73	1.55	1.73	1.55	1.05	0.8	0.2	NR 22
24	23	22.85	1.73	1.55	1.73	1.55	1.05	0.8	0.2	NR 24
26	25.15	25	1.73	1.55	1.73	1.55	1.05	0.8	0.2	NR 26
28	26.7	26.4	1.73	1.55	1.73	1.55	1.2	0.95	0.25	NR 28
30	28.17	27.91	–	–	2.06	1.9	1.65	1.35	0.4	NR 30
32	30.15	29.9	2.06	1.9	2.06	1.9	1.65	1.35	0.4	NR 32
35	33.17	32.92	2.06	1.9	2.06	1.9	1.65	1.35	0.4	NR 35
37	34.77	34.52	–	–	2.06	1.9	1.65	1.35	0.4	NR 37
40	38.1	37.85	–	–	2.06	1.9	1.65	1.35	0.4	NR 40
42	39.75	39.5	2.06	1.9	2.06	1.9	1.65	1.35	0.4	NR 42



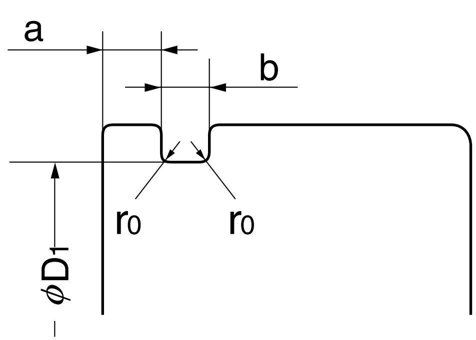
Remarks:

1. These dimensions are not applied to dimension series 00, 82 and 83.
2. Chamfer at groove side of outer ring clears a fillet radius of:
   0.3 mm in diameter series 0 up to and including D = 35 mm,
   0.5 mm in diameter series 0 over D = 35 mm and for all diameters in diameter series 2, 3, and 4

Table 4.5.3 Dimensions of Snap Ring Grooves for Bearing Diameter Series 0, 2, 3 and 4 (2/4)

Unit: mm

Bearing outside diameter Nominal D	Snap ring groove diameter D_1		Snap ring groove location a				Snap ring groove width b		Fillet radius at snap ring groove bottom r_0	Applicable snap ring
			Diameter series 0		Diameter series 2, 3, 4					
	Max	Min	Max	Min	Max	Min	Max	Min	Max	
44	41.75	41.5	2.06	1.9	–	–	1.65	1.35	0.4	NR 44
47	44.6	44.35	2.06	1.9	2.46	2.31	1.65	1.35	0.4	NR 47
50	47.6	47.35	–	–	2.46	2.31	1.65	1.35	0.4	NR 50
52	49.73	49.48	2.06	1.9	2.46	2.31	1.65	1.35	0.4	NR 52
55	52.6	52.35	2.08	1.88	–	–	1.65	1.35	0.4	NR 55
56	53.6	53.35	–	–	2.46	2.31	1.65	1.35	0.4	NR 56
58	55.6	55.35	2.08	1.88	2.46	2.31	1.65	1.35	0.4	NR 58
62	59.61	59.11	2.08	1.88	3.28	3.07	2.2	1.9	0.6	NR 62
65	62.6	62.1	–	–	3.28	3.07	2.2	1.9	0.6	NR 65
68	64.82	64.31	2.49	2.29	3.28	3.07	2.2	1.9	0.6	NR 68
72	68.81	68.3	–	–	3.28	3.07	2.2	1.9	0.6	NR 72
75	71.83	71.32	2.49	2.29	3.28	3.07	2.2	1.9	0.6	NR 75



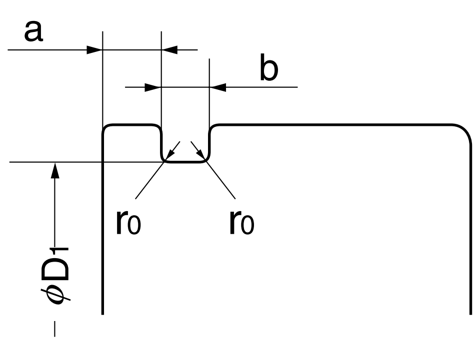
Remarks:

1. These dimensions are not applied to dimension series 00, 82 and 83.
2. Chamfer at groove side of outer ring clears a fillet radius of:
   0.3 mm in diameter series 0 up to and including D = 35 mm,
   0.5 mm in diameter series 0 over D = 35 mm and for all diameters in diameter series 2, 3, and 4

Table 4.5.3 Dimensions of Snap Ring Grooves for Bearing Diameter Series 0, 2, 3 and 4 (3/4)

Unit: mm

Bearing outside diameter Nominal D	Snap ring groove diameter D_1		Snap ring groove location a				Snap ring groove width b		Fillet radius at snap ring groove bottom r_0	Applicable snap ring
			Diameter series 0		Diameter series 2, 3, 4					
	Max	Min	Max	Min	Max	Min	Max	Min	Max	
80	76.81	76.3	2.49	2.29	3.28	3.07	2.2	1.9	0.6	NR 80
85	81.81	81.31	–	–	3.28	3.07	2.2	1.9	0.6	NR 85
90	86.79	86.28	2.87	2.67	3.28	3.07	3	2.7	0.6	NR 90
95	91.82	91.31	2.87	2.67	–	–	3	2.7	0.6	NR 95
100	96.8	96.29	2.87	2.67	3.28	3.07	3	2.7	0.6	NR100
110	106.81	106.3	2.87	2.67	3.28	3.07	3	2.7	0.6	NR110
115	111.81	111.3	2.87	2.67	–	–	3	2.7	0.6	NR115
120	115.21	114.71	–	–	4.06	3.86	3.4	3.1	0.6	NR120
125	120.22	119.71	2.87	2.67	4.06	3.86	3.4	3.1	0.6	NR125
130	125.22	124.71	2.87	2.67	4.06	3.86	3.4	3.1	0.6	NR130
140	135.23	134.72	3.71	3.45	4.9	4.65	3.4	3.1	0.6	NR140
145	140.23	139.73	3.71	3.45	–	–	3.4	3.1	0.6	NR145



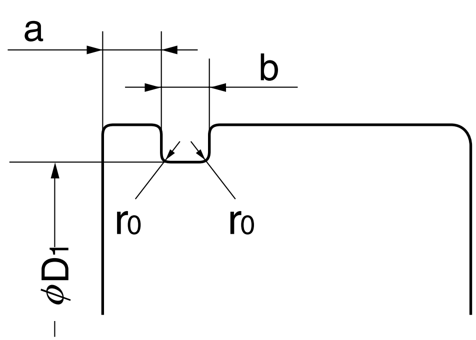
Remarks:

1. These dimensions are not applied to dimension series 00, 82 and 83.
2. Chamfer at groove side of outer ring clears a fillet radius of:
   0.3 mm in diameter series 0 up to and including D = 35 mm,
   0.5 mm in diameter series 0 over D = 35 mm and for all diameters in diameter series 2, 3, and 4

Table 4.5.3 Dimensions of Snap Ring Grooves for Bearing Diameter Series 0, 2, 3 and 4 (4/4)

Unit: mm

Bearing outside diameter Nominal D	Snap ring groove diameter D_1		Snap ring groove location a				Snap ring groove width b		Fillet radius at snap ring groove bottom r_0	Applicable snap ring
			Diameter series 0		Diameter series 2, 3, 4					
	Max	Min	Max	Min	Max	Min	Max	Min	Max	
150	145.24	144.73	3.71	3.45	4.9	4.65	3.4	3.1	0.6	NR150
160	155.22	154.71	3.71	3.45	4.9	4.65	3.4	3.1	0.6	NR160
170	163.65	163.14	3.71	3.45	5.69	5.44	3.8	3.5	0.6	NR170
180	173.66	173.15	3.71	3.45	5.69	5.44	3.8	3.5	0.6	NR180
190	183.64	183.13	–	–	5.69	5.44	3.8	3.5	0.6	NR190
200	193.65	193.14	5.69	5.44	5.69	5.44	3.8	3.5	0.6	NR200
210	203.6	203.1	5.69	5.44	–	–	3.8	3.5	1	NR210
215	208.6	208.1	–	–	5.69	5.44	3.8	3.5	1	NR215
225	217	216.5	6.5	6.2	6.5	6.2	4.9	4.5	1	NR225
230	222	221.5	–	–	6.5	6.2	4.9	4.5	1	NR230
240	232	231.5	6.5	6.2	6.5	6.2	4.9	4.5	1	NR240
250	242	241.5	–	–	6.5	6.2	4.9	4.5	1	NR250



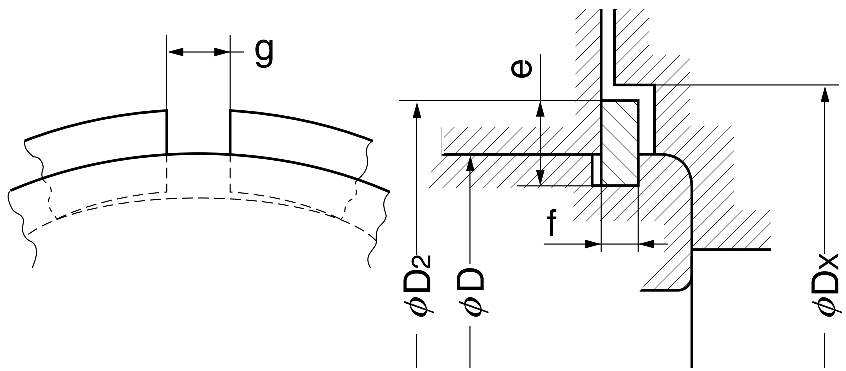
Remarks:

1. These dimensions are not applied to dimension series 00, 82 and 83.
2. Chamfer at groove side of outer ring clears a fillet radius of:
   0.3 mm in diameter series 0 up to and including D = 35 mm,
   0.5 mm in diameter series 0 over D = 35 mm and for all diameters in diameter series 2, 3, and 4

Table 4.5.4 Snap Ring Dimensions for Bearing Diameter Series 0, 2, 3 and 4 (1/4)

Unit: mm

Snap ring No.	Snap ring dimensions: Section height e, Max	Section height e, Min	Thickness f, Max	Thickness f, Min	After snap ring mounting: Gap g	After snap ring mounting: Outside diameter of snap ring D_2 (Max)	Applicable bearing: Bearing outside diameter Nominal D	Dimension series 0: Bearing bore diameter d	Dimension series 2: Bearing bore diameter d	Dimension series 3: Bearing bore diameter d	Dimension series 4: Bearing bore diameter d	Diameter of end cover bore D_X (Min)
NR 13	1.15	1.0	0.7	0.6	3	14.3	13	–	4	3	–	14.5
NR 16	1.65	1.5	0.7	0.6	3	18.5	16	–	5	4	–	19
NR 19	1.65	1.5	0.7	0.6	3	21.5	19	7	6	5	–	22
NR 22	2.00	1.85	0.7	0.6	3	25.1	22	8	7	6	–	25.5
NR 24	2.00	1.85	0.7	0.6	3	27	24	9	8	–	–	27.5
NR 26	2.00	1.85	0.7	0.6	3	29.2	26	10	9	7	–	30
NR 28	2.05	1.90	0.85	0.75	3	30.8	28	12	–	8	–	31.5
NR 30	3.25	3.1	1.12	1.02	3	34.7	30	–	10	9	8	35.5
NR 32	3.25	3.1	1.12	1.02	3	36.7	32	15	12	–	9	37.5
NR 35	3.25	3.1	1.12	1.02	3	39.7	35	17	15	10	–	40.5
NR 37	3.25	3.1	1.12	1.02	3	41.3	37	–	–	12	10	42
NR 40	3.25	3.1	1.12	1.02	3	44.6	40	–	17	–	–	45.5
NR 42	3.25	3.1	1.12	1.02	3	46.3	42	20	–	15	12	47



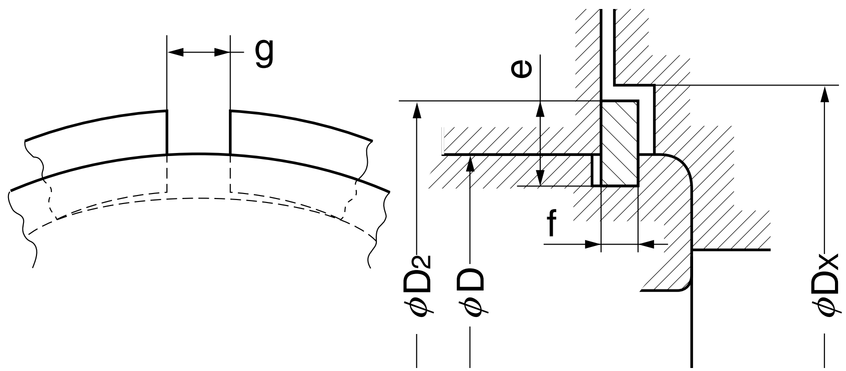
Remarks:

1. These dimensions are not applied to dimension series 00, 82 and 83.
2. Chamfer at groove side of outer ring clears a fillet radius of:
   0.3 mm in diameter series 0 up to and including D = 35 mm,
   0.5 mm in diameter series 0 over D = 35 mm and for all diameters in diameter series 2, 3, and 4

Table 4.5.4 Snap Ring Dimensions for Bearing Diameter Series 0, 2, 3 and 4 (2/4)

Unit: mm

Snap ring No.	Snap ring dimensions: Section height e Max	Section height e Min	Thickness f Max	Thickness f Min	After snap ring mounting: Gap g	Outside diameter of snap ring D_2 (Max)	Applicable bearing: Bearing outside diameter Nominal D	Dimension series 0: Bearing bore diameter d	Dimension series 2	Dimension series 3	Dimension series 4	Diameter of end cover bore D_X (Min)
NR 44	3.25	3.1	1.12	1.02	3	48.3	44	22	–	–	–	49
NR 47	4.04	3.89	1.12	1.02	4	52.7	47	25	20	17	–	53.5
NR 50	4.04	3.89	1.12	1.02	4	55.7	50	–	22	–	–	56.5
NR 52	4.04	3.89	1.12	1.02	4	57.9	52	28	25	20	15	58.5
NR 55	4.04	3.89	1.12	1.02	4	60.7	55	30	–	–	–	61.5
NR 56	4.04	3.89	1.12	1.02	4	61.7	56	–	–	22	–	62.5
NR 58	4.04	3.89	1.12	1.02	4	63.7	58	32	28	–	–	64.5
NR 62	4.04	3.89	1.7	1.6	4	67.7	62	35	30	25	17	68.5
NR 65	4.04	3.89	1.7	1.6	4	70.7	65	–	32	–	–	71.5
NR 68	4.85	4.7	1.7	1.6	5	74.6	68	40	–	28	–	76
NR 72	4.85	4.7	1.7	1.6	5	78.6	72	–	35	30	20	80
NR 75	4.85	4.7	1.7	1.6	5	81.6	75	45	–	32	–	83



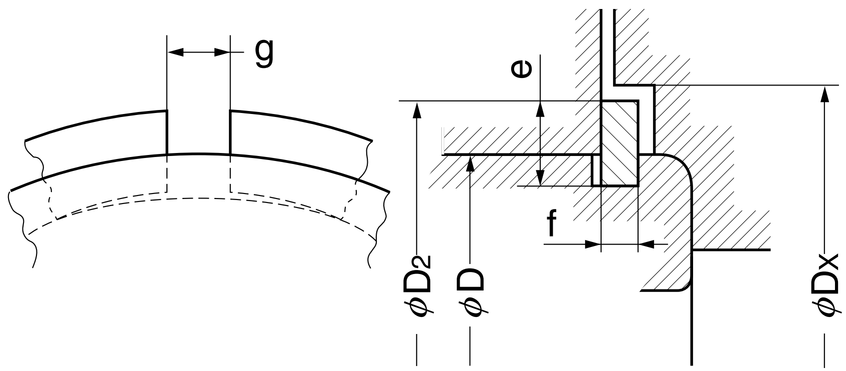
Remarks:

1. These dimensions are not applied to dimension series 00, 82 and 83.
2. Chamfer at groove side of outer ring clears a fillet radius of:
   0.3 mm in diameter series 0 up to and including D = 35 mm,
   0.5 mm in diameter series 0 over D = 35 mm and for all diameters in diameter series 2, 3, and 4

Table 4.5.4 Snap Ring Dimensions for Bearing Diameter Series 0, 2, 3 and 4 (3/4)

Unit: mm

Snap ring No.	Snap ring dimensions: Section height e Max	Section height e Min	Thickness f Max	Thickness f Min	After snap ring mounting: Gap g	Outside diameter of snap ring D_2 (Max)	Applicable bearing: Bearing outside diameter Nominal D	Dimension series 0 (Bearing bore diameter d)	2	3	4	Diameter of end cover bore D_x (Min)
NR 80	4.85	4.7	1.7	1.6	5	86.6	80	50	40	35	25	88
NR 85	4.85	4.7	1.7	1.6	5	91.6	85	–	45	–	–	93
NR 90	4.85	4.7	2.46	2.36	5	96.5	90	55	50	40	30	98
NR 95	4.85	4.7	2.46	2.36	5	101.6	95	60	–	–	–	103
NR100	4.85	4.7	2.46	2.36	5	106.5	100	65	55	45	35	108
NR110	4.85	4.7	2.46	2.36	5	116.6	110	70	60	50	40	118
NR115	4.85	4.7	2.46	2.36	5	121.6	115	75	–	–	–	123
NR120	7.21	7.06	2.82	2.72	7	129.7	120	–	65	55	45	131.5
NR125	7.21	7.06	2.82	2.72	7	134.7	125	80	70	–	–	136.5
NR130	7.21	7.06	2.82	2.72	7	139.7	130	85	75	60	50	141.5
NR140	7.21	7.06	2.82	2.72	7	149.7	140	90	80	65	55	152
NR145	7.21	7.06	2.82	2.72	7	154.7	145	95	–	–	–	157



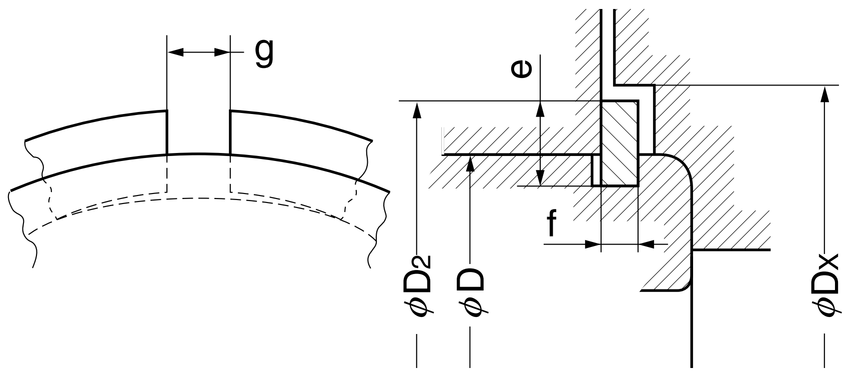
Remarks:

1. These dimensions are not applied to dimension series 00, 82 and 83.
2. Chamfer at groove side of outer ring clears a fillet radius of:
   0.3 mm in diameter series 0 up to and including D = 35 mm,
   0.5 mm in diameter series 0 over D = 35 mm and for all diameters in diameter series 2, 3, and 4

Table 4.5.4 Snap Ring Dimensions for Bearing Diameter Series 0, 2, 3 and 4 (4/4)

Unit: mm

Snap ring No.	Snap ring dimensions: Section height e Max	Section height e Min	Thickness f Max	Thickness f Min	After snap ring mounting: Gap g	Outside diameter of snap ring D_2 (Max)	Bearing outside diameter Nominal D	Dimension series 0 — Bearing bore diameter d	2	3	4	Diameter of end cover bore D_X (Min)
NR150	7.21	7.06	2.82	2.72	7	159.7	150	100	85	70	60	162
NR160	7.21	7.06	2.82	2.72	7	169.7	160	105	90	75	65	172
NR170	9.6	9.45	3.1	3	10	182.9	170	110	95	80	–	185
NR180	9.6	9.45	3.1	3	10	192.9	180	120	100	85	70	195
NR190	9.6	9.45	3.1	3	10	202.9	190	–	105	90	75	205
NR200	9.6	9.45	3.1	3	10	212.9	200	130	110	95	80	215
NR210	9.6	9.45	3.1	3	10	222.8	210	140	–	–	85	225
NR215	9.6	9.45	3.1	3	10	227.8	215	–	120	100	–	230
NR225	10	9.85	3.5	3.4	10	237	225	150	–	105	90	240
NR230	10	9.85	3.5	3.4	10	242	230	–	130	–	–	245
NR240	10	9.85	3.5	3.4	10	252	240	160	–	110	95	255
NR250	10	9.85	3.5	3.4	10	262	250	–	140	–	100	265



Remarks:

1. These dimensions are not applied to dimension series 00, 82 and 83.
2. Chamfer at groove side of outer ring clears a fillet radius of:
   0.3 mm in diameter series 0 up to and including D = 35 mm,
   0.5 mm in diameter series 0 over D = 35 mm and for all diameters in diameter series 2, 3, and 4

4.6 Nachi Bearing Numbers

Fig 4.8 NACHI Bearing Prefixes and Suffixes

Supplementary Symbol	Basic Number			
Material Symbol	Type Symbol	Dimension Series Number	Bore Diameter Number	Contact Angle Symbol
Table.4.6.1	**Table.4.6.2**			**Table.4.6.3**

Note 1:
Denotes polyamide cages for angular contact ball bearing of contact angle symbol C.

Remarks:
1. Symbol in parentheses can be omitted.
2. Code marked with "*" is not marked on bearing.
3. Bearing modification symbol NR is marked without R on bearing.

Supplementary symbol								
Special Design Symbol	Cage Symbol	Seal or shield	Ring modification	*Duplex mounting	*Sleeve	Internal clearance	Tolerance	*Grease
Table.4.6.4	**Table.4.6.5**	**Table.4.6.6**	**Table.4.6.7**	**Table.4.6.8**	**Table.4.6.9**	**Table.4.6.10**	**Table.4.6.11**	**Table.4.6.12**

Table 4.6.1 Material Symbol

Prefix	Description
B–	Case hardened steel
C–	Case hardened steel
D–	Case hardened steel
H–	High speed steel
S–	Stainless steel

Table 4.6.8 *Duplex mounting

Suffix	Description
DB	Back-to-back mounting
DF	Face-to-face mounting
DT	Tandem mounting
KB	DB mounting with spacer to outer ring
$+\alpha$	Spacer (α is nominal width in mm)
U DU	Flush ground angular contact ball bearing

Table 4.6.2 Type Symbol

Prefix	Description
N	Cylindrical roller bearings
NU	
NF	
NJ	
NP	
NUP	
NH	
NNU	
NN	
R	Cylindrical roller bearing roller assembly and outer or inner ring

Table 4.6.7 Ring modification

Suffix	Description
K	Tapered bore: 1/12 taper on bearing bore
K30	Tapered bore: 1/30 taper on bearing bore
N	Snap ring groove on outer ring without snap ring
NR	Snap ring on outer ring

Table 4.6.4 Special Design Symbol

Suffix	Description
A	Inner ring, bearing width variation for Tapered roller bearing
E	Roller bearing design change
J	Tapered roller bearing rings interchangeable
S26	Heat stabilized
S28	Heat stabilized
W20	Oil holes in outer ring
W33	Oil holes and groove in outer ring
E2	Spherical roller bearing with machined cage
EX	High capacity spherical roller bearing
A2X	High speed spherical roller bearing
AEX	High speed and high capacity spherical roller bearing
V	Special design for vibrating machine

Table 4.6.5 Cage Symbol

Suffix	Description
F	Machined mild steel cage
G	Non-metalic cage
L	Machined light alloy cage
MY	Machined bronze cage
V	No cage
Y	Pressed non-ferrous metal cage (Note 1)

Table 4.6.6 Seal or shield

Suffix		Description
ZE	Z	Shield one side
ZZE	ZZ	Shield both sides
NKE	NK	Labyrinth seal one side
–2NKE	–2NK	Labyrinth seal both sides
NSE	NSL	Contact seal one side
–2NSE	–2NSL	Contact seal both sides

Table 4.6.3 Contact Angle Symbol

Suffix	Description	
C	Single row Angular contact ball bearings	Nominal contact angle over 10° under 22° (standard 15°)
(A)		Nominal contact angle over 22° under 32° (standard 30°)
B		Nominal contact angle over 32° under 45° (standard 40°)
D	Tapered roller bearings	Nominal contact angle over 24° under 32°
C		Nominal contact angle over 17° under 24°

Table 4.6.10 Internal clearance

Suffix	Description
C1	Radial clearance C1
C2	Radial clearance C2
(CN)	Normal Radial clearance
C3	Radial clearance C3
C4	Radial clearance C4
C5	Radial clearance C5
C1P	Radial clearance C1P (Note 2)
C2P	Radial clearance C2P (Note 2)
⋮	⋮
C6P	Radial clearance C6P (Note 2)
C9na	Cylindrical roller bearing (C9) (Note 3)
C1na	Cylindrical roller bearing (C1) (Note 3)
C2na	Cylindrical roller bearing (C2) (Note 3)
Cna	Cylindrical roller bearing (Normal) (Note 3)
C3na	Cylindrical roller bearing (C3) (Note 3)
C4na	Cylindrical roller bearing (C4) (Note 3)
C5na	Cylindrical roller bearing (C5) (Note 3)
CM	Electric motor bearing radial clearance (of deep groove ball bearing and of non-interchangeable cylindrical roller bearing)
CT	Radial clearance for electric motor bearing (interchangeable cylindrical roller bearings)

Note 2: Extra small ball bearing and miniature ball bearing
Note 3: Non-interchangeable clearance

Table 4.6.9 *Sleeve

Suffix	Description
+H	Adapter sleeve
+AH	Withdrawal sleeve

Table 4.6.11 Tolerance

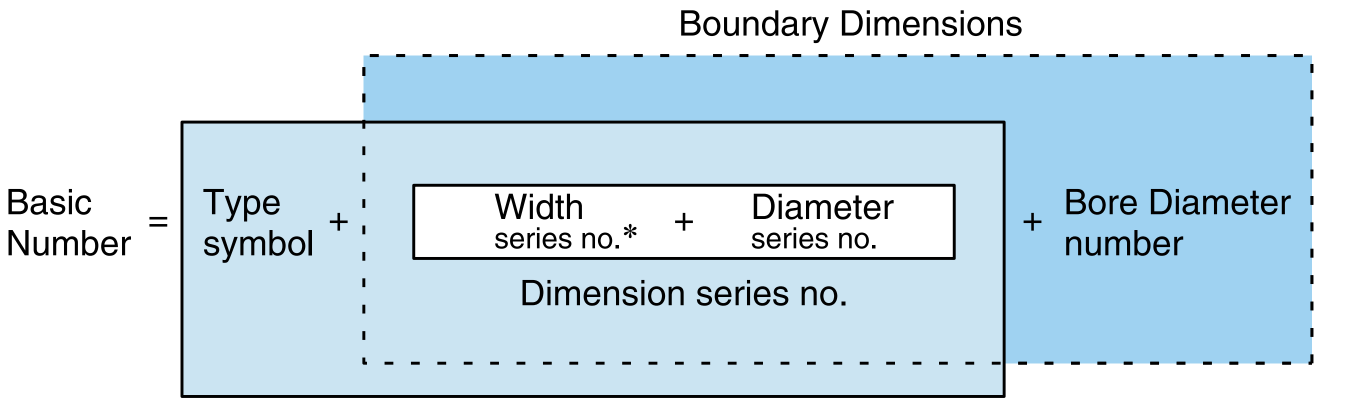
Suffix	Description
(0)	JIS class 0 (ISO Normal class)
P6	JIS class 6 (ISO class 6)
P6X	JIS class 6X
P5	JIS class 5 (ISO class 5)
P4	JIS class 4 (ISO class 4)
P2	JIS class 2 (ISO class 2)
UP	NACHI class UP

Table 4.6.12 *Grease

Suffix	Description
ADC	Shell Andoc C
AV2	Shell Alvania grease 2S
BC325	Esso Beacon 325
MTSRL	Multemp SRL

NACHI Rolling Contact Bearing Numbers ••• Examples

The NACHI part number for rolling contact bearings consists of the basic number and supplementary codes. The part number defines the bearing configuration, tolerance, general boundary dimensions, and other specifications.
NACHI uses supplemental prefix and suffix symbols as shown in Fig. 4.8. The NACHI basic number consists of the following:



Bearing series symbol

* Height series number for thrust bearings.

Bore Diameter Number

Bore (mm)	4	5	6	7	8	9	10	12	15	17	20	25	....	480	500	530	....
Bore diameter number	4	5	6	7	8	9	00	01	02	03	04	05	....	96	/500	/530	....
Remarks	Bore Diameter						–				(bore dia.)/5				/bore diameter		

Example 1

6 2 04 ZZE C3 P6

- Tolerance symbol (JIS/ISO class 6)
- Internal clearance symbol (C3)
- Shields (2 shields)
- Bore diameter number (20 mm)
- Diameter series no. (series 2)
- Type symbol (Single row deep groove ball bearing)

Example 2

7 2 10 C Y DB /GL P4

- Tolerance symbol (JIS/ISO class 4)
- Internal clearance (Light preload)
- Duplex mounting (Back-to-back)
- Cage symbol (Polyamide cage)
- Contact angle symbol (15° angle)
- Bore diameter number (50 mm)
- Diameter series no. (series 2)
- Type symbol (single row angular contact ball bearing)

Example 3

2 3 0 34 E W33 K

- Ring modification symbol (1/12 tapered bore)
- Special design symbol (Oil hole and groove in outer ring)
- Special design symbol (improvement)
- Bore diameter number (170 mm bore)
- Diameter series no. (Series 0)
- Width series no. (Series 3)
- Type symbol (Spherical roller bearing)

Example 4

5 1 2 08

- Bore diameter number (40 mm)
- Diameter series no. (series 2)
- Height series no. (Series 1)
- Type symbol (Thrust ball bearing)

5. Accuracy of Bearings

5. Accuracy of Rolling Contact Bearings

The tolerance of rolling contact bearings includes dimensional and running accuracy. According to JIS (1), tolerance is classified into 6 classes; class 0, 6, 6X, 5, 4 and 2 with accuracy ascending from class 0 to 2.
Applicable tolerance classes to individual bearing types and applicable standards are shown in the next page.

Accuracy of Rolling Contact Bearings

Dimensional Accuracy

Mounting element tolerances
- Bearing bore, outside dia., width
- Width variation
- Inscribed and circumscribed circle diameter of rollers
- Chamfer dimensions
- Tapered bore

Running Accuracy

Dynamic elements
- Radial run-out of rings
- Axial run-out of rings
- Side face run-out of rings
- Tolerance of variation outer ring raceway dia. to outside dia.

Bearing types and tolerance classes

Bearing Type		Tolerance class					Related Standard	Reference Tables
Deep groove Ball Bearings		JIS 0	JIS 6	JIS 5	JIS 4	JIS 2	JIS B 1514	5.1.1 5.1.2
Angular Contact Ball Bearings		JIS 0	JIS 6	JIS 5	JIS 4	JIS 2	JIS B 1514	5.1.1 5.1.2
Self-aligning Ball Bearings		JIS 0	–	–	–	–		
Cylindrical Roller Bearings		JIS 0	JIS 6	JIS 5	JIS 4	JIS 2		
Spherical Roller (Radial) Bearings		JIS 0	–	–	–	–		
Tapered Roller Bearings	Metric Series	JIS 0 JIS 6X	JIS 6	JIS 5	JIS 4	–	JIS B 1514	5.2.1 5.2.2 5.2.3
	Inch Series	CLASS 4	CLASS 2	CLASS 3	CLASS 0	CLASS 00	ANSI / ABMA 19	5.5.1 5.5.2 5.5.3 5.5.4
Thrust, Ball Bearings		JIS 0	JIS 6	JIS 5	JIS 4	–	JIS B 1514	5.3.1 5.3.2 5.3.3
Spherical Roller Thrust Bearings		JIS 0	–	–	–	–	JIS B 1514	5.4.1 5.4.2

Metric Radial Bearings (Except Tapered Roller Bearings) Class Comparison

Comparative Classes	ISO (2)		NORMAL CLASS	CLASS 6	CLASS 5	CLASS 4	CLASS 2	ISO 492 ISO 582	–
	DIN (3)		P0	P6	P5	P4	P2	DIN 620	–
	ANSI (4) / ABMA (5)	Ball Bearings	ABEC 1	ABEC 3	ABEC 5	ABEC 7	ABEC 9	ANSI / ABMA 20	–
		Roller Bearings	RBEC 1	RBEC 3	RBEC 5	–	–	ANSI / ABMA 20	–

(1) Japanese Industrial Standard (2) International Organization for Standardization (3) German Industrial Standards
(4) American National Standards Institute(5) American Bearing Manufacturers Association
Remarks: For tolerances of chamfer dimensions, see Table 5.6; for accuracy of tapered bore, see Table 5.7.

Table 5.1.1 Tolerance Values of Inner Ring and of Outer Ring Width **(1/4)** Unit: μm

Bearing bore diameter Nominal d (mm)		Bearing with cylindrical bore													
		Single plane mean bore diameter deviation Δd_{mp}										Deviation of a single bore diameter (2) Δd_s			
		Class 0		Class 6		Class 5		Class 4		Class 2		Class 4 Diameter series 0,1,2,3,4		Class 2	
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
0.6[1]	2.5	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5
2.5	10	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5
10	18	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5
18	30	0	−10	0	−8	0	−6	0	−5	0	−2.5	0	−5	0	−2.5
30	50	0	−12	0	−10	0	−8	0	−6	0	−2.5	0	−6	0	−2.5
50	80	0	−15	0	−12	0	−9	0	−7	0	−4	0	−7	0	−4
80	120	0	−20	0	−15	0	−10	0	−8	0	−5	0	−8	0	−5
120	150	0	−25	0	−18	0	−13	0	−10	0	−7	0	−10	0	−7
150	180	0	−25	0	−18	0	−13	0	−10	0	−7	0	−10	0	−7
180	250	0	−30	0	−22	0	−15	0	−12	0	−8	0	−12	0	−8
250	315	0	−35	0	−25	0	−18	−	−	−	−	−	−	−	−
315	400	0	−40	0	−30	0	−23	−	−	−	−	−	−	−	−
400	500	0	−45	0	−35	−	−	−	−	−	−	−	−	−	−
500	630	0	−50	0	−40	−	−	−	−	−	−	−	−	−	−
630	800	0	−75	−	−	−	−	−	−	−	−	−	−	−	−
800	1000	0	−100	−	−	−	−	−	−	−	−	−	−	−	−
1000	1250	0	−125	−	−	−	−	−	−	−	−	−	−	−	−
1250	1600	0	−160	−	−	−	−	−	−	−	−	−	−	−	−
1600	2000	0	−200	−	−	−	−	−	−	−	−	−	−	−	−

Notes: (1) This diameter is included in this group.
(2) Applies to bearings with cylindrical bore.
(3) Width deviation and variation of outer ring are the same with of inner ring. Outer ring width variation of classes 5, 4 and 2 are listed in Table 5.1.2.
(4) Applies to the rings of single bearings made for paired of stack mounting.
(5) Applies ro radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.1 Tolerance Values of Inner Ring and of Outer Ring Width (2/4) Unit: μm

Bearing bore diameter Nominal d (mm)		Bearing with cylindrical bore															
		Bore diameter variation in a single radial plane (2) Vdp										Main bore diameter variation (2) $Vdmp$					
		Class 0			Class 6			Class 5		Class 4							
		Diameter series			Diameter series			Diameter series		Diameter series		Class 2	Class 0	Class 6	Class 5	Class 4	Class 2
		7,8,9	0,1	2,3,4	7,8,9	0,1	2,3,4	7,8,9	0,1,2,3,4	7,8,9	0,1,2,3,4						
Over	Incl.	Max			Max			Max		Max		Max	Max	Max	Max	Max	Max
0.6[1]	2.5	10	8	6	9	7	5	5	4	4	3	2.5	6	5	3	2	1.5
2.5	10	10	8	6	9	7	5	5	4	4	3	2.5	6	5	3	2	1.5
10	18	10	8	6	9	7	5	5	4	4	3	2.5	6	5	3	2	1.5
18	30	13	10	8	10	8	6	6	5	5	4	2.5	8	6	3	2.5	1.5
30	50	15	12	9	13	10	8	8	6	6	5	2.5	9	8	4	3	1.5
50	80	19	19	11	15	15	9	9	7	7	5	4	11	9	5	3.5	2
80	120	25	25	15	19	19	11	10	8	8	6	5	15	11	5	4	2.5
120	150	31	31	19	23	23	14	13	10	10	8	7	19	14	7	5	3.5
150	180	31	31	19	23	23	14	13	10	10	8	7	19	14	7	5	3.5
180	250	38	38	23	28	28	17	15	12	12	9	8	23	17	8	6	4
250	315	44	44	26	31	31	19	18	14	–	–	–	26	19	9	–	–
315	400	50	50	30	38	38	23	23	18	–	–	–	30	23	12	–	–
400	500	56	56	34	44	44	26	–	–	–	–	–	34	26	–	–	–
500	630	63	63	38	50	50	30	–	–	–	–	–	38	30	–	–	–
630	800	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
800	1000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1000	1250	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1250	1600	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1600	2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies to bearings with cylindrical bore.
(3) Width deviation and variation of outer ring are the same with of inner ring. Outer ring width variation of classes 5, 4 and 2 are listed in Table 5.1.2.
(4) Applies to the rings of single bearings made for paired of stack mounting.
(5) Applies ro radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.1 Tolerance Values of Inner Ring and of Outer Ring Width (3/4) Unit: μm

Bearing bore diameter Nominal d (mm)		Deviation of a single inner ring width (or a single outer ring width) (2) ΔB_s (or ΔC_s)										Inner (or outer) ring width variation V_{Bs} (or V_{Cs})				
		Single bearing						Paired or stack mounted bearing (4)				Inner ring (or outer ring) (3)		Inner ring		
		Class 0 Class 6		Class 5 Class 4		Class 2		Class 0 Class 6		Class 5 Class 4		Class 0	Class 6	Class 5	Class 4	Class 2
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low	Max	Max	Max	Max	Max
0.6 (1)	2.5	0	− 40	0	− 40	0	− 40	–	–	0	–250	12	12	5	2.5	1.5
2.5	10	0	− 120	0	− 40	0	− 40	0	–250	0	–250	15	15	5	2.5	1.5
10	18	0	− 120	0	− 80	0	− 80	0	–250	0	–250	20	20	5	2.5	1.5
18	30	0	− 120	0	–120	0	–120	0	–250	0	–250	20	20	5	2.5	1.5
30	50	0	− 120	0	–120	0	–120	0	–250	0	–250	20	20	5	3	1.5
50	80	0	− 150	0	–150	0	–150	0	–380	0	–250	25	25	6	4	1.5
80	120	0	− 200	0	–200	0	–200	0	–380	0	–380	25	25	7	4	2.5
120	150	0	− 250	0	–250	0	–250	0	–500	0	–380	30	30	8	5	2.5
150	180	0	− 250	0	–250	0	–250	0	–500	0	–380	30	30	8	5	4
180	250	0	− 300	0	–300	0	–300	0	–500	0	–500	30	30	10	6	5
250	315	0	− 350	0	–350	–	–	0	–500	0	–500	35	35	13	–	–
315	400	0	− 400	0	–400	–	–	0	–630	0	–630	40	40	15	–	–
400	500	0	− 450	–	–	–	–	–	–	–	–	50	45	–	–	–
500	630	0	− 500	–	–	–	–	–	–	–	–	60	50	–	–	–
630	800	0	− 750	–	–	–	–	–	–	–	–	70	–	–	–	–
800	1000	0	–1000	–	–	–	–	–	–	–	–	80	–	–	–	–
1000	1250	0	–1250	–	–	–	–	–	–	–	–	100	–	–	–	–
1250	1600	0	–1600	–	–	–	–	–	–	–	–	120	–	–	–	–
1600	2000	0	–2000	–	–	–	–	–	–	–	–	140	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies to bearings with cylindrical bore.
(3) Width deviation and variation of outer ring are the same with of inner ring. Outer ring width variation of classes 5, 4 and 2 are listed in Table 5.1.2.
(4) Applies to the rings of single bearings made for paired of stack mounting.
(5) Applies ro radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.1 Tolerance Values of Inner Ring and of Outer Ring Width **(4/4)** Unit: μm

Bearing bore diameter Nominal d (mm)		Radial runout of assembled bearing inner ring K_{ia}					Inner ring reference face runout with bore S_d			Assembled bearing inner ring face runout with raceway S_{ia} (5)		
		Class 0	Class 6	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
0.6(1)	2.5	10	5	4	2.5	1.5	7	3	1.5	7	3	1.5
2.5	10	10	6	4	2.5	1.5	7	3	1.5	7	3	1.5
10	18	10	7	4	2.5	1.5	7	3	1.5	7	3	1.5
18	30	13	8	4	3	2.5	8	4	1.5	8	4	2.5
30	50	15	10	5	4	2.5	8	4	1.5	8	4	2.5
50	80	20	10	5	4	2.5	8	5	1.5	8	5	2.5
80	120	25	13	6	5	2.5	9	5	2.5	9	5	2.5
120	150	30	18	8	6	2.5	10	6	2.5	10	7	2.5
150	180	30	18	8	6	5	10	6	4	10	7	5
180	250	40	20	10	8	5	11	7	5	13	8	5
250	315	50	25	13	–	–	13	–	–	15	–	–
315	400	60	30	15	–	–	15	–	–	20	–	–
400	500	65	35	–	–	–	–	–	–	–	–	–
500	630	70	40	–	–	–	–	–	–	–	–	–
630	800	80	–	–	–	–	–	–	–	–	–	–
800	1000	90	–	–	–	–	–	–	–	–	–	–
1000	1250	100	–	–	–	–	–	–	–	–	–	–
1250	1600	120	–	–	–	–	–	–	–	–	–	–
1600	2000	140	–	–	–	–	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies to bearings with cylindrical bore.
(3) Width deviation and variation of outer ring are the same with of inner ring. Outer ring width variation of classes 5, 4 and 2 are listed in Table 5.1.2.
(4) Applies to the rings of single bearings made for paired of stack mounting.
(5) Applies ro radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.2 Tolerance Values of Outer Ring (1/4)

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter: Single plane mean outside diameter deviation ΔD_{mp}										Deviation of a single outside diameter ΔD_s			
		Class 0		Class 6		Class 5		Class 4		Class 2		Class 4 Diameter series 0,1,2,3,4		Class 2	
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
2.5 (1)	6	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5
6	18	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5
18	30	0	−9	0	−8	0	−6	0	−5	0	−4	0	−5	0	−4
30	50	0	−11	0	−9	0	−7	0	−6	0	−4	0	−6	0	−4
50	80	0	−13	0	−11	0	−9	0	−7	0	−4	0	−7	0	−4
80	120	0	−15	0	−13	0	−10	0	−8	0	−5	0	−8	0	−5
120	150	0	−18	0	−15	0	−11	0	−9	0	−5	0	−9	0	−5
150	180	0	−25	0	−18	0	−13	0	−10	0	−7	0	−10	0	−7
180	250	0	−30	0	−20	0	−15	0	−11	0	−8	0	−11	0	−8
250	315	0	−35	0	−25	0	−18	0	−13	0	−8	0	−13	0	−8
315	400	0	−40	0	−28	0	−20	0	−15	0	−10	0	−15	0	−10
400	500	0	−45	0	−33	0	−23	–	–	–	–	–	–	–	–
500	630	0	−50	0	−38	0	−28	–	–	–	–	–	–	–	–
630	800	0	−75	0	−45	0	−35	–	–	–	–	–	–	–	–
800	1000	0	−100	0	−60	–	–	–	–	–	–	–	–	–	–
1000	1250	0	−125	–	–	–	–	–	–	–	–	–	–	–	–
1250	1600	0	−160	–	–	–	–	–	–	–	–	–	–	–	–
1600	2000	0	−200	–	–	–	–	–	–	–	–	–	–	–	–
2000	2500	0	−250	–	–	–	–	–	–	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies before mounting and after removal of internal or external snap ring.
(3) Applies to radial ball bearings such as deep groove ball bearings, angular contact ball bearings.
(4) Outer ring width variation of class 0 and 6 are listed in Table 5.1.1.
(5) Applies to radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.2　Tolerance Values of Outer Ring　　(2/4)

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter – Outside diameter variation in a single radial plane (2) V_{Dp}												
		Class 0				Class 6				Class 5		Class 4		Class 2
		Open bearing			Seal · shield bearing	Open bearing			Seal · shield bearing	Open bearing		Open bearing		Open bearing
		Diameter series				Diameter series				Diameter series		Diameter series		
		7,8,9	0,1	2,3,4	2,3,4	7,8,9	0,1	2,3,4	0,1,2,3,4	7,8,9	0,1,2,3,4	7,8,9	0,1,2,3,4	
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
2.5 (1)	6	10	8	6	10	9	7	5	9	5	4	4	3	2.5
6	18	10	8	6	10	9	7	5	9	5	4	4	3	2.5
18	30	12	9	7	12	10	8	6	10	6	5	5	4	4
30	50	14	11	8	16	11	9	7	13	7	5	6	5	4
50	80	16	13	10	20	14	11	8	16	9	7	7	5	4
80	120	19	19	11	26	16	16	10	20	10	8	8	6	5
120	150	23	23	14	30	19	19	11	25	11	8	9	7	5
150	180	31	31	19	38	23	23	14	30	13	10	10	8	7
180	250	38	38	23	–	25	25	15	–	15	11	11	8	8
250	315	44	44	26	–	31	31	19	–	18	14	13	10	8
315	400	50	50	30	–	35	35	21	–	20	15	15	11	10
400	500	56	56	34	–	41	41	25	–	23	17	–	–	–
500	630	63	63	38	–	48	48	29	–	28	21	–	–	–
630	800	94	94	55	–	56	56	34	–	35	26	–	–	–
800	1000	125	125	75	–	75	75	45	–	–	–	–	–	–
1000	1250	–	–	–	–	–	–	–	–	–	–	–	–	–
1250	1600	–	–	–	–	–	–	–	–	–	–	–	–	–
1600	2000	–	–	–	–	–	–	–	–	–	–	–	–	–
2000	2500	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies before mounting and after removal of internal or external snap ring.
(3) Applies to radial ball bearings such as deep groove ball bearings, angular contact ball bearings.
(4) Outer ring width variation of class 0 and 6 are listed in Table 5.1.1.
(5) Applies to radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.2 Tolerance Values of Outer Ring (3/4)

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter Mean outside diameter variation (2) V_{Dmp}					Radial runout of assembled bearing outer ring K_{ea}					Variation of bearing outside suface generarix inclination with outer ring reference face S_D		
		Class 0	Class 6	Class 5	Class 4	Class 2	Class 0	Class 6	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
2.5 (1)	6	6	5	3	2	1.5	15	8	5	3	1.5	8	4	1.5
6	18	6	5	3	2	1.5	15	8	5	3	1.5	8	4	1.5
18	30	7	6	3	2.5	2	15	9	6	4	2.5	8	4	1.5
30	50	8	7	4	3	2	20	10	7	5	2.5	8	4	1.5
50	80	10	8	5	3.5	2	25	13	8	5	4	8	4	1.5
80	120	11	10	5	4	2.5	35	18	10	6	5	9	5	2.5
120	150	14	11	6	5	2.5	40	20	11	7	5	10	5	2.5
150	180	19	14	7	5	3.5	45	23	13	8	5	10	5	2.5
180	250	23	15	8	6	4	50	25	15	10	7	11	7	4
250	315	26	19	9	7	4	60	30	18	11	7	13	8	5
315	400	30	21	10	8	5	70	35	20	13	8	13	10	7
400	500	34	25	12	–	–	80	40	23	–	–	15	–	–
500	630	38	29	14	–	–	100	50	25	–	–	18	–	–
630	800	55	34	18	–	–	120	60	30	–	–	20	–	–
800	1000	75	45	–	–	–	140	75	–	–	–	–	–	–
1000	1250	–	–	–	–	–	160	–	–	–	–	–	–	–
1250	1600	–	–	–	–	–	190	–	–	–	–	–	–	–
1600	2000	–	–	–	–	–	220	–	–	–	–	–	–	–
2000	2500	–	–	–	–	–	250	–	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies before mounting and after removal of internal or external snap ring.
(3) Applies to radial ball bearings such as deep groove ball bearings, angular contact ball bearings.
(4) Outer ring width variation of class 0 and 6 are listed in Table 5.1.1.
(5) Applies to radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.2 Tolerance Values of Outer Ring (4/4)

Bearing outside diameter Nominal D (mm)		Assembled bearing outer ring face runout with raceway S_{ea} (3)			Outer ring width variation V_{Cs} (4)		
		Class 5	Class 4	Class 2	Class 5	Class 4	Class 2
Over	Incl.	Max	Max	Max	Max	Max	Max
2.5 (1)	6	8	5	1.5	5	2.5	1.5
6	18	8	5	1.5	5	2.5	1.5
18	30	8	5	2.5	5	2.5	1.5
30	50	8	5	2.5	5	2.5	1.5
50	80	10	5	4	6	3	1.5
80	120	11	6	5	8	4	2.5
120	150	13	7	5	8	5	2.5
150	180	14	8	5	8	5	2.5
180	250	15	10	7	10	7	4
250	315	18	10	7	11	7	5
315	400	20	13	8	13	8	7
400	500	23	–	–	15	–	–
500	630	25	–	–	18	–	–
630	800	30	–	–	20	–	–
800	1000	–	–	–	–	–	–
1000	1250	–	–	–	–	–	–
1250	1600	–	–	–	–	–	–
1600	2000	–	–	–	–	–	–
2000	2500	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies before mounting and after removal of internal or external snap ring.
(3) Applies to radial ball bearings such as deep groove ball bearings, angular contact ball bearings.
(4) Outer ring width variation of class 0 and 6 are listed in Table 5.1.1.
(5) Applies to radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

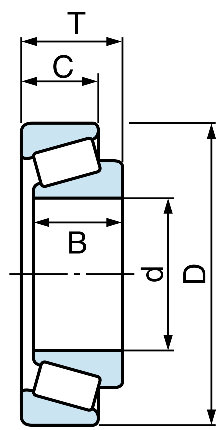
Table 5.2.1 Tolerance Values of Inner Ring (1/2)

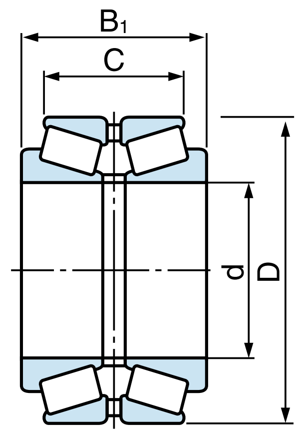
Unit: μm

Bearing bore diameter Nominal d (mm)		Bearing bore diameter											
		Single plane mean bore diameter deviation Δd_{mp}						Deviation of a single bore diameter Δd_s		Bore diameter variation in a single radial plane V_{dp}			
		Class 0 Class 6X		Class 6 Class 5		Class 4		Class 4		Class 0 Class 6X	Class 6	Class 5	Class 4
Over	Incl.	High	Low	High	Low	High	Low	High	Low	Max	Max	Max	Max
10	18	0	−12	0	−7	0	−5	0	−5	12	7	5	4
18	30	0	−12	0	−8	0	−6	0	−6	12	8	6	5
30	50	0	−12	0	−10	0	−8	0	−8	12	10	8	6
50	80	0	−15	0	−12	0	−9	0	−9	15	12	9	7
80	120	0	−20	0	−15	0	−10	0	−10	20	15	11	8
120	180	0	−25	0	−18	0	−13	0	−13	25	18	14	10
180	250	0	−30	0	−22	0	−15	0	−15	30	22	17	11
250	315	0	−35	−	−	−	−	−	−	35	−	−	−
315	400	0	−40	−	−	−	−	−	−	40	−	−	−
400	500	0	−45	−	−	−	−	−	−	−	−	−	−
500	630	0	−50	−	−	−	−	−	−	−	−	−	−
630	800	0	−75	−	−	−	−	−	−	−	−	−	−

Remarks:

1. The high deviation of bearing bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.
2. Some of these tolerances conform with the NACHI Standard.





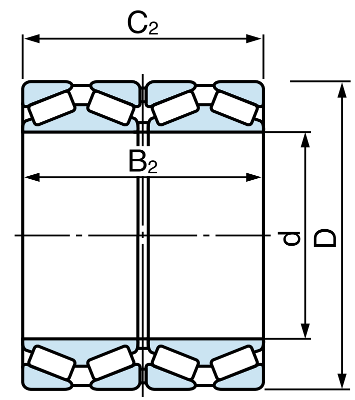


Table 5.2.1 Tolerance Values of Inner Ring (2/2)

Unit: μm

Bearing bore diameter Nominal d (mm)		Bearing bore diameter: Mean bore diameter variation V_{dmp}				Radial runout of assembled bearing inner ring K_{ia}				Inner ring reference face runout with bore S_d		Assembled bearing inner ring face runout with raceway S_{ia}
		Class 0 Class 6X	Class 6	Class 5	Class 4	Class 0 Class 6X	Class 6	Class 5	Class 4	Class 5	Class 4	Class 4
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
10	18	9	5	5	4	15	7	5	3	7	3	3
18	30	9	6	5	4	18	8	5	3	8	4	4
30	50	9	8	5	5	20	10	6	4	8	4	4
50	80	11	9	6	5	25	10	7	4	8	5	4
80	120	15	11	8	5	30	13	8	5	9	5	5
120	180	19	14	9	7	35	18	11	6	10	6	7
180	250	23	16	11	8	50	20	13	8	11	7	8
250	315	26	–	–	–	60	–	–	–	–	–	–
315	400	30	–	–	–	70	–	–	–	–	–	–
400	500	–	–	–	–	70	–	–	–	–	–	–
500	630	–	–	–	–	85	–	–	–	–	–	–
630	800	–	–	–	–	100	–	–	–	–	–	–

Remarks:
1. The high deviation of bearing bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.
2. Some of these tolerances conform with the NACHI Standard.

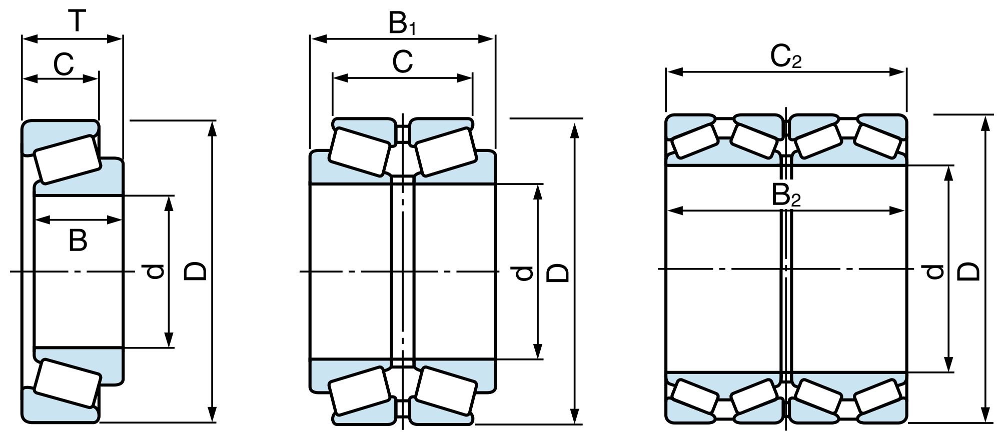


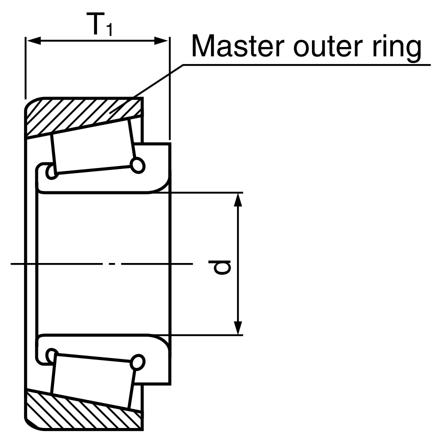
Table 5.2.2 Tolerance Values of Outer Ring (1/2)

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter											
		Single plane mean outside diameter deviation ΔD_{mp}						Deviation of a single outside diameter ΔD_s		Outside diameter variation in a single radial plane V_{Dp}			
		Class 0 Class 6X		Class 6 Class 5		Class 4		Class 4		Class 0 Class 6X	Class 6	Class 5	Class 4
Over	Incl.	High	Low	High	Low	High	Low	High	Low	Max	Max	Max	Max
18	30	0	− 12	0	− 8	0	− 6	0	− 6	12	8	6	5
30	50	0	− 14	0	− 9	0	− 7	0	− 7	14	9	7	5
50	80	0	− 16	0	−11	0	− 9	0	− 9	16	11	8	7
80	120	0	− 18	0	−13	0	−10	0	−10	18	13	10	8
120	150	0	− 20	0	−15	0	−11	0	−11	20	15	11	8
150	180	0	− 25	0	−18	0	−13	0	−13	25	18	14	10
180	250	0	− 30	0	−20	0	−15	0	−15	30	20	15	11
250	315	0	− 35	0	−25	0	−18	0	−18	35	25	19	14
315	400	0	− 40	0	−28	0	−20	0	−20	40	28	22	15
400	500	0	− 45	−	−	−	−	−	−	45	−	−	−
500	630	0	− 50	−	−	−	−	−	−	50	−	−	−
630	800	0	− 75	−	−	−	−	−	−	−	−	−	−
800	1000	0	−100	−	−	−	−	−	−	−	−	−	−

Remarks: 1. The low deviation of bearing outside diameter specified in this table does not apply within a distance of $1.2 \times r$ (max) from the ring face.

2. Some of these tolerances conform with the NACHI Standard.



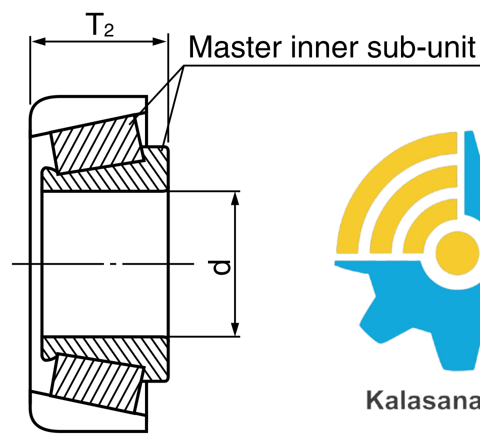
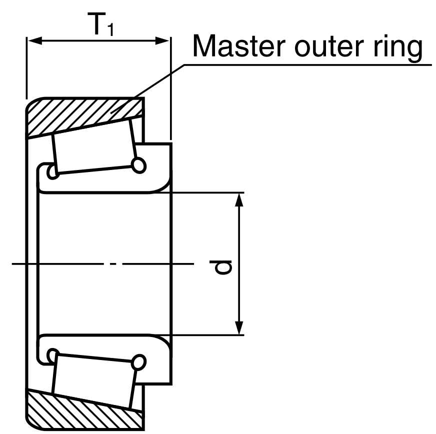


Table 5.2.2 Tolerance Values of Outer Ring (2/2)

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter — Mean outside diameter variation V_{Dmp}				Radial runout of assembled bearing outer ring K_{ea}				Variation of bearing outside surface generatrix inclination with outer ring reference face S_D		Assembled bearing outer ring face runout with raceway S_{ea}
		Class 0 Class 6X	Class 6	Class 5	Class 4	Class 0 Class 6X	Class 6	Class 5	Class 4	Class 5	Class 4	Class 4
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
18	30	9	6	5	4	18	9	6	4	8	4	5
30	50	11	7	5	5	20	10	7	5	8	4	5
50	80	12	8	6	5	25	13	8	5	8	4	5
80	120	14	10	7	5	35	18	10	6	9	5	6
120	150	15	11	8	6	40	20	11	7	10	5	7
150	180	19	14	9	7	45	23	13	8	10	5	8
180	250	23	15	10	8	50	25	15	10	11	7	10
250	315	26	19	13	9	60	30	18	11	13	8	10
315	400	30	21	14	10	70	35	20	13	13	10	13
400	500	34	–	–	–	80	–	–	–	–	–	–
500	630	38	–	–	–	100	–	–	–	–	–	–
630	800	–	–	–	–	120	–	–	–	–	–	–
800	1000	–	–	–	–	120	–	–	–	–	–	–

Remarks: 1. The low deviation of bearing outside diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.
2. Some of these tolerances conform with the NACHI Standard.



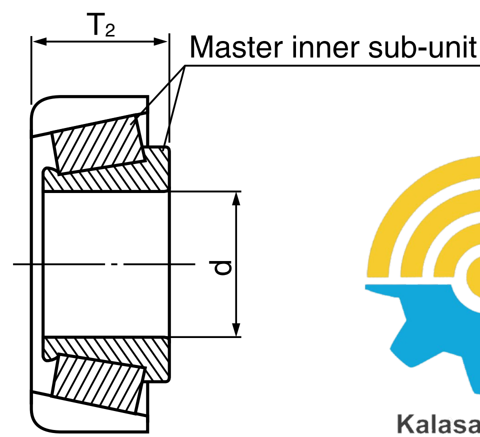


Table 5.2.3 Deviations of Single Ring Width, Bearing Width and Duplex/Stack Mounted Bearing Width

Unit: μm

Bearing bore diameter Nominal d (mm)		Deviation of a single inner ring width Δ_{Bs}						Deviation of a single outer ring width Δ_{Cs}					
		Class 0 Class 6		Class 6X		Class 5 Class 4		Class 0 Class 6		Class 6X		Class 5 Class 4	
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
10	18	0	–120	0	–50	0	–200	0	–120	0	–100	0	–200
18	30	0	–120	0	–50	0	–200	0	–120	0	–100	0	–200
30	50	0	–120	0	–50	0	–240	0	–120	0	–100	0	–240
50	80	0	–150	0	–50	0	–300	0	–150	0	–100	0	–300
80	120	0	–200	0	–50	0	–400	0	–200	0	–100	0	–400
120	180	0	–250	0	–50	0	–500	0	–250	0	–100	0	–500
180	250	0	–300	0	–50	0	–600	0	–300	0	–100	0	–600
250	315	0	–350	0	–50	–	–	0	–350	0	–100	–	–
315	400	0	–400	0	–50	–	–	0	–400	0	–100	–	–
400	500	0	–450	–	–	–	–	0	–450	–	–	–	–
500	630	0	–500	–	–	–	–	0	–500	–	–	–	–
630	800	0	–750	–	–	–	–	0	–750	–	–	–	–

Remarks: Effective width of an inner sub-unit T_1 is the bearing width obtained when this sub-unit is mated with a master outer ring.
Effective width of an outer ring T_2 is the bearing width obtained when this ring is mated with a master inner sub-unit.

Table 5.2.3 Deviations of Single Ring Width, Bearing Width and Duplex/Stack Mounted Bearing Width

Unit: μm

Bearing bore diameter Nominal d (mm)		Deviation of a actual bearing width ΔT_s						Deviation of the actual effective width of inner sub-unit ΔT_{1s}			
		Class 0 Class 6		Class 6X		Class 5 Class 4		Class 0		Class 6X	
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low
10	18	+200	0	+100	0	+200	−200	+100	0	+ 50	0
18	30	+200	0	+100	0	+200	−200	+100	0	+ 50	0
30	50	+200	0	+100	0	+200	−200	+100	0	+ 50	0
50	80	+200	0	+100	0	+200	−200	+100	0	+ 50	0
80	120	+200	−200	+100	0	+200	−200	+100	−100	+ 50	0
120	180	+350	−250	+150	0	+350	−250	+150	−150	+ 50	0
180	250	+350	−250	+150	0	+350	−250	+150	−150	+ 50	0
250	315	+350	−250	+200	0	−	−	+150	−150	+100	0
315	400	+400	−400	+200	0	−	−	+200	−200	+100	0
400	500	+400	−400	−	−	−	−	−	−	−	−
500	630	+500	−500	−	−	−	−	−	−	−	−
630	800	+600	−600	−	−	−	−	−	−	−	−

Remarks: Effective width of an inner sub-unit T_1 is the bearing width obtained when this sub-unit is mated with a master outer ring.
Effective width of an outer ring T_2 is the bearing width obtained when this ring is mated with a master inner sub-unit.

Table 5.2.3 Deviations of Single Ring Width, Bearing Width and Duplex/Stack Mounted Bearing Width

Unit: μm

Bearing bore diameter Nominal d (mm)		Deviation of the actual effective width of outer sub-unit ΔT_{2s}				Deviation of duplex/stack mounted bearing width			
						ΔB_{1s}		$\Delta B_{2s} \bullet \Delta C_{2s}$	
		Class 0		Class 6X		Duplex mounted bearing class 0		Four row bearing class 0	
Over	Incl.	High	Low	High	Low	High	Low	High	Low
10	18	+100	0	+ 50	0	+ 200	− 200	−	−
18	30	+100	0	+ 50	0	+ 200	− 200	−	−
30	50	+100	0	+ 50	0	+ 240	− 240	−	−
50	80	+100	0	+ 50	0	+ 300	− 300	+ 400	− 400
80	120	+100	−100	+ 50	0	+ 400	− 400	+ 500	− 500
120	180	+200	−100	+100	0	+ 500	− 500	+ 600	− 600
180	250	+200	−100	+100	0	+ 600	− 600	+ 750	− 750
250	315	+200	−100	+100	0	+ 700	− 700	+ 900	− 900
315	400	+200	−200	+100	0	+ 800	− 800	+1000	−1000
400	500	−	−	−	−	+ 900	− 900	+1200	−1200
500	630	−	−	−	−	+1000	−1000	+1200	−1200
630	800	−	−	−	−	+1500	−1500	+1500	−1500

Remarks: Effective width of an inner sub-unit T_1 is the bearing width obtained when this sub-unit is mated with a master outer ring.
Effective width of an outer ring T_2 is the bearing width obtained when this ring is mated with a master inner sub-unit.

Table 5.3.1 Tolerance Values of Shaft Washer Bore Diameter

Unit: μm

Bearing bore diameter Nominal d or d_2 (mm)		Single plane mean bore diameter deviation Δd_{mp} or Δd_{2mp}				Bore diameter variation, in a single radial plane V_{dp} or V_{d2p}		Washer thickness (raceway to back face or raceway) variation (1) S_i (or S_e)			
		Class 0 Class 6 Class 5		Class 4		Class 0 Class 6 Class 5	Class 4	Class 0	Class 6	Class 5	Class 4
Over	Incl.	High	Low	High	Low	Max	Max	Max	Max	Max	Max
–	18	0	− 8	0	− 7	6	5	10	5	3	2
18	30	0	− 10	0	− 8	8	6	10	5	3	2
30	50	0	− 12	0	−10	9	8	10	6	3	2
50	80	0	− 15	0	−12	11	9	10	7	4	3
80	120	0	− 20	0	−15	15	11	15	8	4	3
120	180	0	− 25	0	−18	19	14	15	9	5	4
180	250	0	− 30	0	−22	23	17	20	10	5	4
250	315	0	− 35	0	−25	26	19	25	13	7	5
315	400	0	− 40	0	−30	30	23	30	15	7	5
400	500	0	− 45	0	−35	34	26	30	18	9	6
500	630	0	− 50	0	−40	38	30	35	21	11	7
630	800	0	− 75	0	−50	–	–	40	25	13	8
800	1000	0	−100	–	–	–	–	45	30	15	–
1000	1250	0	−125	–	–	–	–	50	35	18	–

Table 5.3.2 Tolerance Values of Housing Washer Outside Diameter

Unit: μm

Bearing outside diameter Nominal D (mm)		Mean outside diameter deviation, in a single plane ΔD_{mp}				Outside diameter variation in a single radial plane V_{Dp}	
		Class 0 Class 6 Class 5		Class 4		Class 0 Class 6 Class 5	Class 4
Over	Incl.	High	Low	High	Low	Max	Max
10	18	0	− 11	0	− 7	8	5
18	30	0	− 13	0	− 8	10	6
30	50	0	− 16	0	− 9	12	7
50	80	0	− 19	0	−11	14	8
80	120	0	− 22	0	−13	17	10
120	180	0	− 25	0	−15	19	11
180	250	0	− 30	0	−20	23	15
250	315	0	− 35	0	−25	26	19
315	400	0	− 40	0	−28	30	21
400	500	0	− 45	0	−33	34	25
500	630	0	− 50	0	−38	38	29
630	800	0	− 75	0	−45	55	34
800	1000	0	−100	–	–	75	–
1000	1250	0	−125	–	–	–	–
1250	1600	0	−160	–	–	–	–

Note: (1) For double acting bearings, use size classification d, not d_2.
Raceway to back face thickness variation of housing washer Se applies to the bearing with seat.

Table 5.3.3 Height Tolerances of Thrust Ball Bearings (with Flat Seat) and Center Washers (Class 0) Unit: μm

Bearing bore diameter Nominal d (mm)		Deviation of single height, T ΔT_s		Deviation of single height, T_2 of double direction rhrust bearing (1) ΔT_{2s}		Deviation of single height, T_1 of double direction rhrust bearing (1) ΔT_{1s}		Deviation of center washer height (1) ΔB_s	
Over	Incl.	High	Low	High	Low	High	Low	High	Low
–	30	0	– 75	0	– 75	+ 50	–150	0	– 50
30	50	0	–100	0	–100	+ 75	–200	0	– 75
50	80	0	–125	0	–125	+100	–250	0	–100
80	120	0	–150	0	–150	+125	–300	0	–125
120	180	0	–175	0	–175	+150	–350	0	–150
180	250	0	–200	0	–200	+175	–400	0	–175
250	315	0	–225	0	–225	+200	–450	0	–200
315	400	0	–300	0	–300	+250	–600	0	–250

Note: (1) For double acting bearings,use size classification d, not d_2.
(2) Height deviations ΔT_s , ΔT_{1s} , ΔT_{2s} apply to the bearings with flat seat.

Table 5.4.1 Tolerance Values of Inner Rings Unit: μm

Bearing bore diameter Nominal d (mm)		Single plane mean bore diameter deviation Δd_{mp}		Bore diameter variation, in a single radial plane V_{dp}	References: Inner ring reference face runout with bore S_d	References: Deviation of single height, ΔT_s	
Over	Incl.	High	Low	Max	Max	High	Low
50	80	0	–15	11	25	+150	–150
80	120	0	–20	15	25	+200	–200
120	180	0	–25	19	30	+250	–250
180	250	0	–30	23	30	+300	–300
250	315	0	–35	26	35	+350	–350
315	400	0	–40	30	40	+400	–400
400	500	0	–45	34	45	+450	–450

Table 5.4.2 Tolerance Values of Outer Rings Unit: μm

Bearing bore diameter Nominal D (mm)		Outside diameter deviation ΔD_{mp}	
Over	Incl.	High	Low
120	180	0	– 25
180	250	0	– 30
250	315	0	– 35
315	400	0	– 40
400	500	0	– 45
500	630	0	– 50
630	800	0	– 75
800	1000	0	–100

Remarks: The high deviation of bearing bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.
The low deviation of bearing outside diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.5.1 Tolerance of Inner Ring (Cone) Bore

Unit: μm

Bearing bore diameter Nominal d mm (inch)		Deviation of single bore diameter Δd_s							
		Class 4		Class 3		Class 0		Class 00	
Over	Incl.	High	Low	High	Low	High	Low	High	Low
–	76.200 (3)	+ 13	0	+13	0	+13	0	+8	0
76.200 (3)	304.800 (12)	+ 25	0	+13	0	+13	0	+8	0
304.800 (12)	609.600 (24)	+ 51	0	+25	0	–	–	–	–
609.600 (24)	914.400 (36)	+ 76	0	+38	0	–	–	–	–
914.400 (36)	1219.200 (48)	+102	0	+51	0	–	–	–	–
1219.200 (48)	–	+127	0	+76	0	–	–	–	–

Table 5.5.2 Tolerance of Outer Ring (Cup) Outside Diameter

Unit: μm

Bearing outside diameter Nominal D mm (inch)		Deviation of single outside diameter ΔD_s							
		Class 4		Class 3		Class 0		Class 00	
Over	Incl.	High	Low	High	Low	High	Low	High	Low
–	304.800 (12)	+ 25	0	+13	0	+13	0	+8	0
304.800 (12)	609.600 (24)	+ 51	0	+25	0	–	–	–	–
609.600 (24)	914.400 (36)	+ 76	0	+38	0	–	–	–	–
914.400 (36)	1219.200 (48)	+102	0	+51	0	–	–	–	–
1219.200 (48)	–	+127	0	+76	0	–	–	–	–

Table 5.5.3 Tolerance of Bearing Width and Duplex/Stack Mounted Bearing Width

Unit: μm

Bearing bore diameter Nominal d mm (inch)		Bearing outside diameter Nominal D mm (inch)		Deviation of the actual bearing width Δ_{Ts}					
				Class 4		Class 3		Class 0 Class 00	
Over	Incl.	Over	Incl.	High	Low	High	Low	High	Low
–	101.600 (4)	–	–	+203	0	+203	–203	+203	–203
101.600 (4)	304.800 (12)	–	–	+356	–254	+203	–203	+203	–203
304.800 (12)	609.600 (24)	–	508.000 (20)	+381	–381	+203	–203	–	–
304.800 (12)	609.600 (24)	508.000 (20)	–	+381	–381	+381	–381	–	–
609.600 (24)	–	–	–	+381	–381	+381	–381	–	–

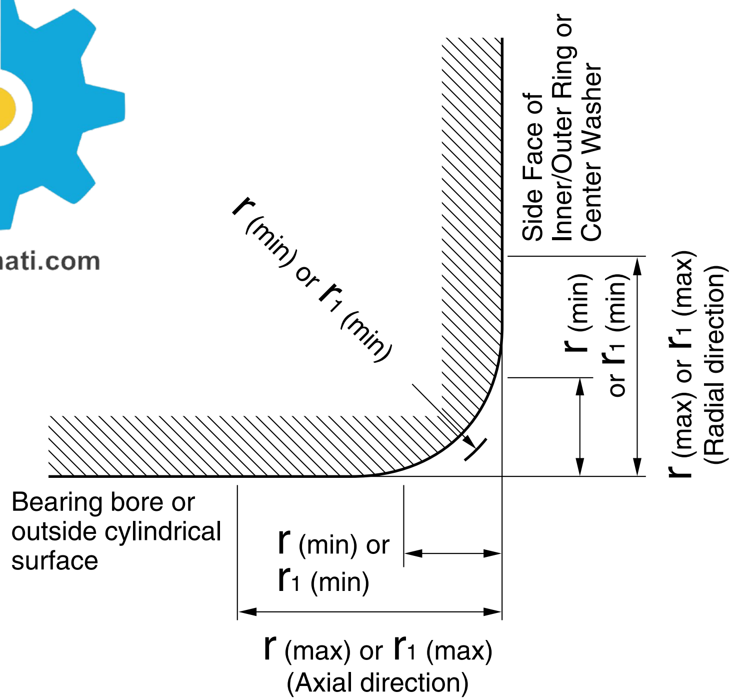
Note: (1) Deviation of the actual bearing width B_2, and C_2 for row tapered roller bearing is ±1524 μm fof the tolerance classes of 4, 3 and 0.

Table 5.5.4 Radial Runout of Assembled Bearing Inner Ring and Outer Ring

Unit: μm

Bearing outside diameter Nominal D mm (inch)		Radial runout of assembled bearing inner ring Kia and of assembled bearing outer ring Kea (Max)			
Over	Incl.	Class 4	Class 3	Class 0	Class 00
–	304.800 (14)	51	8	4	2
304.800 (12)	609.600 (24)	51	18	–	–
609.600 (24)	914.400 (36)	76	51	–	–
914.400 (36)	–	76	76	–	–

5.6 Chamfer Dimension Limits



r : Chamfer dimensions of inner ring and outer ring.
r_1 : Chamfer dimensions of inner ring and outer ring (front face) or of inner ring of double direction thrust bearing.

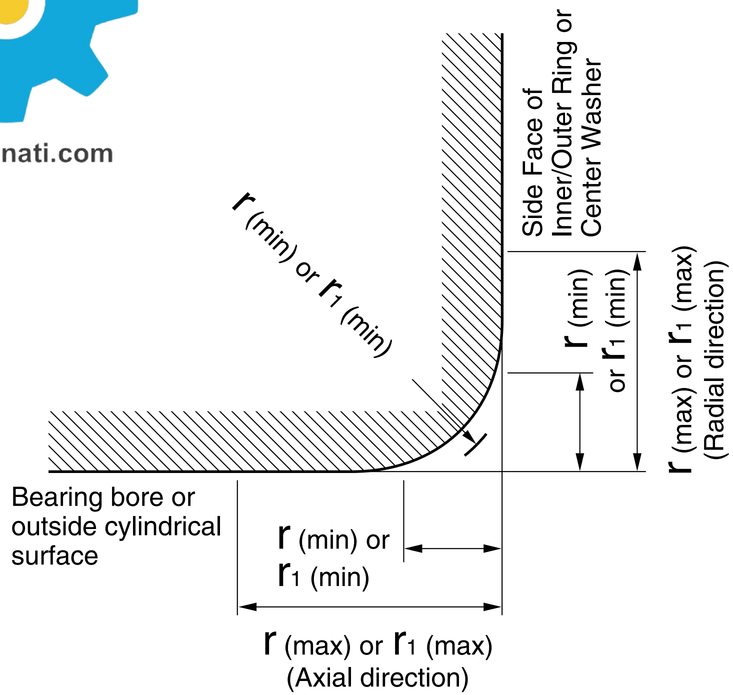
Remarks: The exact shape of the chamfer surface is not specified, but its contour in an axial plane shall not be allowed to project beyond the imaginary circular arc, of radius r min, tangential to the ring face and the bore or outside cylindrical surface of the ring (see figure).

Table 5.6.1 Chamfer Dimension Limits of Radial Bearings Except Tapered Roller Bearings (1/2)

Unit: mm

Smallest permissible chamfer dimensions of inner and outer rings	Bearing bore diameter Nominal d		Largest permissible chamfer dimensions of inner and outer rings r (max) or r_1 (max)		Reference: Shaft and housing fillet radius r_a
r (min) or r_1 (min)	Over	Incl.	Radial direction	Axial direction	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	

Remarks: For bearings with a width of 2mm or less the r max values for the radial direction apply also in the axial direction.



r : Chamfer dimensions of inner ring and outer ring.
r_1 : Chamfer dimensions of inner ring and outer ring (front face) or of inner ring of double direction thrust bearing.

Remarks: The exact shape of the chamfer surface is not specified, but its contour in an axial plane shall not be allowed to project beyond the imaginary circular arc, of radius r min, tangential to the ring face and the bore or outside cylindrical surface of the ring (see figure).

Table 5.6.1 Chamfer Dimension Limits of Radial Bearings Except Tapered Roller Bearings

2/2)

Unit: mm

Smallest permissible chamfer dimensions of inner and outer rings	Bearing bore diameter Nominal d		Largest permissible chamfer dimensions of inner and outer rings r (max) or r_1 (max)		Reference: Shaft and housing fillet radius r_a
r (min) or r_1 (min)	Over	Incl.	Radial direction	Axial direction	Max
2	– 80 220	80 220 –	3 3.5 3.8	4.5 5 6	2
2.1	– 280	280 –	4 4.5	6.5 7	2
2.5	– 100 280	100 280 –	3.8 4.5 5	6 6 7	2
3	– 280	280 –	5 5.5	8 8	2.5
4 5	– –	– –	6.5 8	9 10	3 4
6 7.5 9.5	– – –	– – –	10 12.5 15	13 17 19	5 6 8
12 15 19	– – –	– – –	18 21 25	24 30 38	10 12 15

Remarks: For bearings with a width of 2mm or less the r max values for the radial direction apply also in the axial direction.

Table 5.6.2 Chamfer Dimension Limits of Tapered Roller Bearings

Unit: mm

Smallest permissible chamfer dimensions of inner and outer rings r (min)	Bearing bore diameter or outside diameter (1) d or D		Largest permissible chamfer dimensions of inner and outer rings r (max)		Reference: Shaft and housing fillet radius r_a
	Over	Incl.	Radial direction	Axial direction	Max
0.3	– 40	40 –	0.7 0.9	1.4 1.6	0.3
0.6	– 40	40 –	1.1 1.3	1.7 2	0.6
1	– 50	50 –	1.6 1.9	2.5 3	1
1.5	– 120 250	120 250 –	2.3 2.8 3.5	3 3.5 4	1.5
2	– 120 250	120 250 –	2.8 3.5 4	4 4.5 5	2
2.5	– 120 250	120 250 –	3.5 4 4.5	5 5.5 6	2
3	– 120 250 400	120 250 400 –	4 4.5 5 5.5	5.5 6.5 7 7.5	2.5
4	– 120 250 400	120 250 400 –	5 5.5 6 6.5	7 7.5 8 8.5	3
5	– 180	180 –	6.5 7.5	8 9	4
6	– 180	180 –	7.5 9	10 11	5

Table 5.6.3 Chamfer Dimension Limits of Thrust Bearings

Unit: mm

Smallest permissible chamfer dimensions of inner and outer rings r (min) or r_1 (min)	Largest permissible single chamfer dimensions of inner and outer rings r (max) or r_1 (max)	Reference: Shaft and housing fillet radius r_a
	Radial direction and axial direction	Max
0.05 0.08 0.1	0.1 0.16 0.2	0.05 0.08 0.1
0.15 0.2 0.3	0.3 0.5 0.8	0.15 0.2 0.3
0.6 1 1.1	1.5 2.2 2.7	0.6 1 1
1.5 2 2.1	3.5 4 4.5	1.5 2 2
3 4 5	5.5 6.5 8	2.5 3 4
6 7.5 9.5	10 12.5 15	5 6 8
12 15 19	18 21 25	10 12 15

Note: (1) d and D are applied to inner ring and outer ring respectively.

5.7 Tolerances for Tapered Bores

d : Bearing bore diameter, nominal

d_1 : Basic diameter at the theoretical large end of a tapered bore

in case of 1/12 taper $d_1 = d + \frac{1}{12}B$

in case of 1/30 taper $d_1 = d + \frac{1}{30}B$

Δd_{mp} : Mean bore diameter deviation at theoretical small end of a tapered bore

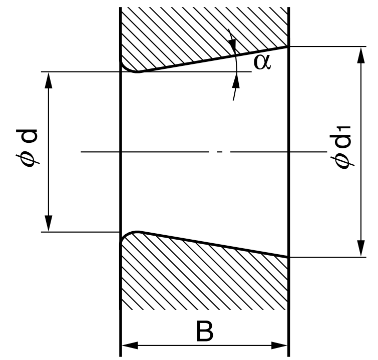
Δd_{1mp} : Mean bore diameter deviation at theoretical large end of a tapered bore

B : Bearing inner ring width, nominal

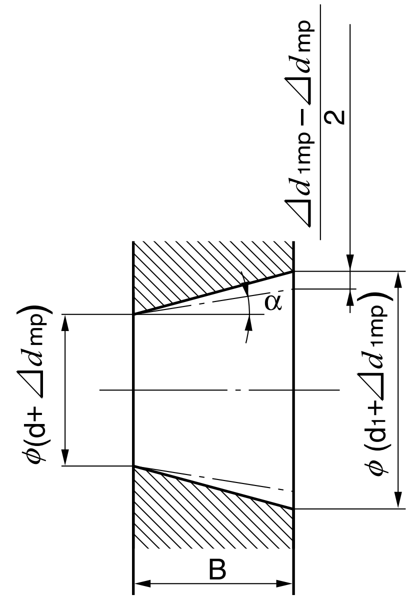
α : Nominal taper angle (half of cone angle)

in case of 1/12 taper α = 2° 23' 9.4"
= 2.38594°
= 0.041643 rad

in case of 1/30 taper α = 0°57' 17.4"
= 0.95484°



Theoretical tapered bore



Tapered bore with actual mean diameters at their deviations

Table 5.7.1 1/12 Tapered Bore (Class 0)
Table 5.7.2 1/30 Tapered Bore (Class 0)

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Table 5.7.1 1/12 Tapered Bore (Class 0)

Unit: μm

Nominal bearing bore dimension d (mm)		Mean bore diameter deviation at theoretical small end of a tapered bore				Bore diameter variation in a single radial plane (1)(2)
		Δ_{dmp}		$\Delta_{d1mp} - \Delta_{dmp}$		V_{dp}
Over	Incl.	High	Low	High	Low	Max
	10	+ 22	0	+ 15	0	9
10	18	+ 27	0	+ 18	0	11
18	30	+ 33	0	+ 21	0	13
30	50	+ 39	0	+ 25	0	16
50	80	+ 46	0	+ 30	0	19
80	120	+ 54	0	+ 35	0	22
120	180	+ 63	0	+ 40	0	40
180	250	+ 72	0	+ 46	0	46
250	315	+ 81	0	+ 52	0	52
315	400	+ 89	0	+ 57	0	57
400	500	+ 97	0	+ 63	0	63
500	630	+110	0	+ 70	0	70
630	800	+125	0	+ 80	0	–
800	1000	+140	0	+ 90	0	–
1000	1250	+165	0	+105	0	–
1250	1600	+195	0	+125	0	–

Note: (1) Applicable to all radial planes of tapered bore.
(2) Not applicable to bearings of diameter series 7 and 8.

Table 5.7.2 1/30 Tapered Bore (Class 0)

Unit: μm

Nominal bearing bore dimension d (mm)		Mean bore diameter deviation at theoretical small end of a tapered bore				Bore diameter variation in a single radial plane (1)(2)
		Δ_{dmp}		$\Delta_{d1mp} - \Delta_{dmp}$		V_{dp}
Over	Incl.	High	Low	High	Low	Max
50	80	+15	0	+30	0	19
80	120	+20	0	+35	0	22
120	180	+25	0	+40	0	40
180	250	+30	0	+46	0	46
250	315	+35	0	+52	0	52
315	400	+40	0	+57	0	57
400	500	+45	0	+63	0	63
500	630	+50	0	+70	0	70

Note: (1) Applicable to all radial planes of tapered bore.
(2) Not applicable to bearings of diameter series 7 and 8.

6. Internal Clearance of Rolling Contact Bearings

Bearing internal clearance refers to the distances between the bearing rings and rolling elements as shown in Fig. 6.1 and Fig. 6.2. The amount of alternating radial movement of the free bearing rings is defined as radial clearance, and the amount of alternating axial movement of the free bearing rings is defined as axial clearance.
The term internal clearance refers to a state where no force is applied to the bearing rings and rolling elements, i.e., an unloaded state.
Since a stabilizing, measuring load is applied to bearings when measuring the internal clearance, some elastic deformation occurs to the bearing rings and rolling elements, and the measured internal clearance will be larger than the real clearance by the value of deformation. The amount of elastic deformation caused by the measuring load may be disregarded for roller bearings, but must be compensated for when measuring ball bearing clearance because it will skew the internal clearance measurement.
Internal clearance values are described in the JIS (ISO) and the Japan Bearing Industrial Association Standards (BAS) as follows:

Bearing types	Standard
Deep-groove ball bearings Self-aligning ball bearings Cylindrical roller bearings Spherical roller bearings	JIS B1520 (ISO 5753)

For electric motor

Bearing types	Standard
Deep-groove ball bearings Cylindrical roller bearings	BAS 1003

Bearings not covered by either JIS (ISO) or BAS are standardized by NACHI. Tables 6.1 through 6.7 show internal clearance values for NACHI bearings.

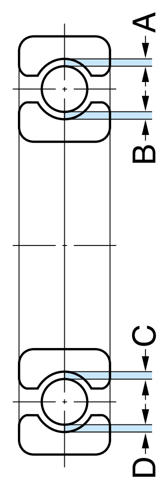

Fig. 6.1
Radial Clearance
= A+B+C+D

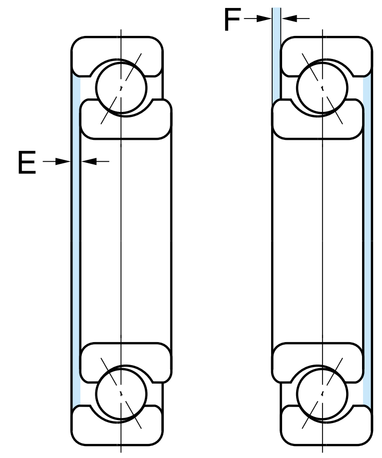

Fig. 6.2
Axial Clearance
= E+F

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Table 6.1 Radial Internal Clearance of Deep-groove Ball Bearings (with Cylindrical Bore) (JIS) (1/2) Unit: μm

Bearing bore dia. Nominal d (mm)		Radial clearance									
		C2		CN (Normal)		C3		C4		C5	
Over	Incl.	min	max	min	max	min	max	min	max	min	max
2.5	6	0	7	2	13	8	23	–	–	–	–
6	10	0	7	2	13	8	23	14	29	20	37
10	18	0	9	3	18	11	25	18	33	25	45
18	24	0	10	5	20	13	28	20	36	28	48
24	30	1	11	5	20	13	28	23	41	30	53
30	40	1	11	6	20	15	33	28	46	40	64
40	50	1	11	6	23	18	36	30	51	45	73
50	65	1	15	8	28	23	43	38	61	55	90
65	80	1	15	10	30	25	51	46	71	65	105
80	100	1	18	12	36	30	58	53	84	75	120
100	120	2	20	15	41	36	66	61	97	90	140
120	140	2	23	18	48	41	81	71	114	105	160
140	160	2	23	18	53	46	91	81	130	120	180
160	180	2	25	20	61	53	102	91	147	135	200
180	200	2	30	25	71	63	117	107	163	150	230

Table 6.1 Radial Internal Clearance of Deep-groove Ball Bearings (with Cylindrical Bore) (JIS) (2/2)

Unit: μm

Bearing bore dia. Nominal d (mm)		Radial clearance									
		C2		CN (Normal)		C3		C4		C5	
Over	Incl.	min	max	min	max	min	max	min	max	min	max
200	225	2	35	25	85	75	140	125	195	175	265
225	250	2	40	30	95	85	160	145	225	205	300
250	280	2	45	35	105	90	170	155	245	225	340
280	315	2	55	40	115	100	190	175	270	245	370
315	355	3	60	45	125	110	210	195	300	275	410
355	400	3	70	55	145	130	240	225	340	315	460
400	450	3	80	60	170	150	270	250	380	350	510
450	500	3	90	70	190	170	300	280	420	390	570
500	560	10	100	80	210	190	330	310	470	440	630
560	630	10	110	90	230	210	360	340	520	490	690
630	710	20	130	110	260	240	400	380	570	540	760
710	800	20	140	120	290	270	450	430	630	600	840
800	900	20	160	140	320	300	500	480	700	670	940
900	1000	20	170	150	350	330	550	530	770	740	1040
1000	1120	20	180	160	380	360	600	580	850	820	1150
1120	1250	20	190	170	410	390	650	630	920	890	1260

Table 6.2 Radial Internal Clearance of Extra-small and Miniature Ball Bearings (NACHI)

Unit: μm

Bearing bore dia. Nominal d (mm)		Radial clearance											
		C1P		C2P		C3P		C4P		C5P		C6P	
Over	Incl.	min	max	min	max	min	max	min	max	min	max	min	max
–	10	0	5	3	8	5	10	8	13	13	20	20	28

Remarks: The standard internal clearance is C3P.

Table 6.3 Radial Internal Clearance of Self-aligning Ball Bearings (JIS)

Unit: μm

Bearing bore dia. Nominal d (mm)		Radial clearance, cylindrical bore										Radial clearance, tapered bore									
		C2		CN (Normal)		C3		C4		C5		C2		CN (Normal)		C3		C4		C5	
Over	Incl.	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
2.5	6	1	8	5	15	10	20	15	25	21	33	–	–	–	–	–	–	–	–	–	–
6	10	2	9	6	17	12	25	19	33	27	42	–	–	–	–	–	–	–	–	–	–
10	14	2	10	6	19	13	26	21	35	30	48	–	–	–	–	–	–	–	–	–	–
14	18	3	12	8	21	15	28	23	37	32	50	–	–	–	–	–	–	–	–	–	–
18	24	4	14	10	23	17	30	25	39	34	52	7	17	13	26	20	33	28	42	37	55
24	30	5	16	11	24	19	35	29	46	40	58	9	20	15	28	23	39	33	50	44	62
30	40	6	18	13	29	23	40	34	53	46	66	12	24	19	35	29	46	40	59	52	72
40	50	6	19	14	31	25	44	37	57	50	71	14	27	22	39	33	52	45	65	58	79
50	65	7	21	16	36	30	50	45	69	62	88	18	32	27	47	41	61	56	80	73	99
65	80	8	24	18	40	35	60	54	83	76	108	23	39	35	57	50	75	69	98	91	123
80	100	9	27	22	48	42	70	64	96	89	124	29	47	42	68	62	90	84	116	109	144
100	120	10	31	25	56	50	83	75	114	105	145	35	56	50	81	75	108	100	139	130	170
120	140	10	38	30	68	60	100	90	135	125	175	40	68	60	98	90	130	120	165	155	205
140	160	15	44	35	80	70	120	110	161	150	210	45	74	65	110	100	150	140	191	180	240

Radial Internal Clearance of Cylindrical Roller Bearings

Table 6.4.1 Radial Internal Clearance of Cylindrical Roller Bearings with Cylindrical Bore (JIS)

Unit: μm

Bearing bore diameter Nominal d (mm)		Radial clearance									
		C2		CN (Normal)		C3		C4		C5	
Over	Incl.	min	max	min	max	min	max	min	max	min	max
–	10	0	25	20	45	35	60	50	75	–	–
10	24	0	25	20	45	35	60	50	75	65	90
24	30	0	25	20	45	35	60	50	75	70	95
30	40	5	30	25	50	45	70	60	85	80	105
40	50	5	35	30	60	50	80	70	100	95	125
50	65	10	40	40	70	60	90	80	110	110	140
65	80	10	45	40	75	65	100	90	125	130	165
80	100	15	50	50	85	75	110	105	140	155	190
100	120	15	55	50	90	85	125	125	165	180	220
120	140	15	60	60	105	100	145	145	190	200	245
140	160	20	70	70	120	115	165	165	215	225	275
160	180	25	75	75	125	120	170	170	220	250	300
180	200	35	90	90	145	140	195	195	250	275	330
200	225	45	105	105	165	160	220	220	280	305	365
225	250	45	110	110	175	170	235	235	300	330	395
250	280	55	125	125	195	190	260	260	330	370	440
280	315	55	130	130	205	200	275	275	350	410	485
315	355	65	145	145	225	225	305	305	385	455	535
355	400	100	190	190	280	280	370	370	460	510	600
400	450	110	210	210	310	310	410	410	510	565	665
450	500	110	220	220	330	330	440	440	550	625	735

Table 6.4.2 Non-interchangeable Radial Internal Clearance of Cylindrical Roller Bearings with Tapered Bore (NACHI)

Unit: μm

Bearing bore diameter Nominal d (mm)		Radial clearance					
		C9na		C1na		C2na	
Over	Incl.	min	max	min	max	min	max
14	18	5	10	10	20	20	30
18	24	5	10	10	20	20	30
24	30	5	10	15	25	25	35
30	40	5	12	15	25	25	40
40	50	5	15	17	30	30	45
50	65	5	15	20	35	35	50
65	80	10	20	25	40	40	60
80	100	10	25	35	55	45	70
100	120	10	25	40	60	50	80
120	140	15	30	45	70	60	90
140	160	15	35	50	75	65	100
160	180	15	35	55	85	75	110
180	200	20	40	60	90	80	120
200	225	20	45	60	95	90	135
225	250	25	50	65	100	100	150
250	280	25	55	75	110	110	165
280	315	30	60	80	120	120	180
315	355	30	65	90	135	135	200
355	400	35	75	100	150	150	225
400	450	40	85	110	170	170	255
450	500	45	95	120	190	190	285

Remarks: JIS (ISO) has not standardized non-interchangeable radial clearance for tapered bore bearings.

Radial Internal Clearance of Spherical Roller Bearings

Table 6.5.1 Radial Internal Clearance of Spherical Roller Bearings with Cylindrical Bore (JIS)

Unit: μm

Bearing bore diameter Nominal d (mm)		Radial clearance									
		C2		CN (Normal)		C3		C4		C5	
Over	Incl.	min	max	min	max	min	max	min	max	min	max
14	18	10	20	20	35	35	45	45	60	60	75
18	24	10	20	20	35	35	45	45	60	60	75
24	30	15	25	25	40	40	55	55	75	75	95
30	40	15	30	30	45	45	60	60	80	80	100
40	50	20	35	35	55	55	75	75	100	100	125
50	65	20	40	40	65	65	90	90	120	120	150
65	80	30	50	50	80	80	110	110	145	145	180
80	100	35	60	60	100	100	135	135	180	180	225
100	120	40	75	75	120	120	160	160	210	210	260
120	140	50	95	95	145	145	190	190	240	240	300
140	160	60	110	110	170	170	220	220	280	280	350
160	180	65	120	120	180	180	240	240	310	310	390
180	200	70	130	130	200	200	260	260	340	340	430
200	225	80	140	140	220	220	290	290	380	380	470
225	250	90	150	150	240	240	320	320	420	420	520
250	280	100	170	170	260	260	350	350	460	460	570
280	315	110	190	190	280	280	370	370	500	500	630
315	355	120	200	200	310	310	410	410	550	550	690
355	400	130	220	220	340	340	450	450	600	600	750
400	450	140	240	240	370	370	500	500	660	660	820
450	500	140	260	260	410	410	550	550	720	720	900
500	560	150	280	280	440	440	600	600	780	780	1000
560	630	170	310	310	480	480	650	650	850	850	1100
630	710	190	350	350	530	530	700	700	920	920	1190
710	800	210	390	390	580	580	770	770	1010	1010	1300
800	900	230	430	430	650	650	860	860	1120	1120	1440
900	1000	260	480	480	710	710	930	930	1220	1220	1570

Table 6.5.2 Radial Internal Clearance of Spherical Roller Bearings with Tapered Bore (JIS)

Unit: μm

Bearing bore diameter Nominal d (mm)		Radial clearance									
		C2		CN (Normal)		C3		C4		C5	
Over	Incl.	min	max	min	max	min	max	min	max	min	max
18	24	15	25	25	35	35	45	45	60	60	75
24	30	20	30	30	40	40	55	55	75	75	95
30	40	25	35	35	50	50	65	65	85	85	105
40	50	30	45	45	60	60	80	80	100	100	130
50	65	40	55	55	75	75	95	95	120	120	160
65	80	50	70	70	95	95	120	120	150	150	200
80	100	55	80	80	110	110	140	140	180	180	230
100	120	65	100	100	135	135	170	170	220	220	280
120	140	80	120	120	160	160	200	200	260	260	330
140	160	90	130	130	180	180	230	230	300	300	380
160	180	100	140	140	200	200	260	260	340	340	430
180	200	110	160	160	220	220	290	290	370	370	470
200	225	120	180	180	250	250	320	320	410	410	520
225	250	140	200	200	270	270	350	350	450	450	570
250	280	150	220	220	300	300	390	390	490	490	620
280	315	170	240	240	330	330	430	430	540	540	680
315	355	190	270	270	360	360	470	470	590	590	740
355	400	210	300	300	400	400	520	520	650	650	820
400	450	230	330	330	440	440	570	570	720	720	910
450	500	260	370	370	490	490	630	630	790	790	1000
500	560	290	410	410	540	540	680	680	870	870	1100
560	630	320	460	460	600	600	760	760	980	980	1230
630	710	350	510	510	670	670	850	850	1090	1090	1360
710	800	390	570	570	750	750	960	960	1220	1220	1500
800	900	440	640	640	840	840	1070	1070	1370	1370	1690
900	1000	490	710	710	930	930	1190	1190	1520	1520	1860

Table 6.6 Radial Internal Clearance of Double-row and Duplex Tapered Roller Bearings with Cylindrical Bore (NACHI)

Unit: μm

Bearing bore diameter Nominal d (mm)		Radial clearance											
		C1		C2		CN (Normal)		C3		C4		C5	
Over	Incl.	min	max	min	max	min	max	min	max	min	max	min	max
14	18	2	10	10	20	20	30	35	45	45	55	65	75
18	24	2	10	10	20	20	30	35	45	45	55	65	75
24	30	2	10	10	25	25	35	40	50	50	60	70	80
30	40	2	12	12	25	25	40	45	55	55	70	80	95
40	50	2	15	15	30	30	45	50	65	65	80	95	110
50	65	2	15	15	35	35	50	55	75	75	90	110	130
65	80	5	20	20	40	40	60	70	90	90	110	130	150
80	100	5	25	25	45	45	70	80	105	105	125	155	180
100	120	5	25	25	50	50	80	95	120	120	145	180	205
120	140	10	30	30	60	60	90	105	135	135	160	200	230
140	160	10	35	35	65	65	100	115	150	150	180	225	260
160	180	10	35	35	75	75	110	125	165	165	200	250	285
180	200	10	40	40	80	80	120	140	180	180	220	275	315
200	225	10	45	45	90	90	135	155	200	200	240	305	350
225	250	15	50	50	100	100	150	170	215	215	265	330	380
250	280	15	55	55	110	110	165	185	240	240	295	370	420
280	315	15	60	60	120	120	180	205	265	265	325	410	470
315	355	15	65	65	135	135	200	225	295	295	360	455	520
355	400	20	75	75	150	150	225	255	330	330	405	510	585
400	450	20	85	85	170	170	255	285	370	370	455	565	650
450	500	20	95	95	190	190	285	315	410	410	505	625	720

Radial Internal Clearance of Bearings for Electric Motor

Table 6.7.1 Radial Internal Clearance of Deep-groove Ball Bearings (BAS)

Unit: μm

Bearing bore diameter Nominal d (mm)		Radial clearance CM	
Over	Incl.	min	max
10 [1]	18	4	11
18	30	5	12
30	50	9	17
50	80	12	22
80	120	18	30
120	160	24	38

Note: (1) 10 mm is included in this group.
Remarks: The value in this table is under the condition of unloaded state.

Table 6.7.2 Radial Internal Clearance of Cylindrical Roller Bearings (BAS)

Unit: μm

Bearing bore diameter Nominal d (mm)		Radial clearance			
		Interchangeable CT		Non-interchangeable CT	
Over	Incl.	min	max	min	max
24	40	15	35	15	30
40	50	20	40	20	35
50	65	25	45	25	40
65	80	30	50	30	45
80	100	35	60	35	55
100	120	35	65	35	60
120	140	40	70	40	65
140	160	50	85	50	80
160	180	60	95	60	90
180	200	65	105	65	100

Remarks: "Interchangeability" in this table means interchangeability between NACHI bearings only not with other brand bearings.

7. Materials for Rolling Contact Bearings

A rolling contact bearing consist of one or more rings and rolling elements (which directly support the loads) and, usually, a cage which keeps the rolling elements at equal intervals. Both rolling and sliding movements occur between these parts.

7.1 Bearing Ring and Rolling Elements

Because of high, repetitive stress to the rolling contact areas, fatigue phenomenon will occur to the bearing material after a duration of operation. Loading stress ultimately dislodges a surface section and the bearing fails. To delay the advent of material fatigue, bearing ring and rolling element materials should have the following properties:

- High level of hardness
- High rolling contact fatigue resistance
- Good wear resistance
- Dimensional stability
- Good mechanical strength

Standard NACHI material for bearing rings and rolling elements is vacuum-degassed, high-carbon, chrome bearing steel. See Table 7.1.
For applications requiring a higher degree of reliability, bearing steel using a vacuum-melting process or electroslag solution (ESR).
The NACHI steel used for standard bearings is SUJ2 (JIS) steel. For large size bearings, SUJ3 or SUJ5 steels are used for hardenability.
If impact resistance is required, SNCM series steel may be used (see Table 7.2).
In addition to the above, high-speed steel may be used for bearings for applications requiring tolerance to high temperatures.
Stainless steel may be used for bearings operating in a corrosive atmosphere.
Ceramic materials may be used for special applications.

7.2 Cage Material

Materials for cages are required to have the following properties:

- Good wear resistance
- Dimensional stability
- Good mechanical strength

[→Continue]

Cold-rolled steel (see Table 7.5) is used for pressed cages. High-tensile-strength brass castings or machined-steel are used for machined cages (see Tables 7.6 and 7.7). Polyamide resin are used depending on the type of bearing and the application.
For selection of cage material, it is important to consider the operating conditions.
Polyamide cages should not be used at temperatures above 120°C or below -40°C.
Polyamide cages should not be used in vacuum because they become brittle due to dehydration.
Polyamide cages may be affected by the use of specific lubricants.

Brass cages should not be used at temperatures in excess 300°C.
Brass cages are not suitable in Ammonia (e.g. in refrigeration) because Ammonia causes season cracking in brass.

Table 7.1 High-Carbon Chrome Bearing Steel

Standard	Symbol	Chemical composition (%)						
		C	Si	Mn	P	S	Cr	Mo
JIS	SUJ 2	0.95 ~ 1.10	0.15 ~ 0.35	≤ 0.50	≤ 0.025	≤ 0.025	1.30 ~ 1.60	≤ 0.08
	SUJ 3	0.95 ~ 1.10	0.40 ~ 0.70	0.90 ~ 1.15	≤ 0.025	≤ 0.025	0.90 ~ 1.20	≤ 0.08
	SUJ 4	0.95 ~ 1.10	0.15 ~ 0.35	≤ 0.50	≤ 0.025	≤ 0.025	1.30 ~ 1.60	0.10 ~ 0.25
	SUJ 5	0.95 ~ 1.10	0.40 ~ 0.70	0.90 ~ 1.15	≤ 0.025	≤ 0.025	0.90 ~ 1.20	0.10 ~ 0.25
SAE	52100	0.98 ~ 1.10	0.15 ~ 0.35	0.25 ~ 0.45	≤ 0.025	≤ 0.025	1.30 ~ 1.60	≤ 0.10

Table 7.2 Case Hardening Steel

Standard	Symbol	Chemical composition (%)							
		C	Si	Mn	P	S	Ni	Cr	Mo
JIS	SNCM220	0.17 ~ 0.23	0.15 ~ 0.35	0.60 ~ 0.90	≤ 0.030	≤ 0.030	0.40 ~ 0.70	0.40 ~ 0.65	0.15 ~ 0.30
	SNCM420	0.17 ~ 0.23	0.15 ~ 0.35	0.40 ~ 0.70	≤ 0.030	≤ 0.030	1.60 ~ 2.00	0.40 ~ 0.65	0.15 ~ 0.30
	SNCM815	0.12 ~ 0.18	0.15 ~ 0.35	0.30 ~ 0.60	≤ 0.030	≤ 0.030	4.00 ~ 4.50	0.70 ~ 1.00	0.15 ~ 0.30
	SCr420	0.18 ~ 0.23	0.15 ~ 0.35	0.60 ~ 0.85	≤ 0.030	≤ 0.030	–	0.90 ~ 1.20	–
SAE	8620	0.18 ~ 0.23	0.15 ~ 0.35	0.70 ~ 0.90	≤ 0.035	≤ 0.040	0.40 ~ 0.70	0.40 ~ 0.60	0.15 ~ 0.25
	4320	0.17 ~ 0.22	0.15 ~ 0.35	0.45 ~ 0.65	≤ 0.035	≤ 0.040	1.65 ~ 2.00	0.40 ~ 0.60	0.20 ~ 0.30

Table 7.3 High-Speed Steel

Standard	Symbol	Chemical composition (%)											
		C	Si	Mn	P	S	Cr	Mo	V	Ni	Cu	Co	W
AISI	M50	0.77 ~ 0.85	≤ 0.25	≤ 0.35	≤ 0.015	≤ 0.015	3.75 ~ 4.25	4.00 ~ 4.50	0.90 ~ 1.10	≤ 0.15	≤ 0.10	≤ 0.25	≤ 0.25

Table 7.4 Stainless Steel

Standard	Symbol	Chemical composition (%)						
		C	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**
JIS	SUS440C	0.95 ~ 1.20	≤ 1.00	≤ 1.00	≤ 0.040	≤ 0.030	16.00 ~ 18.00	≤ 0.75

Table 7.5 Cold Rolled Steel Strip and Cold Rolled Steel Sheet and Plate for Pressed Cage

Standard	Symbol	Chemical composition (%)				
		C	Si	Mn	P	S
BAS	SPB 1	≤ 0.10	≤ 0.04	0.25 ~ 0.45	≤ 0.030	≤ 0.030
BAS	SPB 2	0.13 ~ 0.20	≤ 0.04	0.25 ~ 0.60	≤ 0.030	≤ 0.030
JIS	SPCC	≤ 0.12	–	≤ 0.50	≤ 0.040	≤ 0.045

Table 7.6 High Tensile Strength Brass Casting for Machined Cage

Standard	Symbol	Chemical composition (%)									
		Cu	Zn	Mn	Fe	Al	Sn	Ni	Pb	Si	Others
BAS	HBsCR	55.0 ~ 62.0	33.0 ~ 37.0	2.0 ~ 4.0	0.5 ~ 1.5	0.1 ~ 1.0	0.1 ~ 1.0	≤ 1.0	0.1 ~ 1.0	≤ 0.2	≤ 1.0
JIS	HBsC1	55.0 ~ 60.0	Residue	≤ 1.5	0.5 ~ 1.5	0.5 ~ 1.5	≤ 1.0	≤ 1.0	≤ 0.4	≤ 0.1	–
	HBsC2	55.0 ~ 60.0	30.0 ~ 42.0	0.1 ~ 3.5	0.5 ~ 2.0	0.5 ~ 2.0	≤ 1.0	≤ 1.0	≤ 0.4	≤ 0.1	–

Table 7.7 Steel for Machined Cage

Standard	Symbol	Chemical composition (%)				
		C	Si	Mn	P	S
JIS	S25C	0.22 ~ 0.28	0.15 ~ 0.35	0.30 ~ 0.60	≤ 0.030	≤ 0.035

8. Application of Bearings

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8. Application of Rolling Contact Bearings

8.1 Fits and Clearance

8.1.1 Importance of Fit

To get the best performance from a rolling contact bearing, the fit between the inner ring and shaft, and outer ring and housing must be correct. If the mating surfaces lack interference, the bearing ring may move circumferentially on the shaft or in the housing. This phenomenon is called creep. Once mating surfaces start to creep, the bearing ring will begin to wear excessively and the shaft and/or housing may be damaged. Abrasive debris may enter the bearing to cause abnormal heating or vibration.
Creep is often impossible to prevent by mere fastening of the bearing in an axial direction. To prevent creep, the bearing rings that support the rotating load must be provided with necessary interference. The bearing rings that support stationary load normally do not require interference unless contact corrosion from vibration is a concern.

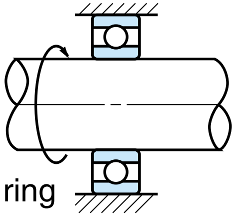
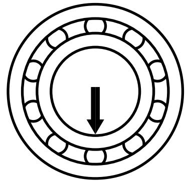
8.1.2 Selection of Fit

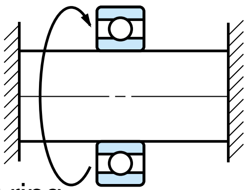
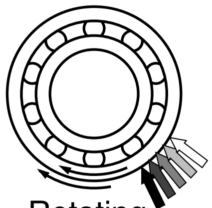
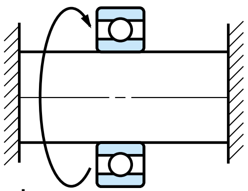
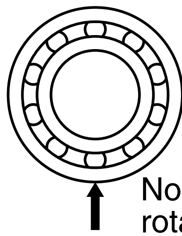
To select the most appropriate fit, the following items must be considered:

- direction of load
- characteristics of load
- magnitude of load
- temperature conditions
- mounting, and dismounting conditions

For general recommendations see Table 8.1.
For mounting bearings in a thin-walled housing or on a hollow shaft, large interference than normal must be provided.
Split-housing applications requiring high precision or tight housing bore fits are not recommended.(A split housing may cause the outer ring to deform).
For application of bearings subjected to vibration, an interference fit should be applied to both inner and outer rings.
Tables 8.2 through 8.14 describe general fit recommendations. For fits not covered by these tables, please contact NACHI.

Table 8.1 Fits vs. Load Characteristics

<table>
<tr><th rowspan="2">Rotating condition</th><th rowspan="2">Type of load</th><th rowspan="2">Load conditions</th><th colspan="2">Fit</th></tr>
<tr><th>Inner ring</th><th>Outer ring</th></tr>
<tr><td>
inner ring</td><td>
Non-rotating</td><td rowspan="2">Rotating inner ring load

Stationary outer ring load</td><td rowspan="2">Interference fit</td><td rowspan="2">Loose fit</td></tr>
<tr><td>
outer ring</td><td>
Rotating</td></tr>
<tr><td>
outer ring</td><td>
Non-rotating</td><td rowspan="2">Rotating outer ring load

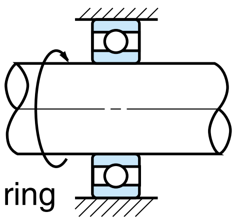
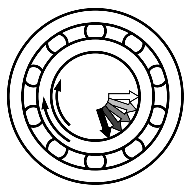
Stationary inner ring load</td><td rowspan="2">Loose fit</td><td rowspan="2">Interference fit</td></tr>
<tr><td>
inner ring</td><td>
Rotating</td></tr>
<tr><td>Load direction not constant because of fluctuation unbalanced load</td><td>Rotating or Non-rotating</td><td>Indeterminate direction load</td><td>Interference fit</td><td>Interference fit</td></tr>
</table>

Table 8.2.1 Bearing Bore [1] Fits for Radial Bearings

Bearing tolerance class	Fit class vs. load type								
	For rotating inner ring load and indeterminate direction load							For rotating outer ring load	
Class 0, class 6	r 6	p 6	n 6	m 5 m 6	k 5 k 6	j 5 j 6 js 6	h 5	h 5 h 6	g 5 g 6
Class 5, class 4	–	–	–	m 5	k 4	js 4	h 4	h 5	–

Table 8.2.2 Bearing Outside Diameter [1] Fits for Radial Bearings

Bearing tolerance class	Fit class vs. load type									
	For rotating inner ring load				For indeterminate direction load			For rotating outer ring load		
Class 0, class 6	–	J 6 J 7	H 6 H 7	G 7	M 7	K 6 K 7	J 6 J 7	P 7	N 7	M 7
Class 5, class 4	K 5	Js 5	H 5	–	–	–	–	–	–	M 5

Table 8.3.1 Bearing Bore or Center Washer Bore [1] Fits for Thrust Bearings

Bearing tolerance class	Fit class vs. load type				
	For centric axial load	For composite load (spherical roller thrust bearing)			
Class 0	j 6 js 6	n 6	m 6	k 6	j 6 js 6

Table 8.3.2 Bearing Outside Diameter [1] Fits for Thrust Bearings

Bearing tolerance class	Fit class vs. load type		
	For centric axial load	For composite load (spherical roller thrust bearing)	
Class 0	–	M 7	H 7

Note: (1) These dimensional fits are based on JIS B 1514.

Table 8.4 Shaft Tolerances (1) for Radial Bearings

Operating conditions		Shaft diameter (mm)			Tolerance symbols	Remarks	Examples of application (Reference)
		Bell bearings	Cylindrical roller bearings Tapered roller bearings	Spherical roller bearings			
Bearings with cylindrical bore							
Rotating outer ring load	When the inner ring is required to move on the shaft easily	For all shaft diameters			g6	When high precision is required, adopt g5 and h5 respectively. For large bearings, f6 is adopted because of easy bearing movement in axial direction.	Driven wheel
	When the inner ring is required to move on the shaft easily	For all shaft diameters			h6		Tension pully, rope sheave

Note: (1) Shaft tolerances in this table are applied to solid steel shaft for bearings with tolerance class 0 and 6.

Remarks: Heavy load $P > 0.12Cr$, Normal Load $0.06Cr < P \leq 0.12Cr$, Light Load $P \leq 0.06Cr$ Cr: Basic Dynamic Load Rating

Table 8.4 Shaft Tolerances (1) for Radial Bearings

Operating conditions		Shaft diameter (mm): Bell bearings	Shaft diameter (mm): Cylindrical roller bearings Tapered roller bearings	Shaft diameter (mm): Spherical roller bearings	Tolerance symbols	Remarks	Examples of application (Reference)
Rotating inner ring load or indeterminate direction load	Light load or fluctuating load	18 under and incl.	–	–	h5	When high precision is required, adopt j5, k5 and m5 instead of j6, k5 and m6 respectively	Electrical appliance, machining tool, pump, blower, haulage car
		18 Over 100 Incl.	40 under and incl.	–	j6		
		100 Over 200 Incl.	40 Over 140 Incl.	–	k6		
		–	140 Over 200 Incl.	–	m6		
	Normal load or heavy load	18 under and incl.	–	–	j5	The tolerances of k6 and m6 instead of k5 and m5 can be used for single row tapered roller bearings and single row angular contact ball bearings.	Electric motor, turbine, pump, internal combustion engine, wood working machine, bearing application in general.
		18 Over 100 Incl.	40 under and incl.	40 under and incl.	k5		
		100 Over 200 Incl.	40 Over 100 Incl.	40 Over 65 Incl.	m5		
		–	100 Over 140 Incl.	65 Over 100 Incl.	m6		
		–	140 Over 200 Incl.	100 Over 140 Incl.	n6		
		–	200 Over 400 Incl.	140 Over 200 Incl.	p6		
		–	–	280 Over	r6		
	Composite load	–	50 Over 140 Incl.	50 Over 100 Incl.	n6	A bearing with an internal clearance larger than the normal clearance is required	Axles of locomotive and passenger train, traction motor
		–	140 Over 200 Incl.	100 Over 140 Incl.	p6		
		–	200 Over	140 Over	r6		

Note: (1) Shaft tolerances in this table are applied to solid steel shaft for bearings with tolerance class 0 and 6.

Remarks: Heavy load $P > 0.12Cr$, Normal Load $0.06Cr < P \leq 0.12Cr$, Light Load $P \leq 0.06Cr$ Cr: Basic Dynamic Load Rating

Table 8.4 Shaft Tolerances [1] for Radial Bearings (3/3)

Operating conditions	Shaft diameter (mm)			Tolerance symbols	Remarks	Examples of application (Reference)
	Bell bearings	Cylindrical roller bearings Tapered roller bearings	Spherical roller bearings			
Centric axial load	250 under and incl.			j6	–	–
	250 Over			js6, j6		
Bearing with tapered bore (with sleeve)						
For all load condition	For all shaft condition			h9/IT5	h10/IT7 instead of h9/IT5 can be used for power transmission shaft. IT5 and IT7 mean the form error (out of roundness, taper) should be limited within the tolerance ranges of IT5 and IT7	Railroad car axle, bearing application in general

Note: (1) Shaft tolerances in this table are applied to solid steel shaft for bearings with tolerance class 0 and 6.
Remarks: Heavy load $P > 0.12Cr$, Normal Load $0.06Cr < P \le 0.12Cr$, Light Load $P \le 0.06Cr$ Cr: Basic Dynamic Load Rating

Table 8.5 Shaft Tolerances for Thrust Bearings

Operating conditions		Shaft diameter (mm)	Tolerance symbols
Centric axial load (Thrust ball bearings and spherical roller thrust bearings)		250 under and incl.	j6
		250 Over	js6, j6
Composite load (Spherical roller thrust bearings)	Rotating outer ring load	250 under and incl.	j6
		250 Over	js6, j6
	Rotation inner ring load or indeterminate direction load	200 under and incl.	k6
		200 Over 400 Incl.	m6
		400 Over	n6

Table 8.7 Housing Bore Tolerances for Thrust Bearings

Operating conditions		Tolerance symbols	Remarks
Centric axial load (All thrust bearings)	Thrust ball bearing	H8	When high accuracy is not required, radial clearance will be provided between outer ring (housing washer)/aligning housing washer and housing
	Spherical roller thrust bearing; When housing is located in radial direction by another bearing.	–	0.001D is recommended as a radial clearance between outer ring and housing. D: outside diameter of housing washer
Composite load (Spherical roller thrust bearings)	Stationary outer ring load or indeterminate direction load	H7 J7	–
	Rotating outer ring load	K7 M7	In case when the radial load is comparatively large, bearing application in general

Table 8.6 Housing Bore Tolerances (1) for Radial Bearings (Except Inch-series Tapered Roller Bearings) (1/2)

Operating conditions			Tolerance symbols	Outer ring movement (2)	Examples of application (Reference)
Monoblock housing	Rotating outer ring load	When a heavy load is applied to a thin-walled housing or impact load	P7	Outer ring can not be moved in axial direction.	Automotive wheel (roller bearing)
		Normal load or heavy load	N7		Automotive wheel (ball bearing)
		Light load or fluctuating load	M7		Conveyer roller, pulley, tension pulley
	Indeterminate direction load	Heavy impact load			Traction motor
		Heavy load or normal load; When the outer ring is not required to move in axial direction	K7	Outer ring can not be moved in axial direction as a rule.	Electric motor, pump, crank shaft
Monoblock or split housing		Normal load or light load; When it is desirable that the outer ring can be moved in axial direction	J7	Outer ring can be moved in axial direction.	Electric motor, pump, crank shaft
	Rotating inner ring load	Impact load; When no-load condition occurs instantaneously			Railroad car axle
		All kinds of load	H7	Outer ring can be moved easily in axial direction.	Railroad car axle, bearing application in general
		Normal load or light load	H8		Gear transmission
		When thermal conduction through the shaft is caused	G7		Paper mill (Drying cylinder)

Note: (1) The tolerances in this table are applied to cast iron or steel housing for bearings with tolerance class 0 and 6. Tighter fit is adopted for light alloy housing.
(2) Outer ring of non-separable bearing

Table 8.6 Housing Bore Tolerances [1] for Radial Bearings (Except Inch-series Tapered Roller Bearings)

Operating conditions			Tolerance symbols	Outer ring movement (2)	Examples of application (Reference)
Monoblock housing	When extremely high accuracy is required	Fluctuating load; When extremely accurate rotation and high rigidity are required	N6	Outer ring can not be moved in axial direction.	Main shaft of machine tool (roller bearing, outside diameter is over 125 mm)
			M6		Main shaft of machine tool (roller bearing outside diameter is under and including 125 mm)
		Indeterminate direction light load; When extremely accurate rotation is required.	K6	Outer ring can not be moved in axial direction as a rule.	Main shaft of grinding machine, ball bearing on grinding wheel side High speed centrifugal compressor, clamping side bearing
		When extremely accurate rotation is required and it is desirable that the outer ring can be moved in axial direction.	J6	Outer ring can be moved in axial direction.	Main shaft of grinding machine, ball bearing on driving side High speed centrifugal compressor, floating side bearing

Note: (1) The tolerances in this table are applied to cast iron or steel housing for bearings with tolerance class 0 and 6. Tighter fit is adopted for light alloy housing.

(2) Outer ring of non-separable bearing

Table 8.8 Fits of Inch Series Tapered Roller Bearings with Shafts

Table 8.8.1 For Bearings with ABMA Classes 4 and 2

Unit: μm

Operating conditions			Bearing bore diameter Nominal d (mm)		Bearing bore deviation		Shaft diameter deviation		Amounts [1]	
			Over	Incl.	High	Low	High	Low	Max	Min
Rotating inner ring load	Normal load No impact		–	76.2	+13	0	+ 38	+ 26	38T	12T
			76.2	304.8	+25	0	+ 64	+ 38	64T	13T
			304.8	609.6	+51	0	+127	+ 76	127T	25T
			609.6	914.4	+76	0	+191	+114	191T	38T
	Heavy load High speed rotation Impact load		–	76.2	+13	0	+ 64	+ 38	64T	25T
			76.2	304.8	+25	0			(2)	
			304.8	609.6	+51	0				
			609.6	914.4	+76	0	+381	+305	381T	229T
Rotating outer ring load	Normal load No impact	Non-ground shaft (When the inner ring is not required to move in axial direction.)	–	76.2	+13	0	+ 13	0	13T	13L
			76.2	304.8	+25	0	+ 25	0	25T	25L
			304.8	609.6	+51	0	+ 51	0	51T	51L
			609.6	914.4	+76	0	+ 76	0	76T	76L
	Normal load No impact	Ground shaft (When the inner ring is required to move in axial direction)	–	76.2	+13	0	0	– 13	0	26L
			76.2	304.8	+25	0	0	– 25	0	51L
			304.8	609.6	+51	0	0	– 51	0	102L
			609.6	914.4	+76	0	0	– 76	0	152L

Note:

(1) T: Tight fit L: Loose fit

(2) Mean amounts of tight fits are d/2000 mm

Table 8.8.2 For Bearings with ABMA Classes 3 and 0

Unit: μm

Operating conditions		Bearing bore diameter Nominal d (mm)		Bearing bore deviation		Shaft diameter deviation		Amounts (1)	
		Over	Incl.	High	Low	High	Low	Max	Min
Rotating inner ring load	Main shaft of precision machine tool	–	304.8	+13	0	+ 38	+18	31T	5T
		304.8	609.6	+25	0	+ 64	+38	64T	13T
		609.6	914.4	+38	0	+102	+63	102T	25T
	Heavy load High speed rotation Impact load	–	76.2	+13	0	(2)			
		76.2	304.8	+13	0				
		304.8	609.6	+25	0				
		609.6	914.4	+38	0				
Rotating outer ring load	Main shaft of precision machine tool	–	304.8	+13	0	+ 13	+18	31T	5T
		304.8	609.6	+25	0	+ 64	+38	64T	13T
		609.6	914.4	+38	0	+102	+63	102T	25T

Note:

(1) T: Tight fit L: Loose fit

(2) Mean amounts of tight fits are d/4000mm

(3) This table is not applied to the bearing with tolerance class 0 whose bore diameter is over 241.3 mm

Table 8.9 Fits of Inch Series Tapered Roller Bearings with Housings

Table 8.9.1 For Bearings with ABMA Classes 4 and 2

Unit: μm

Operating conditions		Bearing outside diameter Nominal D (mm)		Bearing outside diameter deviation		Housing bore diameter deviation		Amounts (1)	
		Over	Incl.	High	Low	High	Low	Max	Min
Rotating inner ring load	Floating side or Clamping side	–	76.2	+25	0	+76	+50	25L	76L
		76.2	127.0	+25	0	+76	+50	25L	76L
		127.0	304.8	+25	0	+76	+50	25L	76L
		304.8	609.6	+51	0	+152	+102	51L	152L
		609.6	914.4	+76	0	+229	+152	76L	229L
	Outer ring location in axial direction can be adjusted	–	76.2	+25	0	+25	0	25T	25L
		76.2	127.0	+25	0	+25	0	25T	25L
		127.0	304.8	+25	0	+51	0	25T	51L
		304.8	609.6	+51	0	+76	+26	25T	76L
		609.6	914.4	+76	0	+127	+51	25T	127L
	Outer ring location in axial direction can not be adjusted	–	76.2	+25	0	−13	−39	64T	13T
		76.2	127.0	+25	0	−25	−51	76T	25T
		127.0	304.8	+25	0	−25	−51	76T	25T
		304.8	609.6	+51	0	−25	−76	127T	25T
		609.6	914.4	+76	0	−25	−102	178T	25T
Rotating outer ring load	Outer ring location in axial direction can not be adjusted	–	76.2	+25	0	−13	−39	64T	13T
		76.2	127.0	+25	0	−25	−51	76T	25T
		127.0	304.8	+25	0	−25	−51	76T	25T
		304.8	609.6	+51	0	−25	−76	127T	25T
		609.6	914.4	+76	0	−25	−102	178T	25T

Note: (1) T: Tight fit L: Loose fit

Table 8.9.2 For Bearings with ABMA Classes 3 and 0

Unit: μm

Operating conditions		Bearing outside diameter Nominal D (mm)		Bearing outside diameter deviation		Housing bore diameter deviation		Amounts [1]	
		Over	Incl.	High	Low	High	Low	Max	Min
Rotating inner ring load	Floating side	–	152.4	+13	0	+38	+26	13L	38L
		152.4	304.8	+13	0	+38	+26	13L	38L
		304.8	609.6	+25	0	+64	+38	13L	64L
		609.6	914.4	+38	0	+89	+51	13L	89L
	Clamping side	–	152.4	+13	0	+25	+13	0	25L
		152.4	304.8	+13	0	+25	+13	0	25L
		304.8	609.6	+25	0	+51	+25	0	51L
		609.6	914.4	+38	0	+76	+38	0	76L
	Outer ring location in axial direction can be adjusted	–	152.4	+13	0	+13	0	13T	13L
		152.4	304.8	+13	0	+25	0	13T	25L
		304.8	609.6	+25	0	+25	0	25T	25L
		609.6	914.4	+38	0	+38	0	38T	38L
	Outer ring location in axial direction can not be adjusted	–	152.4	+13	0	0	–12	25T	0
		152.4	304.8	+13	0	0	–25	38T	0
		304.8	609.6	+25	0	0	–26	51T	0
		609.6	914.4	+38	0	0	–38	76T	0
Rotating outer ring load	Normal load Outer ring location in axial direction can not be adjusted	–	152.4	+13	0	–13	–25	38T	13T
		152.4	304.8	+13	0	–13	–38	51T	13T
		304.8	609.6	+25	0	–13	–39	64T	13T
		609.6	914.4	+38	0	–13	–51	89T	13T

Note: (1) T: Tight fit L: Loose fit
(2) This tables is not applied to the bearing with tolerance class 0 whose bore diameter is over 304.8 mm.

Table 8.10 Amounts of Fits: Radial Bearings with Tolerance JIS Class 0 (ISO Normal Class)

Table 8.10.1 Inner Ring with Shaft (1/2)

Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing Δdmp		Shaft with tolerance grade IT5									
				m5		k5		j5		h5		g5	
				Tight		Tight		Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max
3	6	0	− 8	–	–	–	–	11	2	8	5	4	9
6	10	0	− 8	–	–	–	–	12	2	8	6	3	11
10	18	0	− 8	–	–	17	1	13	3	8	8	2	14
18	30	0	−10	–	–	21	2	15	4	10	9	3	16
30	50	0	−12	32	9	25	2	18	5	12	11	3	20
50	80	0	−15	39	11	30	2	21	7	15	13	5	23
80	120	0	−20	48	13	38	3	26	9	20	15	8	27
120	140	0	−25	58	15	46	3	–	–	25	18	11	32
140	160												
160	180												
180	200	0	−30	67	17	54	4	–	–	30	20	15	35
200	225												
225	250												
250	280	0	−35	–	–	–	–	–	–	35	23	18	40
280	315												
315	355	0	−40	–	–	–	–	–	–	40	25	22	43
355	400												
400	450	0	−45	–	–	–	–	–	–	45	27	25	47
450	500												

Table 8.10 Amounts of Fits: Radial Bearings with Tolerance JIS Class 0 (ISO Normal Class)

Table 8.10.1 Inner Ring with Shaft (2/2) Unit: μm

Nominal diameter (mm)		Shaft with tolerance grade IT6															
		r6		p6		n6		m6		k6		j6		h6		g6	
		Tight		Tight		Tight		Tight		Tight		Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max
3	6	–	–	–	–	–	–	–	–	–	–	14	2	8	8	4	12
6	10	–	–	–	–	–	–	–	–	–	–	15	2	8	9	3	14
10	18	–	–	–	–	–	–	–	–	20	1	16	3	8	11	2	17
18	30	–	–	–	–	–	–	–	–	25	2	19	4	10	13	3	20
30	50	–	–	–	–	45	17	37	9	30	2	23	5	12	16	3	25
50	80	–	–	–	–	54	20	45	11	36	2	27	7	15	19	5	29
80	120	–	–	76	37	65	23	55	13	45	3	33	9	20	22	8	34
120	140	113	63														
140	160	115	65	93	43	77	27	65	15	53	3	39	11	25	25	11	39
160	180	118	68														
180	200	136	77														
200	225	139	80	109	50	90	31	76	17	63	4	46	13	30	29	15	44
225	250	143	84														
250	280	161	94	123	56	–	–	–	–	–	–	51	16	35	32	18	49
280	315	165	98														
315	355	184	108	138	62	–	–	–	–	–	–	58	18	40	36	22	54
355	400	190	114														
400	450	211	126	–	–	–	–	–	–	–	–	65	20	45	40	26	60
450	500	217	132														

Table 8.10 Amounts of Fits: Radial Bearings with Tolerance JIS Class 0 (ISO Normal Class)

Table 8.10.2 Outer Ring with Housing (1/2)

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT6					
				K6		J6		H6	
				Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max	Max	Max
6	10	0	− 8	7	10	4	13	0	17
10	18	0	− 8	9	10	5	14	0	19
18	30	0	− 8	11	11	5	17	0	22
30	50	0	−11	13	14	6	21	0	27
50	80	0	−13	15	17	6	26	0	32
80	120	0	−15	18	19	6	31	0	37
120	150	0	−18	21	22	7	36	0	43
150	180	0	−25	21	29	7	43	0	50
180	250	0	−30	24	35	7	52	0	59
250	315	0	−35	27	40	7	60	0	67
315	400	0	−40	29	47	7	69	0	76
400	500	0	−45	32	53	7	78	0	85

Table 8.10 Amounts of Fits: Radial Bearings with Tolerance JIS Class 0 (ISO Normal Class)

Table 8.10.2 Outer Ring with Housing

(2/2)

Unit: μm

Nominal diameter (mm)		Housing with tolerance grade IT7													
		P7		N7		M7		K7		J7		H7		G7	
		Tight		Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose	Loose	
Over	Incl.	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Min	Max
6	10	24	1	19	4	15	8	10	13	7	16	0	23	5	28
10	18	29	3	23	3	18	8	12	14	8	18	0	26	6	32
18	30	35	5	28	2	21	9	15	15	9	21	0	30	7	37
30	50	42	6	33	3	25	11	18	18	11	25	0	36	9	45
50	80	51	8	39	4	30	13	21	22	12	31	0	43	10	53
80	120	59	9	45	5	35	15	25	25	13	37	0	50	12	62
120	150	68	10	52	6	40	18	28	30	14	44	0	58	14	72
150	180	68	3	60	13	40	25	28	37	14	51	0	65	14	79
180	250	79	3	60	16	46	30	33	43	16	60	0	76	15	91
250	315	88	1	66	21	52	35	36	51	16	71	0	87	17	104
315	400	98	1	73	24	57	40	40	57	18	79	0	97	18	115
400	500	108	0	80	28	63	45	45	63	20	88	0	108	20	128

Table 8.11 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 6

Table 8.11.1 Inner Ring with Shaft

(1/2)

Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing Δdmp		Shaft with tolerance grade IT5									
				m5		k5		j5		h5		g5	
				Tight		Tight		Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max
3	6	0	– 7	–	–	–	–	10	2	7	5	3	9
6	10	0	– 7	–	–	–	–	11	2	7	6	2	11
10	18	0	– 7	–	–	16	1	12	3	7	8	1	14
18	30	0	– 8	–	–	19	2	13	4	8	9	1	16
30	50	0	–10	30	9	23	2	16	5	10	11	1	20
50	80	0	–12	36	11	27	2	18	7	12	13	2	23
80	120	0	–15	43	13	33	3	21	9	15	15	3	27
120	140												
140	160	0	–18	51	15	39	3	–	–	18	18	4	32
160	180												
180	200												
200	225	0	–22	59	17	46	4	–	–	22	20	7	35
225	250												

Table 8.11 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 6

(2/2)

Table 8.11.1 Inner Ring with Shaft

Unit: μm

Nominal diameter (mm)		Shaft with tolerance grade IT6															
		r6		p6		n6		m6		k6		j6		h6		g6	
		Tight		Tight		Tight		Tight		Tight		Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max
3	6	–	–	–	–	–	–	–	–	–	–	13	2	7	8	3	12
6	10	–	–	–	–	–	–	–	–	–	–	14	2	7	9	2	14
10	18	–	–	–	–	–	–	–	–	19	1	15	3	7	11	1	17
18	30	–	–	–	–	–	–	–	–	23	2	17	4	8	13	1	20
30	50	–	–	–	–	43	17	35	9	28	2	21	5	10	16	1	25
50	80	–	–	–	–	51	20	42	11	33	2	24	7	12	19	2	29
80	120	–	–	74	37	60	23	50	13	40	3	28	9	15	22	3	34
120	140	106	63														
140	160	108	65	86	43	70	27	58	15	46	3	32	11	18	25	4	39
160	180	111	68														
180	200	128	77														
200	225	131	80	101	50	82	31	68	17	55	4	38	13	22	29	7	44
225	250	135	84														

Table 8.11 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 6

Table 8.11.2 Outer Ring with Housing (1/2)

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT6					
				K6		J6		H6	
				Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max	Max	Max
6	10	0	– 7	7	9	4	12	0	16
10	18	0	– 7	9	9	5	13	0	18
18	30	0	– 8	11	10	5	16	0	21
30	50	0	– 9	13	12	6	19	0	25
50	80	0	–11	15	15	6	24	0	30
80	120	0	–13	18	17	6	29	0	35
120	150	0	–15	21	19	7	33	0	40
150	180	0	–18	21	22	7	36	0	43
180	250	0	–20	24	25	7	42	0	49
250	315	0	–25	27	30	7	50	0	57
315	400	0	–28	29	35	7	57	0	64

Table 8.11 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 6

Table 8.11.2 Outer Ring with Housing

(2/2)

Unit: μm

Nominal diameter (mm)		Housing with tolerance grade IT7													
		P7		N7		M7		K7		J7		H7		G7	
		Tight		Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose	Loose	
Over	Incl.	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Min	Max
6	10	24	2	19	3	15	7	10	12	7	15	0	22	5	27
10	18	29	4	23	2	18	7	12	13	8	17	0	25	6	31
18	30	35	6	28	1	21	8	15	14	9	20	0	29	7	36
30	50	42	8	33	1	25	9	18	16	11	23	0	34	9	43
50	80	51	10	39	2	30	11	21	20	12	29	0	41	10	51
80	120	59	11	45	3	35	13	25	23	13	35	0	48	12	60
120	150	68	13	52	3	40	15	28	27	14	41	0	55	14	69
150	180	68	10	60	6	40	18	28	30	14	44	0	58	14	72
180	250	79	13	60	6	46	20	33	33	16	50	0	66	15	81
250	315	88	11	66	11	52	25	36	41	16	61	0	77	17	94
315	400	98	13	73	12	57	28	40	45	18	67	0	85	18	103

Table 8.12 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 5

Table 8.12.1 Inner Ring with Shaft

Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing Δdmp		Shaft with tolerance grade IT4								Shaft with tolerance grade IT5			
				m4		k4		js4		h4		m5		h5	
				Tight		Tight		Tight	Loose	Tight	Loose	Tight		Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Max	Max	Max	Max	Min	Max	Max
3	6	0	− 5	13	4	10	1	7	2	5	4	14	4	5	5
6	10	0	− 5	15	6	10	1	7	2	5	4	17	6	5	6
10	18	0	− 5	17	7	11	1	7.5	2.5	5	5	20	7	5	8
18	30	0	− 6	20	8	14	2	9	3	6	6	23	8	6	9
30	50	0	− 8	24	9	17	2	11.5	3.5	8	7	28	9	8	11
50	80	0	− 9	28	11	19	2	13	4	9	8	33	11	9	13
80	120	0	−10	33	13	23	3	15	5	10	10	38	13	10	15
120	180	0	−13	40	15	28	3	19	6	13	12	46	15	13	18
180	250	0	−15	46	17	33	4	22	7	15	14	52	17	15	20

Table 8.12 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 5

Table 8.12.2 Outer Ring with Housing

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT5							
				M5		K5		Js5		H5	
				Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max	Max	Max	Max	Max
6	10	0	− 5	10	1	5	6	3	8	0	11
10	18	0	− 5	12	1	6	7	4	9	0	13
18	30	0	− 6	14	1	8	7	4.5	10.5	0	15
30	50	0	− 7	16	2	9	9	5.5	12.5	0	18
50	80	0	− 9	19	3	10	12	6.5	15.5	0	22
80	120	0	−10	23	2	13	12	7.5	17.5	0	25
120	150	0	−11	27	2	15	14	9	20	0	29
150	180	0	−13	27	4	15	16	9	22	0	31
180	250	0	−15	31	4	18	17	10	25	0	35
250	315	0	−18	36	5	20	21	11.5	29.5	0	41
315	400	0	−20	39	6	22	23	12.5	32.5	0	45

Table 8.13 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 4

Table 8.13.1 Inner Ring with Shaft

Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing Δdmp		Shaft with tolerance grade IT4								Shaft with tolerance grade IT5			
				m4		k4		js4		h4		m5		h5	
				Tight		Tight		Tight	Loose	Tight	Loose	Tight		Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Max	Max	Max	Max	Min	Max	Max
3	6	0	− 4	12	4	9	1	6	2	4	4	13	4	4	5
6	10	0	− 4	14	6	9	1	6	2	4	4	16	6	4	6
10	18	0	− 4	16	7	10	1	6.5	2.5	4	5	19	7	4	8
18	30	0	− 5	19	8	13	2	8	3	5	6	22	8	5	9
30	50	0	− 6	22	9	15	2	9.5	3.5	6	7	26	9	6	11
50	80	0	− 7	26	11	17	2	11	4	7	8	31	11	7	13
80	120	0	− 8	31	13	21	3	13	5	8	10	36	13	8	15
120	180	0	10	37	15	25	3	16	6	10	12	43	15	10	18
180	250	0	−12	43	17	30	4	19	7	12	14	49	17	12	20

Table 8.13 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 4

Table 8.13.2 Outer Ring with Housing

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT5							
				M5		K5		Js5		H5	
				Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max	Max	Max	Max	Max
6	10	0	− 4	10	0	5	5	3	7	0	10
10	18	0	− 4	12	0	6	6	4	8	0	12
18	30	0	− 5	14	0	8	6	4.5	9.5	0	14
30	50	0	− 6	16	1	9	8	5.5	11.5	0	17
50	80	0	− 7	19	1	10	10	6.5	13.5	0	20
80	120	0	− 8	23	0	13	10	7.5	15.5	0	23
120	150	0	− 9	27	0	15	12	9	18	0	27
150	180	0	−10	27	1	15	13	9	19	0	28
180	250	0	−11	31	0	18	13	10	21	0	31
250	315	0	−13	36	0	20	16	11.5	24.5	0	36
315	400	0	−15	39	1	22	18	12.5	27.5	0	40

Table 8.14 Amounts of Fits: Thrust Bearings with Tolerance JIS (ISO) Class 0

Table 8.14.1 Shaft Washer or Center Washer with Shaft

Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing Δdmp		Shaft with tolerance grade IT6							
				n6		m6		k6		j6	
				Tight		Tight		Tight		Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Min	Max	Max
6	10	0	− 8	–	–	–	–	18	1	15	2
10	18	0	− 8	–	–	–	–	20	1	16	3
18	30	0	−10	–	–	–	–	25	2	19	4
30	50	0	−12	–	–	–	–	30	2	23	5
50	80	0	−15	–	–	–	–	36	2	27	7
80	120	0	−20	–	–	–	–	45	3	33	9
120	180	0	−25	–	–	–	–	53	3	39	11
180	250	0	−30	–	–	76	17	63	4	46	13
250	315	0	−35	–	–	87	20	–	–	51	16
315	400	0	−40	–	–	97	21	–	–	58	18
400	500	0	−45	125	40	–	–	–	–	65	20

Table 8.14 Amounts of Fits: Thrust Bearings with Tolerance JIS (ISO) Class 0

Table 8.14.2 Housing Washer with Housing

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT7			
				M7		H7	
				Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max
10	18	0	–11	18	11	0	29
18	30	0	–13	21	13	0	34
30	50	0	–16	25	16	0	41
50	80	0	–19	30	19	0	49
80	120	0	–22	35	22	0	57
120	180	0	–25	40	25	0	65
180	250	0	–30	46	30	0	76
250	315	0	–35	52	35	0	87
315	400	0	–40	57	40	0	97
400	500	0	–45	63	45	0	108

8.1.3 Calculating Fits

The fits for bearings are often determined empirically according to Table 8.1 through Table 8.14. These tables are NOT to be used for the following cases:

- If special materials are used for interfaces.
- If a hollow shaft is used.
- For high-precision applications.

(1) Reduction of Interference due to Bearing Load

When load is applied through a rotating inner ring, the ring will deform slightly and a gap will occur between the ring and the shaft at a position 180°from the point of load. This gap and "arc-of-no-contact" will increase as the load becomes heavier. A gearing effect will also occur due to the difference in diameters of rotation of the interfacing parts.

Formula (8.1) and Fig. 8.1 define the reduction (millimeters) in interference fit of the inner ring due to bearing load.

$$\Delta dF = 0.08 \times 10^{-3} \sqrt{\frac{d}{B} Fr} \quad \cdots\cdots (8.1)$$

where:

ΔdF	: Reduction in interference of inner ring fit due to bearing load (mm)
d	: Bearing bore (shaft diameter) (mm)
B	: Bearing inner ring width (mm)
Fr	: Radial load on the bearing (N)

If the radial load is greater than 20% of the basic static load rating Cor, Formula (8.2) is to be used.

$$\Delta dF \geq 0.02 \times 10^{-3} \frac{Fr}{B} \quad \cdots\cdots (8.2)$$

Calculation example: 6

Object: to obtain the amount of reduction in interference from bearing load where Fr on a single-row, Deep-groove ball bearing number 6320 is 21000N.

From the dimensional tables, d=100 mm, B=47 mm. From Fig. 8.1;

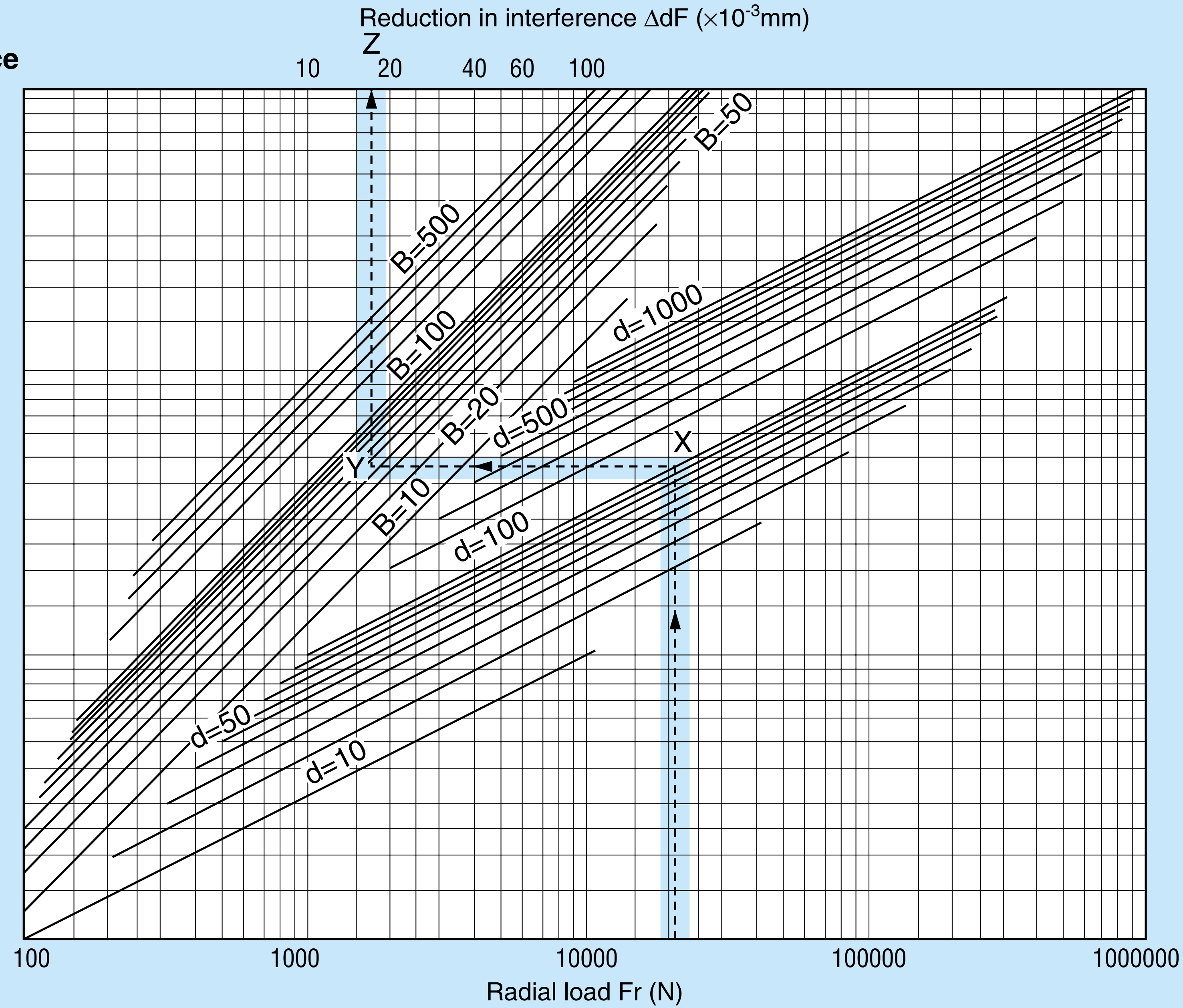
(a) Find 21000 on the line of Fr. Move vertically and intersect the line of d=100 (at point X).

(b) From the point X, move parallel with line Fr and intersect the line of B=47 (at point Y).

(c) Extend vertically from point Y. The intercept with the chart upper limit at point Z indicates the reduction dF (mm) of interference. In this case, ΔdF loss=0.017 (mm).

[Fig. 8.1 Change in interference due to load](#)

Fig. 8.1
Change in interference due to load



[Continue→]

(2) Reduction in Interference due to temperature difference

Operating temperature differences will generally exist between the inner ring and shaft or the outer ring and bearing housing. Fits must be adjusted for differences of thermal expansion coefficients in the mating materials.

- If the bearing temperature is higher than that of the shaft, increase the fit.
- If heat is transferred through the shaft, the fit becomes tighter due to thermal expansion of the shaft. In such cases, increase the radial internal clearance of the bearing.
- When the outer ring temperature is higher than the housing, reduce the fit with the housing and the radial internal clearance of the bearing.
- If the housing temperature is hotter than the bearing outer ring, check the rates of thermal expansion. It will probably be necessary to increase the fit due to larger growth of the housing bore.

Reduction of interference fit of the inner ring due to temperature differentials can be calculated using Formula (8.3) and Fig. 8.2.

$$\Delta dT = 0.0015 \Delta T \cdot d \cdot 10^{-3} \quad \cdots\cdots \text{(8.3)}$$

where:

ΔdT: Reduction in interference of inner ring fit due to temperature difference (mm)

ΔT: Temperature difference between bearing and housing ambient (°C)

d : Bearing bore (shaft diameter) (mm)

Calculation example: 7

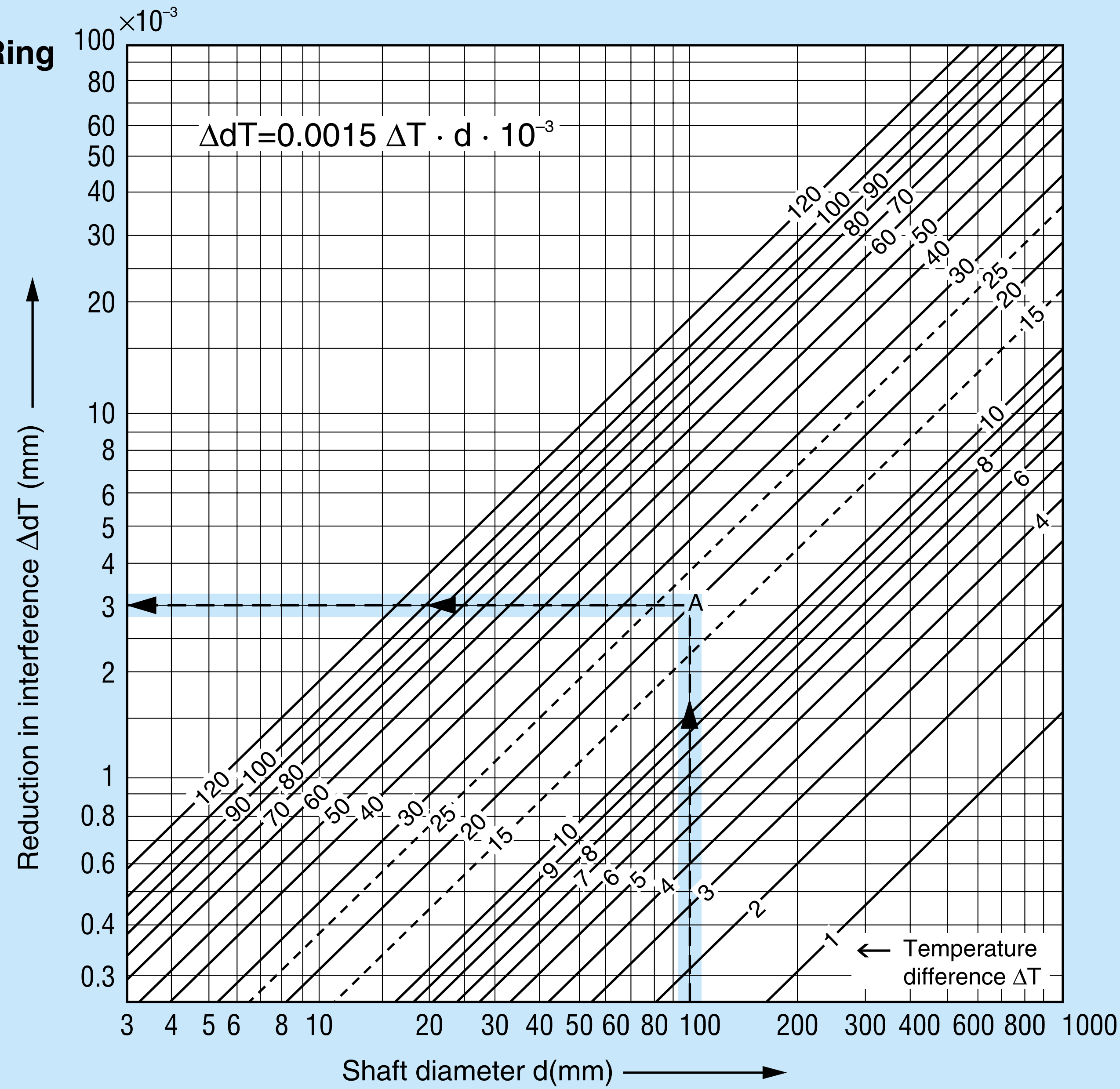
Obtain the reduction in interference for a temperature difference of 20°C existing between housing ambient temperature and internal temperature of a bearing with a bore diameter of 100 mm. From Fig. 8.2.

(a) Find the bore diameter d=100 on the horizontal axis. Draw a vertical line from the point until it intersects the line of temperature difference of 20 °C at point A.

(b) Extend a line horizontally from point A left to the Y-axis. The reduction in interference can be read from the intersection with the vertical axis as ΔdT=0.003mm.

Fig. 8.2 Reduction in Interference of Inner Ring Due to Temperature Difference

Fig. 8.2
Reduction in Interference of Inner Ring Due to Temperature Difference



[Continue→]

(3) Surface Finish Effects on Interference

Since surface asperities are subjected to smoothing when bearings are press-fit, the effective fit becomes smaller than the calculated fit. The amount of reduction in fit is dependent on the surface finish of the interfacing materials.
Effective fit of the inner ring to a solid shaft is calculated using Formulas (8.4.1), and (8.4.2).
For ground and polished shafts,

$$\Delta de = \frac{d}{d+2}\Delta da \qquad \cdots\cdots (8.4.1)$$

For machined shafts,

$$\Delta de = \frac{d}{d+3}\Delta da \qquad \cdots\cdots (8.4.2)$$

where:

Δde : Effective interference (mm)
Δda : Calculated interference (mm)
d : Bearing bore diameter (mm)

(4) Necessary Interference for Inner Rings

Formulas (8.1), (8.2), (8.3), (8.4.1) and (8.4.2) have been used to calculate the effects of Load, Temperature, and Surface Finish in interference. To summarize the effects to a total required interference for the inner ring and shaft (where inner ring rotates against load), refer to Formulas (8.5.1) and (8.5.2).
For ground and polished shafts,

$$\Delta da \geq (\Delta dF + \Delta dT)\left(\frac{d+2}{d}\right) \qquad \cdots\cdots (8.5.1)$$

For machined shafts,

$$\Delta da \geq (\Delta dF + \Delta dT)\left(\frac{d+3}{d}\right) \qquad \cdots\cdots (8.5.2)$$

(5) Expansion Stress from Fits

When interference is provided, the bearing ring undergoes tensile stress. If the stress is excessive, the bearing ring will be damaged. When an inner ring is fitted to a solid steel shaft, stress,σi, should be limited to 100MPa or smaller using Formula (8.6). Empirically, the criterion of interference 0.001 of shaft diameter,

$$\sigma_i = \frac{E}{2} \cdot \frac{\Delta de}{d} \left\{ 1 + \left(\frac{d}{di} \right)^2 \right\} \quad \cdots\cdots (8.6)$$

where:

σi	: Maximum bore diameter surface stress (MPa)
E	: Vertical elastic coefficient for steel: 2.07×10^5(MPa)
Δde	: Effective interference (mm)
d	: Bearing bore diameter (mm)
di	: Mean outside diameter of inner ring (mm)

Cylindrical roller bearings; and Self-aligning ball bearings of series 22 and 23:

$$di \fallingdotseq 0.25(D+3d)$$

where:

D	: Bearing outside diameter (mm)

All other bearings:

$$di \fallingdotseq 0.1(3D+7d)$$

(6) Fits for Inner Rings with Hollow Shafts

Equivalent effective fit for a hollow shaft.

(a) Calculate the interference, Δda for a solid shaft of the identical diameter inner ring with either Table 8.4 or Formulas (8.5.1) and (8.5.2).

(b) Calculate interference Δdha for a hollow shaft and inner ring with Formula (8.7).

$$\Delta dha = \frac{1 - \left(\frac{d_h}{di} \right)^2}{1 - \left(\frac{d_h}{d} \right)^2} \Delta da \quad \cdots\cdots (8.7)$$

where:

Δdha	: Calculated interference of hollow shaft (mm)
dh	: Bore diameter of hollow shaft (mm). For solid shaft, dh=0
d	: bearing bore diameter (mm)
Δda	: Calculated interference of solid shaft and inner ring (mm)

(c) Expansion stress force from fits for hollow steel shaft is calculated using Formula (8.8).

$$\sigma_i = \frac{E}{2} \cdot \frac{\Delta de}{d} \cdot \frac{\left\{ 1 - \left(\frac{d_h}{d} \right)^2 \right\} \left\{ 1 + \left(\frac{d}{di} \right)^2 \right\}}{\left\{ 1 - \left(\frac{d_h}{di} \right)^2 \right\}} \quad \cdots\cdots (8.8)$$

(7) Outer Ring to Housing Fits

Interference fit must be provided between the outer ring and housing where there is rotating outer ring load or indeterminate load. Fits for outer ring and steel housing can be obtained by using Table 8.6 and maximum stress of the outer ring can be calculated with Formula (8.9).

$$\sigma_o = \frac{E}{2} \cdot \frac{\Delta De}{D} \cdot \frac{1-\left(\frac{D}{Dh}\right)^2}{1-\left(\frac{De}{Dh}\right)^2} \quad \cdots\cdots\cdot (8.9)$$

where:

σo	: Maximum outer ring bore surface stress (MPa)
E	: Vertical elastic coefficient for steel: 2.07×10^5(MPa)
ΔDe	: Effective interference (mm)
D	: Bearing outside diameter (mm)
Dh	: Housing outside diameter (mm)

(Note): If the housing is rigid body;
$Dh = \infty$
De = Mean bore diameter of outer ring (mm)
Cylindrical roller bearings and Self-aligning ball bearings of series 22 and 23:

$$De \fallingdotseq 0.25(3D+d)$$

All other bearings:

$$De \fallingdotseq 0.1(7D+3d)$$

8.1.4 Selection of Bearing Clearance

The internal clearance of rolling contact bearings during operation (the operating clearance) is a factor which can affect bearing life, vibration, heat, sound, etc.

Theoretically, bearing life is maximum if bearings operate with a slight preload (a slight negative operating clearance). If a bearing is to operate with a slight preload, great care must be taken in the analysis and design of the application to be sure that preloads do not begin to rise during the bearing operation to a level which will lead to an upward spiraling of heat=greater preload=more heat=early bearing failure. And also a bearing with an excessive operating clearance will not perform its maximum load capability.

To prevent clearance problems, unmounted bearing clearance should be selected so that operating clearance will be slightly positive. (Note that bearings chosen for precision location functions are preloaded, but the amount of preload must be precisely controlled at assembly).

For non-separable, radial bearings, and for radial Cylindrical roller bearings, which are assembled in clearance groups with a set amount of “unmounted” internal clearance; the initial internal clearance will be the unmounted clearance minus clearance losses from mounting fits.

Typical clearance groups for the above types of bearings are:

C2 : less than Normal clearance
CN : Normal clearance
C3 : more than Normal clearance

CN (Normal) internal clearance is determined so that appropriate clearance will remain after the bearing is mounted to the shaft with an interference fit, but with no fit (no interference) between the outer ring and housing and the temperature difference between inner and outer ring is 10 °C or less.

Table 8.15 indicates examples of selection for clearance groups other than CN (Normal) internal clearance.

Bearing clearance varies during operation with respect to the temperature rise and the type and magnitude of load. For example, if large reduction of clearance is expected, more initial clearance is required.

Fig. 8.3 illustrates radial clearance of a single-row Deep-groove ball bearing.

Table 8.15 Examples of Selection of Clearance Other Than CN (Normal) Clearance

Fig. 8.3 Radial Clearance

Table 8.15 Examples of Selection of Clearance Other Than CN (Normal) Clearance

Service Conditions	Clearance	Application Examples (reference)
Large interference for heavy or impact load	C3 clearance or larger	Railroad car axle
Interference in required for both inner and outer rings due to indeterminate heavy impact load		Traction motor
Inner ring is exposed to high temperature. Outer ring exposed to low temperature.		Pulp and paper machine dryer For outdoor use in cold area
When shaft has a large deflection. For increasing axial load capacity by increasing contact angle.		Semi-floating axle of automobile Bearing of rail road car axle for carring axial load. Thrust bearing of axles of rolling stock
When both inner and outer rings are clearance-fitted.	C2 clearance or smaller	Roll neck of rolling machine
For controlling vibration and sound.		Small, special electric motors
For post-assembly adjustment of clearance such as controlling deviation of shaft, etc.	C9na , C1na	Cylindrical roller bearing for lathe main shaft

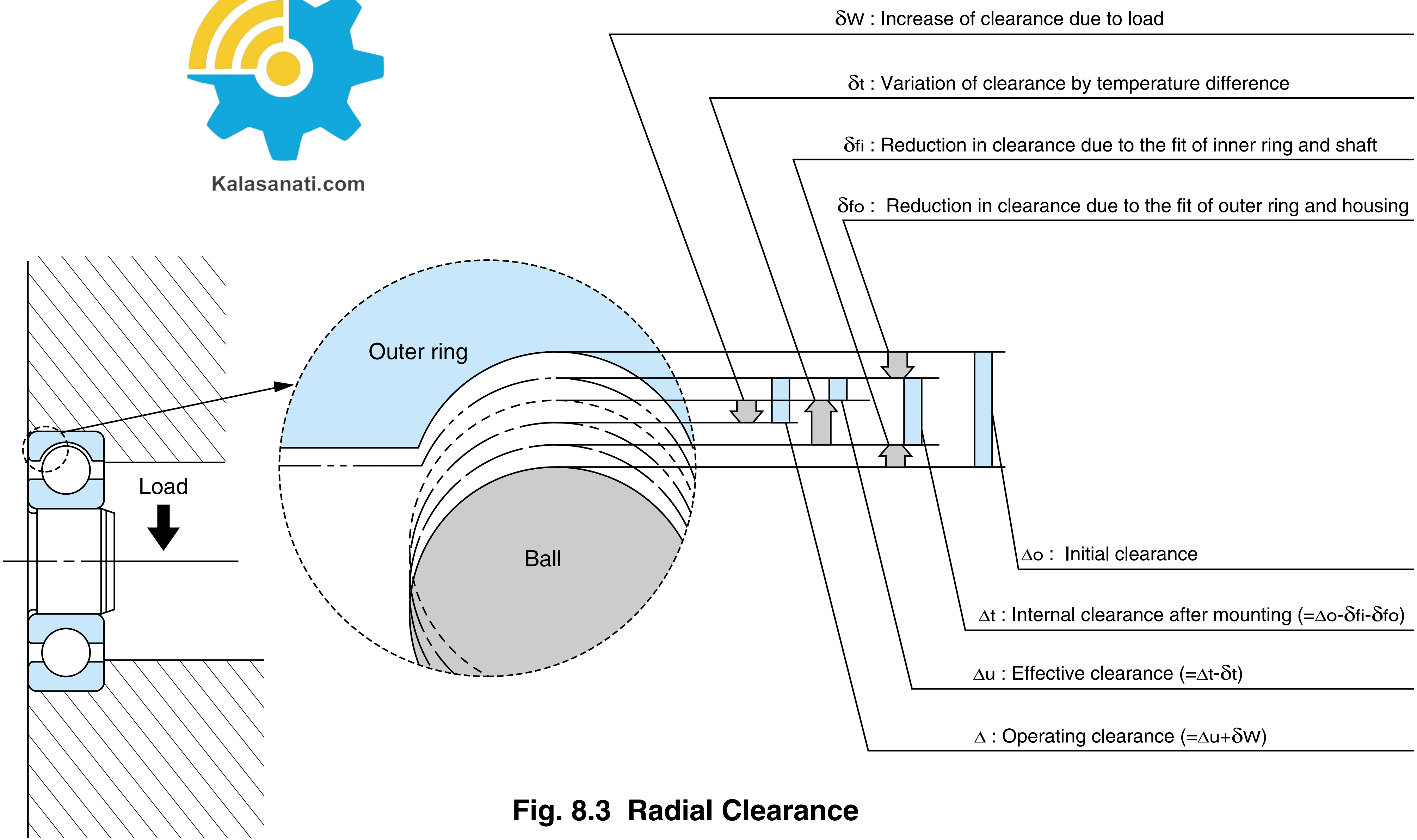


Fig. 8.3 Radial Clearance

[Continue→]

(1) Operating Clearance

Operating clearance is defined as the clearance of a bearing operating in a machine at the operating temperature and load.

$$\Delta = \Delta o - (\delta t + \delta f) + \delta w \quad \cdots\cdots (8.10)$$

where:

- Δ : Operating clearance (mm)
- Δo : Unmounted bearing clearance
- δt : Variation of clearance from temperature difference between inner and outer rings (mm)
- δf : Reduction in clearance due to the fit of inner and outer rings (mm)
- δw : Increase of clearance due to load (mm)

(2) Internal clearance reduction due to temperature difference between inner and outer rings

Under normal operating conditions, the temperature of the rolling contact bearing components is, in ascending order from the lowest to the highest; the outer ring, the inner ring, and the rolling elements.

Since it is extremely difficult to measure the temperature of the rolling elements, operating temperature is calculated under the assumption that the temperature of the rolling element is equal to that of the inner ring. Therefore, the reduction in clearance due to temperature difference between the inner and outer rings can be obtained by the following formula:

$$\delta t = \alpha \cdot \Delta T \cdot Do \quad \cdots\cdots (8.11)$$

where:

- δt : Reduction in clearance due to temperature difference between inner and outer rings (mm)
- α : Linear expansion coefficient of bearing steel: 1.12×10^{-5} (1/ °C) for operating temperature 300°C or less
- ΔT : Temperature difference between the inner and outer rings (°C)
- Do : Outer ring raceway diameter (mm)

$Do \fallingdotseq 0.2(4D+d)$ for Deep-groove ball bearings and Spherical roller bearings.

$Do \fallingdotseq 0.25(3D+d)$ for Cylindrical roller bearings.

[Continue→]

(3) Reduction in clearance due to fit

When a bearing is mounted to a shaft or housing with an interference fit, the inner ring will expand or the outer ring will contract (due to the fit), causing reduction in the bearing internal clearance. Reduction in clearance due to fit can be calculated from the following formula:

$$\delta f = \delta fi + \delta fo \qquad \cdots\cdots (8.12)$$

where:

- δf : Reduction in clearance due to fit (mm)
- δfi : Reduction in clearance due to expansion of the inner ring (mm)
- δfo : Reduction in clearance due to the contraction of the outer ring (mm)

$$\delta fi = \Delta de \cdot \frac{d}{di} \cdot \frac{1-\left(\frac{dh}{d}\right)^2}{1-\left(\frac{dh}{di}\right)^2} \qquad \cdots\cdots (8.13)$$

$$\delta fo = \Delta De \cdot \frac{De}{D} \cdot \frac{1-\left(\frac{D}{Dh}\right)^2}{1-\left(\frac{De}{Dh}\right)^2} \qquad \cdots\cdots (8.14)$$

where:

- Δde : Effective interference of the inner ring (mm)
- d : Bearing bore diameter (mm)
- di : Mean outside diameter of inner ring (mm)
- dh : Inside diameter of hollow shaft (mm)
  (Note): For solid shaft, dh=0
- ΔDe : Effective interference of outer ring (mm)
- D : Bearing outside diameter (mm)
- De : Mean inside diameter of outer ring (mm)
- Dh : Housing outside diameter (mm)
  Note: If the housing is a rigid body, $Dh=\infty$.
- $di \fallingdotseq 0.25(D+3d)$ for Cylindrical roller bearings and Self-aligning Ball bearings of bearing series 22 and 23
- $di \fallingdotseq 0.1(3D+7d)$ for other bearings
- $De \fallingdotseq 0.25(3D+d)$ for Cylindrical roller bearings and Self-aligning Ball bearings of bearing series 22 and 23
- $De \fallingdotseq 0.1(7D+3d)$ for other bearings

For estimating δf, the following may be used:

$\delta f = 0.7\ (\Delta de + \Delta De)$ to

$0.9\ (\Delta de + \Delta De)$,

with smaller values for heavy-section bearings (e.g. bearings of diameter series 4) and larger values for light-section bearing rings. (e.g. bearings of diameter series 9)

[Continue→]

(4) Increase of clearance due to load

When a bearing is subjected to a load, elastic deformation will occur and this deformation will cause an increase in internal clearance. Table 8.16 outlines elastic deformation δr and δa.

Table 8.16 Load and Elastic Deformation

Table 8.16 Load and Elastic Deformation

Bearing type	Approximation of deformation from radial load δr (mm)	Approximation of deformation from axial load δa (mm)
Self-aligning Ball bearings	$\delta r = \dfrac{0.00070}{\cos\alpha}\sqrt[3]{\dfrac{Po^2}{Dw}}$	$\delta a = \dfrac{0.00070}{\sin\alpha}\sqrt[3]{\dfrac{P^2}{Dw}}$
Deep groove ball bearings Angular Contact ball bearings	$\delta r = \dfrac{0.00044}{\cos\alpha}\sqrt[3]{\dfrac{Po^2}{Dw}}$	$\delta a = \dfrac{0.00044}{\sin\alpha}\sqrt[3]{\dfrac{P^2}{Dw}}$
Spherical roller bearings	$\delta r = \dfrac{0.00018}{\cos\alpha}\sqrt[4]{\dfrac{Po^3}{Lwe^2}}$	$\delta a = \dfrac{0.00018}{\sin\alpha}\sqrt[4]{\dfrac{P^3}{Lwe^2}}$
Cylindrical roller bearings Tapered roller bearings	$\delta r = \dfrac{0.000077}{\cos\alpha}\cdot\dfrac{Po^{0.9}}{Lwe^{0.8}}$	$\delta a = \dfrac{0.000077}{\sin\alpha}\cdot\dfrac{P^{0.9}}{Lwe^{0.8}}$
Thrust ball bearings	–	$\delta a = \dfrac{0.00052}{\sin\alpha}\sqrt[3]{\dfrac{P^2}{Dw}}$
Po and P	$Po = \dfrac{5Fr}{iz\cos\alpha}$	$P = \dfrac{Fa}{z\sin\alpha}$

where:
Fr = Radial load (N)
Fa = Axial load (N)
α = Contact angle (°)
Dw = Diameter of ball or roller (mm)
Lwe = Effective roller length (mm)
i = Number of row of ball or roller
z = Number of ball or roller per row

8.2 Preload and Rigidity

Generally, rolling contact bearings are mounted so that in operation, there will be a small amount of internal clearance. Applications may sometimes require that the bearings be provided with appropriate negative clearance called "preload" when assembled.
Preload has various purposes and effects. Since an incorrect amount of preload may adversely affect the rolling resistance, life, temperature rise, sound, etc. of bearings; extreme care must be taken when applying preload.

8.2.1 Purposes of Preload

(1) Increases rigidity of a shaft (that is, preloading can help to decrease the deflection of shafting).
(2) Enhances rotating accuracy of shaft. Minimizes axial movements and helps to prevent vibration and decrease noise.
(3) Prevents fretting caused by external vibration.
Item 1 and 2 are pertinent with respect to proper gear engagement, rotating accuracy of precision machinery and resonance of electric motor rotors.

8.2.2 Preloading Method and Measurement

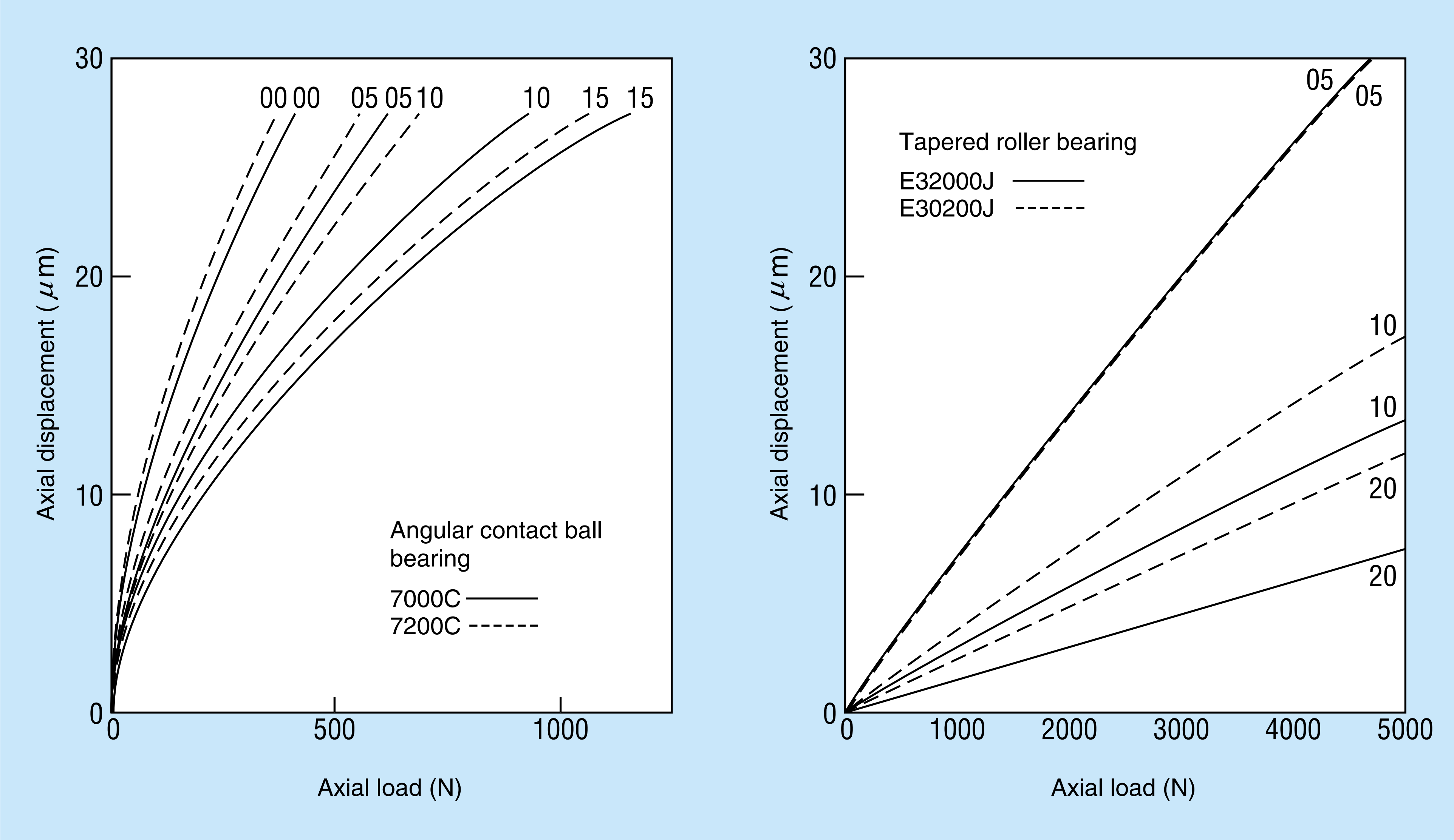
(1) Preloading method
Preloading can be accomplished using one or more of the following methods:
a) Use of springs (disc and coil springs) "Constant-pressure" preloading.
b) Use of clamping nut "Fixed-position" preloading.
c) Use of spacer (spacer and shim) "Fixed-position" preloading.

(2) Measurement of preloading amount
a) Measuring method using axial load.
- If preloading is done using springs, the preloading amount is determined by the amount of spring displacement.
- If preloading is done using a clamping nut, the preload amount is determined by the relationship of the fastening torque of the nut and clamping force.

b) Measuring method using the bearing axial displacement (Fig. 8.4).
Preload amount is determined by relationship of axial load on the bearing and resulting axial displacement.
c) Measuring method using start-up friction torque of the bearing. Relationship between axial load and friction torque should be known for this method.

Fig 8.4 Axial Load and Axial Displacement

Fig 8.4 Axial Load and Axial Displacement



8.2.3 Effect of Preloading

To illustrate the effects of preloading on a duplex Tapered roller bearing set, apply the formula from Table 8.16 to calculate a set of curves for bearing A and bearing B. The example bearing set (see Fig. 8.5) is preloaded (fixed-position), and external load, Tw, is applied.

Load distribution to the two units of bearing in terms of the axial displacement will be calculated using the graphical solution procedures described as follows:

(1) Draw T-δa curve of bearing A.

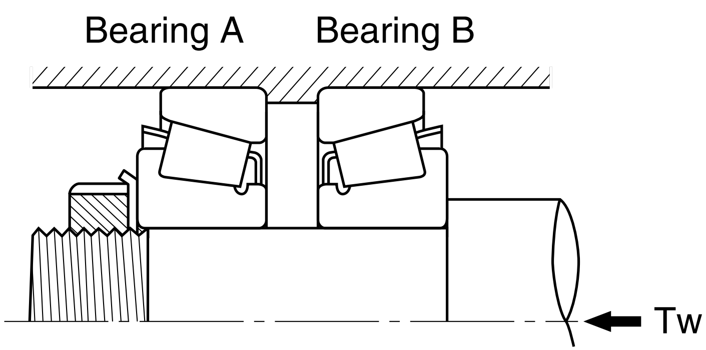
(2) Take preload Tp on axis T, determine intersection P with the curve of bearing A, and draw T-δa curve of bearing B through point P.

(3) Connect the two curves with a length equivalent to the value of external load Tw.

(4) Load Ta and Tb equivalent to this point will become the load of the individual bearings under external load Tw.

(5) Disposition of bearing is obtained by the disposition δw of bearing B.

The disposition of bearing B will be obtained by subtracting disposition to Tp from the counterpart to Tb. The reason for this is that if the bearings are preloaded, the disposition of both bearings becomes constant within a range where preload is not offset to zero by an external load (O - O' in Fig. 8.5 is constant). In other words, bearing A becomes loosened by the amount displaced by the external load on bearing B. If the external load increases and preload is eliminated, load Tb on bearing B will be equal to the external load Tw and the load on bearing A becomes zero. Magnitude of the external load causing loss of preload is represented by Tpo in Fig. 8.5.



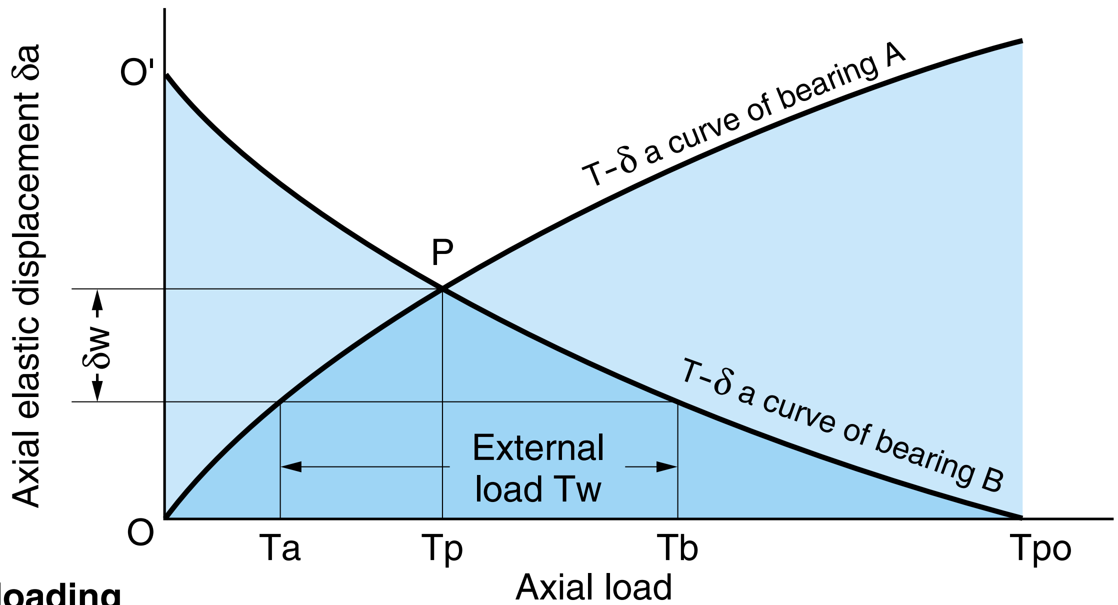


Fig. 8.5 Description of Fixed Position Preloading

8.2.4 Duplex Bearing Preload, Clearance

The preload of duplex bearings can be defined as the clearance, 2A as shown in Fig. 8.6.

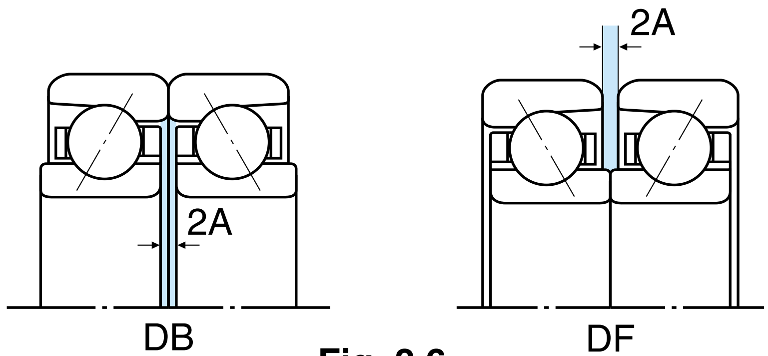


Fig. 8.6

If preloading is an application necessity, it is very important that a very thorough application analysis is made, since, if an excessive amount of preload is applied, there can be abnormal heating, increase in rotating torque and / or a sharp drop in bearing life. Table 8.17 shows standard preload and Table 8.18 outlines target amount of fits for precision (tolerance class 5 or 4), Angular Contact ball bearings.

Table 8.17 Standard Preload Amounts for Precision (tolerance class 5 or 4) Angular Contact Ball Bearings

Table 8.18 Target Interference Values for Precision (tolerance class 5 or 4) Angular Contact Ball Bearings

Table 8.17 Standard Preload Amounts for Precision (tolerance class 5 or 4) Angular Contact Ball Bearings Unit: N

Bore diameter number \ Preload (N)	7000C (DB , DF)				7200C (DB , DF)				7300C (DB , DF)			
	E	L	M	H	E	L	M	H	E	L	M	H
00	20	50	100	145	30	70	145	195	50	100	195	295
01	20	50	100	145	30	70	145	195	50	100	195	295
02	20	50	100	145	30	70	145	195	50	100	195	295
03	20	50	100	145	30	70	145	195	50	100	195	295
04	50	100	195	295	70	145	295	490	100	195	390	590
05	50	100	195	295	70	145	295	490	100	195	390	590
06	50	100	195	390	70	145	295	590	100	195	390	685
07	70	145	295	390	100	195	490	590	145	295	590	685
08	70	145	295	590	100	195	490	785	145	295	590	980
09	70	145	295	590	100	195	490	785	145	295	590	980
10	70	145	295	590	100	195	490	785	145	295	590	980
11	100	195	390	785	145	295	590	980	195	390	785	1470
12	100	195	390	785	145	295	590	980	195	390	785	1470
13	100	195	390	785	145	295	590	980	195	390	785	1470
14	145	295	590	1170	195	390	785	1470	295	590	980	1960
15	145	295	590	1170	195	390	785	1470	295	590	980	1960
16	145	295	590	1170	195	390	785	1470	295	590	980	1960
17	195	390	785	1470	295	490	980	1960	390	785	1470	2940
18	195	390	785	1470	295	490	980	1960	390	785	1470	2940
19	195	390	785	1470	295	490	980	1960	390	785	1470	2940
20	195	390	785	1470	295	490	980	1960	390	785	1470	2940

Table 8.18 Target Interference Values for Precision (tolerance class 5 or 4) Angular Contact Ball Bearings

Unit: μm

Bearing bore diameter Nominal d (mm)		Shaft to inner ring	Bearing outside diameter Nominal D (mm)		Housing to outer ring
Over	Incl.	Interference	Over	Incl.	Clearance
–	18	0 ~ 2	–	18	–
18	30	0 ~ 3	18	30	2 ~ 6
30	50	0 ~ 3	30	50	2 ~ 6
50	80	0 ~ 4	50	80	3 ~ 9
80	120	0 ~ 4	80	120	3 ~ 9
120	150	–	120	150	4 ~ 12
150	180	–	150	180	4 ~ 12
180	250	–	180	250	5 ~ 15

Remarks: Regarding the fit of housing and outer ring, take the samller values of target clearance for the clamping side bearing and the larger values for the floating side.

8.2.5 Thrust Bearing Minimum Axial Loads

When rotated at relatively high speeds, the contact angle between rolling elements and raceways of a thrust bearing changes due to centrifugal force. This can cause a skidding (sliding) action between the rolling elements and the raceways. This skidding action may cause smearing and scuffing on the rolling elements and raceway surfaces.
To prevent sliding action, thrust bearings must always be loaded with a minimum axial load. The minimum axial load is derived form Formulas (8.15), (8.16) and (8.17).
Thrust bearings can sustain axial load in only one direction. When a bi-directional axial load exists, preload must be provided by either using double bearings or springs (or load washers) to maintain the minimum axial load.
For vertical shafts, the axial load due to dead weight of the shaft (etc.), will often exceed the minimum axial load. Even in such cases, reversing axial loads may occur during operation causing the initial axial load to fall below the minimum load.

(1) Thrust ball bearing (adopt larger of values below)

$$Fa\,min = K \cdot n^2 \quad \cdots\cdots (8.15)$$

$$Fa\,min = \frac{Coa}{1000} \quad \cdots\cdots (8.16)$$

where:

Fa min : Minimum axial load (N)
K : Minimum axial load factor
n : Rotating speed (rpm)
Coa : Basic static load rating (N)

(2) Spherical Roller Thrust Bearing

$$Fa\,min = \frac{Coa}{1000} \quad \cdots\cdots (8.17)$$

Minimum axial factor K $(\times 10^{-6})$

Bore No. \ Series	511	512, 522	513, 523	514, 524
00	1.03	1.55	–	–
01	1.26	1.92	–	–
02	1.56	3.36	–	–
03	1.84	4.09	–	–
04	3.42	7.33	–	–
05	7.19	13.1	20.4	43.8
06	9.36	17.2	33.1	81.4
07	11.2	32.8	58.3	128
08	20.4	49.7	97.2	221
09	24.6	57.9	138	316
10	29.3	66.8	211	440
11	44.6	133	326	656
12	64.7	160	375	956
13	72.0	179	428	1240
14	82.8	200	596	1580
15	94.3	222	808	1800
16	103	245	907	2230
17	116	359	1240	2740
18	187	528	1390	4320
20	363	850	1850	4790
22	423	1010	2740	8220

Bore No. \ Series	511	512, 522	513, 523	514, 524
24	488	1130	4130	9980
26	648	1940	5140	16100
28	782	2150	6330	16900
30	886	2490	7140	25800
32	997	2880	9960	30000
34	1420	3940	11100	40100
36	1540	4330	15800	46330
38	2340	6290	23100	–
40	2520	6880	29700	–
44	3000	8130	–	–
48	4900	15900	–	–
52	5580	18400	–	–
56	9800	20400	–	–
60	14600	38000	–	–
64	16400	41800	–	–
68	18300	45700	–	–
72	20300	75600	–	–

Minimum axial factor K (×10^{-6})

Series / Bore No.	29	39	Series / Bore No.	29	39	Series / Bore No.	O –	Series / Bore No.	O –
00	1.55	–	14	99.5	556	3	1.34	18	82.8
01	1.92	–	15	114	704	4	3.62	19	110
02	2.64	–	16	152	927	5	4.65	20	121
03	3.30	–	17	172	1210	6	6.40	21	132
04	3.82	–	18	187	1580	7	7.76	22	176
04 1/2	6.41	–	19	286	2010	8	9.24	23	204
05	7.51	14.2	20	321	2090	9	11.6	24	223
06	9.72	28.9	21	346	2390	10	16.5	26	350
07	20.1	52.3	22	361	3220	11	19.0	28	395
08	25.1	81.0	23	350	3940	12	23.0	30	431
09	31.6	140	24	538	4500	13	21.0	32	580
10	46.1	209	25	498	–	14	31.3	36	1100
11	54.4	284	26	–	–	15	42.1	40	1730
12	60.7	350	27	–	–	16	46.9	44	2840
13	86.0	426	28	794	–	17	75.0	48	3690

8.3 Shaft and Housing Selection

Care must be taken in the design and manufacture of shafts and housings since inaccuracies in these components will probably result in poor bearing performance.

8.3.1 Accuracy and Surface Finish; Shafts and Housings

For general service conditions, the fit surfaces for shafts and housing bores for rolling contact bearings can be made using lathes or fine boring machines.
For applications requiring high-running accuracy, or for very quiet operation, or where high loads exist, a ground finish will be necessary.
Table 8.19 indicates the shaft and housing accuracy and surface roughness for normal service condition.

Table 8. 19 Shaft and Housing Accuracy and Surface Roughness

Table 8. 19 Shaft and Housing Accuracy and Surface Roughness

Item	Shaft	Housing Bore
Roundness	≤0.5 times shaft diametral deviation	≤0.5 times housing bore diametral deviation
Cylindricity	≤0.5 times shaft diametral deviation within range of bearing width	≤0.5 times housing bore diametral deviation within range of bearing width
Shoulder Squareness	≤0.0003 (small bearing) ≤0.0004 (medium bearing) ≤0.0005 (large bearing)	
Fit Surface Roughness	Ra<0.8 μm (small & medium bearing) Ra<1.6 μm (large bearing)	Ra<0.8 μm (small & medium bearing) Ra<3.2 μm (large bearing)

8.3.2 Shaft and Housing Design; Recommendations

- Design shafts as short as possible and of sufficient diameter to prevent bending. Design the housing and supports for appropriate rigidity.
- Use care in specifying the roundness, cylindricity, and surface finish of shaft and housing fit surfaces. See Table 8.19.
- Use care in specifying the squareness of the shaft shoulder to the shaft center and squareness of the housing shoulder to the housing. See Table 8.19.
- Make sure that the radius, ra, of the corner roundness is smaller than the bearing chamfer dimension, r, (minimum) or, r1 (minimum) to prevent the shaft or housing from interfering with proper bearing seating. See Fig. 8.7.

For radial bearings in general, determine the maximum value of radius ra of the corner roundness and the minimum value of the shoulder height according to Table 8.20.

When using a ground finish, provide and undercut as shown in Fig. 8.8. See Table 8.21 for undercut dimensions.

- When using a radius, (ra2) of corner roundness larger than the bearing chamfer dimension (for enhancing the strength of the shaft or when shoulder height must be lower than specified in the dimension tables), install a spacer between the bearing and the shaft shoulder as shown in Fig. 8.9 and Fig. 8.10.
- For ease of dismounting, make the height of the shaft shoulder smaller than the inner ring outside (or land) diameter. If a higher shoulder is required for applying heavy axial load, install an undercut in the shaft as shown in Fig. 8.11.
- Finish bearing mounting screws, or clamping nuts as right-angled to the shaft as possible and thread screws reverse to the rotating direction of the shaft.
- For split-type housings, carefully finish the matching faces of the split housing and install a relief on both sides of the bore diameter of the cap to prevent excessive force from being applied to the bearing when the housing cap is tightened.
- For light-alloy housings (having less rigidity), insert a steel bushing to provide additional rigidity. In general the interference fit is not enough to locate a bearing axially. In principle it is necessary to fix a bearing axially by same method.
- Generally, an interference fit is not adequate to axially locate a bearing. A shaft or housing backing shoulder should be used.

- **Fig. 8.8 Chamfer Dimension and Radius of Corner Roundness**
- **Fig. 8.9 Chamfer Dimension and Radius of Corner Roundness when Using a Spacer**
- **Fig. 8.10**
- **Fig. 8.11**
- **Table 8.20 Maximum Corner Radius and Minimum Shoulder Heights**
- **Table 8.21 Undercut dimensions for Ground Shaft Finish**

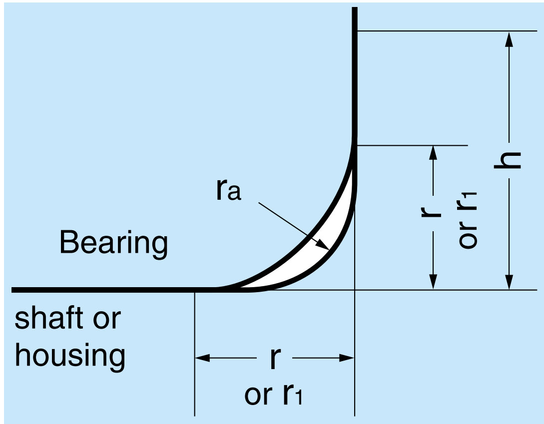


Fig. 8.7 Chamfer Dimension, Radius of Corner Roundness, and Shoulder Height

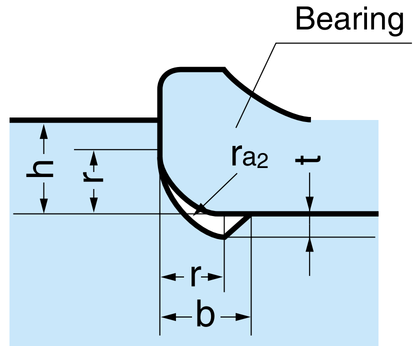


Fig. 8.8 Chamfer Dimension and Radius of Corner Roundness

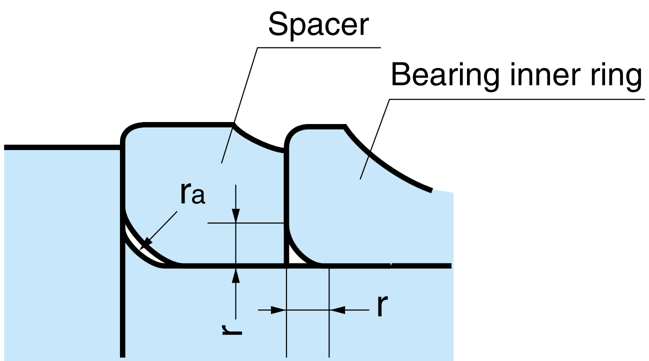


Fig. 8.9 Chamfer Dimension and Radius of Corner Roundness when Using a Spacer

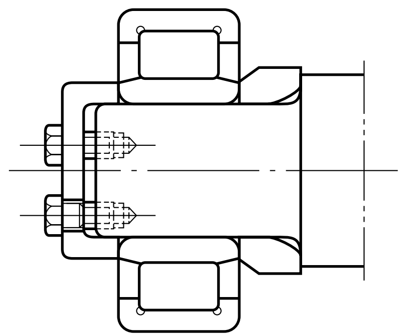


Fig. 8.10

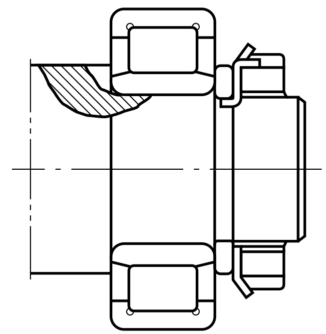


Fig. 8.11

Table 8.20 Maximum Corner Radius and Minimum Shoulder Heights

Unit: mm

Minimum tolerance chamfer dimension r (min) or r_1 (min)	Shaft or housing		
	Radius r_a (max) of corner roundness	Shoulder height h (min)	
		General cases	Special cases (1)
0.1	0.1	0.4	0.4
0.15	0.15	0.6	0.6
0.2	0.2	0.8	0.8
0.3	0.3	1.25	1
0.6	0.6	2.25	2
1	1	2.75	2.5
1.1	1	3.5	3.25
1.5	1.5	4.25	4
2	2	5	4.5
2.1	2	6	5.5
2.5	2	6	5.5
3	2.5	7	6.5
4	3	9	8
5	4	11	10
6	5	14	12
7.5	6	18	16
9.5	8	22	20
12	10	27	–
15	12	32	–
19	15	–	–

Note (1) Data in the columns for special cases should be used when axial load is extremely small.The values Table 8. 21 do not apply to tapered roller bearings, spherical roller bearingsand angular contact ball bearings.

Remarks: Symbols are based on Fig. 8.7.

Table 8.21 Undercut dimensions for Ground Shaft Finish

Unit: mm

Minimum tolerance chamfer dimension r (min) or r_1 (min)	Notch dimensions		
	t	r_{a2}	b
1	0.2	1.3	2
1.1	0.3	1.5	2.4
1.5	0.4	2	3.2
2	0.5	2.5	4
2.1	0.5	2.5	4
2.5	0.5	2.5	4
3	0.5	3	4.7
4	0.5	4	5.9
5	0.6	5	7.4
6	0.6	6	8.6
7.5	0.6	7	10

Remarks: Symbols are based on Fig. 8. 8.

8.3.3 Examples of Shaft Designs

(1) Cylindrical-bore Bearing Shaft Design

- If axial load is applied away from the shaft shoulder, the inner ring can be locked into position using; a) nuts and washers (Fig. 8.12a); b) nuts and lock washers (Fig. 8.12b); or end plates and bolts (Fig. 8.12c). When using a lock washer WITHOUT a shaft keyway or slot, it is recommended that the direction of the nut thread be made reverse to that of the shaft rotation. Note: Careful analysis of bearing load, shaft fits, and finishes, and bearing clearance may show that the shaft fit may be more than adequate to support the axial loading on the bearing.
- When not supporting axial load on the shaft-end on the side opposite the shaft shoulder, you may elect to insert a snap ring in a shaft groove to prevent the inner ring from moving axially. To remove clearance between the snap ring and bearing ring, shims or spacers can be inserted. See Fig. 8.13.
- Snap rings can be applied when using spacers between gears, or pulleys instead of using a shaft shoulder. If axial load will act on the snap ring, insert a shim or spacer between the bearing ring and the snap ring to prevent the axial load from applying bending stress to the snap ring, and to eliminate any axial clearance from between the snap ring and the ring groove. See Fig. 8.13.

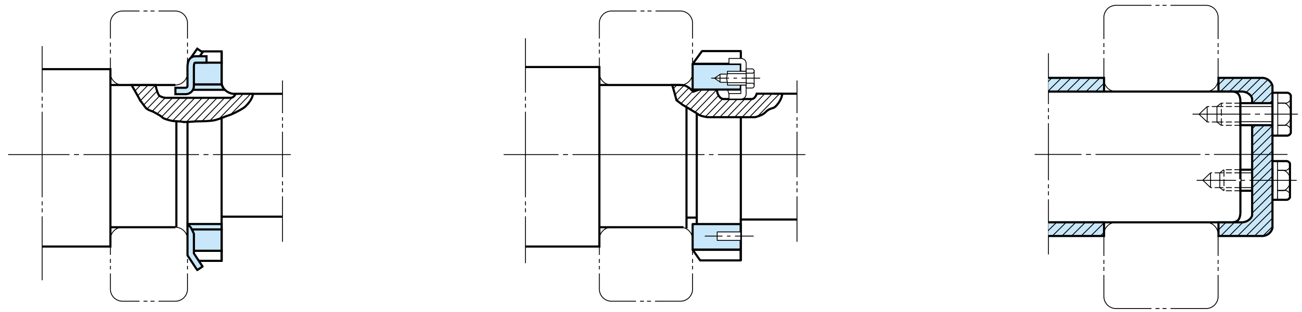


Fig. 8.12 (a) Shaft Nut and Washer (b) Shaft Nut and Lock Washer (c) End Plate and Bolts

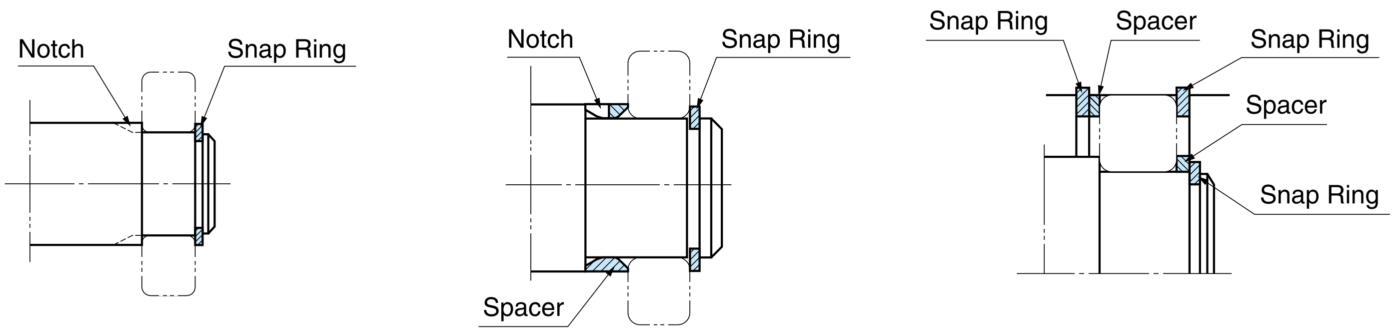


Fig. 8.13 (a) Snap Ring and Notched Shoulder (b) Snap Ring and Notched Spacer (c) Snap Ring and Spacer

(2) Tapered-bore Bearing Shaft Designs

Two methods of mounting tapered-bore bearings to a shaft are; direct mounting to a tapered shaft, or mounting to a cylindrical shaft using adapter or withdrawal sleeves.
Use of adapter or withdrawal sleeves may allow use of less expensive shaft seats (no tapering cost), permits use of a larger shaft tolerance and allows variable location of a bearing on a shaft. See Figs. 8.14 to 8.16. Since the dimensional accuracy of sleeves is not as high as that of bearings, sleeves are not appropriate for applications requiring high accuracy or high rotational speed.

- Normally, tapered-bore bearings used with adapters do not employ shaft shoulders.
  To prevent nuts from loosening, use washers for shafts of diameters 200 mm or less, and lock plates for shafts of diameters 200 mm or more.
  Nut thread direction to be made reverse to direction of rotation.
- For shafts with shoulders, mount the tapered-bore bearing with withdrawal sleeves with nuts and washer or end plates and bolts. See Fig. 8.17.
  Nut thread direction should be reverse to direction of rotation.
- When accuracy is of primary importance, use the direct mount method using tapered-bore bearings mounted directly to tapered shafts. See Fig. 8.18.

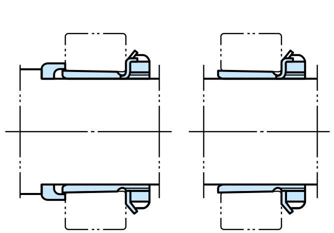


Fig. 8.14 Adapter Sleeve Mounting

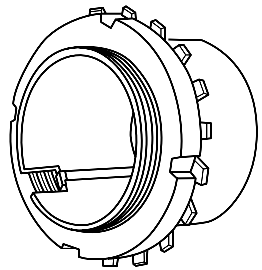


Fig. 8.15 Adapter Using Washer (Bearing Bore ≤ 200 mm)

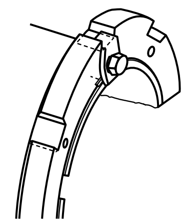


Fig. 8.16 Adapter Using Lock plate (Bearing Bore > 200 mm)

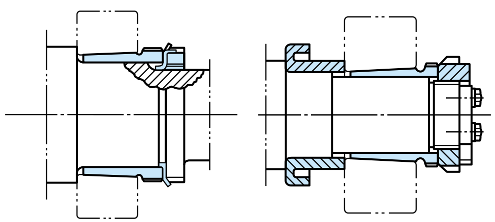


Fig. 8.17 Withdrawal Sleeve Mounting

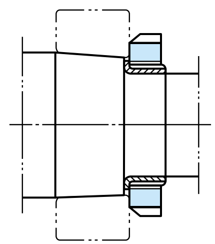


Fig. 8.18 Tapered Shaft Mounting Using Split Ring, Nut and Washer

8.3.4 Housing Designs

- When mounting two bearings to a common shaft, it is necessary to design a structure that allows linear expansion of the shaft due to temperature rise, and for mounting interval errors made during assembly. To accomplish this, mount one of the bearings to support both radial and axial loads. Fix the inner and outer rings to the shaft and housing so that neither ring will move axially. Mount the other bearing so it can move axially as the "free" side bearing capable of supporting only radial load.
  If a bearing configuration is selected for the free side bearing which will not accommodate the linear movement of the shaft created by thermal expansion, select a housing fit which will permit axial movement of the outer ring in the housing.

- If a Cylindrical roller bearing with an N, NU, or RNU configuration is used for the free side bearing, then shaft expansion due to temperature rise can be relieved by axial movement of the inner ring of the bearing. See Fig. 8.19. Use of Cylindrical roller bearings may also facilitate assembly if an interference fit is required for both inner and outer rings (due to the load relationship).

- If Cylindrical roller bearings with an NF or NJ configuration are used at both ends of a shaft, axial clearance must be prevented from becoming too small. Referring to Fig. 8.20, make width B (inner ring spacer) larger than the distance A between the outer rings.

- If the amount of shaft expansion is small (due to small temperature rise or short shaft), and precise axial location is not needed then two units of non-separable configuration bearings may be used with both units having floating axial movement. In such cases, assemble the two units with axial clearance on both ends of the assembly. See Fig. 8.21. For mounting of two Deep-groove ball bearing pillow blocks with spherical outer ring bearing surfaces, lock and bolt the first pillow block into position, then lock the second block to the shaft. Pull the second block away from the first block while tightening the mounting bolts. Where axial expansion can not be handled by the clearance within the bearings, please consult NACHI.

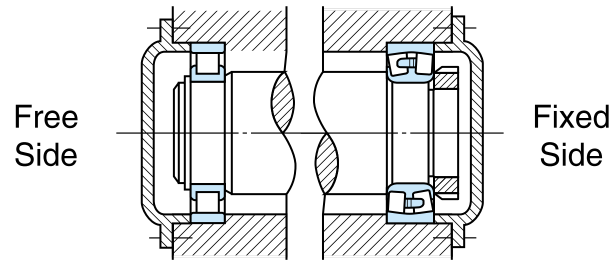


Fig. 8.19 N-Configuration Cylindrical Roller Bearing as Free Bearing

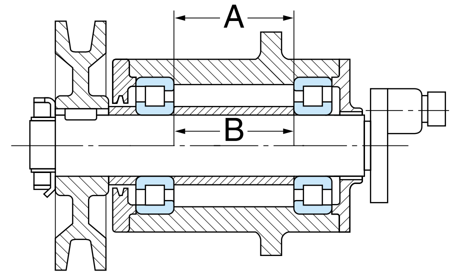


Fig. 8.20

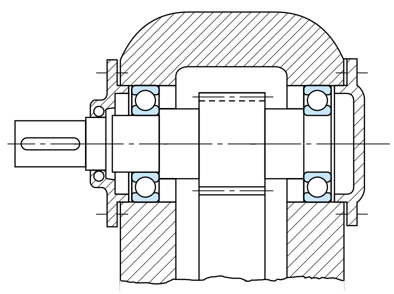


Fig. 8.21

• Pairs of single-row Angular Contact ball, or Tapered roller bearings are often used for axial positioning. When bearing spacing is large, axial expansion from temperature rise is best handled using an assembly as shown in Fig. 8.22, where the paired bearings take axial and radial loads and another bearing (in the Figure, an NU-configured Cylindrical roller bearing), permits linear shaft expansion.

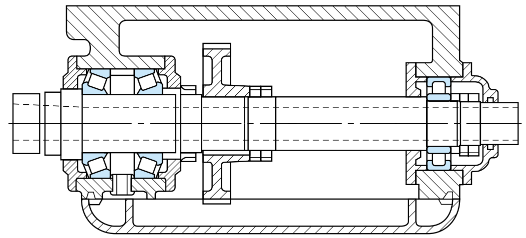


Fig. 8.22

• When using horizontally-split pillow blocks as the fixed side bearing, the outer ring is located by using one or two positioning rings. When one ring is used, place it to the side of the adapter nut as shown in Fig. 8.23. When two positioning rings are used, place one on each side of the bearing (also see Fig. 8.23). To use a horizontally-split pillow block as the floating side bearing, mount the bearing without positioning rings.

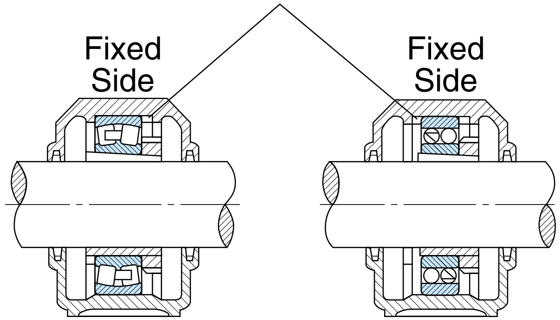


Fig. 8.23

• Determine the position of the fixed bearing by considering the machinery application and the balance of rated life of the individual bearings. For example, when a bevel gear is used (see Fig. 8.24), set the bevel gear side as the fixed side to maintain the accuracy of the gear engagement. For electric motors, the fixed side bearing is often positioned on the non-driving side where a lower amount of radial load is applied, in order to equalize the bearing equivalent load and rated life between the two bearings.

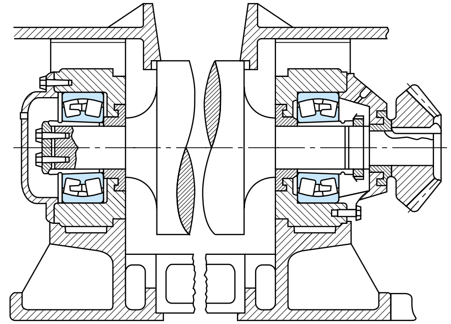


Fig. 8.24

8.4 Sealing Devices

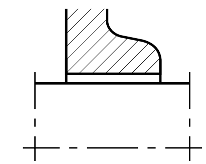
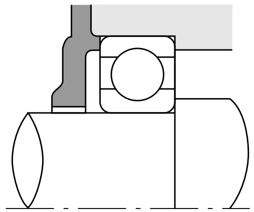
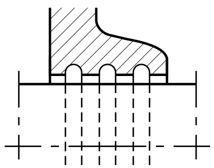
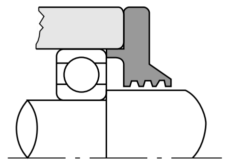
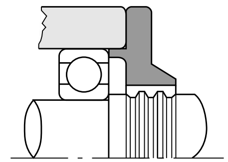
8.4.1 Sealing Device Requirements

- Must effectively stop foreign material intrusion.
- Must not create excessive frictional loss or heat.
- Must be easy to mount, dismount, and maintain.
- Must be inexpensive.

The lubrication method and sealing devices used must be compatible and appropriate for the application.

Integrally-sealed or shielded bearings may need separate, additional sealing devices if they are to be operated in an adverse atmosphere.

- Linear gap (simple gap type)
- Coaxial groove (oil groove type)
- Threaded groove
- Slinger type
- Slinger type (for oil lubrication)
- Radial labyrinth type
- Axial labyrinth type
- Self-aligning type labyrinth
- Seal ring type (felt, leather, rubber, plastic)
- Adjustable Seal type (includes metal packing O-ring, etc)
- Oil seal Type

<table>
<tr><th colspan="2">Type of Sealing Device</th><th>Design Example</th><th>Design Precautions</th></tr>
<tr><td>Linear gap
(simple gap
type)</td><td></td><td></td><td rowspan="3">1) Clearance between shaft and bearing housing
<table><tr><th>Shaft dia. (mm)</th><th>Radial clearance (mm)</th></tr><tr><td>50 or less</td><td>0.25 ~ 0.4</td></tr><tr><td>50 Over 200 Incl.</td><td>0.5 ~ 1.5</td></tr></table>
2) Groove dimensions
Width: 3 to 5 mm
Depth: 4 to 5 mm
3) Where possible, provide three grooves or more.
4) Fill grooves with grease to aid in sealing out foreign material.
5) The threaded grooves type is applicable to oil lubricated, applications where the shaft is horizontal and operates in a constant rotational direction. Thread grooves must be reverse to the rotation direction.
6) Oil grooves are used alone only where preventional oil relatively clean.
Oil grooves are for preventing oil leaks and are generally used in combination with other sealing devices.</td></tr>
<tr><td>Coaxial groove
(oil groove
type)</td><td></td><td>
(a)

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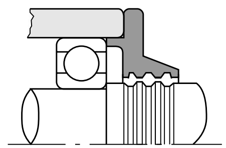
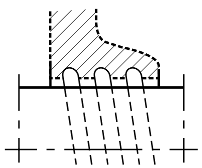
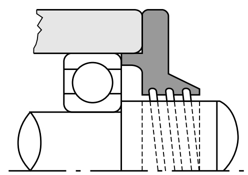
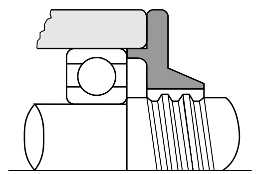

(c)</td></tr>
<tr><td>Threaded
groove</td><td></td><td>
</td></tr>
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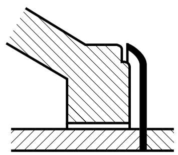
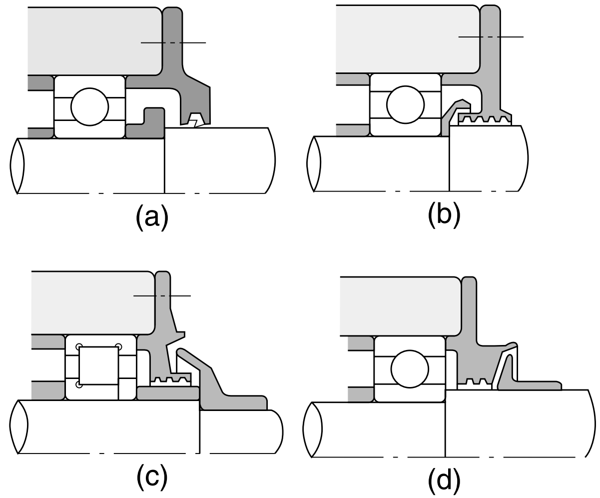
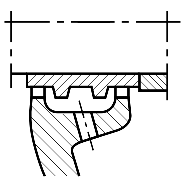
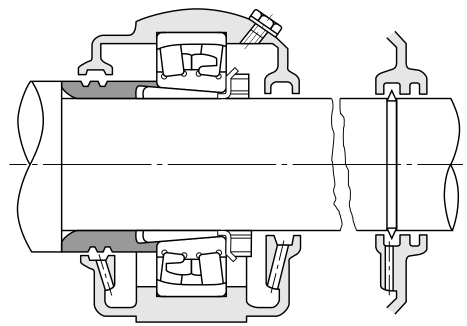
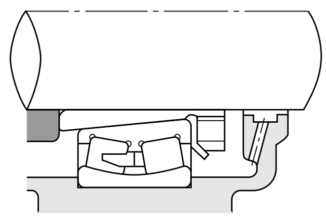
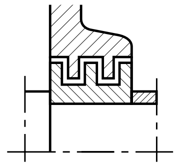
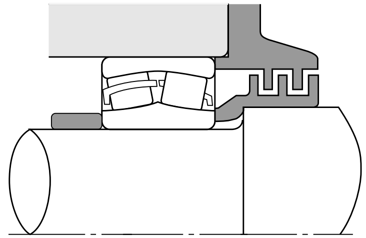
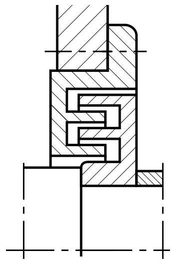
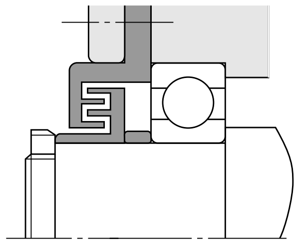
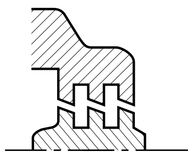
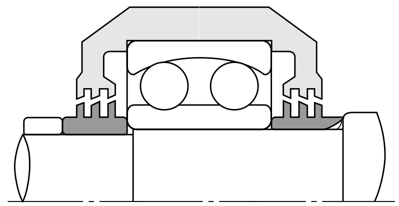
Type of Sealing Device		Design Example	Design Precautions
Slinger type			1) Seal types that sling oil, prevent oil leakage and dust entry through the centrifugal force generated by a rotor attached to the shaft. 2) (a) and (b) are good for preventing oil leakage. 3) (c) and (d) are good for preventing dust and water intrusion.
Slinger type (for oil lubrication)		 A type of slinger 	1) Oil deposited in the grooves returns to the housing.

Type of Sealing Device		Design Example
Radial labyrinth type		
Axial labyrinth type		
Self-aligning type labyrinth		

Design Precautions

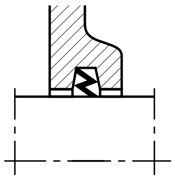
1) Labyrinth Clearance

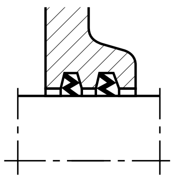
Shaft dia. (mm)	Clearance (mm)	
	Radial	Axial
50 or less	0.25 ~ 0.4	1 ~ 2
50 Over 200 Incl.	0.5 ~ 1.5	2 ~ 5

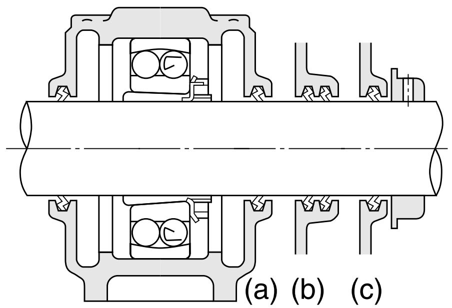
2) Radial and axial labyrinth seals. The radial groove type requires a split housing.
3) These seals are very suitable for the prevention of oil leakage of high speed shafts.
4) For low speed rotation, apply grease to the grooves for better sealing.
5) If angular misalignment exists, use self-aligning type labyrinth.

Type of Sealing Device	Design Example	Design Precautions

Seal ring type (felt, leather, rubber, plastic)







1) Sealing Material Temperature Range

Sealing material	Operating temperature range °C
Nitrile	–25 ~ 100
Acrylic	–15 ~ 130
Silicon	–70 ~ 200
Flourine	–30 ~ 200
Ethylene tetrafluoride	–50 ~ 220
Felt	–40 ~ 120

2) Sealing Material Speed Limits (m/s)

Seal Material	Shaft diameter (mm)		
	to 20	20 to 40	40 and up
Nitrile	4 ~ 8	8 ~ 12	12 ~ 16
Acrylic	4 ~ 12	12 ~ 18	18 ~ 25
Silicon	4 ~ 18	18 ~ 25	25 ~ 32
Flourine	4 ~ 18	18 ~ 25	25 ~ 32
Ethylene tetrafluoride	15		
Felt	3.5 ~ 4.5		

These values apply when shafts have good surface finish, roundness, and run-out.

3) Lubricate the sliding surfaces of seal and shaft.

4) These seal types are mainly applicable to grease lubricated bearings.

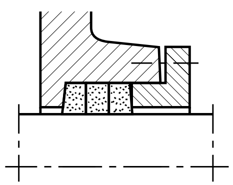
5) Install one to three pieces of felt ring.

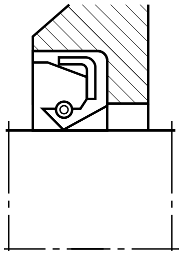
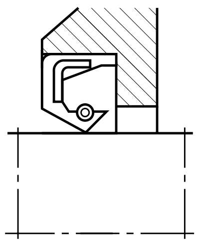
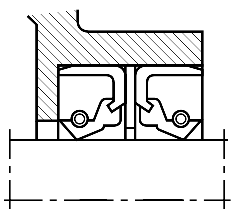
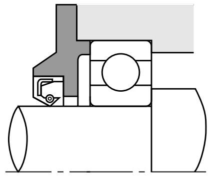
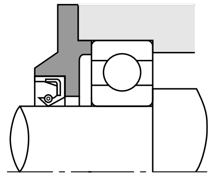
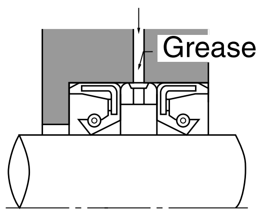
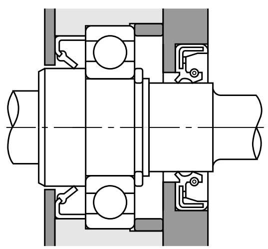
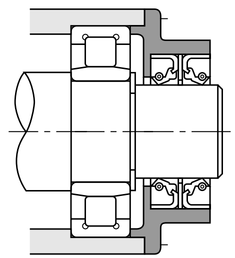
6) For high speed applications, use hard seal material. Coat with mineral oil before mounting and insert tightly.

7) Felt will harden and lose elasticity under high temperature or speed.

8) Felt rings are good for relatively. clean, dust-free conditions. For application in excessively dusty conditions, synthetic rubber rings or additional seal made of synthetic rubber should be used.

Adjustable Seal type (includes metal packing O-ring, etc)



Type of Sealing Device		Design Example
Oil seal Type	  	 (a)  (b)   Example 1  Example 2

Design Precautions

1) Speed and shaft Surface Roughness

Speed (m/s)	Surface Finish	Finish method
to 5	Ra < 0.8μm	Paper finish after grinding
5 ~ 10	Ra < 0.4μm	Paper finish after grinding
10-up	Ra < 0.2μm	Lapping, or superfinishing, or electro polishing after quenching and grinding

2) Seal contact to shaft section should be minimum hardness of HRC40. HRC55 or even higher is desirable.
3) Dimensional tolerance of seal contact to shaft section should be h9 and the counterpart for seal housing should be H8 or H7.
4) Since there are various shapes and materials for seal, select those that meet purposes.
5) Control the shaft eccentricity to under 0.02 to 0.05 mm where possible.
6) Coat the contact surfaces of seal and shaft with lubricant at initial installation.

8.5 Lubrication

8.5.1 Functions of Lubrication

The main purpose of lubricants in rolling contact bearings is to reduce friction and wear of each element. Lubricants perform this function by separating rolling and sliding surfaces with a very thin film of oil. Bearing performance and service life is largely dependent on the suitability of the lubricating system and lubricant to the application. Functions of lubrication in rolling contact bearings are:

① Lubrication of friction surfaces:
Reduction in;
1) Rolling friction between the rolling elements and raceways.
2) Sliding friction between roller end and guide faces of roller bearings.
3) Sliding friction between the rolling elements and retainer.
4) Sliding friction between the retainer and raceway guide surface.

② Removal of the heat from system produced by friction and external sources. An example of the heat removal function would be use of a circulating oil lubrication system for a high-speed application.

③ Dust-proofing and rust prevention:
1) Prevention of foreign material from entering the bearing.
2) Protection of bearing components from corrosion.

④ Relief of stress concentration:
1) Uniform distribution of stress to the rolling contact surface.
2) Relief of impact loads.

8.5.2 Lubrication Cautions

① Adequate lubricant film separation should be maintained between friction surfaces.
② Since the oil film required on contact surfaces is thermally feeble, adequate oil viscosity must be maintained.
③ Since lubricants tend to deteriorate with increase in temperature, bearing applications should be designed to keep the operating temperature as low as possible.
④ The lubricating system (method) must be suitable for the application and the lubricant must have appropriate properties.
⑤ The lubricant must be kept free from contamination.

8.5.3 Lubricating Methods

(1) Oil Lubrication

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(1.1) Oil Bath Lubrication

- Oil bath lubrication is generally used for low-to-medium-speed operation.
- Excessive oil causes churning which can cause excessive temperature rise. Insufficient oil will probably lead to early bearing failure.
- Oil level gauges are recommended to check (and maintain) the proper oil level.
- Separation ribs may be installed at the bottom of the housing to reduce churning and or to dissipate heat. See Fig. 8.25.
- Static oil level should be at slightly below the center of the lowest rolling element of a bearing applied to a horizontal shaft. For vertical shafts, static oil level should cover 50% to 80% of the rolling element.
- When two or more bearings are used on a vertical shaft in the same housing, the lower bearing may create excessive temperature rise if an oil bath system is used (unless operated at very low speed). If excessive heat occurs, use a drip, splash, or circulating oil system.

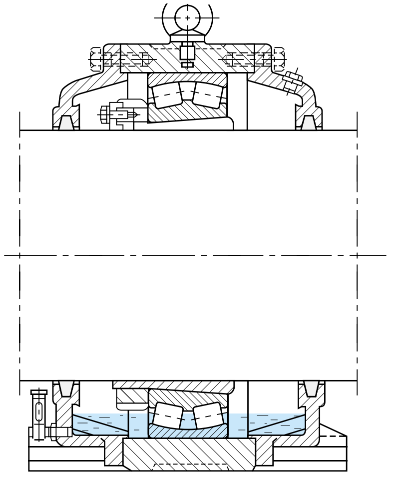


Fig. 8.25

(1.2) Splash Lubrication

- In splash lubrication, oil is splashed on the bearing by a rotating element (an impeller or "slinger") mounted on the shaft. The bearing is not immersed in the oil.
- In a gear box, the gears and bearings are often lubricated from a common oil reservoir with the gears serving as a slinger. Since oil viscosity for the gears may differ from that required for the bearings and the oil may contain particles worn from the gears, a separate lubrication system or method may provide improved bearing life. Sealed or shielded bearings and "magnetic" plugs are often used in conjunction with gear drives.
- A bearing on a vertical shaft can be provided with a conical rotary element under the bearing so that the oil rises on the conical surface and is atomized before entering the bearing. See Fig. 8.26.

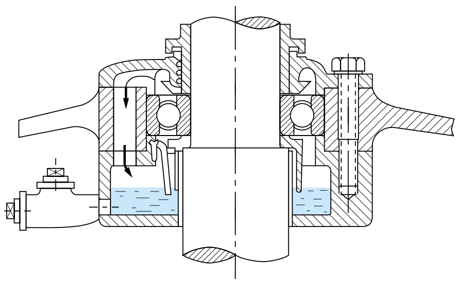


Fig. 8.26

(1.3) Drip Lubrication

- Drip lubrication is used for bearings operated at relatively high speeds under low-to-medium loads.
- Drip lubrication is generally used for the radial bearing on a vertical or inclined shaft and oil is fed directly to the bearing.
- The lubricating oil is contained in a lubricator, and is fed to the bearing through a wick which also serves as a filter. A sight window is provided to allow checking the oil level.
  Fig. 8.27 shows a drip lubricating system provided with a lubricator on top of the housing. Oil is dripped onto the shaft nut in the bearing box, and is atomized before entering the bearing.
  Fig. 8.28 shows an oil metering system designed to feed several oil drops per minute to the bearing.

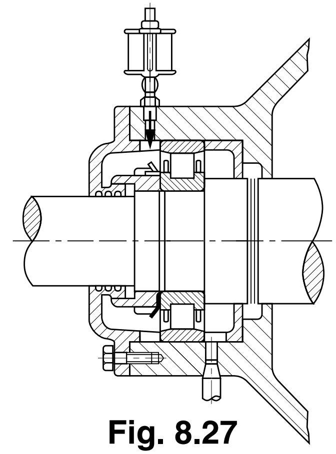


Fig. 8.27

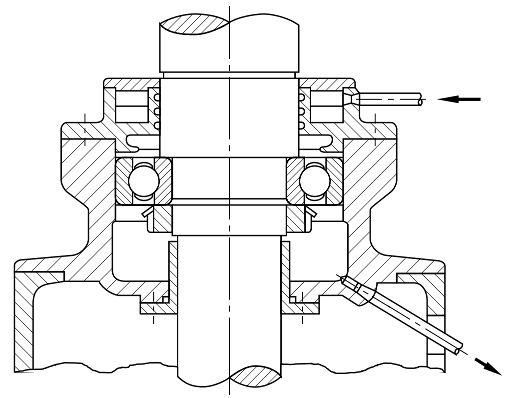


Fig. 8.28

(1.4) Circulating Oil Lubrication

- Circulating oil lubrication is used for two purposes:
  1) To cool the bearing.
  2) To automatically feed oil to a specific area from a central system.
- A circulating oil system consists of an oil pump, cooling device, filter and delivery piping. Circulating oil systems utilize the pumping action of the bearings and augment the cooling effects of slingers.
- Circulating oil lubrication includes: drip, forced, and spray-mist lubrication.
- In the circulating oil lubricating system, the bearing is provided with an oil inlet located on one side of the bearing, and an oil outlet on the other side of the bearing.
- The oil outlet should be larger than the oil inlet so that excess oil does not remain in the bearing housing.
  Fig. 8.29 shows a circulating system with an oil passage in the area of the housing which carries no load. This system is for steam-heated calender rolls in a paper mill. Cooled oil is circulated through the inner wall of the housing and passes through both bearings.

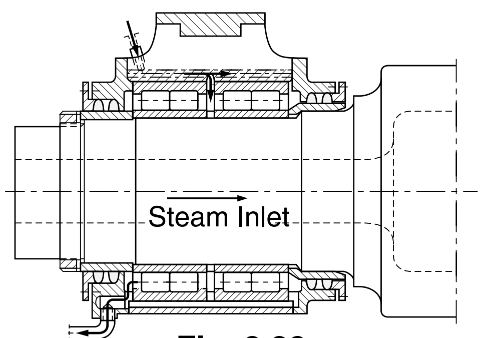


Fig. 8.29

(1.5) Forced Lubrication

Forced lubrication is used to feed oil under pressure to overcome internal housing pressure in high-speed operation.

- The oil outlet should have a cross section twice that of the oil inlet.
- A "jet" lube system is sometimes used in high-speed applications to target oil directly to the rolling and sliding components of the bearing. See Fig. 8.30. Excessive oil should be discharged with a pump.

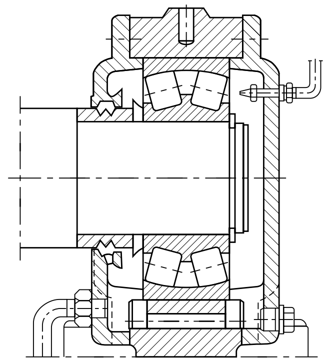


Fig. 8.30

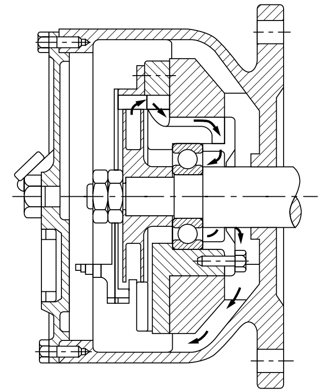


Fig. 8.31

(1.6) Disk Lubrication

Disk lubrication utilizes a disk on the shaft which rotates at high speed. The disk is partially submerged in oil, and splashes oil to an upper oil sump, which in turn delivers the oil to the bearing by gravity. Disk lubrication is used on the bearings of superchargers and blowers. See Fig. 8.31.

(1.7) Spray Mist Lubrication

- Fig. 8.32 shows an example of spray lubrication, which uses a turbo-compressor impeller to force oil into the bearing.
- Fig. 8.33 shows an example of oil mist applied to an oil atomizer (0.5 to 5.0 cc/h).

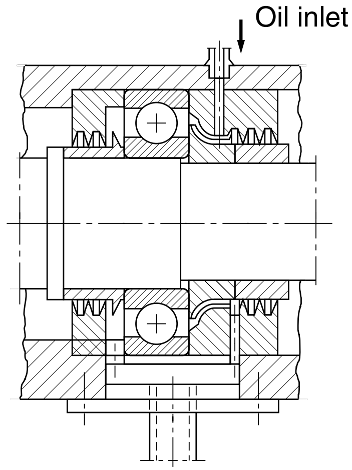
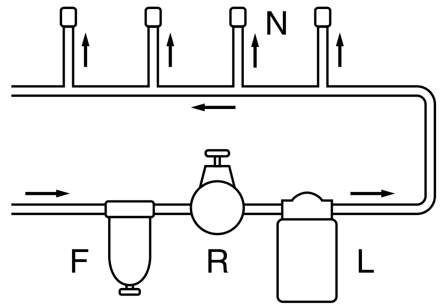


Fig. 8.32



F : air filter R : pressure regulator
L : oil atomizer N : nozzle

Fig. 8.33

(1.8) Oil/Air Lubrication

Using the oil/air lubrication, a very small amount of oil is mixed with a certain amount of compressed air with a constant-quantity piston and mixing valve. This mixture is supplied to rolling part of bearings.

Because oil/air lubrication can remove heat generation from bearings, this method is suited for high speed application such as machine tool.

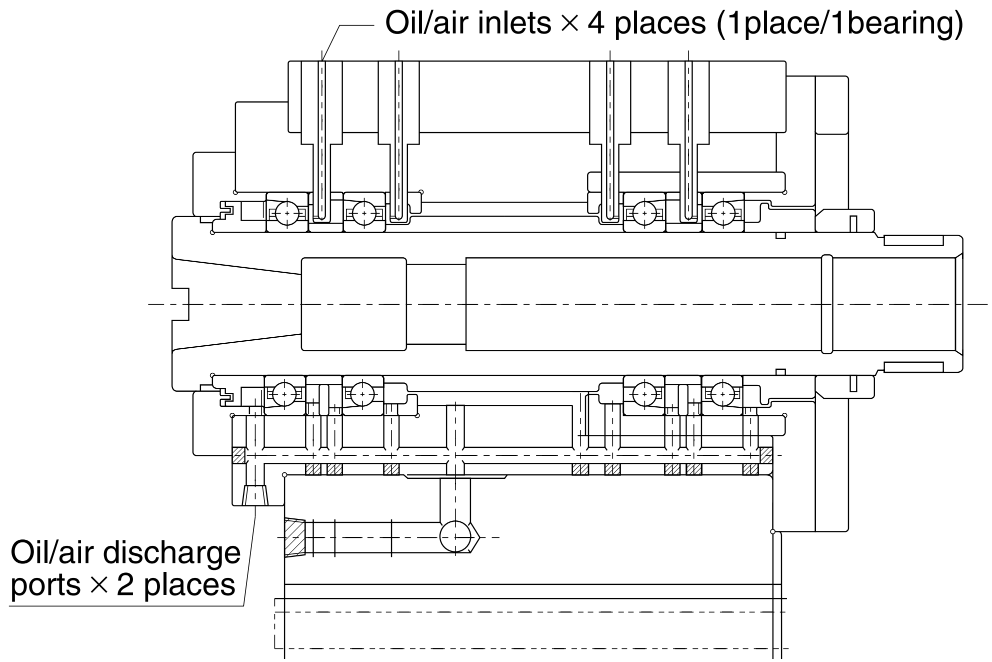


Fig. 8.34

(2) Grease Lubrication

In using grease lubrication, the following items should be considered:

- Select grease having correct properties.
- Grease must be delivered in the right amount to the correct bearing area.
- Determine method of relubrication. Different greases should not be mixed because it can cause a poor lubrication performance.
- Consider centralized lubrication for large-size machinery such as rolling mill equipment. See Fig. 8.35.1.

Fig. 8.35.2 shows a design utilizing a grease supply plate. Symbols S, R, and Z refer to the nozzle, oil groove, and supply plate, respectively.

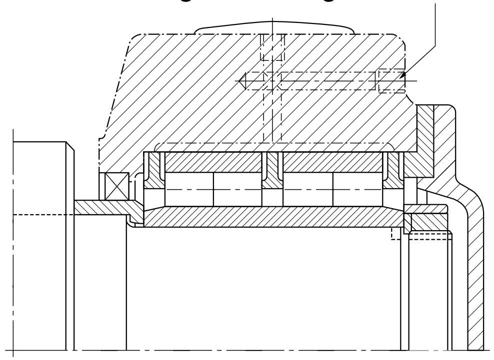


Fig. 8.35.1

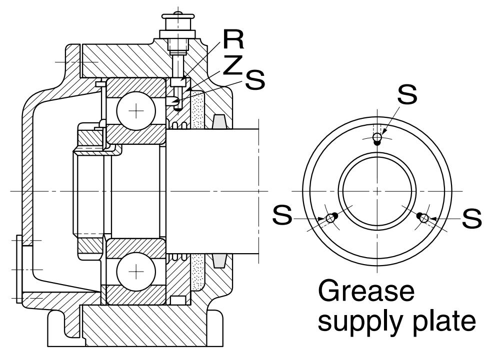


Fig. 8.35.2

8.5.4 Lubricants

Rolling contact bearings use two forms of lubricants; lubricating oil and grease. In some special applications, solid lubricant such as molybdenum-disulfide, graphite, or PTFE are used. The lubricant should have the following properties:

- Low impurity and moisture content
- Temperature stability
- Non-corrosiveness
- Load pressure resistance
- Anti-wear action
- Anti-friction action
- High mechanical stability

See Table 8.22 for a guide to selection of lubricating oil and grease.

Table 8.22 Guide to selecting Oil and Grease

Operating Condition	Grease	Oil
Temperature	Available for range of -30° to $+150^\circ$	Applicable for high temperatures (with circulating cooling)
Speed	Low to medium speeds	Applicable for high speed operation (depending on lube method)
Load	Low to medium loads	Suitable for high loads
Housing Design	Simple	Complicated by sealing requirements
Maintenance	Easy	Easy to difficult
Centralized Lubrication	Possible	Possible
Dust Filtration	Dependent on seal devices.	Possible (Circulating lubrication provides a filter to trap dust)
Rolling Resistance	Relatively high	Small (Correct oil quantity must be maintained)

A wide variety of lubricating oils and greases are commercially available for rolling contact bearings. It is important to select oils or greases with base oils having a viscosity which is appropriate for the operating condition.
Table 8.23.1 and 8.23.2 give generally recommended viscosities for bearings under normal operating conditions.

Table 8.23.1 Bearing types and Proper Viscosity of Lubricating Oils

Bearing Type	Viscosity at Operating Temperature
Deep Groove Ball Cylindrical Roller	Over 13 mm^2/s
Tapered Roller Spherical Roller	Over 20 mm^2/s
Spherical Roller thrust	Over 32 mm^2/s

Remarks: 1mm^2/s = 1cSt (centistokes)

Table 8.23.2 General Oil Selection Guide

(1) Lubricating Oil
Oils with a viscosity too low for the application may allow a partial loss of raceway to rolling element separation, leading to early bearing failure. Oils with too high a viscosity will cause an increase in torque, resulting in power loss and abnormal temperature rise. In general, as the load increases, increase the oil viscosity. As speed of rotation increases, decrease the oil viscosity.
For Extra-small or Miniature ball bearings, low-viscosity lubricating oil will often be selected for low-torque requirements.
Table 8.23.2, and Fig. 8.36 on following pages can be used to aid in selection of appropriate oil viscosity.

Fig 8.36 Viscosity-Temperture Line Diagram

Table 8.23.2 General Oil Selection Guide

Bearing Operating Temperature (°C)	dn value	ISO Viscosity grade (VG) of lubricating oil		Suitable bearing type(s)
		Normal load	Heavy or impact load	
−30 ~ 0	Up to speed limit	22 32	46	All
0 ~ 60	Up to 15000	46 68	100	All
	15000 ~ 80000	32 46	68	All
	80000 ~ 150000	22 32	32	Except thrust ball bearing
	150000 ~ 500000	10	22 32	Single row deep groove ball and cylindrical roller bearing
60 ~ 100	Up to 15000	150	220	All
	15000 ~ 80000	100	150	All
	80000 ~ 150000	68	100 150	Except thrust ball bearing
	150000 ~ 500000	32 46	68	Single row deep groove ball and cylindrical roller bearing
100 ~ 150	Up to speed limit	320		All
0 ~ 60	Up to speed limit	46 68		Spherical roller bearings
60 ~ 100	Up to speed limit	150		

Remarks: 1. This Table shows the guide for selecting oil, based on JIS K 2001 classification of Industrial Lubricating Oil Viscosity.
2. Generally as load increases or speed decreases, viscosity is increased.
3. This Table is applicable for oil bath lubrication and circulating oil lubrication.
4. For information on operating conditions beyond those of This Table, contact NACHI.

Fig 8.36
Viscosity-Temperture Line Diagram

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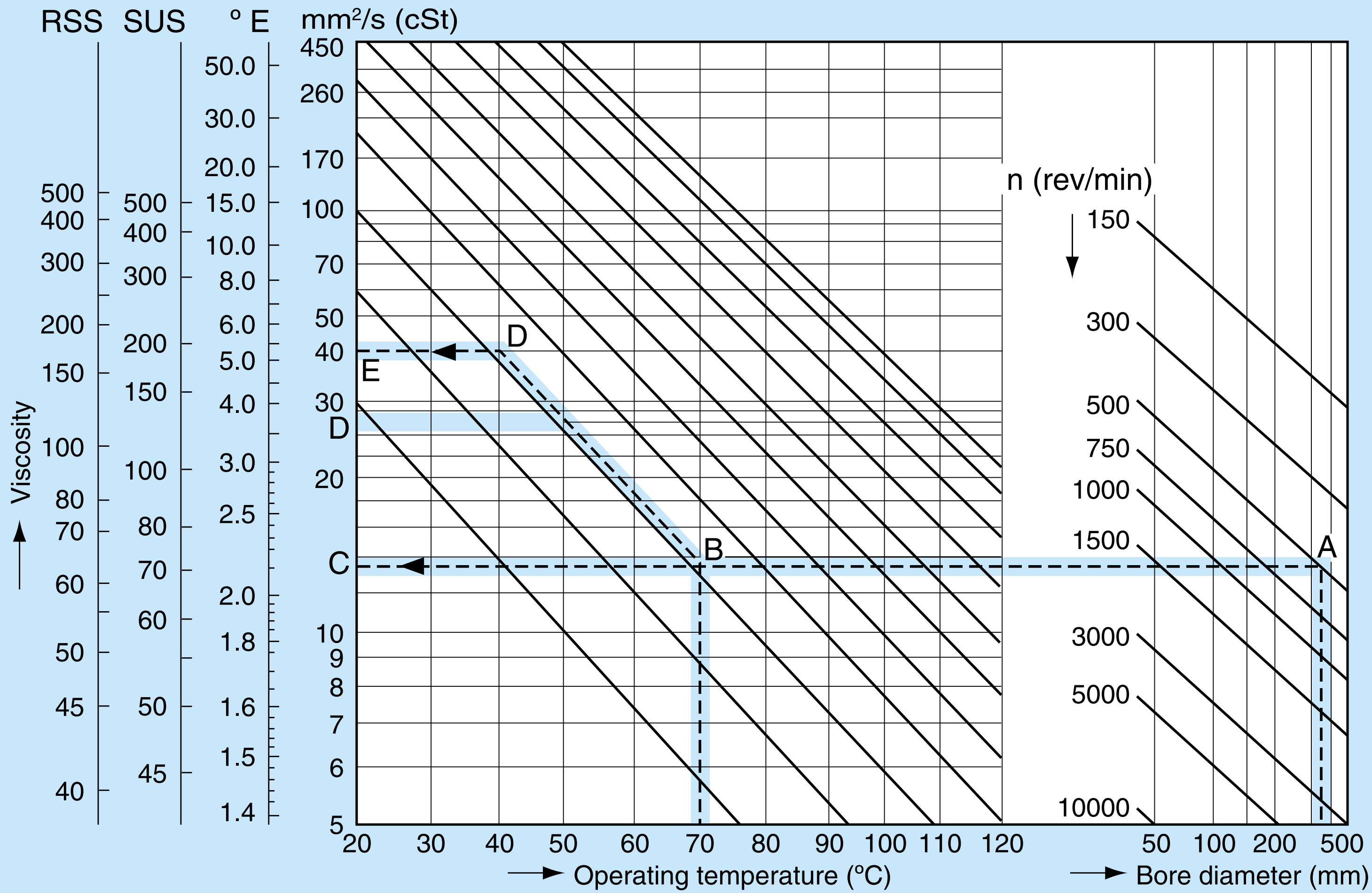


Example:

Bearing Type : Cylindrical roller bearing
Bearing Bore : 340mm
Rotating Speed : 500rpm
Operating temp : 70 °C

Fig. 8.36 can be used to select both the correct minimum viscosity at operating temperature and to establish the required oil viscosity rating (at 40°C) which will meet the specified minimum viscosity .
Find the intersection of 340 and 500 (see point A) and an horizontal line from point A to point C (intersection of Y-axis)
To find the minimum viscosity required AT THE OPERATING temperature: read the minimum viscosity required ($13mm^2/s$) at point C.

To establish the required oil viscosity rating ;

1) At the intersection of A - C and a vertical line from 70 (point B), draw a line toward the 40° -axis line parallel to the closest viscosity-temperature line.
2) Draw a horizontal line from the point (point D) of intersection of the above line with the 40° -axis to the Y-axis (see point E).
3) Read the viscosity $40mm^2/s$ at point E. As a result, ISO viscosity grade VG46 should be selected.

(2) Lubricating Grease

Lubricating grease is composed of a base oil, a thickener, and additives.

• Base Oil

Base oil refers to the liquid lubricant carried by a thickener. Mineral oils are widely used as the base oils for grease. Synthetic oils such as diester or silicone oil are also used for improving the heat resistance and stability of grease. In general, grease with a low-viscosity base oil is suitable for low temperatures and or low loads, while grease with a high viscosity base oil is suitable for high temperatures and or high loads.

Since lubricating performance is dependent on the thickener, additives, and viscosity, these components must be carefully selected to meet operating conditions.

• Thickener

The thickener has a sponge-like structure composed of a loose combination of fine fibers or particles. Thickeners are roughly divided into metal soap, and non-soap types as shown below.

Sodium (Na) soap grease may react with water to form an emulsion, and should not be used for bearings operating in a high-moisture atmosphere.

THICKENER
- Metal soap: Ca, Li, Na
- Non-soap
  - Heat resistant organic base: Polyurea & Fluorides
  - Inorganic base: Silica gel and organic bentonite

• Additives

An additive is an agent that provides extreme pressure and rust resistance, anti-oxidation performance, and other properties to grease.

Various additives are added to grease to provide specific properties to the grease. Additives such as anti-oxidants, extreme pressure enhancers, and rust preventatives are often added to lubricating greases.

Anti-oxidant additives protect grease from oxidation and deterioration under thermal influence over a long period. Extreme pressure additives improve load resistance and impact resistance. Rust preventive additives protect the bearing and other surrounding components against rusting.

• Penetration

Penetration is a measure which indicates the solidity of grease. A measurment device has a cone with a specified weight and shape. The cone is penetrated into the sample grease for a specified time. Penetration is the depth to which the cone penetrates (in units of 1/10 mm).

• Dropping Point

Dropping point is the temperature at which a grease sample drops through a specified hole size after being heated and fluidized.

Table 8. 24 Grease Number and Penetration

NLGI No.	ASTM Worked penetration
0	355 ~ 385
1	310 ~ 340
2	265 ~ 295
3	220 ~ 250
4	175 ~ 205
5	130 ~ 160
6	85 ~ 115

Grease is numbered differently by the grease manufacturers. Numbers 250 and 300 of cup and fiber grease generally use penetration (at 25°C), while most versatile greases employ NLGI penetration numbers such as 0, 1, and 2.

(3) Lubrication Amount

① Oil

When oil bath lubrication is being used and a bearing is mounted with its axis horizontal, oil should be added until the static oil level is at the center of the lowest bearing rolling element. For vertical shafts, add oil to cover 50% to 80% of the rolling element.

② Grease

The rolling bearing and bearing housing should be filled until the grease occupies about 33 to 50 % of the respective volumes. Temperatures will tend to rise as speed increases (due to churning). Higher-speed operation will be more sensitive to excess grease fill, so it follows that at higher dmn values, the grease-fill quantity must be reduced.

a) Amount of Initial Grease Fill

The amount of initial grease-fill required is calculated from the following equations:

Ball bearing:

$$Q = \frac{d^{2.5}}{900} \qquad \cdots\cdots (8.18)$$

Roller bearing:

$$Q = \frac{d^{2.5}}{350} \qquad \cdots\cdots (8.19)$$

where:
- Q =Amount of filling grease (g)
- (specific gravity of grease=0.9)
- d =Bore diameter of bearing (mm)

b) Relubrication Amount Added at Service

$$Q = 0.005 \times D \cdot B \qquad \cdots\cdots (8.20)$$

where:
- Q =Amount of grease to add (g)
- (specific gravity of grease=0.9)
- D =Outside diameter of bearing (mm)
- B =Inner ring width (mm)

③ Lubrication Interval

For a typical bearing, which operates at about 50°C, lubricant should be replaced once a year. If operating temperature is 100°C or more, the lubricant should be replaced more than once every three months even if it has good heat stability.
If oil bath lubricant becomes contaminated by water or foreign particles, it must be replaced immediately.
The grease relubrication interval can be estimated from Fig 8.37.

Fig. 8.37 Grease lubrication interval

④ Grease Service Life

For applications where relubrication is not possible or practical, grease service life may be estimated using Formula (8.21).
The following formula was derived using a grease with Lithium thickener and mineral oil base.

$$\log L = (0.018f - 0.025)T - 2.77f + 6.3 \quad \cdots\cdots\cdot \ (8.20)$$

where:
- L =Grease life (h)
- f =(Operating speed) (rpm)/(Bearing grease speed limit) (rpm)
  If f is less than 0.25, f is set = 0.25
- T =Operating temperature (°C)

If T is less than 30°C, T is set = 30.

Table 8.25 Grease Properties

Fig. 8.37
Grease lubrication interval

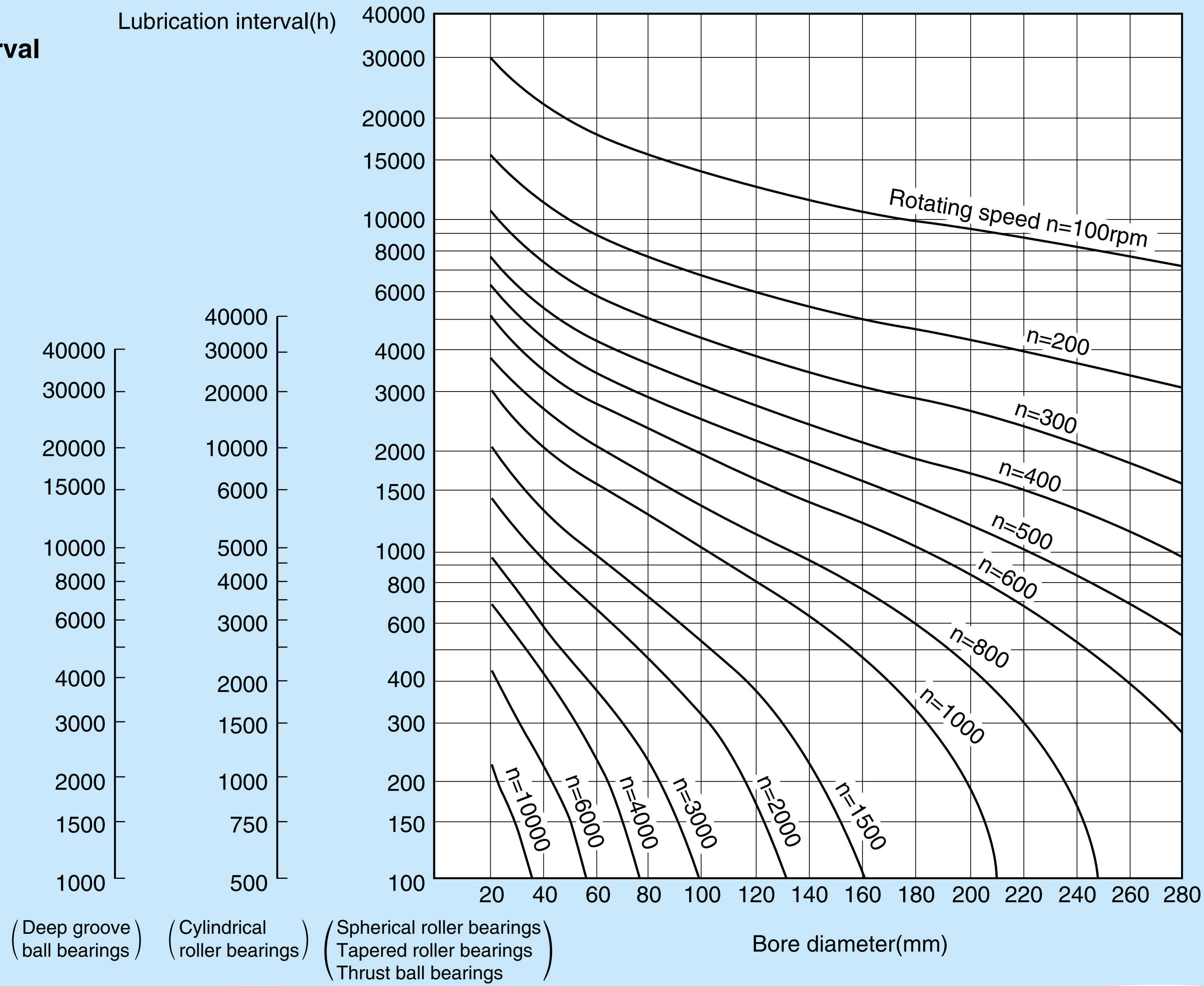


Table 8.25 Grease Properties

Popular Name / Thickener / Base Oil / Properties	Cup Grease	Fiber Grease	Aluminum Grease	General -purpose Grease	Diester Grease	Silicone Grease	Mixed Base Grease	Complex Grease	Non-Soap Base Grease	
Thickener	Ca Soap	Na Soap	Al Soap	Li Soap			Ca + Na Soap, etc.	Li Complex Soap, etc.	Bentonite, Urea Fluoric, etc.	
Base Oil	Mineral Oil	Mineral Oil	Mineral Oil	Mineral Oil	Diester Oil	Silicone Oil	Mineral Oil	Mineral Oil	Mineral Oil	Synthetic Oil
Dropping Point (°C)	85	160 or Higher	85	170 or Higher		200 or Higher	150 or Higher	200 or Higher	250 or Higher	
Working Temperature (°C)	–20 ~ +70	–10 ~ +120	–10 ~ +80	–30 ~ +120	–50 ~ +130	–50 ~ +170	–30 ~ +120	–30 ~ +140	–10 ~ +130	–50 ~ +200
Water Resistance	Good	Poor	Good	Good			Poor for Na Soap	Good	Good	
Mechanical Stability	Fair	Good	Fair	Good			Good	Good	Good	
Remarks	Contains small amount of moisture for structure stability Not suitable for use at high temperature	Can not be used with water or moisture due to emulsification with water Used at relatively high temperature	Used in vibrating condition due to good tackiness	General purpose grease widely used small or medium size ball bearings	Suitable for low temperature operation	Wide working temperature range Mainly for light load conditions.	Used in large size bearings	Suitable for high temperature and heavy load conditions	Wide working temperature range Depending on combination of thickener and base oil used, good high temperature, low temperature or chemical stability can be obtained	

Note: 1. Greases with sodium (Na) soap thickener can not be used in applications there is a risk of water or high humidity because they became soft and flow out if they mix with water.
2. In case of mixing different brands of grease (not recommendable), please consult grease manufacturer to determine if there are any detrimental effects.
3. In case operating temperature are beyond what is shown in the table, please consult NACHI.

8.6 Speed Limit

- Bearings exceeding a certain operating speed will begin to create internal heat which may not be controllable.
- Speed limits vary with bearing types, dimensions, lubrication system, internal design of the bearing, and working loads. In addition, speed limits will vary according to the type of integral bearing seal which may be used (dependent on the speed of the seal contact area).
- The term "speed limit" refers to the estimated speed, in revolutions per minute, at which bearings will remain serviceable.

The dimension tables show speed limits for both grease and oil lubrication. Please note that the published speed limits are based on operation of properly lubricated, lightly-loaded bearings, installed on a horizontal shaft.

8.6.1 Speed Limit Correction for Load

As noted above, bearing speed limits will vary with respect to load. Figs. 8.38.1 and 8.38.2 allow calculation of a speed limit correction factor which is applied to the speed limit tables.

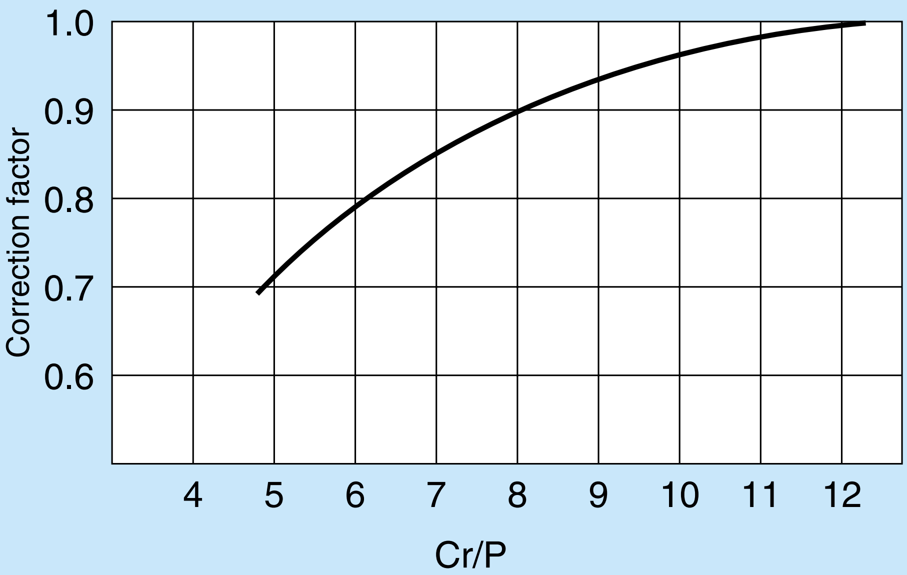
- In Fig. 8.38.1, Cr is the basic dynamic load rating and P is the equivalent dynamic load. If Cr/P is < 13, then the table speed limit is multiplied by the correction factor from the curve shown in Fig. 8.38.1.
- In addition, if the ratio of the axial load (Fa) to the radial load (Fr) is larger than 0.3, that is, if $Fa/Fr > 0.3$, then the speed limit must be FURTHER multiplied by a correction factor as shown in Fig. 8.38.2
- Where the bearing is used at 75% or more of the speed limit, lubrication becomes a more sensitive operating consideration. If grease is to be used, then selection of the correct type and amount of grease is of paramount importance. If oil is used, then the correct selection of the feeding method and rate, and oil specification is of extreme importance.
- Please contact NACHI for help in cases where application rotating speed exceeds the corrected bearing speed limit.
- If the bearing is used in excess of the corrected speed limit, consideration must be given to the accuracy and clearance of the bearing; and to the material and shape of the retainer. Table 8.26 provides a guideline for maximum speed for bearings using special cages and internal design.

Table 8.26
Correction of Allowable Speed Limit in High-speed Operation

Bearing type	Correction Factor
Deep groove ball	2.5
Angular Contact ball	2
Cylindrical roller (single-row)	2.5
Tapered roller	2
Spherical roller	1.5

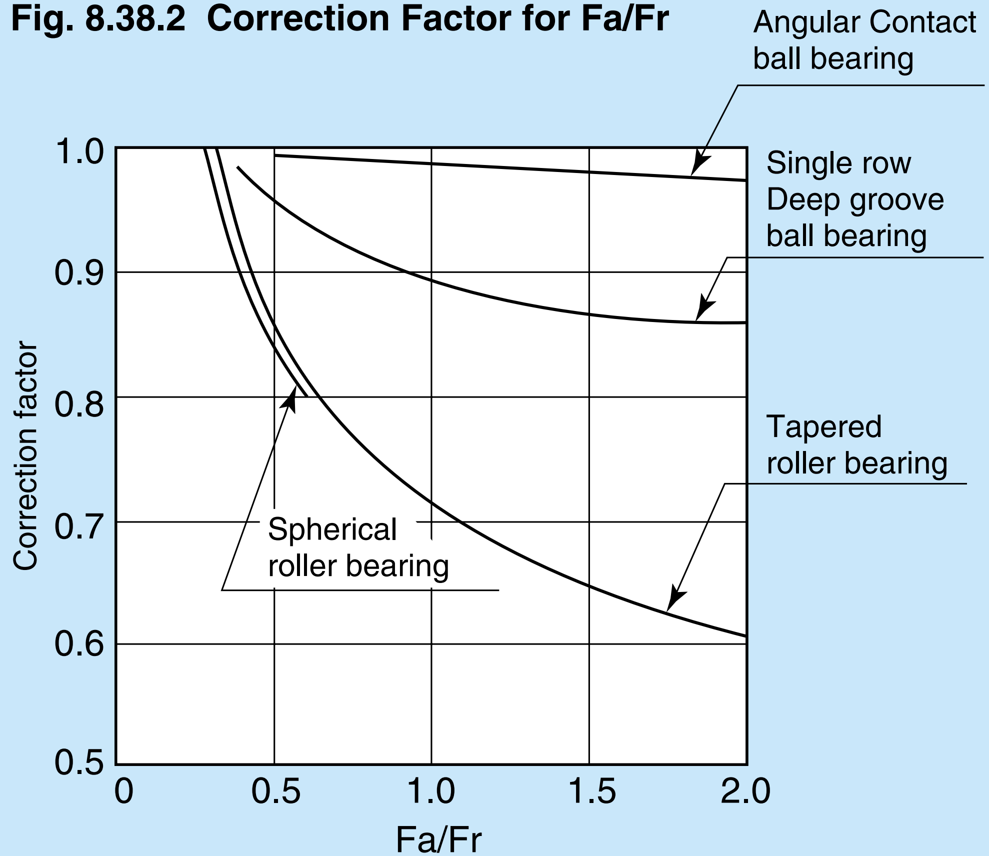
Fig. 8.38.1 Correction Factor for Bearing Load
Fig. 8.38.2 Correction Factor for Fa/Fr

Fig. 8.38.1 Correction Factor for Bearing Load



Cr: Dynamic load rating (N)
P : Dynamic equivalent load (N)

Fig. 8.38.2 Correction Factor for Fa/Fr



Fa : Axial load (N)
Fr : Radial load (N)

8.7 Friction and Temperature Rise

8.7.1 Friction Torque

Friction torque in rolling bearings will vary with the bearing load and the condition of the lubricant.
Where the bearing load is light-to-normal ($P \leq 0.12C$) and the lubricant provides good separation between the rolling contact surfaces, bearing friction torque may be calculated using the following formula:

$$M = \mu \cdot F \cdot \frac{d}{2} \qquad \cdots\cdots (8.22)$$

where:
M = friction torque (N·mm)
μ = coefficient of friction
F = bearing load (N)
d = shaft diameter (mm)

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The coefficient of friction for various bearing types is shown in Table 8.27.

Table 8.27 Coefficient of Friction

Bearing type	Coefficient of friction (μ)	Load condition
Ball Bearings: Single row deep groove	0.0010 ~ 0.0015	Radial load
Single row angular contact	0.0012 ~ 0.0018	Radial load
Self-aligning	0.0008 ~ 0.0012	Radial load
Thrust	0.0010 ~ 0.0015	Axial load
Roller Bearings: Cylindrical	0.0008 ~ 0.0012	Radial load
Spherical	0.0020 ~ 0.0025	Radial load
Spherical thrust	0.0020 ~ 0.0025	Axial load
Tapered	0.0018 ~ 0.0025	Radial load

8.7.2 Temperature Rise

- Temperature rise in bearings is caused by the conversion of friction energy into heat.
- Bearing temperature will generally rise quite abruptly during the initial stage of operation and then gradually climb until a steady state is reached. The steady state condition will exist if temperature rise from frictional energy is removed by the cooling "heat-sink" effect from the shaft and housing, and from heat conductance via the shaft, housing and lubricant.
- The time until equilibrium is attained depends on the difference between heating volume generated by the bearing and the heating volume removed by the cooling effect.
- If the equilibrium temperature is excessively high, then review of the bearing application should be done. The bearing internal clearance or preload, fits, bearing support structure, seal contact area surface finish, rotating speed, load, and lubrication type, amount, and delivery system are subjects for investigation where excessive temperature occurs.
- An abnormal temperature rise can cause a spiraling condition where no equilibrium will occur, thus leading to a break-down in the lubricant and lubricant film, with catastrophic results.

8.8 Mounting and Dismounting

Rolling bearings have higher accuracy than other parts in most equipment and are often considered to be the most important rotating component. Improper handling of bearings reduces machine accuracy and can cause early bearing failures. To attain predicted bearing performance, utmost care should be taken in handling bearings from the point-of-receipt through the mounting operation.

8.8.1 Storage and Handling

The major problems encountered during the bearing storage and retrieval operations are in rusting and impact damage to the parts.

- To protect bearings against rusting during storage, parts should be placed in a dry, clean, cool area. Bearings should not be subjected to extremes of humidity during storage.
- Impacts to bearings can create damage to the raceways, rolling elements, and cages. Do not drop bearings. Bearings which are dropped should not be used for service.

8.8.2 Mounting

Proper bearing mounting governs the life, accuracy, and performance of a bearing. Before mounting the bearing, carefully check the following points.

Check to see if:

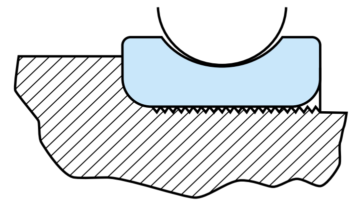
- the job standards are established and the necessary jigs are prepared.
- the shaft and housing size, tolerance, and finish are defined and met.
- lubricant type and amount specified is at hand.
- inspection standards are established.
- the method of cleaning the bearing and relevant parts is clear.

(1) Mounting Precautions

- Select a clean, dry place to handle the bearing, and keep necessary tools and workbench clean.
- Do not unpack the bearing until it is to be mounted.
- If the bearing is unpacked before mounting for acceptance inspection or for any other reason, follow these directions:

  a) If the bearing is to be mounted within a short time period, coat it with rust preventive oil and place it in a clean container.
  b) If the bearing will not be mounted in a short time, coat it with rust preventative oil and repack it in the original container.

- Check to see that the lubricant drums, cans, tubes, or applicators are clean and or closed. Check to be sure that the bearing housing is clean and free from flaws, impressions, burrs, or any other defects.
- For grease lubrication, you may fill the new bearing with grease without cleaning the bearing. If the bearing is small or is used for high-speed operation, whether it is lubricated with oil or grease, wash the bearing with clean kerosene or warm, light oil to remove the rust preventative. However bearings with seals or shields must not be washed and heated.
  If gear oil is used for lubrication, clean the bearing to remove any rust preventive oil.

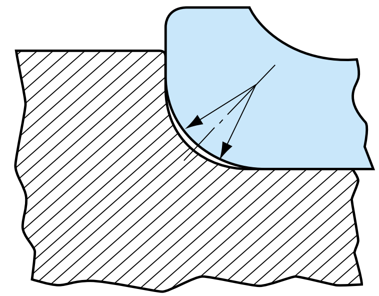


Surface finish

Fig. 8.39

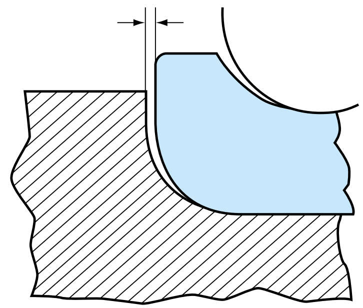
(2) Shaft

- Before mounting the bearing on the shaft, check to see that the shaft is finished to the specified size and accuracy.
- Check the shaft for surface finish. If the shaft fit surface has a poor surface finish (see Fig. 8.39), the surface may be smoothed during mounting, possibly resulting in bearing ring creep, shaft wear, and early bearing failure.
- Be sure that the shaft shoulders are finished at a right angle to the shaft axis, otherwise the bearing will be misaligned resulting in early bearing failure.
- Finish the corner radius of the shaft to the specified dimensions. Make sure the corner radius of the shaft is slightly smaller than that of the bearing as shown in Fig. 8.40. Never have the corner radius of the shaft larger than that of the bearing (see Fig. 8.41), otherwise, the bearing ring may be misaligned and early bearing failure will occur.
- Out-of-roundness of shaft
  Make sure that the shaft is accurate to out-of-roundness and cylindricity specifications. The inner ring of the bearing is an elastic body, having a relatively thin wall, so if the inner ring is fitted to a shaft having poor roundness, the inner ring raceway will be deformed accordingly.
- Contact surface of oil seals
  When using an oil seal, finish the seal contact surface to Ra < 0.8 μm. If the finish is rougher than Ra < 0.8 μm, the seal will gradually wear until it has no sealing effect. Also make sure that the contact surface is within the runout tolerance, otherwise oil leaks may occur since the seal lip may not stay in contact with the rotating shaft.



Corner radius of shaft (Good)

Fig. 8.40



Corner radius of shaft (Poor)

Fig. 8.41

(3) Bearing Housing

- Purposes of the bearing housing are:

  a) to maintain the bearing position for load support.
  b) to protect the bearing from the intrusion of foreign material.
  c) to provide a structure that will keep the bearing well lubricated.

- Verify that the housing bore diameter is to design specifications. If a loose fit class of H or looser is specified, check to make certain that the bearing will move freely in the bearing housing during installation. On horizontally-split bearing housings such as used on pillow blocks, do not mix the caps and bases during a reassembly procedure since these parts are mated during manufacture. In the latter case, mixing may cause either pinching or looseness of the bearing.
- Allowance must be made for linear expansion of the shaft due to temperature rise. When two or more bearings are mounted on a single shaft, comply with the following directions:
  Fix one bearing in the axial direction in the housing, and make sure that the other bearing(s) are free to move in an axial direction.

(4) Accessory Mounting Parts

Prior to bearing mounting, gather a set of the parts required for the mounting job. These accessory parts may include washers, adapters, withdrawal sleeves, spacer rings, slingers, oil seals, O-rings, shaft nuts, and snap rings for the shaft and or housing bore. Thoroughly clean these accessory parts and check them for appearance and size.

Other Precautions

- Be sure that the side of the shaft nut is at a right angle to the thread, otherwise, when tightened, the side of the shaft nut will make uneven contact with the side of the bearing causing early bearing failure. Use particular care when the bearing is used for high-accuracy applications such as lathes.
- Check the washer and spacer ring for parallelism of both sides.
- The oil seal and O-ring may create a temperature rise because the contact force is too great or because they are initially dry. Apply oil or grease to the contact surfaces to help prevent premature wear and reduce torque.

8.8.3 Bearing Mounting Considerations

When pressing a bearing into position, press against the ring with interference fit. Pressing through the rolling elements will cause damage, such as brinell marks or cracks to the elements and rings and the bearing will be unusable.
For inner ring rotating loads, the bearing is generally interference-fit to the shaft and either expansion fitting or press fitting can be used. expansion fitting may be the more appropriate method for mounting larger bore bearings.
A tapered-bore bearing can be mounted directly to a tapered shaft or with an adapter or withdrawal sleeve. When a withdrawal sleeve is used for larger bore bearings, the hydraulic mounting procedure will facilitate the process. Note that the use of hydraulic mounting of bearings to tapered journals is also very useful for larger bearing sizes.
For an outer ring rotating load, the bearing is usually interference-fitted with the housing. Either press fitting or shrink fitting may be used. In the case of the latter process, the bearing or bearing outer ring may be cooled to attain the fit.

(1) Mounting Cylindrical-bore Bearings

• Press fitting

Many cylindrical-bore bearing applications use press fitting with the shaft. Use a jig which matches the inner ring as shown in Fig. 8.42. Press fit the inner ring using a press or jack.
To press fit the inner and outer rings simultaneously, use a jig as shown in Fig. 8.43.
Apply high-viscosity oil to the shaft and the contact faces of the bearing before press fitting.

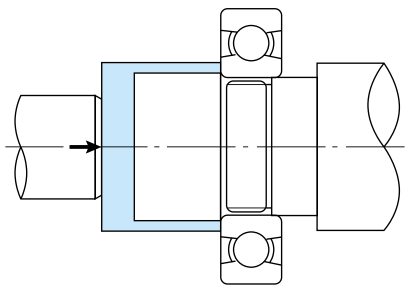


Fig. 8.42 Press Fitting of Inner Ring

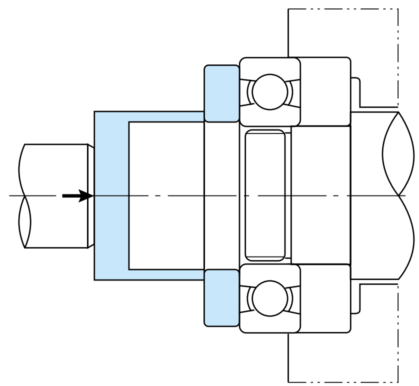


Fig. 8.43 Simultaneous Press Fitting of Inner Ring

• Expansion Fitting

Expansion fitting is an appropriate procedure for mounting larger bore bearings. This fitting procedure can be completed quickly without applying undue stress to the ring being fit. The ring may be heated using a heating tank or an induction heater. Bearing rings must not be heated to a temperature exceeding 120 ºC.

Fig. 8.44 provides the amount of heat rise required, vs. bore size, to expand inner rings to net 6 interference fit classes.

After mounting a heated bearing, secure it in the required position otherwise the bearing will tend to move axially as it cools.

Caution: When expansion fitting rings onto a shaft or into a housing, be sure that the procedure can be completed smoothly and quickly. If the ring should misalign or stop movement before it has reached the desired fit position, it may be very difficult to reposition the ring to the correct fit position.

As noted above, adapter or withdrawal sleeves are used for mounting tapered-bore bearings to cylindrical shafts. Tapered-bore bearings are also mounted directly to tapered shafts. While these methods are technically not press or expansion fitting procedures, the resulting shaft fits are similar to those obtained using the press fitting procedure, and, in certain cases, these methods are far more convenient.

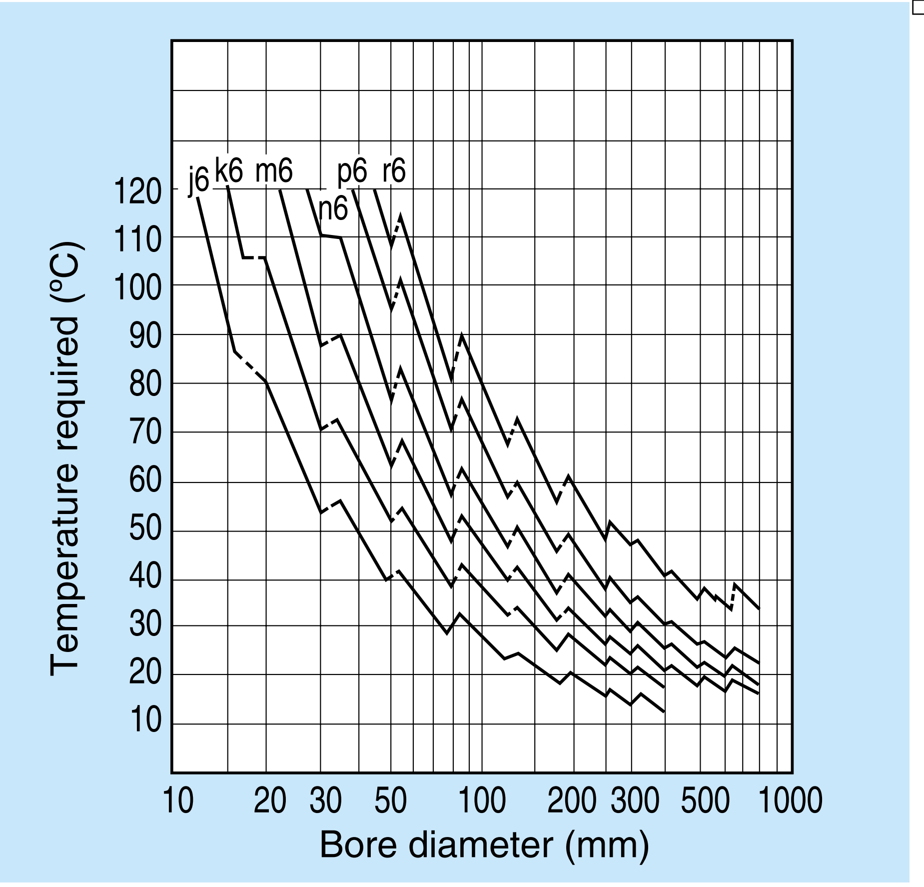


Fig. 8.44 Expension Heat Required

(2) Mounting Tapered-bore Bearings

Using a split-sleeve adapter permits the mounting of tapered-bore bearings in any axial position on shaft but care must be take to ensure that the bearing will be located at the correct position.

To mount a tapered-bore bearing using an adapter sleeve, first mount the bearing which is to be the stationary (fixed) bearing. Define and record the distance which the free bearing is expected to move in an axial direction in the housing.

Mount the free bearing so that the axial clearance provided for axial travel of the outer ring of the free bearing is on the outboard side (side farthest from the stationary bearing).

The required interference fit for tapered-bore, Spherical roller bearings can be attained using one of two methods:

[→Continue]

a) by driving the bearing onto the sleeve by a predetermined distance; or,
b) by measurement of residual bearing internal clearance as the sleeve is pushed into the bearing inner ring (see Table 8.28).

Since exact measurement of the axial drive-up distance is extremely difficult, the residual method is usually the method of choice.

The residual method involves measuring the bearing unmounted internal clearance and then pulling up the adapter sleeve until the measured clearance (the residual) = the unmounted (original) clearance - the reduction amount required to attain the correct interference fit (see Table 8.28 for the reduction amount). Clearance measurements are made using a thickness (feeler) gauge. (Note that the thickness gauge should be inserted over two or three unloaded rollers on each row of rollers and that the bearing bore must be in a horizontal position with respect to the shaft axis, with the outer ring centered over the rolling elements).

Table 8.28 shows axial movement and radial clearance reduction for the mounting of Spherical roller bearings.

Heating of larger tapered-bore bearings may be used in conjunction with measurement of travel distance but be sure to check the results using the residual method (taking the unmounted clearance measurements and the final, residual clearance, when the bearing is cool). Also be sure that the bearing is not heated to over 120 °C.

When using a withdrawal sleeve for large-bore bearings, use of a hydraulic assist procedure is recommended. See Fig. 8.45 which shows use of a hydraulic nut.

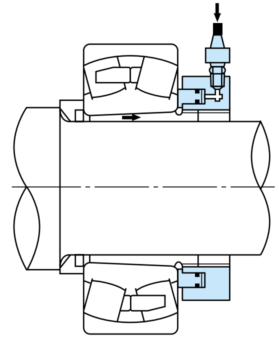


Fig. 8.45 Hydraulic Nut

Table 8.28 Tapered-bore Spherical Roller Bearings: Axial Movement and Radial Clearance Reduction

(3) Other Mounting Precautions

- For paired Tapered roller bearings, be sure to adjust the axial clearance to the specified value using shims where necessary.
- For bearing types with separable inner and outer members such as Cylindrical or Tapered roller bearings, mount the inner and outer ring separately and carefully assemble the shaft into the housing while making sure that no damage occurs to the inner or outer rings or rolling elements.

Table 8.28 Tapered-bore Spherical Roller Bearings: Axial Movement and Radial Clearance Reduction

Nominal bore diameter d (mm)		Radial clearance reduction (mm)		Axial movement (mm)			
				Taper: 1/12		Taper: 1/30	
Over	Incl.	min	max	min	max	min	max
30	40	0.020	0.025	0.35	0.4	–	–
40	50	0.025	0.030	0.4	0.45	–	–
50	65	0.030	0.040	0.45	0.6	–	–
65	80	0.040	0.050	0.6	0.75	–	–
80	100	0.045	0.060	0.7	0.9	1.75	2.25
100	120	0.050	0.070	0.75	1.1	1.9	2.75
120	140	0.065	0.090	1.1	1.4	2.75	3.5
140	160	0.075	0.100	1.2	1.6	3.0	4.0
160	180	0.080	0.110	1.3	1.7	3.25	4.25
180	200	0.090	0.120	1.4	1.9	3.5	5.0
200	225	0.100	0.140	1.6	2.2	4.0	5.5
225	250	0.110	0.150	1.7	2.4	4.25	6.0
250	280	0.120	0.170	1.9	2.7	4.75	6.75
280	315	0.130	0.190	2.0	3.0	5.0	7.5
315	355	0.150	0.210	2.4	3.3	6.0	8.25
355	400	0.170	0.230	2.6	3.6	6.5	9.0
400	450	0.200	0.260	3.1	4.0	7.75	10.0
450	500	0.210	0.280	3.3	4.4	8.25	11.0

8.8.4 Mounting and Dismounting Force

An approximate force necessary to install or remove an inner ring from a shaft may be calculated using the following equation.

$$Ka = fk \cdot fe \cdot \Delta de \qquad \cdots\cdots\cdots (8.23)$$

where:

Ka	= press fit or dismount force (KN)
Δde	= effective interference (mm)
fk	= factor from Table 8.29
fe	= from following equation

Table. 8.29 Value fk (Average)

Condition	fk
Inner ring pressed to cylindrical shaft*	39
Inner ring pulled from cylindrical shaft	59
Inner ring press fit to tapered shaft or sleeve*	54
Inner ring pulled from tapered shaft	44
Tapered sleeve press fit between shaft & bearing*	98
Tapered sleeve pulled from between shaft & bearing	108

* Shaft and bearing bore thinly coated with oil.

$$fe = B \cdot \left[1 - \left(\frac{d}{di}\right)^2\right]$$

where:

B	= inner ring width (mm)
d	= inner ring bore diameter (mm)
di	= mean inner ring outside diameter (mm)
di	≒ 0.25 (D+3d)···for Cylindrical roller bearings and Self-aligning Ball bearing series 22 and 23
di	≒ 0.1 (3D+7d)···for other bearings

where:

D	= Bearing outside diameter

Fig. 8.46 ~ 8.49 show dismount and press fit force by diameter series.

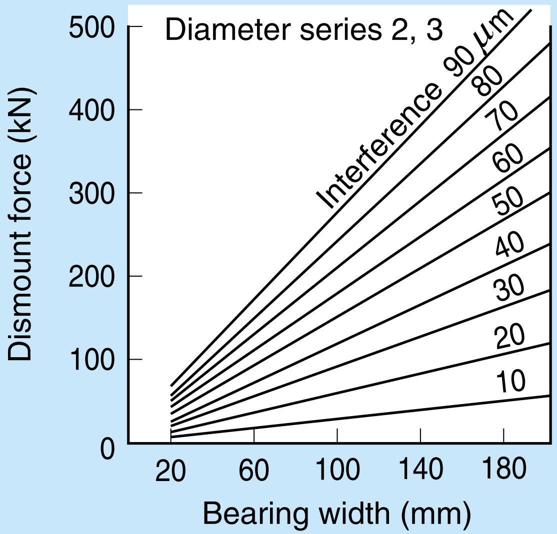


Fig. 8.46 Dismount Force

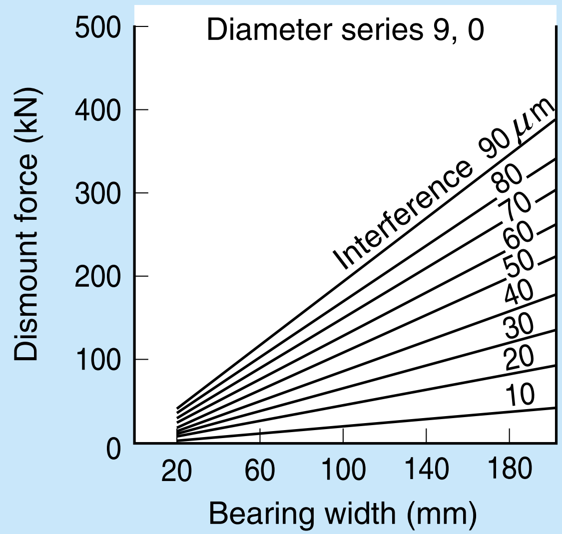


Fig. 8.47 Dismount Force

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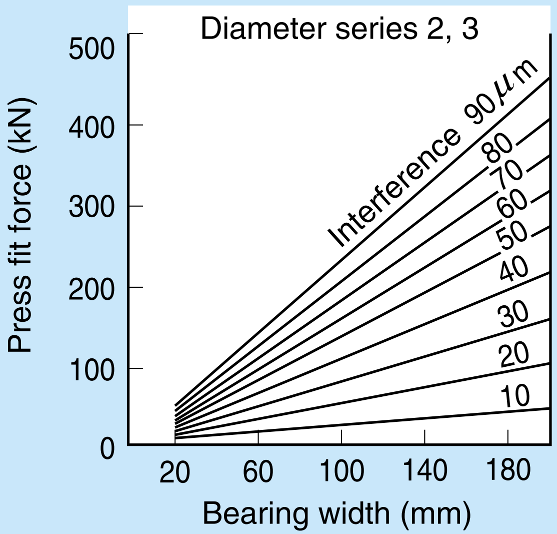


Fig. 8.48 Press-fit Force

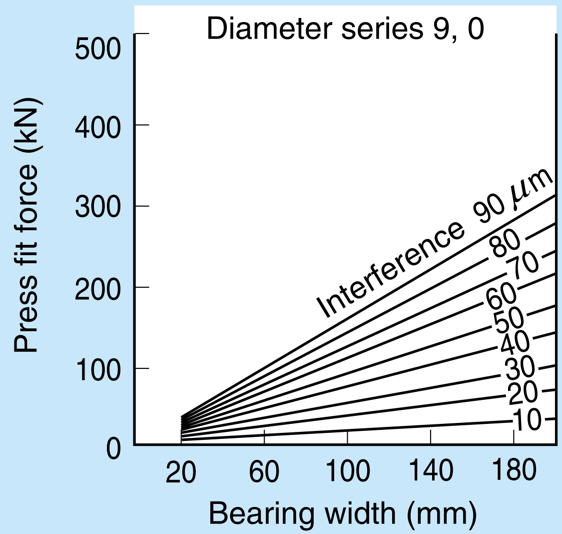


Fig. 8.49 Press-fit Force

8.8.5 Operation Inspection

Verify satisfactory service with a test run. General precautions for a test run are:

- Make sure that all drive covers are in place, all bolts and nuts are tight, and appropriate clearance is provided between the shaft and all stationary parts.
- If possible, manually turn the shaft to see if there is rubbing or abnormal noise.
- If the machine is large and the shaft cannot be turned by hand, start the machine at as low speed as possible and check for rubbing or abnormal noise while coasting the machine.
- If no trouble is found during the above checks, run the machine at the design speed until attaining a steady-state temperature.
- Recheck bolt and nut tightness. Check for oil leaks, and abnormal noise. If possible, extract a sample of the oil and check it for foreign matter.
- Begin regular operation.

If trouble is encountered during machine operation, refer to Section 9, "Trouble-shooting Bearing Problems".

8.8.6 Dismounting

Bearings may be dismounted for periodic machine inspection, or when machine break down has occurred. The condition of all rotating parts and interfaces should be checked and recorded to collect data for operating improvements. The recording of data is essential where a parts failure has occurred to enable a solution to any existing trouble.
In dismounting the bearing, check to see:

- If the bearing is satisfactorily mounted. (Bolts, and nuts tightened, interference of slinger with bearing housing, etc.)
- If there is (was) an adequate lube supply. Check for lubricant contamination and sample for residues.
- That the inner and outer ring have retained the fits as mounted.
- If the bearing clearance is as specified. If possible, measure the clearance of the mounted bearing.
- The condition of the bearing.

[→Continue]

Before starting to dismount a bearing, review the following points:

- Dismount method
- Fit conditions
- Jigs required for dismounting
  - Press (Fig. 8.50)
  - Spanner wrench (Fig. 8.51)
  - Puller (Fig. 8.52)
  - Special puller (Fig. 8.53)
  - Holder (Fig. 8.54)

To dismount a Cylindrical roller bearing, the inner ring may be locally heated with an induction heater to facilitate removal from the shaft. (See Fig. 8.55.)
For large-bore bearings, which are often difficult to dismount, a hydraulic nut or oil injector system is recommended. See Fig. 8.45 and Fig. 8.56 respectively.

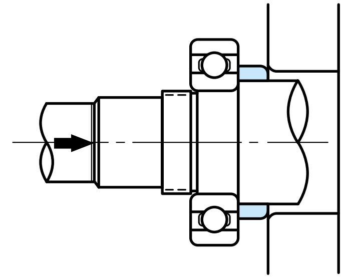


Fig. 8.50 Dismounting Bearing Using Press

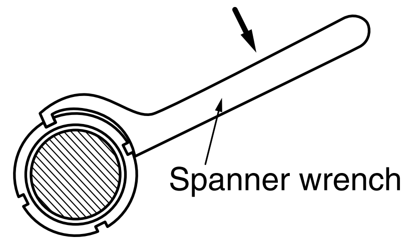


Fig. 8.51 Dismounting Bearing with Spanner Wrench

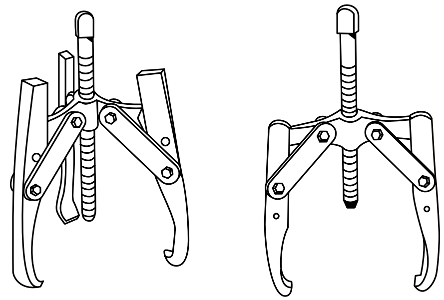


Fig. 8.52

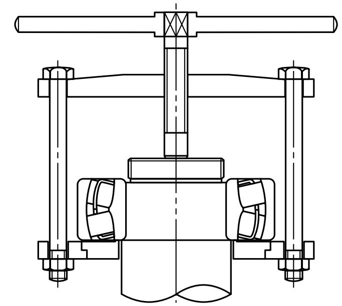


Fig. 8.53 Dismounting Bearing with Special Puller

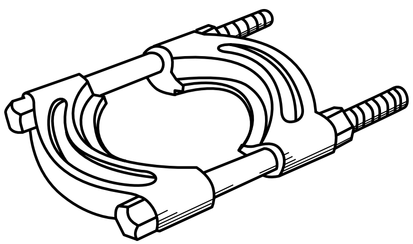


Fig. 8.54 Puller Attachment

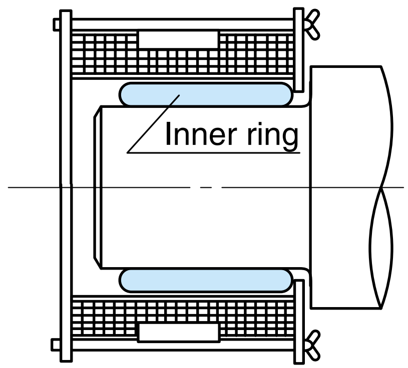


Fig. 8.55 Inner Ring Removal with Induction Heater

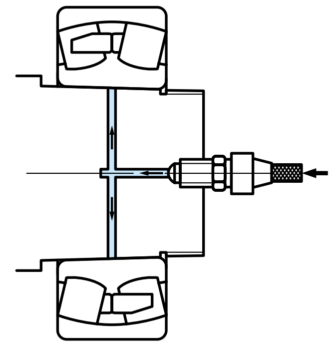


Fig. 8.56 Oil Injector

9. Trouble-shooting Bearing Problems

Rolling contact bearings must be carefully handled, mounted, and maintained in order to operate satisfactorily.
The cause of unsatisfactory operation must be determined to prevent recurrence. There are three categories of data which should be gathered to enable the correct diagnosis of bearing problems:

- Time of occurrence.
- Symptoms during operation.
- Condition of bearing.

Although the origin of bearing problems can sometimes be determined using data from only one of the data categories, quick and accurate analysis requires as much data as possible.
See Tables 9.1, 9.2 and 9.3.

Table 9.1 Time of Occurrence

Cause / Time of Occurrence	Bearing selection	Design or manufacture of other drive parts	Lubricant type, system or amount	Defective bearing	Bearing installation	Seal failure
Soon after installation	○	○	○	○	○	
Soon after periodic disassembly			○		○	
Soon after re-lubrication			○			
After replacement or repair of other drive parts		○	○		○	
During normal operation						○

Table 9.2 Symptom During Operation

Operation condition		Cause	Remarks
Noise	Low level metallic sound	Impressions on raceway	Check with audiophone, vibration pickup, etc.
	High level metallic sound	Loss of clearance, poor lubrication	
	Irregular sound	Excess clearance, contaminants, defect of rolling element surface, improper lube	
	Ever-changing sound	Change of clearance by temperature rise Defect in progress on raceway	
Abnormal temperature rise		Loss of clearance, creep, insufficient or excess lubricant, excess load	Use a surface thermometer.
Reduction in accuracy		Raceway or rolling element broken by impurities, or insufficient lubricant	Example: Lathe: stick-slip marks Grinder: wavy pattern Cold roll mill: occulting wave pattern
Unstable operation		Broken raceway, rolling element Foreign matter Excess clearance	Example: vibration
Contaminated lubricant		Poor lubrication, foreign matter, wear	

Table 9.3

(1) Premature Flaking
(2) Seizure
(3) Breakage
(4) Brinelling
(5) Fretting
(6) Smearing
(7) Excessive Wear
(8) Rusting, Corrosion
(9) Creep

(1) Premature Flaking

The repeated heavy stress cycle between the bearing raceway and rolling element surface results in fatigue cracks which become loosened from bearing materials.

■ Causes

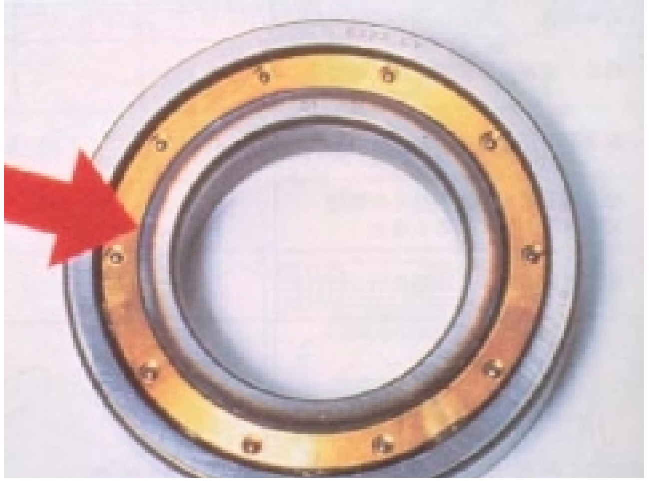
- Abnormal axial load or excessive load caused by expanded shaft.
- Deflection or misalignment of shaft.
- Poor parallelism of inner and outer rings.
- Poor lublication
- Rusting, Nicks, Galling from dirt, etc.

■ Countermeasures

- Abnormal axial load or excessive load caused by expanded shaft.
- Deflection or misalignment of shaft.
- Poor parallelism of inner and outer rings.
- Poor lublication
- Rusting, Nicks, Galling from dirt, etc.

(2) Seizure

Bearing is seized up by excessive heat. Discoloration, softening and fusion of raceway and rolling element.



■ Causes

- Loss of clearance
- Operating over limiting speed
- Poor or improper lubricant.

■ Countermeasures

- Review fitting and bearing clearance.
- Review type of bearing.
- Select a proper lubricant, and feed it in proper quantity.

(3) Breakage

Splits and cracks in the inner/outer ring or rolling element.

■ Causes

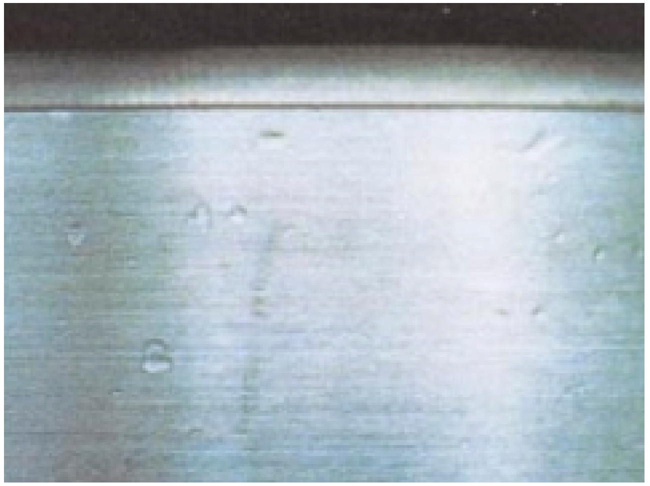
- Excessive interference fit.
- Bearing seat has larger corner radius than bearing.
- Excess clearance during operation.
- Excess impact load.

■ Countermeasures

- Check fits. Finish shaft and sleeve to higher accuracy.
- Make shaft corner radius smaller than that of the bearing.
- Check fits and bearing clearance.
- Re-check load conditions.

(4) Brinelling

Brinelling, indentation and pear skin of bearing raceway and rolling element.



■ Causes

- Impact applied during mounting.
- Impact from dropped bearing
- Contamination
- Load applied to bearing at rest in excess of static load rating.

■ Countermeasures

- Carefully handle the bearing.
- Clean shaft and housing
- Improve the sealing
- Re-check load conditions.

(5) Fretting

Occurred when a small relative motion is repeatedly caused in non rotating bearing. Fretting surface wear producing red colored particles at fitting surface.

■ Causes

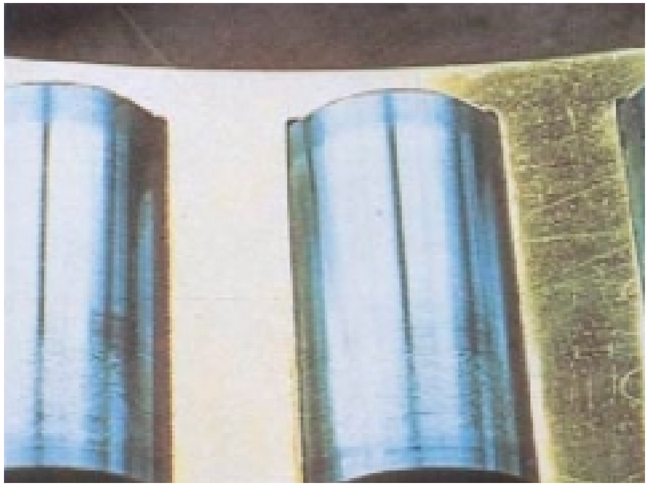
- Vibration applied to bearing at rest (e. g. during shipment)
- swing with smaller amplitude.
- Minute clearance on fit surface.
- Slight sliding during operation as a result reduced interference under a load.

■ Countermeasures

- Fix the shaft and housing during shipment.
- Apply a preload. Use oil for lubrication.
- Increase the interference.
- Apply oil

(6) Smearing

Metal to metal contact due to the destruction of oil film.
Sliding motion between outer/inner ring and rolling element.



■ Causes

- Excess axial load. Misalignment of bearing.
- Poor lubrication.
- Intrusion and galling of foreign matter.
- High acceleration on start-up.

■ Countermeasures

- Correct mounting errors.
- Review the load condition.
- Select a proper lubricant, and feed it in proper quantity.
- Improve the sealing.
- Clean shaft and housing.
- Avoid sharp acceleration.

(7) Excessive Wear

Abnormal wear of flange face, rolling element and retainer.

■ Causes

- Foreign matter and corrosion acting as lapping agent
- Insufficient or incorrect lubricant.

■ Countermeasures

- Improve sealing
- Clean shaft and housing
- Check lubricant for type and amount.

(8) Rusting, Corrosion

Rusting and corrosion of bearing ring and rolling element surface.

■ Causes

- Improper storage, cleaning.
- Improper washing oil.
- Poor rust prevention
- Corrosive gas, liquid or water.
- Handling with unprotected hand.
- Chemical action of lubricant.

■ Countermeasures

- Improve storage and handling.
- Re-check washing oil
- Review rust prevention.
- Improve sealing
- Correct handling.
- Check lubricant.

(9) Creep

Galling, wear, sliding and discoloration of fit face.

■ Causes

- Insufficient interference.
- Insufficient tightened sleeve.
- Insufficient surface pressure due to low rigidity and inaccurate shaft and housing.

■ Countermeasures

- Check fits.
- Tighten sleevel
- Redesign for greater rigidity.

Table 5.1.1 Tolerance Values of Inner Ring and of Outer Ring Width (1/4) Unit: μm

Bearing bore diameter Nominal d (mm)		Bearing with cylindrical bore													
		Single plane mean bore diameter deviation Δd_{mp}										Deviation of a single bore diameter (2) Δd_s			
		Class 0		Class 6		Class 5		Class 4		Class 2		Class 4 Diameter series 0,1,2,3,4		Class 2	
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
0.6 (1)	2.5	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5
2.5	10	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5
10	18	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5
18	30	0	−10	0	−8	0	−6	0	−5	0	−2.5	0	−5	0	−2.5
30	50	0	−12	0	−10	0	−8	0	−6	0	−2.5	0	−6	0	−2.5
50	80	0	−15	0	−12	0	−9	0	−7	0	−4	0	−7	0	−4
80	120	0	−20	0	−15	0	−10	0	−8	0	−5	0	−8	0	−5
120	150	0	−25	0	−18	0	−13	0	−10	0	−7	0	−10	0	−7
150	180	0	−25	0	−18	0	−13	0	−10	0	−7	0	−10	0	−7
180	250	0	−30	0	−22	0	−15	0	−12	0	−8	0	−12	0	−8
250	315	0	−35	0	−25	0	−18	−	−	−	−	−	−	−	−
315	400	0	−40	0	−30	0	−23	−	−	−	−	−	−	−	−
400	500	0	−45	0	−35	−	−	−	−	−	−	−	−	−	−
500	630	0	−50	0	−40	−	−	−	−	−	−	−	−	−	−
630	800	0	−75	−	−	−	−	−	−	−	−	−	−	−	−
800	1000	0	−100	−	−	−	−	−	−	−	−	−	−	−	−
1000	1250	0	−125	−	−	−	−	−	−	−	−	−	−	−	−
1250	1600	0	−160	−	−	−	−	−	−	−	−	−	−	−	−
1600	2000	0	−200	−	−	−	−	−	−	−	−	−	−	−	−

Notes: (1) This diameter is included in this group.
(2) Applies to bearings with cylindrical bore.
(3) Width deviation and variation of outer ring are the same with of inner ring. Outer ring width variation of classes 5, 4 and 2 are listed in Table 5.1.2.
(4) Applies to the rings of single bearings made for paired of stack mounting.
(5) Applies ro radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.1 Tolerance Values of Inner Ring and of Outer Ring Width (2/4)

Unit: μm

Bearing bore diameter Nominal d (mm)		Bearing with cylindrical bore															
		Bore diameter variation in a single radial plane (2) V_{dp}											Main bore diameter variation (2) V_{dmp}				
		Class 0			Class 6			Class 5		Class 4							
		Diameter series			Diameter series			Diameter series		Diameter series		Class 2	Class 0	Class 6	Class 5	Class 4	Class 2
		7,8,9	0,1	2,3,4	7,8,9	0,1	2,3,4	7,8,9	0,1,2,3,4	7,8,9	0,1,2,3,4						
Over	Incl.	Max			Max			Max		Max		Max	Max	Max	Max	Max	Max
0.6[1]	2.5	10	8	6	9	7	5	5	4	4	3	2.5	6	5	3	2	1.5
2.5	10	10	8	6	9	7	5	5	4	4	3	2.5	6	5	3	2	1.5
10	18	10	8	6	9	7	5	5	4	4	3	2.5	6	5	3	2	1.5
18	30	13	10	8	10	8	6	6	5	5	4	2.5	8	6	3	2.5	1.5
30	50	15	12	9	13	10	8	8	6	6	5	2.5	9	8	4	3	1.5
50	80	19	19	11	15	15	9	9	7	7	5	4	11	9	5	3.5	2
80	120	25	25	15	19	19	11	10	8	8	6	5	15	11	5	4	2.5
120	150	31	31	19	23	23	14	13	10	10	8	7	19	14	7	5	3.5
150	180	31	31	19	23	23	14	13	10	10	8	7	19	14	7	5	3.5
180	250	38	38	23	28	28	17	15	12	12	9	8	23	17	8	6	4
250	315	44	44	26	31	31	19	18	14	–	–	–	26	19	9	–	–
315	400	50	50	30	38	38	23	23	18	–	–	–	30	23	12	–	–
400	500	56	56	34	44	44	26	–	–	–	–	–	34	26	–	–	–
500	630	63	63	38	50	50	30	–	–	–	–	–	38	30	–	–	–
630	800	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
800	1000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1000	1250	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1250	1600	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1600	2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies to bearings with cylindrical bore.
(3) Width deviation and variation of outer ring are the same with of inner ring. Outer ring width variation of classes 5, 4 and 2 are listed in Table 5.1.2.
(4) Applies to the rings of single bearings made for paired of stack mounting.
(5) Applies ro radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.1 Tolerance Values of Inner Ring and of Outer Ring Width (3/4)

Unit: μm

Bearing bore diameter Nominal d (mm)		Deviation of a single inner ring width (or a single outer ring width) (2) ΔB_s (or ΔC_s)										Inner (or outer) ring width variation V_{Bs} (or V_{Cs})				
		Single bearing						Paired or stack mounted bearing (4)				Inner ring (or outer ring) (3)		Inner ring		
		Class 0 Class 6		Class 5 Class 4		Class 2		Class 0 Class 6		Class 5 Class 4		Class 0	Class 6	Class 5	Class 4	Class 2
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low	Max	Max	Max	Max	Max
0.6 (1)	2.5	0	– 40	0	– 40	0	– 40	–	–	0	–250	12	12	5	2.5	1.5
2.5	10	0	– 120	0	– 40	0	– 40	0	–250	0	–250	15	15	5	2.5	1.5
10	18	0	– 120	0	– 80	0	– 80	0	–250	0	–250	20	20	5	2.5	1.5
18	30	0	– 120	0	–120	0	–120	0	–250	0	–250	20	20	5	2.5	1.5
30	50	0	– 120	0	–120	0	–120	0	–250	0	–250	20	20	5	3	1.5
50	80	0	– 150	0	–150	0	–150	0	–380	0	–250	25	25	6	4	1.5
80	120	0	– 200	0	–200	0	–200	0	–380	0	–380	25	25	7	4	2.5
120	150	0	– 250	0	–250	0	–250	0	–500	0	–380	30	30	8	5	2.5
150	180	0	– 250	0	–250	0	–250	0	–500	0	–380	30	30	8	5	4
180	250	0	– 300	0	–300	0	–300	0	–500	0	–500	30	30	10	6	5
250	315	0	– 350	0	–350	–	–	0	–500	0	–500	35	35	13	–	–
315	400	0	– 400	0	–400	–	–	0	–630	0	–630	40	40	15	–	–
400	500	0	– 450	–	–	–	–	–	–	–	–	50	45	–	–	–
500	630	0	– 500	–	–	–	–	–	–	–	–	60	50	–	–	–
630	800	0	– 750	–	–	–	–	–	–	–	–	70	–	–	–	–
800	1000	0	–1000	–	–	–	–	–	–	–	–	80	–	–	–	–
1000	1250	0	–1250	–	–	–	–	–	–	–	–	100	–	–	–	–
1250	1600	0	–1600	–	–	–	–	–	–	–	–	120	–	–	–	–
1600	2000	0	–2000	–	–	–	–	–	–	–	–	140	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies to bearings with cylindrical bore.
(3) Width deviation and variation of outer ring are the same with of inner ring. Outer ring width variation of classes 5, 4 and 2 are listed in Table 5.1.2.
(4) Applies to the rings of single bearings made for paired of stack mounting.
(5) Applies ro radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.1　Tolerance Values of Inner Ring and of Outer Ring Width (4/4) Unit: μm

Bearing bore diameter Nominal d (mm)		Radial runout of assembled bearing inner ring K_{ia}					Inner ring reference face runout with bore S_d			Assembled bearing inner ring face runout with raceway S_{ia} (5)		
		Class 0	Class 6	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
0.6(1)	2.5	10	5	4	2.5	1.5	7	3	1.5	7	3	1.5
2.5	10	10	6	4	2.5	1.5	7	3	1.5	7	3	1.5
10	18	10	7	4	2.5	1.5	7	3	1.5	7	3	1.5
18	30	13	8	4	3	2.5	8	4	1.5	8	4	2.5
30	50	15	10	5	4	2.5	8	4	1.5	8	4	2.5
50	80	20	10	5	4	2.5	8	5	1.5	8	5	2.5
80	120	25	13	6	5	2.5	9	5	2.5	9	5	2.5
120	150	30	18	8	6	2.5	10	6	2.5	10	7	2.5
150	180	30	18	8	6	5	10	6	4	10	7	5
180	250	40	20	10	8	5	11	7	5	13	8	5
250	315	50	25	13	–	–	13	–	–	15	–	–
315	400	60	30	15	–	–	15	–	–	20	–	–
400	500	65	35	–	–	–	–	–	–	–	–	–
500	630	70	40	–	–	–	–	–	–	–	–	–
630	800	80	–	–	–	–	–	–	–	–	–	–
800	1000	90	–	–	–	–	–	–	–	–	–	–
1000	1250	100	–	–	–	–	–	–	–	–	–	–
1250	1600	120	–	–	–	–	–	–	–	–	–	–
1600	2000	140	–	–	–	–	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies to bearings with cylindrical bore.
(3) Width deviation and variation of outer ring are the same with of inner ring. Outer ring width variation of classes 5, 4 and 2 are listed in Table 5.1.2.
(4) Applies to the rings of single bearings made for paired of stack mounting.
(5) Applies ro radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.2 Tolerance Values of Outer Ring **(1/4)**

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter: Single plane mean outside diameter deviation ΔD_{mp}										Deviation of a single outside diameter ΔD_s			
		Class 0		Class 6		Class 5		Class 4		Class 2		Class 4, Diameter series 0,1,2,3,4		Class 2	
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
2.5[1]	6	0	− 8	0	− 7	0	− 5	0	− 4	0	− 2.5	0	− 4	0	− 2.5
6	18	0	− 8	0	− 7	0	− 5	0	− 4	0	− 2.5	0	− 4	0	− 2.5
18	30	0	− 9	0	− 8	0	− 6	0	− 5	0	− 4	0	− 5	0	− 4
30	50	0	− 11	0	− 9	0	− 7	0	− 6	0	− 4	0	− 6	0	− 4
50	80	0	− 13	0	−11	0	− 9	0	− 7	0	− 4	0	− 7	0	− 4
80	120	0	− 15	0	−13	0	−10	0	− 8	0	− 5	0	− 8	0	− 5
120	150	0	− 18	0	−15	0	−11	0	− 9	0	− 5	0	− 9	0	− 5
150	180	0	− 25	0	−18	0	−13	0	−10	0	− 7	0	−10	0	− 7
180	250	0	− 30	0	−20	0	−15	0	−11	0	− 8	0	−11	0	− 8
250	315	0	− 35	0	−25	0	−18	0	−13	0	− 8	0	−13	0	− 8
315	400	0	− 40	0	−28	0	−20	0	−15	0	−10	0	−15	0	−10
400	500	0	− 45	0	−33	0	−23	−	−	−	−	−	−	−	−
500	630	0	− 50	0	−38	0	−28	−	−	−	−	−	−	−	−
630	800	0	− 75	0	−45	0	−35	−	−	−	−	−	−	−	−
800	1000	0	−100	0	−60	−	−	−	−	−	−	−	−	−	−
1000	1250	0	−125	−	−	−	−	−	−	−	−	−	−	−	−
1250	1600	0	−160	−	−	−	−	−	−	−	−	−	−	−	−
1600	2000	0	−200	−	−	−	−	−	−	−	−	−	−	−	−
2000	2500	0	−250	−	−	−	−	−	−	−	−	−	−	−	−

Notes: (1) This diameter is included in this group.
(2) Applies before mounting and after removal of internal or external snap ring.
(3) Applies to radial ball bearings such as deep groove ball bearings, angular contact ball bearings.
(4) Outer ring width variation of class 0 and 6 are listed in Table 5.1.1.
(5) Applies to radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.2 Tolerance Values of Outer Ring **(2/4)**

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter — Outside diameter variation in a single radial plane (2) V_{Dp}												
		Class 0				Class 6				Class 5		Class 4		Class 2
		Open bearing			Seal · shield bearing	Open bearing			Seal · shield bearing	Open bearing		Open bearing		Open bearing
		Diameter series				Diameter series				Diameter series		Diameter series		
		7,8,9	0,1	2,3,4	2,3,4	7,8,9	0,1	2,3,4	0,1,2,3,4	7,8,9	0,1,2,3,4	7,8,9	0,1,2,3,4	
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
2.5 (1)	6	10	8	6	10	9	7	5	9	5	4	4	3	2.5
6	18	10	8	6	10	9	7	5	9	5	4	4	3	2.5
18	30	12	9	7	12	10	8	6	10	6	5	5	4	4
30	50	14	11	8	16	11	9	7	13	7	5	6	5	4
50	80	16	13	10	20	14	11	8	16	9	7	7	5	4
80	120	19	19	11	26	16	16	10	20	10	8	8	6	5
120	150	23	23	14	30	19	19	11	25	11	8	9	7	5
150	180	31	31	19	38	23	23	14	30	13	10	10	8	7
180	250	38	38	23	–	25	25	15	–	15	11	11	8	8
250	315	44	44	26	–	31	31	19	–	18	14	13	10	8
315	400	50	50	30	–	35	35	21	–	20	15	15	11	10
400	500	56	56	34	–	41	41	25	–	23	17	–	–	–
500	630	63	63	38	–	48	48	29	–	28	21	–	–	–
630	800	94	94	55	–	56	56	34	–	35	26	–	–	–
800	1000	125	125	75	–	75	75	45	–	–	–	–	–	–
1000	1250	–	–	–	–	–	–	–	–	–	–	–	–	–
1250	1600	–	–	–	–	–	–	–	–	–	–	–	–	–
1600	2000	–	–	–	–	–	–	–	–	–	–	–	–	–
2000	2500	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies before mounting and after removal of internal or external snap ring.
(3) Applies to radial ball bearings such as deep groove ball bearings, angular contact ball bearings.
(4) Outer ring width variation of class 0 and 6 are listed in Table 5.1.1.
(5) Applies to radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.2 Tolerance Values of Outer Ring (3/4)

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter Mean outside diameter variation (2) V_{Dmp}					Radial runout of assembled bearing outer ring K_{ea}					Variation of bearing outside suface generarix inclination with outer ring reference face S_D		
		Class 0	Class 6	Class 5	Class 4	Class 2	Class 0	Class 6	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
2.5 (1)	6	6	5	3	2	1.5	15	8	5	3	1.5	8	4	1.5
6	18	6	5	3	2	1.5	15	8	5	3	1.5	8	4	1.5
18	30	7	6	3	2.5	2	15	9	6	4	2.5	8	4	1.5
30	50	8	7	4	3	2	20	10	7	5	2.5	8	4	1.5
50	80	10	8	5	3.5	2	25	13	8	5	4	8	4	1.5
80	120	11	10	5	4	2.5	35	18	10	6	5	9	5	2.5
120	150	14	11	6	5	2.5	40	20	11	7	5	10	5	2.5
150	180	19	14	7	5	3.5	45	23	13	8	5	10	5	2.5
180	250	23	15	8	6	4	50	25	15	10	7	11	7	4
250	315	26	19	9	7	4	60	30	18	11	7	13	8	5
315	400	30	21	10	8	5	70	35	20	13	8	13	10	7
400	500	34	25	12	–	–	80	40	23	–	–	15	–	–
500	630	38	29	14	–	–	100	50	25	–	–	18	–	–
630	800	55	34	18	–	–	120	60	30	–	–	20	–	–
800	1000	75	45	–	–	–	140	75	–	–	–	–	–	–
1000	1250	–	–	–	–	–	160	–	–	–	–	–	–	–
1250	1600	–	–	–	–	–	190	–	–	–	–	–	–	–
1600	2000	–	–	–	–	–	220	–	–	–	–	–	–	–
2000	2500	–	–	–	–	–	250	–	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies before mounting and after removal of internal or external snap ring.
(3) Applies to radial ball bearings such as deep groove ball bearings, angular contact ball bearings.
(4) Outer ring width variation of class 0 and 6 are listed in Table 5.1.1.
(5) Applies to radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.1.2 Tolerance Values of Outer Ring (4/4)

Bearing outside diameter Nominal D (mm)		Assembled bearing outer ring face runout with raceway S_{ea} (3)			Outer ring width variation V_{Cs} (4)		
		Class 5	Class 4	Class 2	Class 5	Class 4	Class 2
Over	Incl.	Max	Max	Max	Max	Max	Max
2.5 (1)	6	8	5	1.5	5	2.5	1.5
6	18	8	5	1.5	5	2.5	1.5
18	30	8	5	2.5	5	2.5	1.5
30	50	8	5	2.5	5	2.5	1.5
50	80	10	5	4	6	3	1.5
80	120	11	6	5	8	4	2.5
120	150	13	7	5	8	5	2.5
150	180	14	8	5	8	5	2.5
180	250	15	10	7	10	7	4
250	315	18	10	7	11	7	5
315	400	20	13	8	13	8	7
400	500	23	–	–	15	–	–
500	630	25	–	–	18	–	–
630	800	30	–	–	20	–	–
800	1000	–	–	–	–	–	–
1000	1250	–	–	–	–	–	–
1250	1600	–	–	–	–	–	–
1600	2000	–	–	–	–	–	–
2000	2500	–	–	–	–	–	–

Notes: (1) This diameter is included in this group.
(2) Applies before mounting and after removal of internal or external snap ring.
(3) Applies to radial ball bearings such as deep groove ball bearings, angular contact ball bearings.
(4) Outer ring width variation of class 0 and 6 are listed in Table 5.1.1.
(5) Applies to radial ball bearings such as deep groove ball bearing, angular contact ball bearings.

Remarks: The high deviation of bearing cylindrical bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

Table 5.2.1 Tolerance Values of Inner Ring (1/2)

Unit: μm

Bearing bore diameter Nominal d (mm)		Bearing bore diameter											
		Single plane mean bore diameter deviation Δd_{mp}						Deviation of a single bore diameter Δd_s		Bore diameter variation in a single radial plane V_{dp}			
		Class 0 Class 6X		Class 6 Class 5		Class 4		Class 4		Class 0 Class 6X	Class 6	Class 5	Class 4
Over	Incl.	High	Low	High	Low	High	Low	High	Low	Max	Max	Max	Max
10	18	0	−12	0	− 7	0	− 5	0	− 5	12	7	5	4
18	30	0	−12	0	− 8	0	− 6	0	− 6	12	8	6	5
30	50	0	−12	0	−10	0	− 8	0	− 8	12	10	8	6
50	80	0	−15	0	−12	0	− 9	0	− 9	15	12	9	7
80	120	0	−20	0	−15	0	−10	0	−10	20	15	11	8
120	180	0	−25	0	−18	0	−13	0	−13	25	18	14	10
180	250	0	−30	0	−22	0	−15	0	−15	30	22	17	11
250	315	0	−35	−	−	−	−	−	−	35	−	−	−
315	400	0	−40	−	−	−	−	−	−	40	−	−	−
400	500	0	−45	−	−	−	−	−	−	−	−	−	−
500	630	0	−50	−	−	−	−	−	−	−	−	−	−
630	800	0	−75	−	−	−	−	−	−	−	−	−	−

Remarks:

1. The high deviation of bearing bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.
2. Some of these tolerances conform with the NACHI Standard.

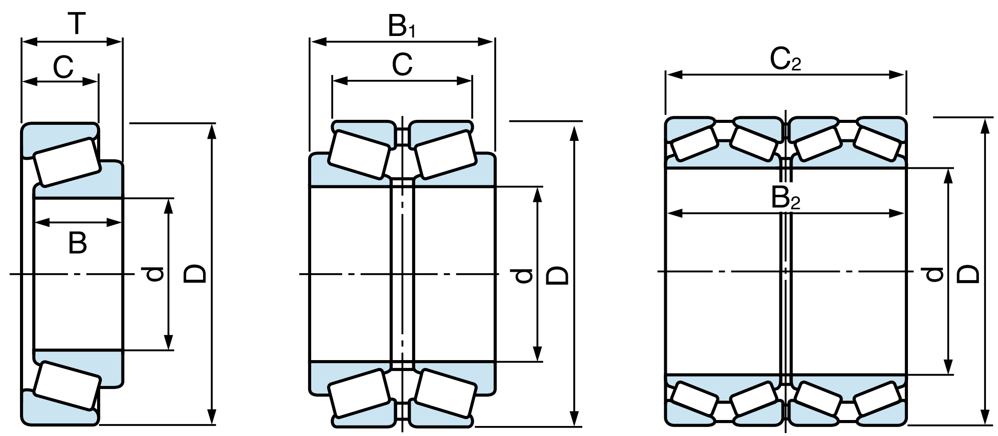


Table 5.2.1 Tolerance Values of Inner Ring (2/2)

Unit: μm

Bearing bore diameter Nominal d (mm)		Bearing bore diameter: Mean bore diameter variation $Vdmp$				Radial runout of assembled bearing inner ring Kia				Inner ring reference face runout with bore Sd		Assembled bearing inner ring face runout with raceway Sia
		Class 0 Class 6X	Class 6	Class 5	Class 4	Class 0 Class 6X	Class 6	Class 5	Class 4	Class 5	Class 4	Class 4
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
10	18	9	5	5	4	15	7	5	3	7	3	3
18	30	9	6	5	4	18	8	5	3	8	4	4
30	50	9	8	5	5	20	10	6	4	8	4	4
50	80	11	9	6	5	25	10	7	4	8	5	4
80	120	15	11	8	5	30	13	8	5	9	5	5
120	180	19	14	9	7	35	18	11	6	10	6	7
180	250	23	16	11	8	50	20	13	8	11	7	8
250	315	26	–	–	–	60	–	–	–	–	–	–
315	400	30	–	–	–	70	–	–	–	–	–	–
400	500	–	–	–	–	70	–	–	–	–	–	–
500	630	–	–	–	–	85	–	–	–	–	–	–
630	800	–	–	–	–	100	–	–	–	–	–	–

Remarks:
1. The high deviation of bearing bore diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.
2. Some of these tolerances conform with the NACHI Standard.

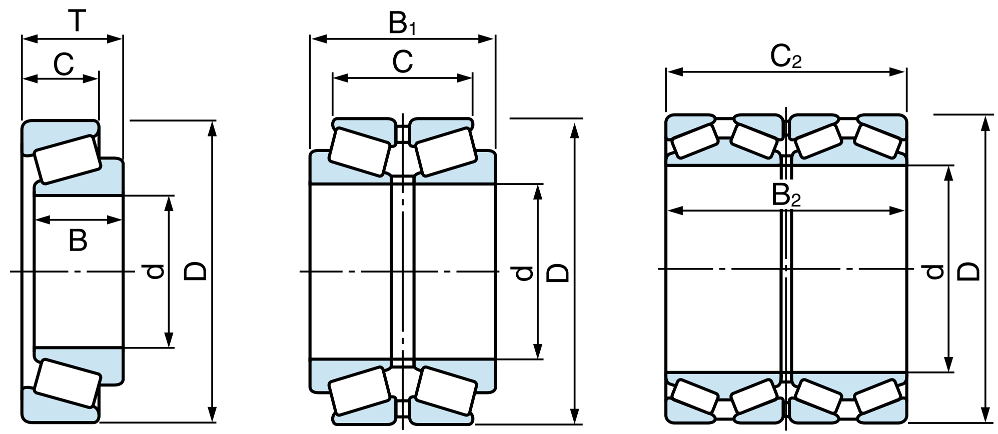
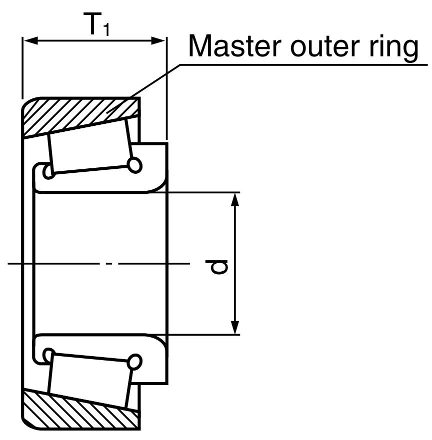


Table 5.2.2 Tolerance Values of Outer Ring (1/2)

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter											
		Single plane mean outside diameter deviation Δ_{Dmp}						Deviation of a single outside diameter Δ_{Ds}		Outside diameter variation in a single radial plane V_{Dp}			
		Class 0 Class 6X		Class 6 Class 5		Class 4		Class 4		Class 0 Class 6X	Class 6	Class 5	Class 4
Over	Incl.	High	Low	High	Low	High	Low	High	Low	Max	Max	Max	Max
18	30	0	− 12	0	− 8	0	− 6	0	− 6	12	8	6	5
30	50	0	− 14	0	− 9	0	− 7	0	− 7	14	9	7	5
50	80	0	− 16	0	−11	0	− 9	0	− 9	16	11	8	7
80	120	0	− 18	0	−13	0	−10	0	−10	18	13	10	8
120	150	0	− 20	0	−15	0	−11	0	−11	20	15	11	8
150	180	0	− 25	0	−18	0	−13	0	−13	25	18	14	10
180	250	0	− 30	0	−20	0	−15	0	−15	30	20	15	11
250	315	0	− 35	0	−25	0	−18	0	−18	35	25	19	14
315	400	0	− 40	0	−28	0	−20	0	−20	40	28	22	15
400	500	0	− 45	−	−	−	−	−	−	45	−	−	−
500	630	0	− 50	−	−	−	−	−	−	50	−	−	−
630	800	0	− 75	−	−	−	−	−	−	−	−	−	−
800	1000	0	−100	−	−	−	−	−	−	−	−	−	−

Remarks: 1. The low deviation of bearing outside diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.
2. Some of these tolerances conform with the NACHI Standard.



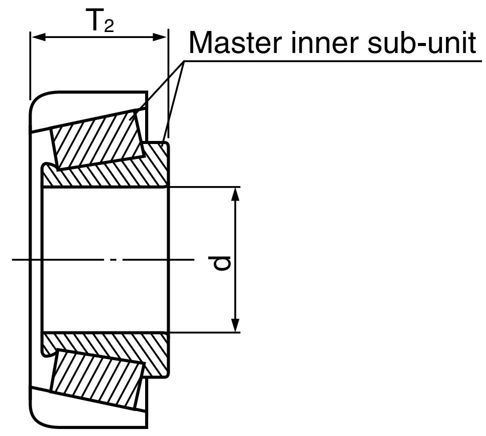


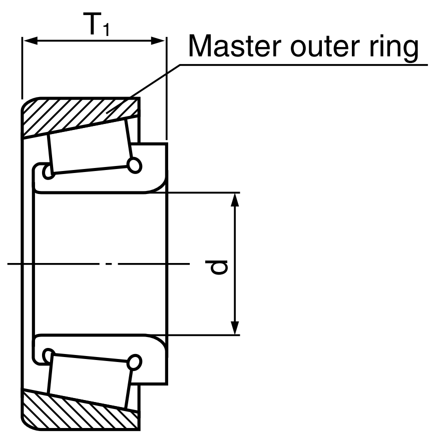
Table 5.2.2 Tolerance Values of Outer Ring (2/2)

Unit: μm

Bearing outside diameter Nominal D (mm)		Bearing outside diameter – Mean outside diameter variation V_{Dmp}				Radial runout of assembled bearing outer ring K_{ea}				Variation of bearing outside surface generatrix inclination with outer ring reference face S_D		Assembled bearing outer ring face runout with raceway S_{ea}
		Class 0 Class 6X	Class 6	Class 5	Class 4	Class 0 Class 6X	Class 6	Class 5	Class 4	Class 5	Class 4	Class 4
Over	Incl.	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
18	30	9	6	5	4	18	9	6	4	8	4	5
30	50	11	7	5	5	20	10	7	5	8	4	5
50	80	12	8	6	5	25	13	8	5	8	4	5
80	120	14	10	7	5	35	18	10	6	9	5	6
120	150	15	11	8	6	40	20	11	7	10	5	7
150	180	19	14	9	7	45	23	13	8	10	5	8
180	250	23	15	10	8	50	25	15	10	11	7	10
250	315	26	19	13	9	60	30	18	11	13	8	10
315	400	30	21	14	10	70	35	20	13	13	10	13
400	500	34	–	–	–	80	–	–	–	–	–	–
500	630	38	–	–	–	100	–	–	–	–	–	–
630	800	–	–	–	–	120	–	–	–	–	–	–
800	1000	–	–	–	–	120	–	–	–	–	–	–

Remarks: 1. The low deviation of bearing outside diameter specified in this table does not apply within a distance of 1.2 × r (max) from the ring face.

2. Some of these tolerances conform with the NACHI Standard.



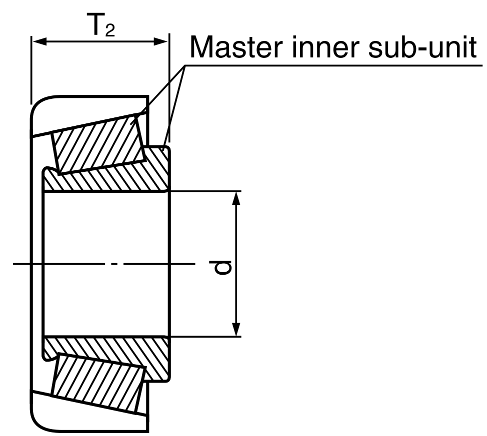


Table 5.2.3 Deviations of Single Ring Width, Bearing Width and Duplex/Stack Mounted Bearing Width

Unit: μm

Bearing bore diameter Nominal d (mm)		Deviation of a single inner ring width ΔB_s						Deviation of a single outer ring width ΔC_s					
		Class 0 Class 6		Class 6X		Class 5 Class 4		Class 0 Class 6		Class 6X		Class 5 Class 4	
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
10	18	0	–120	0	–50	0	–200	0	–120	0	–100	0	–200
18	30	0	–120	0	–50	0	–200	0	–120	0	–100	0	–200
30	50	0	–120	0	–50	0	–240	0	–120	0	–100	0	–240
50	80	0	–150	0	–50	0	–300	0	–150	0	–100	0	–300
80	120	0	–200	0	–50	0	–400	0	–200	0	–100	0	–400
120	180	0	–250	0	–50	0	–500	0	–250	0	–100	0	–500
180	250	0	–300	0	–50	0	–600	0	–300	0	–100	0	–600
250	315	0	–350	0	–50	–	–	0	–350	0	–100	–	–
315	400	0	–400	0	–50	–	–	0	–400	0	–100	–	–
400	500	0	–450	–	–	–	–	0	–450	–	–	–	–
500	630	0	–500	–	–	–	–	0	–500	–	–	–	–
630	800	0	–750	–	–	–	–	0	–750	–	–	–	–

Remarks: Effective width of an inner sub-unit T_1 is the bearing width obtained when this sub-unit is mated with a master outer ring.
Effective width of an outer ring T_2 is the bearing width obtained when this ring is mated with a master inner sub-unit.

Table 5.2.3 Deviations of Single Ring Width, Bearing Width and Duplex/Stack Mounted Bearing Width

Unit: μm

Bearing bore diameter Nominal d (mm)		Deviation of a actual bearing width ΔT_s						Deviation of the actual effective width of inner sub-unit ΔT_{1s}			
		Class 0 Class 6		Class 6X		Class 5 Class 4		Class 0		Class 6X	
Over	Incl.	High	Low	High	Low	High	Low	High	Low	High	Low
10	18	+200	0	+100	0	+200	−200	+100	0	+ 50	0
18	30	+200	0	+100	0	+200	−200	+100	0	+ 50	0
30	50	+200	0	+100	0	+200	−200	+100	0	+ 50	0
50	80	+200	0	+100	0	+200	−200	+100	0	+ 50	0
80	120	+200	−200	+100	0	+200	−200	+100	−100	+ 50	0
120	180	+350	−250	+150	0	+350	−250	+150	−150	+ 50	0
180	250	+350	−250	+150	0	+350	−250	+150	−150	+ 50	0
250	315	+350	−250	+200	0	–	–	+150	−150	+100	0
315	400	+400	−400	+200	0	–	–	+200	−200	+100	0
400	500	+400	−400	–	–	–	–	–	–	–	–
500	630	+500	−500	–	–	–	–	–	–	–	–
630	800	+600	−600	–	–	–	–	–	–	–	–

Remarks: Effective width of an inner sub-unit T_1 is the bearing width obtained when this sub-unit is mated with a master outer ring.
Effective width of an outer ring T_2 is the bearing width obtained when this ring is mated with a master inner sub-unit.

Table 5.2.3 Deviations of Single Ring Width, Bearing Width and Duplex/Stack Mounted Bearing Width

Unit: μm

Bearing bore diameter Nominal d (mm)		Deviation of the actual effective width of outer sub-unit ΔT_{2s}				Deviation of duplex/stack mounted bearing width ΔB_{1s}		$\Delta B_{2s} \bullet \Delta C_{2s}$	
		Class 0		Class 6X		Duplex mounted bearing class 0		Four row bearing class 0	
Over	Incl.	High	Low	High	Low	High	Low	High	Low
10	18	+100	0	+ 50	0	+ 200	− 200	−	−
18	30	+100	0	+ 50	0	+ 200	− 200	−	−
30	50	+100	0	+ 50	0	+ 240	− 240	−	−
50	80	+100	0	+ 50	0	+ 300	− 300	+ 400	− 400
80	120	+100	−100	+ 50	0	+ 400	− 400	+ 500	− 500
120	180	+200	−100	+100	0	+ 500	− 500	+ 600	− 600
180	250	+200	−100	+100	0	+ 600	− 600	+ 750	− 750
250	315	+200	−100	+100	0	+ 700	− 700	+ 900	− 900
315	400	+200	−200	+100	0	+ 800	− 800	+1000	−1000
400	500	−	−	−	−	+ 900	− 900	+1200	−1200
500	630	−	−	−	−	+1000	−1000	+1200	−1200
630	800	−	−	−	−	+1500	−1500	+1500	−1500

Remarks: Effective width of an inner sub-unit T_1 is the bearing width obtained when this sub-unit is mated with a master outer ring.
Effective width of an outer ring T_2 is the bearing width obtained when this ring is mated with a master inner sub-unit.

Table 8.1 Fits vs. Load Characteristics

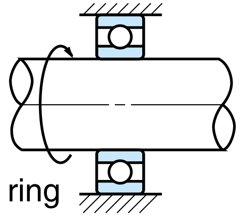
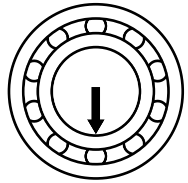
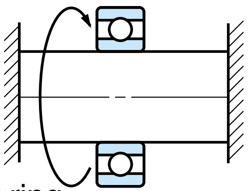
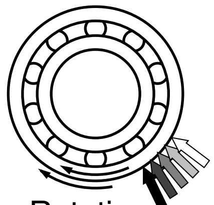
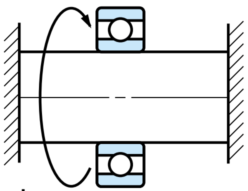
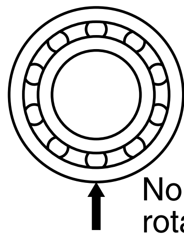
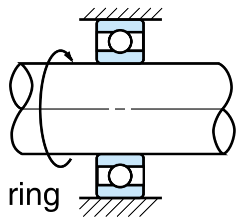
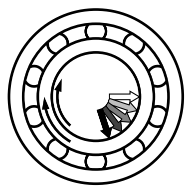
Rotating condition	Type of load	Load conditions	Fit	
			Inner ring	Outer ring
 inner ring	 Non-rotating	Rotating inner ring load	Interference fit	Loose fit
 outer ring	 Rotating	Stationary outer ring load		
 outer ring	 Non-rotating	Rotating outer ring load	Loose fit	Interference fit
 inner ring	 Rotating	Stationary inner ring load		
Load direction not constant because of fluctuation unbalanced load	Rotating or Non-rotating	Indeterminate direction load	Interference fit	Interference fit

Table 8.2.1 Bearing Bore [(1)] Fits for Radial Bearings

Bearing tolerance class	Fit class vs. load type								
	For rotating inner ring load and indeterminate direction load							For rotating outer ring load	
Class 0, class 6	r 6	p 6	n 6	m 5 m 6	k 5 k 6	j 5 j 6 js 6	h 5	h 5 h 6	g 5 g 6
Class 5, class 4	–	–	–	m 5	k 4	js 4	h 4	h 5	–

Table 8.2.2 Bearing Outside Diameter [(1)] Fits for Radial Bearings

Bearing tolerance class	Fit class vs. load type									
	For rotating inner ring load				For indeterminate direction load			For rotating outer ring load		
Class 0, class 6	–	J 6 J 7	H 6 H 7	G 7	M 7	K 6 K 7	J 6 J 7	P 7	N 7	M 7
Class 5, class 4	K 5	Js 5	H 5	–	–	–	–	–	–	M 5

Table 8.3.1 Bearing Bore or Center Washer Bore (1) Fits for Thrust Bearings

Bearing tolerance class	Fit class vs. load type				
	For centric axial load	For composite load (spherical roller thrust bearing)			
Class 0	j 6 js 6	n 6	m 6	k 6	j 6 js 6

Table 8.3.2 Bearing Outside Diameter (1) Fits for Thrust Bearings

Bearing tolerance class	Fit class vs. load type		
	For centric axial load	For composite load (spherical roller thrust bearing)	
Class 0	–	M 7	H 7

Note: (1) These dimensional fits are based on JIS B 1514.

Table 8.4 Shaft Tolerances [1] for Radial Bearings

Operating conditions		Shaft diameter (mm)			Tolerance symbols	Remarks	Examples of application (Reference)
		Bell bearings	Cylindrical roller bearings Tapered roller bearings	Spherical roller bearings			
Bearings with cylindrical bore							
Rotating outer ring load	When the inner ring is required to move on the shaft easily	For all shaft diameters			g6	When high precision is required, adopt g5 and h5 respectively. For large bearings, f6 is adopted because of easy bearing movement in axial direction.	Driven wheel
	When the inner ring is required to move on the shaft easily	For all shaft diameters			h6		Tension pully, rope sheave

Note: (1) Shaft tolerances in this table are applied to solid steel shaft for bearings with tolerance class 0 and 6.

Remarks: Heavy load $P > 0.12Cr$, Normal Load $0.06Cr < P \leq 0.12Cr$, Light Load $P \leq 0.06Cr$ Cr: Basic Dynamic Load Rating

Table 8.4 Shaft Tolerances [1] for Radial Bearings

(2/3)

Operating conditions		Shaft diameter (mm) Bell bearings	Cylindrical roller bearings Tapered roller bearings	Spherical roller bearings	Tolerance symbols	Remarks	Examples of application (Reference)
Rotating inner ring load or indeterminate direction load	Light load or fluctuating load	18 under and incl.	–	–	h5	When high precision is required, adopt j5, k5 and m5 instead of j6, k5 and m6 respectively	Electrical appliance, machining tool, pump, blower, haulage car
		18 Over 100 Incl.	40 under and incl.	–	j6		
		100 Over 200 Incl.	40 Over 140 Incl.	–	k6		
		–	140 Over 200 Incl.	–	m6		
	Normal load or heavy load	18 under and incl.	–	–	j5	The tolerances of k6 and m6 instead of k5 and m5 can be used for single row tapered roller bearings and single row angular contact ball bearings.	Electric motor, turbine, pump, internal combustion engine, wood working machine, bearing application in general.
		18 Over 100 Incl.	40 under and incl.	40 under and incl.	k5		
		100 Over 200 Incl.	40 Over 100 Incl.	40 Over 65 Incl.	m5		
		–	100 Over 140 Incl.	65 Over 100 Incl.	m6		
		–	140 Over 200 Incl.	100 Over 140 Incl.	n6		
		–	200 Over 400 Incl.	140 Over 200 Incl.	p6		
		–	–	280 Over	r6		
	Composite load	–	50 Over 140 Incl.	50 Over 100 Incl.	n6	A bearing with an internal clearance larger than the normal clearance is required	Axles of locomotive and passenger train, traction motor
		–	140 Over 200 Incl.	100 Over 140 Incl.	p6		
		–	200 Over	140 Over	r6		

Note: (1) Shaft tolerances in this table are applied to solid steel shaft for bearings with tolerance class 0 and 6.

Remarks: Heavy load $P > 0.12Cr$, Normal Load $0.06Cr < P \leq 0.12Cr$, Light Load $P \leq 0.06Cr$ Cr: Basic Dynamic Load Rating

Table 8.4 Shaft Tolerances [1] for Radial Bearings (3/3)

Operating conditions	Shaft diameter (mm)			Tolerance symbols	Remarks	Examples of application (Reference)
	Bell bearings	Cylindrical roller bearings Tapered roller bearings	Spherical roller bearings			
Centric axial load	250 under and incl.			j6	–	–
	250 Over			js6, j6		
Bearing with tapered bore (with sleeve)						
For all load condition	For all shaft condition			h9/IT5	h10/IT7 instead of h9/IT5 can be used for power transmission shaft. IT5 and IT7 mean the form error (out of roundness, taper) should be limited within the tolerance ranges of IT5 and IT7	Railroad car axle, bearing application in general

Note: (1) Shaft tolerances in this table are applied to solid steel shaft for bearings with tolerance class 0 and 6.

Remarks: Heavy load $P > 0.12Cr$, Normal Load $0.06Cr < P \leq 0.12Cr$, Light Load $P \leq 0.06Cr$ Cr: Basic Dynamic Load Rating

Table 8.5 Shaft Tolerances for Thrust Bearings

Operating conditions		Shaft diameter (mm)	Tolerance symbols
Centric axial load (Thrust ball bearings and spherical roller thrust bearings)		250 under and incl.	j6
		250 Over	js6, j6
Composite load (Spherical roller thrust bearings)	Rotating outer ring load	250 under and incl.	j6
		250 Over	js6, j6
	Rotation inner ring load or indeterminate direction load	200 under and incl.	k6
		200 Over 400 Incl.	m6
		400 Over	n6

Table 8.7 Housing Bore Tolerances for Thrust Bearings

Operating conditions		Tolerance symbols	Remarks
Centric axial load (All thrust bearings)	Thrust ball bearing	H8	When high accuracy is not required, radial clearance will be provided between outer ring (housing washer)/aligning housing washer and housing
	Spherical roller thrust bearing; When housing is located in radial direction by another bearing.	–	0.001D is recommended as a radial clearance between outer ring and housing. D: outside diameter of housing washer
Composite load (Spherical roller thrust bearings)	Stationary outer ring load or indeterminate direction load	H7 J7	–
	Rotating outer ring load	K7 M7	In case when the radial load is comparatively large, bearing application in general

Table 8.6 Housing Bore Tolerances (1) for Radial Bearings (Except Inch-series Tapered Roller Bearings) (1/2)

Operating conditions			Tolerance symbols	Outer ring movement (2)	Examples of application (Reference)
Monoblock housing	Rotating outer ring load	When a heavy load is applied to a thin-walled housing or impact load	P7	Outer ring can not be moved in axial direction.	Automotive wheel (roller bearing)
		Normal load or heavy load	N7		Automotive wheel (ball bearing)
		Light load or fluctuating load	M7		Conveyer roller, pulley, tension pulley
	Indeterminate direction load	Heavy impact load			Traction motor
		Heavy load or normal load; When the outer ring is not required to move in axial direction	K7	Outer ring can not be moved in axial direction as a rule.	Electric motor, pump, crank shaft
Monoblock or split housing		Normal load or light load; When it is desirable that the outer ring can be moved in axial direction	J7	Outer ring can be moved in axial direction.	Electric motor, pump, crank shaft
	Rotating inner ring load	Impact load; When no-load condition occurs instantaneously			Railroad car axle
		All kinds of load	H7	Outer ring can be moved easily in axial direction.	Railroad car axle, bearing application in general
		Normal load or light load	H8		Gear transmission
		When thermal conduction through the shaft is caused	G7		Paper mill (Drying cylinder)

Note: (1) The tolerances in this table are applied to cast iron or steel housing for bearings with tolerance class 0 and 6. Tighter fit is adopted for light alloy housing.
(2) Outer ring of non-separable bearing

Table 8.6 Housing Bore Tolerances [1] for Radial Bearings (Except Inch-series Tapered Roller Bearings) (2/2)

Operating conditions			Tolerance symbols	Outer ring movement (2)	Examples of application (Reference)
Monoblock housing	When extremely high accuracy is required	Fluctuating load; When extremely accurate rotation and high rigidity are required	N6	Outer ring can not be moved in axial direction.	Main shaft of machine tool (roller bearing, outside diameter is over 125 mm)
			M6		Main shaft of machine tool (roller bearing outside diameter is under and including 125 mm)
		Indeterminate direction light load; When extremely accurate rotation is required.	K6	Outer ring can not be moved in axial direction as a rule.	Main shaft of grinding machine, ball bearing on grinding wheel side High speed centrifugal compressor, clamping side bearing
		When extremely accurate rotation is required and it is desirable that the outer ring can be moved in axial direction.	J6	Outer ring can be moved in axial direction.	Main shaft of grinding machine, ball bearing on driving side High speed centrifugal compressor, floating side bearing

Note: (1) The tolerances in this table are applied to cast iron or steel housing for bearings with tolerance class 0 and 6. Tighter fit is adopted for light alloy housing.
(2) Outer ring of non-separable bearing

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 Unit : mm

Single row, radial ball bearings				69 79									160	60 70								
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49							N10		NN30						
Spherical roller bearings						239										230	240					
Bearing bore diameter Nominal		Diameter series 9											Diameter series 0									
		Bearing outside diameter D	Width series							Chamfer dimension			Bearing outside diameter D	Width series							Chamfer dimension	
			0	1	2	3	4	5	6					0	1	2	3	4	5	6		
			Dimension series											Dimension series								
			09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r_{min}				Width B							r_{min}	
00	10	22	ñ	6	8	10	13	16	22	ñ	0.3	0.3	26	ñ	8	10	12	16	21	29	ñ	0.3
01	12	24	ñ	6	8	10	13	16	22	ñ	0.3	0.3	28	7	8	10	12	16	21	29	0.3	0.3
02	15	28	ñ	7	8.5	10	13	18	23	ñ	0.3	0.3	32	8	9	11	13	17	23	30	0.3	0.3
03	17	30	ñ	7	8.5	10	13	18	23	ñ	0.3	0.3	35	8	10	12	14	18	24	32	0.3	0.3
04	20	37	7	9	11	13	17	23	30	0.3	0.3	0.3	42	8	12	14	16	22	30	40	0.3	0.6
/22	22	39	7	9	11	13	17	23	30	0.3	0.3	0.3	44	8	12	14	16	22	30	40	0.3	0.6
05	25	42	7	9	11	13	17	23	30	0.3	0.3	0.3	47	8	12	14	16	22	30	40	0.3	0.6
/28	28	45	7	9	11	13	17	23	30	0.3	0.3	0.3	52	8	12	15	18	24	32	43	0.3	0.6
06	30	47	7	9	11	13	17	23	30	0.3	0.3	0.3	55	9	13	16	19	25	34	45	0.3	1
/32	32	52	7	10	13	15	20	27	36	0.3	0.6	0.6	58	9	13	16	20	26	35	47	0.3	1
07	35	55	7	10	13	15	20	27	36	0.3	0.6	0.6	62	9	14	17	20	27	36	48	0.3	1
08	40	62	8	12	14	16	22	30	40	0.3	0.6	0.6	68	9	15	18	21	28	38	50	0.3	1

Remarks: 1. $r$min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 4.2.1 Boundary Dimensions of Diameter Series 9, 0 (3/8) Unit : mm

Single row, radial ball bearings				69 79										160	60 70							
Double row, radial ball bearings																						
Cylindrical roller bearings							NN49								N10		NN30					
Spherical roller bearings						239											230	240				
Bearing bore diameter Nominal		Diameter series 9											Diameter series 0									
		Bearing outside diameter D	Width series							Chamfer dimension			Bearing outside diameter D	Width series							Chamfer dimension	
			0	1	2	3	4	5	6					0	1	2	3	4	5	6		
			Dimension series											Dimension series								
			09	19	29	39	49	59	69	09	19 ~ 39	49 ~ 69		00	10	20	30	40	50	60	00	10 ~ 60
Bore No.	d		Width B							r min				Width B							r min	
09	45	68	8	12	14	16	22	30	40	0.3	0.6	0.6	75	10	16	19	23	30	40	54	0.6	1
10	50	72	8	12	14	16	22	30	40	0.3	0.6	0.6	80	10	16	19	23	30	40	54	0.6	1
11	55	80	9	13	16	19	25	34	45	0.3	1	1	90	11	18	22	26	35	46	63	0.6	1.1
12	60	85	9	13	16	19	25	34	45	0.3	1	1	95	11	18	22	26	35	46	63	0.6	1.1
13	65	90	9	13	16	19	25	34	45	0.3	1	1	100	11	18	22	26	35	46	63	0.6	1.1
14	70	100	10	16	19	23	30	40	54	0.6	1	1	110	13	20	24	30	40	54	71	0.6	1.1
15	75	105	10	16	19	23	30	40	54	0.6	1	1	115	13	20	24	30	40	54	71	0.6	1.1
16	80	110	10	16	19	23	30	40	54	0.6	1	1	125	14	22	27	34	45	60	80	0.6	1.1
17	85	120	11	18	22	26	35	46	63	0.6	1.1	1.1	130	14	22	27	34	45	60	80	0.6	1.1
18	90	125	11	18	22	26	35	46	63	0.6	1.1	1.1	140	16	24	30	37	50	67	90	1	1.5
19	95	130	11	18	22	26	35	46	63	0.6	1.1	1.1	145	16	24	30	37	50	67	90	1	1.5
20	100	140	13	20	24	30	40	54	71	0.6	1.1	1.1	150	16	24	30	37	50	67	90	1	1.5

Remarks: 1. r min is the smallest chamfer dimension.
2. The chamfer dimensions given in this table do not necessarily apply to:
(1) the groove side of bearing rings with snap ring groove
(2) the flangeless side of thin cylindrical roller bearing rings
(3) the front face side of angular contact bearing
(4) inner rings of bearings with tapered bore

Table 8.9 Fits of Inch Series Tapered Roller Bearings with Housings

Table 8.9.1 For Bearings with ABMA Classes 4 and 2

Unit: μm

Operating conditions		Bearing outside diameter Nominal D (mm)		Bearing outside diameter deviation		Housing bore diameter deviation		Amounts (1)	
		Over	Incl.	High	Low	High	Low	Max	Min
Rotating inner ring load	Floating side or Clamping side	–	76.2	+25	0	+ 76	+ 50	25L	76L
		76.2	127.0	+25	0	+ 76	+ 50	25L	76L
		127.0	304.8	+25	0	+ 76	+ 50	25L	76L
		304.8	609.6	+51	0	+152	+102	51L	152L
		609.6	914.4	+76	0	+229	+152	76L	229L
	Outer ring location in axial direction can be adjusted	–	76.2	+25	0	+ 25	0	25T	25L
		76.2	127.0	+25	0	+ 25	0	25T	25L
		127.0	304.8	+25	0	+ 51	0	25T	51L
		304.8	609.6	+51	0	+ 76	+ 26	25T	76L
		609.6	914.4	+76	0	+127	+ 51	25T	127L
	Outer ring location in axial direction can not be adjusted	–	76.2	+25	0	− 13	− 39	64T	13T
		76.2	127.0	+25	0	− 25	− 51	76T	25T
		127.0	304.8	+25	0	− 25	− 51	76T	25T
		304.8	609.6	+51	0	− 25	− 76	127T	25T
		609.6	914.4	+76	0	− 25	−102	178T	25T
Rotating outer ring load	Outer ring location in axial direction can not be adjusted	–	76.2	+25	0	− 13	− 39	64T	13T
		76.2	127.0	+25	0	− 25	− 51	76T	25T
		127.0	304.8	+25	0	− 25	− 51	76T	25T
		304.8	609.6	+51	0	− 25	− 76	127T	25T
		609.6	914.4	+76	0	− 25	−102	178T	25T

Note: (1) T: Tight fit L: Loose fit

Table 8.9.2 For Bearings with ABMA Classes 3 and 0

Unit: μm

Operating conditions		Bearing outside diameter Nominal D (mm)		Bearing outside diameter deviation		Housing bore diameter deviation		Amounts (1)	
		Over	Incl.	High	Low	High	Low	Max	Min
Rotating inner ring load	Floating side	–	152.4	+13	0	+38	+26	13L	38L
		152.4	304.8	+13	0	+38	+26	13L	38L
		304.8	609.6	+25	0	+64	+38	13L	64L
		609.6	914.4	+38	0	+89	+51	13L	89L
	Clamping side	–	152.4	+13	0	+25	+13	0	25L
		152.4	304.8	+13	0	+25	+13	0	25L
		304.8	609.6	+25	0	+51	+25	0	51L
		609.6	914.4	+38	0	+76	+38	0	76L
	Outer ring location in axial direction can be adjusted	–	152.4	+13	0	+13	0	13T	13L
		152.4	304.8	+13	0	+25	0	13T	25L
		304.8	609.6	+25	0	+25	0	25T	25L
		609.6	914.4	+38	0	+38	0	38T	38L
	Outer ring location in axial direction can not be adjusted	–	152.4	+13	0	0	–12	25T	0
		152.4	304.8	+13	0	0	–25	38T	0
		304.8	609.6	+25	0	0	–26	51T	0
		609.6	914.4	+38	0	0	–38	76T	0
Rotating outer ring load	Normal load Outer ring location in axial direction can not be adjusted	–	152.4	+13	0	–13	–25	38T	13T
		152.4	304.8	+13	0	–13	–38	51T	13T
		304.8	609.6	+25	0	–13	–39	64T	13T
		609.6	914.4	+38	0	–13	–51	89T	13T

Note: (1) T: Tight fit L: Loose fit
(2) This tables is not applied to the bearing with tolerance class 0 whose bore diameter is over 304.8 mm.

Table 8.10 Amounts of Fits: Radial Bearings with Tolerance JIS Class 0 (ISO Normal Class)

Table 8.10.1 Inner Ring with Shaft **(1/2)** Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing Δdmp		Shaft with tolerance grade IT5									
				m5		k5		j5		h5		g5	
				Tight		Tight		Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max
3	6	0	− 8	–	–	–	–	11	2	8	5	4	9
6	10	0	− 8	–	–	–	–	12	2	8	6	3	11
10	18	0	− 8	–	–	17	1	13	3	8	8	2	14
18	30	0	−10	–	–	21	2	15	4	10	9	3	16
30	50	0	−12	32	9	25	2	18	5	12	11	3	20
50	80	0	−15	39	11	30	2	21	7	15	13	5	23
80	120	0	−20	48	13	38	3	26	9	20	15	8	27
120 140 160	140 160 180	0	−25	58	15	46	3	–	–	25	18	11	32
180 200 225	200 225 250	0	−30	67	17	54	4	–	–	30	20	15	35
250 280	280 315	0	−35	–	–	–	–	–	–	35	23	18	40
315 355	355 400	0	−40	–	–	–	–	–	–	40	25	22	43
400 450	450 500	0	−45	–	–	–	–	–	–	45	27	25	47

Table 8.10 Amounts of Fits: Radial Bearings with Tolerance JIS Class 0 (ISO Normal Class)

Table 8.10.1 Inner Ring with Shaft

(2/2)

Unit: μm

Nominal diameter (mm)		Shaft with tolerance grade IT6															
		r6		p6		n6		m6		k6		j6		h6		g6	
		Tight		Tight		Tight		Tight		Tight		Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max
3 6 10	6 10 18	– – –	– – –	– – –	– – –	– – –	– – –	– – –	– – –	– – 20	– – 1	14 15 16	2 2 3	8 8 8	8 9 11	4 3 2	12 14 17
18 30 50 80	30 50 80 120	– – – –	– – – –	– – – 76	– – – 37	– 45 54 65	– 17 20 23	– 37 45 55	– 9 11 13	25 30 36 45	2 2 2 3	19 23 27 33	4 5 7 9	10 12 15 20	13 16 19 22	3 3 5 8	20 25 29 34
120 140 160	140 160 180	113 115 118	63 65 68	93	43	77	27	65	15	53	3	39	11	25	25	11	39
180 200 225	200 225 250	136 139 143	77 80 84	109	50	90	31	76	17	63	4	46	13	30	29	15	44
250 280	280 315	161 165	94 98	123	56	–	–	–	–	–	–	51	16	35	32	18	49
315 355	355 400	184 190	108 114	138	62	–	–	–	–	–	–	58	18	40	36	22	54
400 450	450 500	211 217	126 132	–	–	–	–	–	–	–	–	65	20	45	40	26	60

Table 8.10 Amounts of Fits: Radial Bearings with Tolerance JIS Class 0 (ISO Normal Class)

Table 8.10.2 Outer Ring with Housing (1/2)

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT6					
				K6		J6		H6	
				Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max	Max	Max
6	10	0	– 8	7	10	4	13	0	17
10	18	0	– 8	9	10	5	14	0	19
18	30	0	– 8	11	11	5	17	0	22
30	50	0	–11	13	14	6	21	0	27
50	80	0	–13	15	17	6	26	0	32
80	120	0	–15	18	19	6	31	0	37
120	150	0	–18	21	22	7	36	0	43
150	180	0	–25	21	29	7	43	0	50
180	250	0	–30	24	35	7	52	0	59
250	315	0	–35	27	40	7	60	0	67
315	400	0	–40	29	47	7	69	0	76
400	500	0	–45	32	53	7	78	0	85

Table 8.10 Amounts of Fits: Radial Bearings with Tolerance JIS Class 0 (ISO Normal Class)

Table 8.10.2 Outer Ring with Housing

Unit: μm

Nominal diameter (mm)		Housing with tolerance grade IT7													
		P7		N7		M7		K7		J7		H7		G7	
		Tight		Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose	Loose	
Over	Incl.	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Min	Max
6	10	24	1	19	4	15	8	10	13	7	16	0	23	5	28
10	18	29	3	23	3	18	8	12	14	8	18	0	26	6	32
18	30	35	5	28	2	21	9	15	15	9	21	0	30	7	37
30	50	42	6	33	3	25	11	18	18	11	25	0	36	9	45
50	80	51	8	39	4	30	13	21	22	12	31	0	43	10	53
80	120	59	9	45	5	35	15	25	25	13	37	0	50	12	62
120	150	68	10	52	6	40	18	28	30	14	44	0	58	14	72
150	180	68	3	60	13	40	25	28	37	14	51	0	65	14	79
180	250	79	3	60	16	46	30	33	43	16	60	0	76	15	91
250	315	88	1	66	21	52	35	36	51	16	71	0	87	17	104
315	400	98	1	73	24	57	40	40	57	18	79	0	97	18	115
400	500	108	0	80	28	63	45	45	63	20	88	0	108	20	128

Table 8.11 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 6

Table 8.11.1 Inner Ring with Shaft **(1/2)**

Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing Δdmp		Shaft with tolerance grade IT5									
				m5		k5		j5		h5		g5	
				Tight		Tight		Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max
3	6	0	− 7	–	–	–	–	10	2	7	5	3	9
6	10	0	− 7	–	–	–	–	11	2	7	6	2	11
10	18	0	− 7	–	–	16	1	12	3	7	8	1	14
18	30	0	− 8	–	–	19	2	13	4	8	9	1	16
30	50	0	−10	30	9	23	2	16	5	10	11	1	20
50	80	0	−12	36	11	27	2	18	7	12	13	2	23
80	120	0	−15	43	13	33	3	21	9	15	15	3	27
120 140 160	140 160 180	0	−18	51	15	39	3	–	–	18	18	4	32
180 200 225	200 225 250	0	−22	59	17	46	4	–	–	22	20	7	35

Table 8.11 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 6

Table 8.11.1 Inner Ring with Shaft

Unit: μm

Nominal diameter (mm)		Shaft with tolerance grade IT6															
		r6		p6		n6		m6		k6		j6		h6		g6	
		Tight		Tight		Tight		Tight		Tight		Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max
3	6	–	–	–	–	–	–	–	–	–	–	13	2	7	8	3	12
6	10	–	–	–	–	–	–	–	–	–	–	14	2	7	9	2	14
10	18	–	–	–	–	–	–	–	–	19	1	15	3	7	11	1	17
18	30	–	–	–	–	–	–	–	–	23	2	17	4	8	13	1	20
30	50	–	–	–	–	43	17	35	9	28	2	21	5	10	16	1	25
50	80	–	–	–	–	51	20	42	11	33	2	24	7	12	19	2	29
80	120	–	–	74	37	60	23	50	13	40	3	28	9	15	22	3	34
120	140	106	63														
140	160	108	65	86	43	70	27	58	15	46	3	32	11	18	25	4	39
160	180	111	68														
180	200	128	77														
200	225	131	80	101	50	82	31	68	17	55	4	38	13	22	29	7	44
225	250	135	84														

Table 8.11 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 6

Table 8.11.2 Outer Ring with Housing (1/2)

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT6					
				K6		J6		H6	
				Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max	Max	Max
6	10	0	− 7	7	9	4	12	0	16
10	18	0	− 7	9	9	5	13	0	18
18	30	0	− 8	11	10	5	16	0	21
30	50	0	− 9	13	12	6	19	0	25
50	80	0	−11	15	15	6	24	0	30
80	120	0	−13	18	17	6	29	0	35
120	150	0	−15	21	19	7	33	0	40
150	180	0	−18	21	22	7	36	0	43
180	250	0	−20	24	25	7	42	0	49
250	315	0	−25	27	30	7	50	0	57
315	400	0	−28	29	35	7	57	0	64

Table 8.11 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 6

Table 8.11.2 Outer Ring with Housing **(2/2)**

Unit: μm

Nominal diameter (mm)		Housing with tolerance grade IT7													
		P7		N7		M7		K7		J7		H7		G7	
		Tight		Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose	Loose	
Over	Incl.	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Min	Max
6	10	24	2	19	3	15	7	10	12	7	15	0	22	5	27
10	18	29	4	23	2	18	7	12	13	8	17	0	25	6	31
18	30	35	6	28	1	21	8	15	14	9	20	0	29	7	36
30	50	42	8	33	1	25	9	18	16	11	23	0	34	9	43
50	80	51	10	39	2	30	11	21	20	12	29	0	41	10	51
80	120	59	11	45	3	35	13	25	23	13	35	0	48	12	60
120	150	68	13	52	3	40	15	28	27	14	41	0	55	14	69
150	180	68	10	60	6	40	18	28	30	14	44	0	58	14	72
180	250	79	13	60	6	46	20	33	33	16	50	0	66	15	81
250	315	88	11	66	11	52	25	36	41	16	61	0	77	17	94
315	400	98	13	73	12	57	28	40	45	18	67	0	85	18	103

Table 8.12 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 5

Table 8.12.1 Inner Ring with Shaft

Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing $\varDelta d$mp		Shaft with tolerance grade IT4								Shaft with tolerance grade IT5			
				m4		k4		js4		h4		m5		h5	
				Tight		Tight		Tight	Loose	Tight	Loose	Tight		Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Max	Max	Max	Max	Min	Max	Max
3	6	0	− 5	13	4	10	1	7	2	5	4	14	4	5	5
6	10	0	− 5	15	6	10	1	7	2	5	4	17	6	5	6
10	18	0	− 5	17	7	11	1	7.5	2.5	5	5	20	7	5	8
18	30	0	− 6	20	8	14	2	9	3	6	6	23	8	6	9
30	50	0	− 8	24	9	17	2	11.5	3.5	8	7	28	9	8	11
50	80	0	− 9	28	11	19	2	13	4	9	8	33	11	9	13
80	120	0	−10	33	13	23	3	15	5	10	10	38	13	10	15
120	180	0	−13	40	15	28	3	19	6	13	12	46	15	13	18
180	250	0	−15	46	17	33	4	22	7	15	14	52	17	15	20

Table 8.12 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 5

Table 8.12.2 Outer Ring with Housing

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT5							
				M5		K5		Js5		H5	
				Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max	Max	Max	Max	Max
6	10	0	− 5	10	1	5	6	3	8	0	11
10	18	0	− 5	12	1	6	7	4	9	0	13
18	30	0	− 6	14	1	8	7	4.5	10.5	0	15
30	50	0	− 7	16	2	9	9	5.5	12.5	0	18
50	80	0	− 9	19	3	10	12	6.5	15.5	0	22
80	120	0	−10	23	2	13	12	7.5	17.5	0	25
120	150	0	−11	27	2	15	14	9	20	0	29
150	180	0	−13	27	4	15	16	9	22	0	31
180	250	0	−15	31	4	18	17	10	25	0	35
250	315	0	−18	36	5	20	21	11.5	29.5	0	41
315	400	0	−20	39	6	22	23	12.5	32.5	0	45

Table 8.13 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 4

Table 8.13.1 Inner Ring with Shaft

Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing Δdmp		Shaft with tolerance grade IT4								Shaft with tolerance grade IT5			
				m4		k4		js4		h4		m5		h5	
				Tight		Tight		Tight	Loose	Tight	Loose	Tight		Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Max	Max	Max	Max	Min	Max	Max
3	6	0	– 4	12	4	9	1	6	2	4	4	13	4	4	5
6	10	0	– 4	14	6	9	1	6	2	4	4	16	6	4	6
10	18	0	– 4	16	7	10	1	6.5	2.5	4	5	19	7	4	8
18	30	0	– 5	19	8	13	2	8	3	5	6	22	8	5	9
30	50	0	– 6	22	9	15	2	9.5	3.5	6	7	26	9	6	11
50	80	0	– 7	26	11	17	2	11	4	7	8	31	11	7	13
80	120	0	– 8	31	13	21	3	13	5	8	10	36	13	8	15
120	180	0	10	37	15	25	3	16	6	10	12	43	15	10	18
180	250	0	–12	43	17	30	4	19	7	12	14	49	17	12	20

Table 8.13 Amounts of Fits: Radial Bearings with Tolerance JIS (ISO) Class 4

Table 8.13.2 Outer Ring with Housing

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT5							
				M5		K5		Js5		H5	
				Tight	Loose	Tight	Loose	Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max	Max	Max	Max	Max
6	10	0	− 4	10	0	5	5	3	7	0	10
10	18	0	− 4	12	0	6	6	4	8	0	12
18	30	0	− 5	14	0	8	6	4.5	9.5	0	14
30	50	0	− 6	16	1	9	8	5.5	11.5	0	17
50	80	0	− 7	19	1	10	10	6.5	13.5	0	20
80	120	0	− 8	23	0	13	10	7.5	15.5	0	23
120	150	0	− 9	27	0	15	12	9	18	0	27
150	180	0	−10	27	1	15	13	9	19	0	28
180	250	0	−11	31	0	18	13	10	21	0	31
250	315	0	−13	36	0	20	16	11.5	24.5	0	36
315	400	0	−15	39	1	22	18	12.5	27.5	0	40

Table 8.14 Amounts of Fits: Thrust Bearings with Tolerance JIS (ISO) Class 0

Table 8.14.1 Shaft Washer or Center Washer with Shaft

Unit: μm

Nominal diameter (mm)		Single plane mean bore diameter deviation of bearing Δdmp		Shaft with tolerance grade IT6							
				n6		m6		k6		j6	
				Tight		Tight		Tight		Tight	Loose
Over	Incl.	High	Low	Max	Min	Max	Min	Max	Min	Max	Max
6	10	0	− 8	–	–	–	–	18	1	15	2
10	18	0	− 8	–	–	–	–	20	1	16	3
18	30	0	−10	–	–	–	–	25	2	19	4
30	50	0	−12	–	–	–	–	30	2	23	5
50	80	0	−15	–	–	–	–	36	2	27	7
80	120	0	−20	–	–	–	–	45	3	33	9
120	180	0	−25	–	–	–	–	53	3	39	11
180	250	0	−30	–	–	76	17	63	4	46	13
250	315	0	−35	–	–	87	20	–	–	51	16
315	400	0	−40	–	–	97	21	–	–	58	18
400	500	0	−45	125	40	–	–	–	–	65	20

Table 8.14 Amounts of Fits: Thrust Bearings with Tolerance JIS (ISO) Class 0

Table 8.14.2 Housing Washer with Housing

Unit: μm

Nominal diameter (mm)		Single plane mean outside diameter deviation of bearing ΔDmp		Housing with tolerance grade IT7			
				M7		H7	
				Tight	Loose	Tight	Loose
Over	Incl.	High	Low	Max	Max	Max	Max
10	18	0	–11	18	11	0	29
18	30	0	–13	21	13	0	34
30	50	0	–16	25	16	0	41
50	80	0	–19	30	19	0	49
80	120	0	–22	35	22	0	57
120	180	0	–25	40	25	0	65
180	250	0	–30	46	30	0	76
250	315	0	–35	52	35	0	87
315	400	0	–40	57	40	0	97
400	500	0	–45	63	45	0	108