Ball and Roller Bearings

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Technical Data

1. Construction and Characteristics of Rolling Bearings

1.1 Rolling bearing construction

Most rolling bearings consist of rings with raceways(an inner and an outer ring), rolling elements(either balls or rollers) and a cage. The cage separates the rolling elements at regular intervals, holds them in place within the inner and outer raceways, and allows them to rotate freely. See Fig. 1.1.

Theoretically, rolling bearings are so constructed as to allow the rolling elements to rotate orbitally while also rotating on their own axes at the same time.

While the rolling elements and the bearing rings take any load applied to the bearings (at the contact point between the rolling elements and raceway surfaces), the cage takes no direct load. It only serves to hold the rolling elements at equal distances from each other and prevent them from falling out.

1.2 Deep groove ball bearings

Deep groove ball bearings are very widely used. A deep groove is formed on each inner and outer ring of the bearing enabling them to sustain radial and axial loads in either direction as well as the combined loads which result from the combination of these forces. Deep groove ball bearings are suitable for high speed applications. In addition to the open type, deep groove ball bearings come in a number of varieties, including pre-lubricated bearings, bearings with one or both sides sealed or shielded, bearings with snap rings and high capacity specification, etc. The construction of deep groove ball bearing is shown in Fig. 1.2.

As shown in Table 1.1, pressed cages are generally used in deep groove ball bearings. However, machined cages are also used in larger sized bearings designed for high speed applications.

1.2.1 Shielded ball bearings

Shielded ball bearings are deep groove ball bearings having the same boundary dimensions as those of open type bearings. Protection against the penetration of foreign material and the prevention of grease leakage are provided by the steel shield plates of these bearings.

There are two types: one is Type ZZ fitted with shield plates on both sides and the other is Type Z fitted with a plate on one side. Since the shields are non-contact type, friction torque is very low.

1.2.2 Sealed ball bearings

Like shielded ball bearings, sealed ball bearings have the same boundary dimensions as those of the open type bearings. Sealed ball bearings also have the function of keeping foreign matter out and grease in with seals.

Seals consisting of synthetic rubber molded to a steel plate are incorporated into the outer rings of these ball

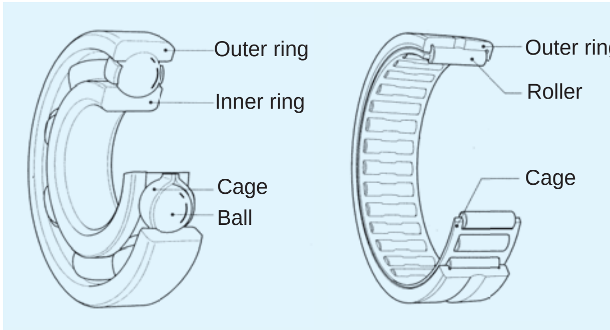


Fig. 1.1 Rolling bearings

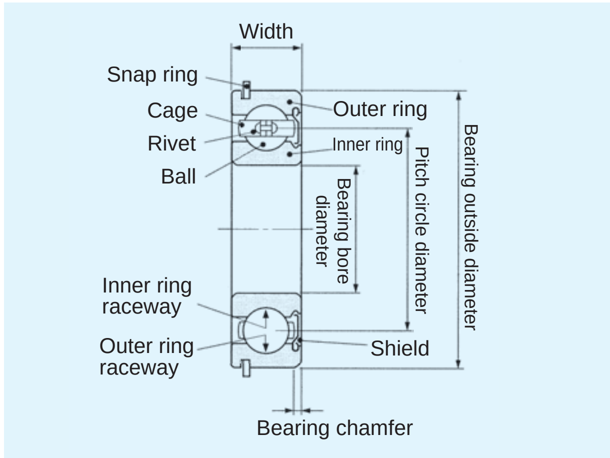
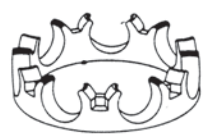


Fig. 1.2 The construction of deep groove ball bearing

Table 1.1 Cage type and material

Type	
	Pressed steel riveted cage
	Pressed steel ribbon cage
	Plastic snap cage
	Stainless snap cage

bearings. There are two major types of sealed bearings: contact type and non-contact type sealed bearings. The LLU type is equipped with two contact seals, one on each side of the bearings while the LLB type uses non-contact type seas instead. Similar construction to LLU type, the LLH type sealed bearings perform better low torque characteristics than that of LLU type because of its special lip design. Basically, bearings with contact seals have excellent and effective functions of dust and water proofing while bearings with non-contact seals are suitable for applications requiring low torque operation.

1.2.3 Expansion compensating bearings

Expansion compensating bearings have the same boundary dimensions as standard bearings, except that a high polymer material with a large coefficient of thermal expansion has been inserted along the outer circumference of the outer ring. Due to the extremely small difference of thermal expansion attained between the fitted surfaces of the high polymer and the light alloy bearing housing, a good interference fit can be achieved with stable performance across a wide temperature range. Another advantage is a large reduction in the occurrence of outer ring creeping.

In cases where the bearing is going to be interference fit with the housing, it is very important not to damage the high polymer material. Regulations for radial internal clearance are the same as those for standard deep groove ball bearings. For standard fit and application conditions, a C3 clearance is used with this bearing.

1.2.4 CSB ball bearings

CSB bearings have the same boundary dimensions as standard deep groove ball bearings, but have undergone a special heat treatment that considerably extends wear life. These bearings are especially effective in countering reduced wear life due to the effects of infiltration by dust and other foreign matter. CSB 62 series bearings can be used in place of standard 63 series bearings enabling lighter weight, more compact designs.

1.2.5 ESB bearings

ESB bearings have the same boundary dimensions as standard deep groove ball bearings, but have undergone a special heat treatment and surface structure stabilization with nitrogen under the proper material and conditions. ESB bearings are designed to be able to withstand in the harsh lubrication conditon containing hard foreign matter. These bearings enhance wear property and fatigue life even superior to CSB bearings under such condition.

1.2.6 AC bearings (creep prevention bearings)

AC bearings have the same boundary dimensions as standard bearings with the addition of two O-rings imbedded in the outside circumference of the outer ring. This bearing has a steel housing, can withstand rotating outer ring loads, and is suitable for applications where a "tight fit" is not possible but the fear of creeping exists. With its capacity for axial load displacement, an AC bearing can also be installed as a floating side bearing to accommodate shaft fluctuations.

1.2.7 TS bearings

Special care is needed for bearings used in high operating temperature, such as 120oC and above. The TS bearings is designed to accommodate such strict condition. These TS bearings are dimension stabilized and can withstand operation with high temperature up to 250 oC.

1.2.8 Low noise bearings

The smaller sizes of series 60 and 62 with shields and seals are also available in a special low noise quality for applications where silent running is of prime importance, such as the application of fan motors in air conditioning. The low noise bearings require good running accuracy and made by improved washing and assembly manufacturing process. In addition, The bearings are usually pre-lucricated with low noise grease.

In order to prevent fretting corrosion on raceways and balls of bearings due to poor transportation condition in some areas, The grease with good fretting resistance and low noise characteristics is selected and performs well in such condition.

1.2.9 BL (maximum capacity type) ball bearings

The boundary dimensions of the maximum capacity ball bearings are the same as those of series 62 and 63 of deep groove ball bearings. In order to assemble the steel balls, filling slots are provided on both inner and outer rings of the bearings. Accordingly, more steel balls are assembled in these bearings than those of the standard type deep groove ball bearings. Therefore, the load carrying capacity becomes 20% to 35% larger than that of standard bearings. Due to the filling slot, BL bearings are not suitable for applications that employ heavy axial loads.

1.2.10 Angular contact ball bearings

In mechanical design, subject to both radial and axial loads, the so-called angular contact bearings are recommended. According to various load ratio of axial to radial load, these bearings with appropriate contact angle may be applied. They are usually applied in duplex arrangement to

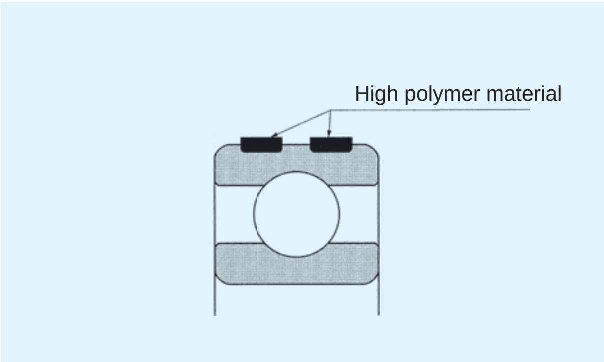


Fig. 1.3 Expansion compensating bearing

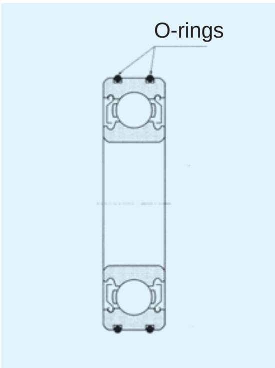


Fig. 1.4 AC bearing

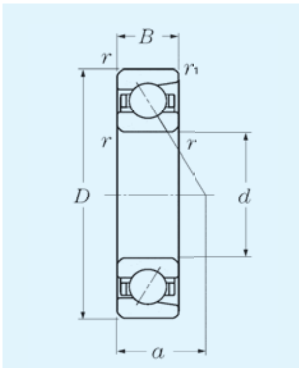


Fig. 1.5 Angular contact ball bearing

gain axial rigidity. In high speed spindle application, angular contact ball bearings need to be adjusted with higher dimensional and running accuracy, precision cage, and used in an appropriate way of lubrication to reach their maximum speed.

Other types of angular contact ball bearings include thrust angular contact bearings and double row angular contact ball bearings. Thrust angular contact bearings with a larger contact angle of 60° boast greater axial rigidity. Besides, since balls are used as the rolling elements, the starting torque of a angular contact thrust ball bearing is less than that of a roller bearing.The structure of double row angular contact ball bearing is designed by arranging two single row angular contact bearings back-to-back in duplex (DB) to form in one bearing with a contact angle of 30° . These bearings are capable of accommodating radial loads, axial loads in either direction, and have a high capacity for momentary loads as well.

1.2.11 Stainless ball bearings

Stainless ball bearings have the same boundary dimensions and ISO tolerance as standard deep groove ball bearings, but have better corrosive resistance than standard bearings in special environments.

The rings and balls of these bearings are made of martensite stainless steel with hardness at least HRc 58 , while cages and shields are made of austenite stainless steel, please refer to 8. Bearing Material for their chemical composition.

1.3 Cylindrical roller bearings

Cylindrical roller bearings have a larger load carrying capacity which make them more suitable for applications requiring long life and endurance for heavy loads and shock loads.

Cylindrical roller bearings can be categorized into cylindrical roller bearings and needle roller bearings, according to its roller dimension ratio: ratio of roller length to its diameter.

1.3.1 Needle Roller bearings

Needle roller bearings have relatively smaller diameter cylindrical rolling elements whose length is much larger that their diameter.

Compared with other types of rolling bearings, needle roller bearings have a small cross-sectional height and significant load-bearing capacity and rigidity relative to their volume. Also, because the inertial force action on them is limited, they are ideal choice for oscillating motion. Needle roller bearings contribute to compact light weight machine designs. They serve also as a ready replacement for sliding bearings.

TPI offers two types of needle roller bearings commonly used in motorcycle industry: needle roller and cage assembly and drawn-cup needle roller bearing.Needle roller and cage assembly is the most commonly used needle roller bearings. It comprises needle rollers and a cage to support the rollers. It is used typically for connecting rods in reciprocating compressors and small- and mid-sized internal combustion engines such as those for motorcycles. This assembly features such a cage that is specifically optimized for severe operating conditions involving high impact loads, complicated motions, high speed revolution and/or high operating temperatures.

The drawn-cup needle roller bearing is composed of an outer ring drawn from special thin steel plate by precision deep drawing, needle rollers, and a cage assembled in the outer ring after the hardened raceway surface. This bearing is the type with the lowest section height, of the rolling bearings with outer ring, and best-suited for space-saving design.

2. Bearing Number Codes

Rolling bearing part numbers indicate bearing type, dimensions, tolerances, internal construction, and other related specifications. Bearing numbers are comprised of a "basic number" followed by "supplementary codes." The makeup and order of bearing numbers is shown in Table 2.1(Number and code arrangement for deep groove and miniature ball bearings), Table 2.6(for angular contact ball bearings), and Table 2.7(for needle roller bearings).

The basic number indicates general information about a bearing, such as its fundamental type, boundary dimensions, series number, bore diameter code and contact angle. These coded series are shown in Table 2.2 and Table 2.3 respectively.

The supplementary codes derive from prefixes and suffixes which indicate a bearing's tolerances, internal clearances, and related specifications. These two codes are shown in Table 2.4 and Table 2.5.

Table 2.1 Number and code arrangement for deep groove and miniature ball bearings

TS2- 6 2 05 ZZ C3 P5 / 2A

Number and code arrangement				Example
Supplementary prefix code	Special application code Material/heat treatment code			TS2-
Basic numbers	Dimension series code		Design code	6
		Dimensional series code	Width/height series code	
			Diameter series code	2
	Bore diameter number			05
Supplementary suffix code	Internal modification code			
	Cage codes			
	Seal/shield code			ZZ
	Ring configuration code			
	Internal clearance code			C3
	Tolerance code			P5
	Lubrication code			2A

Table 2.2 Supplementary prefix code

code	Definition
F-	Stainless steel bearings
TS2-	Dimension stabilized bearings for high temperature use (to 160˚C)
TS3-	Dimension stabilized bearings for high temperature use (to 200˚C)
TS4-	Dimension stabilized bearings for high temperature use (to 250˚C)
TM-	Special heat treated long-life bearings
CS-	Special heat treated long-life bearings
ES-	Special heat treated and material extra long-life bearings
EC-	Expansion compensating bearings
AC-	Creep preventing bearings

Table 2.3 Bearing series symbol

Bearing series	Type symbol	Dimensions series: width series	Dimensions series: diameter series	Bearing type
68	6	(1)	8	Single-row deep groove ball bearings
69		(1)	9	
60		(1)	0	
62		(0)	2	
63		(0)	3	
64		(0)	4	

Note: Please consult TPI concerning bearing series codes, and supplementary prefix/suffix codes not listed in the above table.

Table 2.4 Bore diameter number

Bore diameter number	Bore diameter d mm	Remark
/0.6 /1.5 /2.5	0.6 1.5 2.5	Slash (/) before bore diameter number
1 : 9	1 : 9	Bore diameter expressed in single digits without code
00 01 02 03	10 12 15 17	—
/22 /28 /32	22 28 32	Slash (/) before bore diameter number
04 05 06 07 08 09 10	20 25 30 35 40 45 50	Bore diameter number in double digits after dividing bore diameter by 5

Table 2.5 Supplementary suffix number

Code		Explanation
Cage	L1	Machined brass cage
	F1	Machined steel cage
	G1	Machined brass cage, rivetless
	G2	Pin-type steel cage
	J	Pressed steel cage
	T1	Phenolic cage
	T2	Plastic cage, nylon or teflon
Seal or shield	LLB	Synthetic rubber seal (non-contact type)
	LLU	Synthetic rubber seal (contact type)
	LLH	Synthetic rubber seal (low torque type)
	ZZ	Shield
	ZZA	Removable shield
Ring configuration	N	Snap ring groove on outer ring, but without snap ring
	NR	Snap ring on outer ring
	D	Bearings with oil holes
Internal clearance	C2	Radial internal clearance less than Normal
	(CN)	Normal radial internal clearance, but not shown in nominal numbers
	C3	Radial internal clearance greater than Normal
	C4	Radial internal clearance greater than C3
	CM	Radial internal clearance for electric motor bearings
	NA	Non-interchangeable clearance (shown after clearance code)
	/GL	Light preload
	/GN	Normal preload
	/GM	Medium preload
	/GH	Heavy preload
Tolerance standard	(P0)	JIS standard Class 0 (ABEC-1)
	P6	JIS standard Class 6 (ABEC-3)
	P5	JIS standard Class 5 (ABEC-5)
	P4	JIS standard Class 4 (ABEC-7)
	P2	JIS standard Class 2 (ABEC-9)
Lubrication	/2A	Shell Alvania S2 grease
	/5C	Caltex RPM SRI 2 grease
	/3E	ESSO Beacon 325 grease
	/5K	MULTEMP SRL grease

5S-7014C T1 DB G/GL P4

Table 2.6 Number and code arrangement for angular contact ball bearings(ACBB)

code			Explanation
Basic Numbers	Ball material	5S-	Si_3N_4 Ceramic balls
		blank	SUJ2
	Ring material	F-	SUS440C
		blank	SUJ2
	Bearing series	7	Standard type ACBB
		HSE	High speed type ACBB
		HTA	High Speed Thrust ACBB
		BS	Thrust ACBB (60° Contact angle)
	Diameter series	9 0 2	Refer to Table 2.3, BS's code is blank
	Bore diameter number	8 : 20	Refer to Table 2.4, BS's code is bore diameter(mm) x outside diameter(mm)
	Contact angle code	C	15°
		CE1	18°
		AD	25°
		(A)	30°,may not shown in code
		B	40°
Supplementary suffix code	Cage	T1	Phenolic cage
		blank	Nylon cage
	Matching code	DB	Back to back(double-row)
		DF	Face to face(double-row)
		DT	Tandem(double-row)
		DBT	Tandem and back to back (triple-row)
		DTBT	Tandem and back to back(quad-row)
	Flush grinding	G	Flush ground type
		blank	Without flush ground
	Internal clearance	/GL	Light preload
		/GN	Normal preload
		/GM	Medium preload
		/Gxx	Special preload
		/CSxx	Special clearance
	Tolerance standard	P5	JIS standard Class 5
		P4	JIS standard Class 4
		P4X	JIS standard Class 4、special bore and outside diameter tolerance
		P42	JIS standard Class 4 (dimensional)、JIS standard Class 2 (running accuracy)
		P4A	BS, above JIS standard Class 4
		P2	JIS standard Class 2

Table 2.7 Number and code arrangement for needle roller bearings

K 28 X 32 X 17 S V1

code			Explanation
Supplementary prefix code		8Q	Bearings with cage assemblies treated by soft-nitriding
Basic number	Series code	K, KJ, KMJ, PCJ, PK, KBK	Needle roller and cage assemblies bearing
		HK, HMK, BK	Drawn-cup needle roller bearing
	Dimension code		Bore diameter
			Outside diameter
			Width
Suffix supplemental code	Cage assemblies code	S	Welded cage
	Seal, shield code	L	With the synthetic rubber seal on one side(contact type)
		LL	With the synthetic rubber seal on both side(contact type)
	Lubricant code	/2A	ALVANIA S2
		/3A	ALVANIA S3
		/5K	MULTEMP SRL
		/LPO3	Heat hardening type grease
	Tolerance standard	P6	JIS standard Class 6
		P5	JIS standard Class 5
		P4	JIS standard Class 4
		PX1~PXn	Special dimension tolerance
	Special code	V1~Vn	Special specifications, requirements

3. Bearing Tolerances

Bearing "tolerances" or dimensional accuracy and running accuracy, are regulated by ISO and JIS B 1514 standards (rolling bearing tolerances). For dimensional accuracy, these standards prescribe the tolerances necessary when installing bearings on shafts or in housings. Running accuracy is defined as the allowable limits for bearing runout during operation.

Dimensional accuracy constitutes the acceptable values for bore diameter, outer diameter, assembled bearing width, and bore diameter uniformity as seen in chamfer dimensions. Running accuracy constitutes the acceptable values for inner and outer ring radial runout and axial runout, inner ring side runout, and outer ring outer diameter runout.

Allowable rolling bearing tolerances have been established according to precision classes. JIS Class 0 corresponds to normal precision class bearings, and precision becomes progressively higher as the class number becomes smaller. Table 3.1 shows a relative comparison between JIS B 1514 precision class standards and other standards.

Table 3.1 Comparison of tolerance classifications of national standards

Standard		Tolerance Class					Bearing Types
Japanese industrial standard (JIS)	JIS B 1514	class 0,6X	class 6	class 5	class 4	class 2	All type
International Organization for Standardization (ISO)	ISO 492	Normal class Class 6X	Class 6	Class 5	Class 4	Class 2	Radial bearings
	ISO 199	Normal class	Class 6	Class 5	Class 4	—	Thrust ball bearings
	ISO 578	Class 4	—	Class 3	Class 0	Class 00	Tapered roller bearings (Inch series)
	ISO 1224	—	—	Class 5A	Class 4A	—	Precision instrument bearings
Deutsches Institut fur Normung (ISO)	DIN 620	P0	P6	P5	P4	P2	All type
American National Standards Institute(ANSI) Anti-Friction Bearing Manufacturers(AFBMA)	ANSI/ABMA Std.20 ❶	ABEC-1 RBEC-1	ABEC-3 RBEC-3	ABEC-5 RBEC-5	ABEC-7	ABEC-9	Radial bearings (Except tapered roller bearings)
	ANSI/ABMA Std. 19.1	Class K	Class N	Class C	Class B	Class A	Tapered roller bearings (Metric series)
	ANSI/ABMA Std. 19	Class 4	Class 2	Class 3	Class 0	Class 00	Tapered roller bearings (Inch series)

❶ "ABEC" is applied for ball bearings and "RBEC" for roller bearings.

Notes 1: JIS B 1514, ISO 492 and 199, and DIN 620 have the same specification level.

2: The tolerance and allowance of JIS B 1514 are a little different from those of AFBMA standards.

4. Load Rating and Life

4.1 Bearing life

When in service, even a bearing that is properly lubricated, properly installed, and adequately protected from abrasives, moisture, and corrosive reagents, can fail from material fatigue. Material fatigue is manifested as flaking off of metallic particles from the surface of a raceway or rolling element. This flaking will eventually cause the bearings to fail. The effective life of a bearing is usually defined in terms of the total number of revolutions a bearing can undergo before flaking of either the raceway surface or the rolling element surfaces occurs.

Other causes of bearing failure are often attributed to problems such as seizing, abrasions, cracking, chipping, gnawing, rust, etc. However, these so called "causes" of bearing failure are usually themselves caused by improper installation, insufficient or improper lubrication, faulty sealing or inaccurate bearing selection. Since the above mentioned "causes" of bearing failure can be avoided by taking the proper precautions, and are not simply caused by material fatigue, they are considered separately from the flaking aspect.

4.2 Basic rating life and basic dynamic load rating

A group of seemingly identical bearings when subjected to identical load and operating conditions will exhibit a wide diversity in their durability. This "life" disparity can be accounted for by the difference in the fatigue of the bearing material itself. This disparity is considered statistically when calculating bearing life, and the basic rating life is defined as follows. The basic rating life is based on a 90% statistical model which is expressed as the total number of revolutions 90% of the bearings in an identical group of bearings subjected to identical operating conditions will attain or surpass before flaking due to material fatigue. For bearings operating at fixed constant speeds, the basic rating life (90% reliability) is expressed in the total number of hours in operation.

The basic dynamic load rating is an expression of the load capacity of a bearing based on a constant load which the bearing can sustain for one million revolutions (the basic life rating). For radial bearings this rating applies to pure radial loads, and for thrust bearings it refers to pure axial loads. The basic dynamic load ratings given in the bearing tables of this catalog are for bearings constructed of TPI standard bearing materials, using standard manufacturing techniques. Please consult TPI for basic load ratings of bearings constructed of special materials or using special manufacturing techniques.

The relationship between the basic rating life, the basic dynamic load rating and the bearing load is given in formula (4.1).

$$L_{10}=\left(\frac{C_r}{P}\right)^p \quad\text{..................(4-1)}$$

where，

p=3 ················for ball bearings

p=10/3············for roller bearings

L_{10} ：Basic rated life 10^6 revolutions

C_r ：Basic dynamic rated load, N or kgf

P ： Equivalent dynamic load, N or kgf

The basic rating life can also be expressed in terms of hours of operation (revolution), and is calculated as shown in formula (4.2).

$$L_{10h}=500\, f_h^{\,p} \quad\text{....................(4-2)}$$

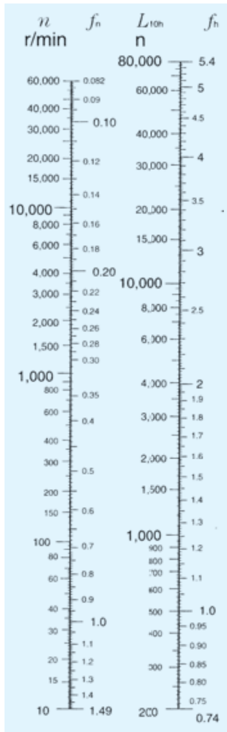


Fig. 4.1 Bearing life rating scale

$$f_h= f_n\,\frac{C_r}{P} \quad\text{.......................(4-3)}$$

$$f_n=\left(\frac{33.3}{n}\right)^{1/p} \quad\text{....................(4-4)}$$

where,

L_{10h} ：Basic rated life, hour

f_h ：Life factor

f_n ：Speed factor

n : Rotational speed, rpm

Formula (4.2) can also be expressed as shown in formula (4.5).

$$L_{10h}=\frac{10^6}{60n}\left(\frac{C_r}{P}\right)^p \text{ ....(4-5)}$$

The relationship between rotational speed n and speed factor as well as the relation between the basic rating life and the life factor is shown in Fig. 4.1.

4.3 Machine applications and requisite life

When selecting a bearing, it is essential that the requisite life of the bearing be established in relation to the operating conditions. The requisite life of the bearing is usually determined by the type of machine in which the bearing will be used, and duration of service and operational reliability requirements.

A general guide to these requisite life criteria is shown in Table 4.1. When determining bearing size, the fatigue life of the bearing is an important factor; however, besides bearing life, the strength and rigidity of the shaft and housing must also be taken into consideration.

4.4 Equivalent load

(1) Dynamic equivalent load

When both dynamic radial loads and dynamic axial loads act on a bearing at the same time, the hypothetical load acting on the center of the bearing which gives the bearings the same life as if they had only a radial load or only an axial load is called the dynamic equivalent load. For radial bearings, this load is expressed as pure radial load and is called the dynamic equivalent radial load.

The dynamic equivalent radial load is expressed by formula (4.6).

$$P_r=XF_r+YF_a \text{ ....(4-6)}$$

where,

P_r : Dynamic equivalent radial load, N or kgf

F_r : Actual radial load, N or kgf

F_a : Actual axial load, N or kgf

X : Radial load factor

Y : Axial load factor

The values for X and Y are listed in the bearing tables.

Generally speaking, it is considered that bearings are under the light load condition if the magnitude of equivalent radial load ≦ 0.06 Cr. Normal and heavy load conditions are defined as follows:

Normal loads: 0.06 C_r < equivalent radial load ≦ 0.12 C_r

Heavy loads: 0.12 C_r < equivalent radial load

Table 4-1 Machine application and requiste life L_{10h}

Service calssification	Life factor and machine application $L_{10h}\times 10^3$ hour				
	～4	4～12	12～30	30～60	60～
Machinees used for short periods or used only occasionally	Electric hand tools, Household appliances	Farm machinery Office equipmment	–	–	–
Short period or intermittent use, but with high reliability requirements	Medical appliances, Measuring instruments	Home air-conditioning motor, Construction equipment, Elevators Cranes	Crane (sheaves)	–	–
Machines not in constant use, but used for long periods	Automobiles Two-wheeled vehicles	Small motors Buses/trucks Drivers Woodworking machines	Machine spindles Industrial motors Crushers Vibrating screens	Main gear drives, Rubber/plastic Calender rolls, Printing machines	–
Machines in constant use over 8 hours a day	–	Rolling mills Escalators Conveyors Centrifuges	Railway vehicle axles, Air conditioners Large motors, Compressor pumps	Locomotive axles, Traction motors, Mine hoists, Pressed flywheels	Papermaking machines, Propulsion equipment for marine vessels
24 hour continuous operation, non-interruptible	–	–	–	–	Water supply equipment, Mine drain pumps/ ventilators, Power generating equipmment

(2) Static equivalent load

The static equivalent load is a hypothetical load which would cause the same total permanent deformation at the most heavily stressed contact point between the rolling elements and the raceway under the actual load conditions where both static radial load and static axial load are simultaneously applied to a bearing. For a radial bearing, this hypothetical load refers to pure radial load.

For radial bearings the static equivalent radial load can be found by using formula (4.7) or (4.8). The greater of the two resultant values is always taken for P_{or}.

$$P_{or}=X_oF_r+Y_oF_a \text{.............................}(4\text{-}7)$$

$$P_{or}=F_r \text{...}(4\text{-}8)$$

where,

P_{or} : Static equivalent radial load, N or kgf

F_r : Actual radial load, N or kgf

F_a : Actual axial load , N or kgf

X_o : Static radial load factor

Y_o : Static axial load factor

The values for X_o and Y_o are given in the respective bearing tables.

4.5 Bearing load distribution

For shafting, the static tension is considered to be supported by the bearings, and any loads acting on the shafts are distributed to the bearings.

For example, in the gear shaft assembly depicted in Fig. 4.2, the applied bearing loads can be found by using formulas (4.9) and (4.10).

$$F_{rA}=\frac{a+b}{b}F_I+\frac{d}{c+d}F_{II} \text{...........}(4\text{-}9)$$

$$F_{rB}=-\frac{a}{b}F_I+\frac{c}{c+d}F_{II} \text{......}(4\text{-}10)$$

where,

F_{rA} : Radial load on bearing A, N or kgf

F_{rB} : Radial load on bearing B, N or kgf

F_I, F_{II} : Radial load on shaft, N or kgf

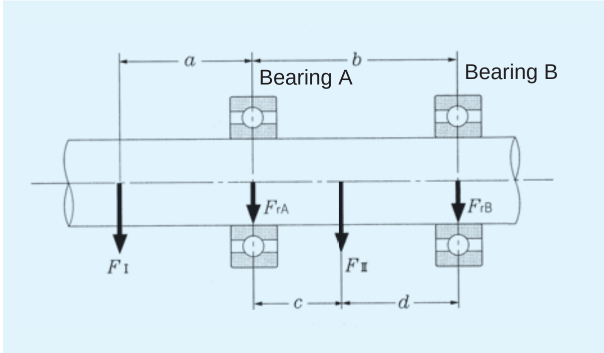


Fig. 4.2 Gear Shaft

【**Example 1**】What is the rating life in hours of operation (L_{10h}) for deep groove ball bearing 6207 operating at 650 r/min, with a radial load of 2.8 kN or 286 kgf ?

【**Solution 1**】From formula (4.17) the dynamic equivalent radial load:

$P_r=F_r$ = 2.8 kN or 286 kgf

The basic dynamic rated load for bearing 6207 (from bearing table) is 25.7 kN or 2620 kgf, and the speed factor (f_h) for ball bearings at 650 r/min (n) from Fig. 4.1 is 0.37. The life factor, f_h , from formula (4.3) is:

$$f_h=f_n\frac{C_r}{P_r}=0.37\times\frac{25.7}{2.8}=3.40$$

Therefore, with f_n =3.40 from Fig. 4.1 the rated life,L_{10h} , is approximately 20,000 hours.

【**Example 2**】What is the life rating L_{10h} for the same bearing and conditions as in **Example 1**, but with an additional axial load F_a of 1.6 kN or 163 kgf?

【**Solution 2**】To find the dynamic equivalent radial load value for P_r , the radial load factor X and axial load factor Y are used. The basic static load rating,C_{or} , for bearing 6207 is 15.3 kN or 1560 kgf.

F_a / C_{or}=1.6 / 15.3 = 0.10

e = 0.29

For the operating radial load and axial load:

F_a / F_r=1.6 / 2.8 = 0.57 $>$ e = 0.29

From the bearing tables X=0.56 and Y=1.48, and from formula (4.17) the equivalent radial load, P_r , is:

$$P_r = XF_r + YF_a = 0.56 \times 2.8 + 1.48 \times 1.6$$
$$= 3.94 \text{ kN or } 420\text{kgf}$$

From Fig. 4.1 and formula (4.3) the life factor, f_h , is:

$$f_h = f_n \frac{C_r}{P_r} = 0.37 \times \frac{25.7}{3.94} = 2.41$$

Therefore, with life factor f_h =2.41, from Fig. 4.1 the rated life, L_{10h} , is approximately 7,000 hours.

5. Bearing Fits

For rolling bearings, inner and outer rings are fixed on the shaft or in the housing so that relative movement does not occur between fitted surfaces during operation or under load. This relative movement (referred to as "creep") between the fitted surfaces of the bearing and the shaft or housing can occur in a radial direction, an axial direction, or in the direction of rotation. To help prevent this creeping movement, bearing rings and the shaft or housing are installed with one of three interference fits, a "tight fit" (also called shrink fit), "transition fit," or "loose fit" (also called clearance fit), and the degree of interference between their fitted surfaces varies.

Selection of a proper fit is dependent upon the operating conditions of bearings. Table 5.1 shows the basic principle of bearing fit under a radial load. Fig. 5.1 shows 0 Class tolerance bearings fits for various shaft and housing bore diameter tolerances. Table 5.2~5.4 show general standards for radial bearing fits.

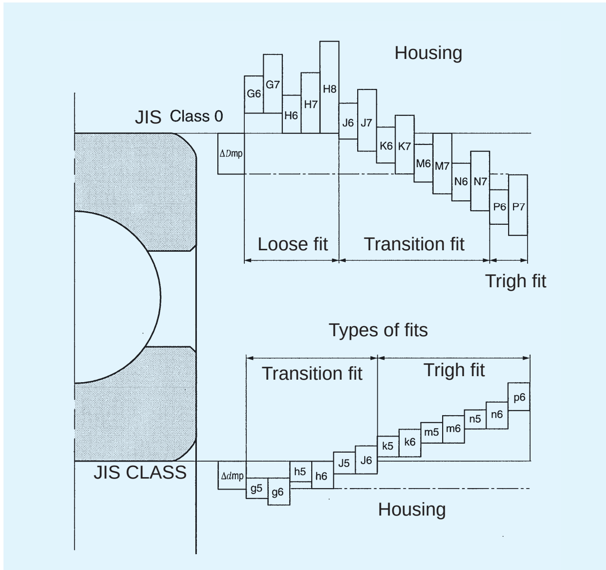


Fig 5.1

Table 5.1 Radial load and bearing fit

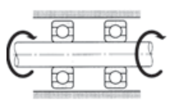
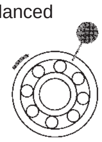
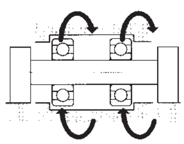
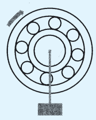
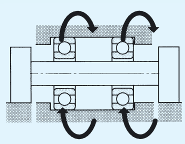
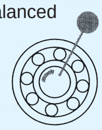
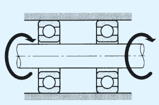
Illustration	Bearing rotation	Ring load	Fit
Static load 	 Inner ring: Rotating Outer ring: Stationary	Rotating Inner : ring load Static Outer : ring load	Inner ring : Tight fit Outer ring : Loose fit
Unbalanced load 	 Inner ring: Rotating Outer ring: Stationary		
Static load 	 Inner ring: Rotating Outer ring: Stationary	Static Outer : ring load Rotating Inner : ring load	Inner ring : Loose fit Outer ring : Tight fit
Unbalanced load 	 Inner ring: Rotating Outer ring: Stationary		

Table 5.2 Fit with shaft

Nature of load	Fit	Load conditions, magnitude	Load conditions, magnitude Ball bearing: Shaft diameter mm (over ～ incl)	Tolerance class	Remarks
Indeterminate direction load Rotating inner ring load	Tight fit / Transition fit	Light or fluctuating variable load	～ 18 18 ～ 100 100 ～ 200	h5 js6 k6	When greater accuracy is required js5, k5, and m5 may be substituted for js6, k6, and m6.
		Normal load	～ 18 18 ～ 100 100 ～ 140 140 ～ 200	js5 k5 m5 m6	Alteration of inner clearances to accommodate fit is not a consideration with single-row angular contact bearings and tapered roller bearings. There fore, k5 and m5 may be substituted for k6 and m6.
		Heavy① load or shock load			Use bearings with larger internal clearances than CN clearance bearings.
Static inner ring boad	Transition fit	Inner ring axial displacement possible	All shaft diameters	g6	When greater accuracy is required use g5. For large bearings, f6 may be used
		Inner ring axial displacement unnecessary		h6	When greater accuracy is required use h5.
Centric axial load only	Transition fit	All loads	All shaft diameters	js6	General; depending on the fit, shaft and inner rings are not fixed.

Table 5.3 IT clearance

Dimension(mm)		Level of clearance									
Excess	Under	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10
_		0.8	1.2	2	3	4	6	10	14	25	40
3	6	1	1.5	2.5	4	5	8	12	18	30	48
6	10	1	1.5	2.5	4	6	9	15	22	36	58
10	18	1.2	2	3	5	8	11	18	27	43	70
18	30	1.5	2.5	4	6	9	13	21	33	52	84
30	50	1.5	2.5	4	7	11	16	25	39	62	100
50	80	2	3	5	8	13	19	30	46	74	120
80	120	2.5	4	6	10	15	22	35	54	87	140
120	180	3.5	5	8	12	18	25	40	63	100	160

Table 5.4 Housing fits

Nature of load	Housing	Fit	Load conditions, magnitude	Tolerance class	Outer ring axial displacement	Remarks
Rotating outer ring load or static outer ring load	Solid or split housing	Loose fit	All loads	H7 G7	Displacement possible Easy displacement	G7 also acceptable for large type bearings as well as outer rings and housings with large temperature differences.
			Light ① to normal load	H8	Displacement possible	—
			Shaft and inner rings reach high temperature	G7 F7	Easy displacement Easy displacement	F7 also acceptable for large type bearings as well as outer rings and housings with large temperature differences.
	Solid housing	Transition or loose fit	Requires sillent operation	H6	Displacement possible	—
			High rotation accuracy required with light to normal loads	Js6	Displacement not possible (in principle)	Applies primarily to ball bearings
				K6	Displacement not possible (in principle)	Applies primarily to roller bearings
Direction indeterminate load		Tight to transition fit	Light to normal load	Js7	Displacement possible	When greater accuracy is required substitute Js6 for Js7 and K6 for K7.
			Normal to heavy load	K7	Displacment not possible (in principle)	
			Heavy shock load	M7	Displacment not possible	—
Inner ring static load or outer ring rotating load		Tight fit	Light or variable load	M7	Displacement not possible	—
			Normal to heavy load	N7	Displacement not possible	Applies primarily to ball bearings
			Heavy load(thin wall housing) or heavy shock load	P7	Displacement not possible	Applies primarily to roller bearings
Centered axial load only - Loose fit		Loose fit	—	Select a tolerance class that will provide clearance between outer ring and housing.		—

❶ Standards for ligh loads, normal loads, and heavy loads

- Light loads: equivalent radial load ≦0.06Cr
- Normal loads : 0.12 Cr < equivalent radial load ≦0.12Cr
- Heavy loads : 0.12 Cr< equivalent radial load

❷ Indicates whether or not outer ring axial displacement is possible with non-separable type bearings.

Note 1: All values and fits listed in the above tables are for cast iron or steel housings.
2: In cases where only a centered axial load acts on the bearing, select a tolerance class that will provide clearance in the axia direction for the outer ring.

5.1 Fit selection

Selection of the proper fit is generally based on the bearing rotation and load conditions. Generally-used, standard fits for most types of bearings and operating conditions can be obtained in bearing technical manuals. In combine with the following recommendations:

(1) The interference should be tighter for heavy bearings load.
(2) The interference should be tighter for vibration and shock load conditions.
(3) In general, the larger of the bearing size the tighter of the interference.
(4) A tighter than normal fit should be given when the bearing is installed in hollow shafts or in housings with thin walls.
(5) The interference calculation needs to be considered the roughness of the mating surfaces.
(6) A tighter than normal fit should be given when the bearing is installed in housings made of light alloys or plastics.
(7) The interference calculation needs to be considered the loosening of the inner ring on shaft due to temperature increase.

Table 5-1 lists the fits for electric motor bearings. The dimensional tolerance for both shaft and housing bore are shown in Appendix II and given as reference for bearing fits against shaft and housing bore.

Table 5.5 Fits for electric motor bearing (deep groove ball)

Bearing fit	Shaft diammeter mm over incl.	Tolerance class
Shafts fit	～18	j5
	18～100	k5
	100～160	m5
Housing fit	All sizes	H6 or J6

6. Bearing Internal Clearance and Preload

6.1 Bearing internal clearance

Bearing internal clearance (initial clearance) is the amount of internal clearance a bearing has before being installed on a shaft or in a housing.

As shown in Fig. 6.1, when either the inner ring or the outer ring is fixed and the other ring is free to move, displacement can take place in either an axial or radial direction. This amount of displacement (radially or axially) is termed the internal clearance and, depending on the direction, is called the radial internal clearance or the axial internal clearance.

The internal clearance values for deep groove ball bearings are shown in Table 6.2. The radial internal clearance of bearings for electric motor is given in Table 6.3.

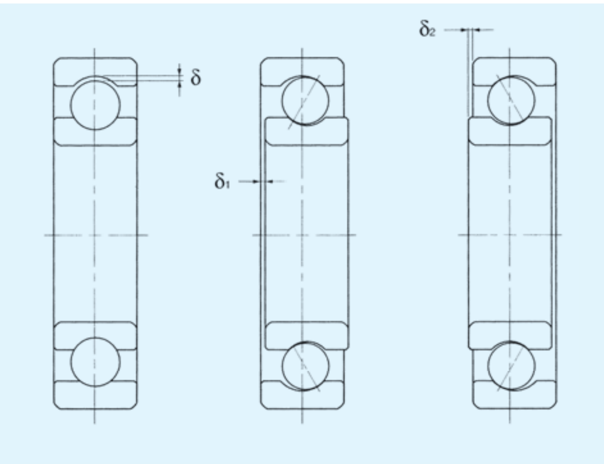
6.2 Internal clearance selection

The internal clearance of a bearing under operating conditions (effective clearance) is usually smaller than the same bearing's initial clearance before being installed and operated. This is due to several factors including bearing fit, the difference in temperature between the inner and outer rings, etc. As a bearing's operating clearance has an effect on bearing life, heat generation, vibration, noise, etc.; care must be taken in selecting the most suitable operating clearance.

6.3 Preload

Giving preload to a bearing results in the rolling element and raceway surfaces being under constant elastic compressive forces at their contact points. This has the effect of making the bearing extremely rigid so that even when load is applied to the bearing, radial or axial shaft displacement does not occur. Thus, the natural frequency of the shaft is increased, which is suitable for high speeds.

Preload is also used to prevent or suppress shaft runout, vibration, and noise; improve running accuracy and locating accuracy; reduce smearing, and regulate rolling element rotation.



Radial clearance= δ Axial clearance= $\delta_1 + \delta_2$

Fig. 6.1 Internal clearance

The most common method of preloading is to apply an axial load to two duplex bearings so that the inner and outer rings are displaced axially in relation to each other, illustrated in Fig. 6.2. This preloading method is divided into fixed position preload and constant pressure preload. In the electric motor applications, preloading is accomplished by using coil or Belleville springs. Recommended preloads are as follows:

For deep groove ball bearings:

$4\sim8d$ N

or $0.4\sim0.8d$ kgf

d : shaft diameter mm

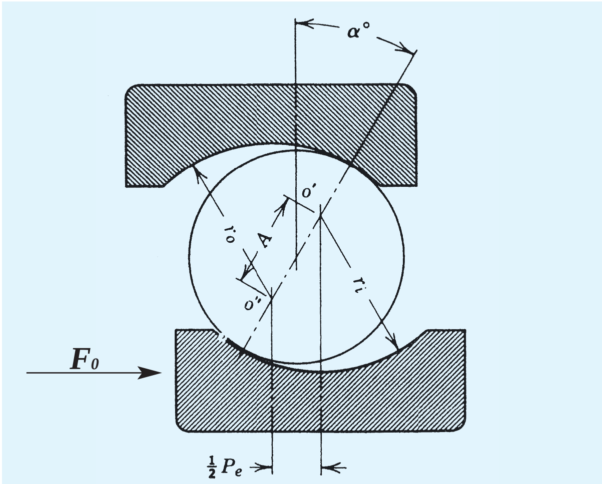


Fig. 6.2 Preload

Table 6.2 Radial internal clearance of deep groove ball bearings

Nominal bore diameter d (mm)		Radial internal clearance								Unit μm	
		C2		CN		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

Table 6.3 Radial internal clearance of bearings for electric motor

Nominal bore diameter d (mm)		Radial internal clearance CM (μm)	
over	incl.	min	max
10 (incl.)	18	4	11
18	24	5	12
24	30	5	12
30	40	9	17
40	50	9	17
50	65	12	22

For miniature bearings, the recommended preloads are listed in Table 6.4.

Preload	Amount	Characteristics
Light preload	≦1.0%Cr	Consider low friction torque rather than shaft rigidity
Medium preload	≦1.5%Cr	Consider both low friction torque and shaft rigidity
Heavy preload	≦2.0%Cr	Consider shaft rigidity and allow friction torque

7. Lubrication

7.1 Lubrication of rolling bearings

The purpose of bearing lubrication is to prevent direct metal to metal contact between the various rolling and sliding elements. This is accomplished through the formation of a thin oil(or grease) film on contact surfaces. Lubrication also helps to reduce friction and wear, dissipate friction heat, keep away from dust. In order to achieve the above advantages and prolong the bearing life, the most effective lubrication method and lubricant has to be selected for each individual operating conditions.

7.2 Grease lubrication

Grease type lubricants are relatively easy to handle and require only the simplest sealing devices—for these reasons, grease is the most widely used lubricant for rolling bearings. Lubricating grease are composed of either a mineral oil base or a synthetic oil base. To this base a thickener and other additives are added. Thickening agents are compounded with base oils to maintain the semi-solid state of the grease. Various additives are added to greases to improve various properties and efficiency. The properties of all greases are mainly determined by the kind of base oil used and by the combination of thickening agent and various additives.

Thickening agents is critical to grease performance., particularly with respect to temperature capability, water-resistance, and oil-bleeding characteristics. They are divided into two broad classes: metallic soaps and non-soaps. Metallic soap thickeners include: lithium, sodium, calcium, etc. Common greases type, property and their characteristics are listed in Table 7.1. As performance characteristics of even the same type of grease will vary widely from brand to brand, it is best to check the manufacturers' data when selecting a grease.

For some light load applications, such as the application of fan motors in air conditioning, the grease life becomes of prime bearing design parameter. If a pre-lubricated bearing is properly installed, keep free of abrasive, moisture, corrosive reagents, and dirt. The prediction of grease life can be calculated according to the method of Kawamura et al. The calculated life L_{50} (50% reliability life) of grease can be expressed as follows:

For urea-based grease：

$\log L = -2.02\times10^{-6}\times K\times V$

$-2.95\times10^{-2}\,T - 8.36\,F + 8.50 + K_1$........................(7-1)

where,

$10 \leqq dm \leqq 100,\ dmn \leqq 400000,\ 70 \leqq T \leqq 180$

For Li-based grease：

$\log L = -1.58\times10^{-6}\times K\times V$

$-2.18\times10^{-2}\,T - 9.84\,F + 6.33 + K_1$........................(7-2)

where,

$10 \leqq dm \leqq 100,\ dmn \leqq 400000,\ 70 \leqq T \leqq 150$

L : L_{50} grease life, hour

K : compensation factor for outer ring rotation(if inner ring rotation: K=1; if outer ring rotation: K= inner ring rotating speed calculated from the cage orbital speed when inner ring rotation condition is assumed/ outer ring rotating speed)

V : dmn value

dm : pitch diameter $\approx \dfrac{d+D}{2}$

D : outside diameter mm

T : bearing temperature ℃

F : load ratio P/C_r

K_1 : compensation factor for base oil type (Table 7.2)

Table 7-1 Common grease types, properties and characteristics

Code	Thickener	Base oil	Penetration (25°C 60W, mm)	Viscosity 40°C (100°C) (mm2/s , cSt)	Dropping point (°C)	Operating temperature range (°C)	Characteristics
2A	Li	mineral	273	130	182	- 25 ~ + 120	general used, light load
1K	Li	diester+ mineral	265 ~ 295	(3.8)	190	- 55 ~ + 130	general used, low temperature, low torque
3ES	Li	ester	265 ~ 295	11.5	193	- 50 ~ + 120	general used, low temperature, low torque
5K	Li	polyester	240 ~ 270	26 (5.2)	191	- 50 ~ + 150	general used, low noise
5K*	Li	polyester +diester	250	76.9 (10.4)	201	- 40 ~ + 150	general used, low noise
5C	polyurea	mineral	265 ~ 295	99 (11)	243	- 30 ~ +177	general used, high temperature
8A	Li	mineral	294	(16.0)	185	- 15 ~ + 110	EP
L627	polyurea	mineral	284	115	288	- 40 ~ + 180	high temperature, long life
L542	diurea	hydrocarbon	220	47.6	260	- 40 ~ + 200	high temperature, long life, low noise
L448	Urea	ester Oil	243	41	252	- 40 ~ + 150	low, noise, long life
L417	Urea	ether	300	72.3 (10.1)	240	- 40 ~ + 180	high temperature
L051	Ba complex	SHF	265~295	37	240	-60 ~ +180	low temperature, low torque, good water-proof

Table 7-2(1) K_1 value for urea based grease

Base oil type	compensation factor K_1
mineral	-0.08
PAO	-0.05
ester	-0.21
ether	0.18
mineral +PAO	-0.06
mineral + ester	-0.16
PAO+ ester	0
PAO+ ether	0
ester + ether	0.07

Table 7-2(2) K_1 value for Lithium based grease

Base oil type	compensation factor K_1
mineral	-0.29
PAO	-0.05
ester	0.42
diester	-0.5
silicon	0.54

Reference : T. Kawamura, M. Minami and M. Hirata, "Grease Life Prediction for Sealed Ball Bearings," Tribology Transactions, 44, 2, pp 256-262, (2001).

7.3 Oil lubrication

Oil lubrication is suitable for applications requiring that bearing-generated heat or heat applied to the bearing from other sources be carried away from the bearing and dissipated to the outside.

Under normal operating conditions, spindle oil, machine oil, turbine oil, and other mineral oils are widely used for the lubrication of rolling bearings. However, for temperatures above 150˚C or below -30˚C, synthetic oils such as diester oil, silicone oil, and fluorocarbon oil are used.

For lubricating oils, viscosity is one of the most important properties and determines an oil's lubricating efficiency. If viscosity is too low, formation of the oil film will be insufficient, and damage will occur to the load carrying surfaces of the bearing. If viscosity is too high, viscous resistance will also be great and result in temperature increase and friction loss.

7.4 Bearing seals

Bearing seals have two main functions: to prevent lubricating oil from leaking out, and to prevent dust, water, and other contaminants from entering the bearing. Bearings have to be adequately lubricated to prevent direct metallic contact between the rolling elements, raceways and cages. In addition, it can prevent wear and protect the bearing surfaces against corrosion.

Bearings with shields or seals filled with grease are widely used. Grease has the advantage over oil; it is more easily retained in the bearing arrangement. These bearings have the following advantages:

(1) Lubricated for life and maintenance-free

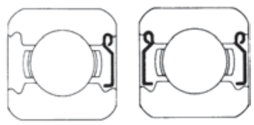
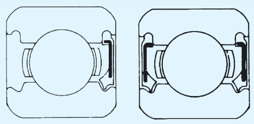
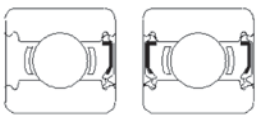
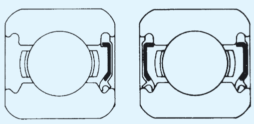
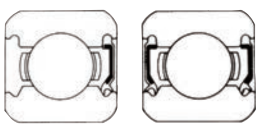
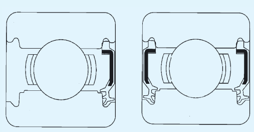
(2) Suited for normal and light load, modrate and low speed

(3) Low production cost

(4) No need of relubrication of greasing

According to the above advantages and their simplicity of housing and seal design, these bearings are widely used in electric appliance and electric motor industries. Table 7.3 lists three types of shielded and sealed bearings and their construction and characteristics.

Table 7.3 Construction and characteristics of shielded and sealed bearings

Code	Type and construction	Explanation
Z ZZ	 SHIELD	・ Metal shield plate is affixed to outer ring ・ Inner ring incorporates a V-groove and labyrinth clearance ・ Non-contact type ・ Low torque ・ Limiting speed same as open type ・ Very good in dust proofing, poor in water proofing, relative wide allowable temperature range
LB LLB	 SEAL	・ Outer ring incorporates synthetic rubber molded to a steel plate ・ Seal edge is aligned with V-groove along inner ring surface with labyrinth clearance ・ Non-contact type ・ Low torque ・ Limiting speed same as open type ・ Better than ZZ-type in dust proofing, poor in water proofing ・ Allowable temperature range: -25~120˚C
LU LLU	 SEAL	・ Metal plate wraps synthentic rubber affixed outer ring has better sealed effect ・ Seal plate has two lips, the inner lip contacts with V-groove of inner ring , the outer lip keeps small clearance with another side of V-groove, in the shape of a labyrinth. ・ Contact type ・ Good dust-resistance, standard contact type of seal plate ・ Fit low torque, dust-resistance motor ・ Allowable temperature of general material ranges from -25~120°C
LU-X LLU-X	 SEAL	・ Metal plate wraps synthentic rubber affixed outer ring hass better sealed effect ・ Seal plate has two lips, the inner lip contacts with V-groove of inner ring , the outer lip keeps small clearance with another side of V-groove, in the shape of a labyrinth. ・ Contact type ・ Higher torque than LLU ・ Good dust-resistance, water-resistance than standard LLU seal plate ・ Allowable temperature of general material ranges from -25~120°C
LH LLH	 SEAL	・ Outer ring incorporates synthetic rubber molded to a steel plate ・ Basic construction the same as LU type, but specially designed lip on edge of seal prevents penetration by foreign matter ・ Contact type ・ low torque construction; Much better that LLU-type ・ Much better that LLB-type in dust proofing, very good in water proofing ・ Allowable temperature range: -25~120˚C
LE LLE	 SEAL	・ Metal plate wraps synthentic rubber affixed outer ring has better sealed effect ・ Seal plate has four lips, two inner lip contacts with V-groove of inner ring , another inner lip form labyrinth with V-groove of inner ring, the outer lip keeps small clearance with another side of V-groove, in the shape of a labyrinth. ・ Contact type ・ Good dust-resistance, low-torque characteristic close to standard type of seal plate ・ Allowable temperature of general material ranges from -25~120˚C

Please consult TPI about applications which exceed the allowable temperature range of products listed on this table.

8. Bearing Materials

8.1 Raceway and rolling element materials

While the contact surfaces of a bearing's raceways and rolling elements are subjected to repeated heavy stress, they still must maintain high precision and rotational accuracy. To accomplish this, the raceways and rolling elements must be made of a material that has high hardness, is resistant to rolling fatigue, wear and has good dimensional stability. The most common cause of fatigue cracking in bearings is the inclusion of non-metallic impurities in the steel. By using pure materials low in these non-metallic impurities, the rolling fatigue life of the bearing is lengthened. In general, steel varieties can be hardened not just on the surface but also can be deeply hardened by the so called "through hardening method". It is used for the raceways and rolling elements of bearings. The hardness of the rings and rolling elements is usually on the order of HRc 58 to HRc 65. The most widely used and most adaptable materials for rolling bearings are high carbon steels. The most commonly used of the steels, SUJ2, is equivalent to such steels as AISI 52100 (U.S.A.), DIN 100 Cr6 (Germany), and GS 534A 99(U.K.). For bearings with large cross section dimensions, SUJ3 having good hardening prosperities are used. The chemical composition for SUJ2 and SUJ3 is shown in Table 8.1. For possible corrosive environment, the bearings made of SUS440C or NSS125 are recommended for such environment, also shown in Table 8.1

8.2 Cage materials

Bearing cage materials must have the strength to withstand rotational vibrations and shock loads. These materials must also have a low friction coefficient, be light weight, and be able to withstand bearing operation temperatures.

For small and medium sized bearings, pressed cages of cold or hot rolled steel with a low carbon content of approx. 0.1% are used. However, depending on the application, austenitic stainless steel is also used.

For those conditions where fluctuating load and high temperature are applied, some pressed cages are soft nitrided to enhance their shock resistance. Materials for press cage are listed in Table 8.2.

Injection molded plastic cages are now widely used: most are made from fiber glass reinforced heat resistant polyamide resin. Plastic cages are light weight, corrosion resistant and have excellent damping and sliding properties. Heat resistant polyamide resins now enable the production of cages that perform well in applications ranging between -40°C — 120°C. However, they are not recommended for use at temperatures exceeding 120°C.

Table 8-1 Bearing steel

Symbol	Chemical composition %						
	C	Si	Mn	P	S	Cr	Mo
SUJ 2	0.95~1.10	0.15~0.35	0.50max	0.025max	0.025max	1.30~1.60	—
SUJ 3	0.95~1.10	0.40~0.70	0.90~1.15	0.025max	0.025max	0.90~1.20	—
SUS440C	0.95~1.20	1.0max	1.0max	1.040max	0.030max	16.00~18.00	—
NSS125	0.60~0.75	1.0max	1.0max	—	—	11.50~13.50	—

Table 8-2 Materials for pressed cage

Symbol	Chemical composition %						
	C	Si	Mn	P	S	Ni	Cr
SUS304	0.08max	1.00max	2.00max	0.045max	0.03max	8.0~10.5	18.00~20.00
SPCC	0.12max	—	0.50max	0.04max	0.045max	—	—

9. Bearing Handling

Bearings are precision part. In order to preserve their accuracy and reliability, care must be exercised in their handling. In particular, bearing cleanliness must be maintained, sharp impacts avoided, and rust prevented.

9.1 Bearing storage

Most rolling bearings are coated with a rust preventative before being packed and shipped. If the package remains intact, bearings can be stored for many years. Observe the following precautions:

(1) Bearings should be stored at room temperature with a relatively humidity of less than 60%.

(2) If bearings come packed in a wooden box, take them out of the wooden box immediately, and store them on a shelf, at least 20 cm off the ground. (Shown in Fig. 9.1)

(3) Do not stack bearings because the protective anti-rust compound may be squeezed out of bottom bearings.

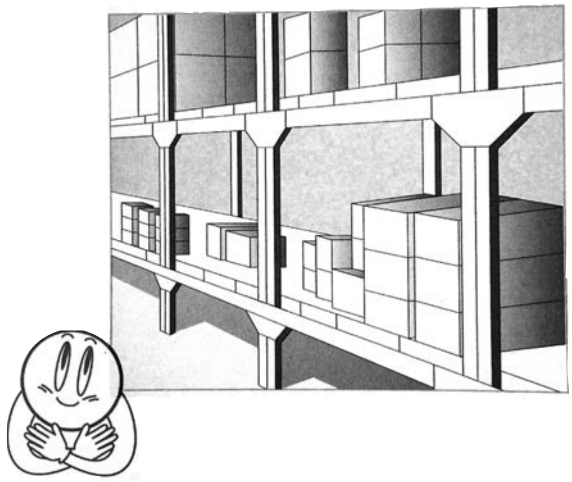


Fig 9.1 Storage of bearings

9.2 Installation

When bearings are being installed on shafts or in housings, the bearing rings should never be struck directly with a hammer or a drift, because it may damage the bearing. Any force applied to the bearing should always be evenly distributed over the entire bearing ring face. Also, when fitting both rings simultaneously, applying pressure to one ring should be avoided because indentations in the raceway surface may, or other internal damage may result.

Bearings should be fitted in a clean and dry work area. Especially for small and miniature bearings, a "clean room" should be provided, as any dust in the bearing will greatly affect bearing efficiency.

Shaft and housing surfaces should be inspected for the dimensions specified in the drawing. The corners and right angle of the shaft and bearing housing fit the side of the bearing also should be checked. Some other details for bearing installation are stated as follows:

(1) Shaft and housing bore surfaces

Before installation, shaft, housings and related parts should be cleaned and any burrs or cutting chips removed if necessary. Several steps for installation preparation as shown in Fig. 9.2。

(2) Mounting tools

It is important that the correct method of mounting is selected and the suitable tools are used. All mounting tools should be cleaned and any burrs or cutting chips removed if necessary.

(3) Bearings

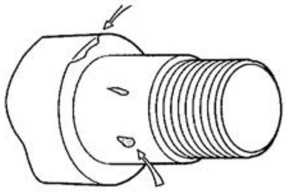
Open the bearing packaging just prior to use. As high precision components, rolling bearings are made and monitored under clean manufacturing environment before packaging. Most bearings may be mounted without washing or removing the rust preventive, unless special care procedures are stated.

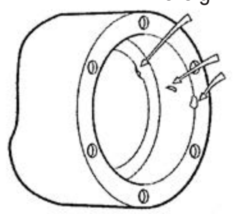
(4) Bearings with small interference fits

Bearings with relatively small interference fits can be press fit at room temperature by using a sleeve against the inner ring face. Some proper installation and tools for bearings are shown in Fig. 9.3. Usually, bearings are installed by striking the sleeve with a hammer; however, when installing a large number of bearings, a mechanical or hydraulic press should be used. When installing non-separable bearings on a shaft and in a housing simultaneously, a pad which distributes the fitting pressure evenly over the inner and outer rings is used.

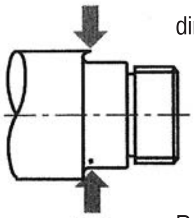
In addition to the proper installation, indentations in the raceways and balls due to dirt intrusion and improper impact load should also be avoided as shown in Fig. 9.4.

Make sure the fitting surfaces of the shaft and the bearing housing are free from scratches, burrs, dirt, and that no molding sand remains in the housing.

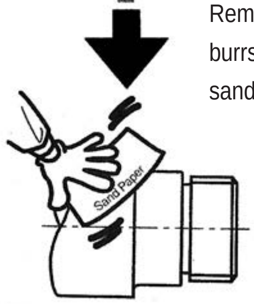


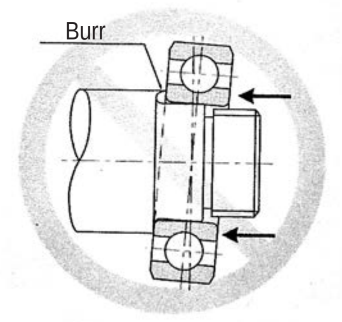


Make sure the fitting surfaces of the shaft and the bearing housing are free from scratches, burrs, dirt, and that no molding sand remains in the housing.

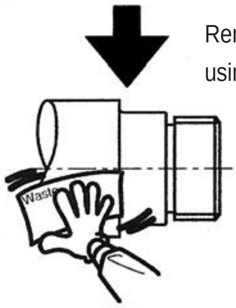


Remove scratches and burrs using fine sandpaper





Remove dirt and sand using clean cloth



Coat the area with mineral oil

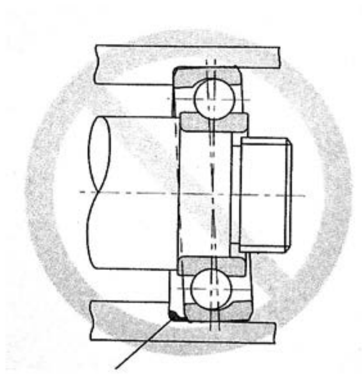
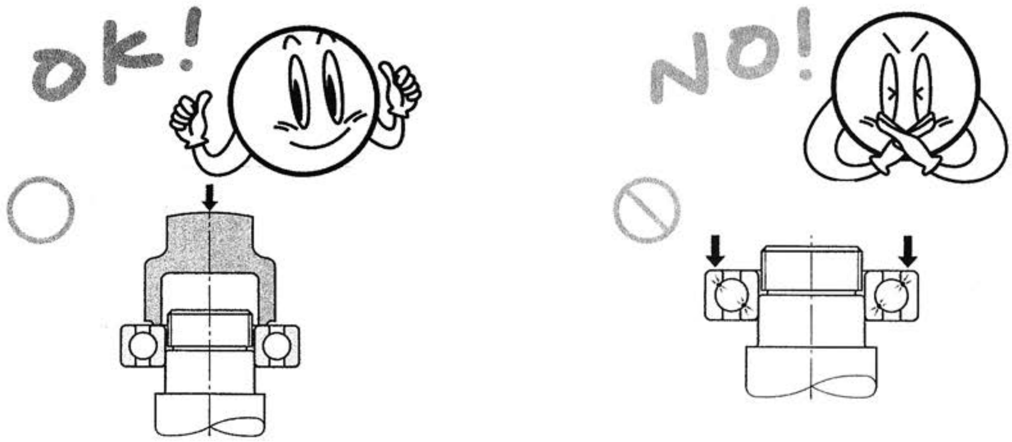
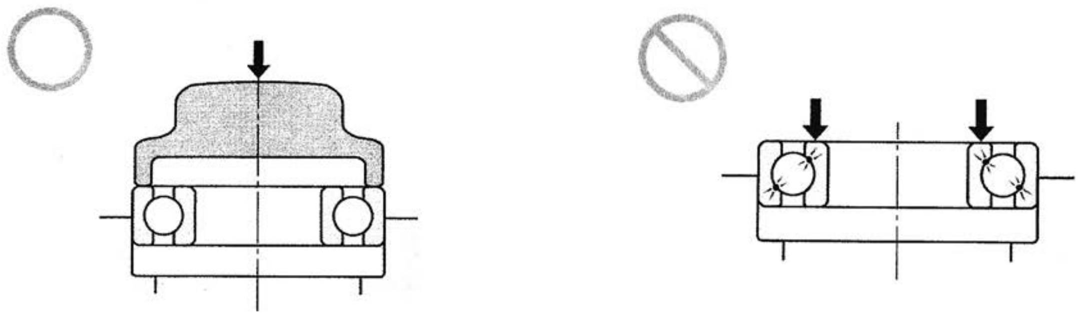


Fig. 9.2 Installation preparations

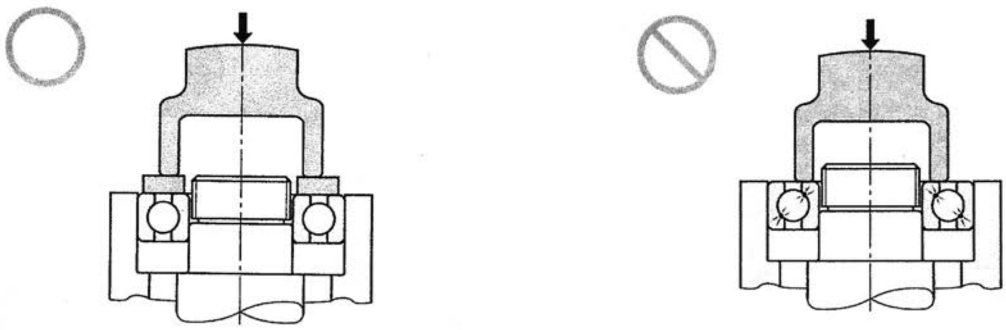
Correct **Wrong**



Press the inner ring to mount the bearing on the shaft



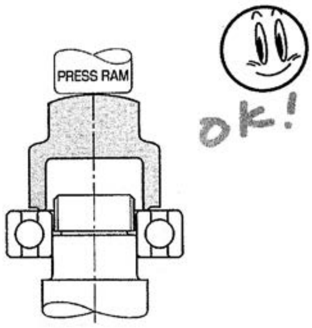
Press the outer ring to mount it in the housing

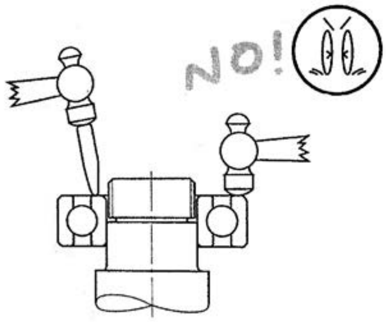


Apply even force to the bearing at a right angle

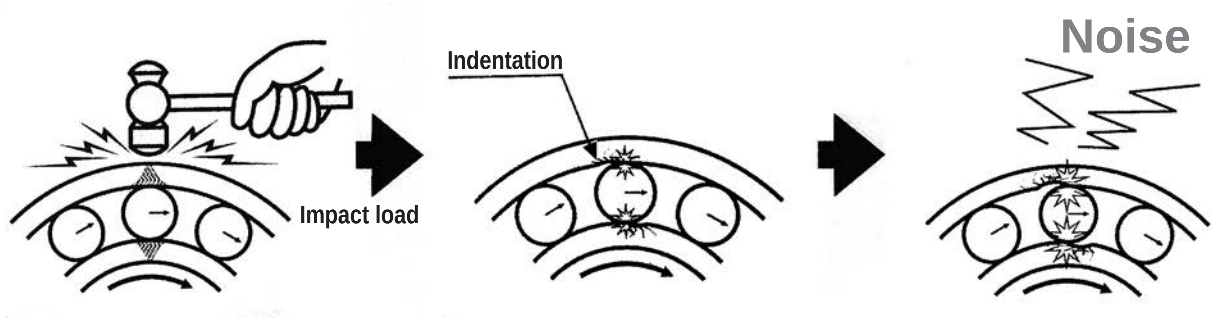
Fig. 9.3 Some proper installation and tools

※Select proper installation and tools
The bearing rings should never be struck directly with a hammer or a drift,
because damage to the bearing may result.





※Bearings are subject to damage due to impact load
Excessive and impact load may indent the contact surfaces. Therefore,
Care needs to be taken from bumping or dropping bearings.



※Dirt is harmful for bearings
Intrusion of dirt or other contaminants is a major cause of early bearing failure.

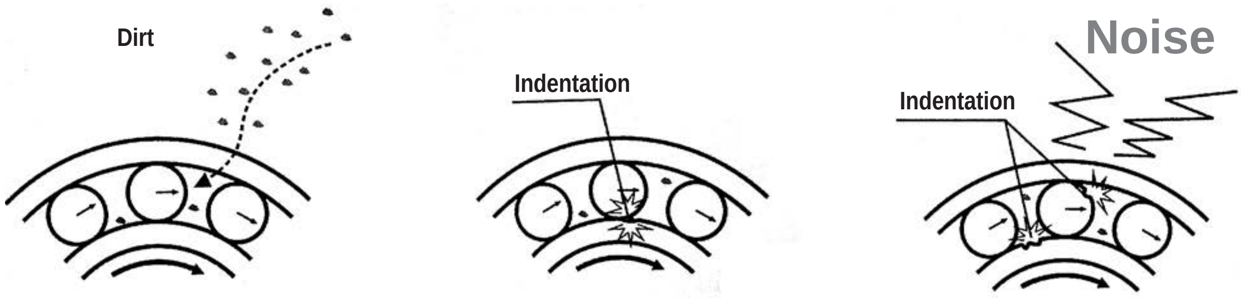
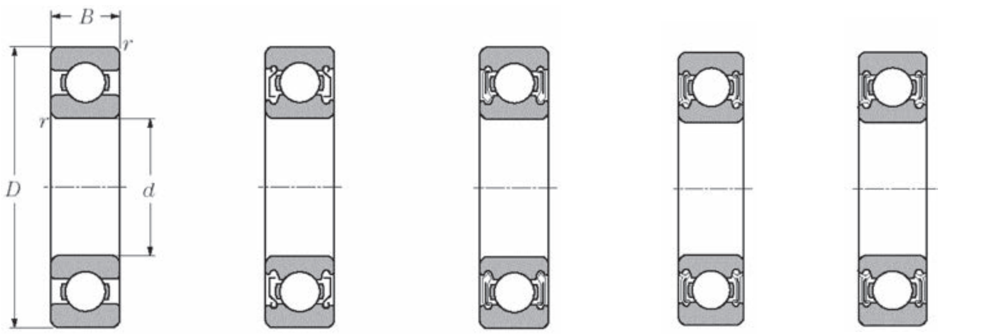


Fig. 9.4 Proper installation and tools, indentation due to improper impact load and dirt

Single-row Deep Groove Ball Bearings

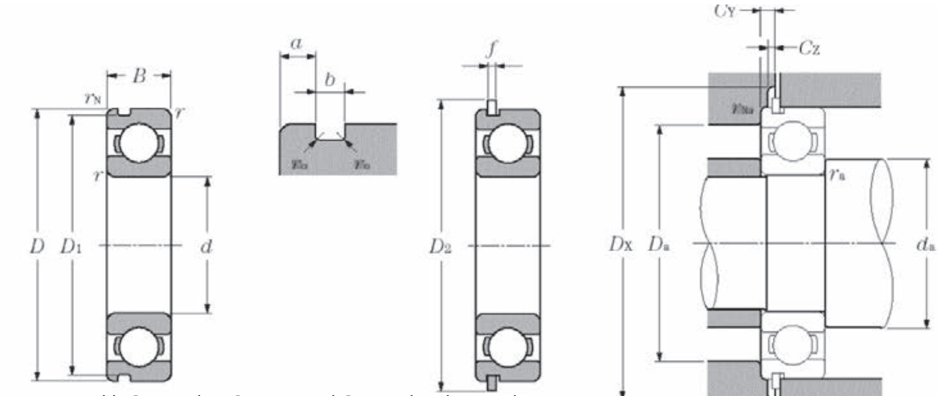


Open Type | Shielded Type (ZZ) | Non-contact Sealed Type (LLB) | Low-torque Sealed Type (LLH) | Cotact Sealed Type(LLU)

d 10~20mm

Boundary Dimensions (mm)				Basic Load Ratings (N)		Limiting Speeds (rpm)				Bearing Numbers Type				
						Grease			Oil					
d	D	B	$r_{s\ min}$	dynamic C_r	static C_{or}	Open Z、ZZ LB、LLB	LLH	LLU	Open Z LB	Open	Shield ZZ	Seal Non-Contact LLB	Low Torque Type LLH	Seal Contact LLU
10	19	5	0.3	1830	925	32000	–	24000	38000	6800	ZZ	LLB	–	LLU
	22	6	0.3	2700	1270	30000	–	21000	36000	6900	ZZ	LLB	–	LLU
	26	8	0.3	4550	1960	29000	25000	21000	34000	6000	ZZ	LLB	LLH	LLU
	30	9	0.6	5100	2390	25000	21000	18000	30000	6200	ZZ	LLB	LLH	LLU
	35	11	0.6	8200	3500	23000	20000	16000	27000	6300	ZZ	LLB	LLH	LLU
12	21	5	0.3	1920	1040	29000	–	20000	35000	6801	ZZ	LLB	–	LLU
	24	6	0.3	2890	1460	27000	–	19000	32000	6901	ZZ	LLB	–	LLU
	28	7	0.3	5100	2390	26000	–	–	30000	16001	–	–	–	–
	28	8	0.3	5100	2390	26000	21000	18000	30000	6001	ZZ	LLB	LLH	LLU
	32	10	0.6	6100	2750	22000	20000	16000	26000	6201	ZZ	LLB	LLH	LLU
	37	12	1	9700	4200	20000	19000	15000	24000	6301	ZZ	LLB	LLH	LLU
15	24	5	0.3	2080	1260	26000	–	17000	31000	6802	ZZ	LLB	–	LLU
	28	7	0.3	3650	2000	24000	–	16000	28000	6902	ZZ	LLB	–	LLU
	32	8	0.3	5600	2830	22000	–	–	26000	16002	–	–	–	–
	32	9	0.3	5600	2830	22000	18000	15000	26000	6002	ZZ	LLB	LLH	LLU
	35	11	0.6	7750	3600	19000	18000	15000	23000	6202	ZZ	LLB	LLH	LLU
	42	13	1	11400	5450	17000	15000	12000	21000	6302	ZZ	LLB	LLH	LLU
17	26	5	0.3	2230	1460	24000	–	15000	28000	6803	ZZ	LLB	–	LLU
	30	7	0.3	4650	2580	22000	–	14000	26000	6903	ZZ	LLB	–	LLU
	35	8	0.3	6800	3350	20000	–	–	24000	16003	–	–	–	–
	35	10	0.3	6800	3350	20000	16000	14000	24000	6003	ZZ	LLB	LLH	LLU
	40	12	0.6	9600	4600	18000	15000	12000	21000	6203	ZZ	LLB	LLH	LLU
	47	14	1	13500	6550	16000	14000	11000	19000	6303	ZZ	LLB	LLH	LLU
20	32	7	0.3	4000	2470	21000	–	13000	25000	6804	ZZ	LLB	–	LLU
	37	9	0.3	6400	3700	19000	–	12000	23000	6904	ZZ	LLB	–	LLU
	42	8	0.3	7900	4500	18000	–	–	21000	16004*	–	–	–	–
	42	12	0.6	9400	5050	18000	13000	11000	21000	6004	ZZ	LLB	LLH	LLU
	47	14	1	12800	6650	16000	12000	10000	18000	6204	ZZ	LLB	LLH	LLU
	52	15	1.1	15900	7900	14000	12000	10000	17000	6304	ZZ	LLB	LLH	LLU

Bearings with * mark are not available and could be supplied on request



With Snap Ring Groove and Snap Ring (N、NR)

Equivalent bearing load

dynamic

$P_r = XF_r + YF_a$

$\frac{F_a}{C_{or}}$	e	$\frac{F_a}{F_r} \leq e$ X	$\frac{F_a}{F_r} \leq e$ Y	$\frac{F_a}{F_r} > e$ X	$\frac{F_a}{F_r} > e$ Y
0.010	0.18	1	0	0.56	2.46
0.020	0.20				2.14
0.040	0.24				1.83
0.070	0.27				1.61
0.10	0.29				1.48
0.15	0.32				1.35
0.20	0.35				1.25
0.30	0.38				1.13
0.40	0.41				1.05
0.50	0.44				1.00

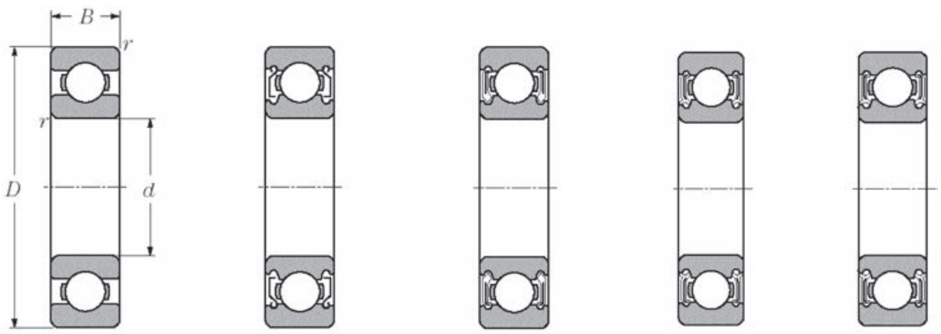
static

$P_{or} = 0.6F_r + 0.5F_a$

When $P_{or} < F_r$ use $P_{or} = F_r$

		Snap Ring Groove Dimensions				Snap Ring Dimensions		Abutment and Fillet Dimensions (mm)								Mass (kg)
Snap Ring Groove	Snap Ring	D_1 max	a max	b min	r_0 max	D_2 max	f max	d_a min	d_a max	D_a max	r_{as} max	D_x (Approx.)	C_Y max	C_Z max	r_{Nas} max	Open (Approx)
–	–	–	–	–	–	–	–	12	12.5	17	0.3	–	–	–	–	0.005
N	NR	20.8	1.05	0.8	0.2	24.8	0.7	12	13	20	0.3	25.5	1.5	0.7	0.3	0.009
–	–	–	–	–	–	–	–	12	13.5	24	0.3	–	–	–	–	0.019
N	NR	28.17	2.06	1.35	0.4	34.7	1.12	14	16	26	0.6	35.5	2.9	1.2	0.5	0.032
N	NR	33.17	2.06	1.35	0.4	39.7	1.12	14	17	31	0.6	40.5	2.9	1.2	0.5	0.053
–	–	–	–	–	–	–	–	14	14.5	19	0.3	–	–	–	–	0.006
N	NR	22.8	1.05	0.8	0.2	26.8	0.7	14	15	22	0.3	27.5	1.5	0.7	0.3	0.011
–	–	–	–	–	–	–	–	14	–	26	0.3	–	–	–	–	0.019
–	–	–	–	–	–	–	–	14	16	26	0.3	–	–	–	–	0.021
N	NR	30.5	2.06	1.35	0.4	36.7	1.12	16	17	28	0.6	37.5	2.9	1.2	0.5	0.037
N	NR	34.77	2.06	1.35	0.4	41.3	1.12	17	18.5	32	1	42	2.9	1.2	0.5	0.060
–	–	–	–	–	–	–	–	17	17.5	22	0.3	–	–	–	–	0.007
N	NR	26.7	1.3	0.95	0.25	30.8	0.85	17	17.5	26	0.3	31.5	1.9	0.9	0.3	0.016
–	–	–	–	–	–	–	–	17	–	30	0.3	–	–	–	–	0.025
N	NR	30.15	2.06	1.35	0.4	36.7	1.12	17	19	30	0.3	37.5	2.9	1.2	0.3	0.030
N	NR	33.17	2.06	1.35	0.4	39.7	1.12	19	20	31	0.6	40.5	2.9	1.2	0.5	0.045
N	NR	39.75	2.06	1.35	0.4	46.3	1.12	20	23	37	1	47	2.9	1.2	0.5	0.082
–	–	–	–	–	–	–	–	19	19.5	24	0.3	–	–	–	–	0.008
N	NR	28.7	1.3	0.95	0.25	32.8	0.85	19	20	28	0.3	33.5	1.9	0.9	0.3	0.018
–	–	–	–	–	–	–	–	19	–	33	0.3	–	–	–	–	0.032
N	NR	33.17	2.06	1.35	0.4	39.7	1.12	19	21	33	0.3	40.5	2.9	1.2	0.3	0.039
N	NR	38.1	2.06	1.35	0.4	44.6	1.12	21	23	36	0.6	45.5	2.9	1.2	0.5	0.066
N	NR	44.6	2.46	1.35	0.4	52.7	1.12	22	25	42	1	53.5	3.3	1.2	0.5	0.115
N	NR	30.7	1.3	0.95	0.25	34.8	0.85	22	22.5	30	0.3	35.5	1.9	0.9	0.3	0.019
N	NR	35.7	1.7	0.95	0.25	39.8	0.85	22	24	35	0.3	40.5	2.3	0.9	0.3	0.036
–	–	–	–	–	–	–	–	22	–	40	0.3	–	–	–	–	0.051
N	NR	39.75	2.06	1.35	0.4	46.3	1.12	24	26	38	0.6	47	2.9	1.2	0.5	0.069
N	NR	44.6	2.46	1.35	0.4	52.7	1.12	25	28	42	1	53.5	3.3	1.2	0.5	0.106
N	NR	49.73	2.46	1.35	0.4	57.9	1.12	26.5	28.5	45.5	1	58.5	3.3	1.2	0.5	0.144

Single-row Deep Groove Ball Bearings

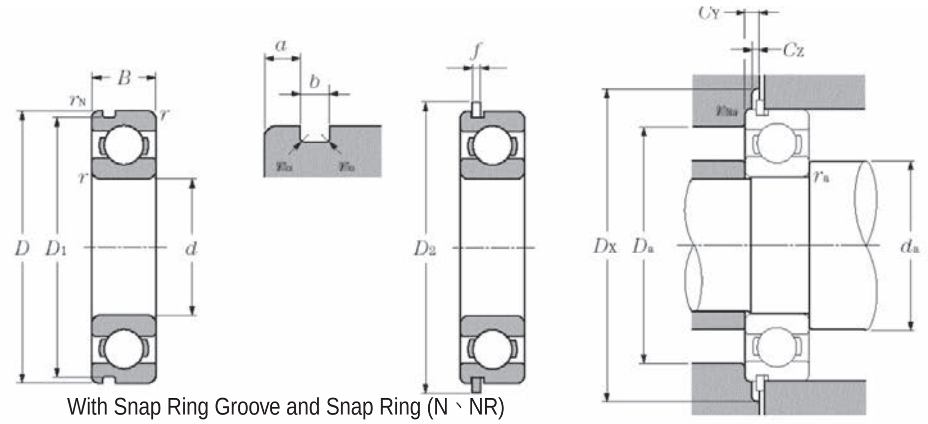


Open Type | Shield Type (ZZ) | Non-contact Sealed Type (LLB) | Low-torque Sealed Type (LLH) | Cotact Sealed Type(LLU)

d 22~35mm

Boundary Dimensions (mm)				Basic Load Ratings (N)		Limiting Speeds (rpm)				Bearing Numbers Type				
						Grease			Oil					
d	D	B	$r_{s\ min}$	dynamic C_r	static C_{or}	Open Z、ZZ LB、LLB	LLH	LLU	Open Z LB	Open	Shield ZZ	Seal Non-Contact LLB	Low Torque Type LLH	Seal Contact LLU
22	44	12	0.6	9400	5050	17000	13000	10000	20000	60/22	ZZ	LLB	LLH	LLU
	50	14	1	12900	6800	14000	12000	9700	17000	62/22	ZZ	LLB	LLH	LLU
	56	16	1.1	18400	9250	13000	11000	9200	15000	63/22	ZZ	LLB	LLH	LLU
25	37	7	0.3	4300	2950	18000	–	10000	21000	6805	ZZ	LLB	–	LLU
	42	9	0.3	7050	4550	16000	–	9800	19000	6905	ZZ	LLB	–	LLU
	47	8	0.3	8350	5100	15000	–	–	18000	16005	–	–	–	–
	47	12	0.6	10100	5850	15000	11000	9400	18000	6005	ZZ	LLB	LLH	LLU
	52	15	1	14000	7850	13000	11000	8900	15000	6205	ZZ	LLB	LLH	LLU
	62	17	1.1	21200	10900	12000	9700	8100	14000	6305	ZZ	LLB	LLH	LLU
	80	21	1.5	34500	17500	10000	–	–	12000	6405	–	–	–	–
28	52	12	0.6	12500	7400	14000	10000	8400	16000	60/28	ZZ	LLB	LLH	LLU
	58	16	1	17900	9750	12000	9700	8100	14000	62/28	ZZ	LLB	LLH	LLU
	68	18	1.1	26700	14000	11000	8900	7400	13000	63/28	ZZ	LLB	LLH	LLU
30	42	7	0.3	4700	3650	15000	–	8800	18000	6806*	ZZ	LLB	–	LLU
	47	9	0.3	7250	5000	14000	–	8400	17000	6906	ZZ	LLB	–	LLU
	55	9	0.3	11200	7350	13000	–	–	15000	16006*	–	–	–	–
	55	13	1	13200	8300	13000	9200	7700	15000	6006	ZZ	LLB	LLH	LLU
	62	16	1	19500	11300	11000	8800	7300	13000	6206	ZZ	LLB	LLH	LLU
	72	19	1.1	26700	15000	10000	7900	6600	12000	6306	ZZ	LLB	LLH	LLU
32	58	13	1	11800	8050	12000	8700	7200	15000	60/32	ZZ	LLB	LLH	LLU
	65	17	1	20700	11600	11000	8400	7100	12000	62/32	ZZ	LLB	LLH	LLU
	75	20	1.1	29800	16900	9500	7700	6500	11000	63/32*	ZZ	LLB	LLH	LLU
35	47	7	0.3	4900	4050	13000	–	–	16000	6807*	ZZ	LLB	–	LLU
	55	10	0.6	9550	6850	12000	–	7100	15000	6907	ZZ	LLB	–	LLU
	62	9	0.3	11700	8200	12000	–	–	14000	16007*	–	–	–	–
	62	14	1	16000	10300	12000	8200	6800	14000	6007	ZZ	LLB	LLH	LLU
	72	17	1.1	25700	15300	9800	7600	6300	11000	6207	ZZ	LLB	LLH	LLU
	80	21	1.5	33500	19100	8800	7300	6000	10000	6307	ZZ	LLB	LLH	LLU

Bearings with * mark are not available and could be supplied on request



With Snap Ring Groove and Snap Ring (N、NR)

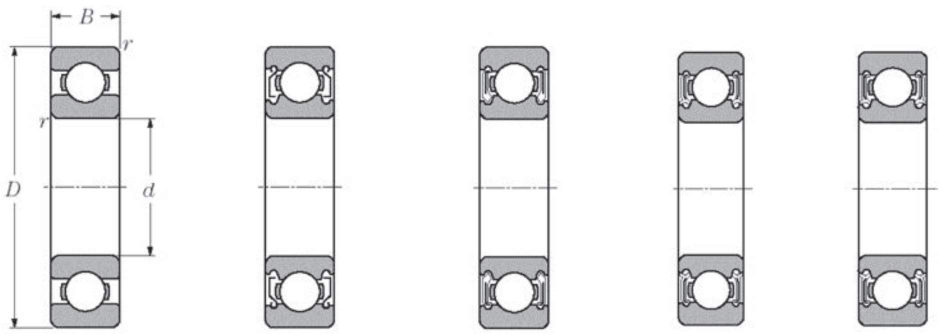
Equivalent bearing load
dynamic
$P_r = XF_r + YF_a$

$\frac{F_a}{C_{or}}$	e	$\frac{F_a}{F_r} \le e$ X	$\frac{F_a}{F_r} \le e$ Y	$\frac{F_a}{F_r} > e$ X	$\frac{F_a}{F_r} > e$ Y
0.010	0.18	1	0	0.56	2.46
0.020	0.20				2.14
0.040	0.24				1.83
0.070	0.27				1.61
0.10	0.29				1.48
0.15	0.32				1.35
0.20	0.35				1.25
0.30	0.38				1.13
0.40	0.41				1.05
0.50	0.44				1.00

static
$P_{or} = 0.6F_r + 0.5F_a$
When $P_{or} < F_r$ use $P_{or} = F_r$

		Snap Ring Groove Dimensions				Snap Ring Dimensions		Abutment and Dimensions (mm)								Mass (kg)
Snap Ring Groove	Snap Ring	D_1 max	a max	b min	r_0 max	D_2 max	f max	d_a min	d_a max	D_a max	r_{as} max	D_x (Approx.)	C_Y max	C_Z max	r_{Nas} max	Open (Approx)
N	NR	41.75	2.06	1.35	0.4	48.3	1.12	26	26.5	40	0.6	49	2.9	1.2	0.5	0.074
N	NR	47.6	2.46	1.35	0.4	55.7	1.12	27	29.5	45	1	56.5	3.3	1.2	0.5	0.117
N	NR	53.6	2.46	1.35	0.4	61.7	1.12	28.5	31	49.5	1	62.5	3.3	1.2	0.5	0.176
N	NR	35.7	1.3	0.95	0.25	39.8	0.85	27	28	35	0.3	40.5	1.9	0.9	0.3	0.022
N	NR	40.7	1.7	0.95	0.25	44.8	0.85	27	29	40	0.3	45.5	2.3	0.9	0.3	0.042
–	–	–	–	–	–	–	–	27	–	45	0.3	–	–	–	–	0.060
N	NR	44.6	2.06	1.35	0.4	52.7	1.12	29	30.5	43	0.6	53.5	2.9	1.2	0.5	0.080
N	NR	49.73	2.46	1.35	0.4	57.9	1.12	30	32	47	1	58.5	3.3	1.2	0.5	0.128
N	NR	59.61	3.28	1.9	0.6	67.7	1.7	31.5	35	55.5	1	68.5	4.6	1.7	0.5	0.232
–	–	–	–	–	–	–	–	33	–	72	1.5	–	–	–	–	0.53
N	NR	49.7	2.06	1.35	0.4	57.9	1.12	32	34	48	0.6	58.5	2.9	1.2	0.5	0.098
N	NR	55.6	2.46	1.35	0.4	63.7	1.12	33	35.5	53	1	64.5	3.3	1.2	0.5	0.171
N	NR	64.82	3.28	1.9	0.6	74.6	1.7	34.5	38.5	61.5	1	76	4.6	1.7	0.5	0.284
N	NR	40.7	1.3	0.95	0.25	44.8	0.85	32	33	40	0.3	45.5	1.9	0.9	0.3	0.026
N	NR	45.7	1.7	0.95	0.25	49.8	0.85	32	34	45	0.3	50.5	2.3	0.9	0.3	0.048
–	–	–	–	–	–	–	–	32	–	53	0.3	–	–	–	–	0.091
N	NR	52.6	2.08	1.35	0.4	60.7	1.12	35	37	50	1	61.5	2.9	1.2	0.5	0.116
N	NR	59.61	3.28	1.9	0.6	67.7	1.7	35	39	57	1	68.5	4.6	1.7	0.5	0.199
N	NR	68.81	3.28	1.9	0.6	78.6	1.7	36.5	43	65.5	1	80	4.6	1.7	0.5	0.360
N	NR	55.6	2.08	1.35	0.4	63.7	1.12	37	39	53	1	64.5	2.9	1.2	0.5	0.129
N	NR	62.6	3.28	1.9	0.6	70.7	1.7	37	40	60	1	71.5	4.6	1.7	0.5	0.226
N	NR	71.83	3.28	1.9	0.6	81.6	1.7	38.5	43.5	68.5	1	83	4.6	1.7	0.5	0.382
N	NR	45.7	1.3	0.95	0.25	49.8	0.85	37	38	45	0.3	50.5	1.9	0.9	0.3	0.029
N	NR	53.7	1.7	0.95	0.25	57.8	0.85	39	40	51	0.6	58.8	2.3	0.9	0.5	0.074
–	–	–	–	–	–	–	–	37	–	60	0.3	–	–	–	–	0.110
N	NR	59.61	2.08	1.9	0.6	67.7	1.7	40	42	57	1	68.5	3.4	1.7	0.5	0.155
N	NR	68.81	3.28	1.9	0.6	78.6	1.7	41.5	45	65.5	1	80	4.6	1.7	0.5	0.288
N	NR	76.81	3.28	1.9	0.6	86.6	1.7	43	47	72	1.5	88	4.6	1.7	0.5	0.457

Single-row Deep Groove Ball Bearings

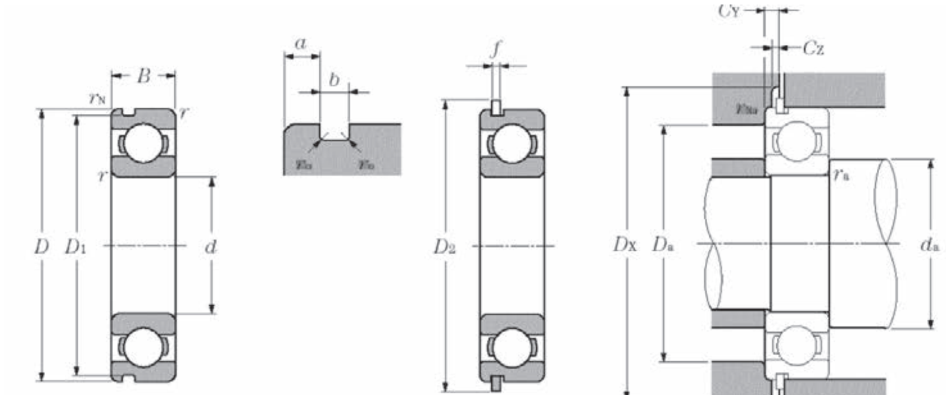


Open Type | Shield Type (ZZ) | Non-contact Sealed Type (LLB) | Low-torque Sealed Type (LLH) | Cotact Sealed Type(LLU)

d 40~60mm

Boundary Dimensions (mm)				Basic Load Ratings (N)		Limiting Speeds (rpm)				Bearing Numbers Type				
						Grease			Oil					
d	D	B	$r_{s\ min}$	dynamic C_r	static C_{or}	Open Z、ZZ LB、LLB	LLH	LLU	Open Z LB	Open	Shield ZZ	Seal Non-Contact LLB	Low Torque Type LLH	Seal Contact LLU
40	52	7	0.3	5100	4400	12000	–	–	14000	6808	ZZ	LLB	–	LLU
	62	12	0.6	12200	8900	11000	–	6300	13000	6908	ZZ	LLB	–	LLU
	68	9	0.3	12600	9650	10000	–	–	12000	16008*	–	–	–	–
	68	15	1	16800	11500	10000	7300	6100	12000	6008	ZZ	LLB	LLH	LLU
	80	18	1.1	29100	17800	8700	6700	5600	10000	6208	ZZ	LLB	LLH	LLU
	90	23	1.5	40500	24000	7800	6400	5300	9200	6308	ZZ	LLB	LLH	LLU
45	58	7	0.3	5350	4950	11000	–	5900	12000	6809*	ZZ	LLB	–	LLU
	68	12	0.6	13100	10400	9800	–	5600	12000	6909	ZZ	LLB	–	LLU
	75	10	0.6	12900	10500	9200	–	–	11000	16009*	–	–	–	–
	75	16	1	21000	15100	9200	6500	5400	11000	6009	ZZ	LLB	LLH	LLU
	85	19	1.1	32500	20400	7800	6200	5200	9200	6209	ZZ	LLB	LLH	LLU
	100	25	1.5	53000	32000	7000	5600	4700	8200	6309	ZZ	LLB	LLH	LLU
50	65	7	0.3	6600	6100	9600	–	5300	11000	6810*	ZZ	LLB	–	LLU
	72	12	0.6	13400	11200	8900	–	5100	11000	6910*	ZZ	LLB	–	LLU
	80	10	0.6	13200	11300	8400	–	–	9800	16010	–	–	–	–
	80	16	1	21800	16600	8400	6000	5000	9800	6010*	ZZ	LLB	LLH	LLU
	90	20	1.1	35000	23200	7100	5700	4700	8300	6210*	ZZ	LLB	LLH	LLU
	110	27	2	62000	38500	6400	5000	4200	7500	6310	ZZ	LLB	LLH	LLU
55	72	9	0.3	8800	8100	8700	–	4800	10000	6811*	ZZ	LLB	–	LLU
	80	13	1	16000	13300	8200	–	4600	9600	6911*	ZZ	LLB	–	LLU
	90	11	0.6	18600	15300	7700	–	–	9000	16011*	–	–	–	–
	90	18	1.1	28300	21200	7700	–	4500	9000	6011	ZZ	LLB	–	LLU
	100	21	1.5	43500	29200	6400	–	4300	7600	6211*	ZZ	LLB	–	LLU
	120	29	2	71500	45000	5800	–	3900	6800	6311	ZZ	LLB	–	LLU
60	78	10	0.3	11500	10600	8000	–	4400	9400	6812*	ZZ	LLB	–	LLU
	85	13	1	16400	14300	7600	–	4300	8900	6912*	ZZ	LLB	–	LLU
	95	11	0.6	20000	17500	7000	–	–	8300	16012*	–	–	–	–
	95	18	1.1	29500	23200	7000	–	4100	8300	6012*	ZZ	LLB	–	LLU
	110	22	1.5	52500	36000	6000	–	3800	7000	6212	ZZ	LLB	–	LLU
	130	31	2.1	82000	52000	5400	–	3600	6300	6312	ZZ	LLB	–	LLU

Bearings with * mark are not available and could be supplied on request



With Snap Ring Groove and Snap Ring (N、NR)

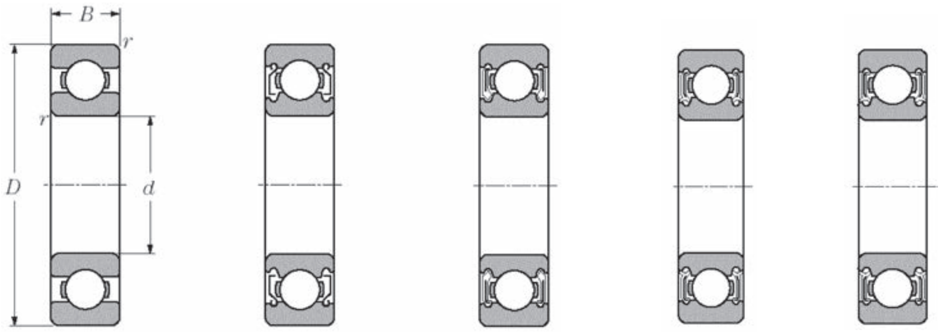
Equivalent bearing load
dynamic
$P_r = XF_r + YF_a$

$\frac{F_a}{C_{or}}$	e	$\frac{F_a}{F_r} \le e$ X	$\frac{F_a}{F_r} \le e$ Y	$\frac{F_a}{F_r} > e$ X	$\frac{F_a}{F_r} > e$ Y
0.010	0.18	1	0	0.56	2.46
0.020	0.20				2.14
0.040	0.24				1.83
0.070	0.27				1.61
0.10	0.29				1.48
0.15	0.32				1.35
0.20	0.35				1.25
0.30	0.38				1.13
0.40	0.41				1.05
0.50	0.44				1.00

static
$P_{or} = 0.6F_r + 0.5F_a$
When $P_{or} < F_r$ use $P_{or} = F_r$

		Snap Ring Groove Dimensions				Snap Ring Dimensions		Abutment and Dimensions (mm)								Mass (kg)
Snap Ring Groove	Snap Ring	D_1 max	a max	b min	r_0 max	D_2 max	f max	d_a min	d_a max	D_a max	r_{as} max	D_x (Approx.)	C_Y max	C_Z max	r_{Nas} max	Open (Approx.)
N	NR	50.7	1.3	0.95	0.25	54.8	0.85	42	43	50	0.3	55.5	1.9	0.9	0.3	0.033
N	NR	60.7	1.7	0.95	0.25	64.8	0.85	44	45	58	0.6	65.5	2.3	0.9	0.5	0.110
–	–	–	–	–	–	–	–	42	–	66	0.3	–	–	–	–	0.125
N	NR	64.82	2.49	1.9	0.6	74.6	1.7	45	47	63	1	76	3.8	1.7	0.5	0.190
N	NR	76.81	3.28	1.9	0.6	86.6	1.7	46.5	51	73.5	1	88	4.6	1.7	0.5	0.366
N	NR	86.79	3.28	2.7	0.6	96.5	2.46	48	54	82	1.5	98	5.4	2.5	0.5	0.630
N	NR	56.7	1.3	0.95	0.25	60.8	0.85	47	48	56	0.3	61.5	1.9	0.9	0.3	0.04
N	NR	66.7	1.7	0.95	0.25	70.8	0.85	49	51	64	0.6	72	2.3	0.9	0.5	0.128
–	–	–	–	–	–	–	–	49	–	71	0.6	–	–	–	–	0.171
N	NR	71.83	2.49	1.9	0.6	81.6	1.7	50	52.5	70	1	83	3.8	1.7	0.5	0.237
N	NR	81.81	3.28	1.9	0.6	91.6	1.7	51.5	55.5	78.5	1	93	4.6	1.7	0.5	0.398
N	NR	96.8	3.28	2.7	0.6	106.5	2.46	53	61.5	92	1.5	108	5.4	2.5	0.5	0.814
N	NR	63.7	1.3	0.95	0.25	67.8	0.85	52	54	63	0.3	68.5	1.9	0.9	0.3	0.052
N	NR	70.7	1.7	0.95	0.25	74.8	0.85	54	55.5	68	0.6	76	2.3	0.9	0.5	0.132
–	–	–	–	–	–	–	–	54	–	76	0.6	–	–	–	–	0.18
N	NR	76.81	2.49	1.9	0.6	86.6	1.7	55	57.5	75	1	88	3.8	1.7	0.5	0.261
N	NR	86.79	3.28	2.7	0.6	96.5	2.46	56.5	60	83.5	1	98	5.4	2.5	0.5	0.454
N	NR	106.81	3.28	2.7	0.6	116.6	2.46	59	68.5	101	2	118	5.4	2.5	0.5	1.07
N	NR	70.7	1.7	0.95	0.25	74.8	0.85	57	59	70	0.3	76	2.3	0.9	0.3	0.083
N	NR	77.9	2.1	1.3	0.4	84.4	1.12	60	61.5	75	1	86	2.9	1.2	0.5	0.18
–	–	–	–	–	–	–	–	59	–	86	0.6	–	–	–	–	0.258
N	NR	86.79	2.87	2.7	0.6	96.5	2.46	61.5	64	83.5	1	98	5	2.5	0.5	0.388
N	NR	96.8	3.28	2.7	0.6	106.5	2.46	63	67	92	1.5	108	5.4	2.5	0.5	0.601
N	NR	115.21	4.06	3.1	0.6	129.7	2.82	64	74	111	2	131.5	6.5	2.9	0.5	1.37
N	NR	76.2	1.7	1.3	0.4	82.7	1.12	62	64.5	76	0.3	87	2.5	1.2	0.3	0.106
N	NR	82.9	2.1	1.3	0.4	89.4	1.12	65	66.5	80	1	91	2.9	1.2	0.5	0.193
–	–	–	–	–	–	–	–	64	–	91	0.6	–	–	–	–	0.283
N	NR	91.82	2.87	2.7	0.6	101.6	2.46	66.5	69	88.5	1	103	5	2.5	0.5	0.414
N	NR	106.81	3.28	2.7	0.6	116.6	2.46	68	75	102	1.5	118	5.4	2.5	0.5	0.783
N	NR	125.22	4.06	3.1	0.6	139.7	2.82	71	80.5	119	2	141.5	6.5	2.9	0.5	1.73

Single-row Deep Groove Ball Bearings

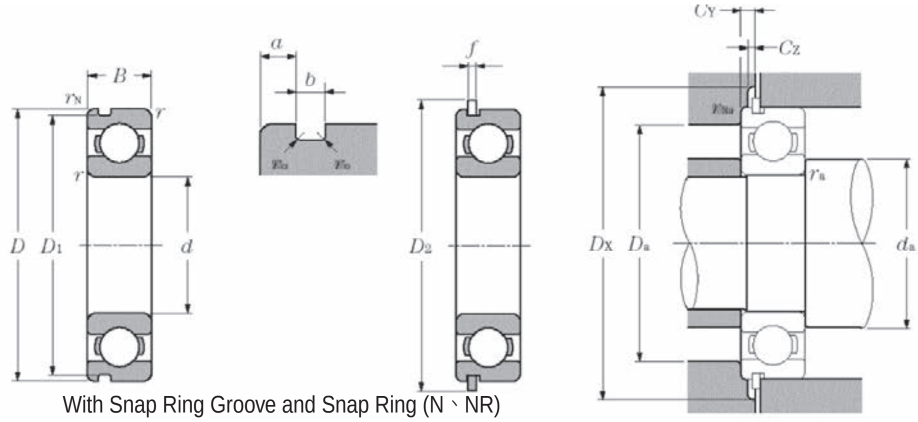


Open Type | Shield Type (ZZ) | Non-contact Sealed Type (LLB) | Low-torque Sealed Type (LLH) | Cotact Sealed Type(LLU)

Special Dimensions of Bearings

Boundary Dimensions(mm)				Basic Load Ratings (N)		Limiting Speeds (rpm)	
d	D	B	$r_{s\ min}$	dynamic C_r	static C_{or}	Grease	Oil
12	28	8	0.3	5100	2390	26000	30000
12	32	10	0.6	7550	3400	22000	26000
12	37	12	1.0	9700	4200	20000	24000
15	32	9	0.3	5600	2830	22000	26000
15	35	11	0.6	7750	3600	19000	23000
17	35	10	0.3	6800	3350	20000	24000
17	40	12	0.6	9600	4600	18000	21000
17	40	12	0.6	11400	5200	18000	21000
17	42	12	0.6	11400	5200	18000	21000
17	42	12	0.6	11400	5450	18000	21000
17	42	13	0.6	11400	5200	18000	21000
17	42	13	0.6	11400	5200	18000	21000
20	42	12	0.6	9400	5050	18000	21000
20	47	14	1.0	12800	6650	16000	18000
20	47	14	1.0	12800	6650	16000	18000
20	52	15	1.1	15900	7900	14000	17000
20	37	9	0.3	6400	3700	19000	23000
22	50	14	1.0	15100	7900	14000	17000
22	56	15	1.1	20700	10400	13000	15000
22	56	16	1.1	18400	9250	13000	15000
25	52	15	1.0	14000	7850	13000	15000
25	52	15	1.0	14000	7850	13000	15000
25	62	17	1.1	23600	12100	12000	14000
28	68	18	1.1	26700	14000	11000	13000
30	55	13	1.0	13200	8300	13000	15000
30	72	19	1.1	26700	15000	10000	12000
30	62	16	1.0	19500	11300	11000	13000
35	72	17	1.1	25700	15300	9800	11000
35	62	14	1.0	16000	10300	12000	14000
35	80	21	1.5	33500	19100	8800	10000
50	80	16	1.0	21800	16600	8400	9800
50	90	20	1.1	35000	23200	7100	8300
55	120	29	2.0	71500	45000	5800	6800
12	32	10	0.6	6100	2750	22000	26000
15	35	11	0.6	7750	3600	19000	23000

Bearings with * mark are not available and could be supplied on request



With Snap Ring Groove and Snap Ring (N、NR)

Equivalent bearing load

dynamic

$P_r = XF_r + YF_a$

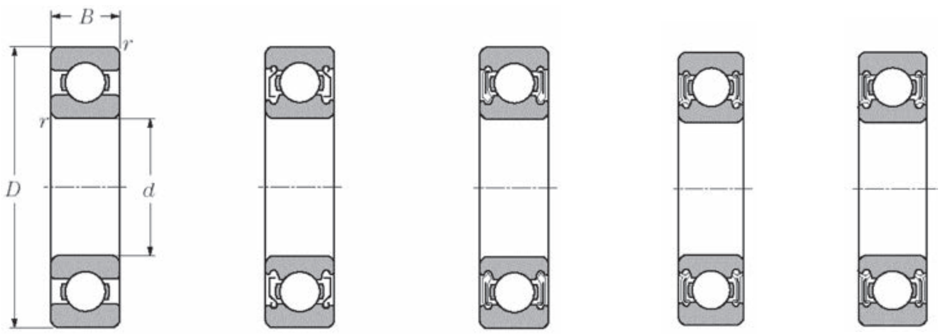
$\frac{F_a}{C_{or}}$	e	$\frac{F_a}{F_r} \leq e$		$\frac{F_a}{F_r} > e$	
		X	Y	X	Y
0.010	0.18	1	0	0.56	2.46
0.020	0.20				2.14
0.040	0.24				1.83
0.070	0.27				1.61
0.10	0.29				1.48
0.15	0.32				1.35
0.20	0.35				1.25
0.30	0.38				1.13
0.40	0.41				1.05
0.50	0.44				1.00

static

$P_{or} = 0.6F_r + 0.5F_a$

When $P_{or} < F_r$ use $P_{or} = F_r$

Bearing Numbers			Abutment and Fillet Dimensions (mm)			Mass (kg)
Open	Non Contact Seal LLB Shield ZZ	Contact Seal LLU	d_a (mm) min	D_a (mm) max	r_{as} (mm) max	Open Type (Approx.)
–	–	TMB001LLH	14	26	0.3	0.021
CSB201A	–	–	16	28	0.6	0.037
CSB301	–	–	17	32	1.0	0.060
CSB002	–	–	17	30	0.3	0.030
CSB202	–	–	19	31	0.6	0.045
CSB003	–	–	19	33	0.3	0.039
–	–	TMB203LLH	21	36	0.6	0.066
CSB203A	–	–	21	36	0.6	0.066
CSB203A/42	–	–	21	36	0.6	0.074
–	–	TM-SC0345LU	21	36	0.6	0.074
CS-SC03A39	–	–	21	36	0.6	0.080
–	–	TM-SC03A39	21	36	0.6	0.080
–	–	CSB004LUA	26	38	0.6	0.069
CSB204	–	–	25	42	1.0	0.106
ESB204	–	–	25	42	1.0	0.106
CSB304	–	–	26.5	45.5	1.0	0.144
CSB904	–	–	22	35	0.3	0.036
CSB2/22C	–	–	27	55	1.0	0.120
CS-SC04A86	–	–	29	49	1.1	0.166
TMB3/22	–	–	28.5	49.5	1.0	0.176
CSB205	–	–	30	47	1.0	0.128
ESB205	–	–	30	47	1.0	0.128
CSB305C	–	–	31.5	55.5	1.0	0.232
CSB3/28	–	–	34.5	61.5	1.0	0.284
–	–	TMB006LLU	35	50	1.0	0.116
CSB306	–	–	36.5	65.5	1.0	0.360
–	–	TMB206LLU	35	57	1.0	0.199
ESB207	–	–	41.5	65.5	1.0	0.288
CSB007	–	–	40	57	1.0	0.155
CSB307	–	–	43	72	1.5	0.457
–	–	CSB010LLB	55	75	1.0	0.261
–	–	TMB210LC	56.5	83.5	1.0	0.454
–	–	TMB311LC	64	111	2.0	1.37
AC-6201	AC-6201ZZ	AC-6201LLU	16	28	0.6	0.037
AC-6202	AC-6202ZZ	AC-6202LLU	19	31	0.6	0.045

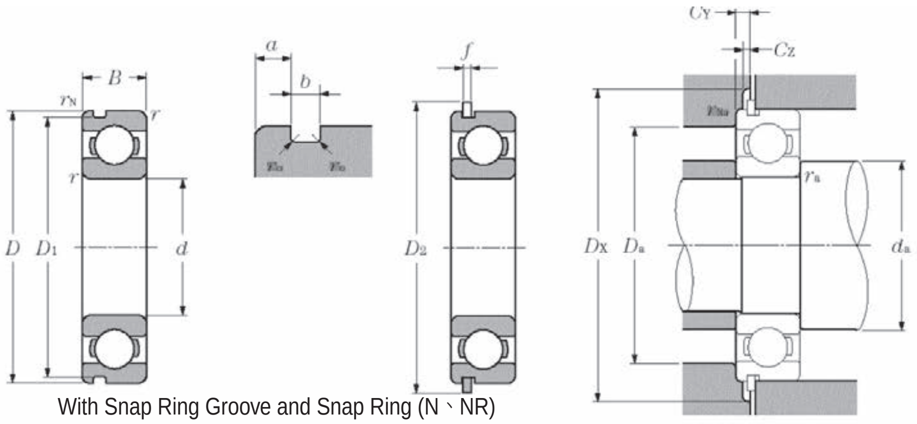


Open Type   Shield Type (ZZ)   Non-contact Sealed Type (LLB)   Low-torque Sealed Type (LLH)   Cotact Sealed Type(LLU)

Special Dimensions of Bearings

Boundary Dimensions(mm)					Basic Load Ratings (N)		Limiting Speeds (rpm)	
d	B_i	D	B_o	$r_{s\ min}$	dynamic C_r	static C_{or}	Grease	Oil
17	12	40	12	0.6	9600	4600	18000	21000
25	15	52	15	1.0	14000	7850	13000	15000
30	13	55	13	1.0	13200	8300	13000	15000
8	14	23	14	0.3	3950	1540	22000	26000
8	7	22	7	0.3	3350	1400	32000	37000
9	8	26	8	0.3	4550	1960	30000	35000
10	8	26	8	0.3	4550	1960	29000	34000
12	8	28	8	0.3	5100	2390	26000	30000
15	9	32	9	0.3	5600	2830	22000	26000
30	16	62	16	1.0	24900	16300	10000	12000
35	17	72	17	1.1	33000	22100	8800	10000
7	6	18	6	0.2	2240	910	34000	40000
8	6	18	6	0.2	2240	910	34000	40000
9.525	7.142	22.225	7.142	0.41	3300	1400	31000	37000
9.525	5.557	22.225	5.557	0.41	3300	1400	31000	37000
10	8	26	8	0.3	4590	1980	29000	34000
10	8	30	8	0.6	5100	2390	25000	30000
11.087	9	30	9	0.6	5100	2390	18000	30000
12.7	6.35	28.575	6.35	0.41	5100	2390	25000	29000
12.7	7.938	28.575	7.938	0.41	5100	2390	25000	29000
14	7	26	7	0.3	3430	1795	26000	31000
15	11.5	42	11.5	0.6	11400	5450	17000	21000
15	13	35	13	0.6	7760	3610	19000	23000
15.875	11	34.925	11	0.6	7750	3600	15000	23000
15.875	11.112	34.925	11.112	0.6	7750	3600	15000	23000
15.875	11	34.925	11	0.6	7750	3600	15000	23000
15.875	11	34.925	11	0.6	7750	3600	15000	23000
17	13	42	13	0.6	11400	5200	18000	21000
17	14	40	14	0.6	9600	4600	18000	21000
17	14	46	14	0.6	13500	6550	11000	19000
17	16	52	16	1.0	16000	7940	11000	19000
18	7	30	7	0.3	4600	2620	22000	26000
19.05	15.494	45.225	15.494	1.0	13500	6550	16000	19000
19.06	15.494	45.224	15.494	1.0	12800	6550	16000	19000
20	12	47	12	1.0	12800	6650	16000	18000
20	12	47	12	1.0	10100	5750	14000	17000
20	12	52	12	1.0	10100	5750	14000	17000
20	12	52	12	1.0	12800	6650	16000	18000
22	15	56	15	1.1	20700	10400	13000	15000
22	15	56	15	1.5	20700	10400	13000	15000
25	13	52	13	1.0	14000	7850	13000	15000
25	15	52	15	1.0	14000	7850	13000	15000
25	12	56	12	0.6	14000	7850	13000	15000
25	12	62	12	0.6	16700	9600	12000	14000

Bearings with * mark are not available and could be supplied on request



With Snap Ring Groove and Snap Ring (N、NR)

Equivalent bearing load
dynamic
$P_r = XF_r + YF_a$

$\frac{F_a}{C_{or}}$	e	$\frac{F_a}{F_r} \le e$		$\frac{F_a}{F_r} > e$	
		X	Y	X	Y
0.010	0.18	1	0	0.56	2.46
0.020	0.20				2.14
0.040	0.24				1.83
0.070	0.27				1.61
0.10	0.29				1.48
0.15	0.32				1.35
0.20	0.35				1.25
0.30	0.38				1.13
0.40	0.41				1.05
0.50	0.44				1.00

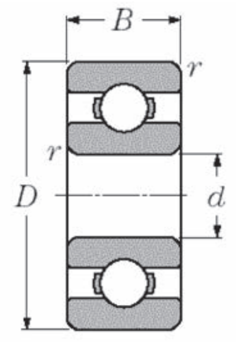
static
$P_{or} = 0.6F_r + 0.5F_a$
When $P_{or} < F_r$ use $P_{or} = F_r$

Bearing Numbers			Abutment and Fillet Dimensions (mm)			Mass (kg)
Open	Non Contact Seal LLB Shield ZZ	Contact Seal LLU	d_a (mm) min	D_a (mm) max	r_{as} (mm) max	Open Type (Approx.)
AC-6203	AC-6203ZZ	AC-6203LLU	21	36	0.6	0.066
–	AC-6205ZZ	–	30	47	1.0	0.128
–	AC-6006ZZ	–	35	50	1.0	0.116
EC1-SC8A37	–	–	10	21	0.3	0.024
EC-608	EC-608ZZ	–	10	20	0.3	0.012
EC-629	EC-629ZZ	EC-629LLU	13	22	0.3	0.020
EC-6000	EC-6000ZZ	EC-6000LLU	12	24	0.3	0.019
–	EC1-6001ZZ	v	14	26	0.3	0.021
EC-6002	EC-6002ZZ	EC-6002LLU	17	30	0.3	0.030
BL206	–	–	36	56	1.0	0.214
BL207	–	–	42	65	1.0	0.318
–	SC727ZZ	–	9	17	0.2	0.007
–	SC8A96ZZ*	–	9	17	0.2	0.006
–	R6ZZ	R6LLU	12.5	20.2	0.4	0.014
EE3	–	–	12.5	20.2	0.4	0.009
–	SC0039ZZ	–	12	24	0.3	0.018
SC00T50	–	–	14	26	0.6	0.029
–	–	SC0117LLU	14	26	0.6	0.029
EE4	–	–	14.5	25.5	0.3	0.017
R8U	R8ZZ	R8LLU	14.5	25.5	0.3	0.022
–	SC02T01LLB	–	16	24	0.3	0.013
SC0284	–	–	20	37	0.6	0.074
–	–	SC02A51LLU	19	31	0.6	0.049
–	SC0217ZZ	SC0217LLU	19	31	0.6	0.045
–	SC0228LLB	SC0228LLU	19	31	0.6	0.045
99502	99502HV	99502H	19	31	0.6	0.044
–	–	SC02A47LLU	19	31	0.6	0.039
SC03A39	–	–	21	36	0.6	0.080
–	–	SC03T01LLU	21	36	0.6	0.068
–	–	SC03T52LLU	22	42	0.6	0.115
–	–	SC03T50LLU	22	47	1.0	0.166
–	–	SC03T02LLB	20	28	0.3	0.018
SC04B09	–	–	22	42	1.0	0.099
–	–	SC0440LLU	25	39	1.0	0.108
SC04A31	–	–	25	42	1.0	0.068
SC04A34	–	–	25	47	0.6	0.079
SC04A47	–	–	25	47	0.6	0.116
SC04A50	–	–	26	44	1.0	0.105
SC04A86	–	–	29	49	1.1	0.166
SC632201	–	–	28.5	49.5	1.5	0.166
SC05T52*	–	–	30	51	0.6	–
SC05T51	–	–	30	51	0.6	0.128
SC05A97	–	–	30	51	0.6	0.125
SC0563*	–	–	30	55	0.6	–

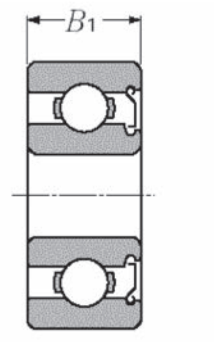
Boundary Dimensions(mm)					Basic Load Ratings (N)		Limiting Speeds (rpm)	
d	B_i	D	B_o	$r_{s\ min}$	dynamic C_r	static C_{or}	Grease	Oil
35	14	72	14	1.0	25700	15300	9800	11000
6	6.6	19	6	0.3	2340	885	34000	40000
12	10.8	32	10	0.6	6100	2750	22000	26000
12	16	32	10	0.6	6100	2750	22000	26000
15	11	35	11	0.6	7750	3600	19000	23000
27	8	47	12	0.3	10100	5850	15000	18000
30	12	55	11.6	–	13200	8300	13000	15000

Bearings with * mark are not available and could be supplied on request

Miniature and Extra Small Ball Bearings



Open Type



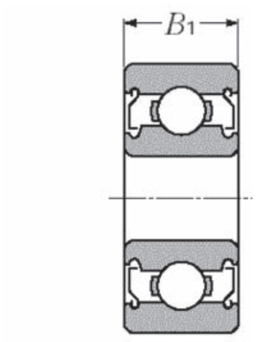
With Single Shield (Z)

d 1.5~9mm

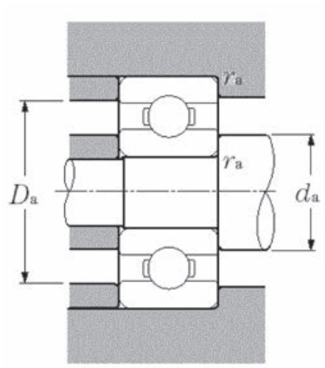
Boundary Dimensions (㎜)					Basic Load Ratings (N)		Limiting Speeds rpm	
d	D	B	B_1	$r_{s\ min}$	dynamic C_r	static C_{or}	Grease	Oil
6	17	6	6	0.3	2 190	865	35 000	42 000
6	19	6	6	0.3	2 340	885	34 000	40 000
7	19	6	6	0.3	2 240	910	34 000	40 000
7	22	7	7	0.3	3 350	1 400	32 000	37 000
8	19	6	6	0.3	1 990	865	33 000	39 000
8	22	7	7	0.3	3 350	1 400	32 000	37 000
8	24	8	8	0.3	4 000	1 590	31 000	36 000
8	28	9	9	0.3	5100	2390	29000	34000
9	20	6	6	0.3	2 480	1 090	32 000	38 000
9	24	7	7	0.3	3 400	1 450	31 000	36 000
9	26	8	8	0.3	4 550	1 960	30 000	35 000

Bearings with * mark are not available and could be supplied on request

Bearing Numbers			Abutment and Fillet Dimensions (mm)			Mass (kg)
Open	Non Contact Seal LLB Shield ZZ	Contact Seal LLU	d_a (mm) min	D_a (mm) max	r_{as} (mm) max	Open Type (Approx.)
SC07B37	–	–	41.5	65.5	1.0	0.241
–	SX6A54ZZ	–	8	17	0.3	0.010
SX01A36	–	–	16	28	0.6	0.037
SX01T50	–	–	16	28	0.6	0.037
–	SX02A26ZZ	–	19	31	0.6	0.041
SX05A81*	–	–	29	43	0.3	–
–	SX0647ZZ	–	35	50	1.0	0.116



With Double Shield (ZZ)



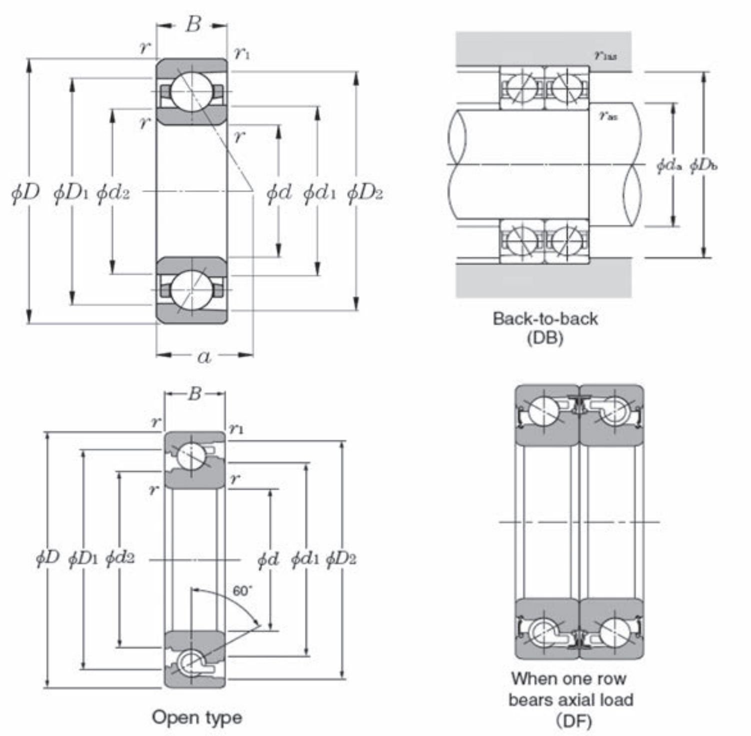
Equivalent bearing load
dynamic
$P_r = XF_r + YF_a$

$\frac{F_a}{C_{or}}$	e	$\frac{F_a}{F_r} \le e$ X	$\frac{F_a}{F_r} \le e$ Y	$\frac{F_a}{F_r} > e$ X	$\frac{F_a}{F_r} > e$ Y
0.010	0.18	1	0	0.56	2.46
0.020	0.20				2.14
0.040	0.24				1.83
0.070	0.27				1.61
0.10	0.29				1.48
0.15	0.32				1.35
0.20	0.35				1.25
0.30	0.38				1.13

static
$P_{or} = 0.6F_r + 0.5F_a$
When $P_{or} < F_r$ use $P_{or} = F_r$

Bearing Numbers	Type		Abutment and Fillet Dimensions mm				Mass (gr)
			d_a		D_a	r_a	
Open	Shield Z	Shields ZZ	min	max	max	max	Open Type (Approx.)
606	606Z	606ZZ*	8	8.6	15	0.3	6.5
626	626Z	626ZZ	8	9.5	17	0.3	9.2
607	607Z	607ZZ	9	10.4	17	0.3	8.0
627	627Z	627ZZ	9	12.2	20	0.3	13.0
698	698Z	698Z*	10	10.6	17	0.3	7.3
608	608Z	608ZZ	10	12.2	20	0.3	12.0
628	628Z	628ZZ*	10	12.1	22	0.3	17.0
638	638Z	638ZZ	10	13.9	24	0.3	27.0
699	699Z	699ZZ	11	11.6	18	0.3	8.2
609	609Z	609ZZ*	11	13.1	22	0.3	14.0
629	629Z	629ZZ	13	13.9	22	0.3	20.0

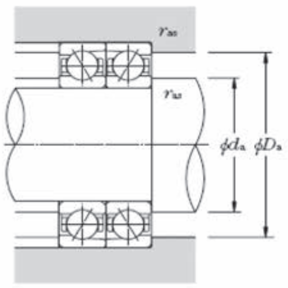
Angular Contact Ball Bearings



d 8~100mm

Boundary Dimensions (mm)					Basic Load ratings				Static Axial Load Capacity		Bearing Numbers Type
					dynamic		static				
d	D	B	$r_{s\ min}$	$r_{ls\ min}$	C_r (KN)	C_r (Kgf)	C_{or} (KN)	C_{or} (Kgf)	(KN)	(Kgf)	
8	22	7	0.30	0.15	3.35	340	1.45	147	1.02	104	708A＊
8	22	7	0.30	0.15	3.5	357	1.5	153	1.3	132	708C＊
8	22	10.31	0.30	0.15	3.55	360	1.54	157	1.41	144	5S1-SF8AT01C
10	26	8	0.30	0.15	5.00	510	2.33	238	3.1	314	7000A
12	28	8	0.30	0.15	5.3	555	2.6	269	5.3	540	7001C＊
12	28	8	0.30	0.15	5.05	515	2.46	251	3.25	331	7001A
15	32	9	0.30	0.15	5.80	590	3.15	320	4	407	7002A
15	32	9	0.00	0.15	6.25	635	3.4	345	6.4	650	7002C
15	35	11	0.60	0.30	8.5	866	4.4	449	3.10	323	7202A
17	30	8	0.30	0.15	6.25	635	3.4	345	6.76	690	5S1-SF03T01CE
17	35	10	0.30	0.20	3.8	387	2.6	265	4.17	425	HSE003C＊
17	40	14	0.60	0.30	11.2	1140	6.2	632	9.91	1011	7203A
20	47	14	1.00	0.60	12.9	1315	7.2	734	3.46	353	7204A
20	47	14	1.00	0.60	14.6	1490	8.15	835	3.70	375	7204C＊
20	47	15	1.00	0.60	24.3	2470	37.5	3850	25.7	2620	BS2047
25	47	12	0.60	0.30	11.6	1182	7.4	758	11.2	1140	7005C＊
25	52	15	1.00	0.60	14.7	14883	9.1	928	4.28	436	7205A
25	62	15	1.00	0.60	29.2	2980	59.0	6050	40.0	4100	BS2562
30	55	13	1.00	0.60	15.1	1540	10.3	1050	15.7	1600	7006C
30	62	15	1.00	0.60	29.2	2980	59.0	6050	40	4100	BS3062
30	62	16	1.00	0.60	23.0	2350	14.7	1500	7.10	725	7206C＊
35	62	14	1.00	0.60	19.1	1950	13.7	1400	20.6	2100	7007C
35	62	14	1.00	0.60	12.9	1320	12.7	1300	16.3	1660	HSE007CE1
35	72	15	1.00	0.60	31.0	3150	70.0	7150	47.5	4850	BS3572
35	72	17	1.10	0.60	30.5	3100	19.9	2030	10.6	1090	7207C＊
40	68	15	1.00	0.60	18.20	1855	14.3	1457	12.8	1306	7008A
40	68	15	1.00	0.60	13.7	1400	14.5	1480	18.6	1900	HSE008CE1＊

Note:＊means the type is mixed bcaring, it can be changed to ceramic ball by customer's demand.



Face-to-face
(DF)

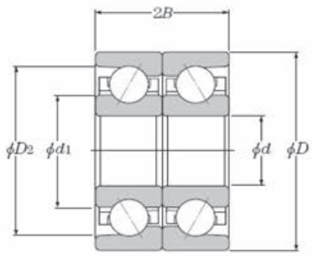
Dynamic equivalent radial load
$P_r = XF_r + YF_a$

$\frac{i \cdot f_0 F_a}{C_{or}}$	e	Single row / Tandem $F_a/F_r \leqq e$ X	Y	$F_a/F_r > e$ X	Y	Back-to-back / Face-to-face $F_a/F_r \leqq e$ X	Y	$F_a/F_r > e$ X	Y
0.178	0.38				1.47		1.65		2.39
0.357	0.4				1.4		1.57		2.28
0.714	0.43				1.3		1.46		2.11
1.07	0.46				1.23		1.38		2
1.43	0.47	1	0	0.44	1.19	1	1.34	0.72	1.93
2.14	0.5				1.12		1.26		1.82
3.57	0.55				1.02		1.14		1.66
5.35	0.56				1		1.12		1.63
7.14	0.56				1		1.12		1.63

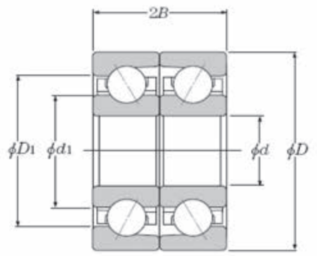
Static equivalent radial load
$P_{or} = X_o F_r + Y_o F_a$

Single row / Tandem X_o	Y_o	Back-to-back / Face-to-face X_o	Y_o
0.5	0.46	1	0.92

When $P_{or} < F_r$ with single-row or tandem arrangement, $P_{or} = F_r$.



Back-to-back (DB)



Face-to-face (DF)

Dynamic equivalent axial load $P_a = XF_r + YF_a$

Number of rows in bearing arrangement		2		3			4			
Number of rows subjected to axial load		1	2	1	2	3	1	2	3	4
$F_a/F_r \leqq 2.17$	X	1.90	–	1.43	2.32	–	1.17	1.90	2.52	–
	Y	0.55	–	0.76	0.35	–	0.88	0.55	0.26	–
$F_a/F_r > 2.17$	X	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
	Y	1	1	1	1	1	1	1	1	1

Static equivalent axial load
$P_{oa} = F_a + 3.98F_r$

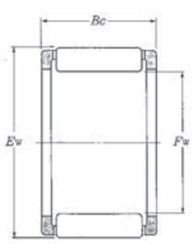
Load Center (mm)	Limiting Speeds (rpm)		Reference Dimensions				Abutment and Dimensions (mm)					Space Capacity (cm^3)	Weight (kg)
a	Grease	Oil	d_1	d_2	D_1	D_2	d_a min	D_a max	D_b max	r_{as} max	r_{las} max	Open (Approx.)	Open (Approx.)
7.8	50000	67000	12.8	-	17.5	19.1	10.5	19.5	-	0.3	-	0.8	0.012
5.5	77000	117000	12.8	-	17.5	19.1	10.5	19.5	-	0.3	-	0.8	0.012
7.2	92400	140400	12.8	-	17.5	19.2	10.5	19.5	-	0.3	-	0.8	0.015
9.2	46600	60300	15.5	-	20.3	22.7	12.5	23.5	24.8	0.3	0.15	1.04	0.021
6.5	57500	87500	18.1	-	22.6	25.4	14.5	25.5	26.8	0.3	0.15	1.04	0.021
10.0	41900	54200	18.1	-	22.9	25.4	14.5	25.5	26.8	0.3	0.15	0.9	0.025
11.5	35700	46100	21.1	-	25.9	28.4	17.5	29.5	30.8	0.3	0.15	1.33	0.03
7.5	49000	74500	21.1	-	26.1	28.5	17.5	29.5	30.8	0.3	0.15	1.33	0.03
12.7	22000	29000	21.8	-	28.9	31.3	19.5	30.5	32.5	0.6	0.3	1.5	0.045
7.0	38000	51000	21.1	-	25.9	28.4	19.5	27.5	28.8	0.3	0.15	1.2	0.025
9.0	43100	66300	24.1	22.3	28.1	29.3	21	32	32.6	0.3	0.15	1.32	0.033
14.2	19000	26000	25.0	-	32	35.51	21.5	35.5	37.5	0.6	0.3	2.1	0.065
16.7	17000	23000	29.2	-	38.5	41.9	25.5	41.5	42.5	1.0	0.6	3.1	0.10
11.5	25500	33000	29.2	-	38.5	41.9	25.5	41.5	42.5	1.0	0.6	3.1	0.10
36.5	6000	8000	29.9	25.7	37.1	41.2	25.5	41.5	42.5	1.0	0.6	3.3	0.135
11.0	32000	48700	33.9	-	43.3	46.8	30.5	46.5	47.5	1.0	0.6	3.85	0.078
13.0	14000	19000	33.9	-	43.3	46.8	30.5	46.5	47.5	1.0	0.6	4.1	0.12
49.2	7200	9600	44.4	40.2	51.6	55.7	38.9	58	57.5	1.0	0.6	4.6	0.18
12.0	27100	41200	38.6	-	46.4	50	36	49	50	1.0	0.5	5.11	0.114
49.2	7200	9600	44.4	40.2	51.6	55.7	38.9	58	57.5	1.0	0.6	4.6	0.21
14.0	18900	24500	40.8	-	52.0	56.0	35.5	56.5	57.5	1.0	0.6	6.6	0.19
13.5	23800	36100	44.2	-	52.8	56.9	41	56	57	1.0	0.5	7.26	0.151
15.0	29900	46100	44.2	40.9	52.8	56.0	39.6	57.4	59.4	1.0	0.6	5.93	0.190
53.8	3600	5000	52.4	48.2	59.6	63.7	40.5	66.5	67.5	1.0	0.6	5.4	0.31
16.0	16400	21300	47.4	-	60.5	65.2	42	65	67.5	1.0	0.6	8.8	0.27
23.1	15500	20100	49.6	-	58.3	61.8	45.5	62.5	63.5	1.0	0.6	8.89	0.189
16.0	27000	41500	49.7	46.4	58.2	61.6	44.6	63.4	65.4	1.0	0.6	5.93	0.19

Boundary Dimensions (mm)					Basic Load Ratings				Static Axial Load Capacity		Bearing Numbers Type
					dynamic		static				
d	D	B	$r_{s\ min}$	$r_{ls\ min}$	C_r (KN)	C_r (Kgf)	C_{or} (KN)	C_{or} (Kgf)	(KN)	(Kgf)	
40	72	15	1.00	0.60	31.0	3150	70	7150	47.5	4850	BS4072
40	80	18	1.10	0.60	36.5	3700	25.2	2570	14.4	1470	7208C
45	75	16	1.00	0.60	14.4	1470	16.3	1660	20.9	2130	HSE009CE1*
50	80	16	1.00	0.60	26.0	2650	21.9	2230	31.4	3200	7010C
50	80	16	1.00	0.60	17.5	1790	20.1	2050	25.8	2630	HSE010CE1*
50	90	20	1.10	0.60	43.0	4350	31.5	3250	15.3	1560	7210C
60	95	18	1.10	0.60	35.0	3600	30.5	3100	43.1	4400	7012C*
60	95	18	1.10	0.60	33.2	3390	29.0	2960	31.8	3240	7012AD*
60	95	18	1.10	0.60	19.0	1940	24.6	2510	31.40	3200	HSE012CE1*
65	100	18	1.10	0.60	35.1	3580	32.5	3315	34.8	3550	7013AD*
65	100	18	1.10	0.60	37.0	3800	34.5	3500	47.5	4850	7013C
65	100	18	1.10	0.60	22.7	2320	29.7	3000	38	3900	HSE013CE1*
70	110	20	1.10	0.60	44.4	4530	40.9	4170	48.5	4950	7014AD*
70	110	20	1.10	0.60	47.0	4800	43.0	4400	65.1	6640	7014C
70	110	20	1.10	0.60	32.3	3293	33.7	3435	71	7235	HSE014AD*
70	110	20	1.10	0.60	26.5	2700	35.3	3600	45	4600	HSE014CE1
80	125	22	1.10	0.60	55.6	5670	52.5	5360	58.3	5950	7016AD
100	150	24	1.50	1.10	75.50	7700	77.7	7900	111.7	11400	7020C
100	150	24	1.50	1.10	46.5	4780	68.1	6950	880	8950	HSE020CE1
100	150	45	1.50	1.00	37.2	3800	54.2	5500	41.2	4200	HTA020A

Needle Roller Bearings

Boundary Dimensions (㎜)				Basic Load	
				dynamic	
				C_r	
F_w	E_w	B_c ${}^{-0}_{-0.2}$	Lw	(N)	(kgf)
18	24	11.8	7.8	11300	1150
25	30	14.8	11.8	15100	1540
25.1	30.1	13.8	10.8	14300	1450
26	31	13.8	10.8	14200	1450
28	33	13.8	10.8	15100	1540
28	35	13.8	10.8	17800	1820
12	17	14.2	11.8	9750	995
28	32	17	13.8	15300	1560
17	25	18	10.8	13400	1360
20	29	18	10.3	14100	1440

Load Center (mm)	Limiting Speeds (rpm)		Reference Dimensions				Abutment and dimensions (mm)					Space Capacity (cm^3)	Weight (kg)
a	Grease	Oil	d_1	d_2	D_1	D_2	d_a min	D_a max	D_b max	r_{as} max	r_{las} max	Open (Approx.)	Open (Approx.)
56.0	3600	5000	52.4	48.2	59.6	63.7	45.5	66.5	67.5	1.0	0.6	5.4	0.257
17.0	14700	19000	53.5	-	67.5	72.4	47	73	75.5	1.0	0.6	11.0	0.35
18.0	24600	37800	55.7	52.2	64.2	67.6	49.6	70.4	72.4	1.0	0.6	8.15	0.24
16.0	17700	27000	60.2	-	69.8	74.2	55.5	74.5	75.5	1.0	0.6	11.85	0.259
19.0	22800	35000	60.2	56.6	69.8	73.4	54.6	75.4	77.4	1.0	0.6	8.89	0.25
19.0	12600	16300	63.1	-	78.0	82.5	57	83	85.5	1.0	0.6	17	0.45
19.5	14900	22600	71.8	-	83.1	88.4	67	88	90	1.0	0.6	19.26	0.405
25.0	13400	20300	71.8	-	83.1	88.4	67	88	90	1.0	0.6	19.26	0.405
21.5	18000	27600	72.7	68.9	82.3	86.0	66	89	91.2	1.1	0.6	13.33	0.42
26.5	12600	19200	76.8	-	88.1	93.4	72	93	95.5	1.0	0.6	21.23	0.435
20.0	14000	21300	76.8	-	88.1	9.4	72	93	95.5	1.0	0.6	21.23	0.435
2.5	16800	25800	77.3	73.2	87.7	91.8	71	94	96.2	1.1	0.6	14.07	0.419
29.0	11500	17600	83.6	-	96.4	102.5	77	103	105	1.0	0.6	26.67	0.606
22.0	12800	19500	83.6	-	96.4	102.5	77	103	105	1.0	0.6	26.67	0.606
30.8	13400	18900	84.3	81.1	95.3	99.3	76	104	106.2	1.1	0.6	20.00	0.640
24.5	15600	24000	84.3	79.8	95.3	100.1	76	104	106.2	1.1	0.6	20.00	0.640
32.5	10200	15400	95.1	-	109.9	116.7	87	118	120.5	1.0	0.6	37.78	0.855
29.0	9200	14000	116.8	-	133.2	140.8	108.5	141.5	144.5	1.5	1.0	53.33	1.27
32.0	10700	16500	117.4	111.6	132.6	138.4	107	143	146	1.5	1.1	40.00	1.300
63.7	5300	6600	118.2	114.2	131.6	137.9	108.5	141.5	144.5	1.5	1.0	81.80	2.620



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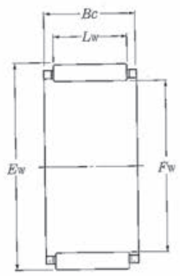

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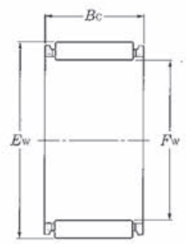

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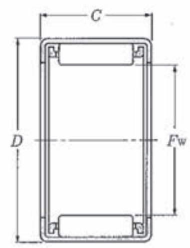

TYPE HKS

Ratings		Bearing Numbers	Mass (gr)
static			(Approx.)
C_{or}			
(N)	(kgf)		
12400	1260	PK18×24×11.8	11.0
22800	2330	PK25×30×14.8 X	14.7
20800	2120	PK25.1×30.1×13.8 X2	14.5
20900	2130	PK26×31×13.8X31	15.0
23100	2360	PK28×33×13.8 X	15.3
22800	2330	PK28×35×13.8 X1	23.0
10400	1060	KBK12×17×14.2 X2	5.80
27500	2810	K28×32×17	17.0
15200	1550	HKS17×25×18	24.0
15300	1560	HKS20×29×18	27.7

Appendix I：Tolerance for radial bearings

(1)Inner rings

Nominal bore diameter *d* (mm) over	incl.	Single plane mean bore diameter deviation Δ_{dmp} class 0 high	class 0 low	class 6 high	class 6 low	class 5 high	class 5 low	class 4[1)] high	class 4[1)] low	diameter series 7，8，9 class 0 max	class 6 max	class 5 max
0.6[4)]	2.5	0	-8	0	-7	0	-5	0	-4	10	9	5
2.5	10	0	-8	0	-7	0	-5	0	-4	10	9	5
10	18	0	-8	0	-7	0	-5	0	-4	10	9	5
18	30	0	-10	0	-8	0	-6	0	-5	13	10	6
30	50	0	-12	0	-10	0	-8	0	-6	15	13	8

Nominal bore diameter *d* (mm) over	incl.	Inner ring radial runout K_{ia} class 0 max	class 6 max	class 5 max	class 4 max	Face runout with bore S_d class 5 max	class 4 max	Inner ring axial runout[2)] S_{ia}[2)] class 5 max	class 4 max	class 0 high
0.6	2.5	10	5	4	2.5	7	3	7	3	0
2.5	10	10	6	4	2.5	7	3	7	3	0
10	18	10	7	4	2.5	7	3	7	3	0
18	30	13	8	4	3	8	4	8	4	0
30	50	15	10	5	4	8	4	8	4	0

1) The dimensional difference Δ_{ds} of bore diameter to applied for class 4 and 2 is the same as the tolerance of dimensional difference Δ_{dmp} of average bore diameter. However, the dimensional difference is applied to diameter series 0, 1, 2, 3 and 4 against Class 4, and to all the diameter series against Class 2.
2) To be applied for deep groove ball bearing and angular contact ball bearings.
3) To be applied for individual raceway rings manufactured for combined bearing use.
4) Nominal bore diameter of bearings of 0.6 mm is included in this dimensional division.

(2)Outer rings

Nominal bore diameter *D* (mm) over	incl.	Single plane mean bore diameter deviation Δ_{Dmp} diameter class 0 high	class 0 low	class 6 high	class 6 low	class 5 high	class 5 low	class 4[5)] high	class 4[5)] low	series class 0	series class 6
2.5[8)]	6	0	-8	0	-7	0	-5	0	-4	10	9
6	18	0	-8	0	-7	0	-5	0	-4	10	9
18	30	0	-9	0	-8	0	-6	0	-5	12	10
30	50	0	-11	0	-9	0	-7	0	-6	14	11
50	80	0	-13	0	-11	0	-9	0	-7	16	14
80	120	0	-15	0	-13	0	-10	0	-8	19	16

Nominal bore diameter *D* (mm) over	incl.	Mean single plane outside diameter variation V_{Dmp} class 0 max	class 6 max	class 5 max	class 4 max	Outer ring radial runout K_{ea} class 0 max	class 6 max	class 5 max	class 4 max	Outside surface S_D class 5 max
2.5[8)]	6	6	5	3	2	15	8	5	3	8
6	18	6	5	3	2	15	8	5	3	8
18	30	7	6	3	2.5	15	9	6	4	8
30	50	8	7	4	3	20	10	7	5	8
50	80	10	8	5	3.5	25	13	8	5	8
80	120	11	10	5	4	35	18	10		

5) The dimensional difference Δ_{Ds} of outer diameter to be applied for classes 4 and 2 is the same as the tolerance of dimensional difference Δ_{Dmp} of average outer diameter. However, the dimensional difference is applied to diameter series 0, 1, 2, 3 and 4 against Class 4, and also to all the diameter series against Class 2.
6) To be applied in case snap rings are not installed on the bearings.
7) To be applied for deep groove ball bearings and angular contact ball bearings.
8) Nominal outer diameter of bearings of 2.5 mm is included in this dimensional division.

Unit μm

	Single radial plane bore diameter variation V_{dp}								Mean single plane bore diameter variation V_{dmp}			
	diameter series 0, 1				diameter series 2, 3, 4							
class 4	class 0	class 6	class 5	class 4	class 0	class 6	class 5	class 4	class 0	class 6	class 5	class 4
	max				max				max			
4	8	7	4	3	6	5	4	3	6	5	3	2
4	8	7	4	3	6	5	4	3	6	5	3	2
4	8	7	4	3	6	5	4	3	6	5	3	2
5	10	8	5	4	8	6	5	4	8	6	3	2.5
6	12	10	6	5	9	8	6	5	9	8	4	3

Unit μm

Inner ring width deviation Δ_{Bs}							Inner ring width variation V_{Bs}				
normal			modified[3]								
class 6	class 5	class 4	class 0	class 6	class 5	class 4	class 0	class 6	class 5	class 4	class 2
low	high	low	high	low	high	low	max				
-40	0	-40	-	-	0	-250	12	12	5	2.5	1.5
-120	0	-40	0	-250	0	-250	15	15	5	2.5	1.5
-120	0	-80	0	-250	0	-250	20	20	5	2.5	1.5
-120	0	-120	0	-250	0	-250	20	20	5	2.5	1.5
-120	0	-120	0	-250	0	-250	20	20	5	3	1.5

Single radial plane outside diameter variation V_{Dp}										Single radial plane outside diameter variation V_{Dp}[6]	
		open type								Capped bearings diameter series	
7, 8, 9		diameter series 0, 1				diameter series 2, 3, 4				2,3,4	0,1,2,3,4
class 5	class 4	class 0	class 6	class 5	class 4	class 0	class 6	class 5	class 4	class 0	class 6
max		max				max				max	
5	4	8	7	4	3	6	5	4	3	10	9
5	4	8	7	4	3	6	5	4	3	10	9
6	5	9	8	5	4	7	6	5	4	12	10
7	6	11	9	5	5	8	7	5	5	16	13
9	7	13	11	7	5	10	8	7	5	20	16
10	8	19	16	8	6	11	10	8	6	26	20

Unit μm

inclination	Outside ring axial runout[7] S_{ea}		Outer ring width deviation Δ_{Cs}	Outer ring width variation V_{Cs}			
class 4	class 5	class 4	all type	class 0	class 6	class 5	class 4
	max			max			
4	8	5	Identical to Δ_{Bs} of inner ring of same bearing.	Identical to Δ_{Bs} and V_{Bs} of inner ring of same bearing		5	2.5
4	8	5				5	2.5
4	8	5				5	2.5
4	8	5				5	2.5
4	10	5				6	3
4	11	6				8	4

Appendix II：Dimensional tolerance for housing bore and shaft

Dimensional tolerance for shaft

Diameter division mm		f5		f6		g5		g6		h4		h5		h6	
over	incl	low	high	low	high	low	high	low	high	low	high	low	high	low	high
3	6	-10	-15	-10	-18	-4	-9	-4	-12	0	-4	0	-5	0	-8
6	10	-13	-19	-13	-22	-5	-11	-5	-14	0	-4	0	-6	0	-9
10	18	-16	-24	-16	-27	-6	-14	-6	-17	0	-5	0	-8	0	-11
18	30	-20	-29	-20	-33	-7	-16	-7	-20	0	-6	0	-9	0	-13
30	40	-25	-36	-25	-41	-9	-20	-9	-25	0	-7	0	-11	0	-16
40	50														

Diameter division mm		j7		k4		k5		k6		m5		m6		n5	
over	incl	low	high	low	high	low	high	low	high	low	high	low	high	low	high
3	6	+8	-4	+5	+1	+6	+1	+9	+1	+9	+4	+12	+4	+13	+8
6	10	+10	-5	+5	+1	+7	+1	+10	+1	+12	+6	+15	+6	+16	+10
10	18	+12	-6	+6	+1	+9	+1	+12	+1	+15	+7	+18	+7	+20	+12
18	30	+13	-8	+8	+2	+11	+2	+15	+2	+17	+8	+21	+8	+24	+15
30	40	+15	-10	+9	+2	+13	+2	+18	+2	+20	+9	+25	+9	+28	+17
40	50														

Dimensional tolerance for housing bore

Diameter division mm		E7		E10		E11		E12		F6		F7		F8	
over	incl	low	high	low	high	low	high	low	high	low	high	low	high	low	high
3	6	+32	+20	+68	+20	+95	+20	+140	+20	+18	+10	+22	+10	+28	+10
6	10	+40	+25	+83	+25	+115	+25	+175	+25	+22	+13	+28	+13	+35	+13
10	18	+50	+32	+102	+32	+142	+32	+212	+32	+27	+16	+34	+16	+43	+16
18	30	+61	+40	+124	+40	+170	+40	+250	+40	+33	+20	+41	+20	+53	+20
30	40	+75	+50	+150	50	+210	+50	+300	+50	+41	+25	+50	+25	+64	+25
40	50														
50	65	+90	+60	+180	+60	+250	+60	+360	+60	+49	+30	+60	+30	+76	+30
65	80														
80	100	+107	+72	+212	+72	+292	+72	+422	+72	+58	+36	+71	+36	+90	+36
100	120														

Diameter division mm		H11		H13		J6		Js6		J7		Js7		K5	
over	incl	low	high	low	high	low	high	low	high	low	high	low	high	low	high
3	6	+75	0	+180	0	+5	-3	+4	-4	+6	-6	+6	-6	0	-5
6	10	+90	0	+220	0	+5	-4	+4.5	-4.5	+8	-7	+7.5	-7.5	+1	-5
10	18	+110	0	+270	0	+6	-5	+5.5	-5.5	+10	-8	+9	-9	+2	-6
18	30	+130	0	+330	0	+8	-5	+6.5	-6.5	+12	-9	+10.5	-10.5	+1	-8
30	40	+160	0	+390	0	+10	-6	+8	-8	+14	-11	+12.5	-12.5	+2	-9
40	50														
50	65	+190	0	+460	0	+13	-6	+9.5	-9.5	+18	-12	+15	-15	+3	-10
65	80														
80	100	+220	0	+540	0	+16	-6	+11	-11	+22	-13	+17.5	-17.5	+2	-13
100	120														

Unit μm

h7		h8		js4		j5		js5		j6		js6		Nominal bore diameter of bearing *d* (mm)	
low	high	low	high	low	high	low	high	low	high	low	high	low	high	over	incl.
0	-12	0	-18	+2	-2	+3	-2	+2.5	-2.5	+6	-2	+4	-4	3	6
0	-15	0	-22	+2	-2	+4	-2	+3	-3	+7	-2	+4.5	-4.5	6	10
0	-18	0	-27	+2.5	-2.5	+5	-3	+4	-4	+8	-3	+5.5	-5.5	10	18
0	-21	0	-33	+3	-3	+5	-4	+4.5	-4.5	+9	-4	+6.5	-6.5	18	30
0	-25	0	-39	+3.5	-3.5	+6	-5	+5.5	-5.5	+11	-5	+8	-8	30 40	40 50

n6		p5		p6		r6		r7		IT tolerance				Nominal bore diameter of bearing *d* (mm)	
low	high	low	high	low	high	low	high	low	high	low	high	low	high	over	incl.
+16	+8	+17	+12	+20	+12	+23	+15	+27	+15	1.5	2.5	5	12	3	6
+19	+10	+21	+15	+24	+15	+28	+19	+34	+19	1.5	2.5	6	15	6	10
+23	+12	+26	+18	+29	+18	+34	+23	+41	+23	2	3	8	18	10	18
+28	+15	+31	+22	+35	+22	+41	+28	+49	+28	2.5	4	9	21	18	30
+33	+17	+37	+26	+42	+26	+50	+34	+59	+34	2.5	4	11	25	30 40	40 50

Unit μm

G6		G7		H6		H7		H8		H9		H10		Nominal bore diameter of bearing *d* (mm)	
low	high	low	high	low	high	low	high	low	high	low	high	low	high	over	incl.
+12	+4	+16	+4	+8	0	+12	0	+18	0	+30	0	+48	0	3	6
+14	+5	+20	+5	+9	0	+15	0	+22	0	+36	0	+58	0	6	10
+17	+6	+24	+6	+11	0	+18	0	+27	0	+43	0	+70	0	10	18
+20	+7	+28	+7	+13	0	+21	0	+33	0	+52	0	+84	0	18	30
+25	+9	+34	+9	+16	0	+25	0	+39	0	+62	0	+100	0	30 40	40 50
+29	+10	+40	+10	+19	0	+30	0	+46	0	+74	0	+120	0	50 65	65 80
+34	+12	+47	+12	+22	0	+35	0	+54	0	+87	0	+140	0	80 100	100 120

K6		K7		M6		M7		N6		N7		P6		P7	
low	high	low	high	low	high	low	high	low	high	low	high	low	high	over	incl.
+2	-6	+3	-9	-1	-9	0	-12	-5	-13	-4	-16	-9	-17	-8	-20
+2	-7	+5	-10	-3	-12	0	-15	-7	-16	-4	-19	-12	-21	-9	-24
+2	-9	+6	-12	-4	-15	0	-18	-9	-20	-5	-23	-15	-26	-11	-29
+2	-11	+6	-15	-4	-17	0	-21	-11	-24	-7	-28	-18	-31	-14	-35
+3	-13	+7	-18	-4	-20	0	-25	-12	-28	-8	-33	-21	-37	-17	-42
+4	-15	+9	-21	-5	-24	0	-30	-14	-33	-9	-39	-26	-45	-21	-51
+4	-18	+10	-25	-6	-28	0	-35	-16	-38	-10	-45	-30	-52	-24	-59

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