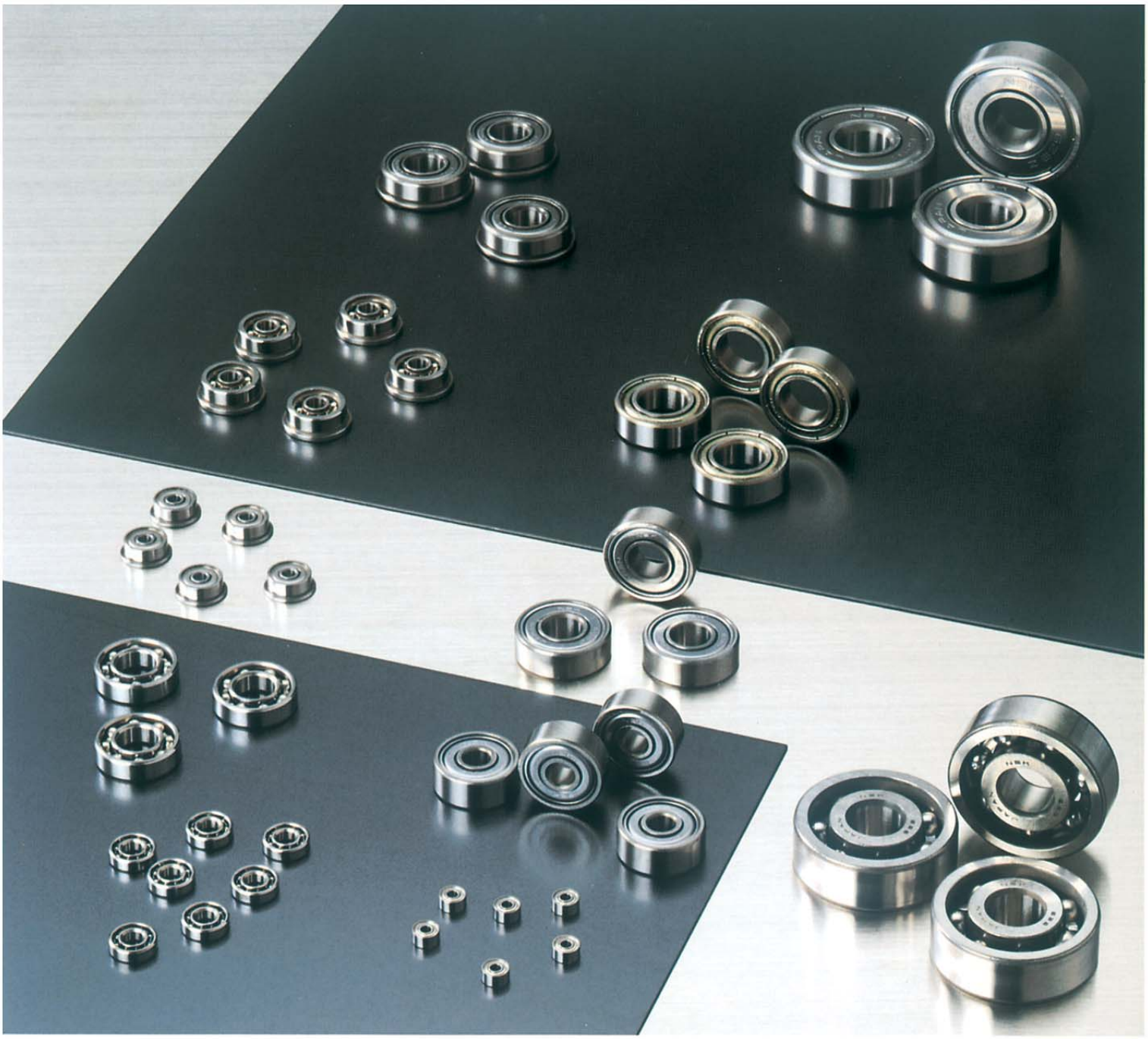
MOTION & CONTROL™

NSK

Miniature Ball Bearings



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Miniature Ball Bearings

CAT. NO. E126g

Introduction to revised NSK miniature ball bearing catalog (CAT. No. E126g)

We want to thank you for your interest in this edition of our miniature ball bearing catalog. It has been revised with our customers in mind, and we hope it fills your needs.

Recently, technology has been advancing at a remarkable pace, and with it has come a host of new products in many fields including computers, office automation, audio-visual equipment, medical equipment, and many others. These striking innovations present a challenge to bearing manufacturers since there are ever increasing demands to offer bearings with higher performance, accuracy, and reliability. Manufacturers of diverse equipment have many different bearing requirements including higher speeds, less torque, less noise and vibration, zero maintenance, survival in harsh environments, integration into units, and many more.

This catalog was revised to reflect certain revisions in JIS and ISO, and to better serve our customers. The first half contains technical information about bearing life, load ratings, limiting speeds, accuracy, lubricaation, etc. to facilitate selection of the most appropriate bearing.

The second half presents extensive tables containing most bearing numbers and showing dimensions and pertinent design data listed in the order of increasing bore size. Data in the tables are given in both the International Unit System (SI) and Engineering Unit System (Gravitational System of Units).

We hope this catalog will allow you to select the optimum bearing for your application. However, if assistance is required, please contact NSK and we engineers will quickly supply the information you need.


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1. Bearing types and features

Miniature and instrument ball bearings can be divided into two basic types, deep groove and angular contact. The first (deep groove) can be further divided into the following five classes depending on their design details:

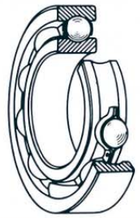
- Standard type
- Flanged outer ring
- Extended inner ring
- Expanded type in which one ring has a radial thickness that is larger than normal compared with the bearing width.
- Thin section type in which both rings are extra thin in the radial direction.

Deep groove ball bearings can also be classified as "Open", "Shielded", or "Sealed" depending on the existence and type of seal or shield. The size ranges of extra small and miniature ball bearings are shown in **Table 1.1**.

Table 1.1 Size ranges of bearings Units: mm

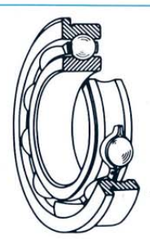
Design	Extra small ball bearings	Miniature ball bearings
Metric	Outside diameter $D \geqq 9$ Bore diameter $d < 10$	Outside diameter $D < 9$
Inch	Outside diameter $D \geqq 9.525$ Bore diameter $d < 10$	Outside diameter $D < 9.525$

(1) Single-row deep groove ball bearings



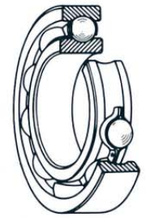
Deep groove ball bearings have two inherent advantages; they can sustain some axial load in either direction as well as radial loads, and the two raceway cross-sections are simple circular arcs which can be very precisely finished so the bearings have low friction and very little noise or vibration. Several different cage designs are available with different characteristics and the choice depends upon the individual application.

(2) Deep groove ball bearings with flanged outer rings



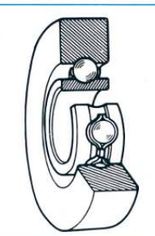
Deep groove ball bearings with flanged outer rings correspond to ordinary ball bearings with snap rings. The flange extends around the entire circumference of the outer ring due to the size limitation and to improve its running accuracy. Since it is not necessary to provide a shoulder on the housing bore if this bearing is used, the bore can be a simple cylindrical shape which facilitates high precision machining and also reduces the machining time.

(3) Deep groove ball bearings with extended inner rings



Deep groove ball bearings with extended inner rings are inch series bearings with their inner rings extended equally on both sides by 1/64 inch (0.0156 inch, 0.397mm) beyond the width of the outer ring. Since the inner ring is therefore wider by 1/32 inch than the outer ring, it is not necessary to provide a projection on parts installed in contact with the inner ring. This feature simplifies the design and fabrication of parts immediately surrounding the bearing.

(4) Deep groove ball bearings for synchros

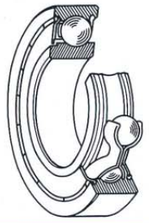


Ball bearings for synchros are inch series bearings with their outer rings thickened radially. Their outer diameter is, therefore, large relative to the bore diameter. These bearings are mainly used for synchros but are convenient in some other applications.

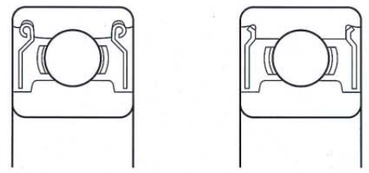
(5) Extra-thin-section deep groove ball bearings

Extra-thin-section deep groove ball bearings have a small radial cross-sectional thickness. NSK offers such bearings with bore diameters from 10 to 15mm. They are used when extreme compactness is important.

(6) Shielded and sealed bearings

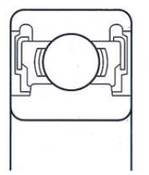


Deep groove ball bearings often have shields or seals installed on both sides and are factory-packed with a lubricant. The use of such bearings simplifies the structure around them and also their installation. It also eliminates the need for relubrication and, therefore, reduces maintenance costs. There are three types of such bearings: shielded bearings, contact sealed bearings, and non-contact sealed bearings.



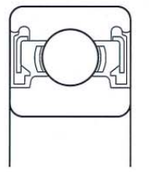
(a) Shielded bearings ZZ1 (Z1), ZZ (Z)

Shielded bearings are protected by a shield plate of pressed steel. The shields can be made of either low carbon steel or stainless steel.



(b) Contact sealed bearings DD (D)

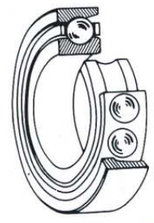
Sealed bearings have superior sealing effectiveness compared to shielded bearings, particularly, the contact type sealed bearings which prevent the intrusion of dust from outside because the seal plate lip slides on a seal groove in the inner ring. The torque is, however, high due to the friction of the seal lip.



(c) Non-contact sealed bearings VV (V)

With this VV type, a rubber seal with metal backing is held in the outer ring by the elasticity of the rubber. Effective sealing is achieved by a labyrinth formed between its bore and the seal groove in the inner ring. It has the advantage that the frictional torque is low because the seal lip does not contact the seal groove.

(7) Single-row angular contact ball bearings



Angular contact ball bearings can sustain radial loads and axial loads in only one direction. Those with one shoulder on the outer ring are generally used, but for extra-high speed operation, bearings with one shoulder on the inner ring are available. Angular contact ball bearings must be used in duplex pairs with a suitable preload. They are recommended for applications requiring high speed and rigidity.

2. Formulaton of bearing numbers

Bearing numbers are alphanumeric combinations that indicate the bearing type, boundary dimensions, internal clearance, dimensional and running accuracies, and other related specifications. They consist of basic numbers and supplementary symbols. The boundary dimensions of commonly used bearings mostly conform to the organizational concept of ISO, and the bearing numbers of these standard bearings are specified by JIS B 1513 (Designation for rolling bearings). Due to a need for more detailed classification, NSK uses auxiliary symbols other than those specified by JIS. Basic numbers, supplementary symbols, and the meanings of common numbers and symbols are listed in **Table 2.1** (Pages 12 and 13). The contact angle symbols and other supplementary designations are shown in successive columns from left to right in **Table 2.1.** For reference, five examples of bearing numbers are shown on Page 13.

Examples of bearing numbers

(1) 60 1X □ □ □ □ W □ MC3 □ P4 L UC3 AF2 Q → 601XWMC3P4LUC3AF2Q
(2) 62 5 □ □ □ h J ZZ MC2 E P5 □ □ B3N S → 624hJZZMC2EP5B3NS
(3) S MR □ 84 □ □ □ W ZZ MC3 □ P5 □ UC1 B3N S → SMR84WZZMC3P5UC1B3NS
(4) S MF □ 148 □ □ □ J □ MC4 □ P5 L □ □ □ → SMF148JMC4P5L
(5) S R □ 2 □ □ □ J ZZ MC3 □ 7P □ □ B3N L → SR2JZZMC37PB3NL

Table 2.1 Formulation of bearing numbers

Basic numbers

Bearing series symbols

Symbol	Meaning
68	Single-row deep groove ball bearings
69	
60	
62	
63	
F68	Deep groove ball bearings with flanged outer rings
F69	
F60	
F62	
F63	
70	Single-row angular contact ball bearings
72	
	Special metric design
MR	Single-row deep groove ball bearnigs
MF	Deep groove ball bearings with flanged outer rings
SMT	Thin-section deep groove ball bearings
	Inch design
R	Single-row deep groove ball bearings
SR...X	Ball bearings for synchros
RW	Deep groove ball bearings with extended inner rings
FRW	Deep groove ball bearings with extended inner rings, flanged

Bore number or size number

Number	Meaning
1	Bearing bore 1mm
2	Bearing bore 2mm
3	Bearing bore 3mm
⋮	
1X	Bearing bore 1.5mm
2X	Bearing bore 2.5mm
⋮	
84	Brg O.D. 8mm Brg bore 4mm
148 ⋮	Brg O.D. 14mm Brg bore 8mm
41X	Brg O.D. 4mm Brg bore 1.2mm
82X ⋮	Brg O.D. 8mm Brg bore 2.5mm
133	Brg O.D. 4.762mm (3/16 inch) Brg bore 2.380mm (3/32 inch)
155 ⋮	Brg O.D. 7.938mm (5/16 inch) Brg bore 3.967mm (5/32 inch)

Contact angle symbol

Symbol	Meaning
	(Angular contact ball bearings)
A	Standard contact angle of 30°
A5	Standard contact angle of 25°
B	Standard contact angle of 40°
C	Standard contact angle of 15°

Internal design symbol

Symbol	Meaning
A	Internal design differs from standard one
B	

Material symbol

Symbol	Meaning
Omitted	High carbon chromium bearing steel SUJ 2 Equivalent to ASTM A295 52100
h	Stainless steel SUS440C Equivalent to SAE J405 51440C
S	Stainless steel for special metric and inch designs "S" is prefix to series symbol

Cage symbol

Symbol	Meaning
J (Omitted)	Pressed steel ribbon cage
W (Omitted)	Pressed steel snap cage
T12 **T1X**	Plastic snap cage

Seals, shields symbol

Symbol	Meaning
Z **Z1**	Shield on one side only
ZZ **ZZ1**	Shields on both sides
D	Contact rubber seal on one side only
DD	Contact rubber seals on both sides
V	Non-contact rubber seal on one side only
VV	Non-contact rubber seals on both sides

Supplementary number

Internal clearance symbol

Symbol	Meaning (radial clearance)
MC1	Clearance less than MC2
MC2	Clearance less than MC3
MC3	Upgrade normal clearance
MC4	Clearance greater than MC3
MC5	Clearance greater than MC4
MC6	Clearance greater than MC5

Noise level symbol

Symbol	Meaning
Omitted	Standard
E	Quieter than standard
ER	Quieter than E

Accuracy class symbol

Symbol	Meaning
Omitted	Normal
P6	Class 6
P5	Class 5
P4	Class 4
Omitted	ANSI/ ABMA ABEC 1
3	ANSI/ ABMA ABEC 3
5P	ANSI/ ABMA Instrument ball bearings inch design CLASS 5P
7P	ANSI/ ABMA Instrument ball bearings inch design CLASS 7P
9P	ANSI/ ABMA Instrument ball bearings inch design CALSS 9P

Torque symbol

Symbol	Meaning
Omitted	Standard
L	Low torque

Special specification symbol

Symbol	Meaning
U1	Special specification
U2	
⋮	
UC1	Bore diameter is sorted into two groups
UC2	Outside diameter is sorted into two groups
UC3	Both bore and outside diameters are sorted into two groups

When selecting these specifications please consult NSK

Lubricant symbol

Symbol	Meaning
AF2	Aeroshell Fluid 12
D4M	Dow Corning DC 44M
B3N	Beacon 325
KOC	Krytox 280AC
NS7	NS Hilube
PS2	Multemp PS 2

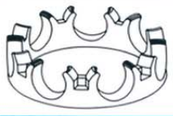
Lubricant quantity symbol

Symbol	Meaning
Q	Oil soaking
K	Grease packed less than L
L	Grease packed less than S
S	Standard grease packing quantity
H	Grease packed more than S
M	Grease packed more than H

3. Cage design

In general, the cages used in miniature bearings are either ribbon cages or snap cages, both made of pressed steel. Pressed steel ribbon cages are generally used in the larger bearings and pressed snap cages in the smaller ones.
In recent years, plastic snap cages, which have the advantages of low torque, long grease life, and low noise, have been used in many kinds of miniature ball bearings.
Table 3.1 shows the various types of cages and their symbols.

Table 3.1 Cage types and symbols

Type	Symbol	Name
	J	Pressed steel ribbon cage
	W	Pressed steel snap cage
	T12	Plastic snap cage

4. Selection of bearing size

4.1 Bearing life

The various functions required of rolling bearings vary according to the bearing application. These functions must be preformed for a prolonged period. Even if bearings are properly mounted and correctly operated, they will eventually fail to perform satisfactorily due to an increase in noise and vibration, loss of running accuracy, deterioration of grease, or fatigue flaking of the rolling surfaces.
Bearing life, in the broad sense of the term, is the period during which bearings continue to operate and satisfy their required functions. This bearing life may be defined as noise life, abrasion life, grease life, or rolling fatique life, depending on which one causes loss of bearing service.
Rolling fatigue life is represented by the total number of revolutions at which time the bearing surface will start flaking due to stress. This is called fatigue life. Even for seemingly identical bearings, which are of the same type, size, and material and receive the same heat treatment and other processing, the rolling fatigue life varies greatly even under identical operating conditions. This is because the flaking of materials due to fatigue is subject to many other variables. Consequently, "rating fatigue life", in which rolling fatique life is treated as a statistical phenomenon, is used in preference to actual rolling fatigue life.
Suppose a number of bearings of the same type are operated individually under the same conditions. After a certain period of time, 10% of them fail as a result of flaking caused by rolling fatique. The total number of revolutions at this point is defined as the rating fatique life or, if the speed is constant, the rating fatique life is often expressed by the total number of operating hours completed when 10% of the bearings become inoperable due to flaking.

4.2 Basic load rating and fatigue life

The basic load rating is defined as the constant load applied on bearings with stationary outer rings that the inner rings can endure for a rating life of one million revolutions (10^6 rev.). The basic load rating of radial bearings is defined as a central radial load of constant direction and magnitude. The load ratings are listed under C_r for radial bearings in the bearing tables.
In the case of bearings that run at a constant speed, it is convenient to express the fatigue life in terms of hours.
The following relation exists between bearing load and rating fatigue life:

For radial ball bearings $$L=\left(\frac{C}{P}\right)^3 \quad \text{..... (4.1)}$$

where L: Rating fatigue life (10^6 rev.)
P: Bearing load (equivalent load) (N), {kgf}
C: Basic load rating (N), {kgf}
For radial bearings, C is written C_r

By designating the rating fatigue life as L_h (h), bearing speed as n (rpm), fatigue life factor as f_h, and speed factor as f_n, the following relations are obtained:

$$L_h=\frac{10^6}{60n}\left(\frac{C}{P}\right)^3=500f_h^3 \quad \text{..... (4.2) (Refer to Fig. 4.2)}$$

$$f_h=f_n\frac{C}{P} \quad \text{..... (4.3)}$$

$$f_n=\left(\frac{10^6}{500\times 60n}\right)^{\frac{1}{3}}=\left(0.03n\right)^{-\frac{1}{3}} \quad \text{..... (4.4) (Refer to Fig. 4.1)}$$

If the bearing load, P, and speed, n, are known, determine a fatique life factor, f_h, appropriate for the projicted life of the machine and then calculate the basi load rating, C, by means of the following equation:

$$C=\frac{f_h\cdot P}{f_n} \quad \text{..... (4.5)}$$

A bearing which satisfies this value of C should then be selected from the bearing tables.
The equivalent load on radial bearings may be calculated using the following equation:

$$P=XF_r+YF_a \quad \text{..... (4.6)}$$

where P : Equivalent load(N), {kgf}
F_r : Radial load (N), {kgf}
F_a : Axial load (N), {kgf}
X : Radial load factor
Y : Axial load factor
The values of X and Y are listed in **Table 4.1**.

Table 4.1 Radial and axial load factors

C_{or}/F_a	$F_a/F_r \leqq e$		$F_a/F_r > e$		e
	X	Y	X	Y	
5	1	0	0.56	1.26	0.35
10	1	0	0.56	1.49	0.29
15	1	0	0.56	1.64	0.27
20	1	0	0.56	1.76	0.25
25	1	0	0.56	1.85	0.24
30	1	0	0.56	1.92	0.23
50	1	0	0.56	2.13	0.20

Fig. 4.1 Bearing speed and speed factor ($n-f_n$)

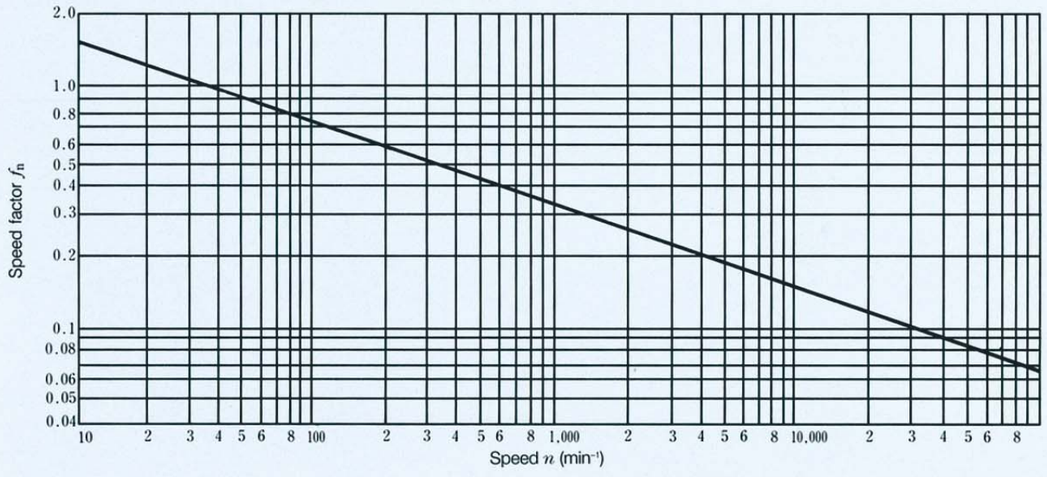
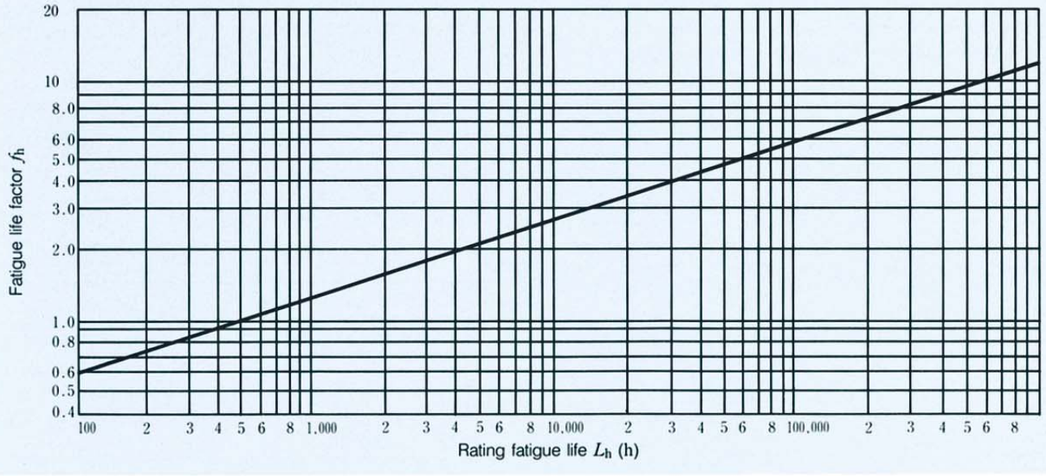


Fig. 4.2 Fatigue life factor and rating fatigue life (f_h-L_h)



The L_{10} life is defined as the rating fatigue life with a statistical reliability of 90%. Depending on the machines in which the bearings are used, sometimes a reliability higher than 90% may be required. However, recent improvements in bearing material have greatly extended the fatigue life. In addition, the development of the Elasto-Hydrodynamic Theory of Lubrication proves that the thickness of the lubricating film in the contact zone between rings and rolling elements greatly influences bearing life. To reflect such improvements in the calculation of fatigue life, the rating fatigue life is corrected using the following correction factors:

$$L_{na} = a_1 a_2 a_3 L_{10} \quad \cdots\cdots (4.7)$$

where L_{na} : Adjusted rating life in which reliability, material improvements, lubricating conditions, etc. are considered

L_{10} : Rating fatigue life with a reliability of 90%
a_1 : Life correction factor for reliability
a_2 : Life correction factor for material
a_3 : Life correction factor for operating conditions

The life correction factor for reliability a_1 is listed in **Table 4.2** for reliabilities higher than 90%.

Table 4.2 Reliability factor a_1

Reliability(%)	90	95	96	97	98	99
a_1	1.00	0.62	0.53	0.44	0.33	0.21

The life correction factor for material, a_2, is greater than one because of improvements in bearing steel. NSK now uses vacuum degassed bearing steel, and the results of tests by NSK show that life is greatly improved when compared with earlier materials. The basic load ratings, C_r, listed in the bearing tables were calculated considering the extended life achieved by improvements in materials and manufacturing techniques. Consequently, when estimating life using **Equation (4.7)**, it is sufficient to assume $a_2 = 1$.
The life correction factor for operating conditions, a_3, is used to correct for various factors, particularly lubrication. If there is no misalignment between the inner and outer rings and the thickness of the lubricating film in the contact zones of the bearing is sufficient, it is possible for a_3 to be greater than one; however, a_3 is less than one in the following cases:

- When the viscosity of the lubricant in the contact zones between the raceways and rolling elements is low.
- When the circumferential speed of the rolling elements is very slow.
- When the bearing temperature is high.
- When the lubricant is contaminated by water or foreign matter.
- When misalignment of the inner and outer rings is excessive.

It is difficult to determine the proper value for a_3 for specific operating conditions because there are still many unknowns. Since the material factor a_2 is also influenced by the operating conditions, there is a proposal to combine a_2 and a_3 into one quantity ($a_2 \times a_3$), and not consider them independently. In this case, under normal lubricating and operating conditions, the product ($a_2 \times a_3$) should be assumed equal to one. However, if the viscosity of the lubricant is too low, the value drops to as low as 0.2. If there is no misalignment and a lubricant with high viscosity is used so sufficient fluid-film thickness is secured, the product of ($a_2 \times a_3$) can be set around two.

It is very rare for extra small and miniature ball bearings to fail because of fatique. Other problems such as wear, reduced accuracy, or deterioration of the grease define the limit of bearing life instead of flaking. This is particularly true of audio-visual equipment in which extra low noise and vibration, low torque, or other requirements are highly important. The elapsed time when a bearing fails to satisfy its functional requirements may be regarded as bearing service life.

4.3 Static load rating and static equivalent load

When subjected to an excessive load or a strong shock load, rolling bearings may incur a local permanent deformation of the rolling elements and raceway surface if the elastic limit is exceeded. The nonelastic deformation increases in area and depth as the load increases, and when the load exceeds a certain limit, the smooth running of the bearing is impeded. The basic static load rating for deep groove ball bearings is defined as that static load which produces 4200 MPa {428kgf/mm^2} contact stress at the center of the contact area between the rolling element subjected to the maximum stress and the raceway surface.
In this most heavily stressed contact area, the sum of the permanent deformation of the rolling element and that of the raceway is nearly 0.0001 times the rolling element's diameter. The basic static load rating, C_o, is written "C_{or}" for radial bearings in the bearing tables.
The static equivalent load is a hypothetical load that produces a contact stress equal to the above maximum stress under actual conditions, while the bearing is stationary (including very slow rotation or oscillation), in the area of contact between the most heavily stressed rolling element and bearing raceway. The greater of the two values calculated from the following equations should be adopted as the static equivalent load on radial bearings.

$$P_o = X_o F_r + Y_o F_a \quad \cdots\cdots (4.8)$$
$$P_o = F_r \quad \cdots\cdots (4.9)$$

where P_o: Static equivalent load (N), {kgf}
F_r: Radial load (N), {kgf}
F_a: Axial load (N), {kgf}
X_o: Static radial load factor (0.6)
Y_o: Static axial load factor (0.5)

The permissible static equivalent load of a bearings varies depending on its basic static load rating and also their application and operating conditions. The permissible static load factor, f_s, is a safety factor that is applied to the basic static load rating. It is defined by the ratio in **Equation(4.10)**. The generally recommended values of f_s are listed in **Table 4.3.**

$$f_s = \frac{C_o}{P_o} \quad \cdots\cdots (4.10)$$

where C_o : Basic static load rating (N), {kgf}
P_o : Static equivalent load (N), {kgf}

Table 4.3 Values of permissible static load factor f_s

Operating conditions of ball bearings	Lower limit of f_s
Low-noise applications	2
Bearings subjected to vibration and shock loads	1.5
Standard operating conditions	1

5. Limiting speeds

The speed of rolling bearings is subject to certain limits. When bearings are operating, the higher the speed, the higher the bearing temperature due to friction. The limiting speed is the empirically obtained value for the maximum speed at which bearings can be continuously operated without failing from seizure or generation of excessive heat. Consequently, the limiting speed of bearings varies depending on such factors as bearing type and size, cage form and material, load, lubrication method, and heat dissipating method including the design of the bearing's surroundings. The maximum permissible speed for contact rubber sealed bearings (DD type) is determined mainly by the sliding surface speed of the inner circumference of the seal.
Values for the limiting speed of bearings lubricated by grease and oil are listed in the bearing tables. The limiting speeds in the tables are applicable to bearings of standard design that are subjected to normal loads, i.e, $C/P \geqq 12$ and $F_a/F_r \leqq 0.2$ approximately. The limiting speeds for oil lubrication listed in the bearing tables are for conventional oil bath lubrication. When speeds are more than 70 percent of the listed limiting speed, it is necessary to select an oil or grease which has good high-speed characteristics.
When the required speed exceeds the limiting speed of the desired bearing, then the accuracy grade, internal clearance, cage type and material, and lubrication, must be carefully studied in order to select a bearing capable of the required speed. If all these conditions are considered, the maximum permissible speed may be higher than the limiting speed found in the bearing table. It is recommended that NSK be consulted regarding high-speed applications.

6. Bearing tolerances

The tolerances for the boundary dimensions and running accuracy of extra small and miniature ball bearings are specified by ISO 492/582 (Rolling bearings-radial bearings tolerances) and ANSI/ABMA Std. 12.2 (Instrument ball bearings inch design). **Tables 6.1, 6.2** and **6.3** apply to metric design extra small and miniature ball bearings. **Tables 6.4** and **6.5** apply to inch design extra small and miniature precision ball bearings for instruments.
Bearing accuracy should be chosen depending on the application. A rough guide for the selection of bearing accuracy is presented in **Table 6.6.**

Symbols for boundary dimensions and running accuracy

d	Brg bore dia., nominal
Δ_{ds}	Deviation of a single bore dia.
Δ_{dmp}	Single plane mean bore dia. deviation
V_{dp}	Bore dia. variation in a single radial plane
V_{dmp}	Mean bore dia. variation
D	Brg outside dia., nominal
Δ_{Ds}	Deviation of a single outside dia.
Δ_{Dmp}	Single plane mean outside dia. deviation
V_{Dp}	Outside dia. variation in a single radial plane
V_{Dmp}	Mean outside dia. variation
D_1	Outside dia. of the outer ring flange, nominal
Δ_{D1s}	Deviation of a single outside diameter of the outer ring flange
B	Inner ring width, nominal
Δ_{Bs}	Deviation of a single inner ring width
V_{Bs}	Inner ring width variation
C	Outer ring width, nominal
Δ_{Cs}	Deviation of a single outer ring width
V_{Cs}	Outer ring width variation
C_1	Outer ring flange width, nominal
Δ_{C1s}	Deviation of a single outer ring flange width
V_{C1s}	Outer ring flange width variation
K_{ia}	Radial runout of assembled brg. inner ring
K_{ea}	Radial runout of assembled brg. outer ring
S_d	Inner ring reference face (backface, where applicable) runout with bore
S_{ia}	Assembled brg. inner ring face (backface) runout with raceway
S_D	Variation of brg outside surface generatrix inclination with outer ring reference face (backface)
S_{ea}	Assembled brg. outer ring face (backface) runout with raceway
S_{ea1}	Assembled brg. outer ring flange back face runout with raceway

Table 6.1 Tolerances and tolerance limits for inner rings and widths of outer rings (Metric design)

Nominal bore diameter d (mm)		Δ_{dmp}										Δ_{ds}								
		Normal		Class 6		Class 5		Class 4		Class 2		Class 4		Class 2		Normal				
												Diameter series				Diameter series				
												0, 2, 3				9		0		2, 3
over	incl	high	low	high	low	high	low	high	low	high	low	high	low	high	low	max				
0.6(1)	**2.5**	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5	10		8		6
2.5	**10**	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5	10		8		6
10	**18**	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5	10		8		6

V_{dp}								V_{dmp}					
Class 6			Class 5		Class 4		Class 2	Normal	Class 6	Class 5	Class 4	Class 2	
Diameter series			Diameter series		Diameter series								
9	0	2, 3	9	0, 2, 3	9	0, 2, 3							
max			max		max		max	max	max	max	max	max	
9	7	5	5	4	4	3	2.5	6	5	3	2	1.5	
9	7	5	5	4	4	3	2.5	6	5	3	2	1.5	
9	7	5	5	4	4	3	2.5	6	5	3	2	1.5	

Δ_{Bs} (or Δ_{Cs})(2)						V_{Bs}(or V_{Cs})					
Single bearing			Combined bearings(3)		Inner ring (or outer ring)(2)	Inner ring					
Normal Class 6	Class 5 Class 4	Class 2	Normal Class 6	Class 5 Class 4		Normal	Class 6	Class 5	Class 4	Class 2	
high low	high low	high low	high low	high low	max	max	max	max	max		
0 −40	0 −40	0 −40	— —	0 −250	12	12	5	2.5	1.5		
0 −120	0 −40	0 −40	0 −250	0 −250	15	15	5	2.5	1.5		
0 −120	0 −80	0 −80	0 −250	0 −250	20	20	5	2.5	1.5		

Notes (1) 0.6mm is inclluded in the group.
(2) Tolerances for width deviation and width dimensional variation of the outer ring are bosed on the values for the inner ring of the same bearing. Tolerance for the width variation of the outer ring of Class 5, 4 and 2 are shown in **Table 6.2**
(3) Applicable to individual rings manufactured for combined bearings.

Units: μm

K_{ia}					S_d			S_{ia}			Nominal bore diameter d (mm)	
Normal	Class 6	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2		
max	max	max	max	max	max	max	max	max	max	max	over	incl
10	5	4	2.5	1.5	7	3	1.5	7	3	1.5	**0.6**(1)	**2.5**
10	6	4	2.5	1.5	7	3	1.5	7	3	1.5	**2.5**	**10**
10	7	4	2.5	1.5	7	3	1.5	7	3	1.5	**10**	**18**

Remarks 1. The cylindrical bore diameter "no-go side" tolerance limit (high) specified in this table does not necessarily apply within a distance of 1.2 times the chamfer dimension r (max) from the ring face.
2. ANSI/ABMA Std 20-1996: ABEC1, ABEC3, ABEC5, ABEC7, and ABEC9 are equivalent to Classes Normal, 6, 5, 4 and 2, respectively.

Table 6.2 Tolerances and tolerance limits for outer rings (Metric design)

Nominal outside diameter D (mm)		Δ_{Dmp}										Δ_{Ds}								
		Normal		Class 6		Class 5		Class 4		Class 2		Class 4		Class 2		Normal				
												Diameter series				Open type				
												0, 2, 3				Diameter series				
																9		0		2, 3
over	incl	high	low	high	low	high	low	high	low	high	low	high	low	high	low	max				
2.5(1)	**6**	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5	10		8		6
6	**18**	0	−8	0	−7	0	−5	0	−4	0	−2.5	0	−4	0	−2.5	10		8		6
18	**30**	0	−9	0	−8	0	−6	0	−5	0	−4	0	−5	0	−4	12		9		7

V_{Dp}										V_{Dmp}					
	Class 6				Class 5		Class 4		Class 2						
Shielded sealed	Open type			Shielded selaed	Open type		Open type		Open type	Normal	Class 6	Class 5	Class 4	Class 2	
	Diameter series				Diameter series		Diameter series								
2, 3	9	0	2, 3	0, 2, 3	9	0, 2, 3	9	0, 2, 3							
	max				max		max		max	max	max	max	max	max	
10	9	7	5	9	5	4	4	3	2.5	6	5	3	2	1.5	
10	9	7	5	9	5	4	4	3	2.5	6	5	3	2	1.5	
12	10	8	6	10	6	5	5	4	4	7	6	3	2.5	2	

Units: μm

Nominal outside diameter D (mm)		K_{ea}					S_D			S_{ea} (or S_{ea1})(2)			V_{Cs}(3)		
		Normal	Class 6	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2	Class 5	Class 4	Class 2
over	incl	max	max	max	max	max	max	max	max	max	masx	max	max	max	max
2.5(1)	**6**	15	8	5	3	1.5	8	4	1.5	8	5	1.5	5	2.5	1.5
6	**18**	15	8	5	3	1.5	8	4	1.5	8	5	1.5	5	2.5	1.5
18	**30**	15	9	6	4	2.5	8	4	1.5	8	5	2.5	5	2.5	1.5

Notes (1) 2.5mm is included in the group.
(2) Applicable to assembled-bearing flange backface runout with raceway.
(3) The tolerances for outer ring width variation of bearings of Class Normal nd 6 are shown in **Table 6.1**

Remarks 1. The outside diameter "no-go-side" tolerance (low) specified in this table does not necessarily apply within a distance of 1.2 times the chamfer dimension r (max) from the ring face.
2. ANSI/ABMA Std 20-1996: ABEC1, ABEC3, ABEC5, ABEC7, and ABEC9 are equivalent to Classes Normal, 6, 5, 4 and 2, respectively.

Table 6.3 Flange tolerances for metric flanged bearings

(1) Tolerances of outside diameter flange

Units: μm

Nominal flange outside diameter D_1 (mm)		Deviation of outside diameter flange Δ_{D1s}	
over	incl	high	low
	10	+220	−36
10	18	+270	−43
18	30	+330	−52

Remarks When the tolerance not shown in the table above, please contact NSK.

(2) Flange width tolerances and running accuracies related to flange

Units: μm

Nominal bearing outside diameter D (mm)		Deviation of flange width Δ_{Cs}		Variation of flange width Δ_{C1s} V_{C1s}				Variation of brg outside surface generatrix inclination with flange backface S_{D1}			Flange backface runout with raceway S_{ea1}		
		Normal and classes 6, 5, 4, 2		Normal and class 6	class 5	class 4	class 2	class 5	class 4	class 2	class 5	class 4	class 2
over	incl	high	low	max				max			max		
2.5(1)	6	Use the Δ_{Bs} tolerance for d of the same bearing of the same class		Use the Δ_{Bs} tolerance for d of the same bearing of the same class	5	2.5	1.5	8	4	1.5	11	7	3
6	18				5	2.5	1.5	8	4	1.5	11	7	3
18	30				5	2.5	1.5	8	4	1.5	11	7	3

Note (1) 2.5 mm is included.

Table 6.4 Tolerances and tolerance limits for inner rings and widths of outer rings (ANSI/ABMA Standard · Instrument ball bearings · inch design)

Units: μm

Nominal bore diameter d (mm)		Δ_{dmp}		Δ_{ds}		V_{dp}		V_{dmp}		Δ_{Bs} (or Δ_{Cs})			V_{Bs}		K_{ia}			S_{ia}			S_d		
		CLASS 5P CLASS 7P	CLASS 9P	CLASS 5P CLASS 7P	CLASS 9P	CLASS 5P CLASS 7P	CLASS 9P	CLASS 5P CLASS7P	CLASS 9P	Single brgs CLASS 5P CLASS 7P CLASS 9P	Combined brgs(1) CLASS 5P CLASS 7P CLASS 9P	CLASS 5P	CLASS 7P	CLASS 9P	CLASS 5P	CLASS 7P	CLASS 9P	CLASS 5P	CLASS 7P	CLASS 9P	CLASS 5P	CLASS 7P	CLASS 9P
over	incl	high low	high low	high low	high low	max	max	max	max	high low	high low	max	max	max	max	max	max	max	max	max	max	max	max
—	**10**	0 −5.1	0 −2.5	0 −5.1	0 −2.5	2.5	1.3	2.5	1.3	0 −25.4	0 −400	5.1	2.5	1.3	3.8	2.5	1.3	7.6	2.5	1.3	7.6	2.5	1.3
10	**18**	0 −5.1	0 −2.5	0 −5.1	0 −2.5	2.5	1.3	2.5	1.3	0 −25.4	0 −400	5.1	2.5	1.3	3.8	2.5	1.3	7.6	2.5	1.3	7.6	2.5	1.3
18	**30**	0 −5.1	0 −2.5	0 −5.1	0 −2.5	2.5	1.3	2.5	1.3	0 −25.4	0 −400	5.1	2.5	2.5	3.8	2.5	2.5	7.6	3.8	1.3	7.6	3.8	1.3

Note (1) Applicable to bearings for which the axial clearance (preload) is to be adjusted by combining two selected bearings.
Remarks CLASSES 5P, 7P and 9P are for precision bearings for instruments.
For the tolerances of Metric Design Pecision Bearings for instruments, it is advisable to consult NSK.

Table 6.5 Tolerances and tolerance limits for outer rings (ANSI/ABMA Standard · Instrument ball bearings · inch design)

Units: μm

Nominal outside diameter D (mm)		Δ_{Dmp}		Δ_{Ds}			V_{Dp}			V_{Dmp}			V_{Cs}(1)		S_D			K_{ea}			S_{ea}			Δ_{D1s}	Δ_{C1s}	S_{ea1}(2)
		CLASS 5P CLASS 7P	CLASS 9P	CLASS 5P CLASS 7P		CLASS 9P	CLASS 5P CLASS 7P		CLASS 9P	CLASS 5P CLASS 7P		CLASS 9P	CLASS 5P	CLASS 7P	CLASS 9P	CLASS 5P	CLASS 7P	CLASS 9P	CLASS 5P	CLASS 7P	CLASS 9P	CLASS 5P	CLASS 7P	CLASS 9P	Flanged outer ring		
				Open	Shielded sealed		Open	Shielded sealed		Open	Shielded sealed														CLASS 5P CLASS 7P	CLASS 5P CLASS 7P	CLASS 5P CLASS 7P
over	incl	high low	high low	high low	high low	high low	max	max	max	max	max	max	max	max	max	max	max	max	max	max	max	max	max	max	high low	high low	max
—	**18**	0 −5.1	0 −2.5	0 −5.1	+1 −6.1	0 −2.5	2.5	5.1	1.3	2.5	5.1	1.3	5.1	2.5	1.3	7.6	3.8	1.3	5.1	3.8	1.3	7.6	5.1	1.3	0 −25.4	0 −50.8	7.6
18	**30**	0 −5.1	0 −3.8	0 −5.1	+1 −6.1	0 −3.8	2.5	5.1	2	2.5	5.1	2	5.1	2.5	1.3	7.6	3.8	1.3	5.1	3.8	2.5	7.6	5.1	2.5	0 −25.4	0 −50.8	7.6
30	**50**	0 −5.1	0 −3.8	0 −5.1	+1 −6.1	0 −3.8	2.5	5.1	2	2.5	5.1	2	5.1	2.5	1.3	7.6	3.8	1.3	5.1	5.1	2.5	7.6	5.1	2.5	0 −25.4	0 −50.8	7.6

Notes (1) Applicable to flange width variation for flanged bearings, but excluding CLASS 9P.
(2) Applicable to flange back face.

Table 6.6 Guide for selection of bearing accuracy

Application	Bearing tolerance classes	
	ISO	ANSI/ABMA
Micro motors, stepping motors, fan motors, VCR pinch rollers, computer printers, copy machine-feed rollers	Normal Class 6	ABEC 1 ABEC 3
High precision motors, hard disk drive motors, dental spindles, servo motors, encoders, VCR drum spindles, VCR capstan motors, polygonal mirror scanner motors	Class 5 Class 4	CLASS 5P CLASS 7P
High frequency spindles, gyro rotors, gyro gimbals	Class 4	CLASS 7P, CLASS 9P

7. Fits and internal clearances

7.1 Shaft and housing fits

The fitting practice used for bearings is extremely important in achieving their expected performance. Since miniature bearings are usually used under light loads, the range between a push fit (light interference) and a slip fit (slightly loose) is generally used.
In the case of a rotating inner ring, ordinary ball bearings are fitted to the shaft with interference, however, a slip fit is generally used for miniature bearings and instrument ball bearings in order to simplify their mounting, prevent damage during mounting and avoid changing the contact angle or preload. This is because the occurrence of creep in miniature bearings is easily prevented by tightening the side face of the inner ring against a shoulder on the shaft with a nut.

When a spring is used to apply a preload to a bearing, the fitting of the bearing ring in contact with the spring should be loosely fitted so the ring slides smoothly. When housings are built of lightweight alloys, the fitting clearance of the outer ring will increase with increasing temperature and possibly impair the machine's operation and reduce the bearing life; therefore, the bearings should be mounted in a steel bushing.

Tables 7.1 and **7.2** show the recommended fittings for various design conditions and applications.
Tables 7.3 and **7.4** show allowable tolerances for shafts and housing bores for various size ranges of miniature ball bearings.

Table 7.1 Inner ring fit with shaft

Condition			Application	Bearing tolerance class	Fit	Shaft finish (μm)	Suggested average fit(1)
Rotating inner ring	Low speed	Inner ring axially free	Synchros Servos Potentiometers Resolvers Gyro gimbals	Class 5 Class 4 CLASS 5P CLASS 7P	Slightly loose fit (slip fit)	$\phi d\ ^{-2}_{-7}$	2L
	Low and medium speeds		Fans Small motors	Normal Class 6 ABEC 1 ABEC 3	Transition fit	ϕd h5	±0
	Medium and high speeds		Computer disk spindles	Class 5 Class 4 CLASS 5P CLASS 7P	Slightly loose fit (2)	$\phi d\ ^{-5}_{-8}$	4L
			Video cassette recorder drum spindles		Close-sliding fit	$\phi d\ ^{-1}_{-6}$	1L
			Gyro rotors Dental spindles High-frequency spindles	Class 4 CLASS 7P	Slight interference fit (push fit)	ϕd ±2.5	2T
			Vacuum cleaners Electric tools	Normal ABEC 1	Light interference fit	ϕd js5	5T
			Polygonal mirror scanner motors	Class 5 Class 4 CLASS 5P CLASS 7P	Close-sliding fit	$\phi d\ ^{-1}_{-6}$	1L
		Inner ring axially fixed	Gyro rotors		Loose fit	$\phi d\ ^{-5}_{-10}$	5L
Rotating outer ring	Low to high speeds	Inner ring axially free	Clutches Small fans	Normal Class 6 ABEC 1 ABEC 3	Loose fit	ϕd g5	5L
		Inner ring axially fixed	Tape guide rolls Pinch rolls	Class 5 Class 4 CLASS 5P CLASS 7P	Loose fit	$\phi d\ ^{-5}_{-10}$	5L

Notes (1) L: Loose fit, T: Interference fit
(2) After mounting, usually bonded

Table 7.2 Outer ring fit with housing

Condition		Application	Bearing tolerance class	Fit	Housing finish (μm)	Suggested average fit(1)
Rotating inner ring	Low speed	Synchros Servos Potentiometers Resolvers Gyro gimbals	Class 5 Class 4 CLASS 5P CLASS 7P	Slightly loose fit	$\phi D\ ^{+3}_{-2}$	2L
	Medium and high speeds	Small motors Electric tools Vacuum cleaners Fan motors	Normal ABEC 1	Loose fit	ϕD H6	9L
		Computer disk spindles	Class 5 Class 4 CLASS 5P CLASS 7P	Loose fit (2)	$\phi D\ ^{+3}_{0}$	4L
		Video cassette recorder drum spindles		Slightly loose fit	$\phi D\ ^{-2}_{-5}$	2TL
		Gyro rotors High frequency spindles	Class 5 Class 4 CLASS 5P CLASS 7P	Loose fit	$\phi D\ ^{+5}_{0}$	5L
		Polygonal mirror scanner motors		Loose fit(2)	$\phi D\ ^{+3}_{0}$	4L
Rotating outer ring	Low to high speeds	Tape guide rolls Pinch rolls	Class 5 Class 4 CLASS 5P CLASS 7P	Slightly Loose fit	$\phi D\ ^{+3}_{-2}$	2L
		Cam followers Tension pulleys Idler gears	Normal Class 6 ABEC 1 ABEC 3	Interference fit	ϕD M5	5T

Notes (1) L: Loose fit, T: Interference fit
(2) After mounting, usually bonded

Table 7.3 Tolerances for shaft diameters

Units: μm

Shaft dia. (mm) over	Shaft dia. (mm) incl	Tolerance class for shafts g4	g5	h4	h5	js4	js5
	3	−2 to − 5	−2 to − 6	0 to −3	0 to −4	±1.5	±2
3	6	−4 to − 8	−4 to − 9	0 to −4	0 to −5	±2	±2.5
6	10	−5 to − 9	−5 to −11	0 to −4	0 to −6	±2	±3
10	18	−6 to −10	−6 to −14	0 to −5	0 to −8	±2.5	±4

Table 7.4 Tolerances for housing bores

Units: μm

Bore dia. (mm) over	Bore dia. (mm) incl	Tolerance class for housings H5	H6	JS5	JS6	K5	K6	M5	M6
	3	+4 to 0	+ 6 to 0	±2	±3	0 to −4	0 to − 6	−2 to − 6	−2 to − 8
3	6	+5 to 0	+ 8 to 0	±2.5	±4	0 to −5	+2 to − 6	−3 to − 8	−1 to − 9
6	10	+6 to 0	+ 9 to 0	±3	±4.5	+1 to −5	+2 to − 7	−4 to −10	−3 to −12
10	18	+8 to 0	+11 to 0	±4	±5.5	+2 to −6	+2 to − 9	−4 to −12	−4 to −15
18	30	+9 to 0	+13 to 0	±4.5	±6.5	+1 to −8	+2 to −11	−5 to −14	−4 to −17

If the accuracy of a shaft or housing does not meet the specification, the performance of the bearings will be affeced and they will not perform to their full capability. For example, inaccuracy in the squareness of the shaft shoulder may cause misalignment of the bearing inner and outer rings, which may reduce the bearing fatique life by adding an edge load in addition to the normal load. Cage fracture and seizure sometimes occur for this same reason.
For normal operating conditions, a truned finish or smooth bored finish is sufficient for the fitting surface; however, a ground finish is necessary for applications where vibration and noise must be low. The accuracy and surface finish of shafts and housings for normal operating conditions are listed in **Table 7.5.**

Table 7.5 Accuracy and roughness of shaft and housing

Item	Class of bearings	Shaft	Housing bore
Tolerance for out-of-roundness	Normal, Class 6 Class 5, Class 4	$\frac{IT3}{2}$ to $\frac{IT4}{2}$ $\frac{IT2}{2}$ to $\frac{IT3}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$ $\frac{IT2}{2}$ to $\frac{IT3}{2}$
Tolerance for cylindricality	Normal, Class 6 Class 5, Class 4	$\frac{IT3}{2}$ to $\frac{IT4}{2}$ $\frac{IT2}{2}$ to $\frac{IT3}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$ $\frac{IT2}{2}$ to $\frac{IT3}{2}$
Tolerance for shoulder runout	Normal, Class 6 Class 5, Class 4	IT3 IT3	IT3 to IT4 IT3
Roughness of fitting surfaces Ra	—	0.8	1.6

Remarks This table is for general recommendation using the radius measuring method. The basic tolerance (IT) class should be selected in accordance with the bearing precision class. For the IT values, please refer to **Appendix Table 8** (Page 62).

7.2 Bearing internal clearances

The internal clearance of ball bearings greatly influences their performance, including fatigue life, vibration, noise, heat generation, etc. Consequently, it is necessary to select the proper clearance considering the bearing fit, load, speed and operating temperature.
NSK provides clearances in six steps as shwon in **Table 7.6.** To obatin accurate measurements, the clearance is generally measured by applying a specified measuring load on the bearing. As a result, the measured clearance is always slightly lager than the theoretical internal clearance by the amount of elastic deformation caused by the measuring load. The theoretical internal clearance may thus be obtained by correcting the measured clearance by the amount of elastic deformation (refer to **Table, 7.6** Remark #2)
Table 7.7 shows the criteria for selecting the radial clearance for extra small and miniature ball bearings.

Table 7.6 Radial internal clearances in extra small and miniature ball bearings

Units: μm

Clearance symbol	MC1		MC2		MC3		MC4		MC5		MC6	
Clearance	min	max	min	max	min	max	min	max	min	max	min	max
	0	5	3	8	5	10	8	13	13	20	20	28

Remarks 1. The standard clearance is MC3.
2. To obtain the measured value, add the correction amount in the table below.

Units: μm

Clearance symbol	MC1	MC2	MC3	MC4	MC5	MC6
Clearance correction for measuring load	1	1	1	1	2	2

The measuring loads are as follows:
For miniature ball bearings 2.5N {0.25kgf}
For extra small ball bearings 4.4N {0.45kgf}

Table 7.7 Selection of radial clearances

Typical application	Requirement	Clearance symbol	Remarks
Shafts for precision gears, servo-mechanisms, stepping motors, VCR capstan motors, other low-speed applications	•Small bearing clearance is required with no preload. •Low torque is not important. •High axial rigidity is not required.	MC1 MC2	Avoid interference fits.
Synchros, gyro gimbal radial bearings, VCR drum spindles, computer disk spindles, polygonal mirror scanner motors, other low or medium-speed applications	•Low torque is required. •Axial load and rigidity are normal.	MC3 MC4	Avoid interference fits in most applications.
Gyro rotors, gyro gimbal thrust bearings, fan motors, vacuum cleaners, other high-speed and high-temperature applications	•Extremely low torque is required. •High endurance and high axial rigidity are required.	MC5 MC6	•Either axial clearance is made adjustable or a spring preload is used. •Interference fit may be allowed.

8. Lubrication

8.1 Purposes of lubrication

The main purpose of lubrication is to reduce friction and wear inside bearings that may cause premature failure.
The effects of lubrication can be briefly explained as follows:

(1) Reduction of friction and wear
Direct metallic contact between the bearing rings, rolling elements and cage is prevented by a lubricant film.
(2) Extension of fatigue life
The rolling fatique life of bearings depends greatly upon the viscosity and film thickness between the rolling contact surfaces. Sufficient film thickness prolongs the fatique life while film thickness shortens it.
(3) Dissipation of frictional heat and cooling
Circulating lubrication may be used to carry away frictional heat or heat transferred from outside the biaring.
(4) Others
Adequate lubrication also helps to prevent foreign matter from entering bearings and guards against corrosion and rust.

8.2 Lubricating methods and lubricants

Lubricating methods are first divided into either grease or oil lubrication. Satisfactory bearing performance can be achieved by adopting the lubricating method which is most suitable for the particular application and operating conditions. In general, oil offers superior lubrication. However, grease lubrication allows a simpler structure around the bearings. A comparison of grease and oil lubrication is given in **Table 8.1.**

Table 8.1 Comparison of grease and oil lubrication

Item	Grease lubrication	Oil lubrication
Housing structure and sealing method	Simple	May be complex. Careful maintenance required.
Speed	Limiting speed is 65% to 80% of that with oil lubrication.	High limiting speed
Cooling effect	Poor	Heat transfer is possible using forced oil circulation.
Fluidity	Poor	Good
Full lubricant replacement	Sometimes difficult	Easy
Removal of foreign matter	Removal of particles from grease is impossible.	Easy
External contamination due to leakage	Surroundings seldom contaminated by leakage.	Offten leaks without proper countermeasures. Not suitable if external contamination must be avoided.

(1) Grease lubrication

Sealed (DD, VV) or shielded (ZZ, ZZS) bearings are generally factory-packed with the proper quantity of good quality grease and can be used as delivered. Too much grease can cause heat generation or grease leakage. Generally, NSK fills less than half of the free internal space inside bearings with grease. Because the brand of grease affects bearing performance, NSK usually recommends those shown in **Tables 8.2** and **8.3** on page 27. Among them, Multemp PS2 is often used as the standard grease for many applications. Besides those listed in **Tables 8.2** and **8.3**, many other brands are available. For assistance when selecting grease, consult NSK.

(2) Oil lubrication

Oil lubrication is used under conditions where satisfactory performance is difficult to achieve using grease, for example, when extremely low torque is required or for high-speed operation. Particularly in the case of gyro gimbal and synchros, which are largely affected by frictional torque, a low viscosity oil is used. Oil mist or oil/air lubrication provides low heating due to agitation and also superior cooling of the bearing. Aeroshell Fluid 12 (MIL-L-6085A) is the standard oil of NSK.

Table 8.2 Specifications of general-purpose greases

Grease name	Manufacturer	Thickener	Base oil	Dropping point (°C)	Consistency	Working temperature range (°C)	Usable speed limit (%)	Characteristics
Beacon 325	ESSO	Lithium soap	Diester oil	191	290	−55 to +100	100	For low temperatures, low torque
Multemp PS2	Kyodo Yushi	Lithium soap	Diester oil + mineral oil	189	280	−50 to +110	100	For low temperatures, low torque
NS Hilube grease	Kyodo Yushi	Lithium soap	Tetraester oil + diester oil	190	255	−40 to +130	100	Wide temperature range, low noise, low torque
DC44M	Dow Corning	Lithium soap	Silicone oil	210	260	−30 to +160	60	For high temperatures
Krytox 280AC	Dupont	Fluorine complex	Fluorine oil	—	280	0 to +200	70	For extra high temperatures

Table 8.3 Specifications of greases developed by NSK

Grease symbol	Thickener	Base oil	Dropping point (°C)	Consistency	Working temperature range (°C)	Usable speed limit (%)	Characteristics	Main applications
VTG	Lithium soap	Diester oil	186	320	−50 to +110	100	Low noise, low torque	Video cassette recorder drum spindles
NSC	Lithium soap	Tetraester oil +ether oil	192	239	−30 to +140	70	Wide temperature range	Office automation machines Fan motors
EA3	Urea	Poly-alpha-olefin	min 260	214	−40 to +150	100	For high speeds and high temperatures	Vacuum cleaners Cooling fan motors for cars
EA6	Urea	Poly-alpha-olefin	min 260	210	−40 to +160	100	For high temperatures	Cooling fan motors for cars

9. Bearing materials

The bearing rings and rolling elements of rolling bearings are repeatedly subjected to high pressure with a small amount of sliding. The materials used for the rings and rolling elements must there fore have the following characteristics:

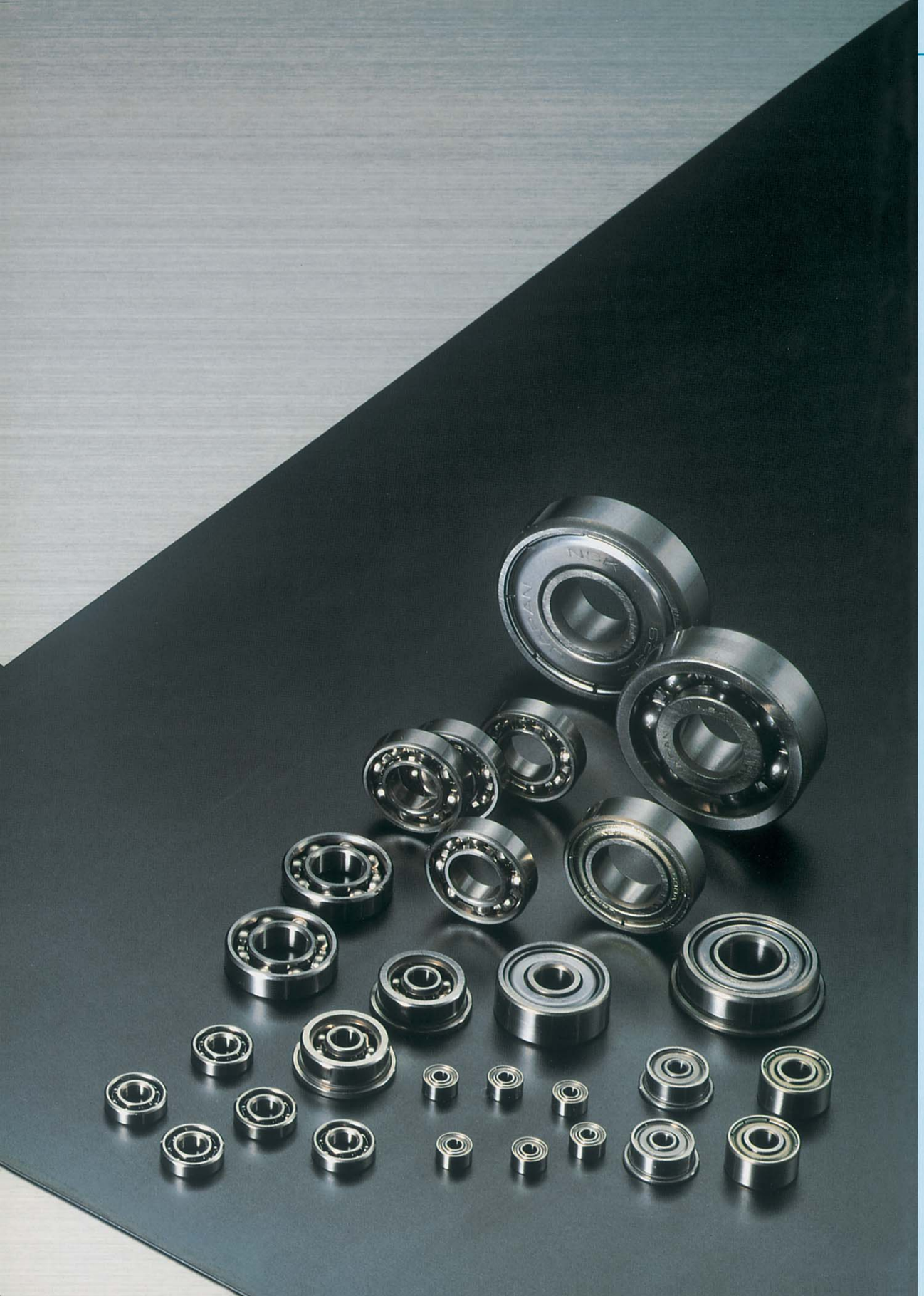
- High rolling contact fatigue strength
- High hardness
- High wear resistance
- High dimensional stability
- High mechanicalstrength

Other characteristics, such as ease of production, shock and heat resistance, and corrosion resistance, are required depending on individual applications.
The material used for the rings and balls in miniature ball bearings is either bearing steel or martensitic stainless steel. The chemical composition of each is shown in **Table 9.1.** Bearing steel provides a longer fatique life because of its high hardness, and it is also superior with respect to running noise and torque. Stainless steel has good corrosion resistance and its hardness does not decrease at high temperature. Therefore, it is used in applications where corrosive elements exist or where operating temperatures are unusually high.
NSK uses vacuum degassed bearing steel designated by Japanese Industrial Standard (JIS) as SUJ2 (equivalent to ASTM A 295 52100). Its stainless steel is JIS SUS440C (equivalent to SAE J 405 51440C) produced using the Electro Slag Remelting Method (ESR).
NSK selects bearing steels containing a minimum of oxygen, hydrogen, nitrogen, and hydrogen-compound impurities. The rolling fatique life of bearings has been remarkably improved using these materials combined with the appropriate heat treatment.
Regarding stainless steel bearings with reduced noise, please consult NSK.

Table 9.1 Chemical composition of high-carbon chromium bearing steel and stainless steel

Standard	Symbol	Chemical composition (%)						
		C	Si	Mn	P	S	Cr	Mo
JIS G 4805	SUJ2	0.95 to 1.10	0.15 to 0.35	max 0.5	max 0.025	max 0.025	1.30 to 1.60	max 0.08
ASTM A 295	52100	0.98 to 1.10	0.15 to 0.35	0.25 to 0.45	max 0.025	max 0.025	1.30 to 1.60	max 0.10
JIS G 4303	SUS 440C	0.95 to 1.20	max 1.00	max 1.00	max 0.040	max 0.030	16.00 to 18.00	max 0.75
SAE J 405	51440C	0.95 to 1.20	max 1.00	max 1.00	max 0.040	max 0.030	16.00 to 18.00	max 0.75

Bearing Tables



Bearing Tables
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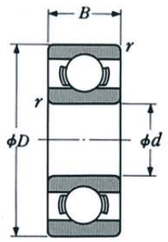
Metric series
600, MR
Bore diameter
1 – 4 mm



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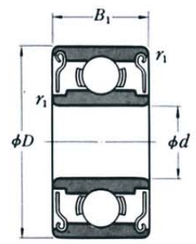
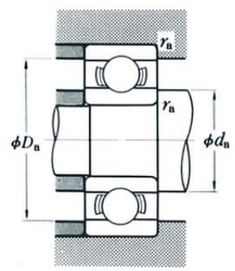
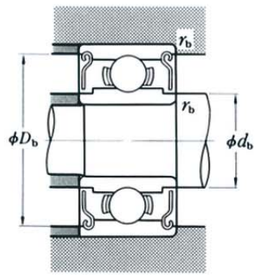


Shielded type
ZZ • ZZ1





Boundary dimensions (mm)						Basic load ratings (N)		{kgf}		Limiting speeds (min⁻¹) Grease	Oil
d	D	B	B_1	r min (1)	r_1 min (1)	C_r	C_{or}	C_r	C_{or}	Open Z·ZZ	Open Z
1	3	1	—	0.05	—	80	23	8	2.5	130 000	150 000
	3	1.5	—	0.05	—	80	23	8	2.5	130 000	150 000
	4	1.6	—	0.1	—	138	35	14	3.5	100 000	120 000
1.2	4	1.8	2.5	0.1	0.1	138	35	14	3.5	110 000	130 000
1.5	4	1.2	2	0.05	0.05	112	33	11	3.5	100 000	120 000
	5	2	2.6	0.15	0.15	237	69	24	7	85 000	100 000
	6	2.5	3	0.15	0.15	330	98	34	10	75 000	90 000
2	5	1.5	2.3	0.08	0.08	169	50	17	5	85 000	100 000
	5	2	2.5	0.1	0.1	187	58	19	6	85 000	100 000
	6	2.3	3	0.15	0.15	330	98	34	10	75 000	90 000
	6	2.5	2.5	0.15	0.15	330	98	34	10	75 000	90 000
	7	2.5	3	0.15	0.15	385	127	39	13	63 000	75 000
	7	2.8	3.5	0.15	0.15	385	127	39	13	63 000	75 000
2.5	6	1.8	2.6	0.08	0.08	208	74	21	7.5	71 000	80 000
	7	2.5	3.5	0.15	0.15	385	127	39	13	63 000	75 000
	8	2.5	—	0.2	—	560	179	57	18	60 000	67 000
	8	2.8	4	0.15	0.15	550	175	56	18	60 000	71 000
3	6	2	2.5	0.1	0.1	208	74	21	7.5	71 000	80 000
	7	2	3	0.1	0.1	390	130	40	13	63 000	75 000
	8	2.5	—	0.15	—	560	179	57	18	60 000	67 000
	8	3	4	0.15	0.15	560	179	57	18	60 000	67 000
	9	2.5	4	0.2	0.15	570	187	58	19	56 000	67 000
	9	3	5	0.15	0.15	570	187	58	19	56 000	67 000
	10	4	4	0.15	0.15	630	218	64	22	50 000	60 000
	13	5	5	0.2	0.2	1300	485	133	49	40 000	48 000
4	7	2	—	0.1	—	310	115	32	12	60 000	67 000
	7	—	2.5	—	0.1	255	107	26	11	60 000	71 000
	8	2	3	0.15	0.1	395	139	40	14	56 000	67 000
	9	2.5	4	(0.15)	(0.15)	640	225	65	23	53 000	63 000
	10	3	4	0.2	0.15	710	270	73	28	50 000	60 000
	11	4	4	0.15	0.15	960	345	98	35	48 000	56 000
	12	4	4	0.2	0.2	960	345	98	35	48 000	56 000
	13	5	5	0.2	0.2	1300	485	133	49	40 000	48 000
	16	5	5	0.3	0.3	1730	670	177	68	36 000	43 000

Bearing numbers			Abutment and fillet dimensions (mm)						Mass (g)		Basic bearing numbers	Actual size (2)
Open	Shielded	Sealed	d_a min	d_b max	D_a max	D_b min	r_a max	r_b max	Open approx	Shielded approx		
681	—	— —	1.4	—	2.6	—	0.05	—	0.03	—	681	
MR 31	—	— —	1.4	—	2.6	—	0.05	—	0.04	—	MR 31	
691	—	— —	1.8	—	3.2	—	0.1	—	0.09	—	691	
MR 41 X	MR 41 XZZ	— —	2.0	1.9	3.2	3.5	0.1	0.1	0.10	0.14	MR 41 X	
681 X	681 XZZ	— —	1.9	2.1	3.6	3.6	0.05	0.05	0.07	0.11	681 X	
691 X	691 XZZ	— —	2.7	2.5	3.8	4.3	0.15	0.15	0.17	0.20	691 X	
601 X	601 XZZ	— —	2.7	3.0	4.8	5.4	0.15	0.15	0.33	0.38	601 X	
682	682 ZZ	— —	2.6	2.7	4.4	4.2	0.08	0.08	0.12	0.17	682	
MR 52B	MR 52 BZZ	— —	2.8	2.7	4.2	4.4	0.1	0.1	0.16	0.23	MR 52 B	
692	692 ZZ	— —	3.2	3.0	4.8	5.4	0.15	0.15	0.28	0.38	692	
MR 62	MR 62 ZZ	— —	3.2	3.0	4.8	5.4	0.15	0.15	0.30	0.29	MR 62	
MR 72	MR 72 ZZ	— —	3.2	3.8	5.8	6.2	0.15	0.15	0.45	0.49	MR 72	
602	602 ZZ	— —	3.2	3.8	5.8	6.2	0.15	0.15	0.51	0.58	602	
682 X	682 XZZ	— —	3.1	3.7	5.4	5.4	0.08	0.08	0.23	0.29	682 X	
692 X	692 XZZ	— —	3.7	3.8	5.8	6.2	0.15	0.15	0.41	0.55	692 X	
MR 82 X	—	— —	4.1	—	6.4	—	0.2	—	0.56	—	MR 82 X	
602 X	602 XZZ	— —	3.7	4.1	6.8	7.0	0.15	0.15	0.63	0.83	602 X	
MR 63	MR 63 ZZ	— —	3.8	3.7	5.2	5.4	0.1	0.1	0.20	0.27	MR 63	
683 A	683 AZZ	— —	3.8	4.0	6.2	6.4	0.1	0.1	0.32	0.45	683 A	
MR 83	—	— —	4.2	—	6.8	—	0.15	—	0.54	—	MR 83	
693	693 ZZ	— —	4.2	4.3	6.8	7.3	0.15	0.15	0.61	0.83	693	
MR 93	MR 93 ZZ	— —	4.6	4.3	7.4	7.9	0.2	0.15	0.73	1.18	MR 93	
603	603 ZZ	— —	4.2	4.3	7.8	7.9	0.15	0.15	0.87	—	603	
623	623 ZZ	— —	4.2	4.3	8.8	8.0	0.15	0.15	1.65	1.66	623	
633	633 ZZ	— —	4.6	6.0	11.4	11.3	0.2	0.2	3.38	3.33	633	
MR 74	—	— —	4.8	—	6.2	—	0.1	—	0.22	—	MR 74	
—	MR 74 ZZ	— —	—	4.8	—	6.3	—	0.1	—	0.29	MR 74	
MR 84	MR 84 ZZ	— —	5.2	5.0	6.8	7.4	0.15	0.1	0.36	0.56	MR 84	
684 A	684 AZZ	— —	4.8	5.2	8.2	8.1	0.1	0.1	0.63	1.01	684 A	
MR 104 B	MR 104 BZZ	— —	5.6	5.9	8.4	8.8	0.2	0.15	1.04	1.42	MR 104 B	
694	694 ZZ	— —	5.2	5.6	9.8	9.9	0.15	0.15	1.7	1.75	694	
604	604 ZZ	— —	5.6	5.6	10.4	9.9	0.2	0.2	2.25	2.29	604	
624	624 ZZ	— —	5.6	6.0	11.4	11.3	0.2	0.2	3.03	3.04	624	
634	634 ZZ1	— —	6.0	7.5	14.0	13.8	0.3	0.3	5.24	5.21	634	

Notes (1) The values in parentheses are not based on ISO 15.
(2) Actual dimensions of bore and outside diameter only.

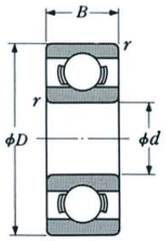
Remarks 1. When using bearings with a rotating outer ring, please contact NSK if they are shielded.
2. Bearings with double shields (ZZ, ZZ1) are also available with single shields (Z, Z1).

Metric series

600, MR

Bore diameter

5 – 9mm



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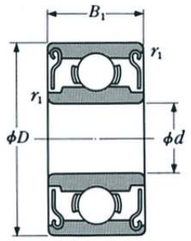
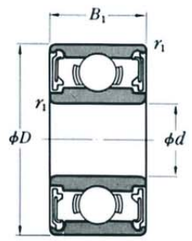
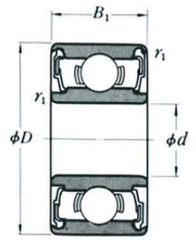


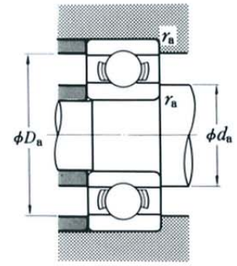
Shielded type
ZZ • ZZ1

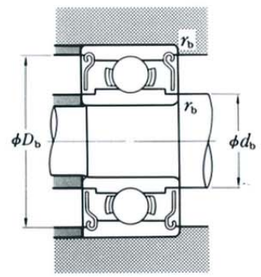


Non-contact
sealed type
VV



Contact sealed type
DD

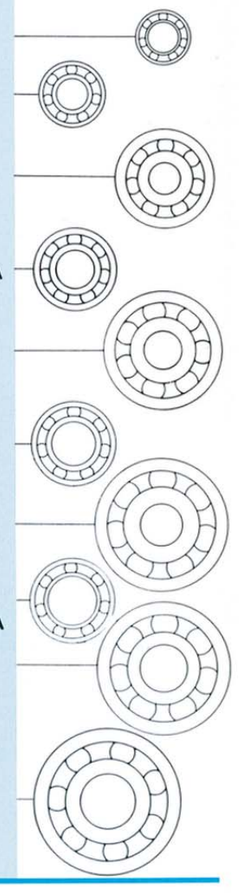




Boundary dimensions (mm)						Basic load ratings (N)		(kgf)		Limiting speeds (min⁻¹) Grease		Oil
d	D	B	B_1	r (1) min	r_1 (1) min	C_r	C_{or}	C_r	C_{or}	Open Z·ZZ V·VV	D·DD	Open Z
5	8	2	—	0.1	—	310	120	31	12	53 000	—	63 000
	8	—	2.5	—	0.1	278	131	28	13	53 000	—	63 000
	9	2.5	3	0.15	0.15	430	168	44	17	50 000	—	60 000
	10	3	4	0.15	0.15	430	168	44	17	50 000	—	60 000
	11	—	4	—	0.15	715	276	73	28	48 000	—	56 000
	11	3	5	0.15	0.15	715	281	73	29	45 000	—	53 000
	13	4	4	0.2	0.2	1 080	430	110	44	43 000	40 000	50 000
	14	5	5	0.2	0.2	1 330	505	135	52	40 000	38 000	50 000
	16	5	5	0.3	0.3	1 730	670	177	68	36 000	32 000	43 000
	19	6	6	0.3	0.3	2 340	885	238	90	32 000	30 000	40 000
6	10	2.5	3	0.15	0.1	495	218	51	22	45 000	—	53 000
	12	3	4	0.2	0.15	715	292	73	30	43 000	40 000	50 000
	13	3.5	5	0.15	0.15	1 080	440	110	45	40 000	38 000	50 000
	15	5	5	0.2	0.2	1 730	670	177	68	40 000	36 000	45 000
	17	6	6	0.3	0.3	2 260	835	231	85	38 000	34 000	45 000
	19	6	6	0.3	0.3	2 340	885	238	90	32 000	30 000	40 000
	22	7	7	0.3	0.3	3 300	1 370	335	140	30 000	28 000	36 000
7	11	2.5	3	0.15	0.1	455	201	47	21	43 000	—	50 000
	13	3	4	0.2	0.15	540	276	55	28	40 000	—	48 000
	14	3.5	5	0.15	0.15	1 170	510	120	52	40 000	34 000	45 000
	17	5	5	0.3	0.3	1 610	710	164	73	36 000	28 000	43 000
	19	6	6	0.3	0.3	2 340	885	238	90	36 000	32 000	43 000
	22	7	7	0.3	0.3	3 300	1 370	335	140	30 000	28 000	36 000
	26	9	9	0.3	0.3	4 550	1 970	465	201	28 000	22 000	34 000
8	12	2.5	3.5	0.15	0.1	545	274	56	28	40 000	—	48 000
	14	3.5	4	0.2	0.15	820	385	83	39	38 000	32 000	45 000
	16	4	5	0.2	0.2	1 610	710	164	73	36 000	28 000	43 000
	19	6	6	0.3	0.3	2 240	910	228	93	36 000	28 000	43 000
	22	7	7	0.3	0.3	3 300	1 370	235	140	34 000	28 000	40 000
	24	8	8	0.3	0.3	3 350	1 430	340	146	28 000	24 000	34 000
	28	9	9	0.3	0.3	4 550	1 970	465	201	28 000	22 000	34 000
9	17	4	5	0.2	0.2	1 330	665	136	68	36 000	24 000	43 000
	20	6	6	0.3	0.3	1 720	840	175	86	34 000	24 000	40 000
	24	7	7	0.3	0.3	3 350	1 430	340	146	32 000	24 000	38 000
	26	8	8	(0.6)	(0.6)	4 550	1 970	465	201	28 000	22 000	34 000
	30	10	10	0.6	0.6	5 100	2 390	520	244	24 000	—	30 000

Bearing numbers				Abutment and fillet dimensions (mm)						Mass (g)		Basic bearing numbers
Open	Shielded	Sealed		d_a min	d_b max	D_a max	D_b min	r_a max	r_b max	Open approx	Shielded approx	
MR 85	—	—	—	5.8	—	7.2	—	0.1	—	0.26	—	**MR 85**
—	**MR 85 ZZ**	—	—	—	5.8	—	7.4	—	0.1	—	0.34	**MR 85**
MR 95	**MR 95 ZZ1**	—	—	6.2	6.0	7.8	8.2	0.15	0.15	0.50	0.58	**MR 95**
MR 105	**MR 105 ZZ**	—	—	6.2	6.0	8.8	8.4	0.15	0.15	0.95	1.29	**MR 105**
—	**MR 115 ZZ**	**VV**	—	—	6.3	—	9.8	—	0.15	—	1.5	**MR 115**
685	**685 ZZ**	—	—	6.2	6.2	9.8	9.9	0.15	0.15	1.2	1.96	**685**
695	**695 ZZ1**	**VV**	**DD**	6.6	6.6	11.4	11.2	0.2	0.2	2.45	2.5	**695**
605	**605 ZZ**	—	**DD**	6.6	6.9	12.4	12.2	0.2	0.2	3.45	3.48	**605**
625	**625 ZZ1**	**VV**	**DD**	7.0	7.5	14.0	13.8	0.3	0.3	4.95	4.86	**625**
635	**635 ZZ1**	**VV**	**DD**	7.0	8.5	17.0	16.5	0.3	0.3	8.56	8.34	**635**
MR 106	**MR 106 ZZ1**	—	—	7.2	7.0	8.8	9.3	0.15	0.1	0.56	0.68	**MR 106**
MR 126	**MR 126 ZZ**	—	**DD**	7.6	7.2	10.4	10.9	0.2	0.15	1.27	1.74	**MR 126**
686 A	**686 A ZZ**	**VV**	**DD**	7.2	7.4	11.8	11.7	0.15	0.15	1.91	2.69	**686 A**
696	**696 ZZ1**	**VV**	**DD**	7.6	7.9	13.4	13.3	0.2	0.2	3.88	3.72	**696**
606	**606 ZZ**	**VV**	**DD**	8.0	8.2	15.0	14.8	0.3	0.3	5.97	6.08	**606**
626	**626 ZZ1**	**VV**	**DD**	8.0	8.5	17.0	16.5	0.3	0.3	8.15	7.94	**626**
636	**636 ZZ**	**VV**	**DD**	8.0	10.5	20.0	19.0	0.3	0.3	14	14	**636**
MR 117	**MR 117 ZZ**	—	—	8.2	8.0	9.8	10.5	0.15	0.1	0.62	0.72	**MR 117**
MR 137	**MR 137 ZZ**	—	—	8.6	9.0	11.4	11.6	0.2	0.15	1.58	2.02	**MR 137**
687	**687 ZZ1**	**VV**	**DD**	8.2	8.5	12.8	12.7	0.15	0.15	2.13	2.97	**687**
697	**697 ZZ1**	**VV**	**DD**	9.0	10.2	15.0	14.8	0.3	0.3	5.26	5.12	**697**
607	**607 ZZ1**	**VV**	**DD**	9.0	9.1	17.0	16.5	0.3	0.3	7.67	7.51	**607**
627	**627 ZZ**	**VV**	**DD**	9.0	10.5	20.0	19.0	0.3	0.3	12.7	12.9	**627**
637	**637 ZZ1**	**VV**	**DD**	9.0	12.8	24.0	22.8	0.3	0.3	24	25	**637**
MR 128	**MR 128 ZZ1**	—	—	9.2	9.0	10.8	11.3	0.15	0.1	0.71	0.97	**MR 128**
MR 148	**MR 148 ZZ**	**VV**	**DD**	9.6	9.2	12.4	12.8	0.2	0.15	1.86	2.16	**MR 148**
688 A	**688 A ZZ1**	**VV**	**DD**	9.6	10.2	14.4	14.2	0.2	0.2	3.12	4.02	**688 A**
698	**698 ZZ**	**VV**	**DD**	10.0	10.0	17.0	16.5	0.3	0.3	7.23	7.18	**698**
608	**608 ZZ**	**VV**	**DD**	10.0	10.5	20.0	19.0	0.3	0.3	12.1	12.2	**608**
628	**628 ZZ**	**VV**	**DD**	10.0	12.0	22.0	20.5	0.3	0.3	17.2	17.4	**628**
638	**638 ZZ1**	**VV**	**DD**	10.0	12.8	26.0	22.8	0.3	0.3	28.3	28.6	**638**
689	**689 ZZ1**	**VV**	**DD**	10.6	11.5	15.4	15.2	0.2	0.2	3.53	4.43	**689**
699	**699 ZZ1**	**VV**	**DD**	11.0	12.0	18.0	17.2	0.3	0.3	8.45	8.33	**699**
609	**609 ZZ**	**VV**	**DD**	11.0	12.0	22.8	20.5	0.3	0.3	14.5	14.7	**609**
629	**629 ZZ**	**VV**	**DD**	11.0	12.8	24.0	22.8	0.3	0.3	19.5	19.3	**629**
639	**639 ZZ**	**VV**	—	13.0	16.1	26.0	25.6	0.6	0.6	35.5	36	**639**

Actual size(2)



Notes (1) The values in parentheses are not based on ISO 15.
(2) Actual dimensions of bore and outside diameter only.

Remarks 1. When using bearings with a rotating outer ring, please contact NSK if they are shielded or shielded.
2. Bearings with double shields (ZZ, ZZ1) are also available with single shields (Z, Z1).
3. Bearings with snap rings are also available, please contact NSK.

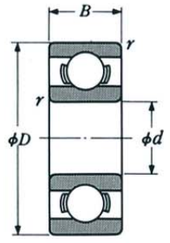
Single-row deep groove ball bearings

Inch series

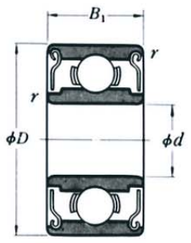
R

Bore diameter

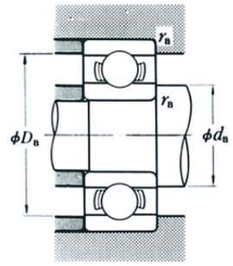
1.016 – 9.525 mm

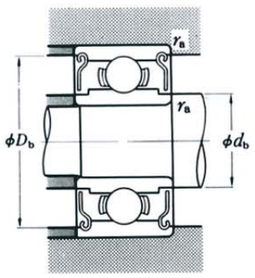


Open type



Shielded type
ZZ · ZZS





Boundary dimensions (mm/inch)								Basic load ratings (N)		{kgf}		Limiting speeds (min⁻¹) Grease	Oil
d		D		B		B_1		r min	C_r	C_{or}	C_r	C_{or}	Open Z·ZZ	Open Z
1.016	0.0400	3.175	0.1250	1.191	0.0469	—	—	0.1	80	23	8	2.5	130 000	150 000
1.191	0.0469	3.967	0.1562	1.588	0.0625	2.380	0.0937	0.1	138	35	14	3.5	110 000	130 000
1.397	0.0550	4.762	0.1875	1.984	0.0781	2.779	0.1094	0.1	231	66	24	6.5	90 000	110 000
1.984	0.0781	6.350	0.2500	2.380	0.0937	3.571	0.1406	0.1	310	108	32	11	67 000	80 000
2.380	0.0937	4.762	0.1875	1.588	0.0625	—	—	0.1	188	60	19	6	80 000	95 000
		4.762	0.1875	—	—	2.380	0.0937	0.1	143	52	15	5.5	80 000	95 000
		7.938	0.3125	2.779	0.1094	3.571	0.1406	0.15	550	175	56	18	60 000	71 000
3.175	0.1250	6.350	0.2500	2.380	0.0937	2.779	0.1094	0.1	283	95	29	9.5	67 000	80 000
		7.938	0.3125	2.779	0.1094	3.571	0.1406	0.1	560	179	57	18	60 000	67 000
		9.525	0.3750	2.779	0.1094	3.571	0.1406	0.15	640	225	65	23	53 000	63 000
		9.525	0.3750	3.967	0.1562	3.967	0.1562	0.3	630	218	64	22	56 000	67 000
		12.700	0.5000	4.366	0.1719	4.366	0.1719	0.3	640	225	65	23	53 000	63 000
3.967	0.1562	7.938	0.3125	2.779	0.1094	3.175	0.1250	0.1	360	149	37	15	53 000	63 000
4.762	0.1875	7.938	0.3125	2.779	0.1094	3.175	0.1250	0.1	360	149	37	15	53 000	63 000
		9.525	0.3750	3.175	0.1250	3.175	0.1250	0.1	710	270	73	28	50 000	60 000
		12.700	0.5000	3.967	0.1562	4.978	0.1960	0.3	1 300	485	133	49	43 000	53 000
6.350	0.2500	9.525	0.3750	3.175	0.1250	3.175	0.1250	0.1	420	204	43	21	48 000	56 000
		12.700	0.5000	3.175	0.1250	4.762	0.1875	0.15	1 080	440	110	45	40 000	50 000
		15.875	0.6250	4.978	0.1960	4.978	0.1960	0.3	1 610	660	164	68	38 000	45 000
		19.050	0.7500	5.558	0.2188	7.142	0.2812	0.4	2 620	1 060	267	108	36 000	43 000
7.938	0.3125	12.700	0.5000	3.967	0.1562	3.967	0.1562	0.15	540	276	55	28	40 000	48 000
9.525	0.3750	22.225	0.8750	5.558	0.2188	7.142	0.2812	0.4	3 350	1 410	340	144	32 000	38 000

Bearing numbers		Abutment and fillet dimensions (mm)					Mass (g)		Basic bearing numbers	Actual size(1)
Open	Shielded	d_a min	d_b max	D_a max	D_b min	r_a max	Open approx	Shielded approx		
R 09	—	1.9	—	2.3	—	0.1	0.04	—	**R 09**	
R 0	**R 0 ZZ**	2.0	1.9	3.1	3.5	0.1	0.09	0.11	**R 0**	
R 1	**R 1 ZZ**	2.2	2.3	3.9	4.1	0.1	0.15	0.19	**R 1**	
R 1-4	**R 1-4 ZZ**	2.8	3.9	5.5	5.9	0.1	0.35	0.50	**R 1-4**	
R 133	—	3.2	—	3.9	—	0.1	0.10	—	**R 133**	
—	**R 133 ZZS**	—	3.0	—	4.2	0.1	—	0.13	**R 133**	
R 1-5	**R 1-5 ZZ**	3.6	4.1	6.7	7.0	0.15	0.60	0.72	**R 1-5**	
R 144	**R 144 ZZ**	4.0	3.9	5.5	5.9	0.1	0.25	0.27	**R 144**	
R 2-5	**R 2-5 ZZ**	4.0	4.3	7.1	7.3	0.1	0.55	0.72	**R 2-5**	
R 2-6	**R 2-6 ZZS**	4.4	4.6	8.3	8.2	0.15	0.96	1.13	**R 2-6**	
R 2	**R 2 ZZ**	5.2	4.8	7.5	8.0	0.3	1.36	1.39	**R 2**	
R 2A	**R 2 AZZ**	5.2	4.6	10.7	8.2	0.3	3.3	3.23	**R 2 A**	
R 155	**R 155 ZZS**	4.8	5.5	7.1	7.3	0.1	0.51	0.56	**R 155**	
R 156	**R 156 ZZS**	5.6	5.5	7.1	7.3	0.1	0.39	0.42	**R 156**	
R 166	**R 166 ZZ**	5.6	5.9	8.7	8.8	0.1	0.81	0.85	**R 166**	
R 3	**R 3 ZZ**	6.8	6.5	10.7	11.2	0.3	2.21	2.79	**R 3**	
R 168 B	**R 168 BZZ**	7.2	7.0	8.7	8.9	0.1	0.58	0.62	**R 168 B**	
R 188	**R 188 ZZ**	7.6	7.4	11.5	11.6	0.15	1.53	2.21	**R 188**	
R 4 B	**R 4 B ZZ**	8.4	8.4	13.8	13.8	0.3	4.50	4.43	**R 4 B**	
R 4 AA	**R 4 AAZZ**	9.4	9.0	16.0	16.6	0.4	7.48	9.17	**R 4 AA**	
R 1810	**R 1810 ZZ**	9.2	9.0	11.5	11.6	0.15	1.56	1.48	**R 1810**	
R 6	**R 6 ZZ**	12.6	11.9	19.2	20.0	0.4	9.02	11	**R 6**	

Note (1) Actual dimensions of bore and outside diameter only.
Remarks 1. When using bearings with a rotating outer ring, please contact NSK if they are shielded.
2. Bearings with double shields (ZZ, ZZS) are also available with single shields (Z, ZS).

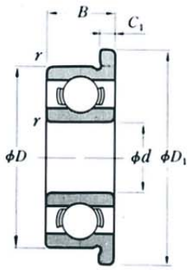
Deep groove ball bearings with flanged outer ring

Metric series

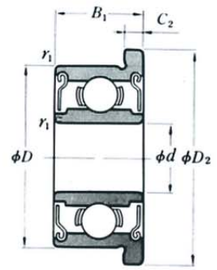
F600, MF

Bore diameter

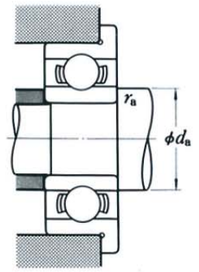
1 – 4 mm

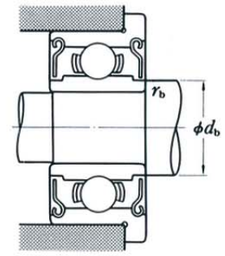


Open type



Shielded type
ZZ · ZZ1





Boundary dimensions (mm)										Basic load ratings (N)		{kgf}		Limiting speeds (min⁻¹) Grease	Oil
d	D	D_1	D_2	B	B_1	C_1	C_2	r(1) min	r_1(1) min	C_r	C_{or}	C_r	C_{or}	Open Z·ZZ	Open Z
1	3	3.8	—	1	—	0.3	—	0.05	—	80	23	8	2.5	130 000	150 000
	4	5	—	1.6	—	0.5	—	0.1	—	138	35	14	3.5	100 000	120 000
1.2	4	4.8	—	1.8	—	0.4	—	0.1	—	138	35	14	3.5	110 000	130 000
1.5	4	5	5	1.2	2	0.4	0.6	0.05	0.05	112	33	11	3.5	100 000	120 000
	5	6.5	6.5	2	2.6	0.6	0.8	0.15	0.15	237	69	24	7	85 000	100 000
	6	7.5	7.5	2.5	3	0.6	0.8	0.15	0.15	330	98	34	10	75 000	90 000
2	5	6.1	6.1	1.5	2.3	0.5	0.6	0.08	0.08	169	50	17	5	85 000	100 000
	5	6.2	6.2	2	2.5	0.6	0.6	0.1	0.1	187	58	19	6	85 000	100 000
	6	7.5	7.5	2.3	3	0.6	0.8	0.15	0.15	330	98	34	10	75 000	90 000
	6	7.2	—	2.5	—	0.6	—	0.15	—	330	98	34	10	75 000	90 000
	7	8.2	8.2	2.5	3	0.6	0.6	0.15	0.15	385	127	39	13	63 000	75 000
	7	8.5	8.5	2.8	3.5	0.7	0.9	0.15	0.15	385	127	39	13	63 000	75 000
2.5	6	7.1	7.1	1.8	2.6	0.5	0.8	0.08	0.08	208	74	21	7.5	71 000	80 000
	7	8.5	8.5	2.5	3.5	0.7	0.9	0.15	0.15	385	127	39	13	63 000	67 000
	8	9.2	—	2.5	—	0.6	—	0.2	—	560	179	57	18	60 000	71 000
	8	9.5	9.5	2.8	4	0.7	0.9	0.15	0.15	550	175	56	18	60 000	71 000
3	6	7.2	7.2	2	2.5	0.6	0.6	0.1	0.1	208	74	21	7.5	71 000	80 000
	7	8.1	8.1	2	3	0.5	0.8	0.1	0.1	390	130	40	13	63 000	75 000
	8	9.2	—	2.5	—	0.6	—	0.15	—	560	179	57	18	60 000	67 000
	8	9.5	9.5	3	4	0.7	0.9	0.15	0.15	560	179	57	18	60 000	67 000
	9	10.2	10.6	2.5	4	0.6	0.8	0.2	0.15	570	187	58	19	56 000	67 000
	9	10.5	10.5	3	5	0.7	1	0.15	0.15	570	187	58	19	56 000	67 000
	10	11.5	11.5	4	4	1	1	0.15	0.15	630	218	64	22	50 000	60 000
	13	15	15	5	5	1	1	0.2	0.2	1 300	485	133	49	36 000	43 000
4	7	8.2	—	2	—	0.6	—	0.1	—	310	115	32	12	60 000	67 000
	7	—	8.2	—	2.5	—	0.6	—	0.1	255	107	26	11	60 000	71 000
	8	9.2	9.2	2	3	0.6	0.6	0.15	0.1	395	139	40	14	56 000	67 000
	9	10.3	10.3	2.5	4	0.6	1	(0.15)	(0.15)	640	225	65	23	53 000	63 000
	10	11.2	11.6	3	4	0.6	0.8	0.2	0.15	710	270	73	28	50 000	60 000
	11	12.5	12.5	4	4	1	1	0.15	0.15	960	345	98	35	48 000	56 000
	12	13.5	13.5	4	4	1	1	0.2	0.2	960	345	98	35	48 000	56 000
	13	15	15	5	5	1	1	0.2	0.2	1 300	485	133	49	40 000	48 000
	16	18	18	5	5	1	1	0.3	0.3	1 730	670	177	68	36 000	43 000

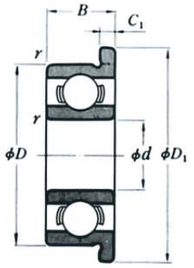
Bearing numbers			Abutment and fillet dimensions (mm)				Mass (g)		Basic bearing numbers	Actual size(2)
Open	Shielded	Sealed	d_a min	d_b max	r_a max	r_b max	Open approx	Shielded approx		
F 681	—	— —	1.4	—	0.05	—	0.04	—	**F 681**	
F 691	—	— —	1.8	—	0.1	—	0.14	—	**F 691**	
MF 41 X	—	— —	2.0	—	0.1	—	0.12	—	**MF 41 X**	
F 681 X	**F 681 XZZ**	— —	1.9	2.1	0.05	0.05	0.09	0.14	**F 681 X**	
F 691 X	**F 691 XZZ**	— —	2.7	2.5	0.15	0.15	0.21	0.28	**F 691 X**	
F 601 X	**F 601 XZZ**	— —	2.7	3.0	0.15	0.15	0.42	0.52	**F 601 X**	
F 682	**F 682 ZZ**	— —	2.6	2.7	0.08	0.08	0.16	0.22	**F 682**	
MF 52 B	**MF 52 B ZZ**	— —	2.8	2.7	0.1	0.1	0.21	0.27	**MF 52 B**	
F 692	**F 692 ZZ**	— —	3.2	3.0	0.15	0.15	0.35	0.48	**F 692**	
MF 62	—	— —	3.2	—	0.15	—	0.36	—	**MF 62**	
MF 72	**MF 72 ZZ**	— —	3.2	3.8	0.15	0.15	0.52	0.56	**MF 72**	
F 602	**F 602 ZZ**	— —	3.2	3.8	0.15	0.15	0.60	0.71	**F 602**	
F 682 X	**F 682 XZZ**	— —	3.1	3.7	0.08	0.08	0.25	0.36	**F 682 X**	
F 692 X	**F 692 XZZ**	— —	3.7	3.8	0.15	0.15	0.51	0.68	**F 692 X**	
MF 82 X	—	— —	4.1	—	0.2	—	0.62	—	**MF 82 X**	
F 602 X	**F 602 XZZ**	— —	3.7	4.1	0.15	0.15	0.74	0.98	**F 602 X**	
MF 63	**MF 63 ZZ**	— —	3.8	3.7	0.1	0.1	0.27	0.33	**MF 63**	
F 683 A	**F 683 A ZZ**	— —	3.8	4.0	0.1	0.1	0.37	0.53	**F 683 A**	
MF 83	—	— —	4.2	—	0.15	—	0.56	—	**MF 83**	
F 693	**F 693 ZZ**	— —	4.2	4.3	0.15	0.15	0.70	0.97	**F 693**	
MF 93	**MF 93 ZZ**	— —	4.6	4.3	0.2	0.15	0.81	1.34	**MF 93**	
F 603	**F 603 ZZ**	— —	4.2	4.3	0.15	0.15	1.0	1.63	**F 603**	
F 623	**F 623 ZZ**	— —	4.2	4.3	0.15	0.15	1.85	1.86	**F 623**	
F 633	**F 633 ZZ**	— —	4.6	6.0	0.2	0.2	3.73	3.59	**F 633**	
MF 74	—	— —	4.8	—	0.1	—	0.29	—	**MF 74**	
—	**MF 74 ZZ**	— —	—	4.8	—	0.1	—	0.35	**MF 74**	
MF 84	**MF 84 ZZ**	— —	5.2	5.0	0.15	0.1	0.44	0.63	**MF 84**	
F 684	**F 684 ZZ**	— —	4.8	5.2	0.1	0.1	0.70	1.14	**F 684**	
MF 104 B	**MF 104 B ZZ**	— —	5.6	5.9	0.2	0.15	1.13	1.59	**MF 104 B**	
F 694	**F 694 ZZ**	— —	5.2	5.6	0.15	0.15	1.91	1.96	**F 694**	
F 604	**F 604 ZZ**	— —	5.6	5.6	0.2	0.2	2.53	2.53	**F 604**	
F 624	**F 624 ZZ**	— —	5.6	6.0	0.2	0.2	3.38	3.53	**F 624**	
F 634	**F 634 ZZ1**	— —	6.0	7.5	0.3	0.3	5.73	5.65	**F 634**	

Notes (1) The values in parentheses are not based on ISO 15.
(2) Actual dimensions of bore and outside diameter only.

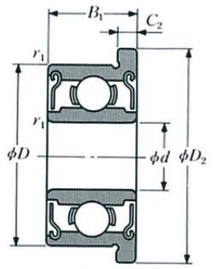
Remarks 1. When using bearings with a rotating outer ring, please contact NSK if they are shielded.
2. Bearings with double shields (ZZ, ZZ1) are also available with single shields (Z, Z1).

Deep groove ball bearings with flanged outer ring

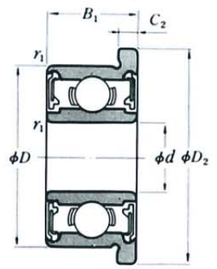
Metric series
F600, MF
Bore diameter
5 – 9 mm



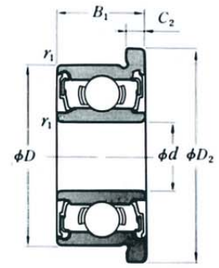
Open type



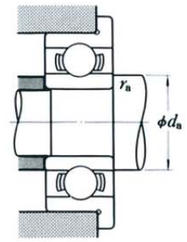
Shielded type
ZZ · ZZ1

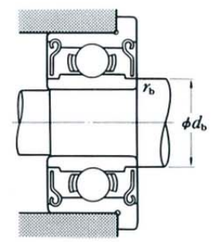


Non-contact sealed type
VV



Contact sealed type
DD

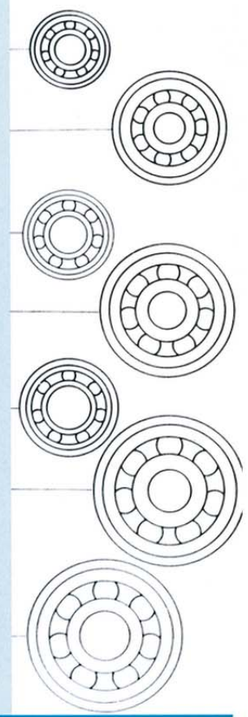




Boundary dimensions (mm)										Basic load ratings (N)		{kgf}		Limiting speeds (min⁻¹) Grease		Oil
d	D	D_1	D_2	B	B_1	C_1	C_2	r min	r_1 min	C_r	C_{or}	C_r	C_{or}	Open Z·ZZ V·VV	D·DD	Open Z
5	8	9.2	—	2	—	0.6	—	0.1	—	310	120	31	12	53 000	—	63 000
	8	—	9.2	—	2.5	—	0.6	—	0.1	278	131	28	13	53 000	—	63 000
	9	10.2	10.2	2.5	3	0.6	0.6	0.15	0.15	430	168	44	17	50 000	—	60 000
	10	11.2	11.6	3	4	0.6	0.8	0.15	0.15	430	168	44	17	50 000	—	60 000
	11	12.5	12.5	3	5	0.8	1	0.15	0.15	715	281	73	29	45 000	—	53 000
	13	15	15	4	4	1	1	0.2	0.2	1 080	430	110	44	43 000	40 000	50 000
	14	16	16	5	5	1	1	0.2	0.2	1 330	505	135	52	40 000	38 000	50 000
	16	18	18	5	5	1	1	0.3	0.3	1 730	670	177	68	36 000	32 000	43 000
	19	22	22	6	6	1.5	1.5	0.3	0.3	2 340	885	238	90	32 000	30 000	40 000
6	10	11.2	11.2	2.5	3	0.6	0.6	0.15	0.1	495	218	51	22	45 000	—	53 000
	12	13.2	13.6	3	4	0.6	0.8	0.2	0.15	715	292	73	30	43 000	40 000	50 000
	13	15	15	3.5	5	1	1.1	0.15	0.15	1 080	440	110	45	40 000	38 000	50 000
	15	17	17	5	5	1.2	1.2	0.2	0.2	1 730	670	177	68	40 000	36 000	45 000
	17	19	19	6	6	1.2	1.2	0.3	0.3	2 260	835	231	85	38 000	34 000	45 000
	19	22	22	6	6	1.5	1.5	0.3	0.3	2 340	885	238	90	32 000	30 000	40 000
	22	25	25	7	7	1.5	1.5	0.3	0.3	3 300	1 370	335	140	30 000	28 000	36 000
7	11	12.2	12.2	2.5	3	0.6	0.6	0.15	0.1	455	201	47	21	43 000	—	50 000
	13	14.2	14.6	3	4	0.6	0.8	0.2	0.15	540	276	55	28	40 000	—	48 000
	14	16	16	3.5	5	1	1.1	0.15	0.15	1 170	510	120	52	40 000	34 000	45 000
	17	19	19	5	5	1.2	1.2	0.3	0.3	1 610	715	164	73	36 000	28 000	43 000
	19	22	22	6	6	1.5	1.5	0.3	0.3	2 340	885	238	90	36 000	32 000	43 000
	22	25	25	7	7	1.5	1.5	0.3	0.3	3 300	1 370	335	140	30 000	28 000	36 000
8	12	13.2	13.6	2.5	3.5	0.6	0.8	0.15	0.1	545	274	56	28	40 000	—	48 000
	14	15.6	15.6	3.5	4	0.8	0.8	0.2	0.15	820	385	83	39	38 000	32 000	45 000
	16	18	18	4	5	1	1.1	0.2	0.2	1 610	710	164	73	36 000	30 000	43 000
	19	22	22	6	6	1.5	1.5	0.3	0.3	2 240	910	228	93	36 000	28 000	43 000
	22	25	25	7	7	1.5	1.5	0.3	0.3	3 300	1 370	335	140	34 000	28 000	40 000
9	17	19	19	4	5	1	1.1	0.2	0.2	1 330	665	136	68	36 000	24 000	43 000
	20	23	23	6	6	1.5	1.5	0.3	0.3	1 720	840	175	86	34 000	24 000	40 000

Bearing numbers				Abutment and fillet dimensions (mm)				Mass (g)		Basic bearing numbers
Open	Shielded	Sealed		d_a min	d_b max	r_a max	r_b max	Open approx	Shielded approx	
MF 85	—	—	—	5.8	—	0.1	—	0.33	—	**MF 85**
—	**MF 85 ZZ**	—	—	—	5.8	—	0.1	—	0.41	**MF 85**
MF 95	**MF 95 ZZ1**	—	—	6.2	6.0	0.15	0.15	0.59	0.66	**MF 95**
MF 105	**MF 105 ZZ**	—	—	6.2	6.0	0.15	0.15	1.05	1.46	**MF 105**
F 685	**F 685 ZZ**	—	—	6.2	6.2	0.15	0.15	1.37	2.18	**F 685**
F 695	**F 695 ZZ**	**VV**	**DD**	6.6	6.6	0.2	0.2	2.79	2.84	**F 695**
F 605	**F 605 ZZ**	—	**DD**	6.6	6.9	0.2	0.2	3.9	3.85	**F 605**
F 625	**F 625 ZZ1**	**VV**	**DD**	7.0	7.5	0.3	0.3	5.37	5.3	**F 625**
F 635	**F 635 ZZ1**	**VV**	**DD**	7.0	8.5	0.3	0.3	9.49	9.49	**F 635**
MF 106	**MF 106 ZZ1**	—	—	7.2	7.0	0.15	0.1	0.65	0.77	**MF 106**
MF 126	**MF 126 ZZ**	—	**DD**	7.6	7.2	0.2	0.15	1.38	1.94	**MF 126**
F 686 A	**F 686 A ZZ**	**VV**	**DD**	7.2	7.4	0.15	0.15	2.25	3.04	**F 686 A**
F 696	**F 696 ZZ1**	**VV**	**DD**	7.6	7.9	0.2	0.2	4.34	4.26	**F 696**
F 606	**F 606 ZZ**	**VV**	**DD**	8.0	8.2	0.3	0.3	6.58	6.61	**F 606**
F 626	**F 626 ZZ1**	**VV**	**DD**	8.0	8.5	0.3	0.3	9.09	9.09	**F 626**
F 636	**F 636 ZZ**	**VV**	**DD**	8.0	10.5	0.3	0.3	14.6	14.7	**F 636**
MF 117	**MF 117 ZZ**	—	—	8.2	8.0	0.15	0.1	0.72	0.82	**MF 117**
MF 137	**MF 137 ZZ**	—	—	8.6	9.0	0.2	0.15	1.7	2.23	**MF 137**
F 687	**F 687 ZZ1**	**VV**	**DD**	8.2	8.5	0.15	0.15	2.48	3.37	**F 687**
F 697	**F 697 ZZ1**	**VV**	**DD**	9.0	10.2	0.3	0.3	5.65	5.65	**F 697**
F 607	**F 607 ZZ1**	**VV**	**DD**	9.0	9.1	0.3	0.3	8.66	8.66	**F 607**
F 627	**F 627 ZZ**	**VV**	**DD**	9.0	10.5	0.3	0.3	14.2	14.2	**F 627**
MF 128	**MF 128 ZZ1**	—	—	9.2	9.0	0.15	0.1	0.82	1.15	**MF 128**
MF 148	**MF 148 ZZ**	**VV**	**DD**	9.6	9.2	0.2	0.15	2.09	2.39	**MF 148**
F 688 A	**F 688 A ZZ1**	**VV**	**DD**	9.6	10.2	0.2	0.2	3.54	4.47	**F 688 A**
F 698	**F 698 ZZ**	**VV**	**DD**	10.0	10.0	0.3	0.3	8.35	8.3	**F 698**
F 608	**F 608 ZZ**	**VV**	**DD**	10.0	10.5	0.3	0.3	13.4	13.5	**F 608**
F 689	**F 689 ZZ1**	**VV**	**DD**	10.6	11.5	0.2	0.2	3.97	4.91	**F 689**
F 699	**F 699 ZZ1**	**VV**	**DD**	11.0	12.0	0.3	0.3	9.51	9.51	**F 699**

Actual size(1)



Notes (1) Actual dimensions of bore and outside diameter only.
Remarks 1. When using bearings with a rotating outer ring, please contact NSK if they are shielded.
2. Bearings with double shields (ZZ, ZZ1) are also available with single shields (Z, Z1).

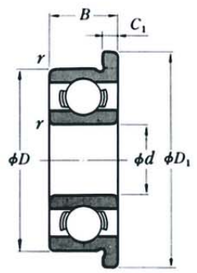
Deep groove ball bearings with flanged outer ring

Inch series

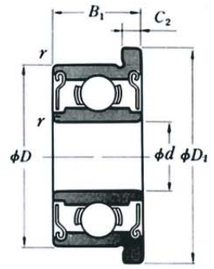
FR

Bore diameter

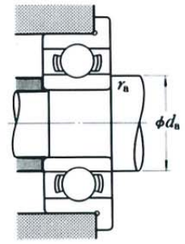
1.191 – 9.525 mm

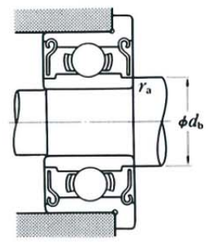


Open type

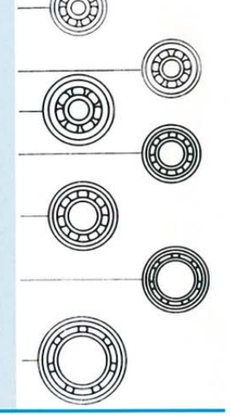


Shielded type
ZZ · ZZS





Boundary dimensions (mm/inch)														Basic load ratings (N)		{kgf}		Limiting speeds (min⁻¹) Grease	Oil	Bearing numbers		Abutment and fillet dimensions (mm)			Mass (g)		Basic bearing numbers	Actual size(1)
d		D		D_1		B		B_1		C_1		C_2	r min	C_r	C_{or}	C_r	C_{or}	Open Z·ZZ	Open Z	Open	Shielded	d_a min	d_b max	r_a max	Open approx	Shielded approx		
1.191	0.0469	3.967	0.1562	5.156	0.203	1.588	0.0625	2.380	0.0937	0.330	0.013	0.790 0.031	0.1	138	35	14	3.5	110 000	130 000	**FR 0**	**FR 0 ZZ**	2.0	1.9	0.1	0.11	0.16	**FR 0**	
1.397	0.0550	4.762	0.1875	5.944	0.234	1.984	0.0781	2.779	0.1094	0.580	0.023	0.790 0.031	0.1	231	66	24	6.5	90 000	110 000	**FR 1**	**FR 1 ZZ**	2.2	2.3	0.1	0.20	0.25	**FR 1**	
1.984	0.0781	6.350	0.2500	7.518	0.296	2.380	0.0937	3.571	0.1406	0.580	0.023	0.790 0.031	0.1	310	108	32	11	67 000	80 000	**FR 1-4**	**FR 1-4 ZZ**	2.8	3.9	0.1	0.41	0.58	**FR 1-4**	
2.380	0.0937	4.762	0.1875	5.944	0.234	1.588	0.0625	—	—	0.460	0.018	— —	0.1	188	60	19	6	80 000	95 000	**FR 133**	—	3.2	—	0.1	0.13	—	**FR 133**	
		4.762	0.1875	5.944	0.234	—	—	2.380	0.0937	—	—	0.790 0.031	0.1	143	52	15	5.5	80 000	95 000	—	**FR 133 ZZS**	—	3.0	0.1	—	0.19	**FR 133**	
		7.938	0.3125	9.119	0.359	2.779	0.1094	3.571	0.1406	0.580	0.023	0.790 0.031	0.15	550	175	56	18	60 000	71 000	**FR 1-5**	**FR 1-5 ZZ**	3.6	4.1	0.15	0.68	0.82	**FR 1-5**	
3.175	0.1250	6.350	0.2500	7.518	0.296	2.380	0.0937	2.779	0.1094	0.580	0.023	0.790 0.031	0.1	283	95	29	9.5	67 000	80 000	**FR 144**	**FR 144 ZZ**	4.0	3.9	0.1	0.31	0.35	**FR 144**	
		7.938	0.3125	9.119	0.359	2.779	0.1094	3.571	0.1406	0.580	0.023	0.790 0.031	0.1	560	179	57	18	60 000	67 000	**FR 2-5**	**FR 2-5 ZZ**	4.0	4.3	0.1	0.62	0.81	**FR 2-5**	
		9.525	0.3750	10.719	0.422	2.779	0.1094	3.571	0.1406	0.580	0.023	0.790 0.031	0.15	640	225	65	23	53 000	63 000	**FR 2-6**	**FR 2-6 ZZS**	4.4	4.6	0.15	1.04	1.25	**FR 2-6**	
		9.525	0.3750	11.176	0.440	3.967	0.1562	3.967	0.1562	0.760	0.030	0.760 0.030	0.3	630	218	64	22	56 000	67 000	**FR 2**	**FR 2 ZZ**	5.2	4.8	0.3	1.51	1.55	**FR 2**	
3.967	0.1562	7.938	0.3125	9.119	0.359	2.779	0.1094	3.175	0.1250	0.580	0.023	0.910 0.036	0.1	360	149	37	15	53 000	63 000	**FR 155**	**FR 155 ZZS**	4.8	5.5	0.1	0.59	0.67	**FR 155**	
4.762	0.1875	7.938	0.3125	9.119	0.359	2.779	0.1094	3.175	0.1250	0.580	0.023	0.910 0.036	0.1	360	149	37	15	53 000	63 000	**FR 156**	**FR 156 ZZS**	5.6	5.5	0.1	0.47	0.53	**FR 156**	
		9.525	0.3750	10.719	0.422	3.175	0.1250	3.175	0.1250	0.580	0.023	0.790 0.031	0.1	710	270	73	28	50 000	60 000	**FR 166**	**FR 166 ZZ**	5.6	5.9	0.1	0.90	0.98	**FR 166**	
		12.700	0.5000	14.351	0.565	4.978	0.1960	4.978	0.1960	1.070	0.042	1.070 0.042	0.3	1300	485	133	49	43 000	53 000	**FR 3**	**FR 3 ZZ**	6.8	6.5	0.3	2.97	3.09	**FR 3**	
6.350	0.2500	9.525	0.3750	10.719	0.422	3.175	0.1250	3.175	0.1250	0.580	0.023	0.910 0.036	0.1	420	204	43	21	48 000	56 000	**FR 168 B**	**FR 168 BZZ**	7.2	7.0	0.1	0.66	0.75	**FR 168 B**	
		12.700	0.5000	13.894	0.547	3.175	0.1250	4.762	0.1875	0.580	0.023	1.140 0.045	0.15	1 080	440	110	45	40 000	50 000	**FR 188**	**FR 188 ZZ**	7.6	7.4	0.15	1.64	2.49	**FR 188**	
		15.875	0.6250	17.526	0.690	4.978	0.1960	4.978	0.1960	1.070	0.042	1.070 0.042	0.3	1 610	660	164	68	38 000	45 000	**FR 4 B**	**FR 4 BZZ**	8.4	8.4	0.3	4.78	4.78	**FR 4 B**	
7.938	0.3125	12.700	0.5000	13.894	0.547	3.967	0.1562	3.967	0.1562	0.790	0.031	0.790 0.031	0.15	540	276	55	28	40 000	48 000	**FR 1810**	**FR 1810 ZZ**	9.2	9.0	0.15	1.71	1.63	**FR 1810**	
9.525	0.3750	22.225	0.8750	24.613	0.969	7.142	0.2812	7.142	0.2812	1.570	0.062	1.570 0.062	0.4	3 350	1 410	340	144	32 000	38 000	**FR 6**	**FR 6 ZZ**	12.6	11.9	0.4	10.1	12.1	**FR 6**	



Note (1) Actual dimensions of bore and outside diameter only.

Remarks 1. When using bearings with a rotating outer ring, please contact NSK if they are shielded.
2. Bearings with double shields (ZZ, ZZS) are also available with single shields (Z, ZS).

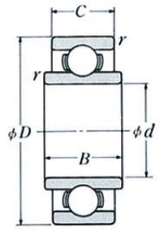
Deep groove ball bearings with extended inner ring

Inch series

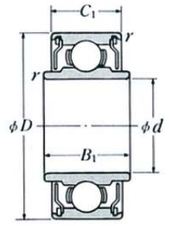
RW

Bore diameter

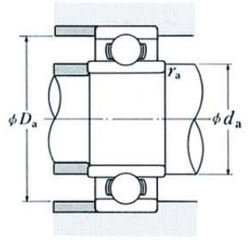
1.191 – 7.938 mm

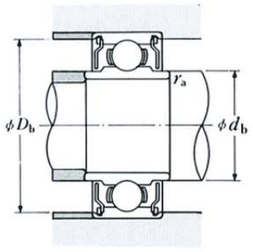


Open type



Shielded type
ZZ · ZZS





Boundary dimensions (mm/inch)												Basic load ratings (N)		{kgf}		Limiting speeds (min⁻¹) Grease	Oil
d		D		B		B_1		C		C_1		r min	C_r	C_{or}	C_r	C_{or}	Open Z·ZZ	Open Z
1.016	0.0400	3.175	0.1250	1.984	0.0781	—	—	1.191	0.0469	—	—	0.1	80	23	8	2.5	130 000	150 000
1.191	0.0469	3.967	0.1562	2.380	0.0937	3.175	0.1250	1.588	0.0625	2.380	0.0937	0.1	138	35	14	3.5	110 000	130 000
1.397	0.0550	4.762	0.1875	2.779	0.1094	3.571	0.1406	1.984	0.0781	2.779	0.1094	0.1	231	66	24	6.5	90 000	110 000
1.984	0.0781	6.350	0.2500	3.175	0.1250	4.366	0.1719	2.380	0.0937	3.571	0.1406	0.1	310	108	32	11	67 000	80 000
2.380	0.0937	4.762	0.1875	2.380	0.0937	—	—	1.588	0.0625	—	—	0.1	188	60	19	6	80 000	95 000
		4.762	0.1875	—	—	3.175	0.1250	—	—	2.380	0.0937	0.1	143	52	15	5.5	80 000	95 000
		7.938	0.3125	3.571	0.1406	4.366	0.1719	2.779	0.1094	3.571	0.1406	0.15	550	175	56	18	60 000	71 000
3.175	0.1250	6.350	0.2500	3.175	0.1250	3.571	0.1406	2.380	0.0937	2.779	0.1094	0.1	283	95	29	9.5	67 000	80 000
		7.983	0.3125	3.571	0.1406	4.366	0.1719	2.779	0.1094	3.571	0.1406	0.1	560	179	57	18	60 000	67 000
		9.525	0.3750	3.571	0.1406	4.366	0.1719	2.779	0.1094	3.571	0.1406	0.15	640	225	65	23	53 000	63 000
		9.525	0.3750	4.762	0.1875	4.762	0.1875	3.967	0.1562	3.967	0.1562	0.3	630	218	64	22	56 000	67 000
3.967	0.1562	7.938	0.3125	3.571	0.1406	3.967	0.1562	2.779	0.1094	3.175	0.1250	0.1	360	149	37	15	53 000	63 000
4.762	0.1875	7.938	0.3125	3.571	0.1406	3.967	0.1562	2.779	0.1094	3.175	0.1250	0.1	360	149	37	15	53 000	63 000
		9.525	0.3750	3.967	0.1562	3.967	0.1562	3.175	0.1250	3.175	0.1250	0.1	710	270	73	28	50 000	60 000
		12.700	0.5000	4.762	0.1875	5.771	0.2272	3.967	0.1562	4.978	0.1960	0.3	1 300	485	133	49	43 000	53 000
6.350	0.2500	9.525	0.3750	3.967	0.1562	3.967	0.1562	3.175	0.1250	3.175	0.1250	0.1	420	204	43	21	48 000	56 000
		12.700	0.5000	3.967	0.1562	5.558	0.2188	3.175	0.1250	4.762	0.1875	0.15	1 080	440	110	45	40 000	50 000
		15.875	0.6250	5.771	0.2272	5.771	0.2272	4.978	0.1960	4.978	0.1960	0.3	1 610	660	164	68	38 000	45 000
7.938	0.3125	12.700	0.5000	4.762	0.1875	4.762	0.1875	3.967	0.1562	3.967	0.1562	0.15	540	276	55	28	40 000	48 000
9.525	0.3750	22.225	0.8750	7.142	0.2812	—	—	5.558	0.2188	—	—	0.4	3 350	1 410	340	144	32 000	38 000

Note (1) Actual dimensions of bore and outside diameter only.
Remarks 1. When using bearings with a rotating outer ring, please contact NSK if they are shielded.
2. Bearings with double shields (ZZ, ZZS) are also available with single shields (Z, ZS).

Bearing numbers		Abutment and fillet dimensions (mm)					Mass (g)		Basic bearing numbers	Actual size(1)
Open	Shielded	d_a min	d_b max	D_a max	D_b min	r_a max	Open approx	Shielded approx		
RW 09	—	1.9	—	2.3	—	0.1	0.05	—	**RW 09**	
RW 0	**RW 0 ZZ**	2.0	1.9	3.1	3.5	0.1	0.11	0.16	**RW 0**	
RW 1	**RW 1 ZZ**	2.2	2.3	3.9	4.1	0.1	0.17	0.25	**RW 1**	
RW 1-4	**RW 1-4 ZZ**	2.8	3.9	5.5	5.9	0.1	0.46	0.46	**RW 1-4**	
RW 133	—	3.2	—	3.9	—	0.1	0.12	—	**RW 133**	
—	**RW 133 ZZS**	—	3.0	—	4.2	0.1	—	0.17	**RW 133**	
RW 1-5	**RW 1-5 ZZ**	3.6	4.1	6.7	7.0	0.15	0.63	0.73	**RW 1-5**	
RW 144	**RW 144 ZZ**	4.0	3.9	5.5	5.9	0.1	0.30	0.33	**RW 144**	
RW 2-5	**RW 2-5 ZZ**	4.0	4.3	7.1	7.3	0.1	0.74	0.74	**RW 2-5**	
RW 2-6	**RW 2-6 ZZS**	4.4	4.6	8.3	8.2	0.15	1.0	1.1	**RW 2-6**	
RW 2	**RW 2 ZZ**	5.2	4.8	7.5	8.0	0.3	1.4	1.3	**RW 2**	
RW 155	**RW 155 ZZS**	4.8	5.5	7.1	7.3	0.1	0.56	0.62	**RW 155**	
RW 156	**RW 156 ZZS**	5.6	5.5	7.1	7.3	0.1	0.44	0.49	**RW 156**	
RW 166	**RW 166 ZZ**	5.6	5.9	8.7	8.8	0.1	0.82	0.87	**RW 166**	
RW 3	**RW 3 ZZ**	6.8	6.5	10.7	11.2	0.3	2.33	2.90	**RW 3**	
RW 168 B	**RW 168 BZZ**	7.2	7.0	8.7	8.9	0.1	0.62	0.66	**RW 168 B**	
RW 188	**RW 188 ZZ**	7.6	7.4	11.5	11.6	0.15	1.7	2.1	**RW 188**	
RW 4 B	**RW 4 BZZ**	8.4	8.4	13.8	13.8	0.3	4.72	4.62	**RW 4 B**	
RW 1810	**RW 1810 ZZ**	9.2	9.0	11.5	11.6	0.15	1.9	1.6	**RW 1810**	
RW 6	—	12.6	—	19.2	—	0.4	10	—	**RW 6**	

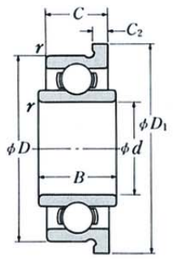
Deep groove ball bearings with extended inner ring, flanged

Inch series

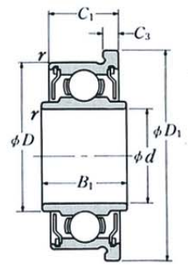
FRW

Bore diameter

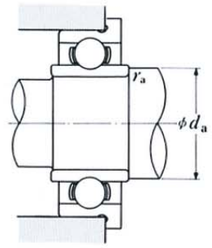
1.191 – 7.938 mm

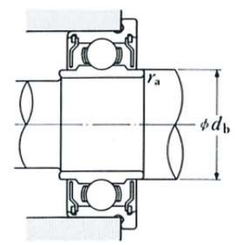


Open type



Shielded type
ZZ · ZZS

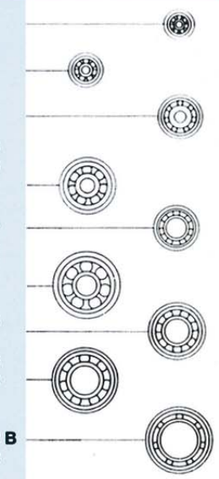




Boundary dimensions (mm/inch)																		Basic load ratings (N)		{kgf}	
d		D		D_1		B		B_1		C		C_1		C_2		C_3		r min	C_r	C_{or}	C_r	C_{or}
1.191	0.0469	3.967	0.1562	5.156	0.203	2.380	0.0937	3.175	0.1250	1.588	0.0625	2.380	0.0937	0.330	0.013	0.790	0.031	0.1	138	35	14	3.5
1.397	0.0550	4.762	0.1875	5.944	0.234	2.779	0.1094	3.571	0.1406	1.984	0.0781	2.779	0.1094	0.580	0.023	0.790	0.031	0.1	231	66	24	6.5
1.984	0.0781	6.350	0.2500	7.518	0.296	3.175	0.1250	4.366	0.1719	2.380	0.0937	3.571	0.1406	0.580	0.023	0.790	0.031	0.1	310	108	32	11
2.380	0.0937	4.762	0.1875	5.944	0.234	2.380	0.0937	—	—	1.588	0.0625	—	—	0.460	0.018	—	—	0.1	188	60	19	6
		4.762	0.1875	5.944	0.234	—	—	3.175	0.1250	—	—	2.380	0.0937	—	—	0.790	0.031	0.1	143	52	15	5.5
		7.938	0.3125	9.119	0.359	3.571	0.1406	4.366	0.1719	2.779	0.1094	3.571	0.1406	0.580	0.023	0.790	0.031	0.15	550	175	56	18
3.175	0.1250	6.350	0.2500	7.518	0.296	3.175	0.1250	3.571	0.1406	2.380	0.0937	2.779	0.1094	0.580	0.023	0.790	0.031	0.1	283	95	29	9.5
		7.938	0.3125	9.119	0.359	3.571	0.1406	4.366	0.1719	2.779	0.1094	3.571	0.1406	0.580	0.023	0.790	0.031	0.1	560	179	57	18
		9.525	0.3750	10.719	0.422	3.571	0.1406	4.366	0.1719	2.779	0.1094	3.571	0.1406	0.580	0.023	0.790	0.031	0.15	640	225	65	23
		9.525	0.3750	11.176	0.440	4.762	0.1875	4.762	0.1875	3.967	0.1562	3.967	0.1562	0.760	0.030	0.760	0.030	0.3	630	218	64	22
3.967	0.1562	7.938	0.3125	9.119	0.359	3.571	0.1406	3.967	0.1562	2.779	0.1094	3.175	0.1250	0.580	0.023	0.910	0.036	0.1	360	149	37	15
4.762	0.1875	7.938	0.3125	9.119	0.359	3.571	0.1406	3.967	0.1562	2.779	0.1094	3.175	0.1250	0.580	0.023	0.910	0.036	0.1	360	149	37	15
		9.525	0.3750	10.719	0.422	3.967	0.1562	3.967	0.1562	3.175	0.1250	3.175	0.1250	0.580	0.023	0.790	0.031	0.1	710	270	73	28
		12.700	0.5000	14.351	0.565	4.762	0.1875	5.771	0.2272	3.967	0.1562	4.978	0.1960	1.070	0.042	1.070	0.042	0.3	1 300	485	133	49
6.350	0.2500	9.525	0.3750	10.719	0.422	3.967	0.1562	3.967	0.1562	3.175	0.1250	3.175	0.1250	0.580	0.023	0.910	0.036	0.1	420	204	43	21
		12.700	0.5000	13.894	0.547	3.967	0.1562	5.558	0.2188	3.175	0.1250	4.762	0.1875	0.580	0.023	1.140	0.045	0.15	1 080	440	110	45
		15.875	0.6250	17.526	0.690	5.771	0.2272	5.771	0.2272	4.978	0.1960	4.978	0.1960	1.070	0.042	1.070	0.042	0.3	1 610	660	164	68
7.938	0.3125	12.700	0.5000	13.894	0.547	4.762	0.1875	4.762	0.1875	3.967	0.1562	3.967	0.1562	0.790	0.031	0.790	0.031	0.15	540	276	55	28

Limiting speeds (min⁻¹) Grease: Open Z·ZZ	Limiting speeds (min⁻¹) Oil: Open Z	Bearing numbers: Open	Bearing numbers: Shielded	Abutment and fillet dimensions (mm): d_a min	d_b max	r_a max	Mass (g): Open approx	Mass (g): Shielded approx	Basic bearing numbers
110 000	130 000	**FRW 0**	**FRW 0 ZZ**	2.0	1.9	0.1	0.14	0.19	**FRW 0**
90 000	110 000	**FRW 1**	**FRW 1 ZZ**	2.2	2.3	0.1	0.24	0.32	**FRW 1**
67 000	80 000	**FRW 1-4**	**FRW 1-4 ZZ**	2.8	3.9	0.1	0.59	0.59	**FRW 1-4**
80 000	95 000	**FRW 133**	—	3.2	—	0.1	0.17	—	**FRW 133**
80 000	95 000	—	**FRW 133 ZZS**	—	3.0	0.1	—	0.22	**FRW 133**
60 000	71 000	**FRW 1-5**	**FRW 1-5 ZZ**	3.6	4.1	0.15	0.83	0.93	**FRW 1-5**
67 000	80 000	**FRW 144**	**FRW 144 ZZ**	4.0	3.9	0.1	0.44	0.47	**FRW 144**
60 000	67 000	**FRW 2-5**	**FRW 2-5 ZZ**	4.0	4.3	0.1	0.93	0.93	**FRW 2-5**
53 000	63 000	**FRW 2-6**	**FRW 2-6 ZZS**	4.4	4.6	0.15	1.3	1.4	**FRW 2-6**
56 000	67 000	**FRW 2**	**FRW 2 ZZ**	5.2	4.8	0.3	1.8	1.7	**FRW 2**
53 000	63 000	**FRW 155**	**FRW 155 ZZS**	4.8	5.5	0.1	0.73	0.79	**FRW 155**
53 000	63 000	**FRW 156**	**FRW 156 ZZS**	5.6	5.5	0.1	0.58	0.63	**FRW 156**
50 000	60 000	**FRW 166**	**FRW 166 ZZ**	5.6	5.9	0.1	1.2	1.2	**FRW 166**
43 000	53 000	**FRW 3**	**FRW 3 ZZ**	6.8	6.5	0.3	3.1	3.2	**FRW 3**
48 000	56 000	**FRW 168 B**	**FRW 168 BZZ**	7.2	7.0	0.1	0.70	0.79	**FRW 168 B**
40 000	50 000	**FRW 188**	**FRW 188 ZZ**	7.6	7.4	0.15	2.1	2.5	**FRW 188**
38 000	45 000	**FRW 4 B**	**FRW 4 BZZ**	8.4	8.4	0.3	5.08	4.98	**FRW 4 B**
40 000	48 000	**FRW 1810**	**FRW 1810 ZZ**	9.2	9.0	0.15	2.3	2.1	**FRW 1810**

Actual size(1)



Note (1) Actual dimensions of bore and outside diameter only.

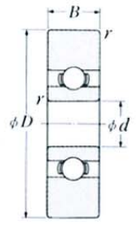
Remarks 1. When using bearings with a rotating outer ring, please contact NSK if they are shielded.
2. Bearings with double shields (ZZ, ZZS) are also available with single shields (Z, ZS).

Inch series

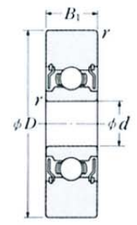
SR··X

Bore diameter

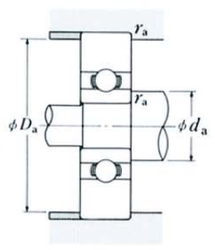
3.175 – 4.762 mm

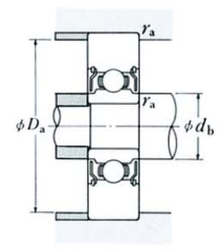


Open type



Shielded type
ZZS





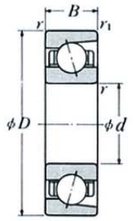
Boundary dimensions (mm/inch)								Basic load ratings (N) {kgf}				Limiting speeds (min⁻¹) Grease	Oil
d		D		B		B_1		r	C_r	C_{or}	C_r	C_{or}	Open ZS·ZZS	Open ZS
3.175	0.1250	9.525	0.3750	—	—	2.779	0.1094	0.1	241	76	25	8.0	53 000	63 000
		10.100	0.3976	—	—	2.380	0.0937	0.1	264	87	27	9.0	63 000	75 000
		10.414	0.4100	—	—	2.380	0.0937	0.1	264	87	27	9.0	63 000	75 000
4.762	0.1875	10.100	0.3976	—	—	2.779	0.1094	0.1	305	119	31	12	53 000	63 000
		10.414	0.4100	—	—	2.779	0.1094	0.1	305	119	31	12	53 000	63 000
		12.700	0.5000	2.779	0.1094	—	—	0.1	605	216	62	22	50 000	60 000
		12.700	0.5000	—	—	3.967	0.1562	0.1	605	216	62	22	50 000	60 000
		14.463	0.5694	4.978	0.1960	4.978	0.1960	0.3	1 110	385	113	40	43 000	53 000
		22.225	0.8750	4.978	0.1960	4.978	0.1960	0.3	1 260	495	128	50	43 000	53 000

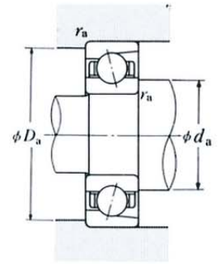
Remarks These bearings are made of stainless steel.

Bearing numbers			Abutment and fillet dimensions (mm)				Mass (g)
Open	Single shielded	Double shielded	d_a min	d_b max	D_a max	r_a max	approx
—	**SR 2X52 ZS**	**SR 2X52 ZZS**	3.9	3.9	8.7	0.1	1.0
—	**SR 144X100 ZS**	**SR 144X100 ZZS**	3.9	3.9	9.3	0.1	1.2
—	**SR 174X5 ZS**	**SR 174X5 ZZS**	3.9	3.9	9.6	0.1	1.2
—	**SR 156X100 ZS**	**SR 156X100 ZZS**	5.5	5.5	9.3	0.1	1.0
—	**SR 156X101 ZS**	**SR 156X101 ZZS**	5.5	5.5	9.6	0.1	1.1
SR 186X1	—	—	5.6	—	11.9	0.1	1.8
—	**SR 186X2 ZS**	**SR 186X2 ZZS**	5.6	5.9	11.9	0.1	2.6
SR 3X31	**SR 3X31 ZS**	**SR 3X31 ZZS**	6.5	6.5	12.9	0.3	4.0
SR 3X23	**SR 3X23 ZS**	**SR 3X23 ZZS**	6.8	8.4	20.6	0.3	13

Angular contact ball bearings

Metric series
700C
Bore diameter
4 – 9mm





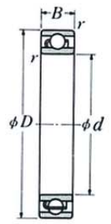
Boundary dimensions (mm)					Basic load ratings (N)		{kgf}		Limiting speeds (min⁻¹)	
d	D	B	r min	r_1 min	C_r	C_{or}	C_r	C_{or}	Grease	Oil
4	16	5	0.3	0.15	1 700	660	174	67	53 000	71 000
5	16	5	0.3	0.15	1 700	660	174	66	53 000	71 000
6	17	6	0.3	0.15	2 030	795	204	81	50 000	67 000
	19	6	0.3	0.15	2 390	1 000	243	102	48 000	63 000
7	19	6	0.3	0.15	2 390	1 000	243	102	48 000	63 000
8	22	7	0.3	0.15	3 550	1 540	360	157	43 000	56 000
	24	8	0.3	0.15	3 600	1 600	365	164	40 000	53 000
9	24	7	0.3	0.15	3 600	1 600	365	164	40 000	53 000

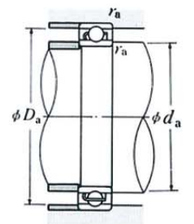
Bearing numbers	Abutment and fillet dimensions (mm)			Mass (g)
	d_a min	D_a max	r_a max	approx
734C	6.5	13.5	0.3	5.3
725C	7.5	13.5	0.3	4.5
706C	8.5	14.5	0.3	5.5
726C	8.5	16.5	0.3	7.8
707C	9.5	16.5	0.3	7.4
708C	10.5	19.5	0.3	12
728C	10.5	21.5	0.3	16
709C	11.5	21.5	0.3	14

Remarks 1. The tolerance classes for this type of bearing are classes 5 and 4.
2. Please contact NSK regarding separable bearings or inch series bearings.

Extra-thin-section deep groove ball bearings

Metric series
SMT
Bore diameter
10 – 15mm





Boundary dimensions (mm)				Basic load ratings (N)		{kgf}		Limiting speeds (min⁻¹)	
d	D	B	r min	C_r	C_{or}	C_r	C_{or}	Grease	Oil
10	15	3	0.15	815	410	83	42	36 000	43 000
15	20	3.5	0.15	800	470	82	48	30 000	36 000

Bearing numbers	Abutment and fillet dimensions (mm)			Mass (g)
	d_a min	D_a max	r_a max	approx
SMT 1510	11.2	13.8	0.15	1.4
SMT 2015	16.2	18.8	0.15	2.2

Remarks 1. These bearings are made of stainless steel.
2. The tolerance classes for this type of bearing are normal and class 6.
3. The radial internal clearance for this type of bearing is specified by ISO 5593 Rolling bearings-Radial internal clearance.

Appendices

Appendix Table 1 Conversion from SI (International Units) System

Comparison of SI, CGS, and Engineering Units

Units / Unit System	Length	Mass	Time	Temp.	Acceleration	Force	Stress	Pressure	Energy	Power
SI	m	kg	s	K	m/s^2	N	Pa	Pa	J	W
CGS System	cm	g	s	°C	Gal	dyn	dyn/cm^2	dyn/cm^2	erg	erg/s
Engineering Unit System	m	$kgf \cdot s^2/m$	s	°C	m/s^2	kgf	kgf/m^2	kgf/m^2	kgf·m	kgf·m/s

Conversion Factors from SI Units

Parameter	SI Units: Names of Units	SI Units: Symbols	Units other than SI: Name of Units	Units other than SI: Symbols	Conversion Factors from SI Units
Angle	Radian	rad	Degree	°	$180/\pi$
			Minute	′	$10\,800/\pi$
			Second	″	$648\,000/\pi$
Length	Meter	m	Micron	μ	10^6
			Angstrom	Å	10^{10}
Area	Square meter	m^2	Are	a	10^{-2}
			Hectare	ha	10^{-4}
Volume	Cubic meter	m^3	Liter	l, L	10^3
			Deciliter	dl, dL	10^4
Time	Second	s	Minute	min	1/60
			Hour	h	1/3 600
			Day	d	1/86 400
Frequency	Hertz	Hz	Cycle	s^{-1}	1
Speed of Rotation	Revolution per second	s^{-1}	Revolution per minute	rpm	60
Speed	Meter per second	m/s	Kilometer per hour	km/h	3 600/1 000
			Knot	kn	3 600/1 852
Acceleration	Meter per second per second	m/s^2	Gal	Gal	10^2
			g	g	1/9.806 65
Mass	Kilogram	kg	Ton	t	10^{-3}
Force	Newton	N	Kilogram-force	kgf	1/9.806 65
			Ton-force	tf	$1/(9.806\,65\times10^3)$
			Dyne	dyn	10^5
Torque or Moment	Newton·meter	N·m	Kilogram-force meter	kgf·m	1/9.806 65
Stress	Pascal	Pa (N/m^2)	Kilogram-force per square centimeter	kgf/cm^2	$1/(9.806\,65\times10^4)$
			Kilogram-force per square millimeter	kgf/mm^2	$1/(9.806\,65\times10^6)$

Prefixes Used In SI System

Multiples	Prefix	Symbols	Multiples	Prefix	Symbols
10^{18}	Exa	E	10^{-1}	Deci	d
10^{15}	Peta	P	10^{-2}	Centi	c
10^{12}	Tera	T	10^{-3}	Milli	m
10^9	Giga	G	10^{-6}	Micro	μ
10^6	Mega	M	10^{-9}	Nano	n
10^3	Kilo	k	10^{-12}	Pico	p
10^2	Hecto	h	10^{-15}	Femto	f
10^1	Deca	da	10^{-18}	Ato	a

Conversion Factors from SI Units (Continued)

Parameter	SI Units: Names of Units	SI Units: Symbols	Units other than SI: Names of Units	Units other than SI: Units	Conversion factors from SI Units
Pressure	Pascal (Newton per square meter)	Pa (N/m^2)	Kilogram-force per square meter	kgf/m^2	1/9.806 65
			Water Column	mH_2O	$1/(9.806\,65\times10^3)$
			Mercury Column	mmHg	$760/(1.013\,25\times10^5)$
			Torr	Torr	$760/(1.013\,25\times10^5)$
			Bar	bar	10^{-5}
			Atmosphere	atm	$1/(1.013\,25\times10^5)$
Energy	Joule (Newton·meter)	J (N·m)	Erg	erg	10^7
			Calorie(International)	cal_{IT}	1/4.186 8
			Kilogram-force meter	kgf·m	1/9.806 65
			Kilowatt hour	kW·h	$1/(3.6\times10^6)$
			French horse power hour	PS·h	$\approx3.776\,72\times10^{-7}$
Work	Watt (Joule per second)	W (J/s)	Kilogram-force meter per second	kgf·m/s	1/9.806 65
			Kilocalorie per hour	kcal/h	1/1.163
			French horse power	PS	≈1/735.498 8
Viscosity, Viscosity Index	Pascal second	Pa·s	Poise	P	10
Kinematic Viscosity, Kinematic Viscosity Index	Square meter per second	m^2/s	Stokes	St	10^4
			Centistokes	cSt	10^6
Temperature	Kelvin	K	Degree, Celsius	°C	(See Note (1))
Electric Current, Magnetomotive Force	Ampere	A	Ampere	A	1
Voltage, Electromotive Force	Volt	V	(Watts per ampere)	(W/A)	1
Magnetic Field Strength	Ampere per meter	A/m	Oersted	Oe	$4\pi/10^3$
Magnetic Flux Density	Tesla	T	Gauss	Gs	10^4
			Gamma	γ	10^9
Electrical Resistance	Ohm	Ω	(Volts per ampere)	(V/A)	1

Note (1) The conversion from T K into θ°C is $\theta = T - 273.15$ but for a temperature difference, it is $\Delta T = \Delta\theta$. However, ΔT and $\Delta\theta$ represent temperature differences measured using the Kelvin and Celsius scales respectively.

Remarks The names and symbols in ( ) are equivalent to those directly above them or on their left.
Example of conversion 1 N = 1/9.806 65 kgf

Appendix Table 2 N-kgf Conversion Table

How to use this table For example, to convert 10N into kgf, read the figure in the right kgf column adjacent to the 10 in the center column in the 1st block. This means that 10N is 1.0197kgf. To convert 10kgf into N, read the figure in the left N column of the same row, which indicates that the answer is 98.066N.

1 N=0.1019716 kgf
1 kgf=9.80665 N

N		kgf	N		kgf	N		kgf
9.8066	**1**	0.1020	333.43	**34**	3.4670	657.05	**67**	6.8321
19.613	**2**	0.2039	343.23	**35**	3.5690	666.85	**68**	6.9341
29.420	**3**	0.3059	353.04	**36**	3.6710	676.66	**69**	7.0360
39.227	**4**	0.4079	362.85	**37**	3.7729	686.47	**70**	7.1380
49.033	**5**	0.5099	372.65	**38**	3.8749	696.27	**71**	7.2400
58.840	**6**	0.6118	382.46	**39**	3.9769	706.08	**72**	7.3420
68.647	**7**	0.7138	392.27	**40**	4.0789	715.89	**73**	7.4439
78.453	**8**	0.8158	402.07	**41**	4.1808	725.69	**74**	7.5459
88.260	**9**	0.9177	411.88	**42**	4.2828	735.50	**75**	7.6479
98.066	**10**	1.0197	421.69	**43**	4.3848	745.31	**76**	7.7498
107.87	**11**	1.1217	431.49	**44**	4.4868	755.11	**77**	7.8518
117.68	**12**	1.2237	441.30	**45**	4.5887	764.92	**78**	7.9538
127.49	**13**	1.3256	451.11	**46**	4.6907	774.73	**79**	8.0558
137.29	**14**	1.4276	460.91	**47**	4.7927	784.53	**80**	8.1577
147.10	**15**	1.5296	470.72	**48**	4.8946	794.34	**81**	8.2597
156.91	**16**	1.6315	480.53	**49**	4.9966	804.15	**82**	8.3617
166.71	**17**	1.7335	490.33	**50**	5.0986	813.95	**83**	8.4636
176.52	**18**	1.8355	500.14	**51**	5.2006	823.76	**84**	8.5656
186.33	**19**	1.9375	509.95	**52**	5.3025	833.57	**85**	8.6676
196.13	**20**	2.0394	519.75	**53**	5.4045	843.37	**86**	8.7696
205.94	**21**	2.1414	529.56	**54**	5.5065	853.18	**87**	8.8715
215.75	**22**	2.2434	539.37	**55**	5.6084	862.99	**88**	8.9735
225.55	**23**	2.3453	549.17	**56**	5.7104	872.79	**89**	9.0755
235.36	**24**	2.4473	558.98	**57**	5.8124	882.60	**90**	9.1774
245.17	**25**	2.5493	568.79	**58**	5.9144	892.41	**91**	9.2794
254.97	**26**	2.6513	578.59	**59**	6.0163	902.21	**92**	9.3814
264.78	**27**	2.7532	588.40	**60**	6.1183	912.02	**93**	9.4834
274.59	**28**	2.8552	598.21	**61**	6.2203	921.83	**94**	9.5853
284.39	**29**	2.9572	608.01	**62**	6.3222	931.63	**95**	9.6873
294.20	**30**	3.0591	617.82	**63**	6.4242	941.44	**96**	9.7893
304.01	**31**	3.1611	627.63	**64**	6.5262	951.25	**97**	9.8912
313.81	**32**	3.2631	637.43	**65**	6.6282	961.05	**98**	9.9932
323.62	**33**	3.3651	647.24	**66**	6.7301	970.86	**99**	10.095

Appendix Table 3 kg-lb Conversion Table

How to use this table For example, to convert 10kg into lb, read the figure in the right lb column adjacent to the 10 in the center column in the 1st block. This means that 10kg is 22.046lb. To convert 10lb into kg, read the figure in the left kg column of the same row, which indicates that the answer is 4.536kg.

1 kg=2.2046226 lb
1 lb=0.45359237 kg

kg		lb	kg		lb	kg		lb
0.454	**1**	2.205	15.422	**34**	74.957	30.391	**67**	147.71
0.907	**2**	4.409	15.876	**35**	77.162	30.844	**68**	149.91
1.361	**3**	6.614	16.329	**36**	79.366	31.298	**69**	152.12
1.814	**4**	8.818	16.783	**37**	81.571	31.751	**70**	154.32
2.268	**5**	11.023	17.237	**38**	83.776	32.205	**71**	156.53
2.722	**6**	13.228	17.690	**39**	85.980	32.659	**72**	158.73
3.175	**7**	15.432	18.144	**40**	88.185	33.112	**73**	160.94
3.629	**8**	17.637	18.597	**41**	90.390	33.566	**74**	163.14
4.082	**9**	19.842	19.051	**42**	92.594	34.019	**75**	165.35
4.536	**10**	22.046	19.504	**43**	94.799	34.473	**76**	167.55
4.990	**11**	24.251	19.958	**44**	97.003	34.927	**77**	169.76
5.443	**12**	26.455	20.412	**45**	99.208	35.380	**78**	171.96
5.897	**13**	28.660	20.865	**46**	101.41	35.834	**79**	174.17
6.350	**14**	30.865	21.319	**47**	103.62	36.287	**80**	176.37
6.804	**15**	33.069	21.772	**48**	105.82	36.741	**81**	178.57
7.257	**16**	35.274	22.226	**49**	108.03	37.195	**82**	180.78
7.711	**17**	37.479	22.680	**50**	110.23	37.648	**83**	182.98
8.165	**18**	39.683	23.133	**51**	112.44	38.102	**84**	185.19
8.618	**19**	41.888	23.587	**52**	114.64	38.555	**85**	187.39
9.072	**20**	44.092	24.040	**53**	116.84	39.009	**86**	189.60
9.525	**21**	46.297	24.494	**54**	119.05	39.463	**87**	191.80
9.979	**22**	48.502	24.948	**55**	121.25	39.916	**88**	194.01
10.433	**23**	50.706	25.401	**56**	123.46	40.370	**89**	196.21
10.886	**24**	52.911	25.855	**57**	125.66	40.823	**90**	198.42
11.340	**25**	55.116	26.308	**58**	127.87	41.277	**91**	200.62
11.793	**26**	57.320	26.762	**59**	130.07	41.730	**92**	202.83
12.247	**27**	59.525	27.216	**60**	132.28	42.184	**93**	205.03
12.701	**28**	61.729	27.669	**61**	134.48	42.638	**94**	207.23
13.154	**29**	63.934	28.123	**62**	136.69	43.091	**95**	209.44
13.608	**30**	66.139	28.576	**63**	138.89	43.545	**96**	211.64
14.061	**31**	68.343	29.030	**64**	141.10	43.998	**97**	213.85
14.515	**32**	70.548	29.484	**65**	143.30	44.452	**98**	216.05
14.969	**33**	72.753	29.937	**66**	145.51	44.906	**99**	218.26

Appendix Table 4 °C-°F Conversion Table

How to use this table For example, to convert 38°C into °F, read the figure in the right °F column adjacent to the 38 in the center column in the 2nd block. This means that 38°C is 100.4°F. To convert 38°F into°C, read the figure in the left °C column of the same row, which indicates that the answer is 3.3°C.

$$C=\frac{5}{9}(F-32)$$

$$F=32+\frac{9}{5}C$$

°C		°F	°C		°F	°C		°F	°C		°F
−73.3	**−100**	−148.0	0.0	**32**	89.6	21.7	**71**	159.8	43.3	**110**	230
−62.2	**− 80**	−112.0	0.6	**33**	91.4	22.2	**72**	161.6	46.1	**115**	239
−51.1	**− 60**	− 76.0	1.1	**34**	93.2	22.8	**73**	163.4	48.9	**120**	248
−40.0	**− 40**	− 40.0	1.7	**35**	95.0	23.3	**74**	165.2	51.7	**125**	257
−34.4	**− 30**	− 22.0	2.2	**36**	96.8	23.9	**75**	167.0	54.4	**130**	266
−28.9	**− 20**	− 4.0	2.8	**37**	98.6	24.4	**76**	168.8	57.2	**135**	275
−23.3	**− 10**	14.0	3.3	**38**	100.4	25.0	**77**	170.6	60.0	**140**	284
−17.8	**0**	32.0	3.9	**39**	102.2	25.6	**78**	172.4	65.6	**150**	302
−17.2	**1**	33.8	4.4	**40**	104.0	26.1	**79**	174.2	71.1	**160**	320
−16.7	**2**	35.6	5.0	**41**	105.8	26.7	**80**	176.0	76.7	**170**	338
−16.1	**3**	37.4	5.6	**42**	107.6	27.2	**81**	177.8	82.2	**180**	356
−15.6	**4**	39.2	6.1	**43**	109.4	27.8	**82**	179.6	87.8	**190**	374
−15.0	**5**	41.0	6.7	**44**	111.2	28.3	**83**	181.4	93.3	**200**	392
−14.4	**6**	42.8	7.2	**45**	113.0	28.9	**84**	183.2	98.9	**210**	410
−13.9	**7**	44.6	7.8	**46**	114.8	29.4	**85**	185.0	104.4	**220**	428
−13.3	**8**	46.4	8.3	**47**	116.6	30.0	**86**	186.8	110.0	**230**	446
−12.8	**9**	48.2	8.9	**48**	118.4	30.6	**87**	188.6	115.6	**240**	464
−12.2	**10**	50.0	9.4	**49**	120.2	31.1	**88**	190.4	121.1	**250**	482
−11.7	**11**	51.8	10.0	**50**	122.0	31.7	**89**	192.2	148.9	**300**	572
−11.1	**12**	53.6	10.6	**51**	123.8	32.2	**90**	194.0	176.7	**350**	662
−10.6	**13**	55.4	11.1	**52**	125.6	32.8	**91**	195.8	204	**400**	752
−10.0	**14**	57.2	11.7	**53**	127.4	33.3	**92**	197.6	232	**450**	842
− 9.4	**15**	59.0	12.2	**54**	129.2	33.9	**93**	199.4	260	**500**	932
− 8.9	**16**	60.8	12.8	**55**	131.0	34.4	**94**	201.2	288	**550**	1022
− 8.3	**17**	62.6	13.3	**56**	132.8	35.0	**95**	203.0	316	**600**	1112
− 7.8	**18**	64.4	13.9	**57**	134.6	35.6	**96**	204.8	343	**650**	1202
− 7.2	**19**	66.2	14.4	**58**	136.4	36.1	**97**	206.6	371	**700**	1292
− 6.7	**20**	68.0	15.0	**59**	138.2	36.7	**98**	208.4	399	**750**	1382
− 6.1	**21**	69.8	15.6	**60**	140.0	37.2	**99**	210.2	427	**800**	1472
− 5.6	**22**	71.6	16.1	**61**	141.8	37.8	**100**	212.0	454	**850**	1562
− 5.0	**23**	73.4	16.7	**62**	143.6	38.3	**101**	213.8	482	**900**	1652
− 4.4	**24**	75.2	17.2	**63**	145.4	38.9	**102**	215.6	510	**950**	1742
− 3.9	**25**	77.0	17.8	**64**	147.2	39.4	**103**	217.4	538	**1 000**	1832
− 3.3	**26**	78.8	18.3	**65**	149.0	40.0	**104**	219.2	593	**1 100**	2012
− 2.8	**27**	80.6	18.9	**66**	150.8	40.6	**105**	221.0	649	**1 200**	2192
− 2.2	**28**	82.4	19.4	**67**	152.6	41.1	**106**	222.8	704	**1 300**	2372
− 1.7	**29**	84.2	20.0	**68**	154.4	41.7	**107**	224.6	760	**1 400**	2552
− 1.1	**30**	86.0	20.6	**69**	156.2	42.2	**108**	226.4	816	**1 500**	2732
− 0.6	**31**	87.8	21.1	**70**	158.0	42.8	**109**	228.2	871	**1 600**	2912

Appendix Table 5 Viscosity Conversion Table

Kinematic Viscosity mm²/s	Saybolt Universal SUS(sec)		No.1 Type Redwood R(sec)		Engler E(degree)
	100°F	210°F	50°C	100°C	
2	32.6	32.8	30.8	31.2	1.14
3	36.0	36.3	33.3	33.7	1.22
4	39.1	39.4	35.9	36.5	1.31
5	42.3	42.6	38.5	39.1	1.40
6	45.5	45.8	41.1	41.7	1.48
7	48.7	49.0	43.7	44.3	1.56
8	52.0	52.4	46.3	47.0	1.65
9	55.4	55.8	49.1	50.0	1.75
10	58.8	59.2	52.1	52.9	1.84
11	62.3	62.7	55.1	56.0	1.93
12	65.9	66.4	58.2	59.1	2.02
13	69.6	70.1	61.4	62.3	2.12
14	73.4	73.9	64.7	65.6	2.22
15	77.2	77.7	68.0	69.1	2.32
16	81.1	81.7	71.5	72.6	2.43
17	85.1	85.7	75.0	76.1	2.54
18	89.2	89.8	78.6	79.7	2.64
19	93.3	94.0	82.1	83.6	2.76
20	97.5	98.2	85.8	87.4	2.87
21	102	102	89.5	91.3	2.98
22	106	107	93.3	95.1	3.10
23	110	111	97.1	98.9	3.22
24	115	115	101	103	3.34
25	119	120	105	107	3.46
26	123	124	109	111	3.58
27	128	129	112	115	3.70
28	132	133	116	119	3.82
29	137	138	120	123	3.95
30	141	142	124	127	4.07
31	145	146	128	131	4.20
32	150	150	132	135	4.32
33	154	155	136	139	4.45
34	159	160	140	143	4.57

Kinematic Viscosity mm²/s	Saybolt Universal SUS(sec)		No.1 Type Redwood R(sec)		Engler E(degree)
	100°F	210°F	50°C	100°C	
35	163	164	144	147	4.70
36	168	170	148	151	4.83
37	172	173	153	155	4.96
38	177	178	156	159	5.08
39	181	183	160	164	5.21
40	186	187	164	168	5.34
41	190	192	168	172	5.47
42	195	196	172	176	5.59
43	199	201	176	180	5.72
44	204	205	180	185	5.85
45	208	210	184	189	5.98
46	213	215	188	193	6.11
47	218	219	193	197	6.24
48	222	224	197	202	6.37
49	227	228	201	206	6.50
50	231	233	205	210	6.63
55	254	256	225	231	7.24
60	277	279	245	252	7.90
65	300	302	266	273	8.55
70	323	326	286	294	9.21
75	346	349	306	315	9.89
80	371	373	326	336	10.5
85	394	397	347	357	11.2
90	417	420	367	378	11.8
95	440	443	387	399	12.5
100	464	467	408	420	13.2
120	556	560	490	504	15.8
140	649	653	571	588	18.4
160	742	747	653	672	21.1
180	834	840	734	757	23.7
200	927	933	816	841	26.3
250	1 159	1 167	1 020	1 051	32.9
300	1 391	1 400	1 224	1 241	39.5

Remarks 1mm²/s=1cSt

Appendix Table 6 inch – mm Conversion Table

1″=25.4mm

inch		0	1	2	3	4	5	6	7	8	9	10
Fraction	Decimal	mm										
0	**0.000000**	**0.000**	**25.400**	**50.800**	**76.200**	**101.600**	**127.000**	**152.400**	**177.800**	**203.200**	**228.600**	**254.000**
1/64	0.015625	0.397	25.797	51.197	76.597	101.997	127.397	152.797	178.197	203.597	228.997	254.397
1/32	0.031250	0.794	26.194	51.594	76.994	102.394	127.794	153.194	178.594	203.994	229.394	254.794
3/64	0.046875	1.191	26.591	51.991	77.391	102.791	128.191	153.591	178.991	204.391	229.791	255.191
1/16	**0.062500**	**1.588**	**26.988**	**52.388**	**77.788**	**103.188**	**128.588**	**153.988**	**179.388**	**204.788**	**230.188**	**255.588**
5/64	0.078125	1.984	27.384	52.784	78.184	103.584	128.984	154.384	179.784	205.184	230.584	255.984
3/32	0.093750	2.381	27.781	53.181	78.581	103.981	129.381	154.781	180.181	205.581	230.981	256.381
7/64	0.109375	2.778	28.178	53.578	78.978	104.378	129.778	155.178	180.578	205.978	231.378	256.778
1/8	**0.125000**	**3.175**	**28.575**	**53.975**	**79.375**	**104.775**	**130.175**	**155.575**	**180.975**	**206.375**	**231.775**	**257.175**
9/64	0.140625	3.572	28.972	54.372	79.772	105.172	130.572	155.972	181.372	206.772	232.172	257.572
5/32	0.156250	3.969	29.369	54.769	80.169	105.569	130.969	156.369	181.769	207.169	232.569	257.969
11/64	0.171875	4.366	29.766	55.166	80.566	105.966	131.366	156.766	182.166	207.566	232.966	258.366
3/16	**0.187500**	**4.762**	**30.162**	**55.562**	**80.962**	**106.362**	**131.762**	**157.162**	**182.562**	**207.962**	**233.362**	**258.762**
13/64	0.203125	5.159	30.559	55.959	81.359	106.759	132.159	157.559	182.959	208.359	233.759	259.159
7/32	0.218750	5.556	30.956	56.356	81.756	107.156	132.556	157.956	183.356	208.756	234.156	259.556
15/64	0.234375	5.953	31.353	56.753	82.153	107.553	132.953	158.353	183.753	209.153	234.553	259.953
1/4	**0.250000**	**6.350**	**31.750**	**57.150**	**82.550**	**107.950**	**133.350**	**158.750**	**184.150**	**209.550**	**234.950**	**260.350**
17/64	0.265625	6.747	32.147	57.547	82.947	108.347	133.747	159.147	184.547	209.947	235.347	260.747
9/32	0.281250	7.144	32.544	57.944	83.344	108.744	134.144	159.544	184.944	210.344	235.744	261.144
19/64	0.296875	7.541	32.941	58.341	83.741	109.141	134.541	159.941	185.341	210.741	236.141	261.541
5/16	**0.312500**	**7.938**	**33.338**	**58.738**	**84.138**	**109.538**	**134.938**	**160.338**	**185.738**	**211.138**	**236.538**	**261.938**
21/64	0.328125	8.334	33.734	59.134	84.534	109.934	135.334	160.734	186.134	211.534	236.934	262.334
11/32	0.343750	8.731	34.131	59.531	84.931	110.331	135.731	161.131	186.531	211.931	237.331	262.731
23/64	0.359375	9.128	34.528	59.928	85.328	110.728	136.128	161.528	186.928	212.328	237.728	263.128
3/8	**0.375000**	**9.525**	**34.925**	**60.325**	**87.725**	**111.125**	**136.525**	**161.925**	**187.325**	**212.725**	**238.125**	**263.525**
25/64	0.390625	9.922	35.322	60.722	86.122	111.522	136.922	162.322	187.722	213.122	238.522	263.922
13/32	0.406250	10.319	35.719	61.119	86.519	111.919	137.319	162.719	188.119	213.519	238.919	264.319
27/64	0.421875	10.716	36.116	61.516	86.916	112.316	137.716	163.116	188.516	213.916	239.316	264.716
7/16	**0.437500**	**11.112**	**36.512**	**61.912**	**87.312**	**112.712**	**138.112**	**163.512**	**188.912**	**214.312**	**239.712**	**265.112**
29/64	0.453125	11.509	36.909	62.309	87.709	113.109	138.509	163.909	189.309	214.709	240.109	265.509
15/32	0.468750	11.906	37.306	62.706	88.106	113.506	138.906	164.306	189.706	215.106	240.506	265.906
31/64	0.484375	12.303	37.703	63.103	88.503	113.903	139.303	164.703	190.103	215.503	240.903	266.303
1/2	**0.500000**	**12.700**	**38.100**	**63.500**	**88.900**	**114.300**	**139.700**	**165.100**	**190.500**	**215.900**	**241.300**	**266.700**
33/64	0.515625	13.097	38.497	63.897	89.297	114.697	140.097	165.497	190.897	216.297	241.697	267.097
17/32	0.531250	13.494	38.894	64.294	89.694	115.094	140.494	165.894	191.294	216.694	242.094	267.494
35/64	0.546875	13.891	39.291	64.691	90.091	115.491	140.891	166.291	191.691	217.091	242.491	267.891
9/16	**0.562500**	**14.288**	**39.688**	**65.088**	**90.488**	**115.888**	**141.288**	**166.688**	**192.088**	**217.488**	**242.888**	**268.288**
37/64	0.578125	14.684	40.084	65.484	90.884	116.284	141.684	167.084	192.484	217.884	243.284	268.684
19/32	0.593750	15.081	40.481	65.881	91.281	116.681	142.081	167.481	192.881	218.281	243.681	269.081
39/64	0.609375	15.478	40.878	66.278	91.678	117.078	142.478	167.878	193.278	218.678	244.078	269.478
5/8	**0.625000**	**15.875**	**41.275**	**66.675**	**92.075**	**117.475**	**142.875**	**168.275**	**193.675**	**219.075**	**244.475**	**269.875**
41/64	0.640625	16.272	41.672	67.072	92.472	117.872	143.272	168.672	194.072	219.472	244.872	270.272
21/32	0.656250	16.669	42.069	67.469	92.869	118.269	143.669	169.069	194.469	219.869	245.269	270.669
43/64	0.671875	17.066	42.466	67.866	93.266	118.666	144.066	169.466	194.866	220.266	245.666	271.066
11/16	**0.687500**	**17.462**	**42.862**	**68.262**	**93.662**	**119.062**	**144.462**	**169.862**	**195.262**	**220.662**	**246.062**	**271.462**
45/64	0.703125	17.859	43.259	68.659	94.059	119.459	144.859	170.259	195.659	221.059	246.459	271.859
23/32	0.718750	18.256	43.656	69.056	94.456	119.856	145.256	170.656	196.056	221.456	246.856	272.256
47/64	0.734375	18.653	44.053	69.453	94.853	120.253	145.653	171.053	196.453	221.853	247.253	272.653
3/4	**0.750000**	**19.050**	**44.450**	**69.850**	**95.250**	**120.650**	**146.050**	**171.450**	**196.850**	**222.250**	**247.650**	**273.050**
49/64	0.765625	19.447	44.847	70.247	95.647	121.047	146.447	171.847	197.247	222.647	248.047	273.447
25/32	0.781250	19.844	45.244	70.644	96.044	121.444	146.844	172.244	197.644	223.044	248.444	273.844
51/64	0.796875	20.241	45.641	71.041	96.441	121.841	147.241	172.641	198.041	223.441	248.841	274.241
13/16	**0.812500**	**20.638**	**46.038**	**71.438**	**96.838**	**122.238**	**147.638**	**173.038**	**198.438**	**223.838**	**249.238**	**274.638**
53/64	0.828125	21.034	46.434	71.834	97.234	122.634	148.034	173.434	198.834	224.234	249.634	275.034
27/32	0.843750	21.431	46.831	72.231	97.631	123.031	148.431	173.831	199.231	224.631	250.031	275.431
55/64	0.859375	21.828	47.228	72.628	98.028	123.428	148.828	174.228	199.628	225.028	250.428	275.828
7/8	**0.875000**	**22.225**	**47.625**	**73.025**	**98.425**	**123.825**	**149.225**	**174.625**	**200.025**	**225.425**	**250.825**	**276.225**
57/64	0.890625	22.622	48.022	73.422	98.822	124.222	149.622	175.022	200.422	225.822	251.222	276.622
29/32	0.906250	23.019	48.419	73.819	99.219	124.619	150.019	175.419	200.819	226.219	251.619	277.019
59/64	0.921875	23.416	48.816	74.216	99.616	125.016	150.416	175.816	201.216	226.616	252.016	277.416
15/16	**0.937500**	**23.812**	**49.212**	**74.612**	**100.012**	**125.412**	**150.812**	**176.212**	**201.612**	**227.012**	**252.412**	**277.812**
61/64	0.953125	24.209	49.609	75.009	100.409	125.809	151.209	176.609	202.009	227.409	252.809	278.209
31/32	0.968750	24.606	50.006	75.406	100.806	126.206	151.606	177.006	202.406	227.806	253.206	278.606
63/64	0.984375	25.003	50.403	75.803	101.203	126.603	152.003	177.403	202.803	228.203	253.603	279.003

Appendix Table 7 Hardness Conversion Table (Reference)

Rockwell C Scale Hardness (1 471N) {150kgf}	Vickers Hardness	Brinell Hardness		Rockwell Hardness		Shore Hardness
		Standard Ball	Tungsten Carbide Ball	A Scale Load 588.4N {60kgf} Brale Indenter	B Scale Load 980.7N {100kgf} 1.588mm (1/16in) Ball	
68	940	—	—	85.6	—	97
67	900	—	—	85.0	—	95
66	865	—	—	84.5	—	92
65	832	—	739	83.9	—	91
64	800	—	722	83.4	—	88
63	772	—	705	82.8	—	87
62	746	—	688	82.3	—	85
61	720	—	670	81.8	—	83
60	697	—	654	81.2	—	81
59	674	—	634	80.7	—	80
58	653	—	615	80.1	—	78
57	633	—	595	79.6	—	76
56	613	—	577	79.0	—	75
55	595	—	560	78.5	—	74
54	577	—	543	78.0	—	72
53	560	—	525	77.4	—	71
52	544	500	512	76.8	—	69
51	528	487	496	76.3	—	68
50	513	475	481	75.9	—	67
49	498	464	469	75.2	—	66
48	484	451	455	74.7	—	64
47	471	442	443	74.1	—	63
46	458	432	432	73.6	—	62
45	446	421	421	73.1	—	60
44	434	409	409	72.5	—	58
43	423	400	400	72.0	—	57
42	412	390	390	71.5	—	56
41	402	381	381	70.9	—	55
40	392	371	371	70.4	—	54
39	382	362	362	69.9	—	52
38	372	353	353	69.4	—	51
37	363	344	344	68.9	—	50
36	354	336	336	68.4	(109.0)	49
35	345	327	327	67.9	(108.5)	48
34	336	319	319	67.4	(108.0)	47
33	327	311	311	66.8	(107.5)	46
32	318	301	301	66.3	(107.0)	44
31	310	294	294	65.8	(106.0)	43
30	302	286	286	65.3	(105.5)	42
29	294	279	279	64.7	(104.5)	41
28	286	271	271	64.3	(104.0)	41
27	279	264	264	63.8	(103.0)	40
26	272	258	258	63.3	(102.5)	38
25	266	253	253	62.8	(101.5)	38
24	260	247	247	62.4	(101.0)	37
23	254	243	243	62.0	100.0	36
22	248	237	237	61.5	99.0	35
21	243	231	231	61.0	98.5	35
20	238	226	226	60.5	97.8	34
(18)	230	219	219	—	96.7	33
(16)	222	212	212	—	95.5	32
(14)	213	203	203	—	93.9	31
(12)	204	194	194	—	92.3	29
(10)	196	187	187	—	90.7	28
(8)	188	179	179	—	89.5	27
(6)	180	171	171	—	87.1	26
(4)	173	165	165	—	85.5	25
(2)	166	158	158	—	83.5	24
(0)	160	152	152	—	81.7	24

NSK

Appendix Table 8 Values of Standard Tolerance Grades IT

Basic Size (mm)		IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11
over	incl	Tolerances (μm)										
—	3	0.8	1.2	2	3	4	6	10	14	25	40	60
3	6	1	1.5	2.5	4	5	8	12	18	30	48	75
6	10	1	1.5	2.5	4	6	9	15	22	36	58	90
10	18	1.2	2	3	5	8	11	18	27	43	70	110
18	30	1.5	2.5	4	6	9	13	21	33	52	84	130
30	50	1.5	2.5	4	7	11	16	25	39	62	100	160
50	80	2	3	5	8	13	19	30	46	74	120	190
80	120	2.5	4	6	10	15	22	35	54	87	140	220
120	180	3.5	5	8	12	18	25	40	63	100	160	250
180	250	4.5	7	10	14	20	29	46	72	115	185	290
250	315	6	8	12	16	23	32	52	81	130	210	320
315	400	7	9	13	18	25	36	57	89	140	230	360
400	500	8	10	15	20	27	40	63	97	155	250	400
500	630	9	11	16	22	30	44	70	110	175	280	440
630	800	10	13	18	25	35	50	80	125	200	320	500
800	1 000	11	15	21	29	40	56	90	140	230	360	560
1 000	1 250	13	18	24	34	46	66	105	165	260	420	660
1 250	1 600	15	21	29	40	54	78	125	195	310	500	780
1 600	2 000	18	25	35	48	65	92	150	230	370	600	920
2 000	2 500	22	30	41	57	77	110	175	280	440	700	1 100
2 500	3 150	26	36	50	69	93	135	210	330	540	860	1 350

Remarks 1. Standard tolerance grades IT14 to IT18 shall not be used for basic sizes less than or equal to 1mm.
2. Values for standard tolerance grades IT1 to IT5 for basic sizes over 500mm are included for experimental use.

Grades							Basic Size (mm)	
IT12	IT13	IT14	IT15	IT16	IT17	IT18		
Tolerances (mm)							over	incl
0.10	0.14	0.26	0.40	0.60	1.00	1.40	—	3
0.12	0.18	0.30	0.48	0.75	1.20	1.80	3	6
0.15	0.22	0.36	0.58	0.90	1.50	2.20	6	10
0.18	0.27	0.43	0.70	1.10	1.80	2.70	10	18
0.21	0.33	0.52	0.84	1.30	2.10	3.30	18	30
0.25	0.39	0.62	1.00	1.60	2.50	3.90	30	50
0.30	0.46	0.74	1.20	1.90	3.00	4.60	50	80
0.35	0.54	0.87	1.40	2.20	3.50	5.40	80	120
0.40	0.63	1.00	1.60	2.50	4.00	6.30	120	180
0.46	0.72	1.15	1.85	2.90	4.60	7.20	180	250
0.52	0.81	1.30	2.10	3.20	5.20	8.10	250	315
0.57	0.89	1.40	2.30	3.60	5.70	8.90	315	400
0.63	0.97	1.55	2.50	4.00	6.30	9.70	400	500
0.70	1.10	1.75	2.80	4.40	7.00	11.00	500	630
0.80	1.25	2.00	3.20	5.00	8.00	12.50	630	800
0.90	1.40	2.30	3.60	5.60	9.00	14.00	800	1 000
1.05	1.65	2.60	4.20	6.60	10.50	16.50	1 000	1 250
1.25	1.95	3.10	5.00	7.80	12.50	19.50	1 250	1 600
1.50	2.30	3.70	6.00	9.20	15.00	23.00	1 600	2 000
1.75	2.80	4.40	7.00	11.00	17.50	28.00	2 000	2 500
2.10	3.30	5.40	8.60	13.50	21.00	33.00	2 500	3 150

Appendix Table 9 Physical and Mechanical Properties of Materials

Materials	Specific Gravity	Coefficient of Linear Expansion (0° to 100°C)	Hardness (Brinell)	Modulus of Direct Elasticity (MPa) {kgf/mm²}	Tensile Strength (MPa) {kgf/mm²}	Yield Point (MPa) {kgf/mm²}	Elongation (%)
Bearing Steel (hardened)	7.83	12.5×10^{-6}	650 to 740	208 000 {21 200}	1 570 to 1 960 {160 to 200}	—	—
Martensitic Stainless Steel SUS 440C	7.68	10.1×10^{-6}	580	200 000 {20 400}	1 960 {200}	1 860 {190}	—
Mild Steel (C=0.12 to 0.20%)	7.86	11.6×10^{-6}	100 to 130	206 000 {21 000}	373 to 471 {38 to 48}	216 to 294 {22 to 30}	24 to 36
Hard Steel (C=0.3 to 0.5%)	7.84	11.3×10^{-6}	160 to 200	206 000 {21 000}	539 to 686 {55 to 70}	333 to 451 {34 to 46}	14 to 26
Austenitic Stainless Steel SUS 304	8.03	16.3×10^{-6}	150	193 000 {19 700}	588 {60}	245 {25}	60
Cast Iron — Gray Iron FC200	7.3	10.4×10^{-6}	223	98 100 {10 000}	200 {21}	—	—
Cast Iron — Spheroidal graphite Iron FCD400	7.0	11.7×10^{-6}	Less than 201		More than 400 {41}	—	More than 12
Aluminum	2.69	23.7×10^{-6}	15 to 26	70 600 {7 200}	78 {8}	34 {3.5}	35
Zinc	7.14	31×10^{-6}	30 to 60	92 200 {9 400}	147 {15}	—	30 to 40
Copper	8.93	16.2×10^{-6}	50	123 000 {12 500}	196 {20}	69 {7}	15 to 20
Brass (Annealed)	8.5	19.1×10^{-6}	45	103 000 {10 500}	294 to 343 {30 to 35}	—	65 to 75
Brass (Machined)			85 to 130		363 to 539 {37 to 55}		15 to 50

Remarks The hardness of hardened bearing steel and martensitic stainless steel is usually expressed using the Rockwell C Scale, but for comparison, it is converted into Brinell hardness.

Bearing Conversion Tables

Conversion Table 1
Deep groove ball bearings
Open type (Metric series)

Bore diameter d		NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
mm	inch									
1	0.0394	681	AX1	—	681	UL103	—	—	L-310	681
		MR31	—	—	—	—	—	—	L-310W51	—
		691	—	—	691	—	—	—	R-410	691
1.2	0.0472	MR41X	—	—	—	—	—	—	R-412	BC1.2-4
1.5	0.0591	681X	AX1.5	—	68/1.5	UL154	—	—	R-415	68/1.5
		691X	619/1.5	MR69/1.5	69/1.5	R1550	19M1-5Y1	EL1.5C	R-515	69/1.5
		601X	—	—	—	—	—	—	R-615	60/1.5
2	0.0787	682	BX2	MR682	682	UL205	—	UL20C	L-520	682
		MR52B	—	—	—	—	—	—	L-520W02	BC2-5
		692	AX2	MR619/2	692	R2060	19M2Y1	EL2C	R-620	692
		MR62	—	—	—	—	—	—	R-620W52	BC2-6
		MR72	—	—	—	—	—	—	R-720Y52	BC2-7
		602	—	—	—	—	—	—	R-720	602
2.5	0.0984	682X	AX2.5	—	68/2.5	UL256	18M2-5	—	L-625	68/2.5
		692X	X2.5	—	69/2.5	—	19M2-5Y1	—	R-725	69/2.5
		MR82X	—	—	—	—	—	—	R-825Y52	BC2.5-8
		602X	60/2.5	MR60/2.5	60/2.5	R2580	—	—	R-825	60/2.5
3	0.1181	MR63	617/3	—	—	—	—	—	L-630	673
		683A	AX3	MR618/3	683	UL307	—	UL30C	L-730	683
		MR83	X3	—	693/003	—	—	—	R-830Y52	BC3-8
		693	619/3	—	693	—	—	—	R-830	693
		MR93	—	—	—	—	—	—	R-930Y52	BC3-9
		603	—	—	—	—	—	—	R930	603
		623	623	MR623	623	R3100	2M3Y1	EL-3R	R-1030	623
		633	—	—	—	—	—	—	—	633
4	0.1575	MR74	617/4	—	—	—	—	—	L-740	674
		MR84	—	—	—	—	—	—	L-840	BC4-8
		684A	AX4	MR618/4	684	UL409	—	UL40C	L-940	684
		MR104B	X4	—	—	—	—	—	L-1040	BC4-10
		694	AY4	—	694	—	—	—	R-1140	694
		604	604	—	604	—	—	—	R-1240	604
		624	624	MR624	624	R4130	2M4	EL4R	R-1340	624
		634	634	MR634	634	R4160	34	—	R-1640	634
5	0.1969	MR85	617/5	—	—	—	—	—	L-850	675
		MR95	—	—	—	—	—	—	L-950	BC5-9
		MR105	—	—	—	—	—	—	L-1050	BC5-10
		685	X5	MR618/5	685	UL511	—	UL50C	L-1150	685
		695	AY5	—	695	—	—	—	R-1350	695
		605	—	—	605	—	—	—	R-1450	605
		625	625	MR625	625	R5160	34-5	EL5R	R-1650	625
		635	635	MR635	635	R5190	35	—	R-1950	635
6	0.2362	MR106	617/6	—	—	—	—	—	L-1060	676
		MR126	X6	—	—	—	—	—	L-1260	BC6-12
		686A	AX6	MR618/6	686	UL613	—	UL60C	L-1360	686
		696	AY6	—	696	—	—	—	R-1560	696
		606	—	—	—	—	—	—	R-1760	606
		626	626	MR626	626	U6190	36	EL6R	R-1960	626
		636	—	—	—	—	—	—	—	636
7	0.2756	MR117	617/7	—	—	—	—	—	L-1170	677
		MR137	—	—	—	—	—	—	L-1370	BC7-13
		687	AX7	618/7	687	UL714	—	UL70C	L-1470	687
		697	AY7	—	697	—	—	—	—	697
		607	607	MR607	607	—	—	EL7R	R-1970	607
		627	627	MR627	627	R7220	37	—	R-2270	627
		637	—	—	—	—	—	—	—	637
8	0.3150	MR128	617/8	—	—	—	—	—	L-1280	678
		MR148	—	—	—	—	—	—	L-1480	BC8-14
		688A	X8	MR618/8	688	UL816	—	—	L-1680	688
		698	AY8	—	698	—	19M8	—	R-1980	698
		608	608	MR608	608	R8220	38	EL8R	R-2280	608
		628	—	—	—	—	—	—	—	628
		638	—	—	—	—	—	—	—	638
9	0.3543	689	X9	—	689	UL917	—	—	L-1790	689
		699	AY9	—	699	—	19M9	—	L-2090	699
		609	609	609	609	609	—	—	—	609
		629	629	MR629	629	—	39	—	—	629
		639	—	—	—	—	—	—	—	639
In case of stainless steel		———h S———	W———	S———	S———	———X	S———	S———	SS———	F———

Conversion Table 2
Deep groove ball bearings
Shielded type (Metric series)

Bore diameter d		NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
mm	inch									
1.5	0.0591	681XZZ	AX1.5ZZ	—	68/1.5-2Z	ULZ154	—	UL15CHH	L-415ZZ	W68/1.5ZZA
		691XZZ	X1.5ZZ	—	69/1.5-2Z	—	—	—	R-515ZZ	W69/1.5ZZA
		601XZZS	—	—	—	—	—	—	R-615ZZ	W60/1.5ZZA
2	0.0787	682ZZ	BX2ZZ	—	682-2Z	ULZ205	38M2SS	UL20CHH	L-520ZZ	W682ZZA
		MR52BZZ	—	—	—	—	—	—	L-520ZZW52	WBC2-5ZZA
		692ZZ	AX2ZZ	—	—	—	—	—	R-620ZZ	W692ZZA
		MR62ZZ	—	—	—	—	—	—	R-620ZZY52	—
		MR72ZZ	—	—	—	—	—	—	R-720ZZY03	WBC2-7ZZA
		602ZZ	—	—	—	—	—	—	R-720ZZ	W602ZZA
2.5	0.0984	682XZZ	AX2.5ZZ	—	68/2.5-2Z	ULZ256	38M2-5SS	—	L-625ZZ	W68/2.5ZZA
		692XZZ	—	—	69/2.5-2Z	—	—	—	R-725ZZ	W69/2.5ZZA
		602XZZ	—	—	—	—	—	—	R-825ZZ	W60/2.5ZZA
3	0.1181	MR63ZZ	—	—	—	—	—	—	L-630ZZ	WA673ZZA
		683AZZ	AX3ZZ	—	683-2Z	ULZ307	38M3SS	UL30CHH	L-730ZZ	W683ZZA
		693ZZ	—	—	693-2Z	—	—	—	R-830ZZ	W693ZZA
		MR93ZZ	—	—	—	—	—	—	R-930ZZY04	WBC3-9ZZA
		623ZZ	623ZZ	623.27	623-2Z	RF310	2M3SSY1	EL3RHH	R-1030ZZ	623ZZ
		633ZZ	—	—	—	—	—	—	—	633ZZ
4	0.1575	MR74ZZ	—	—	—	—	—	—	L-740X2ZZ	WA674ZZA
		MR84ZZ	—	—	—	—	—	—	L-840ZZ	WBC4-8ZZA
		684AZZ	638/4ZZ	—	684-2Z	ULZ409	38M455	UL40CHH	L-940ZZ	W684ZZA
		MR104BZZ	X4ZZ	—	—	—	—	—	L-1040ZZ	WBC4-10ZZA
		694ZZ	AY4ZZ	—	694-2Z	—	—	—	R-1140ZZ	694ZZ
		604ZZ	604ZZ	—	604-2Z	—	—	—	R-1240ZZ	604ZZ
		624ZZ	624ZZ	624.2Z	624-2Z	RF413	2M4SS	EL4RHH	R-1340ZZ	624ZZ
		634ZZ1	634ZZ	MR634.27	634-2Z	RV416	34SS	34RHH	R-1640ZZ	634ZZ
5	0.1969	MR85ZZ	—	—	—	—	—	—	L-850ZZ	WA675ZZA
		MR95ZZ1	—	—	—	—	—	—	L-950X2ZZ	WBC5-9ZZA
		MR105ZZ	—	—	—	—	—	—	L-1050ZZ	WBC5-10ZZA
		685ZZ	638/5ZZ	—	685-2Z	ULZ511	—	UL50CHH	L-1150ZZ	W685ZZ
		695ZZ	AY5ZZ	—	695-2Z	—	—	—	R-1350ZZ	695ZZ
		605ZZ	—	—	605-2Z	—	—	—	R-1450ZZ	605ZZ
		625ZZ1	625ZZ	625.2Z	625-2Z	RV516	34-5SS	EL5RHH	R-1650ZZ	625ZZ
		635ZZ1	635ZZ	MR635.2Z	635-2Z	RV519	35SS	—	R-1950ZZ	635ZZ
6	0.2362	MR106ZZ1	—	—	—	—	—	—	L-1060ZZ	WA676ZZA
		MR126ZZ	X6ZZ	—	—	—	—	—	L-1260ZZ	WBC6-12ZZA
		686AZZ	628/6ZZ	—	686-2Z	ULZ613	—	UL60CHH	L-1360ZZ	W686ZZ
		696ZZ1	ZY6ZZ	MR626.2Z	696-2Z	—	—	—	R-1560ZZ	696ZZ
		606ZZ	—	—	—	—	—	—	R-1760ZZ	606ZZ
		626ZZ1	626ZZ	—	626-2Z	RV619	36SS	EL6RHH	R-1960ZZ	626ZZ
		636ZZ	—	—	—	—	—	—	—	636ZZ
7	0.2756	MR117ZZ	—	—	—	—	—	—	L-1170ZZ	WA677ZZA
		MR137ZZ	—	—	—	—	—	—	L-1370ZZ	WBC7-13ZZA
		687ZZ1	AX7ZZ	—	687-2Z	ULZ714	—	UL70CH	L-1470ZZ	W687ZZ
		697ZZ1	AY7ZZ	—	697-2Z	—	—	—	—	697ZZ
		607ZZ1	607ZZ	607.2Z	607-2Z	—	—	EL7RHH	R-1970ZZ	607ZZ
		627ZZ	627ZZ	MR627.2Z	627-2Z	RV722	37SS	—	R-2270ZZ	627ZZ
		637ZZ	—	—	—	—	—	—	—	637ZZ
8	0.3150	MR128ZZ1	637/8ZZ	—	—	—	—	—	L-1280ZZ	W678ZZA
		MR148ZZ	—	—	—	—	—	—	L-1480ZZ	WBC8-14ZZA
		688AZZ1	X8ZZ	—	—	ULZ816	—	—	L-1680ZZ	W688ZZ
		698ZZ	AY8ZZ	—	698-2Z	—	19M8SS	—	R-1980ZZ	698ZZ
		608ZZ	608ZZ	MR608.2Z	608-2Z	RV822	38SS	EL8RHH	R-2280ZZ	608ZZ
		628ZZ	—	—	—	—	—	—	—	628ZZ
		638ZZ	—	—	—	—	—	—	—	638ZZ
9	0.3543	689ZZ1	X9ZZ	—	—	ULZ917	—	—	L-1790ZZ	W689ZZ
		699ZZ1	AY9ZZ	—	699-2Z	—	19M9SS	—	L-2090ZZ	699ZZ
		609ZZ	609ZZ	609.22	609-2Z	—	—	—	—	609ZZ
		629ZZ	629ZZ	MR629.2Z	629-2Z	—	39SS	—	—	629ZZ
		639ZZ	—	—	—	—	—	—	—	639ZZ
In case of stainless steel		———h S———	W———	S———	S———	———X	S———	S———	SS———	F———

Conversion Table 3
Deep groove ball bearings with flanged outer ring
Open type (Metric series)

Bore diameter d		NSK	ADR	GRW	RMB	BARDEN	MPB	NMB	NTN
mm	inch								
1	0.0394	F681	—	—	—	—	—	LF-310	FL681
		F691	—	—	—	—	—	RF-410	FL691
1.2	0.0472	MF41X	—	—	—	—	—	RF-412	FLBC1.2-4
1.5	0.0591	F681X	FAX1.5	F68/1.5	ULK154	—	—	LF-415	FL68/1.5
		F691X	F619/1.5	F69/1.5	—	F19M1-5Y1	—	RF-515	FL69/1.5
		F601X	—	—	—	—	—	RF-615	EL60/1.5
2	0.0787	F682	FBX2	F682	ULK205	F682	UL20FC	LF-520	FL682
		MF52B	—	—	—	—	—	—	—
		F692	FAX2	F692	RK2060	F692	—	RF-620	FL692
		MF62	—	—	—	—	—	RF-620W52	FLBC2-6
		MF72	—	—	—	—	—	RF-720Y52	—
		F602	—	—	—	—	—	RF-720	FL602
2.5	0.0984	F682X	FAX2.5	F68/2.5	ULK256	F68/2.5	—	LF-625	FL68/2.5
		F692X	FX2.5	F69/2.5	—	F19M2-5Y1	—	RF-725	FI69/2.5
		MF82X	—	—	—	—	—	RF-825Y52	FLBC2.5-8
		F602X	—	—	RK2580	—	—	RF-825	FL60/2.5
3	0.1181	MF63	—	—	—	—	—	LF-630	FL673
		F683A	FAX3	F683	ULK307	F683	UL30FC	LF-730	FL683
		MF83	—	—	—	—	—	RF-830Y52	FLBC3-8
		F693	FX3	F693	—	F693	—	RF-830	FL693
		MF93	—	—	—	—	—	RF930Y52	FLBC3-9
		F603	—	—	—	—	—	RF-930	FL603
		F623	F623	F623	RK3100	F623	—	RF-1030	FL623
4	0.1575	MF74	—	—	—	—	—	LF-740	FL674
		MF84	—	—	—	—	—	LF-840	FLBC4-8
		F684A	FAX4	F684	ULK409	F684	UL40FC	LF-940	FL684
		MF104B	—	—	—	—	—	LF-1040	FLBC4-10
		F694	—	F694	—	F694	—	RF-1140	FL694
		F604	—	—	—	—	—	RF-1240	FL604
		F624	F624	F624	—	F624	—	RF-1340	FL624
		F634	—	F634	—	F634	—	RF-1640	—
5	0.1969	MF85	—	—	—	—	—	LF-850	FL675
		MF95	—	—	—	—	—	LF-950	FLBC5-9
		MF105	—	—	—	—	—	LF-1050	FLBC5-10
		F685	FX5	F685	ULK511	F685	UL50FC	LF-1150	FL685
		F695	—	F695	—	F695	—	RF-1350	FL695
		F605	—	F605	—	—	—	RF-1450	FL605
		F625	—	F625	—	F625	—	RF-1650	FL625
		F635	—	F635	—	F635	—	RF-1950	—
6	0.2362	MF106	—	—	—	—	—	LF-1060	FL676
		MF126	—	—	—	—	—	LF-1260	FLBC6-12
		F686A	FAX6	F686	—	F686	UL60FC	LF-1360	FL686
		F696	—	F696	—	F696	—	RF-1560	FL696
		F606	—	—	—	—	—	RF-1760	FL606
		F626	—	F626	—	F626	—	RF-1960	FL626
7	0.2756	MF117	—	—	—	—	—	LF-1170	FL677
		MF137	—	—	—	—	—	LF-1370	FLBC7-13
		F687	FAX7	F687	ULK714	F687	UL70FC	LF-1470	FL687
		F697	—	F697	—	F697	—	—	FL697
		F607	F607	F607	—	F607	—	—	—
		F627	—	—	—	—	—	RF-2270	—
8	0.3150	MF128	—	—	—	—	—	LF-1280	FL678
		MF148	—	—	—	—	—	LF-1480	FLBC8-14
		F688A	FX8	F688	ULK816	F688	—	LF-1680	FL688
		F698	—	F698	—	F698	—	RF-1980	FL698
		F608	F608	F608	—	—	—	RF-2280	FL608
9	0.3543	F689	FX9	F689	—	—	—	LF-1790	FL689
		F699	—	—	—	—	—	—	—
In case of stainless steel		————h S————	W————	S————	————X	S————	S————	SS————	F————

Conversion Table 4
Deep groove ball bearings with flanged outer ring
Shielded type (Metric series)

Bore diameter d		NSK	ADR	GRW	RMB	BARDEN	MPB	NMB	NTN
mm	inch								
1.5	0.591	F691XZZ	FX1.5ZZ	F69/1.5-2Z	—	—	—	RF-515ZZ	FLW69/1.5ZZA
		F601XZZ	—	—	—	—	—	RF-615ZZ	FLW60/1.5ZZA
2	0.0787	F682ZZ	FBX2ZZ	F682-2Z	ULKZ205	F682SS	UL20FCHH	LF-520ZZ	FLW682ZZA
		MF52BZZ	—	—	—	—	—	—	—
		F692ZZ	FAX2ZZ	—	—	F692SS	—	RF-620ZZ	FLW692ZZA
		MF72ZZ	—	—	—	—	—	RF-720ZZY03	FLWBC2-7ZZA
		F602ZZ	—	—	—	—	—	RF-720ZZ	FLW602ZZA
2.5	0.0984	F682XZZ	FAX2.5ZZ	F68/2.5-2Z	ULKZ256	F68/2.5SS	—	LF-625ZZ	FLW68/2.5ZZA
		F692XZZ	FX2.5ZZ	F69/2.5-2Z	—	F69/2.5SS	—	RF-725ZZ	FLW69/2.5ZZA
		F602XZZ	—	—	—	—	—	RF-825ZZ	FLW60/2.5ZZA
3	0.1181	MF63ZZ	—	—	—	—	—	FL-630ZZ	FLWA673ZZA
		F683AZZ	FAX3ZZ	F683-2Z	ULKZ307	F683SS	UL30FCHH	LF-730ZZ	FLW683ZZA
		F693ZZ	FX3ZZ	F693-2Z	RKF308	—	—	RF-830ZZ	FLW693ZZA
		MF93ZZ	—	—	—	—	—	RF-930ZZY04	FLWBC3-9ZZA
		F623ZZ	F623ZZ	F623-2Z	RKF310	F623SS	—	RF-1030ZZ	FL623ZZA
4	0.1575	MF74ZZ	—	—	—	—	—	LF-740ZZ	FLWA674ZZA
		MF84ZZ	—	—	—	—	—	LF-840ZZ	FLWBC4-8ZZA
		F684AZZ	F638/4ZZ	F684-2Z	ULKZ409	F684SS	UL40FCHH	LF-940ZZ	FLW684ZZA
		MF104BZZ	—	—	—	—	—	LF-1040ZZ	FLAWBC4-10ZZA
		F694ZZ	—	F694-2Z	—	F694SS	—	RF-1140ZZ	FL694ZZA
		F604ZZ	—	—	—	—	—	RF-1240ZZ	FL604ZZ
		F624ZZ	F624ZZ	F624-2Z	—	F624SS	—	RF-1340ZZ	FL624ZZ
		F634ZZ1	—	F634-2Z	—	F634SS	—	RF-1640ZZ	FL634ZZ
5	0.1969	MF85ZZ	—	—	—	—	—	LF-850ZZ	FLWA675ZZA
		MF95ZZ1	—	—	—	—	—	LF-950ZZ	FLWBC5-9ZZA
		MF105ZZ	—	—	—	—	—	LF-1050ZZ	FLAWBC5-10ZZA
		F685ZZ	F638/5ZZ	F685-2Z	ULKZ511	F685SS	UL50FCHH	LF-1150ZZ	FLW685ZZA
		F695ZZ	—	F695-2Z	—	F695SS	—	RF-1350ZZ	FL695ZZ
		F605ZZ	—	F605-2Z	—	—	—	RF-1450ZZ	FL605ZZ
		F625ZZ1	—	F625-2Z	—	F625SS	—	RF-1650ZZ	FL625ZZ
		F635ZZ1	—	F635-2Z	—	F635SS	—	RF-1950ZZ	FL635ZZ
6	0.2362	MF106ZZ1	—	—	—	—	—	LF-1060ZZ	FLWA676ZZA
		MF126ZZ	—	—	—	—	—	UF-1260ZZ	FLAWBC6-12ZZA
		F686AZZ	F628/6ZZ	F686-2Z	ULKZ613	F686SS	UL60FCHH	LF-1360ZZ	FLW686ZZA
		F696ZZ1	—	F696-2Z	—	F696SS	—	RF-1560ZZ	FL696ZZ
		F606ZZ	—	—	—	—	—	RF-1760ZZ	FL606ZZ
		F626ZZ1	—	F626-27	—	F626SS	—	—	FL626ZZ
7	0.2756	MF117ZZ	—	—	—	—	—	LF-1170ZZ	FLWA677ZZA
		MF137ZZ	—	—	—	—	—	LF-1370ZZ	FLAWBC7-13ZZA
		F687ZZ1	FAX7ZZ	F687-2Z	ULKZ714	F687SS	UL70FCHH	LF-1470ZZ	FLW687ZZA
		F697ZZ1	—	F697-2Z	—	F697SS	—	—	FL697ZZ
		F607ZZ1	F607ZZ	F607-2Z	—	F607SS	—	—	FL607ZZ
		F627ZZ	—	F627-2Z	—	F627SS	—	RF-2270ZZ	FL627ZZ
8	0.3150	MF128ZZ1	—	—	—	—	—	LF-1280ZZ	FLAW678ZZA
		MF148ZZ	—	—	—	—	—	UF-1480ZZ	FLWBC8-14ZZA
		F688AZZ1	—	—	—	F688SS	—	UF-1680ZZ	FLW688ZZ
		F698ZZ	—	F698-2Z	—	F698SS	—	—	FL698ZZ
		F608ZZ	F608ZZ	F608-ZZ	—	F608SS	—	RF-2280ZZ	FL608ZZ
9	0.3543	F689ZZ1	—	—	—	F689SS	—	LF-1790ZZ	FLW689ZZ
		F699ZZ1	—	—	—	—	—	—	FL699ZZ
In case of stainless steel		————h S————	<None> W————	S————	————X	S————	S————	SS————	F————

Conversion Table 5
Deep groove ball bearings
Open type (Inch series)

Bore diameter d mm	Bore diameter d inch	NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
1.016	0.0400	R09	R09	R0308	1016	UL1304	—	2C	R1-2	R01
1.191	0.0469	R0	X3/64	R0310	1191	UL1505	R0	2½C	RI-2½	R0
1.397	0.0550	R1	R1	R0412	1397	R1706	R1	3C	RI-3	R1
1.984	0.0781	R1-4	X5/64	R0516	BR5/64	R2508	R1-4	4C	RI-4	R1-4
2.380	0.0937	R133 R1-5	AX3/32 X3/32	R0612 R620	2380 BR3/32	UL3006 R3010	R133 R1-5	3332C 5C	RI-3332 RI-5	R133 R1-5
3.175	0.1250	R144 R2-5 R2-6 R2 R2A	AX1/8 X1/8 — R2 R2A	R0816 R820 R824 R2 R2A	3175 BR1/8A BR1/8A/6 BR1/8B BR1/8B/083	UL4008 R4010 — R4012 —	R144 R2-5 R2-6 R2 R2A	418C 518C 618C R2C R2AC	RI-418 RI-518 RI-618 R-2 —	R144 R2-5 R2-6 R2 RA2
3.967	0.1562	R155	X5/32	R1020	3967	UL5010	R155	5532C	RI-5532	R155
4.762	0.1875	R156 R166 R3	AX3/16 X3/16 Y3/16	R1220 R1224 R3	4763A 4763B BR3/16	UL6010 UL6012 R6016	R156 R166 R3	5632C 6316C R3C	RI-5632 RI-6632 R-3	R156 R166 R3
6.350	0.2500	R168 R188 R4B R4AA	X1/4 R188 Y1/4 R4A	R1624 R1632 R4 R4A	6350A 6350B BR1/4A BR1/4	UL8012 UL8016 R8020 —	R168 R188 R4 R4A	614C 814C R4C R4AR	RI-614 RI-814 R-4 RI-1214	R168 R188 R4 —
7.938	0.3125	R1810	—	R2032	7938	—	R1810	8516C	RI-8516	—
9.525	0.3750	R6	Y3/8	R6	BR3/8	—	R6	R6R	RI-1438	—
In case of stainless steel		S———	W———	S———	S———	———X	S———	S———	SS———	F———

Conversion Table 6
Deep groove ball bearings
Shielded type (Inch series)

Bore diameter d mm	Bore diameter d inch	NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
1.191	0.0469	R0ZZ	X3/64ZZ	R0310.2Z	1191-2Z	ULZ1505	R0SS	2½CHH	RI-2½ZZ	RA0ZZA
1.397	0.0550	R1ZZ	R1ZZ	R0412.2Z	1397-2Z	RF1706	R1S	3CHH	RI-3ZZ	RA1ZZ1
1.984	0.0781	R1-4ZZ	X5/64ZZ	R0516.2Z	BR5/64-2Z	RF2508	R1-4SS	4CHH	RI-4ZZ	RA1-4ZZ1
2.380	0.0937	R133ZZS R1-5ZZ	AX3/32ZZ X3/32ZZ	R0612.2Z R620.2Z	2380-2Z BR3/32ZZ	ULZ3006 RF3010	R133SS R1-5SS	3332CHH 5CHH	RI-3332ZZ RI-5ZZ	RA133ZZA RA1-5ZZA
3.175	0.1250	R144ZZ R2-5ZZ R2-6ZZS R2ZZ R2AZZ	AX1/8ZZ X1/8ZZ — R2ZZ R2AZZ	R0816.2Z R820.2Z R824.2Z R2.2Z R2A.2Z	3175-2Z BR1/8A-2Z BR1/8A/6-2Z BR1/8B-2Z BR1/8B/083-2Z	ULZ4008 RF4010 — RF4012 —	R144SS R2-5SS R2-6SS R2SS R2ASS	418CHH 518CHH 618CHH R2CHH R2ACHH	RI-418ZZ RI-518ZZ RI-618ZZ R-2ZZ —	RA144ZZA RA2-5ZZA RA2-6ZZA R2ZZA RA2ZZA
3.967	0.1562	R155ZZS	X5/32ZZ	R1020.2Z	3967-2Z	ULZ5010	R155SS	5532CHH	RI-5532ZZ	RA155ZZA
4.762	0.1875	R156ZZS R166ZZ R3ZZ	AX3/16ZZ X3/16ZZ Y3/16ZZ	R1220.2Z R1224.2Z R3.2Z	4763A-2Z 4763B-2Z BR3/16-2Z	ULZ6010 ULZ6012 RF6016	R156SS R166SS R3SS	5632CHH 6316CHH R3CHH	RI-5632ZZ RI-6632ZZ R-3ZZ	RA156ZZA R166ZZA RA3ZZ
6.350	0.2500	R168ZZ R188ZZ R4BZZ R4AAZZ	X1/4ZZ R188ZZ Y1/4ZZ R4AZZ	R1624.2Z R1632.2Z R4.2Z R4A.2Z	6350A-2Z 6350B-2Z BR1/4A-2Z BR1/4-2Z	ULZ8012 ULZ8016 RF8020 —	R168SS R188SS R4SS R4ASS	614CHH 814CHH R4CHH R4ARHH	RI-614ZZ RI-814ZZ R-4ZZ RI-1214ZZ	R168ZZA RA188ZZA R4ZZ RA4ZZ
7.938	0.3125	R1810ZZ	—	R2032.2Z	7938-2Z	—	R1810SS	8516CHH	RI-8516ZZ	—
9.525	0.3750	R6ZZ	Y3/8ZZ	R6.2Z	BR3/8-2Z	—	R6SS	R6RHH	RI-1438ZZ	R6ZZ
In case of stainless steel		S———	W———	S———	S———	———X	S———	S———	SS———	F———

Conversion Table 7
Deep groove ball bearings with flanged outer ring
Open type (Inch series)

Bore diameter d mm	Bore diameter d inch	NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
1.191	0.0469	FR0	FX3/64	RF0310	F1191	ULK1505	FR0	2½FC	RIF-2½	FLR0
1.397	0.0550	FR1	FR1	RF0412	F1397	RK1706	FR1	3FC	RIF-3	FLR1
1.984	0.0781	FR1-4	FX5/64	RF0516	F5/64	RK2508	FR1-4	4FC	RIF-4	FLR1-4
2.380	0.0937	FR133 FR1-5	FAX3/32 FX3/32	RF0612 RF620	F2380 F3/32	ULK3006 RK3010	FR133 FR1-5	3332FC 5FC	RIF-3332 RIF-5	FLR133 FLR1-5
3.175	0.1250	FR144 FR2-5 FR2-6 FR2	FAX1/8 FX1/8 — FR2	RF0816 RF820 RF824 RF2	F3175 F1/8A F1/8A/6 F1/88	ULK4008 RK4010 — RK4012	FR144 FR2-5 FR2-6 FR2	418FC 518FC 618FC R2FC	RIF-418 RIF-518 RIF-618 RF-2	RIF-144 FLR2-5 FLR2-6 FLR2
3.967	0.1562	FR155	FX5/32	RF1020	F3967	ULK5010	FR155	5532FC	RIF-5532	FLR155
4.762	0.1875	FR156 FR166 FR3	FAX3/16 FX3/16 FY3/16	RF1220 RF1224 RF3	F4763A F4763B —	ULK6010 ULK6012 RK6016	FR156 FR166 FR3	5632FC 6316FC —	RIF-5632 RIF-6632 —	FLR156 FLR166 FLR3
6.350	0.2500	FR168 FR188 FR4B	FX1/4 FR188 FY1/4	RF1624 RF1632 RF4	F6350A F6350B F1/4A	ULK8012 ULK8016 RK8020	FR168 FR188 FR4	614FC 814FC R4FC	RIF-614 RIF-814 RF-4	FLR168 FLR188 FLR4
7.938	0.3125	FR1810	—	RF2032	F7938	—	FR1810	8156FC	RIF-8516	—
9.525	0.3750	FR6	—	—	—	—	—	—	—	—
In case of stainless steel		S———	W———	S———	S———	———X	S———	S———	SS———	F———

Conversion Table 8
Deep groove ball bearings with flanged outer ring
Shielded type (Inch series)

Bore diameter d mm	Bore diameter d inch	NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
1.191	0.0469	FR0ZZ	FX3/64ZZ	RF0310.2Z	F1191-2Z	ULKZ1505	FR0SS	2½FCHH	RIF-2½ZZ	FLRA0ZZA
1.397	0.0550	FR1ZZ	FR1ZZ	RF0412.2Z	F1397-2Z	RKF1706	FR1SS	3FCHH	RIF-3ZZ	FLRA1ZZA
1.984	0.0781	FR1-4ZZ	FX5/64ZZ	RF0516.2Z	F5/64-2Z	RKF2508	FR1-4SS	4FCHH	RIF-4ZZ	FLRA1-4ZZA
2.380	0.0937	FR133ZZS FR1-5ZZ	FAX3/32ZZ FX3/32ZZ	RF0612.2Z RF620.2Z	F2380-2Z F3/32-2Z	ULKZ3006 RKF3010	FR133SS FR1-5SS	3332FCHH 5FCHH	RIF-3332ZZ RIF-5ZZ	FLRA133ZZA FLRA1-5ZZA
3.175	0.1250	FR144ZZ FR2-5ZZ FR2-6ZZS FR2ZZ	FAX1/8ZZ FX1/8ZZ — FR2ZZ	RF0816.2Z RF820.2Z RF824.2Z RF2.2Z	F3175-2Z F1/8A-2Z F1/8A/6-2Z F1/8B-2Z	ULKZ4008 RKF4010 — RKF4012	FR144SS FR2-5SS FR2-6SS FR2SS	418FCHH 518FCHH 618FCHH R2FCHH	RIF-418ZZ RIF-518ZZ RIF-618ZZ RF-2ZZ	FLRA144ZZA FLRA2-5ZZA FLRA2-6ZZA FLR2ZZA
3.967	0.1562	RF155ZZS	FX5/32ZZ	RF1020.2Z	F3967-2Z	ULKZ5010	FR155SS	5532FCHH	RIF-5532ZZ	FLRA155ZZA
4.762	0.1875	FR156ZZS FR166ZZ FR3ZZ	FAX3/16ZZ FX3/16ZZ FY3/16ZZ	RF1220.2Z RF1224.2Z RF3.2Z	F4763A-2Z F4763B-2Z F3/16-2Z	ULKZ6010 ULKZ6012 RKF6016	FR156SS FR166SS FR3SS	5632FCHH 6316FCHH R3FCHH	RIF-5632ZZ RIF—6632Z RF-3ZZ	FLRA156ZZA FLRA166ZZA FLRA3ZZ
6.350	0.2500	FR168ZZ FR188ZZ FR4BZZ	FX1/4ZZ FR188ZZ FY1/4ZZ	RF1624.2Z RF1632.2Z RF4.2Z	F6350A-2Z F6350B-2Z F1/4A-2Z	ULKZ8012 ULKZ8016 RKF8020	FR168SS FR188SS FR4SS	614FCHH 814FCHH R4FCHH	RIF-614ZZ RIF-814ZZ RF-4ZZ	FLRA168ZZA FLRA188ZZA FLR4ZZ
7.938	0.3125	FR1810ZZ	—	RF2032.2Z	F7938-2Z	—	FR1810SS	8516FCHH	RIF-8516ZZ	—
9.525	0.3750	FR6ZZ	FY3/8ZZ	RF6.2Z	—	—	FR6SS	R6FRHH	RIF-1438ZZ	FLR6ZZ
In case of stainless steel		S———	W———	S———	S———	———X	S———	S———	F———	SS———

Conversion Table 9
Deep groove ball bearings with extended inner ring
Open type (Inch series)

Bore diameter d		NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
mm	inch									
1.191	0.0469	RW0	LX3/64	RE0310	E1191	ULU1505	RW0	2½CE	RI-2½EE	RW0
1.397	0.0550	RW1	LR1	RE0412	E1397	RU1706	RW1	3CE	RI-3EE	RW1
1.984	0.0781	RW1-4	LX5/64	RE0516	E5/64	—	RW1-4	4CE	RI-4EE	RW1-4
2.380	0.0937	RW133 RW1-5	LAX3/32 LX3/32	RE0612 RE620	E2380 E3/32	ULU3006 RU3010	RW133 RW1-5	3332CE 5CE	RI-3332EE RI-5EE	RW133 RW1-5
3.175	0.1250	RW144 RW2-5 RW2-6 RW2	LAX1/8 LX1/8 — LR2	RE0816 RE820 RE824 RE2	E3175 E1/8A E1/8A/6 E1/8B	ULU4008 RU4010 — —	RW144 RW2-5 RW2-6 RW2	418CE 518CE 618CE R2CE	RI-418EE RI-518EE RI-618EE R-2EE	RW144 RW2-5 RW2-6 RW2
3.967	0.1562	RW155	LX5/32	RE1020	E3967	—	RW155	5532CE	RI-5532EE	RW155
4.762	0.1875	RW156 RW166	LAX3/16 LX3/16	RE1220 RE1224	E4763A E4763B	ULU6010 ULU6012	RW156 RW166	5632CE 6316CE	RI-5632EE RI-6632EE	RW156 RW166
63.50	0.2500	RW168 RW188	LX1/4 LR188	RE1624 RE1632	E6350A E6350B	ULU8012 —	RW168 RW188	614CE 814CE	RI-614EE RI-814EE	RW168 RW188
7.938	0.3125	RW1810	—	RE2032	E7938	—	RW1810	8516CE	RI-8516EE	—
In case of stainless steel		S———	W———	S———	S———	———X	S———	S———	SS———	F———

Conversion Table 10
Deep groove ball bearings with extended inner ring
Shielded type (Inch series)

Bore diameter d		NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
mm	inch									
1.191	0.0469	RW0ZZ	LX3/64ZZ	RE0310.2Z	E1191-2Z	—	—	2½CHHE	RI-2½ZZEE	RAW0ZZA
1.397	0.0550	RW1ZZ	LR1ZZ	RE0412.2Z	E1397-2Z	—	—	3CHHE	RI-3ZZEE	RAW1ZZA
1.984	0.0781	RW1-4ZZ	LX5/64ZZ	RE0516.2Z	E5/64-2Z	—	RW1-4SS	4CHHE	RI-4ZZEE	RAW1-4ZZA
2.380	0.0937	RW133ZZS RW1-5ZZ	LAX3/32ZZ LX3/32ZZ	RE0612.2Z RE620.2Z	E2380-2Z E3/32-2Z	— —	RW133SS RW1-5SS	3332CHHE 5CHHE	RI-3332ZZEE RI-5ZZEE	RAW133ZZA RAW1-5ZZA
3.175	0.1250	RW144ZZ RW2-5ZZ RW2-6ZZS RW2ZZ	LAX1/8ZZ LX1/8ZZ — LR2ZZ	RE0816.2Z RE820.2Z RE824.2Z RE2.2Z	E3175-2Z E1/8A-2Z E1/8A/6-2Z E1/8B-2Z	ULUZ4008 — — —	RW144SS RW2-5SS RW2-6SS RW2SS	418CHHE 518CHHE 618CHHE R2CHHE	RI-418ZZEE RI-518ZZEE RI-618ZZEE R-2ZZEE	RAW144ZZA RAW2-5ZZA RAW2-6ZZA RW2ZZA
3.967	0.1562	RW155ZZS	LX5/32ZZ	RE1020.2Z	E3967-2Z	ULUZ5010	RW155SS	5532CHHE	RI-5532ZZEE	RAW155ZZA
4.762	0.1875	RW156ZZS RW166ZZ	LAX5/32ZZ LX3/16ZZ	RE1220.2Z RE1224.2Z	E4763A-2Z E4763B-2Z	ULUZ6010 ULUZ6012	RW156SS RW166SS	5632CHHE 6316CHHE	RI-5632ZZEE RI-6632ZZEE	RAW156ZZA RW166ZZA
6.350	0.2500	RW168ZZ RW188ZZ	LX1/4ZZ LR188ZZ	RE1624.2Z RE1632.2Z	E6350A-2Z E6350B-2Z	ULUZ8012 —	RW168SS RW188SS	614CHHE 814CHHE	RI-614ZZEE RI-814ZZEE	RW168ZZA RAW188ZZA
7.938	0.3125	RW1810ZZ	—	RE2032.2Z	E7938-2Z	—	RW1810SS	8516CHHE	RI-8516ZZEE	—
In case of stainless steel		S———	W———	S———	S———	———X	S———	S———	SS———	F———

Conversion Table 11
Deep groove ball bearings with extended inner ring,
Flanged, open type (Inch series)

Bore diameter d		NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
mm	inch									
1.191	0.0469	FRW0	FLX3/64	RFE0310	FE1191	ULKU1505	FRW0	2½FCE	RIF2½EE	FLRW0
1.397	0.0550	FRW1	FLR1	RFE0412	FE1397	RKU1706	FRW1	3FCE	RIF-3EE	FLRW1
1.984	0.0781	FRW1-4	FLX5/64	RFE0516	FE5/64	—	FRW1-4	4FCE	RIF-4EE	FLRW1-4
2.380	0.0937	FRW133 FRW1-5	FLAX3/32 FLX3/32	RFE0612 RFE620	FE2380 FE3/32	ULKU3006 RKU3010	FRW133 FRW1-5	3332FCE 5FCE	RIF-3332EE RIF-5EE	FLRW133 FLRW1-5
3.175	0.1250	FRW144 FRW2-5 FRW2-6 FRW2	FLAX1/8 FLX1/8 — FLR2	RFE0816 RFE820 RFE824 RFE2	FE3175 FE1/8A FE1/8A/6 FE1/8B	ULKU4008 RKU4010 — —	FRW144 FRW2-5 FRW2-6 FRW2	418FCE 518FCE 618FCE R2FCE	RIF-418EE RIF-518EE RIF-618EE RF-2EE	FLRW144 FLRW2-5 FLRW2-6 FLRW2
3.967	0.1562	FRW155	FLX5/32	RFE1020	FE3967	—	FRW155	5532FCE	RIF-5532EE	FLRW155
4.762	0.1875	FRW156 FRW166	FLAX3/16 FLX3/16	RFE1220 RFE1224	FE4763A FE4763B	ULKU6010 ULKU6012	FRW156 FRW166	5632FCE 6316FCE	RIF-5632EE RIF-6632EE	FLRW156 FLRW166
6.350	0.2500	FRW168 FRW188	FLX1/4 FLR188	RFE1624 RFE1632	FE6350A FE6350B	ULKU8012 —	FRW168 FRW188	614FCE 814FCE	RIF-614EE RIF-814EE	FLRW168 FLRW188
7.938	0.3125	FRW1810	—	RFE2032	FE7938	—	FRW1810	8516FCE	RIF-8516EE	—
In case of stainless steel		S———	W———	S———	S———	———X	S———	S———	SS———	F———

Conversion Table 12
Deep groove ball bearings with extended inner ring,
Flanged, shielded type (Inch series)

Bore diameter d		NSK	ADR	FAG	GRW	RMB	BARDEN	MPB	NMB	NTN
mm	inch									
1.191	0.0469	FRW0ZZ	FLX3/64ZZ	RFE0310.2Z	FE1191-2Z	—	—	2½FCHHE	RIF-2½ZZEE	FLRAW0ZZA
1.397	0.0550	FRW1ZZ	FLR1ZZ	RFE0412.2Z	FE1397-2Z	—	—	3FCHHE	RIF-3ZZEE	FLRAW1ZZA
1.984	0.0781	FRW1-4ZZ	FLX5/64ZZ	RFE0516.2Z	FE5/64-2Z	—	FRW1-4SS	4FCHHE	RIF-4ZZEE	FLRAW-1-4ZZA
2.380	0.0937	FRW133ZZS FRW1-5ZZ	FLAX3/32ZZ FLX3/32ZZ	RFE0612.2Z RFE620.2Z	FE2380-2Z FE3/32-2Z	— —	FRW133SS FRW1-5SS	3332FCHHE 5FCHHE	RIF-3332ZZEE RIF-5ZZEE	FLRAW133ZZA FLRAW1-5ZZA
3.175	0.1250	FRW144ZZ FRW2-5ZZ FRW2-6ZZS FRW2ZZ	FLAX1/8ZZ FLX1/8ZZ — FLR2ZZ	RFE0816.2Z RFE820.2Z RFE824.2Z RFE2.2Z	FE3175-2Z FE1/8A-2Z FE1/8A/6-2Z FE1/8B-2Z	ULKUZ4008 — — —	FRW144SS FRW2-5SS FRW2-6SS FRW2SS	418FCHHE 518FCHHE 618FCHHE R2FCHHE	RIF-418ZZEE RIF-518ZZEE RIF-618ZZEE RF-2ZZEE	FLRAW144ZZA FLRAW2-5ZZA FLRAW2-6ZZA FLRW2ZZA
3.967	0.1562	FRW155ZZS	FLX5/32ZZ	RFE1020.2Z	FE3967-2Z	ULKUZ5010	FRW155SS	5532FCHHE	RIF-5532ZZEE	FLRAW155ZZA
4.762	0.1875	FRW156ZZS FRW166ZZ	FLAX3/16ZZ FLX3/16ZZ	RFE1220.2Z RFE1224.2Z	FE4763A-2Z FE4763B-2Z	ULKUZ6010 ULKUZ6012	FRW156SS FRW166SS	5632FCHHE 6316FCHHE	RIF-5632ZZEE RIF-6632ZZEE	FLRAW156ZZA FLARW166ZZA
6.350	0.2500	FRW168ZZ FRW188ZZ	FLX1/4ZZ FLR188ZZ	RFE1624.2Z RFE1632.2Z	FE6350A-2Z FE6350B-2Z	ULKUZ8012 —	FRW168SS FRW188SS	614FCHHE 814FCHHE	RIF-614ZZEE RIF-814ZZEE	FLARW168ZZA FLRAW188ZZA
7.938	0.3125	FRW1810ZZ	—	RFE2032.2Z	FE7938-2Z	—	FRW1810SS	8516FCHHE	RIF-8516ZZEE	—
In case of stainless steel		S———	W———	S———	S———	———X	S———	S———	SS———	F———

Conversion Table 13
Ball bearings for synchros
(Inch series)

Open type

Bore diameter d		NSK	ADR	FAG	GRW	BARDEN	MPB	NMB
mm	inch							
4.762	0.1875	SR186X1	WSP2824	—	S4763A/8	SR186X1	A245	—
		SR3X31	—	—	—	SR3X31	—	—
		SR3X23	WSP4041	SR1A-559	—	SR3X23	—	—

Single shielded type

Bore diameter d		NSK	ADR	FAG	GRW	BARDEN	MPB	NMB
mm	inch							
3.175	0.1250	SR2X52ZZS	WSP3621ZZ	SR1A-679Z	—	SR2SX52	—	—
		SR144X100ZZS	—	—	—	—	—	—
		SR174X5ZZS	WSP3630Z	SR1A-552Z	—	SR174SX5	—	—
4.762	0.1875	SR156X100ZZS	—	—	—	—	—	—
		SR156X101ZZS	—	—	—	—	—	—
		SR186X2ZZS	WSP2824ZZ	SR1A-779Z	—	SR186SX2	—	—
		SR3X31ZZS	—	—	—	SR3SX31	—	—
		SR3X23ZZS	WSP4041ZZ	SR1A-559Z	—	SR3SX23	—	—

Double shielded type

Bore diameter d		NSK	ADR	FAG	GRW	BARDEN	MPB	NMB
mm	inch							
3.175	0.1250	SR2X52ZZS	WSP3621ZZ	SR1A-679.2Z	S3175/6-2Z	SR2SSX52	A281	SSRI-418ZZA02
		SR144X100ZZS	—	—	—	—	—	—
		SR174X5ZZS	WSP3630ZZ	SR1A-552.2Z	S3175/552-2Z	SR174SSX5	B70	SSRI-418ZZA7204
4.762	0.1875	SR156X100ZZS	—	—	—	—	—	—
		SR156X101ZZS	—	—	—	—	—	—
		SR186X2ZZS	WSP2824ZZ	SR1A-779.2Z	—	SR186SSX2	D893	SSRI-6632ZZA0208
		SR3X31ZZS	—	—	—	SR3SSX31	—	—
		SR3X23ZZS	WSP4041ZZ	SR1A-559.2Z	S3/16/14-2Z	SR3SSX23	—	—

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