

# HIGH PRECISION

BALL BEARINGS

Extra Thin Type Bearings  
Flanged Bearings  
Stainless Bearings  
Bore Dia , 0.6mm to 95mm

**EZO**  
PRECISION BALL BEARINGS

## Introduction

Sapporo Precision group has been fostering “EZO” brand for long years since its establishment. Fortunately, “EZO”, which was derived from the ancient name of Hokkaido Island, “EZO-CHI”, has achieved a remarkable growth and is enjoying profound trust from a number of domestic and foreign users in 35 different countries throughout the world.

This new catalogue includes the recent revisions of ISO standards for ball bearings as well as the new bearing series we have introduced during recent years.

It consists of two parts: TECHNICAL EXPLANATION and DIMENSION TABLES.

The basic dynamic load ratings listed in the Bearing Tables are in accordance with ISO 281.

The values reflect the effect of longer life due to improved manufacturing techniques and materials.

The basic static load ratings listed in the Bearing Tables are in accordance with ISO 76.

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**NOTE 1.** All information, data and dimension tables in this catalogue have been compiled carefully and have been thoroughly checked. However, no responsibility for possible errors or omissions can be assumed.

**NOTE 2.** We reserve the right to change specifications and other information included in this catalogue without notice.

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## Bearing numbering system

**CAGE**

STEEL RIBBON TYPE (SPCC,SUS304)	J
STEEL CROWN TYPE (SUS420J2,SUS304)	W
RESIN CROWN TYPE (POLYAMIDE66)	TW
STEEL RIVET TYPE (SPCC,SUS304)	RJ
FULL COMPLEMENT (WITHOUT CAGE)	V
THRUST FM TYPE (SUS304)	TP
THRUST F TYPE (C3604)	TD

**MATERIAL**

HIGH CARBON CHROMIUM STEEL  
SUJ2..... NO SYMBOL

EQUIVALENT MATERIAL TYPE  
SAE 52100, 100Cr6

STAINLESS STEEL  
KS440 (ACD34,QD51)(OUTER & INNER RING)  
SUS440C (BALL)

EQUIVALENT MATERIAL TYPE  
X65Cr13 (OUTER & INNER RING)  
AISI440C, X102CrMo17 (BALL)

STANDARD METRIC MR, MF, ET AND INCH SERIES H S

**SEAL AND SHIELD**

TEFLON SEAL WITH SNAP RINGS (PTFE) ON BOTH SIDES	TTS
STEEL SHIELD WITH SNAP RINGS (SUS304) ON BOTH SIDES	ZZS
PRESSED STEEL SHIELD (SPCC,SECC-NC,SUS304) ON BOTH SIDES	ZZ
CONTACT RUBBER SEALS (NBR+SPCC) ON BOTH SIDES	2RS
CONTACT RUBBER SEALS FOR HIGH TEMPERATURE (FKM+SPCC) ON BOTH SIDES	2RS-V
NON-CONTACT RUBBER SEAL (NBR-SPCC) ON BOTH SIDES	2RU

**RADIAL CLEARANCE**

STANDARD  
C2, C0(CN), C3, C4, C5

MINIATURE

MC1	0~5 μm
MC2	3~8 μm
MC3	5~10 μm
MC4	8~13 μm
MC5	13~20 μm
MC6	20~28 μm

SPECIAL CLEARANCE  
RC(min)-(max)  
e.g. RC3-18(=3-18μm)

**TOLERANCE CLASS**

·RADIAL & THRUST BALL BEARING

ISO & JIS CLASS 0	NO SYMBOL
ISO & JIS CLASS 6	P6
ISO & JIS CLASS 5	P5
ISO & JIS CLASS 4	P4
ANSI/ABMA ABEC1	NO SYMBOL
ANSI/ABMA ABEC3	A3
ANSI/ABMA ABEC5	A5
ANSI/ABMA ABEC7	A7

·INSTRUMENT BALL BEARING

ANSI/ABMA CLASS3P	A3P
ANSI/ABMA CLASS5P	A5P
ANSI/ABMA CLASS7P	A7P

Ex.1			686		J	ZZ	NR			MC3		SRL
Ex.2		F	608		TW	2RS				MC4	P6	SRL
Ex.3		MR	52		W	ZZ				MC2	P5	AF2
Ex.4	S	MF	128		W	TTS	BW4		CB	RC5-13	P6	SRL
Ex.5	S	ER	1458		W	ZZS				C0	A3	SRL
Ex.6			6205	H	RJ	2RS		S1		C3		AV2
Ex.7		F	6706	H	W	2RU				C0		SRL
Ex.8	S	R	144		J	ZZS				MC4	A5P	AF2
Ex.9		R	10		RJ	ZZ				C2		AV2
Ex.10		F	3-8M	H	TP							AF2

**BEARING TYPE**

INCH	R
INCH WITH FLANGE	FR
INCH WITH EXTENDED INNER RING	RW
INCH WITH EXTENDED INNER RING AND FLANGE	FRW
METRIC STANDARD	NO SYMBOL
METRIC WITH FLANGE	F
SPECIAL METRIC	MR
SPECIAL METRIC WITH FLANGE	MF
SPECIAL METRIC THIN TYPE	ET
SPECIAL INCH THIN TYPE	ER
THRUST WITH RACEWAY	FM
THRUST WITHOUT RACEWAY	F

**BEARING BASIC PART NO.**

SINGLE ROW DEEP GROOVE BALL BEARING METRIC SERIES 67,68,69,60,16,62,63

METRIC SERIES BORE DIAMETER NUMBER: NUMBERS 1-9 DENOTE BORE DIAMETERS IN MM

1X=1.5mm, 2X=2.5mm

00=10mm, 01=12mm, 02=15mm, 03=17mm

04-96:X5 values denote bore dimensions in mm

**RING SHAPE**

SNAP RING GROOVE IN OUTER RING	N
SNAP RING GROOVE WITH SNAP RING IN OUTER RING	NR
SPECIAL WIDTH	W*
EXTENDED OUTER RING	AW**
EXTENDED INNER RING	BW**
SPECIAL OUTSIDE DIAMETER	AD**
SPECIAL BORE DIAMETER	BD**

**LUBRICATION**

EX. GREASE	CODE
MULTEMP SRL (STANDARD)	SRL
ALVANIA NO.2 (SEMI STD)	AV2
ISOFLEX SUPER LDS18 (LOW TEMP)	SL8
BEACON 325J (LOW TEMP)	B32
CASSIDA RLS2 (FOOD)	RL2
MOLYKOTE 44M (HIGH TEMP)	M4M
KRYTOX 240AC (ULTRA HIGH TEMP)	K24

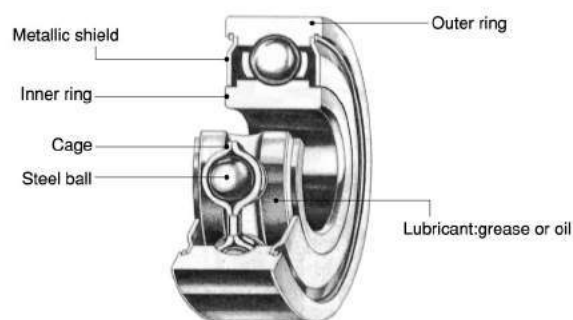
EX. OIL	CODE
AEROSHELL FLUID 12 (STANDARD)	AF2
WINSOR LUBE L-245X (SEMI STD)	WL2
ISOFLEX PDP38	PD8

The following types of bearings would also be available upon request on certain conditions. Please contact us for the details.

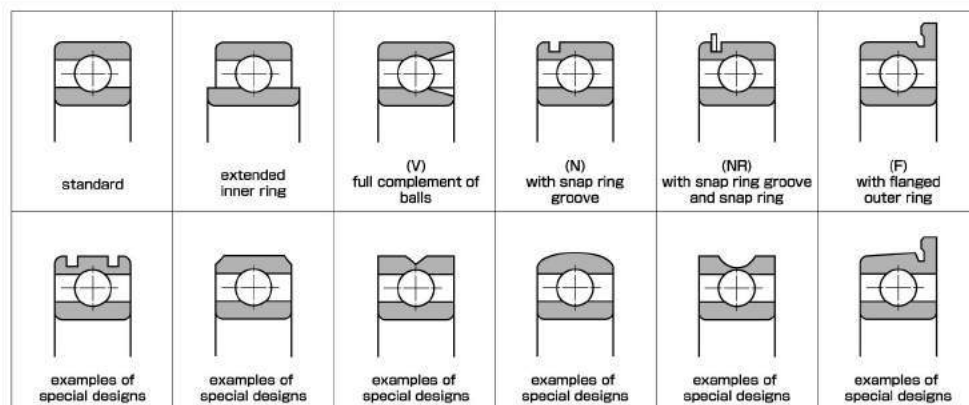
- SINGLE-ROW DEEP GROOVE FULL COMPLEMENT BALL BEARING
- DOUBLE-ROW DEEP GROOVE BALL BEARING
- SINGLE-ROW ANGULAR CONTACT BALL BEARING
- DOUBLE-ROW ANGULAR CONTACT BALL BEARING
- FOUR POINT CONTACT BALL BEARING
- DUPLEX DEEP GROOVE BALL BEARING
- DUPLEX ANGULAR CONTACT BALL BEARING
- OUTER SURFACE SPECIAL SHAPE BALL BEARING (SPHERICAL SURFACE, R SURFACE, V GROOVE, U GROOVE, etc.)

# Design and characteristics of radial ball bearings

## STRUCTURE OF BEARING



## DESIGN OF BEARING



## CHARACTERISTICS OF BEARINGS

<b>LOAD</b>	Single row radial ball bearings with balls separated by a cage can support radial loads, axial loads and tilting moments. A full complement V-type ball bearing can support only radial loads and some low axial loads.
<b>SPEED</b>	Maximum permissible speeds for ball bearings are mainly related to the bearing design and size, cage type, bearing internal clearance, method and type of lubrication, manufacturing accuracy, sealing methods and loads.
<b>TORQUE AND NOISE LEVEL</b>	Single row radial ball bearings are precision components and have low torque and noise levels.
<b>INCLINATION OF INNER/OUTER RINGS</b>	Shaft and housing seats with poor accuracy, fitting errors and shaft bending might cause inclination between the inner and outer rings although the internal clearance of the bearing will permit this to a certain extent.
<b>TOUGHNESS</b>	Bearings under load deform elastically at the contact point between the rolling element and bearing ring. This is influenced by the bearing type, size, form and load.
<b>INSTALLATION AND REMOVAL</b>	The single row radial ball bearing is a non-separable bearing. Therefore, shafts and housings should be so designed to enable bearing inspection and replacement when necessary.
<b>AXIAL LOCATION</b>	Improved axial location is obtained with NR and F type bearings.

# Bearing material

Standard material for rings and balls is a vacuum degassed high carbon chromium steel allowing for high efficiency, low torque, low noise level and long bearing life. For bearings requiring anti-corrosion or heat-resistance properties, martensitic stainless steel is used.

## CHEMICAL COMPOSITION OF BEARING MATERIALS

MATERIAL	SYMBOL	CHEMICAL COMPOSITION (Wt%)							EQUIVALENT	HARDNESS (HRC)
		C	Si	Mn	P	S	Cr	Mo		
HIGH CARBON CHROMIUM STEEL	SUJ2	0.95~1.10	0.15~0.35	≤0.50	≤0.025	≤0.025	1.30~1.60	≤0.08	SAE52100, 100Cr6, ASTM52100, BS535A99, 1.3505	60~64
STAINLESS STEEL	SUS440C (FOR BALL)	0.95~1.20	≤1.00	≤1.00	≤0.040	≤0.030	16.0~18.0	≤0.75	AISI440C, X102CrMo17, X105CrMo17, 1.4125, 1.3543	59~66
	KS440 (ACD34, QD51)	0.60~0.75	≤1.00	≤1.00	≤0.030	≤0.020	11.5~13.5	≤0.30	X65Cr13, 1.4037	58~62

# Type and characteristics of cages, shields and seals

## CAGES

W : ONE-PIECE STEEL CROWN TYPE	J : TWO-PIECES STEEL RIBBON TYPE	RJ : TWO-PIECES STEEL RIVET TYPE	TW : ONE-PIECE NYLON CROWN TYPE	V : FULL COMPLEMENT OF BALLS
The stainless steel pressed cage is inner ring guided. It shows excellent performance in low torque, low speed applications.	Consists of two mating steel pressings, the cover side and the finger side. Usually guided by the rolling elements and designed to reduce frictional torque.	The RJ type cage is suitable for larger bearings with a high load carrying capacity. The two pieces are riveted together and are strong enough to withstand higher levels of vibration and acceleration. The cage is guided by the balls and reduces frictional torque.	Moulded nylon cage. Reduces the fluctuation in running torque. Suitable for high speeds. Guided by the rolling elements. NYLON CAGE operating temperature range: from -30 to +120°C	This type of bearing has no cage but maximum possible number of balls. Due to the fact that the inner and outer ring have a filling slot, the axial load carrying capacity of this bearing type is low. This type of bearing is suitable for high radial load, low speed applications.

## SHIELD, SEAL

ZZ : PRESSED STEEL SHIELD	ZZS : STEEL SHIELD WITH SNAP RING	TTS : TEFLON SEAL WITH SNAP RING	2RS : CONTACT RUBBER SEAL	2RU : NON-CONTACT RUBBER SEAL
Non-contact shield pressed into outer ring. Very little grease leakage and low ingress of contaminants.	Non-contact shield retained in outer ring. Low ingress of contaminants. Mainly used for smaller or narrower bearings.	Teflon seal reinforced with glass fibre is retained in outer ring by snap ring. Low ingress of contaminants. Mainly used for smaller or narrower bearings. Seal can flex to accommodate internal pressure changes. TEFLON SEAL operating temperature range: from -100 to +260°C	Rubber seal fitted into outer ring. Light contact with inner ring, retains grease and prevents ingress of external contaminants. NBR SEAL operating temperature range: from -40 to +120°C FKM(VITON)SEAL operating temperature range: from -30 to +230°C	Non-contact rubber seal fitted into outer ring, still provides effective sealing. NBR SEAL operating temperature range: from -40 to +120°C FKM(VITON)SEAL operating temperature range: from -30 to +230°C



# Life and load rating

## BEARING LIFE

When bearings rotate, the inner and outer rings and rolling elements are constantly loaded. This produces material fatigue and eventually bearing failure. The total number of revolutions before a failure occurs is called the basic rating life.

Life of individual bearings varies considerably, even if they are of the same size, same material, same heat treatment and are under the same operating conditions.

Statistically, the total number of revolutions reached or exceeded by 90% of a sufficiently large group of apparently identical bearings before the first evidence of material fatigue occurs is called the basic rating life.

## BASIC DYNAMIC LOAD RATING "Cr"

The basic dynamic load rating of a bearing with rotating inner ring and stationary outer ring is that load of constant magnitude and size which a sufficiently large group of apparently identical bearings can endure for a basic rating life of one million revolutions.

Radial bearings take central load. Values given for Cr in the dimension tables of this catalogue are for standard high chromium steel. 85% of the chromium steel values should be used for stainless steel.

## LIFE FORMULA

The equation for the basic rating life for dynamically loaded ball bearings is as follows:

$$L_{10} = (Cr/P)^3 \times 10^6 \text{ (Revolutions)}, L_{10h} = 16667/n \cdot (Cr/P)^3 \text{ (Hours)}$$

whereby:  
 $L_{10}$  = BASIC RATING LIFE  
 $Cr$  = BASIC DYNAMIC LOAD RATING(N)  
 $n$  = R.P.M. (REVOLUTIONS PER MINUTE)  
 $L_{10h}$  = BASIC RATING LIFE IN OPERATING HOURS  
 $P$  = EQUIVALENT LOAD(N)

### EXAMPLES OF RATING LIFE $L_{10h}$ VALUES USED:

OPERATING CONDITIONS	BASIC RATING LIFE $L_{10h}$
Infrequent operation.	500
Short or intermittent operation. Failure has little effect on function.	4,000~8,000
Intermittent operation. Failure has significant effect on function.	8,000~12,000
8 hours of non-continuous operation.	12,000~20,000
8 hours of continuous operation.	20,000~30,000
24 hours continuous operation.	40,000~60,000
24 hours of guaranteed trouble-free operation.	100,000~200,000

## ADJUSTED LIFE FORMULA

The above life formula is for general use only. In cases where a reliability of over 90% is required depending on the applications, it is not accurate enough. The fatigue life has been prolonged thanks to the improved steel quality and the better understanding in the relation between lubricants and bearings, so the following adjusted life calculation formula is now being used:

$$L_{na} = a_1 \times a_2 \times a_3 \times (Cr/P)^3 \times 10^6 \text{ (Revolutions)}$$

whereby:  
 $L_{na}$  = Adjusted rating life in millions with a reliability of (100-n)% (n=the reliability rate)  
 $Cr$  = BASIC DYNAMIC LOAD RATING(N)  
 $P$  = EQUIVALENT DYNAMIC LOAD(N)  
 $a_1$  = Factor for a reliability other than 90%  
 $a_2$  = Factor for non-conventional materials  
 $a_3$  = Factor for non-conventional operating conditions, in particular lubrication

### (1) RELIABILITY FACTOR $a_1$

When a reliability of over 90% is required, the corresponding factor should be selected from the following table.

#### ●RELIABILITY FACTOR $a_1$

Reliability (%)	90	95	96	97	98	99	99.2	99.4	99.6	99.8	99.9	99.92	99.94	99.95
$a_1$	1	0.64	0.55	0.47	0.37	0.25	0.22	0.19	0.16	0.12	0.093	0.087	0.080	0.077

### (2) MATERIAL FACTOR $a_2$

Improvement in manufacturing techniques for raw material and for heat treatment of components have led to an extended fatigue life for bearings.

Our standard bearing material is a superior quality of vacuum degassed steel leading to an extended life for bearings.

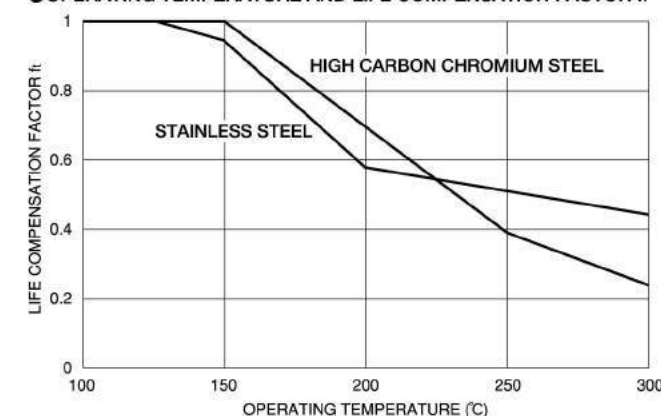
### (3) OPERATING CONDITIONS FACTOR $a_3$

This is an adjustment factor to meet non-conventional operating conditions for lubrication, temperature and load. Under good lubrication conditions with a permanent oil film between rolling elements and rings, the factor  $a_3=1$ . In unfavourable conditions ( $dm \cdot n \leq 10,000$ ), a factor  $a_3 < 1$  must be selected.  $dm$  = mean bearing diameter =  $(D+d)/2$ ,  $n$  = operating speed.

At temperatures above 120°C, greater dimensional changes occur and the material hardness deteriorates which affects the bearing life.

The operating factor  $f_t$  for temperature can be taken from the following figure:

#### ●OPERATING TEMPERATURE AND LIFE COMPENSATION FACTOR $f_t$



Note: These factors are not applicable to the dimensionally stabilized bearings.

At temperatures above 120°C, greater dimensional changes occur. With dimensional stabilization treatment, dimensional changes can be suppressed even under higher temperatures while the basic dynamic load ratings would be reduced due to the decline in hardness.

## BASIC STATIC LOAD RATING "Cor"

The Basic Static Load Rating applies to bearings where rotating motion does not occur or occurs only infrequently. Excessive static load causes brinelling at the contact point between the rolling element and raceway.

As a standard of permissible static load, the basic load rating  $Cor$  for radial bearings is specified as follows:

Maximum contact pressure at the contact point between rolling element and bearing ring to be 4200 MPa and total permanent deformation of the bearing of appr. 1/10000th of the rolling element's diameter.

Basic Static Load Rating for stainless steel is 80% of that for standard bearing steel.

### EQUIVALENT DYNAMIC BEARING LOAD "P"

Load conditions on bearings are usually a combination of radial and axial loads. In order to establish the equivalent radial load with definite force and direction we use the following formula:

●RADIAL LOAD FACTOR AND AXIAL LOAD FACTOR

Fa/(ZD <sup>2</sup> )	e	Fa/Fr ≤ e		Fa/Fr > e	
		X	Y	X	Y
0.172	0.19	1	0	0.56	2.30
0.345	0.22	1	0	0.56	1.99
0.689	0.26	1	0	0.56	1.71
1.03	0.28	1	0	0.56	1.55
1.38	0.30	1	0	0.56	1.45
2.07	0.34	1	0	0.56	1.31
3.45	0.38	1	0	0.56	1.15
5.17	0.42	1	0	0.56	1.04
6.89	0.44	1	0	0.56	1.00

$$P = XFr + YFa (N)$$

Fr=RADIAL LOAD(N)  
Fa=AXIAL LOAD(N)

X=RADIAL LOAD FACTOR  
Y=AXIAL LOAD FACTOR  
D=BALL DIAMETER(mm)

### EQUIVALENT STATIC RADIAL LOAD "Po"

For ball bearings subject to both radial and axial loads, the static radial load with definite force and direction is called the Equivalent Static Radial Load. The higher value from the two formula shown below should be used.

$$Po = 0.6 \times Fr + 0.5 \times Fa (N), Po = Fr (N)$$

### SAFETY MODULUS "fs"

Permissible equivalent static load depends on basic static load rating. But using limit of bearing charge by using condition. Accordingly we use safety modulus which is experimental value.

$$fs = Cor / Po$$

fs=SAFETY MODULUS  
Cor=BASIC STATIC LOAD RATING(N)  
Po=EQUIVALENT STATIC RADIAL LOAD(N)

USING CONDITION	fs
NORMAL OPERATION	1.0
SHOCK LOAD	1.5
SILENT AND HIGH ACCURATE ROTATION	2.0



## Fitting of bearings

### THE IMPORTANCE OF CORRECT FITTING

A bearing can only perform to its full capacity when it is correctly fitted on the shaft and in the housing. Insufficient interference on fitting surfaces could cause bearing rings to creep in a circumferential direction. Once this happens, considerable wear occurs on the fitting surface and both shaft and housing are damaged. Furthermore, abrasive particles may enter the bearing causing vibration, excessive heat and damage to raceways. It is therefore necessary to provide bearing rings under rotating load with an adequate interference fit to prevent creep. When using thin-type bearings under low load, the bearings should be fastened by a nut. Statically loaded bearings generally do not need to be fitted with an interference fit. Only when subject to a high degree of vibration do both inner and outer rings require fitting with an interference fit.

●FITTING OF BEARING AND SHAFT

CONDITION (STEEL SHAFT)	SHAFT BORE DIAMETER	SHAFT TOLERANCE CLASS		
		THIN TYPE	OTHERS	
INNER RING ROTATING LOAD OR INDETERMINATE LOAD DIRECTION	LIGHT LOAD ≤ 0.06Cr OR FLUCTUATING LOAD	10 ≤ d ≤ 18 18 ≤ d ≤ 30 30 ≤ d ≤ 100	h5 h5 h5	js5 js5 js5
	STANDARD LOAD = 0.06 ~ 0.12Cr	10 ≤ d ≤ 18 18 ≤ d ≤ 30 30 ≤ d ≤ 100	js5 js5 js5	j5 k5 k5
OUTER RING ROTATING LOAD	NECESSARY FOR INNER RING TURNING EASILY AROUND SHAFT	ALL BORE DIAMETERS	g5	g6
	UNNECESSARY FOR INNER RING TURNING EASILY AROUND SHAFT	ALL BORE DIAMETERS	h5	h6

●FITTING OF BEARING AND HOUSING

CONDITION (ONE-PIECE HOUSING)	AXIAL DIRECTIONAL MOVEMENT OF OUTER RING	TOLERANCE CLASS OF SHAFT HOUSING SEATS		
		THIN TYPE	OTHERS	
INNER RING ROTATING LOAD	VARYING LOADS	EASY TO MOVE	H6	H7
	LIGHT OR STANDARD LOAD	EASY TO MOVE	H7	H8
	HIGH TEMPERATURE OF INNER RING AND SHAFT	EASY TO MOVE	G6	G7
	LIGHT OR STANDARD LOAD PRECISE ROTATION	AS A RULE, IMPOSSIBLE TO MOVE	K5	K6
	QUIET OPERATION	POSSIBLE TO MOVE	JS6	J6
INDETERMINATE LOAD DIRECTION	LIGHT OR STANDARD LOAD	IN GENERAL, POSSIBLE TO MOVE	JS6	J7
	STANDARD OR HEAVY LOAD	AS A RULE, IMPOSSIBLE TO MOVE	K5	K7
	LARGE SHOCK LOAD	IMPOSSIBLE TO MOVE	M5	M7
	LIGHT OR FLUCTUATING LOAD	IMPOSSIBLE TO MOVE	M5	M7
OUTER RING ROTATING LOAD	STANDARD OR HEAVY LOAD	IMPOSSIBLE TO MOVE	N5	N7
	THIN-TYPE HOUSING SEATS HEAVY LOAD OR LARGE SHOCK LOAD	IMPOSSIBLE TO MOVE	P6	P7

●CHARACTERISTICS OF LOAD AND FITTING

ROTATING RING	LOAD	LOAD CONDITION	FITTING
INNER RING 	STATIC 	INNER RING ROTATING LOAD	INTERFERENCE FIT FOR INNER RING
OUTER RING 	ROTATING 	OUTER RING STATIC LOAD	CLEARANCE FIT FOR OUTER RING
OUTER RING 	STATIC 	OUTER RING ROTATING LOAD	CLEARANCE FIT FOR INNER RING
INNER RING 	ROTATING 	INNER RING STATIC LOAD	INTERFERENCE FIT FOR OUTER RING
IN THE CASE OF FLUCTUATING LOAD DIRECTION OR UNBALANCED LOAD	ROTATING OR STATIC	INDETERMINATE LOAD DIRECTION	INTERFERENCE FIT FOR INNER AND OUTER RING

CALCULATIONS OF FITS

(1) FITTING PRESSURE AND DIMENSIONAL CHANGES OF INNER AND OUTER RING

The right fit for each application is established taking various conditions into consideration such as load, speed, temperature, mounting dismounting of the bearing. The interference fit should be greater than normal in thin housings, housings of soft material or on hollow shafts.

(2) LOAD OF INTERFERENCE

The interference fit of shaft and inner ring decreases under radial load. The decrease in fit of shaft and inner ring is calculated by the following formula:

The higher value from the two formula shown below should be used.

$$\Delta dF = 0.08 \times \sqrt{d/B} \cdot Fr \times 10^{-3} \text{ (mm)} \quad Fr \leq 0.3 \times Cor$$

$$\Delta dF = 0.02 \times Fr / B \times 10^{-3} \text{ (mm)} \quad Fr > 0.3 \times Cor$$

(3) INFLUENCE OF TEMPERATURE ON BEARINGS, SHAFTS AND HOUSINGS

Each inner ring, outer ring or rolling element of a bearing rotating under load generates heat which will affect the interference fits of the shaft and the housing. Assuming a temperature difference within the bearing and the housing of  $\Delta T$ (C), that of the mating surface of the shaft and of the bearing is  $(0.10 \sim 0.15)\Delta T$ .

Consequently,  $\Delta dT$ , the decrease of the inner ring interference fit due to temperature change, is calculated from the following formula:

$$\Delta dT = (0.10 \sim 0.15) \times \Delta T \cdot a \cdot d \approx 0.0015 \times \Delta T \cdot d \times 10^{-3} \text{ (mm)}$$

$\Delta dT$  : DECREASE OF INTERFERENCE DUE TO TEMPERATURE DIFFERENCE(mm)

$\Delta T$  : TEMPERATURE DIFFERENCE BETWEEN BEARING AND SURROUNDING HOUSING(C)

$a$  : COEFFICIENT OF THERMAL EXPANSION FOR BEARING STEEL  $\approx 12.5 \times 10^{-6} / (C)$   
COEFFICIENT OF THERMAL EXPANSION FOR STAINLESS STEEL  $\approx 10.3 \times 10^{-6} / (C)$

$d$  : NOMINAL BORE DIAMETER OF BEARING(mm)

It should also be noted that fit can increase due to temperature changes.

(4) EFFECTIVE INTERFERENCE, SURFACE ROUGHNESS AND ACCURACY

The surface roughness is smoothed during fitting and the effective interference becomes smaller than the theoretical interference. The surface roughness quality of a mating surface has an influence on how much this theoretical interference decreases. Effective interference can usually be calculated as follows:

$$\begin{aligned} \text{Ground Shaft} &: \Delta d = d / (d+2) \cdot \Delta da \text{ (mm)} \\ \text{Turned Shaft} &: \Delta d = d / (d+3) \cdot \Delta da \text{ (mm)} \\ \Delta d &: \text{EFFECTIVE INTERFERENCE (mm)} \\ \Delta da &: \text{THEORETICAL INTERFERENCE (mm)} \\ d &: \text{NOMINAL BORE DIAMETER OF BEARING (mm)} \end{aligned}$$

By combining these factors, the theoretical interference fit required for inner ring and shaft where the inner ring is subjected to rotating load is calculated as follows:

$$\Delta da \geq (\Delta dF + \Delta dT) \cdot ((d+3)/d \text{ or } (d+2)/d) \text{ (mm)}$$

Normally, shaft and housing seats have to meet the accuracy and roughness requirements as given below.

●ACCURACY AND ROUGHNESS OF SHAFT AND HOUSING SEATS

	SHAFT	HOUSING
ROUNDNESS	BELOW 50% OF SHAFT DIAMETER TOLERANCE	BELOW 50% OF HOUSING BORE DIAMETER TOLERANCE
CYLINDRICITY	BELOW 50% OF SHAFT DIAMETER TOLERANCE WITHIN BEARING WIDTH	BELOW 50% OF HOUSING BORE DIAMETER TOLERANCE WITHIN BEARING WIDTH
SQUARENESS	$\leq 3/10000 (0.017^{\circ})$	
ROUGHNESS OF MATING SURFACE	Rmax 3.2	Rmax 6.3

Mounting bearings with extra tight or light interference fits can lead to early bearing failure. In order to ensure safe operating conditions the tolerance variations of shaft seats, housing bores and bearing bore and outside diameter need to be reduced.

We recommend the tolerance zones are divided into two bands and selective assembly is applied. Bearings sorted into two tolerance bands for inner and outer rings are available on request. These bearings are marked as follows:

●SELECTIVE CLASSIFICATION OF OUTER AND BORE DIAMETER TOLERANCES AND INDICATION MARK

TOLERANCES OF OUTER DIAMETER	TOLERANCE OF BORE DIAMETER	TOLERANCES AND INDICATION MARK		
		0~-D/2	-D/2~-D	0~-D
	MARK	1	2	0
0~-d/2	1	C11	C12	C10
-d/2~-d	2	C21	C22	C20
0~-d	0	C01	C02	

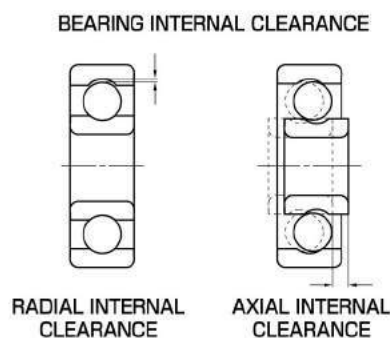
NOTE: 1. THIS IS APPLIED TO BOTH BEARINGS OF ABEC 5P AND P5.  
2. UPON YOUR REQUEST, PLEASE SPECIFY THE MARK LISTED BELOW.  
ZC1.... 2 SELECTIVE CLASSIFICATIONS FOR BORE DIAMETER TOLERANCE (0~-d/2, -d/2~-d)  
1 SELECTIVE CLASSIFICATION FOR OUTER DIAMETER TOLERANCE (0~-D)  
ZC2.... 1 SELECTIVE CLASSIFICATION FOR BORE DIAMETER TOLERANCE (0~-d)  
2 SELECTIVE CLASSIFICATIONS FOR OUTER DIAMETER TOLERANCE (0~-D/2, -D/2~-D)  
ZC3.... 4 SELECTIVE CLASSIFICATIONS FOR BOTH BORE AND OUTER DIAMETER TOLERANCE (0~-d/2~, -d/2~-d, 0~-D/2~, -D/2~-D)  
D.... MINIMUM VALUE OF OUTER DIAMETER TOLERANCE  
d.... MINIMUM VALUE OF BORE DIAMETER TOLERANCE



# Internal clearance

## INTERNAL CLEARANCE AND STANDARD VALUES

Internal clearance is the play between outer ring, inner ring and rolling element. Generally, the amount of up and down movement of the outer ring with respect to the fixed inner ring is called the radial internal clearance and its right and left movement the axial internal clearance. Bearing internal clearance in operation is an important factor that has a significant influence on other factors such as noise, vibration, heat and fatigue life. Radial ball bearings are usually classified by their internal radial clearance. When measuring the internal clearance, the bearing is subjected to a standard load in order to ensure full contact between all bearing components. Under such a load, the measured value is larger than the actual value stated for radial clearance; this is due to elastic deformation. The difference is compensated by the factors given in the tables below.



### ● RADIAL INTERNAL CLEARANCE OF SMALL AND MINIATURE BEARINGS

Unit  $\mu\text{m}$

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

NOTE: 1. STANDARD CLEARANCE IS MC3.  
2. FOR MEASURING CLEARANCE, OFFSET BY COMPENSATION FACTOR LISTED BELOW.

Unit  $\mu\text{m}$

CLEARANCE SYMBOL	MC1	MC2	MC3	MC4	MC5	MC6
COMPENSATION FACTOR	1	1	1	1	2	2

MEASURING LOAD IS AS FOLLOWS.  
MINIATURE BEARINGS 2.5N (0.25kgf)  
SMALL BEARINGS 4.4N (0.45kgf)

### ● RADIAL INTERNAL CLEARANCE OF STANDARD RADIAL BALL BEARINGS

Unit  $\mu\text{m}$

NOMINAL BORE DIAMETER d(mm)		CLEARANCE									
		C2		CN(C0)		C3		C4		C5	
OVER	INCL.	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
10(OONLY)		0	7	2	13	8	23	14	29	20	37
10	18	0	9	3	18	11	25	18	33	25	45
18	24	0	10	5	20	13	28	20	36	28	48
24	30	1	11	5	20	13	28	23	41	30	53
30	40	1	11	6	20	15	33	28	46	40	64
40	50	1	11	6	23	18	36	30	51	45	73
50	65	1	15	8	28	23	43	38	61	55	90
65	80	1	15	10	30	25	51	46	71	65	105
80	100	1	18	12	36	30	58	53	84	75	120

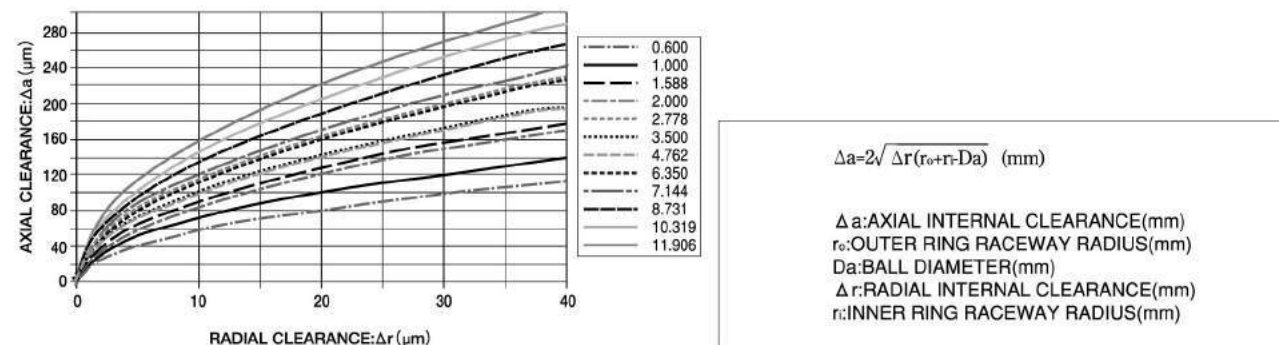
NOTE: 1. FOR MEASURING CLEARANCE, OFFSET BY COMPENSATION FACTOR LISTED BELOW.  
2. STANDARD CLEARANCE IS CN (C0).

Unit  $\mu\text{m}$

BORE DIAMETER OF NOMINAL BEARING d(mm)		MEASURING LOAD N (kgf)	COMPENSATION FACTOR				
OVER	INCL.		C2	CN (C0)	C3	C4	C5
10(INCLUDED)	18	24.5 (2.5)	3~4	4	4	4	4
18	50	49 (5)	4~5	5	6	6	6
50	100	147 (15)	6~8	8	9	9	9

## RELATIONSHIP BETWEEN RADIAL INTERNAL CLEARANCE AND AXIAL INTERNAL CLEARANCE

The axial internal clearance is established from the ball diameter, outer and inner ring raceway radius and the radial internal clearance. Usually it is about 10 times the value of the standard internal radial clearance. Selection of a small internal radial clearance or an extra large interference fit in order to reduce the internal axial clearance after mounting is not recommended.



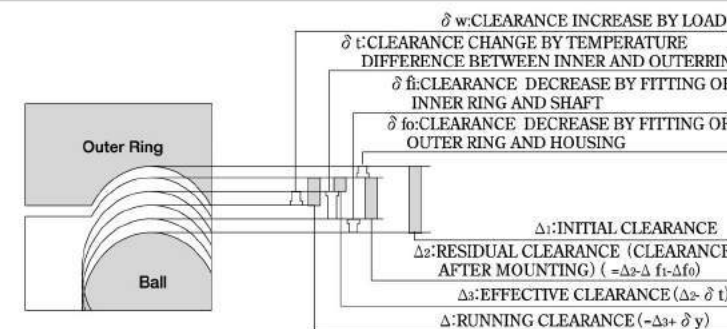
## SELECTION OF BEARING CLEARANCE

Theoretically, maximum bearing life is with very slight preload. However, even a slight increase in this theoretical preload can have a considerably detrimental effect on the bearing life. Positive clearance should therefore be selected. MC3 is usually used for miniature or small bearings, standard clearance for general bearings and the clearance for thin section bearings should never be greater than "standard".

### ● SELECTION OF RADIAL INTERNAL CLEARANCE

Operating Condition	Clearance
Clearance fit for inner and outer ring. Low axial load. No axial load carrying requirement. Select bearing with reduced radial clearance. Lower vibration and noise. Low speeds.	MC1, MC2, C2
Lower frictional torque. Standard axial load. Average axial load carrying requirements. Slight interference fit for inner ring. Clearance fit for outer ring. Average/low speeds.	MC3, MC4, CN(C0)
Extremely low frictional torque. High axial load. High axial load carrying requirements. Heavy interference fit to support high loads or shock loads. Large temperature gradient from inner ring to outer ring. High degree of shaft deflection.	MC5, MC6, C3, C4, C5

## CALCULATION OF CLEARANCE



### (1) RUNNING CLEARANCE

Running clearance is the resultant clearance after load, temperature difference and fitting are taken into consideration.

$$\Delta = \Delta_1 - (\Delta t + \Delta f) + \Delta w \text{ (mm)}$$

### (2) CLEARANCE REDUCTION BY TEMPERATURE DIFFERENCE BETWEEN INNER AND OUTER RING

In a bearing, the highest temperature is generated in the rolling element followed by the inner ring, with the outer ring having the lowest temperature. Since it is impossible to measure the temperature of a rolling element, in practice, the temperature of the inner ring is used.

$$\Delta t = a \times \Delta T \times D_o \text{ (mm)}$$

### (3) CLEARANCE REDUCTION BY FITTING

When a bearing is fitted onto a shaft or into a housing with an interference fit, the internal clearance of the bearing reduces.

$$\delta f = \delta f_i + \delta f_o = \Delta db \times d/db \times ((1-(d_o/d)^2)/(1-(d_o/db)^2)) + \Delta Da \times Da/D \times ((1-(D/D_h)^2)/(1-(D_a/D_h)^2)) \quad (\text{mm})$$

### (4) CLEARANCE INCREASE BY LOAD

Load on a bearing deforms it elastically and increases the internal clearance.

$$\delta w = C \times ((5 \times Fr) / (Z \times \cos \alpha))^2 \times (1/dw)^{1/3} \quad (\text{mm})$$

The initial contact angle  $\alpha_o$  is calculated from the following two formulae:  
 $\cos \alpha_o / \cos \alpha = 1 + C / (2 \times m - 1) \times (Fa / (9.8 \times Z \times Dw^2 \times \sin \alpha))^2$   
 $1 - \cos \alpha_o = \Delta r / (2 \times DW \times (2 \times m - 1))$

#### SYMBOLS

<b>ΔT</b> : TEMPERATURE DIFFERENCE BETWEEN INNER AND OUTER RING	<b>m</b> : OSCULATION
<b>D<sub>o</sub></b> : OUTER RING RACEWAY DIAMETER	<b>Z</b> : NUMBER OF BALLS
<b>Δdb</b> : CLEARANCE OF INNER RING ON SHAFT	<b>D<sub>w</sub></b> : BALL DIAMETER
<b>d<sub>o</sub></b> : BORE DIAMETER OF HOLLOW SHAFT	<b>α</b> : CONTACT ANGLE
<b>D<sub>n</sub></b> : OUTSIDE DIAMETER OF HOUSING SEAT	<b>α<sub>o</sub></b> : INITIAL CONTACT ANGLE
<b>ΔDa</b> : CLEARANCE OF OUTER RING IN HOUSING	<b>F<sub>a</sub></b> : AXIAL LOAD
<b>db</b> : AVERAGE OUTSIDE DIAMETER OF INNER RING	<b>F<sub>r</sub></b> : RADIAL LOAD
<b>Da</b> : AVERAGE OUTSIDE DIAMETER OF OUTER RING	<b>Δr</b> : RADIAL INTERNAL CLEARANCE
<b>a</b> : COEFFICIENT OF THERMAL EXPANSION FOR BEARING STEEL	<b>C</b> : MATERIAL ELASTICITY FACTOR

General Bearing	C=0.00218	m=0.525
Instrument Bearing	C=0.00287	m=0.560

## Lubrication

### OBJECT OF LUBRICATION

The lubrication method and the lubricant have a direct effect on the bearing life; the most suitable lubrication must therefore be selected for each application. Effects of lubrication are described as follows:

#### (1) DECREASE OF FRICTION AND ABRASION

It decreases rolling friction between the raceway and the rolling elements, sliding friction between rolling element and cage and sliding friction of guide surface between the cage and the bearing ring.

#### (2) REDUCTION OF HEAT GENERATION

It dissipates heat generated inside the bearing as well as heat conducted from the outside thus preventing overheating of the bearing and deterioration of the lubricant.

#### (3) PROTECTION FROM CORROSION AND CONTAMINANTS

It prevents corrosion of rolling elements, bearing rings and cages and also prevents the ingress of contaminants and moisture into the bearing.

### REQUIRED CHARACTERISTICS OF THE LUBRICANT

- (1) LOW FRICTION AND ABRASION
- (2) HIGH STABILITY AGAINST HEAT, GOOD THERMAL CONDUCTIVITY
- (3) STRONG OIL FILM
- (4) NON-CORROSIVE
- (5) PROVIDE A GOOD BARRIER AGAINST DUST AND MOISTURE
- (6) MAINTAIN A STABLE VISCOSITY

### STANDARD LUBRICANT

Lubricant	Brand	EZO CODE	Manufacturer	MIL STANDARD	Operating Temperature(°C)	specific gravity
STD.GREASE	Multemp SRL	SRL	Kyodo Yushi		-50~+150	0.93
STD. OIL	AeroShell Fluid 12	AF2	Shell Oil Co.	MIL-PRF-6085D	-54~+135	0.92

### LUBRICATION METHOD

There are two types of lubricant: oil or grease. It is important to select the correct lubricant and lubrication method for each application and its conditions.

#### ●LUBRICATING OIL AND GREASE

	LUBRICATING OIL	LUBRICATING GREASE
ROTATING SPEED	LOW · MEDIUM · HIGH SPEED	LOW · MEDIUM SPEED
LUBRICANT EFFICIENCY	EXCELLENT	GOOD
COOLING EFFECT	GOOD	NONE
TORQUE	COMPARATIVELY LOW	COMPARATIVELY HIGH
LUBRICANT LIFE	LONG	COMPARATIVELY SHORT
LUBRICANT REPLACEMENT	EASY	DIFFICULT
LUBRICANT LEAKAGE	SHOULD NOT BE USED WHERE OIL LEAKAGE IS UNACCEPTABLE	LITTLE GREASE LEAKAGE
IMPURITIES FILTRATION	EASY	DIFFICULT
SEALING EQUIPMENT	COMPLEX	SIMPLE

#### ●GREASE FILLING VOLUME

SYMBOL	FILLING VOLUME(%)	OPERATING CONDITION	
		SPEED	LOAD
M	70±10	LOW	HEAVY
S	50±10	LOW	MEDIUM
G	40±10	MEDIUM	MEDIUM
L	30±10	MEDIUM	MEDIUM
Q	25±5	MEDIUM	MEDIUM
K	20±5	HIGH	LIGHT
X	10±5	HIGH	LIGHT

NOTE: LIGHT LOAD ( ≤0.06Cr)  
MEDIUM LOAD ( ≤0.12Cr)

●CRITERIA FOR LUBRICATING OIL SELECTION

OPERATING TEMPERATURE OF BEARING (°C)	dn	ISO VISCOSITY GRADE OF LUBRICATING OIL(VG)	
		MEDIUM LOAD	HEAVY LOAD/SOCK LOAD
-30~0	UP TO PERMISSIBLE ROTATING SPEED	15,22,32	32,46
0~+60	UP TO 15000	32,46,68	100
	15000~80000	32,46	68
	80000~150000	22,32	32
	150000~500000	10	22,32
+60~+100	UP TO 15000	150	220
	15000~80000	100	150
	80000~150000	68	100,150
	150000~500000	32	68
+100~+150	UP TO PERMISSIBLE ROTATING SPEED	320	

NOTE: 1. IF HEAVY LOADS OCCUR AT LOW SPEEDS, A HIGHER VISCOSITY LUBRICATING OIL SHOULD BE USED.  
 2. THIS TABLE IS FOR OIL BATH LUBRICATION SYSTEM AND RECIRCULATING OIL SYSTEMS.  
 3. dn = BEARING BORE DIAMETER d(mm) X ROTATING SPEED n(r.p.m)

●COMMON OIL BRANDS AND EFFICIENCY

Manufacturer	Brand	Code	Lubricant Base Oil	Flash Point (°C)	Viscosity (m <sup>2</sup> /s)	Operating Temperature (°C)	Approved Standard
Shell Oil Co.	AeroShell Fluid 12 (standard oil)	AF2	Diester	220	11000 (-54°C), 8.2 (54°C)	-54~+135	MIL-PRF-6085D
	AeroShell Fluid 3	AF3	Mineral	155	4000 (-40°C), 10 (38°C)	-54~+121	MIL-PRF-7870D
Fuchs Lubritech	Winsor Lube L-245X	WL2	Diester	227	11.8 (40°C)	-55~+175	MIL-PRF-6085D
Chemours Company	Krytox 143AZ	KAZ	Fluorinated	-	40 (20°C), 12.4 (40°C)	-54~+149	-
Kluber Lub.	Isoplex PDB38	PD8	Diester	210	12.0 (40°C), 3.2 (100°C)	-65~+100	-

●COMMON GREASE BRANDS AND EFFICIENCY

Manufacturer	Brand	Code	Lubricant Base Oil	Thickening Agent	Drop Point (°C)	Cone Penetration: Worked (80 strokes)	Operating Temperature (°C)	Approved Standard (MIL & NSF)	
Kyodo Yushi	Multemp SRL (standard grease)	SRL	Diester, Polyol ester	Lithium	192	250	-50~+150		
	Multemp ET-100K	ETK	Phenyl ether	Diurea	260	280	-40~+200		
	Multemp PS No.1	PS1	Diester, Mineral	Lithium	185	320	-50~+130		
	Multemp PS No.2	PS2	Diester, Mineral	Lithium	190	275	-50~+130		
	Multemp SB-M	SBM	Synthetic hydrocarbon	Diurea	260	220	-40~+200		
	Raremax Super	RMS	Mineral, Synthetic hydrocarbon	Diurea	255	260	-40~+180		
Shell Oil Co.	Shell Alvaria Grease S1	AV1	Mineral	Lithium	180	323	-35~+120		
	Shell Alvaria Grease S2	AV2	Mineral	Lithium	181	283	-25~+120		
	Shell Alvaria Grease S3	AV3	Mineral	Lithium	182	242	-20~+135		
	AeroShell Grease 7	AG7	Synthetic ester (Diester)	Microgel	260	296	-73~+149	MIL-PRF-23827C (Type I)	
	AeroShell Grease 22	AG2	Synthetic hydrocarbon	Microgel	260	275	-65~+204	MIL-PRF-81322G	
	Shell Gadus S2 V100Q 2	2VQ	Mineral	Lithium hydroxystearate	180	280	~+135		
	Shell Gadus S2 V100 3	2V3	Mineral	Lithium hydroxystearate	180	235	~+130		
Shell Stamina Grease RL2	ST2	Mineral	Diurea	271	278	-20~+180			
Fuchs Lubritech	Cassida Grease RLS2	RL2	Synthetic	Aluminum complex	240	280	-35~+120	NSF-H1	
Kluber Lub.	Asonic GHY72	GHY	Ester	Polyurea	250	280	-40~+180		
	Asonic GLY32	GLY	Ester, Synthetic hydrocarbon	Lithium	190	280	-50~+140		
	Asonic HQ7-102	HQ7	Ester	Polyurea	240	265	-40~+180		
	Isoplex Alltime SL2	AS2	Synthetic hydrocarbon, Ester	Lithium	180	280	-50~+150		
	Isoplex TOPAS NB52	B52	Synthetic hydrocarbon	Barium	240	280	-50~+120		
	Isoplex LDS18 Special A	L8A	Ester, Mineral	Lithium	190	280	-50~+120	MIL-G-23827B	
	Isoplex Super LDS18-R	SL8	Ester, Mineral	Lithium	190	280	-50~+120	MIL-G-7118A	
	Isoplex NBU15	NB5	Synthetic hydrocarbon, Mineral, Ester	Barium	220	280	-40~+130	MIL-G-25760A	
	Staburags NBU12	NB2	Mineral	Barium	220	260	-30~+150	NSF-H2	
	Staburags NBU12/300KP	NB3	Mineral	Barium	220	300	-35~+150		
	Barrierta IEL	IEL	PFPE	PTFE	-	280	-50~+180		
	Barrierta IMI	IMI	PFPE	PTFE	-	280	-45~+220		
	Barrierta L55/2 H1	L55	PFPE	PTFE	-	280	-40~+260	NSF-H1	
	Barrierta JFE 552	E55	PFPE	PTFE	-	280	-35~+260		
	Klubersynth UH1 64-62	UH6	Synthetic hydrocarbon, Ester	Silicate	-	280	-40~+140	NSF-H1	
	Chemours Company	Krytox 240AC	K24	PFPE	PTFE	-	280	-34~+288	MIL-PRF-27817 (Type II), NSF-H1
		Krytox 240AB	K2B	PFPE	PTFE	-	280	-40~+232	MIL-PRF-27817 (Type I), NSF-H1
Krytox 240AZ		K2Z	PFPE	PTFE	-	280	-57~+149	MIL-PRF-27817 (Type I)	
Krytox GPL224		PL4	PFPE	PTFE	-	280	-51~+179		
Dow Corning Toray Co.	Molykote 33L	M3L	Silicone	Lithium	210	320	-70~+180		
	Molykote 33M	M3M	Silicone	Lithium	210	280	-70~+180		
	Molykote 44M	M4M	Silicone	Lithium	204	260	-40~+200		
ExxonMobil	Mobilgrease 28	MG2	PAO	Clay	315	295	-54~+177	MIL-PRF-81322G	
	Unirex N3	UN3	Synthetic hydrocarbon	Lithium complex	230	235	-30~+160		
	Beacon 325J	B32	Synthetic	Lithium	180	285	-50~+120		
	Polyree EM (Polyrex EM)	PEM	Mineral	Polyurea	260	285	-20~+180		
Nye Lubricants	Rheotemp 500	LT5	Ester	Sodium Complex	202	302	-54~+175		
	NYOGEL 756G	NL7	PAO	Silica	-	286	-40~+125		
	NYERHEOLUBE 374C	CGA	PAO	Lithium	260	193	-40~+150		
THK	AFF-CA Grease	AFF	Synthetic	Urea	260	280	-40~+180		
	AFF Grease	AFF	Synthetic	Lithium	220	315	-40~+120		
Nippon Grease Co.	NIGACE W	NAW	Mineral, Synthetic	Urea	250	258	-20~+150		
Daikin Industries	Demnum Grease L200	L20	PFPE	PTFE	-	280	-60~+300		
Anderol	ROYCO 27	RY7	Ester	Lithium	184	288	-73~+121	MIL-PRF-23827C (Type I)	
Shin-Etsu Chemical	Shin-Etsu silicone G-40M	S4M	Silicone	Lithium	200	260	-30~+200		
Chevron	Chevron SRI Grease 2	SRI2	Mineral	Polyurea	243	280	-30~+177	NSF-H2	

Note: Please let us know when you use a bearing filled with NSF H1 or H2 registered greases for food machineries.



## Maximum permissible bearing speed

Each bearing type has its own limiting speed. The theoretical speed that bearings can run at safely, even if heat generation by internal friction occurs, is called the maximum permissible speed.

The permissible speed is related to bearing type, type of cage, lubricant type, load and cooling conditions to which the bearing is subjected.

For contact rubber seals(2RS type), the permissible speeds are limited by the peripheral velocity of the seal lip. Normally, this is approximately 50 - 60% of that of non-contact rubber seals. If light contact rubber seals are required, this must be stipulated with the order.

If high loads occur, the permissible speed values must be reduced and the following supplementary factors applied, except under standard operating conditions(Cr/P<12, Fa/Fr>0.2)

●COMPENSATION FOR MAXIMUM PERMISSIBLE SPEED DEPENDENT ON LOAD RATIO

Cr/P	5	6	7	8	9	10	11	12
COMPENSATION FACTOR	0.72	0.79	0.85	0.90	0.93	0.96	0.98	1.00

●COMPENSATION FOR MAXIMUM PERMISSIBLE SPEED UNDER COMBINED AXIAL AND RADIAL LOAD

Fa/Fr	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
COMPENSATION FACTOR	1.00	0.95	0.93	0.91	0.89	0.88	0.87	0.86

If the bearing operates at over 70% of the permissible speed value, a lubricant for high speed should be selected. The values for the permissible speed are for applications with horizontal shafts and with appropriate lubrication. With vertical shafts, only 80% of the maximum speed value should be used. This is necessary due to the reduced cage guidance and reduced lubricant retention in this type of application.



## Frictional torque and temperature

FRICITIONAL TORQUE

Frictional torque of rolling bearings varies under changing load and lubrication conditions. When grease is used as a lubricant, the grease resistance must be added to the bearing frictional torque.

When adequate lubrication under normal loading conditions(Cr/P>12, Fa/Fr<0.2), the frictional torque of a bearing can be expressed as follows:

Technical

Dimension

$$M = \mu \cdot F \cdot d/2 \text{ (N}\cdot\text{mm)}$$

M: FRICTIONAL TORQUE (N·mm)  
 F: BEARING LOAD (N)  
 d: SHAFT DIAMETER (mm)  
 $\mu$ : 0.0015 COEFFICIENT OF FRICTION

#### TEMPERATURE INCREASE

Friction and grease resistance can increase the bearing temperature. In the initial stages of operation, the internal bearing temperature rises rapidly: as the heat dissipates to the shaft and housing and the cooling effect of the lubricant begins to take effect, the temperature stabilizes. Constant high temperatures lead to a reduction in bearing clearance, a deterioration of the running accuracy and of the lubricant and thereby a reduction in bearing life. It is important to consider the effect of temperature increases when selecting the bearing.

- ◆ After assembly, the bearing should be rotated to check its correct operation. If the bearing does not appear to be functioning correctly, it should be re-examined to establish the cause of the malfunction.
- ◆ It is not advisable to mix oils and greases as this will affect the efficiency of the bearing.
- ◆ Bearings must be stored in a clean environment with stable temperature. They should be handled with care to avoid the possibility of corrosion and rusting.
- ◆ Lint-free cloth must be used to wipe shaft and housing seats to avoid the ingress of contaminants into the bearing.

## Basic rules for selecting and handling of bearings

#### NOTES ON SELECTING

- ◆ The efficiency of thin type bearings can be greatly affected by the precision of shaft and housing seats. The accuracy of the surrounding structure must be such that it will not adversely affect the operation of the bearing. If you have any questions, in particular regarding series 670 and 680, please contact us.
- ◆ In applications with steel crown type cages (w type), where high acceleration, heavy loads, shock loads or vertical shafts occur or where oil is the only lubricant available, please contact us.
- ◆ Selection of fitting clearance and grease type requires a careful consideration of rotating speed, load conditions and temperature in order to prevent premature bearing failure.
- ◆ Full complement ball bearings are suitable for low speed and heavy radial load conditions. There is a danger of balls being pushed out of the bearing through the filling slot, even under light axial load. For this reason, full complement ball bearings are not suitable for supporting axial loads.

#### NOTES ON HANDLING

- ◆ The actual assembly area should be kept free from dust as any contamination has a detrimental effect on the operation and life of rolling bearings. If there is any doubt concerning the cleanliness of a bearing, it can be washed with a suitable agent and then relubricated.
- ◆ When fitting bearings, the fitting forces must not be transmitted via the rolling elements. If it is necessary to heat the bearing to facilitate fitting, the temperature should not exceed +120°C.

## Problem, Cause, Remedy

PROBLEM		CAUSE	REMEDY
Noise	High pitched metallic noise	Poor lubrication	Improve lubrication
		Clearance too small	Correct clearance
		Poor fitting	Investigate mounting method and seating
		Excessive load	Examine shaft and housing tolerances for closing effect
	Low pitched metallic noise	Brinelled raceway surface	Avoid shock loads
	Regular noise	Rust and damage	Check and replace seals and relubricate
		Flaking of raceway surface	Improve lubrication and check fitting, clearance and fixing method
	Irregular noise	Ingress of foreign matter	Check and replace seals and relubricate
		Excessive clearance	Correct clearance
		Damage and flaking of rolling element	Reduce loads and/or clearance
Variable noise	Variable clearance due to temperature changes	Check fits taking housing material and temperature into consideration	
	Damage to raceways	Improve lubrication and check fitting, clearance and fixing method	
Heavy vibration	Flaking of raceway and rolling element	Improve lubrication and check fitting, clearance and fixing method	
	Ingress of foreign matter	Check and replace seals and relubricate	
	Excessive clearance	Correct clearance	
	Poor location	Ensure abutment face and fitting diameter are perpendicular	
Excessive heat generation	Clearance too small	Correct clearance	
	Poor location	Ensure abutment face and fitting diameter are perpendicular	
	Excessive load	Examine shaft and housing tolerances for closing effect	
	Poor lubrication	Improve lubrication	
	Creep	Maintain recommended shaft and housing fits	
Lubrication failure	Too much grease	Use correct lubricant quantity	
	Ingress of foreign matter	Check and replace seals and relubricate	



# Damage, Cause, Remedy

Incorrect handling of bearing can cause damage and shorten the life. The following list shows typical causes and suggested remedies.

PROBLEM	DAMAGE	CAUSE	REMEDY
Flaking	Flaking on one side of entire raceway	Excessive axial load by poor fitting or linear expansion	Use clearance fit on non-rotating bearing outer ring
	Flaking at rolling element pitch on raceways	Raceways brinelled during fitting	Careful fitting
		Corrosion during down time	Apply corrosion protective
	Premature flaking of raceway and rolling element surfaces	Excessive load	Check fitting Correct clearance Use correct lubricant quantity
		Clearance too small	
		Poor lubrication	
Poor fitting			
Flaking across the raceway	Corrosion	Fitting and centering with care Use bearing with larger internal clearance Shaft and abutments to be square	
	Poor fitting and eccentricity		
	Shaft deflection		
Flaking around raceway	Geometric inaccuracy of shaft and housing	Check geometric accuracy of housing bore	
	Poor housing accuracy		
Indentations	Indentations on raceway at rolling element pitch	Shock loads during fitting or poor handling	Handling with care
	Overrolling	Excessive static load	Check static load
		Ingress of foreign matter	Ensure cleanliness of components and integrity of seals
Pick-up	Discolouration of raceway and rolling element surface	Excessive load	Check fitting
		Clearance too small	Correct clearance
	Softening of surfaces	Poor lubrication	Use correct lubricant quantity
		Poor fitting	Check fitting method
Electrical erosion	Raceway eroded at regular intervals	Arcing due to bearing conducting electricity	Ground the bearing, Insulate the bearing
		Excessive shock loads	Correct loading
Fracture	Raceway surface fracture	High interference fit	Proper fitting
		Increase of flaking and softening; welding of inner ring to shaft	Ensure correct geometry of shaft and housing
		Corner fillet radii too large	Correct fillet radii
		Excessive shock loads	Correct loading
	Rolling element fracture	Excessive internal clearance	Check fitting and clearance
		Tilting moments	Fit with care
	Cage fracture	High speed impulse and high acceleration	Ensure uniform rotation
		Incorrect lubrication	Check lubricant and lubrication method
Ingress of foreign matter in bearing		Improve sealing	
Skidding	Scoring of raceway and rolling element surfaces	Hard grease	Use soft grease
		High start-up acceleration	Control acceleration
Abrasion	Extreme abrasion of raceway, rolling element and cage	Ingress of foreign matter	Improve sealing
		Corrosion	Improve lubrication
		Poor lubrication	Improve lubrication
	Creep	Loose fit	Correct tolerances and fitting
		Incorrectly fixed	Correct fixing
	Fretting corrosion	Small movements between surfaces	Increase interference fit
False brinelling	Vibration in non-rotating bearing	Insulate bearing from vibration	
		Small oscillations in application	Use oil as lubricant Apply preload
Corrosion	Rust inside bearing	Poor storage	Careful storage and handling
		Condensation	
	Rust on fitting surface	Fretting	Increase interference fit
		Fluctuating load	Use oil as lubricant
Corrosion	Ingress of acid, alkali or gas	Check sealing	
		Chemical reaction with lubricant	Use correct lubricant



## Dimension Contents

- Metric series (0.6 ≤ d ≤ 4mm) ..... 24
- Metric series (5 ≤ d ≤ 9mm) ..... 26
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- Extra thin metric series: 6700, 6800, 6900 (10 ≤ d ≤ 30mm) ..... 30
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- Large sized stainless series: 6000H, 6200H, 6300H ..... 34
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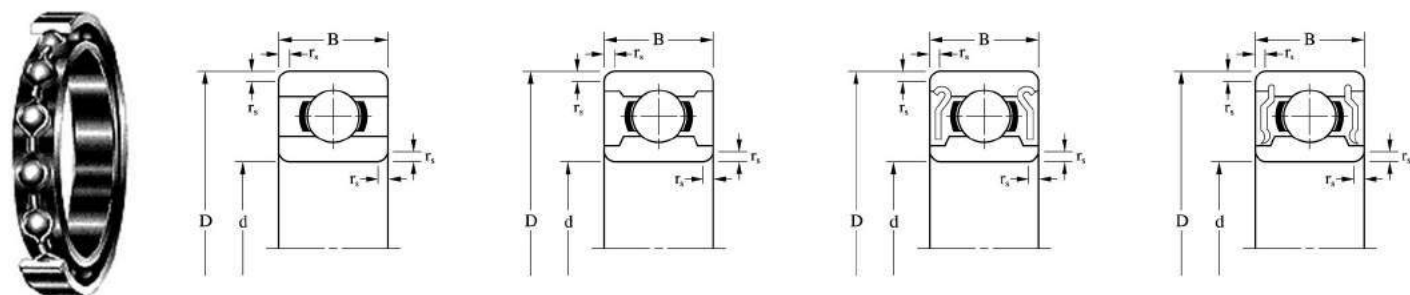








# Extra thin metric series: 6700, 6800, 6900 ( $35 \leq d \leq 95\text{mm}$ )



Technical

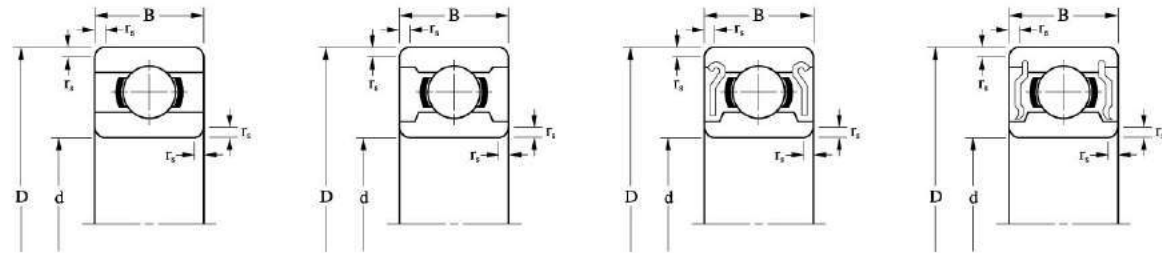
Dimension

Bore Diameter: d		Outer Diameter: D		Chamfer r <sub>s</sub> (min)		Width: B Open		Bearing Reference			
								Open	2 Shields	2 Seals	
mm	inch	mm	inch	mm	inch	mm	inch			2RS	2RU
35	1.3780	44	1.7323	0.3	0.0118	5	0.1969	6707 <sup>(1)</sup>	—	2RS	—
		47	1.8504	0.3	0.0118	7	0.2756	6807 <sup>(1)</sup>	6807ZZ	2RS	2RU
		55	2.1654	0.6	0.0236	10	0.3937	6907 <sup>(1)</sup>	6907ZZ	2RS	2RU
40	1.5748	50	1.9685	0.3	0.0118	6	0.2362	6708 <sup>(1)</sup>	—	2RS	—
		52	2.0472	0.3	0.0118	7	0.2756	6808 <sup>(1)</sup>	6808ZZ	2RS	2RU
		62	2.4409	0.6	0.0236	12	0.4724	6908 <sup>(1)</sup>	6908ZZ	2RS	2RU
45	1.7717	55	2.1654	0.3	0.0118	6	0.2362	6709 <sup>(1)</sup>	—	2RS	—
		58	2.2835	0.3	0.0118	7	0.2756	6809 <sup>(1)</sup>	6809ZZ	2RS	2RU
		68	2.6772	0.6	0.0236	12	0.4724	6909 <sup>(1)</sup>	6909ZZ	2RS	2RU
50	1.9685	62	2.4409	0.3	0.0118	6	0.2362	6710 <sup>(1)</sup>	—	2RS	—
		65	2.5591	0.3	0.0118	7	0.2756	6810 <sup>(1)</sup>	6810ZZ	2RS	2RU
		72	2.8346	0.6	0.0236	12	0.4724	6910 <sup>(1)</sup>	6910ZZ	2RS	2RU
55	2.1654	72	2.8346	0.3	0.0118	9	0.3543	6811 <sup>(1)</sup>	6811ZZ	2RS	2RU
		80	3.1496	1.0	0.0394	13	0.5118	6911 <sup>(1)</sup>	6911ZZ	2RS	2RU
60	2.3622	78	3.0709	0.3	0.0118	10	0.3937	6812 <sup>(1)</sup>	6812ZZ	2RS	2RU
		85	3.3465	1.0	0.0394	13	0.5118	6912 <sup>(1)</sup>	6912ZZ	2RS	2RU
65	2.5591	85	3.3465	0.6	0.0236	10	0.3937	6813 <sup>(1)</sup>	6813ZZ	2RS	—
		90	3.5433	1.0	0.0394	13	0.5118	6913 <sup>(1)</sup>	6913ZZ	2RS	—
70	2.7559	90	3.5433	0.6	0.0236	10	0.3937	6814 <sup>(1)</sup>	6814ZZ	2RS	2RU
		100	3.9370	1.0	0.0394	16	0.6299	6914 <sup>(1)</sup>	6914ZZ	2RS	—
75	2.9528	95	3.7402	0.6	0.0236	10	0.3937	6815 <sup>(1)</sup>	6815ZZ	2RS	—
		105	4.1339	1.0	0.0394	16	0.6299	6915 <sup>(1)</sup>	6915ZZ	2RS	—
80	3.1496	100	3.9370	0.6	0.0236	10	0.3937	6816 <sup>(1)</sup>	6816ZZ	2RS	2RU
		110	4.3307	1.0	0.0394	16	0.6299	6916 <sup>(1)</sup>	6916ZZ	2RS	—
85	3.3465	110	4.3307	1.0	0.0394	13	0.5118	6817 <sup>(1)</sup>	6817ZZ	2RS	—
		120	4.7244	1.1	0.0433	18	0.7087	6917 <sup>(1)</sup>	6917ZZ	2RS	—
90	3.5433	115	4.5276	1.0	0.0394	13	0.5118	6818 <sup>(1)</sup>	6818ZZ	2RS	—
		125	4.9213	1.1	0.0433	18	0.7087	6918 <sup>(1)</sup>	—	2RS	—
95	3.7402	120	4.7244	1.0	0.0394	13	0.5118	6819 <sup>(1)</sup>	—	—	2RU

(1) Open type bearings have shield/seal grooves.  
 (2) Single shield or single seal types are also available; suffix Z, RS or RU.  
 (3) Suffix H is added for stainless material types. Load ratings of stainless material types are calculated by Cr×0.85 and Cor×0.80 of SUJ2 material types.  
 (4) SUJ2 bearings use RJ type retainers, but stainless bearings use J type retainers.  
 (5) Applicable only for open, single Z, ZZ, single RU and 2RU types in inner ring rotating conditions. Max. speeds for the contact rubber seal(s) types will be around 50-60% of above values.

Load Rating		Max. Speed		Cage Type	Ball Complement			Weight(Ref.)
Cr(N)	Cor(N)	Grease	Oil		Qty.:Z	Size:Dw		2 Shields
(N)		x1000min <sup>-1</sup>			pcs.	mm	inch	g
1 860	1 630	4.9	6.0	W	26	2.000	0.0787	15.0
4 740	3 820	13	16	J,RJ <sup>(4)</sup>	19	3.500	0.1378	28.2
10 900	7 750	12	14	RJ	14	5.953	0.2344	73.3
2 510	2 230	4.3	5.0	W	25	2.381	0.0937	23.3
4 930	4 180	12	14	RJ	21	3.500	0.1378	30.3
13 700	9 920	11	13	RJ	14	6.747	0.2656	108
2 570	2 400	3.9	4.6	W	27	2.381	0.0937	25.6
6 210	5 380	11	13	RJ	21	3.969	0.1563	35.8
14 100	10 900	10	11	RJ	15	6.747	0.2656	130
2 670	2 650	3.5	4.1	W	30	2.381	0.0937	36.6
6 170	5 760	9.5	11	RJ	23	3.969	0.1563	49.5
14 500	11 700	9.0	11	RJ	16	6.747	0.2656	131
8 800	8 080	8.6	10	RJ	22	4.762	0.1875	78.3
16 600	14 100	8.1	9.6	RJ	17	7.144	0.2813	177
11 500	10 600	7.9	9.4	RJ	21	5.556	0.2187	99.4
20 200	17 300	7.5	8.9	RJ	17	7.938	0.3125	186
11 900	11 500	7.3	8.6	RJ	23	5.556	0.2187	125
17 300	16 000	7.0	8.3	RJ	19	7.144	0.2813	208
11 600	11 800	6.8	8.1	RJ	24	5.556	0.2187	134
23 700	21 100	6.4	7.6	RJ	17	8.731	0.3437	342
12 300	12 800	6.4	7.6	RJ	26	5.556	0.2187	142
24 000	22 600	6.0	7.1	RJ	18	8.731	0.3437	363
12 600	13 300	6.0	7.1	RJ	27	5.556	0.2187	150
24 800	23 900	5.7	6.7	RJ	19	8.731	0.3437	382
18 700	19 000	5.6	6.6	RJ	23	7.144	0.2813	266
31 900	29 600	5.3	6.2	RJ	17	10.319	0.4063	535
18 300	19 500	5.3	6.2	RJ	24	7.144	0.2813	279
32 400	31 600	5.0	5.9	RJ	18	10.319	0.4063	565
18 800	20 300	5.0	5.9	RJ	25	7.144	0.2813	285

# Large sized stainless series: 6000H, 6200H, 6300H



Technical

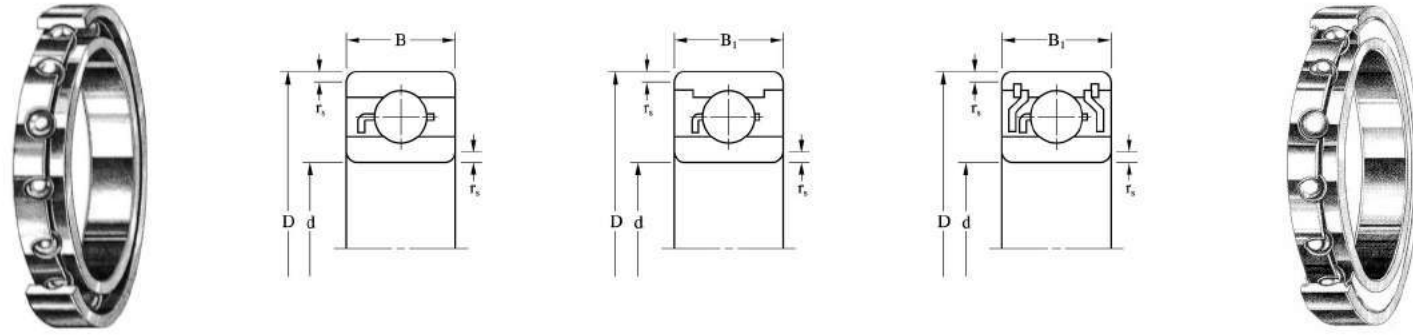
Dimension

Bore Diameter: d		Outer Diameter: D		Width: B		Chamfer rs(min)		Bearing Reference				
mm	inch	mm	inch	mm	inch	mm	inch	Open	2 Shields ZZ	2RS	2RU	TTS
10	0.3937	26	1.0236	8	0.3150	0.3	0.0118	6000H <sup>(1),(2)</sup>	ZZ	2RS	2RU	-
		30	1.1811	9	0.3543	0.6	0.0236	6200H <sup>(1),(2)</sup>	ZZ	2RS	2RU	-
		35	1.3780	11	0.4331	0.6	0.0236	6300H <sup>(1)</sup>	ZZ	2RS	2RU	-
12	0.4724	28	1.1024	8	0.3150	0.3	0.0118	6001H <sup>(1),(2)</sup>	ZZ	2RS	2RU	TTS
		32	1.2598	10	0.3937	0.6	0.0236	6201H <sup>(1)</sup>	ZZ	2RS	2RU	-
		37	1.4567	12	0.4724	1.0	0.0394	6301H <sup>(1)</sup>	ZZ	2RS	2RU	-
15	0.5906	32	1.2598	9	0.3543	0.3	0.0118	6002H <sup>(1),(2)</sup>	ZZ	2RS	2RU	-
		35	1.3780	11	0.4331	0.6	0.0236	6202H <sup>(1)</sup>	ZZ	2RS	2RU	-
		42	1.6535	13	0.5118	1.0	0.0394	6302H <sup>(1)</sup>	ZZ	2RS	2RU	-
17	0.6693	35	1.3780	10	0.3937	0.3	0.0118	6003H <sup>(1),(2)</sup>	ZZ	2RS	2RU	-
		40	1.5748	12	0.4724	0.6	0.0236	6203H <sup>(1)</sup>	ZZ	2RS	2RU	-
		47	1.8504	14	0.5512	1.0	0.0394	6303H <sup>(1)</sup>	ZZ	2RS	2RU	-
20	0.7874	42	1.6535	12	0.4724	0.6	0.0236	6004H <sup>(1)</sup>	ZZ	2RS	2RU	-
		47	1.8504	14	0.5512	1.0	0.0394	6204H <sup>(1)</sup>	ZZ	2RS	2RU	-
		52	2.0472	15	0.5906	1.1	0.0433	6304H <sup>(1)</sup>	ZZ	2RS	2RU	-
25	0.9843	47	1.8504	12	0.4724	0.6	0.0236	6005H <sup>(1)</sup>	ZZ	2RS	2RU	-
		52	2.0472	15	0.5906	1.0	0.0394	6205H <sup>(1)</sup>	ZZ	2RS	2RU	-
		62	2.4409	17	0.6693	1.1	0.0433	6305H <sup>(1)</sup>	ZZ	2RS	2RU	-
30	1.1811	55	2.1654	13	0.5118	1.0	0.0394	6006H <sup>(1)</sup>	ZZ	2RS	2RU	-
		62	2.4409	16	0.6299	1.0	0.0394	6206H <sup>(1)</sup>	ZZ	2RS	2RU	-
		72	2.8346	19	0.7480	1.1	0.0433	6306H <sup>(1)</sup>	ZZ	2RS	2RU	-
35	1.3780	62	2.4409	14	0.5512	1.0	0.0394	6007H <sup>(1)</sup>	ZZ	2RS	2RU	-
		72	2.8346	17	0.6693	1.1	0.0433	6207H <sup>(1)</sup>	ZZ	2RS	2RU	-
		80	3.1496	21	0.8268	1.5	0.0591	6307H <sup>(1)</sup>	ZZ	2RS	2RU	-
40	1.5748	68	2.6772	15	0.5906	1.0	0.0394	6008H <sup>(1)</sup>	ZZ	2RS	2RU	-
		80	3.1496	18	0.7087	1.1	0.0433	6208H <sup>(1)</sup>	ZZ	2RS	2RU	-
45	1.7717	75	2.9528	16	0.6299	1.0	0.0394	6009H <sup>(1)</sup>	ZZ	2RS	2RU	-
		85	3.3465	19	0.7480	1.1	0.0433	6209H <sup>(1)</sup>	ZZ	2RS	2RU	-
50	1.9685	80	3.1496	16	0.6299	1.0	0.0394	6010H <sup>(1)</sup>	ZZ	2RS	2RU	-
		90	3.5433	20	0.7874	1.1	0.0433	6210H <sup>(1)</sup>	ZZ	2RS	2RU	-
55	2.1654	90	3.5433	18	0.7087	1.1	0.0433	6011H <sup>(1)</sup>	ZZ	2RS	2RU	-
		100	3.9370	21	0.8268	1.5	0.0591	6211H <sup>(1)</sup>	ZZ	2RS	2RU	-
60	2.3622	95	3.7402	18	0.7087	1.1	0.0433	6012H <sup>(1)</sup>	ZZ	2RS	2RU	-
		110	4.3307	22	0.8661	1.5	0.0591	6212H <sup>(1)</sup>	ZZ	2RS	2RU	-

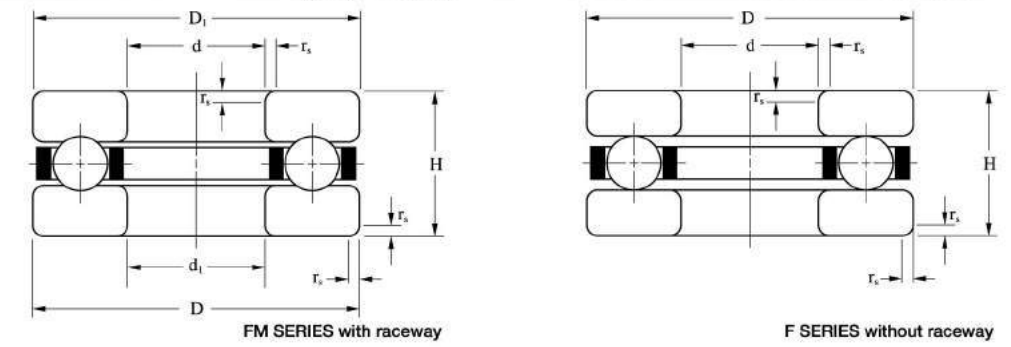
(1) Open type bearings have shield/seal grooves. (2) SUJ2 material type (without suffix H) is also available. Load ratings of SUJ2 material types are calculated by Cr/0.85 and Cor/0.80 of stainless material types.  
 (3) Single shield or single seal types are also available; suffix Z, RS, RU or TS.  
 (4) Applicable only for open, single Z, ZZ, single RU and 2RU types in inner ring rotating conditions. Max. speeds for the contact rubber seal(s) types will be around 50-60% of above values.

Load Rating		Max. Speed		Cage Type	Ball Complement			Weight (Ref.)
Cr(N)	Cor(N)	Grease	Oil		Qty. :Z	Size:Dw		2 Shields g
(N)		x1000min <sup>-1</sup>				pcs.	mm	
3 890	1 570	28	33	J	7	4.762	0.1875	18
4 350	1 910	25	30	RJ,TW	8	4.762	0.1875	30
6 880	2 750	23	27	RJ	6	7.144	0.2813	52
4 350	1 910	25	30	J,TW	8	4.762	0.1875	20
5 780	2 440	24	28	RJ,TW	7	5.953	0.2344	35
8 250	3 350	22	25	RJ	6	7.938	0.3125	58
4 750	2 270	22	26	RJ,TW	9	4.762	0.1875	28
6 490	2 980	21	25	RJ,TW	8	5.953	0.2344	44
9 720	4 350	18	21	RJ	7	7.938	0.3125	81
5 100	2 610	20	24	RJ,TW	10	4.762	0.1875	38
8 130	3 830	18	22	RJ,TW	8	6.747	0.2656	65
11 600	5 290	16	19	RJ	7	8.731	0.3437	111
7 980	4 050	17	20	RJ,TW	9	6.350	0.2500	64
10 900	5 320	16	19	RJ,TW	8	7.938	0.3125	104
13 500	6 270	15	18	RJ	7	9.525	0.3750	141
8 550	4 680	15	18	RJ,TW	10	6.350	0.2500	77
11 900	6 300	14	16	RJ,TW	9	7.938	0.3125	128
17 500	9 000	12	14	RJ	8	10.319	0.4063	232
11 200	6 620	13	15	RJ,TW	11	7.144	0.2813	111
16 500	9 070	12	14	RJ,TW	9	9.525	0.3750	193
22 700	12 000	11	12	RJ	8	11.906	0.4687	340
13 600	8 240	11	13	RJ	11	7.938	0.3125	146
21 800	12 300	10	12	RJ	9	11.112	0.4375	273
28 300	15 400	9.4	11	RJ	8	13.494	0.5313	432
14 300	9 240	10	12	RJ	12	7.938	0.3125	180
24 700	14 300	9.1	11	RJ	9	11.906	0.4687	354
17 800	12 100	9.1	11	RJ	13	8.731	0.3437	233
27 800	16 400	8.4	10	RJ	9	12.700	0.5000	386
18 500	13 300	8.4	9.9	RJ	14	8.731	0.3437	252
29 800	18 600	7.8	9.2	RJ	10	12.700	0.5000	446
24 000	17 000	7.5	8.9	RJ	13	10.319	0.4063	357
36 900	23 500	6.9	8.2	RJ	10	14.288	0.5625	571
25 000	18 500	7.0	8.3	RJ	14	10.319	0.4063	381
44 600	29 000	6.3	7.4	RJ	10	15.875	0.6250	745

# Extra thin metric series: ET, ER



# Thrust series: FM, F



Bore Diameter: d		Outer Diameter: D		Open Type Width: B		Seal·Shield Type Width: B <sub>1</sub>		Chamfer r <sub>s</sub> (min)		Bearing References			Load Rating		Max. Speed		Ball Complement			Weight(Ref.)		
										Open	2Shields	2Seals	Cr (N)	Cor (N)	Grease	Oil	Cage Type	Qty.: Z	Size: Dw		2Shields	Flange 2Shields
mm	inch	mm	inch	mm	inch	mm	inch	mm	inch				(N)		X1000min <sup>-1</sup>		pcs.	mm	inch		g	
<b>ET series</b>																						
15	0.5906	20	0.7874	3.5	0.1378	-	-	0.15	0.0059	ET2015	-	-	943	583	11	13	W	14	1.588	0.0625	2.14	-
		21	0.8268	3.5	0.1378	-	-	0.15	0.0059	ET2115	-	-	937	581	11	13	W	14	1.588	0.0625	3.04	-
16	0.6299	22	0.8661	4.0	0.1575	4.0	0.1575	0.15	0.0059	ET2216 <sup>(1)</sup>	ZZS	TTS	971	620	10	12	W	15	1.588	0.0625	3.39	3.70
		23	0.9055	4.5	0.1772	4.5	0.1772	0.15	0.0059	ET2316 <sup>(1)</sup>	ZZS	TTS	971	620	10	12	W	15	1.588	0.0625	4.98	5.29
20	0.7874	25	0.9843	4.0	0.1575	4.0	0.1575	0.15	0.0059	ET2520 <sup>(1)</sup>	ZZS	TTS	1 010	691	8.5	10	W	17	1.588	0.0625	2.96	3.30
<b>ER series</b>																						
9.525	0.3750	15.875	0.6250	3.967	0.1562	3.967	0.1562	0.25	0.0098	ER1038 <sup>(1)</sup>	ZZS	TTS	857	435	15	17.5	W	11	1.588	0.0625	2.40	2.60
12.700	0.5000	19.050	0.7500	3.967	0.1562	3.967	0.1562	0.25	0.0098	ER1212 <sup>(1)</sup>	ZZS	TTS	919	537	12	14	W	13	1.588	0.0625	3.01	3.26
15.875	0.6250	22.225	0.8750	3.967	0.1562	3.967	0.1562	0.25	0.0098	ER1458 <sup>(1)</sup>	ZZS	TTS	971	620	10	12	W	15	1.588	0.0625	3.64	3.95
19.050	0.7500	25.400	1.0000	3.967	0.1562	3.967	0.1562	0.25	0.0098	ER1634 <sup>(1)</sup>	ZZS	TTS	1 010	691	8.5	10	W	17	1.588	0.0625	4.22	4.56

(1) Open type bearings have shield/seal grooves.  
 (2) Single shield or single seal types are also available; suffix ZS or TS.  
 (3) Prefix S is added for stainless material types. Load ratings of stainless material types are calculated by Cr×0.85 and Cor×0.80 of SUJ2 material types.  
 (4) Applicable only for open, single Z, ZZ, single RU and 2RU types in inner ring rotating conditions. Max. speeds for the contact rubber seal(s) types will be around 50-60% of above values.

## FM series with raceway

Bearing Reference e	Inner Ring Bore Dia.		Outer Ring Outer Dia.		Outer Ring Bore Dia.		Inner Ring Outer Dia.		Chamfer		Hight		Load Rating		Max Speed		Cage Type	Ball Complement			Weight (Ref.)
	d		D		d <sub>1</sub>		D <sub>1</sub>		r <sub>s</sub> (min)		H		(N)		Oil			Qty.:Z	Size:Dw		
	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	(N)	X1000min <sup>-1</sup>	pcs.	mm			inch	g	
F3-8M	3	0.1181	8	0.3150	3.2	0.1260	7.8	0.3071	0.15	0.0059	3.5	0.1378	994	932	24	TP	6	1.588	0.0625	0.8	
F4-9M	4	0.1575	9	0.3543	4.2	0.1654	8.8	0.3465	0.15	0.0059	4.0	0.1575	945	932	22	TP	6	1.588	0.0625	1.2	
F4-10M	4	0.1575	10	0.3937	4.2	0.1654	9.8	0.3858	0.15	0.0059	4.0	0.1575	925	932	21	TP	6	1.588	0.0625	1.5	
F5-12M	5	0.1969	12	0.4724	5.2	0.2047	11.8	0.4646	0.20	0.0079	4.0	0.1575	1 060	1 240	19	TP	8	1.588	0.0625	2.1	
F6-12M	6	0.2362	12	0.4724	6.2	0.2441	11.8	0.4646	0.20	0.0079	4.5	0.1772	1 820	2 220	18	TP	9	2.000	0.0787	2.2	
F6-14M	6	0.2362	14	0.5512	6.25	0.2461	13.8	0.5433	0.20	0.0079	5.0	0.1969	2 160	2 440	16	TP	7	2.381	0.0937	3.5	
F7-13M	7	0.2756	13	0.5118	7.2	0.2835	12.8	0.5039	0.20	0.0079	4.5	0.1772	1 770	2 220	18	TP	9	2.000	0.0787	2.4	
F7-17M	7	0.2756	17	0.6693	7.2	0.2835	16.8	0.6614	0.30	0.0118	6.0	0.2362	3 090	3 800	14	TP	8	2.778	0.1094	6.3	
F8-16M	8	0.3150	16	0.6299	8.2	0.3228	15.8	0.6220	0.30	0.0118	5.0	0.1969	3 920	4 990	16	TP	9	3.000	0.1181	3.9	
F8-19M	8	0.3150	19	0.7480	8.2	0.3228	18.8	0.7402	0.30	0.0118	7.0	0.2756	3 940	4 970	12	TP	8	3.175	0.1250	9.3	
F9-20M	9	0.3543	20	0.7874	9.2	0.3622	19.8	0.7795	0.30	0.0118	7.0	0.2756	3 860	4 970	12	TP	8	3.175	0.1250	9.9	
F10-18M	10	0.3937	18	0.7087	10.2	0.4016	17.8	0.7008	0.30	0.0118	5.5	0.2165	2 470	3 490	14	TP	10	2.381	0.0937	5.3	

(1) Bearings in stainless steel material (suffix H) would also be available upon request. Load ratings of stainless material types are calculated by Cr×0.85 or Cor×0.80 of SUJ2 material types.

## F series without raceway

Bearing Reference	Bore Dia.		Outer Dia.		Chamfer		Hight		Load Rating		Cage Type	Ball Complement			Weight (Ref.)
	d		D		r <sub>s</sub> (min)		H		Ca(N) Coa(N)			Qty.:Z	Size:Dw		
	mm	inch	mm	inch	mm	inch	mm	inch	(N)	(N)			pcs.	mm	
F2-6	2	0.0787	6	0.2362	0.10	0.0039	3.0	0.1181	143	83	TD	6	1.000	0.0394	0.5
F2X-7	2.5	0.0984	7	0.2756	0.10	0.0039	3.5	0.1378	199	120	TD	6	1.200	0.0472	0.9
F3-8	3	0.1181	8	0.3150	0.10	0.0039	3.5	0.1378	212	140	TD	7	1.200	0.0472	1.0
F4-9	4	0.1575	9	0.3543	0.15	0.0059	4.0	0.1575	220	160	TD	8	1.200	0.0472	1.4
F4-10	4	0.1575	10	0.3937	0.15	0.0059	4.5	0.1772	355	245	TD	7	1.588	0.0625	1.9
F5-11	5	0.1969	11	0.4331	0.15	0.0059	4.5	0.1772	341	245	TD	7	1.588	0.0625	2.2
F6-12	6	0.2362	12	0.4724	0.15	0.0059	4.5	0.1772	389	314	TD	9	1.588	0.0625	2.5
F7-15	7	0.2756	15	0.5906	0.20	0.0079	5.0	0.1969	793	628	TD	8	2.381	0.0937	4.2
F8-16	8	0.3150	16	0.6299	0.20	0.0079	5.0	0.1969	537	443	TD	8	2.000	0.0787	4.9
F9-17	9	0.3543	17	0.6693	0.20	0.0079	5.0	0.1969	567	499	TD	9	2.000	0.0787	5.2
F10-18	10	0.3937	18	0.7087	0.20	0.0079	5.5	0.2165	800	707	TD	9	2.381	0.0937	6.1





## <Inch Series>

### ●OPEN BEARINGS

EZO	JTEKT	NMB	NSK	NTN
R09	OB63	RI-2	R09	R01
R0	OB65	RI-2 1/2	R0	R0
R1	OB67	RI-3	R1	R1
R1-4	OB69	RI-4	R1-4	R1-4
R133	OB71	RI3332	R133	R133
R1-5	OB72	RI-5	R1-5	R1-5
R144	OB74	RI-418	R144	R144
R2-5	OB75	RI-518	R2-5	R2-5
R2-6	OB76	RI-618	R2-6	R2-6
R2	EE0	R-2	R2	R2
R2A	EE1/2	-	R2A	RA2
R155	OB79	RI-5532	R155	R155
R156	OB81	RI-5632	R156	R156
R166	OB82	RI-6632	R166	R166
R3	EE1	R-3	R3	R3
R168	OB87	RI-614	R168	R168
R188	OB88	RI-814	R188	R188
R4	EE11/2	R-4	R4	R4
R4A	EE2	RI-1214	R4A	RA4
R1810	OB92-1	RI-8516	R1810	R1810
R6	EE3	RI-1438	R6	R6
R8	-	RI-1812	R8	R8
R10	-	-	R10	R10
R12	-	-	R12	R12

### ●SHIELDED BEARINGS

EZO	JTEKT	NMB	NSK	NTN
R0ZZ	WOB65ZZ	RI-2 1/2ZZ	R0ZZ	RA0ZZA
R1ZZ	WOB67ZZ	RI-3ZZ	R1ZZ	RA1ZZA
R1-4ZZ	WOB69ZZX	RI-4ZZ	R1-4ZZS	RA1-4ZZA
R133ZZS	WOB71ZZX	RI-3332ZZ	R133ZZS	RA133ZZA
R1-5ZZ	WOB72ZZX	RI-5ZZ	R1-5ZZS	RA1-5ZZA
R144ZZS	WOB74ZZX	RI-418ZZ	R144ZZS	RA144ZZA
R2-5ZZ	WOB75ZZ	RI-518ZZ	R2-5ZZ	RA2-5ZZA
R2-6ZZ	WOB76ZZ	RI-618ZZ	R2-6ZZ	RA2-6ZZA
R2ZZ	EE0ZZ	R-2ZZ	R2ZZ	R2ZZA
R2AZZ	EE1/2ZZ	-	R2AZZ	RA2ZZ
R155ZZS	WOB79ZZX	RI-5532ZZ	R155ZZS	RA155ZZA
R156ZZS	WOB81ZZ	RI-5632ZZ	R156ZZS	RA156ZZA
R166ZZ	WOB82ZZ	RI-6632ZZ	R166ZZ	R166ZZA
R3ZZ	EE1SZZ	R-3ZZ	R3ZZ	RA3ZZ
R168ZZS	WOB87ZZX	RI-614ZZ	R168ZZS	RA168ZZA
R188ZZ	WOB88ZZ	RI-814ZZ	R188ZZ	RA188ZZA
R4ZZ	EE11/2ZZ	R-4ZZ	R4ZZ	RA4ZZ
R4AZZ	EE2ZZ	RI-1214ZZ	R4AZZ	RA4ZZ
R1810ZZS	WOB92ZZX	RI-8516ZZ	R1810ZZS	RA1810ZZA
R6ZZ	EE3SZZ	RI-1438ZZ	R6ZZ	R6ZZ
R8ZZ	-	RI-1812ZZ	R8ZZ	R8ZZ
R10ZZ	-	-	R10ZZ	R10ZZ
R12ZZ	-	-	R12ZZ	R12ZZ

### ●FLANGED OPEN BEARINGS

EZO	JTEKT	NMB	NSK	NTN
FR0	OBF65	RIF-2 1/2	FR0	FLR0
FR1	OBF67	RIF-3	FR1	FLR1
FR1-4	OBF69	RIF-4	FR1-4	FLR1-4
FR133	OBF71	RIF-3332	FR133	FLR133
FR1-5	OBF72	RIF-5	FR1-5	FLR1-5
FR144	OBF74	RIF-418	FR144	FLR144
FR2-5	OBF75	RIF-518	FR2-5	FLR2-5
FR2-6	OBF76	RIF-618	FR2-6	FLR2-6
FR2	OBF77	RF-2	FR2	FLR2
FR155	OBF79	RIF-5532	FR155	FLR155
FR156	OBF81	RIF-5632	FR156	FLR156
FR166	OBF82	RIF-6632	FR166	FLR166
FR3	OBF84	RF-3	FR3	FLRA3
FR168	OBF87	RIF-614	FR168	FLR168
FR188	OBF88	RIF-814	FR188	FLR188
FR4	OBF89	RF-4	FR4	FLR4
FR1810	OBF92-1	RIF-8516	FR1810	FLR1810
FR6	OBF93	RIF-1438	FR6	FLR6
FR8	-	RIF-1812	FR8	FLR8
FR10	-	-	FR10	FLR10
FR12	-	-	FR12	FLR12

### ●FLANGED SHIELDED BEARINGS

EZO	JTEKT	NMB	NSK	NTN
FR0ZZ	WOBF65ZZ	RIF-2 1/2ZZ	FR0ZZ	FLRA0ZZA
FR1ZZ	WOBF67ZZ	RIF-3ZZ	FR1ZZ	FLRA1ZZA
FR1-4ZZ	WOBF69ZZX	RIF-4ZZ	FR1-4ZZS	FLRA1-4ZZA
FR133ZZS	WOBF71ZZX	RIF-3332ZZ	FR133ZZS	FLRA133ZZA
FR1-5ZZ	WOBF72ZZX	RIF-5ZZ	FR1-5ZZS	FLRA1-5ZZA
FR144ZZS	WOBF74ZZX	RIF-418ZZ	FR144ZZS	FLRA144ZZA
FR2-5ZZ	WOBF75ZZ	RIF-518ZZ	FR2-5ZZ	FLRA2-5ZZA
FR2-6ZZ	WOBF76ZZ	RIF-618ZZ	FR2-6ZZ	FLRA2-6ZZA
FR2ZZ	WOBF77ZZ	RF-2ZZ	FR2ZZ	FLR2ZZA
FR155ZZS	WOBF79ZZX	RIF-5532ZZ	FR155ZZS	FLRA155ZZA
FR156ZZS	WOBF81ZZ	RIF-5632ZZ	FR156ZZS	FLRA156ZZA
FR166ZZ	WOBF82ZZ	RIF-6632ZZ	FR166ZZ	FLAR166ZZA
FR3ZZ	WOBF84ZZ	RF-3ZZ	FR3ZZ	FLRA3ZZ
FR168ZZS	WOBF87ZZX	RIF-614ZZ	FR168ZZS	FLAR168ZZA
FR188ZZ	WOBF88ZZ	RIF-814ZZ	FR188ZZ	FLRA188ZZA
FR4ZZ	WOBF89ZZ	RF-4ZZ	FR4ZZ	FLR4ZZ
FR1810ZZS	WOBF92ZZX	RIF-8516ZZ	FR1810ZZS	FLRA1810ZZA
FR6ZZ	WOBF93ZZ	RIF-1438ZZ	FR6ZZ	FLR6ZZ
FR8ZZ	-	RIF-1812ZZ	FR8ZZ	FLR8ZZ
FR10ZZ	-	-	FR10ZZ	FLR10ZZ
FR12ZZ	-	-	FR12ZZ	FLR12ZZ



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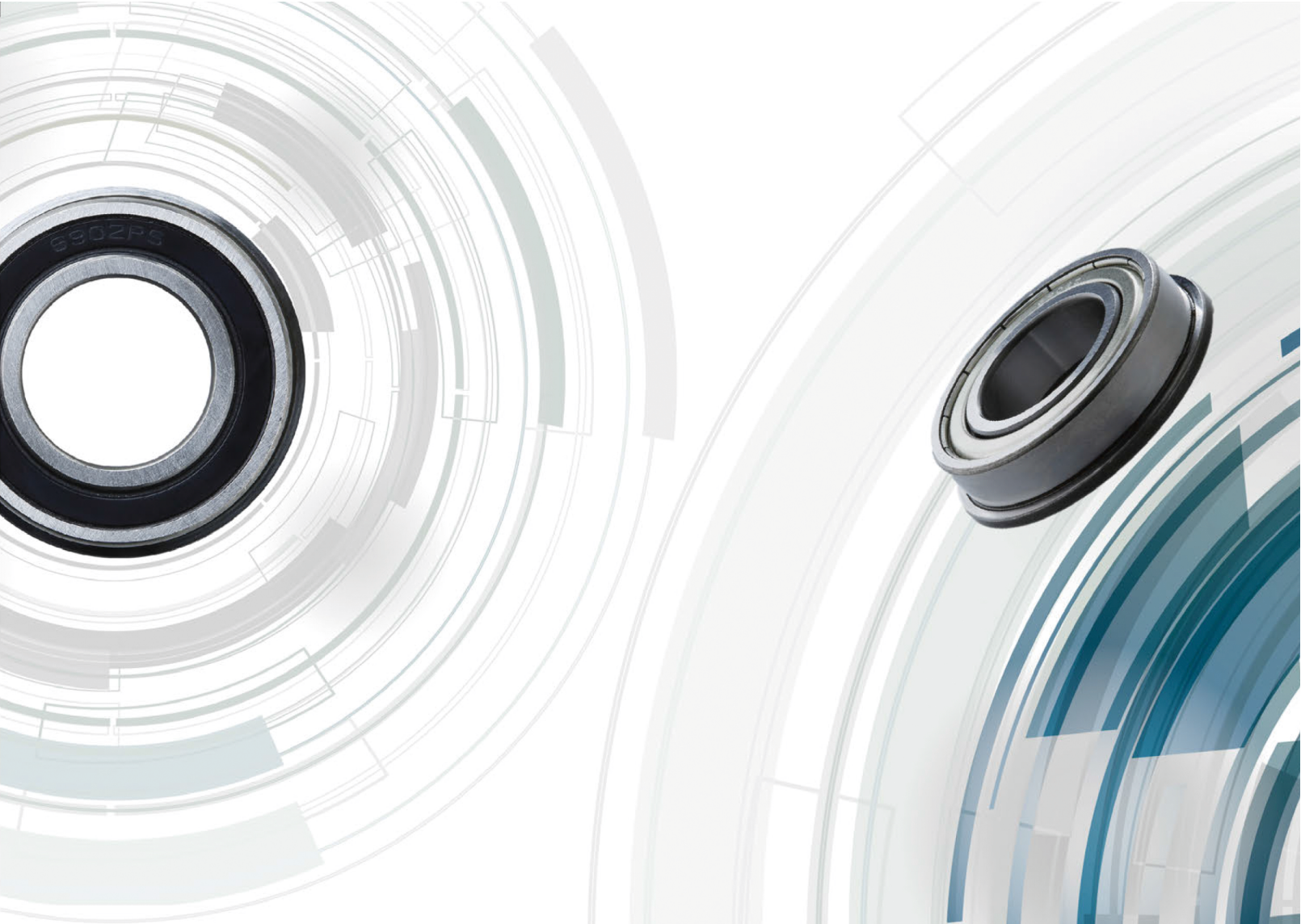
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