SPHERICAL BUSHINGS

- ●Steel-on-steel Spherical Bushings
- ●Maintenance-free Spherical Bushings

Structure and Features

IKO Spherical Bushings are self-aligning spherical plain bushings that have inner and outer rings with spherical sliding surfaces, and can take a large radial load and a bi-directional axial load at the same time. There are many types of Spherical Bushings, but they are basically divided into steel-on-steel types and maintenance-free types according to the kind of sliding surfaces.

Steel-on-steel Spherical Bushings have inner and outer rings of high carbon chromium bearing steel, of which sliding surfaces are phosphate-treated and then dry-coated with molybdenum disulfide (MoS_2). They can, therefore, operate with low torque, and have excellent wear resistance and large load capacity. They are especially suitable for applications where there are alternate loads and shock loads. They have wide applications mainly in industrial and construction machinery.

Maintenance-free Spherical Bushings consist of an outer ring which has a special PTFE liner reinforced with copper alloy meshes on the sliding surface, and a spherical inner ring of which sliding surface has a hard chromium plating. Creep deformation due to compressive load is small, and wear resistance is superior. Thus, they are maintenance-free and can be used for extended periods of time without re-lubrication. They are especially suitable in cases where fixed directional loads are applied and are used mainly in food processing machines and construction machinery and in other applications in which the use of oil is undesirable or lubrication is not possible.

Types

Spherical Bushings are available in various types shown in Table 1.

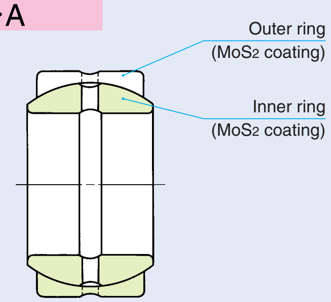
Table 1 Type of bearing

Type / Series	Steel-on-steel		Maintenance-free	
	Without seals	With seals	Without seals	With seals
Metric	SB	—	GE…EC	GE…EC-2RS
	SB…A	—		
	GE…E, ES	GE…ES-2RS		
	GE…G, GS	GE…GS-2RS		
Inch	SBB	SBB… -2RS	—	—

Structures of Spherical Bushings

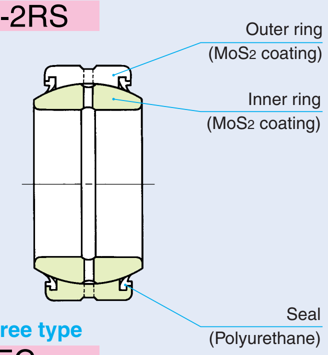
Steel-on-steel type

SB…A



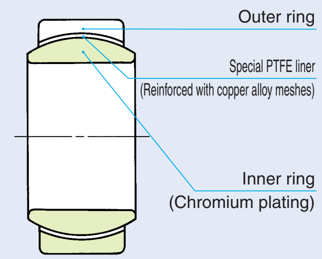
Steel-on-steel type

GE…ES-2RS



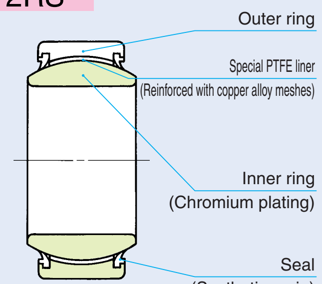
Maintenance-free type

GE…EC



Maintenance-free type

GE…EC-2RS



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SB
GE
SBB

Steel-on-steel Spherical Bushings SB

These bushings have an outer ring split into halves. The split outer ring and the inner ring are held together by a snap ring placed in the groove around the outer periphery of the outer ring.

Steel-on-steel Spherical Bushings SB…A

These bushings have an outer ring split only at one position, and therefore, the outer and inner rings will not separate. Handling before mounting and mounting to the housing are simple. The boundary dimensions are the same as those of the SB type.Therefore, SB and SB…A types are dimensionally interchangeable, but the radial internal clearances of the SB…A type are smaller than those of the SB type.

Steel-on-steel Spherical Bushings GE…E,GE…ES

The dimension series of these types conform to ISO standards and they can be used internationally. The outer ring is split at one position. The GE…E and GE…ES types are available. These are classified by bushing size.
The GE…ES type can be provided with seals, which are double-lip type polyurethane seals effective for prevention against grease leakage and dust penetration. The sealed type is indicated by the suffix "-2RS" at the end of the identification number.

Steel-on-steel Spherical Bushings GE…G,GE…GS

As compared with the GE…E and GE…ES types, these bushings have larger load capacities and larger permissible tilting angles. The dimension series also conform to ISO standards, and they can be used internationally. The outer ring is split at one position. The GE…G and GE…GS types are available. They are classified by bushing size.
The GE…GS type can be provided with seals, which are double-lip type polyurethane seals effective for prevention against grease leakage and dust penetration.

Steel-on-steel Spherical Bushings SBB

These are inch series bushings. The outer ring is split at one position.
These bushings can be provided with seals, which are double-lip type polyurethane seals effective for prevention against grease leakage and dust penetration.

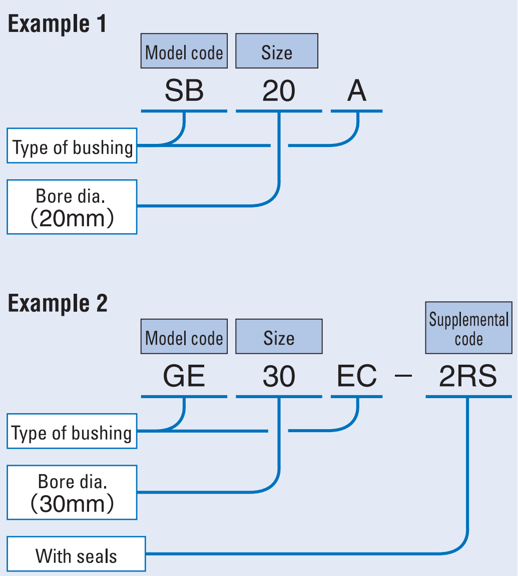
Maintenance-free Spherical Bushings GE…EC

These bushings have the same boundary dimensions as the GE…ES type and can be used internationally. A special PTFE liner reinforced with copper alloy meshes is used on the sliding surface. Therefore, creep deformation due to compressive loads is small, and wear resistance is superior. These bushings are used as maintenance-free bushings.
These bushings can be provided with synthetic resin seals which are effective in preventing dust penetration. They are indicated by the suffix "-2RS" at the end of the identification number.
Spherical Bushings with superior rust prevention properties, which can be used in a corrosive environment or in an environment where water splashes, are also available on request. Please consult IKO.

Identification number

The identification number of Spherical Bushings consists of a model code, a size and any supplemental codes. Examples are shown below.

Examples of identification number



Accuracy

The tolerances of Steel-on-steel Spherical Bushings of the metric series is shown in Table 2.
The tolerances of the GE type are applicable to bushings before splitting the outer ring and after surface treatment.
The tolerances of the SB and SB…A types are applicable to bushings before splitting the outer ring and before surface treatment.
The tolerances of the GE…EC type are applicable to bushings before splitting the outer ring.
The tolerances of the Spherical Bushings of the inch series are shown in Table 3. The tolerances of the bore diameter are applicable to bushings after surface treatment, while other tolerances are applicable to bushings before splitting the outer ring and before surface treatment.
Although minor dimensional changes may occur during surface treatment, they have negligible influence on the overall performance.

Table 2 Tolerances of inner and outer rings of metric series (JIS Class 0) unit: μm

d or D (1) Nominal bore dia. or outside dia. mm		Δ_{dmp} Single plane mean bore dia. deviation		Δ_{Dmp} Single plane mean outside dia. deviation		Δ_{Bs} or Δ_{Cs} Deviation of a single inner ring width or outer ring width	
Over	Incl.	High	Low	High	Low	High	Low
2.5	6	0	− 8	−	−	0	− 120
6	18	0	− 8	0	− 8	0	− 120
18	30	0	− 10	0	− 9	0	− 120
30	50	0	− 12	0	− 11	0	− 120
50	80	0	− 15	0	− 13	0	− 150
80	120	0	− 20	0	− 15	0	− 200
120	150	0	− 25	0	− 18	0	− 250
150	180	0	− 25	0	− 25	0	− 250
180	250	0	− 30	0	− 30	0	− 300
250	315	0	− 35	0	− 35	0	− 350
315	400	0	− 40	0	− 40	0	− 400
400	500	0	− 45	0	− 45	0	− 450

Note(1) d for Δ_{dmp}, Δ_{Bs} and Δ_{Cs} and D for Δ_{Dmp}, respectively.

Table 3 Tolerances of inner and outer rings of inch series SBB unit: μm

d or D (1) Nominal bore dia. or outside dia. mm		Δ_{dmp} Single plane mean bore dia. deviation		Δ_{Dmp} Single plane mean outside dia. deviation		Δ_{Bs} or Δ_{Cs} Deviation of a single inner ring width or outer ring width	
Over	Incl.	High	Low	High	Low	High	Low
−	50.800	0	− 13	0	− 13	0	− 130
50.800	76.200	0	− 15	0	− 15	0	− 130
76.200	80.962	0	− 20	0	− 15	0	− 130
80.962	120.650	0	− 20	0	− 20	0	− 130
120.650	152.400	0	− 25	0	− 25	0	− 130
152.400	177.800	−	−	0	− 25	0	− 130
177.800	222.250	−	−	0	− 30	0	− 130

Note(1) d for Δ_{dmp}, Δ_{Bs} and Δ_{Cs} and D for Δ_{Dmp}, respectively.

Clearance

The radial internal clearances of Spherical Bushings are the values before splitting the outer ring, and are shown in Tables 4, 5 and 6. The radial internal clearances of the inch series are shown in the dimension table.
Clearances other than these can also be prepared on request. Please consult IKO.

Table 4 Radial internal clearance of SB and SB…A types (Steel-on-steel) unit: μm

d Nominal bore dia. mm	SB type		SB…A type	
	Min.	Max.	Min.	Max.
12	70	125	32	68
15			40	82
20	75	140		
22			50	100
25				
30				
35	85	150	60	120
40				
45				
50				
55	90	160	72	142
60				
65				
70	95	170		
75				
80				
85	100	185	85	165
90				
95				
100				
110	110	200		
115				
120				
130	120	215	100	192
150				

K
SB
GE
SBB

1N=0.102kgf=0.2248lbs.
1mm=0.03937inch

Table 5 Radial internal clearance of GE type (Steel-on-steel)

unit: μm

d Nominal bore dia. mm		Radial internal clearance	
GE⋯E GE⋯ES	GE⋯G GE⋯GS	Min.	Max.
4 5 6 8 10 12	— — — 6 8 10	32	68
15 17 20	12 15 17	40	82
25 30 35	20 25 30	50	100
40 45 50 60	35 40 45 50	60	120
70 80 90	60 70 80	72	142
100 110 120 140	90 100 110 120	85	165
160 180 200 220 240	140 160 180 200 220	100	192
260 280 300	240 260 280	110	214

Remark Also applicable to bushings with seals.

Table 6 Radial internal clearance of GE⋯EC type (Maintenance-free)

unit: μm

d Nominal bore dia. mm	Radial internal clearance	
	Min.	Max.
15 17 20	0	40
25 30 35	0	50
40 45 50 60	0	60
70	0	72

Remark Also applicable to bushings with seals.

Fit

The recommended fits for Spherical Bushings are shown in Tables 7 and 8.

Table 7 Recommended fits for Steel-on-steel Spherical Bushings

Condition	Tolerance class	
	Shaft	Housing bore
Normal operation	h6, j6	H7, J7
With directionally indeterminate load	m6, n6	M7, N7

Remark N7 tolerance is recommended for light metal housings.

Table 8 Recommended fits for Maintenance-free Spherical Bushings

Tolerance class of shaft	Tolerance class of housing bore
h6, j6	H7, J7, K7

Remark K7 tolerance is recommended for light metal housings.

Selection of Spherical Bushings

Selection between the steel-on-steel type and the maintenance-free type is made considering the operating conditions such as load, lubrication, temperature, and sliding velocity.

Load capacity

❶ Dynamic load capacity

The dynamic load capacity C_d is the maximum allowable load that can be applied on a spherical bushing under oscillating motion. It is obtained on the basis of the contact pressure on the spherical surfaces. The dynamic load capacity is also used for calculating the life of spherical bushings.

The recommended value of bushing load is obtained by multiplying the dynamic load capacity C_d by a numerical factor, which differs depending on the bushing type and the load condition. A guideline for selection is shown in Table 9.

Table 9 Guide for determination of load

Type of bushing	Load direction	
	Constant	Alternate
Steel-on-steel	$\leqq 0.3C_d$	$\leqq 0.6C_d$
Maintenance-free	$\leqq C_d$	$\leqq 0.5C_d$

When the magnitude of load exceeds the value given in Table 9, please consult IKO.

The dynamic load capacity C_{dt} considering the influence of bushing temperature can be obtained from the following equation using the temperature factor.

$$C_{dt} = f_t C_d \quad \cdots\cdots (1)$$

where, C_{dt} : Dynamic load capacity considering temperature increase N
f_t : Temperature factor (Refer to Table 10.)
C_d : Dynamic load capacity N (Refer to the dimension tables.)

Table 10 Temperature factor f_t

Type of bushing		Temperature ℃					
		−30 +80	+80 +90	+90 +100	+100 +120	+120 +150	+150 +180
Steel-on-steel	Without seals	1	1	1	1	1	0.7
	With seals	1	—	—	—	—	—
Maintenance-free	Without seals	1	1	0.9	0.75	0.55	—
	With seals	1	—	—	—	—	—

❷ Static load capacity

The static load capacity C_s is the maximum static load that can be applied on the spherical bushing without breaking inner and outer rings or causing any permanent deformation severe enough to render the bushing unusable.

It must be noted that if the magnitude of the applied load becomes comparable to the static load capacity of bushing, the stresses in the shaft or housing may also reach to their limits. This possibility must be taken into consideration in the design.

Equivalent radial load

Spherical Bushings can take radial and axial loads at the same time. When the magnitude and direction of loads are constant, the equivalent radial load can be obtained from the following formula.

$$P = F_r + YF_a \quad \cdots\cdots (2)$$

where, P : Equivalent radial load N
F_r : Radial load N
F_a : Axial load N
Y : Axial load factor (Refer to Table 11.)

Table 11 Axial load factor Y

Type of bushing \ F_a/F_r	0.1	0.2	0.3	0.4	0.5	>0.5
Steel-on-steel	1	2	3	4	5	Unusable
Maintenance-free	1	2	3	Unusable		

Life

The life of Spherical Bushings is defined as the total number of oscillating motions before the bushings cannot be operated normally because of wear, increase in internal clearance, increase in sliding torque, rise of operating temperature, etc.

As the actual life is affected by many factors such as the material of the sliding surface, the magnitude and direction of load, lubrication, sliding velocity, etc., the calculated life can be used as a practical measure of expected service life.

❶Life of Steel-on-steel spherical bushings

[1] Confirmation of pV value

Before attempting to calculate the life, make sure that the operating conditions are within the permissible range by referring to the pV diagram in Fig.1.

When the operating conditions are out of the permissible range, please consult IKO.

The contact pressure p and the sliding velocity V are obtained from the following formulae.

$$p = \frac{100P}{C_{dt}} \quad \cdots\cdots (3)$$

$$V = 5.82 \times 10^{-4} d_k \beta f \quad \cdots\cdots (4)$$

where, p : Contact pressure N/mm²
P : Equivalent radial load N (Refer to Formula (2).)
C_{dt} : Dynamic load capacity considering temperature increase N (Refer to Formula (1).)
V : Sliding velocity mm/s
d_k : Sphere diameter mm (Refer to the dimension tables.)
2β : Oscillating angle degrees (Refer to Fig.2.)
when $\beta < 5°$, $\beta = 5$
when rotating, $\beta = 90$
f : Number of oscillations per minute cpm

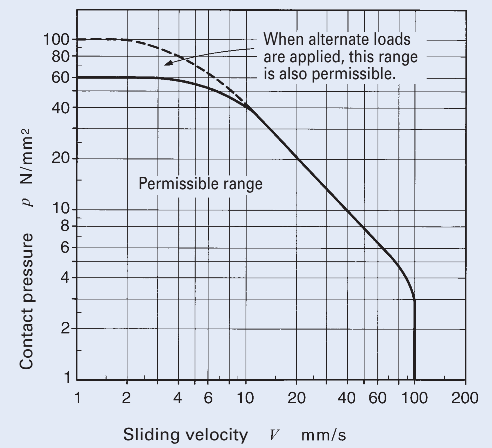


Fig.1 pV diagram of Steel-on-steel spherical bushings

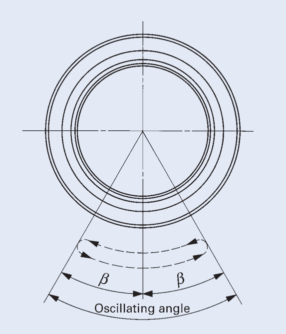


Fig.2 Oscillating angle

K
SB
GE
SBB

1N=0.102kgf=0.2248lbs.
1mm=0.03937inch

[2] Life calculation

The life of steel-on-steel spherical bushings can be calculated from the following formulae.

$$G=\frac{3.18b_1b_2b_3}{\sqrt{d_k}\,\beta}\left(\frac{C_{dt}}{P}\right)^2\times10^5 \cdots\cdots(5)$$

$$L_h=\frac{G}{60f} \cdots\cdots(6)$$

where, G : Life (Total number of oscillations)

b_1 : Load directional factor (Refer to Table 12.)

b_2 : Lubrication factor (Refer to Table 13.)

b_3 : Sliding velocity factor (Refer to Fig.3.)

C_{dt} : Dynamic load capacity considering temperature increase N (Refer to Formula (1).)

P : Equivalent radial load N (Refer to Formula (2).)

L_h : Life in hours h

f : Number of oscillations per minute cpm

Table 12 Load directional factor b_1 (Steel-on-steel)

Load direction	Constant	Alternate
Load directional factor b_1	1	5

Table 13 Lubrication factor b_2

Periodical lubrication	None	Regular
Lubrication factor b_2	1	15

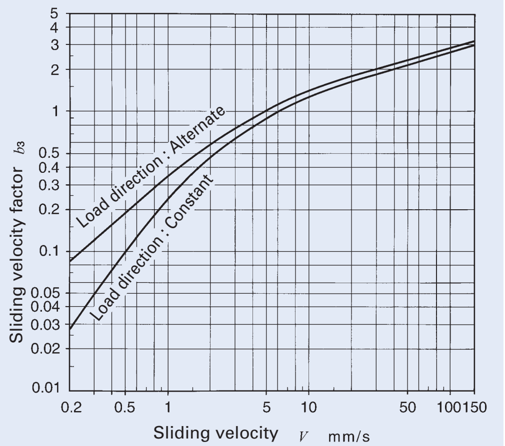


Fig.3 Sliding velocity factor

❷ Life of Maintenance-free spherical bushings

[1] Confirmation of pV value

Before attempting to calculate the life, make sure that the operating conditions are within the permissible range by referring to the pV diagram in Fig.4.

When the operating conditions are out of the permissible range, please consult IKO.

The contact pressure p and the sliding velocity V are obtained from Formulae (3) and (4) shown on page 439.

[2] Life calculation

The life of maintenance-free spherical bushings is obtained from the total sliding distance S which is given in Fig.5 for the contact pressure p obtained from Formula (3).

The total number of oscillations and life in hours can be obtained from the following formulae.

$$G=16.67\times b_1\frac{Sf}{V} \cdots\cdots(7)$$

$$L_h=\frac{G}{60f} \cdots\cdots(8)$$

where, G : Life (Total number of oscillations)

b_1 : Load directional factor (Refer to Table 14.)

S : Total sliding distance m (Refer to Fig.5.)

f : Number of oscillations per minute cpm

V : Sliding velocity mm/s

L_h : Life in hours h

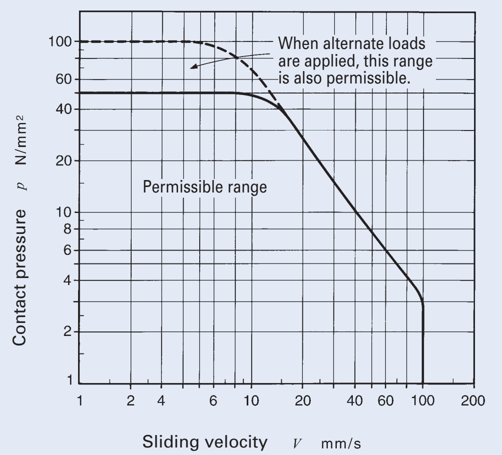


Fig.4 pV diagram of Maintenance-free spherical bushings

Table 14 Load directional factor b_1 (Maintenance-free)

Load direction	Constant	Alternate
Load directional factor b_1	1	0.2(1)

Note(1) This value is applicable when the load changes comparatively slowly. When the load changes rapidly, please consult IKO, as the factor degreases sharply.

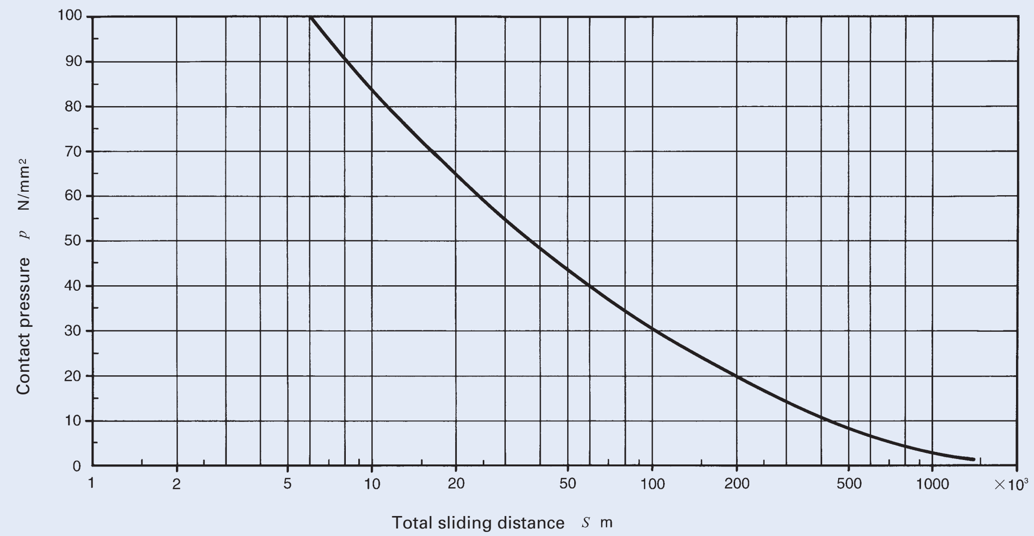


Fig.5 Total sliding distance against contact pressure of Maintenance-free spherical bushings

Lubrication

Steel-on-steel Spherical Bushings can be operated without lubrication when the magnitude of applied load is small and the sliding velocity of oscillation is small. However, in general, it is necessary to supply grease periodically. During initial operation, it is recommended to shorten the lubrication interval. Lithium soap base grease (NLGI consistency No.2) containing molybdenum disulfide (MoS_2) is widely used as the lubricating grease.

Maintenance-free Spherical Bushings can be used without lubrication. However, if lithium soap base grease is supplied before operation, the spherical bushings can be operated for an extended period of time. The spherical bushings can be effectively protected from dust and rust if the space around the bushings is filled with grease.

Oil Hole

The number of oil holes on inner and outer rings is shown in Table 15.

Table 15 Number of oil holes on inner and outer rings

Bushing type			Number of oil holes on inner and outer rings
Steel-on-steel Spherical Bushings	Metric series	GE…E GE…G	0
		SB, SB…A GE…ES, GE…GS	2
	Inch series	SBB	2
Maintenance-free Spherical Bushings	Metric series	GE…EC	0

Remark Types with oil holes are also provided with oil grooves on inner and outer rings.

K

SB
GE
SBB

1N=0.102kgf=0.2248lbs.
1mm=0.03937inch

Operating Temperature Range

The operating temperature range for Spherical Bushings with seals is -30˚C～+80˚C.
The maximum allowable temperature for Spherical Bushings without seals is +180˚C for the steel-on-steel type and +150˚C for the maintenance-free type.

Precautions for Use

Design of shaft

When the load is large, sliding may occur between the shaft and the inner ring bore of bushing. For such cases, it is necessary to prepare the shaft with a hardness of 58HRC or greater and surface roughness of 0.8 μmR_a or less.
Furthermore, attention must be paid to the strength of shaft because the shear and/or bending stresses in the shaft may surpass the allowable values even when the load is below the static load capacity of Spherical Bushings.

Design of housing

The housing should have sufficient rigidity to avoid harmful deformation under load.
When the housing shown in Fig.6 is used, it should be designed with sufficient strength as follows.

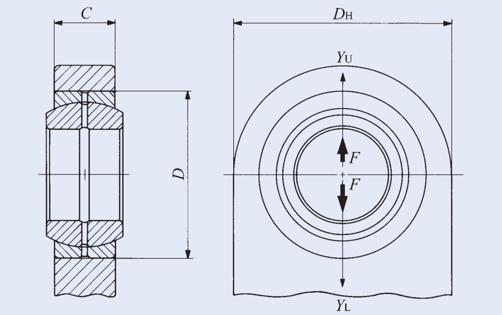


Fig.6 Shape of housing

❶When the load acts in the Y_L direction;
Select the housing material considering the compressive stress obtained from the following formula.

$$\sigma_1 = \frac{F}{CD} \quad \cdots\cdots (9)$$

where, σ_1 : Maximum compressive stress occurring in the housing bore N/mm²
F : Applied load N
C : Width of outer ring and housing mm
D : Outside diameter of outer ring mm

❷When the load acts in the Yu direction ;
Select the housing material considering the tensile stress obtained from the following formula.

$$\sigma_2 = \frac{F}{C\,(D_H - D)}\,k \quad \cdots\cdots (10)$$

where, σ_2 : Maximum tensile stress occurring in the housing bore N/mm²
F : Applied load N
C : Width of outer ring and housing mm
D_H : Outside diameter of housing mm
D : Outside diameter of outer ring mm
k : Stress concentration factor (Refer to Fig.7.)

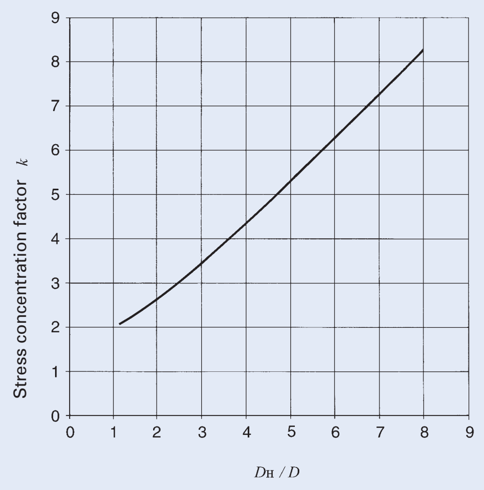


Fig.7 Stress concentration factor

Mounting

❶When mounting Spherical Bushings, pay attention to the location of the split plane of the outer ring. Set the split plane at right angles to the direction of load to avoid the application of load to the split plane as shown in Fig. 8.
❷The shoulder dimensions of shaft and housing are shown in the dimension tables.

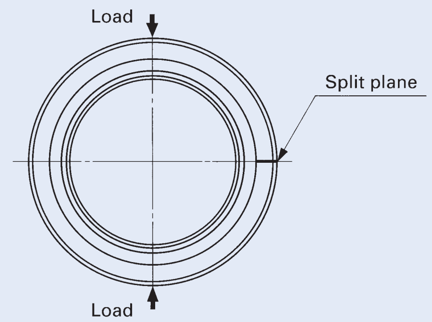


Fig.8 Relationship between the split plane and the loading direction

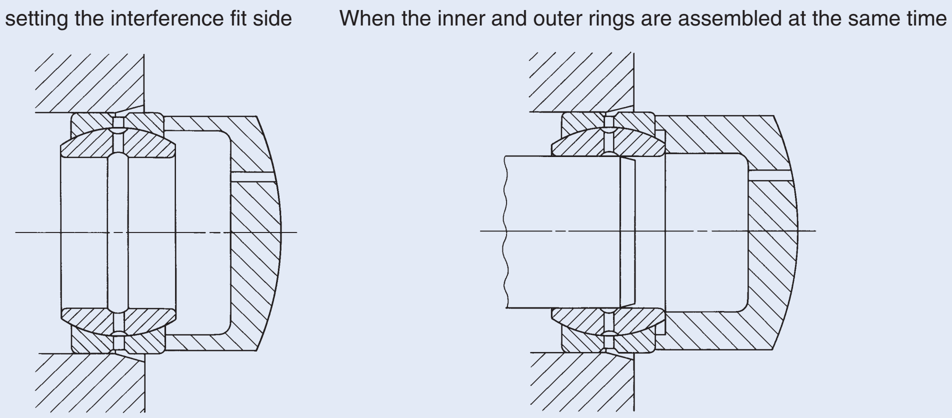


Fig.9 Mounting method

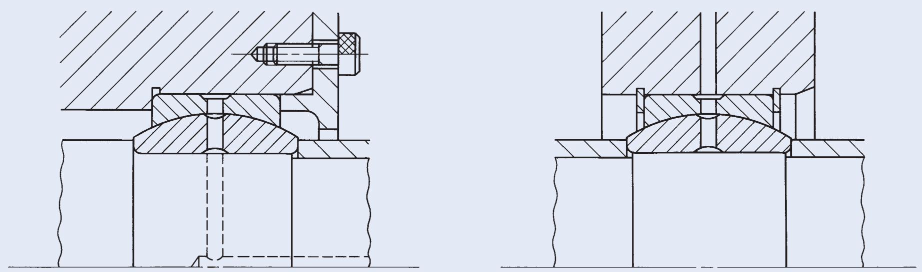


Fig.10 Mounting examples

K
SB
GE
SBB

1N=0.102kgf=0.2248lbs.
1mm=0.03937inch

SPHERICAL BUSHINGS

Steel-on-steel Spherical Bushings

Shaft dia. 110 ─ 150mm

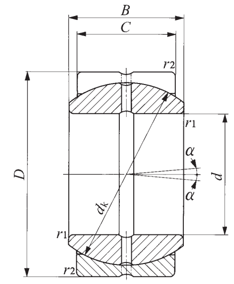
Shaft dia. mm	Identification number		Mass (Ref.) kg	Boundary dimensions mm d	D	B	C	d_k	$r_{s\ min}$ (1)	Permissible tilting angle degree α
110	**SB 110A**	**SB 11017093**	8.55	110	170	93	80	160	1	5
115	**SB 115A**	**SB 11518098**	10.3	115	180	98	85	165	1	5
120	**SB 120A**	**SB 120190105**	12.4	120	190	105	90	175	1	5
130	**SB 130A**	**SB 130200110**	13.8	130	200	110	95	185	1	5
150	**SB 150A**	**SB 150220120**	17.0	150	220	120	105	205	1	5

Notes(1) Minimum allowable value of chamfer dimensions r_1 and r_2

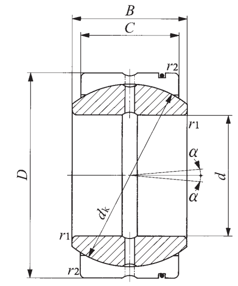
(2) When Spherical Bushings are used with full tilting angle, the shaft shoulder dimension must be less than the maximum value of d_a.

Remarks1. The inner ring and the outer ring have an oil groove and two oil holes, respectively.

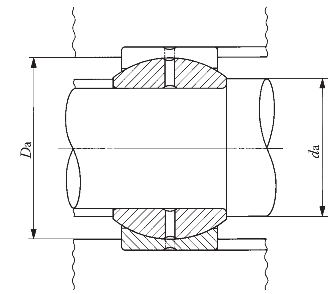
2. Not provided with prepacked grease. Perform proper lubrication for use.



SB···A



SB



Shaft dia. mm	Mounting dimensions mm d_a Min.	d_a Max.(2)	D_a Max.	D_a Min.	Dynamic load capacity C_d N	Static load capacity C_s N
110	115.5	130	164.5	149	1 260 000	7 530 000
115	120.5	132.5	174.5	152	1 380 000	8 250 000
120	125.5	140	184.5	162	1 540 000	9 270 000
130	135.5	148.5	194.5	171	1 720 000	10 300 000
150	155.5	166	214.5	189	2 110 000	12 700 000

K

SB
GE
SBB

1N=0.102kgf=0.2248lbs.
1mm=0.03937inch