MOTION & CONTROL
NSK

SPACEA™ Series
Bearings for Vacuum Environments

- Ideal for semiconductor manufacturing and robots operating in vacuum environments
- Ten-fold increase in operating life achieved with self-lubricating cage

New!

Part of NSK's SPACEA™ Series of bearings for special environments, NSK's bearings for vacuum environments utilize a special self-lubricating MoS_2-based material to extend operating life by as much as ten times over conventional bearings.

NSK's vacuum bearings are best suited for semiconductor manufacturing equipment and robots operating in vacuum environments.

Types of Bearings

Table 1 Major applications of bearings for vacuum environments

Bearing Type	Bearing construction and materials		Operating conditions		Major applications
	Outer/inner ring	Balls	Atmospheric condition	Temperature	
Self-lubricating cage	Stainless steel	Stainless steel + MoS_2 coating	Normal and vacuum	200°C max	Deposition equipment Sputtering equipment Vacuum pump
Spacer joint	Stainless steel	Stainless steel + MoS_2 coating	Vacuum	350°C max	Plasma CVD equipment Normal pressure equipment

Note: Both type of bearings are available with corrosion resistance coating.

Features

- Ten times longer operating life
- Lower particle emissions
- Lower outgassing
- Conductive to life estimation

Application Range

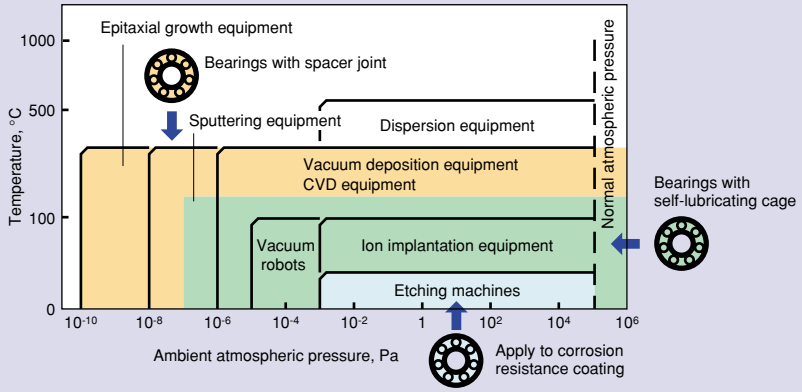


Fig. 1 Application range of bearings for vacuum environments

SPACEA™ Series
Bearings for Vacuum Environments

Life Estimation

Because estimating the operating life of conventional solid-lubricant ball bearings is impossible in the design stage, it is customary to use large-bore ball bearings or to analyze bearing life under actual operation in order to achieve a sufficient degree of safety.
NSK has compiled an extensive volume of operating life data under various usage conditions, including temperature, rotating speed and load. By verifying test data against actual bearing life, service life can be estimated based on the operating conditions of specific applications.

The method for calculating the service life of bearings is described below.

1. Calculating dynamic equivalent load, *P*

By calculating C_{or}/F_a, it is possible to obtain *e*, X and Y from the table on the right.

$P = XF_r + YF_a$

Where,

C_{or}: Basic static load rating [N]
F_r: Radial load [N]
F_a: Axial load [N]
X and *Y*: Load coefficient (Refer to the right table)

2. Calculating ratio of dynamic equivalent load, *P*, to basic dynamic load rating, C_r

$$\frac{P}{C_r} \times 100 = \square\%$$

3. Calculating service life

The life, L_h, of bearings with self-lubricating cage specifications and spacer joint high-temperature specifications is estimated from temperature, *T* (°C), load condition, P/C_r (%).

$$\text{Life, } L_h \text{ (hours)} = \frac{\text{Cumulative number of rotations, } L_r}{\text{Rotational speed, } n \text{ (rpm)} \times 60}$$

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

(a) Deep groove ball bearings with self-lubricating cage

$L_r = 10^{\,l_a}$

$l_a = 8.993 - 0.0023 \times T - 0.295 \times (P/C_r) \times 100 - 0.00257 \times T \times (P/C_r) \times 100$

(b) Deep groove ball bearings with spacer joint

$L_r = 10^{\,l_b}$

$l_b = 13.208 - 0.0115 \times T - 0.9563 \times (P/C_r) \times 100$

Bearings for Vacuum Environments

■ Self-lubricating cage type

Structure

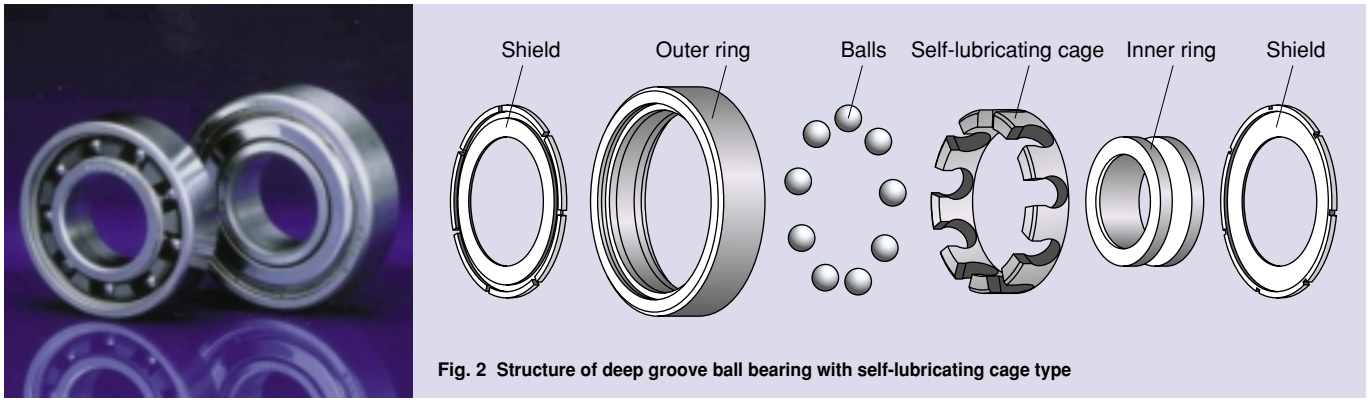


Fig. 2 Structure of deep groove ball bearing with self-lubricating cage type

Features

1. MoS_2-based Low-Friction, Low-Wear Self-Lubricating Cage Material

Benefits of self-lubricating material

- Low frictional coefficient and the highest wear resistance
- Material readily rubs off and adheres to parts in sliding contact
- Low outgassing volume and no emissions of high polymer gas
- High heat resistance

2. Long Life

- At least ten times longer life than conventional bearings for vacuum environments

3. Low Outgassing

Specifications

Operating temperature		200°C max
Operating atmosphere		Normal atmospheric pressure down to 10^{-7} Pa
Accuracy		ISO Normal Class
Standard clearance		C3
Materials	Outer/inner rings	Martensitic stainless steel or equivalent
	Ball	
	Cage	MoS_2-based self-lubricating material
	Shields	Austenitic stainless steel

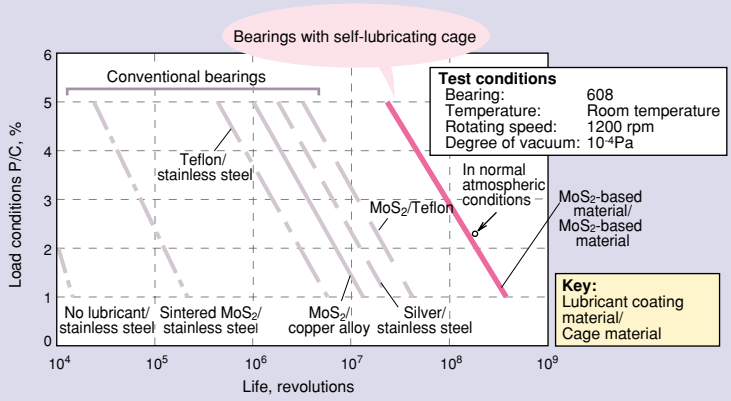


Fig. 3 Relationship between load and life of various ball bearings for vacuum environments

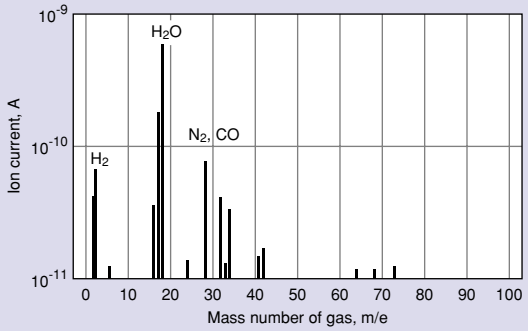
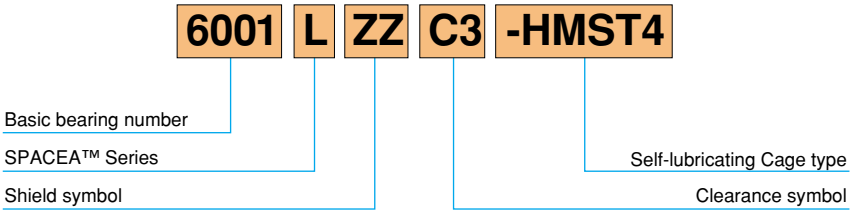


Fig. 4 Outgassing of Bearings with self-lubricating cage type under vacuum conditions

Bearing Nomenclature



Standard Bearing Dimensions

Bore diameter (mm)	Outside diameter (mm)	Width		Basic bearing number	Basic load rating (N)	
		Open (mm)	Sealed (mm)		Dynamic load rating C_r	Static load rating C_{or}
4	9	2.5	4	684	545	180
	11	4	4	694	815	278
	12	4	4	604	815	278
	13	5	5	624	1110	390
	16	5	5	634	815	278
5	11	3	5	685	610	226
	13	4	4	695	860	323
	14	5	5	605	1070	382
	16	5	5	625	1470	535
	19	6	6	635	2220	845
6	13	3.5	5	686	920	350
	15	5	5	696	1470	535
	17	6	6	606	1920	670
	19	6	6	626	2220	845
	22	7	7	636	2670	1070
7	14	3.5	5	687	1000	410
	17	5	5	697	1280	540
	19	6	6	607	1860	670
	22	7	7	627	2630	1040
	26	9	9	637	3660	1480
8	16	4	5	688	1370	570
	19	6	6	698	1900	730
	22	7	7	608	2800	1100
	24	8	8	628	2850	1150
	28	9	9	638	3660	1480
9	17	4	5	689	1060	500
	20	6	6	699	1980	800
	24	7	7	609	2670	1070
	26	8	8	629	3660	1480
	30	10	10	639	3720	1560

Bore diameter (mm)	Outside diameter (mm)	Width		Basic bearing number	Basic load rating (N)	
		Open (mm)	Sealed (mm)		Dynamic load rating C_r	Static load rating C_{or}
10	19	5	5	6800	1460	670
	22	6	6	6900	2290	1020
	26	8	8	6000	3900	1580
	30	9	9	6200	4350	1910
	35	11	11	6300	6900	2750
12	21	5	5	6801	1530	620
	24	6	6	6901	2310	920
	28	8	8	6001	4350	1890
	32	10	10	6201	5800	2440
	37	12	12	6301	7770	3470
15	24	5	5	6802	1660	730
	28	7	7	6902	3700	1810
	32	9	9	6002	4750	2270
	35	11	11	6202	6500	2980
	42	13	13	6302	9700	4350
17	26	5	5	6803	2100	910
	30	7	7	6903	3900	2040
	35	10	10	6003	5100	2600
	40	12	12	6203	8150	3850
	47	14	14	6303	11600	5300
20	32	7	7	6804	3400	1970
	37	9	9	6904	5400	2940
	42	12	12	6004	7950	4000
	47	14	14	6204	10900	5250
	52	15	15	6304	13500	6300
25	42	9	9	6905	5950	3600
	47	12	12	6005	8550	4650
	52	15	15	6205	11900	6300
30	55	13	13	6006	11300	6600
45	75	16	16	6009	17800	12200

Spacer joint type

Structure

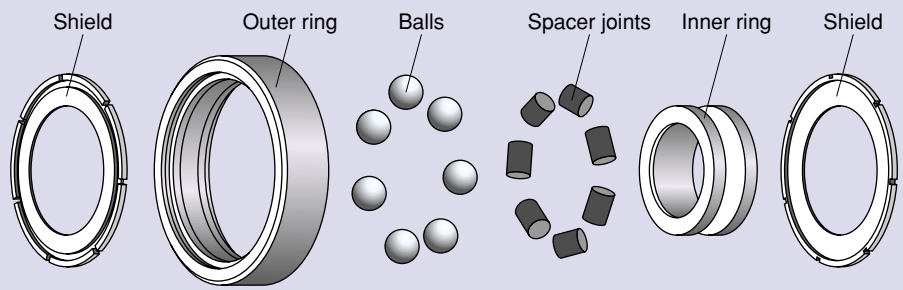


Fig. 5 Structure of deep groove ball bearing with spacer joint type

Features

1. **Long life in temperatures as high as 350°C**
2. **Excellent friction and wear characteristics are realized with alloy-based self-lubricating spacer joint material**

Specifications

Operating temperature		350°C max
Operating atmosphere		Normal atmospheric pressure down to 10^{-10} Pa
Accuracy		ISO Normal Class
Standard clearance		C4
Materials	Outer/inner rings	Martensitic stainless steel or equivalent
	Balls	
	Spacer joints	Sintered MoS_2
	Shields	Austenitic stainless steel

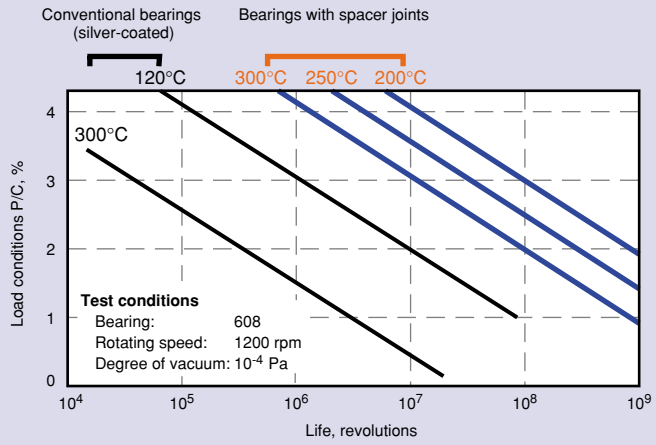
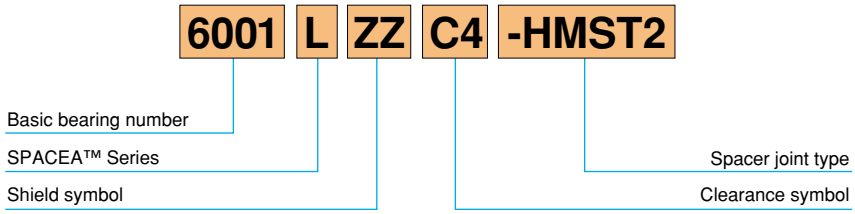


Fig. 6 Relationship between load and operating life of high-temperature ball bearings for vacuum environments

Bearing Nomenclature



Standard Bearing Dimensions

Bore diameter (mm)	Outside diameter (mm)	Width Sealed (mm)	Basic bearing number	Basic load rating (N) Dynamic load rating C_r	Basic load rating (N) Static load rating C_{or}
6	17	6	606	1920	670
7	19	6	607	1860	670
8	16	5	688	1370	570
	19	6	698	1900	730
	22	7	608	2800	1100
	24	8	628	2850	1150
	28	9	638	3660	1480
9	17	5	689	1060	500
	20	6	699	1980	800
	24	7	609	2670	1070
	26	8	629	3660	1480
	30	10	639	3720	1560
10	19	5	6800	1460	670
	22	6	6900	2290	1020
	26	8	6000	3900	1580
	30	9	6200	4350	1910
	35	11	6300	6900	2750
12	21	5	6801	1530	620
	24	6	6901	2310	920
	28	8	6001	4350	1890
	32	10	6201	5800	2440
	37	12	6301	7770	3470
15	24	5	6802	1660	730
	28	7	6902	3700	1810
	32	9	6002	4750	2270
	35	11	6202	6500	2980
	42	13	6302	9700	4350

Bore diameter (mm)	Outside diameter (mm)	Width Sealed (mm)	Basic bearing number	Basic load rating (N) Dynamic load rating C_r	Basic load rating (N) Static load rating C_{or}
17	26	5	6803	2100	910
	30	7	6903	3900	2040
	35	10	6003	5100	2600
	40	12	6203	8150	3850
	47	14	6303	11600	5300
20	32	7	6804	3400	1970
	37	9	6904	5400	2940
	42	12	6004	7950	4000
	47	14	6204	10900	5250
	52	15	6304	13500	6300
25	42	9	6905	5950	3600
	47	12	6005	8550	4650
	52	15	6205	11900	6300
30	55	13	6006	11300	6600
45	75	16	6009	17800	12200