VS

1 The Constitute and Arrangement of Bearing Code

The code of ball bearing is composed of three parts: by prepositive code, the basic code and the postpositive code. The basic code indicates the type, structure and size of bearing; The prepositive and the postpositive code indicates when the shape, size, tolerance and technological conditions of bearing have changed, the additional remarks added to the basic code. The queueing discipline of bearing code is shown as follows:

The Permutation of Bearing Code

The Prepositive Code	The Basic Code				The Postpositive Code									
Bearing Branch Components	Type Code	Dimension Series Code (Diameter Series / Width Series)	ID Code	Internal Structure	Sealing & Dust Proof	Cage & Its Material	Bearing Material	Grade of Tolerance	Clearance	Configuration	Special Code	Lubricant Code	Lubricant Filling Amount Code	
	6	0	8		2RS			P5	MC3					
	Deep groove ball series				Two sides with framework contact type seal ring			P5 Grade	Clearance in group 3					

For Example: 608-2RS/P53

Example1:

6 0 8 RS2 TH P5 MC5

Clearance: MC5
Accuracy Grade: P5
Cage Material: Glass Fibre-reinforced Phenolic Resin Cage
Sealing: One Side Double, One Rubber Side (a Seal)
ID: 8mm
Diameter Series Code: 0 Series
Category Code: Deep Groove Ball Series

Example2:

7 2 10 03 AC P4 C3 DB

Collocation Method: Back-to-Back Collocation
Axial Clearance: C3
Accuracy: P4
Contact Angle: Standard Contact Angle 25°
ID: 15mm
Width Series Code: 0 (It Can Be Left Out)
Diameter Series Code: 2 Series
Category Code: Single Row Angular Contact Ball Bearing

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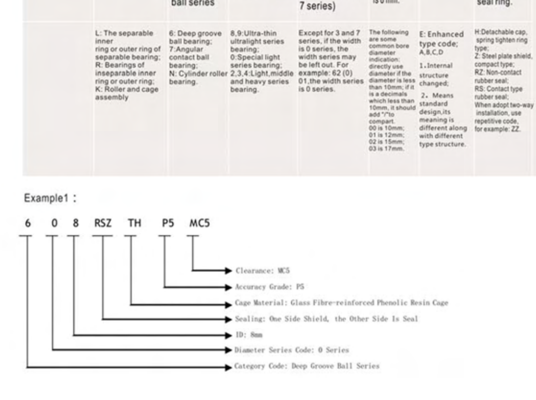
2 Bearing Name & Code

Name of Each Part

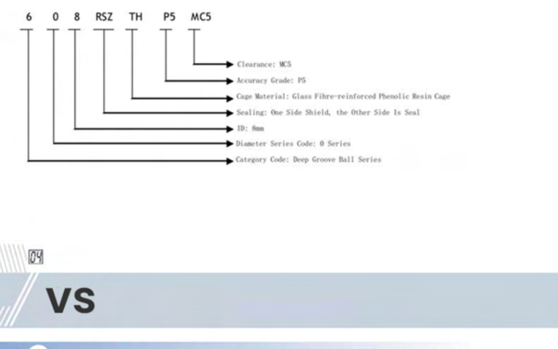
Component and each part name of Deep Groove Ball Bearing



Open Type

Sealing Type

Component and each part name a. Angular Contact Ball Bearing

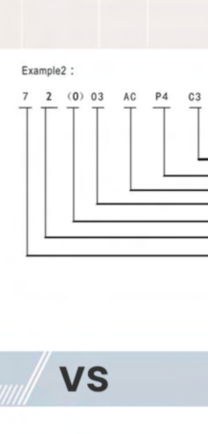


Single row angular contact ball bearings

Double row angular contact ball bearings

Cage

Cage of ball bearing divide into the following kinds:



Wave shape cage

When assembling, the two parts show as a fold around the steel ball shape, the external snap ring in one of the parts block the other part. Normally it used for "Φ"s miniature deep groove ball bearings.

Rivet type cage

Use high precision band steel punch forming into spherical hole cage, and fixed it with rivets. Normally it used for the small size deep groove ball bearings in

Resin cage

The cage made from polyacetal, such as the nylon PA66. These kinds of cage have good lubricity which is making for increasing the using life and decreasing the noise. Normally it used for the extreme low noise bearing in

Bakelite cage

The cage made by phenolic aldehyde lamination tube, which have lots of characteristics like very high mechanical strength, good corrosion resisting, antirust, heat resisting, good lubricity, light gravity and high strength. We normally use them for our angular contact ball bearings.

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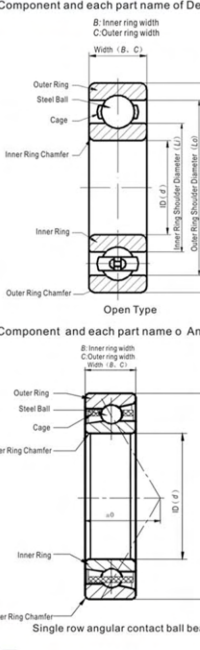
Shield & Sealing Ring



Steel plate shield, detachable cap-tighten ring type (Z)

Its construction is to use spring ring to lock the metal shield. Application for good external environment Occasion. Used in high speed rotating occasion.

Steel plate shield, clamped type (Z)

Its construction is to clamp the metal shield on the outer ring. Application for good external environmentoccasion. Used in high speed rotating occasion.

Rubber seal, non-contact type (RZ)

Its construction is to inset the rubber seal to the outer ring.
- Common sealing property, suitable for good external environment occasion.
- Used in high speed rotating occasion.

Rubber seal, contact type (single lip RS)

Its construction is to inset the rubber seal to the outer ring. Good sealing property, suitable for wicked external environment occasion. Small starting torque, suitable for high rotating speed occasion.

Rubber seal, contact type (two lips RS)

Its construction is to inset the rubber seal to the outer ring. High dust prevention grade, suitable for wicked externalenvironment occasion. Big starting torque, suitable for common rotating speed Occasion.

Rubber seal, contact type (three lips RS)

Its construction is to inset the rubber seal to the outer ring. Excellent dustproof and water proofing performance, suitable for high sealing requirements occasion. Big starting torque, suitable for low rotating speed occasion. Particularly suitable for water sealed bearing which suffer external load.

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3 Accuracy

The accuracy of ball bearing divides into dimensional accuracy and rotating accuracy. The relating accuracy specification is as per the provision of ISO Standard. Spindle requirements for rotating with high precision, so it usually choose P5 level, P4 level or higher precision bearings. Therefore, the demand for high rotation precision bearing must choose ball bearing. The code which used in the accuracy specifications is as follows:

(1) Dimension

- d: Nominal bearing bore diameter
- D: Nominal bearing outside diameter
- B: Nominal inner ring width
- C: Nominal outer ring width
- r: The chamfer dimension of inner ring or Outer ring

(2) Dimensional Deviation

- Δ_{dmp}: Dimensional deviation of ID
- Δ_{dmp}: Dimensional deviation of average ID within a plane
- Δ_{Ds}: Dimensional deviation of OD
- Δ_{Dmp}: Dimensional deviation of average OD within a plane
- Δ_{Bs}: Dimensional deviation of inner ring width or dimensional deviation of middle ring height
- Δ_{Cs}: Dimensional deviation of outer ring width
- Δ_{C1s}: Dimensional deviation of actual measured OD of the flange
- Δ_{C1s}: Dimensional deviation of actual measured width of the flange

(3) Chamfer angle

- r_s min: The minimum allowable chamfer Dimension of inner ring and outer ring
- r_s max: The maximum allowable chamfer Dimension of inner ring and outer ring

(4) Dimension variation amount

- V_{dsp}: ID variation in a flat surface
- V_{dmp}: Average ID variation in a flat surface
- V_{Dsp}: OD variation in a flat surface
- V_{Dmp}: Average OD variation in a flat surface
- V_{Bs}: Width variation of inner ring
- V_{Cs}: Width variation of outer ring
- V_{C1s}: Width variation of flange

(5) Rotating accuracy

- K_{ia}: Radial vibration of inner ring
- K_{ea}: Axial vibration of inner ring
- K_{ea}: Transverse vibration of inner ring
- S_{ia}: Radial vibration of outer ring
- S_{ea}: Axial vibration of outer ring
- S_D: Verticality of outer diameter surface
- S_{ea1}: Axial vibration of the rear surface of the flange

Bearing accuracy grade comparison table:

Nationality	Standard Number	Accuracy Grade				
CHINA	GB307	0	6	5	4	2
CHINA (Old)	GB307	G	E	D	C	B
ISO	ISO492	0	6	5	4	2
JIS	JIS B1514	JIS0	JIS6	JIS5	JIS4	JIS2
GERMANY	DIN 620/2	P0	P6	P5	P4	P2
USA	ANSI B3.14	ABEC1	ABEC3	ABEC5	ABEC7	ABEC9

Inner Ring Accuracy Table of Different Levels

Inner Ring P0 Tolerance

Inner Ring P6 Tolerance

Inner Ring P5 Tolerance

Inner Ring P4 Tolerance

Inner Ring P2 Tolerance

d (mm)	Δ_{dmp}	V_{dsp}	V_{dmp}	K_{ia}	S_d	S_{ia}	Δ_{Bs}	V_{Bs}
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Outer Ring Accuracy Table of Different Levels

Outer Ring P0 Tolerance

Outer Ring P6 Tolerance

Outer Ring P5 Tolerance

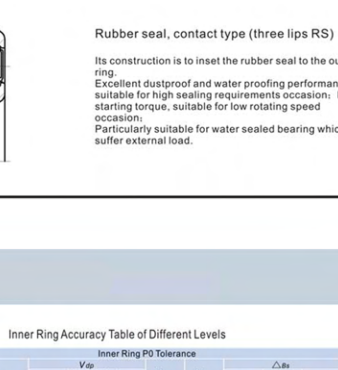
Outer Ring P4 Tolerance

Outer Ring P2 Tolerance

D (mm)	Δ_{Dmp}	V_{Dsp}	V_{Dmp}	K_{ea}	S_D	S_{ea}	Δ_{Cs}	V_{Cs}
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The radial chamfer dimension limit value of ball bearing (Reference from ISO) (Unit: mm)

The minimum allowable value of the chamfer of inner ring and outer ring r_s min	Nominal bearing bore diameter d (mm) Over	Under	The maximum allowable value of the chamfer of inner ring and outer ring r_s max Radial	Axial
0.05			0.1	0.2
0.08			0.16	0.3
0.1			0.2	0.4
0.15			0.3	0.6
0.2			0.5	0.8
0.3		40	0.6	1
	40		0.8	1
0.6		40	1	2
	40		1.3	2
1		50	1.5	3
	50		1.9	3
1.1		120	2	3.5
	120		2.5	4



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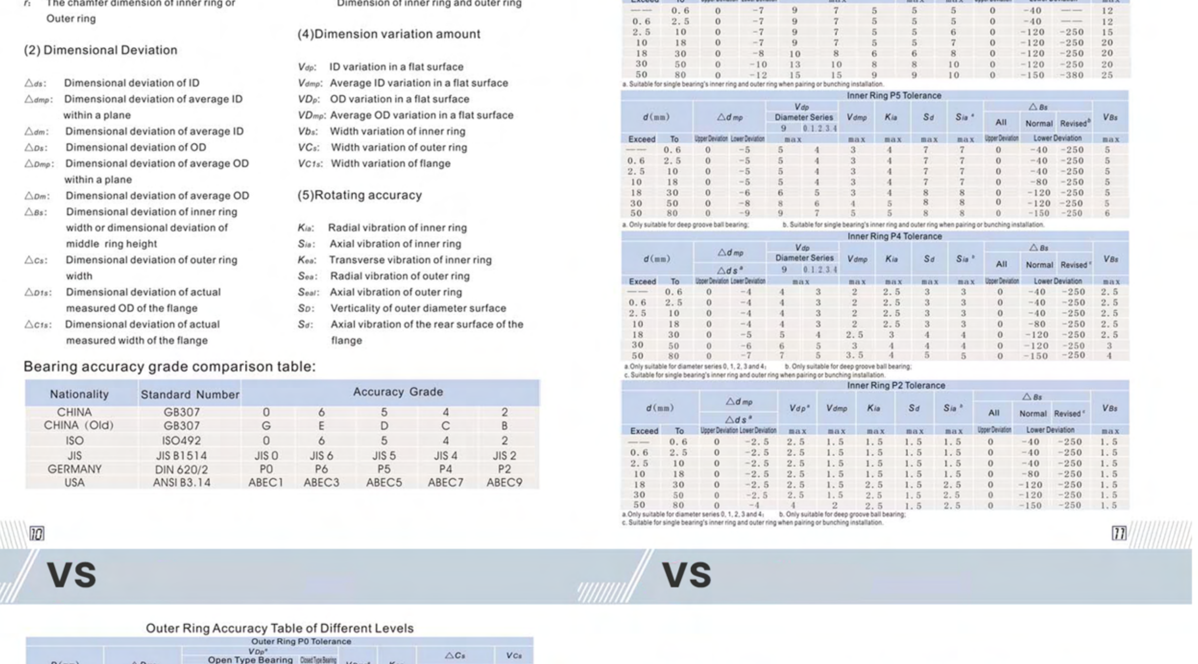
4 Measuring Method

In the ISO Standard, it specifies the measuring method of ball bearing's accuracy, the summary is as follows:

Dimensional Accuracy
1. Bearing bore diameter (d) Picture 4-1
2. Bearing outside diameter (D) Picture 4-2
3. Inner ring width (B) Picture 4-3
4. Outer ring width (C) Picture 4-4

Rotating Accuracy
1. The verticality of inner ring and face to inner bore (Sd) Picture 4-5
2. The verticality of outer ring surface to end face (SD) Picture 4-6
3. The radial runout of whole set bearing inner ring (Kia) Picture 4-7
4. The radial runout of whole set bearing outer ring (Kea) Picture 4-8
5. The axial runout of whole set bearing inner ring (Sia) Picture 4-9
6. The axial runout of whole set bearing outer ring (Sea) Picture 4-10



Picture 4-1 Bearing bore diameter (d)

Picture 4-2 Bearing outside diameter (D)

Picture 4-3 Inner ring width (B)

Picture 4-4 Outer ring width (C)

Picture 4-5 The verticality of inner ring and face to inner bore (Sd)

Picture 4-6 The verticality of outer ring surface to end face (SD)

Picture 4-7 The radial runout of whole set bearing inner ring (Kia)

Picture 4-8 The radial runout of whole set bearing outer ring (Kea)

Picture 4-9 The axial runout of whole set bearing inner ring (Sia)

Picture 4-10 The axial runout of whole set bearing outer ring (Sea)

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5 The Rated Load and Operating Life

Life of Ball Bearing

The life of ball bearing has very large differences in accordance with different operating environment. This is due to the usage mode of ball bearing are in varied forms according to the different requirements of ball bearing, so the measure of estimating the life of ball bearing is either different. Therefore, to set the appropriate service life of ball bearing with considering their application and operating conditions is very important. The following is to have a summary introduction about the service life according to international standard specified. (Single row Ball Bearin)

Rating Life

Concerning the rating life time, the standard (The Rated Dynamic Load's Calculation Method of Ball Bearing) has made the following definition: "The rated life time means when a group of the same bearings running under the same conditions, the total number of revolution of 90% bearings in this group which before the bearing material damaged because of revolution fatigue. In other words, the rated life time is the total number of revolution in a group of bearings which certainly take out from a certain batch, the bearings which can reach a certain conditions, which still can make before 90% of bearings have material stripping.

The basic rated life time can calculate per the following formula:

$$L_{10}=\left(\frac{C}{P}\right)^3$$

Of which L_{10}: Rating life as described above
C: Dynamic radial load rating
P: Dynamic equivalent radial load

The rated life time is normally represents according to hour as the unit, then rated life time and the life value according to (1) and have the following relationship:

$$L_h=\frac{10^6}{60n}\left(\frac{C}{P}\right)^3$$

Of which n: Rotating Speed
L_h: Hour

Basic Rated Dynamical Load

In the international standard, it is defined as "The load is which can reach 1 million revolutions' basic rated life and the direction and magnitude apply onto bearing is fixed." The dimensions list has this value.

Equivalent Dynamical Load

It is defined as "The load is which can reach the same service life as under the actual load and rotating conditions and the direction and magnitude apply onto bearing is fixed". According to the following formula and list, it can be converted into a radial load as the combining load of the radial load and axial load as its center.

$P=XF_r+YF_a$

F_r: Radial load
F_a: Load between the center of shaft

Below is the computation sheet for the equivalent load of deep groove ball bearing:

The axial load Ratio F_a/C_0	$F_a/F_r \le e$		$F_a/F_r > e$		e
Unit	X	Y	X	Y	
0.172				2.30	0.19
0.345				1.99	0.22
0.689				1.71	0.26
1.03				1.55	0.28
1.38	1	0	0.56	1.45	0.30
2.07				1.31	0.34
3.45				1.15	0.38
5.17				1.04	0.42
6.89				1.00	0.44

i: Column number of the rolling element in bearing (Single-row deep groove ball bearing: i=1)
Z: Quantity of rolling element
D_w: Ball diameter

The X, Y and e value which did not list in the table can use one time interpolation method to calculate.

Calculation Example

608ZZ (Basic rated dynamical load is 3297N, ball diameter is 3.969mm, quantity of steel ball is 7), the rotational speed is 3600min⁻¹, the radial load is 60N, the axial load is 30N, please calculate the service life L_h.

① Calculate the axial load ratio

$$\frac{F_a}{iZD_w^2}=\frac{30}{7\times3.969^2}=0.4534$$

② Calculate the e value which relative to the axial load Ratio

$$e=0.22+\frac{0.4534-0.345}{0.689-0.345}\times(0.26-0.22)=0.233$$

③ Calculate the ratio of radial load and axial load

$$\frac{F_a}{F_r}=\frac{50}{60}=0.8333$$

④ To compare the e value and the load ratio, select the X and Y value from the relevant column.

Compare $\frac{F_a}{F_r}(0.8333)$ and e (0.233): $\frac{F_a}{F_r}>e$

⑤ Calculate X and Y value:

X=0.56

$$Y=1.99-\frac{0.4534-0.345}{0.689-0.345}\times(1.99-1.71)=1.902$$

⑥ Calculate the equivalent dynamical load value

$P_r=0.56\times60+1.902\times50=128.7$

⑦ Calculate the service life (Hour)

$$L_h=\frac{10^6}{60\times3600}\times\left(\frac{3297}{128.7}\right)^3=77833h$$

Basic Rated Static load

In ISO Standard "The rated static load calculation method of ball bearing", it defines the basic rated static load of ball bearing as following:

The basic rated static load is the static load of when the central contact stress of supporting maximum load rolling element and the raceway reach 4200Mpa. The amount of the rolling element and the track's permanent deformation which generated under this contact stress is about 0.0001 times of the diameter of rolling element. The dimension list has its revised value.

The called equivalent static load is defined as "The same generated contact force's static load of the contact stress which generated under the actual load". Use the following formula to calculate, the final result is the bigger value.

$P_0=X_0F_r+Y_0F_a$

$P_0=F_r$

X_0, Y_0: According to the coefficient value of ball bearing in national standards.

F_a: Axial load
F_r: Radial load

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6 Internal Clearance

The internal clearance of rolling bearings in operation greatly influences bearing performance including fatigue life, vibration, noise, heat-generation ect. Consequently, the selection of the proper internal clearance is one of the most important tasks when choosing a bearing after the type and size have been determined. Bearing internal clearance is divided into the radial clearance, axial clearance and angle clearance As shown in Fig. 6-1 and Fig. 6-2, when either the inner ring or the outer ring is fixed and the other ring is free to move, displacement can take place in either an axial or radial direction. This amount of displacement (radially or axially) is termed the internal clearance and, depending on the direction, is called the radial clearance or the axial clearance. End clearance and angle clearance is the displacement amount which occurs when the inner ring fixed and the outer ring turn to the axial direction. Please see Fig. 6-3.

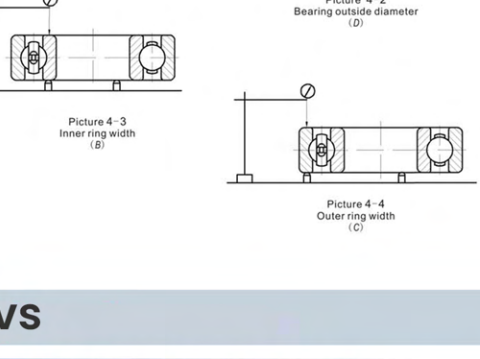

Fig. 6-1

Fig. 6-2

Fig. 6-3

V1 —The radial clearance standard value of Precision Miniature and Small Deep Groove Ball Bearing (μm)

Clearance Code	MC1	MC2	MC3 (standard)	MC4	MC5	MC6
Clearance	0~5	3~8	5~10	8~13	13~20	20~28

The radial clearance standard value of Ball Bearing (μm)

Nominal bore d (mm) Exceed	To	C2 min	C2 max	CN (Normal) min	CN max	C3 min	C3 max	C4 min	C4 max	C5 min	C5 max
2.5	10	0	7	2	13	8	23	14	29	20	37
10	18	0	9	3	18	11	25	18	33	25	45
18	24	0	10	5	20	13	28	20	36	28	48
24	30	1	11	5	20	13	28	23	41	30	53
30	40	1	11	6	20	15	33	28	46	40	64
40	50	1	11	6	23	18	36	30	51	45	73
50	65	1	15	8	28	23	43	38	61	55	90

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7 Bearing Materials

Materials for Bearing rings and Rolling Elements

The bearing rings and rolling elements of rolling bearings are subjected to repetitive high pressure (about 1000MPa) with a small amount of sliding. The cages are subjected to tension and compression and sliding contact with the rolling elements and either or both of the bearing rings. Therefore, the materials used for the rings, rolling elements and cages require the following characteristics: high rolling contact fatigue strength, high hardness, high wear resistance, high dimensional stability and high mechanical strength. This is a very important element for bearings.

Company is mainly use high performance chromium bearing steel and good corrosion resistance's martensitic stainless steel as our materials of bearing rings and steel balls.

The Chemical Composition of High-carbon Chromium Steel

Steel Specification Code	C	Si	Mn	Cr	Mo	P	S
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The Chemical Composition of Stainless Steel

Steel Code	C	Si	Mn	Cr	Mo	P	S
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Cage Material

Cage material is required to have good abrasion resistance properties, dimensional stability and metal intensity, therefore in selecting cage, it should be consider the operating environment.

- Stamping Steel Plate Cage

Material Code	Chemical Composition					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

- Nylon Cage

According to the type and application of bearing, nylon cage used more and more widely, but not for 120 degrees Celsius above or below 40 degrees centigrade environment, nylon cage material is PA66, the intensity and elasticity of this kind of material have good combination.

Shield Material

The shield's standard material of bearing in VS is cold rolling formation, secondary, we may also use AISI-300 stainless steel.

Seal Material

Bearing mainly adopts NBR as materials, aiming at high temperature environment, fluororubber and silicone rubber was also widely used.

Type	Temperature Range	Hardness	Characteristic	Restrictions
NBR	[illegible]	[illegible]	[illegible]	[illegible]
Silastic	[illegible]	[illegible]	[illegible]	[illegible]
Acrylic	[illegible]	[illegible]	[illegible]	[illegible]
Fluororubber	[illegible]	[illegible]	[illegible]	[illegible]
Polyacrylate	[illegible]	[illegible]	[illegible]	[illegible]
EPDM	[illegible]	[illegible]	[illegible]	[illegible]

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8 Vibration & Noise

Vibratory Speed Level

Bearing noise performance can be detected dynamically by BVT vibration gauge. Below are the summary introductions of BVT vibration gauge. BVT gauge is a kind of instrument which used for single rolling bearing's noise and vibration inspection. Because it is not like an vibration which generated by inspection rolling bearing, but the noise vibration which directly generated by inspection bearing, so it would not be inmate to the influence of external conditions. And the Andrew gauge can inspect with various grades with different vibration. If the inner ring of rolling bearing rotating with a speed of 1800 rpm, the static outer ring will generate vibration. Then to use a fast speed detection head to touch the outer ring, and inspect the vibration.

The detected noise vibration is divided into three frequency bands, all the vibration values of each band are shown on the Andrew gauge. Besides, except the values display, the Andrew gauge also installed a loudspeaking which covers all the frequency bands. The frequency assignments of each band are as following:

Low Frequency Band (L): 50~300Hz
Middle Frequency Band (M): 300~1800Hz
High Frequency Band (H): 1800~10000Hz

Vibration Velocity Limit Value & Vibration Velocity Peak Limit Value of Deep Groove Ball Bearings From ID 3mm to 30mm

[illegible]
[illegible]

The vibration acceleration grade of bearing

Bearings vibration acceleration is tested in Z2/Z3 Vibration Acceleration Tester. To pick the relevant peak and radial load according to the size of the bearing and then conduct test under the rotating speed of 1800r/min. The vibration acceleration value is following table:

Vibration Acceleration Limit Value & Vibration Acceleration Peak Limit Value

[illegible]
[illegible]

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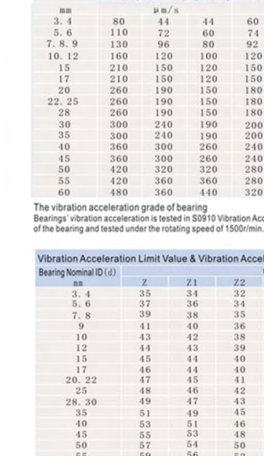
9 Preload

Purpose of Preload

Normally, bearings are used with a slight internal clearance under operating conditions. However, in some applications, bearings are given a preload; this means that the bearings' internal clearance is negative before operation. This is called "preload" and is commonly applied to angular ball bearings. Preload of bearings is not determined optionally, and it should be selected according to bearing size. If the preload is excessive, it will over strain bearings fatigue life and the friction torque of bearing will become larger consequently. But if the preload of bearing is undersize, it will amplify the vibration, the rigidity of inner ring will become bad and it will cause sideway micro vibration abrasion. So, when choosing ball bearing, it is very important to set the preload correctly.

Appropriate Preload

Normally, VS recommend customers adopt the appropriate preload through the surface load calculation. The called surface load is when applying the preload to ball bearing, the contact area of steel ball and the track groove will occur a deformation, and form a elliptical contact area, the generated component force from the vertical direction of the contact area of steel ball and track groove (it is called the load of rolling element), this pressure is the component force formed by elliptical area.



In Fig. 9-1, the radius of elliptical long axis which generated from the contact area between ball and track groove is a, the minor axis radius is b, then the ellipse's acreage is $\pi\cdot a\cdot b$. Besides, if the component force from the vertical direction of the contact area is Q, then the surface load is Q/S. The unit is normally use MPa (kgf/mm²).

The selection standard of surface load is as following:

When considering the factor of noise and bearing life: When the bearing life need to exceed 10,000 hours, we take the preload of surface load below 600 MPa (About 60kgf/mm²). When the bearing life need to between 5,000 to 10,000 hours (Common grade products), we take the preload of surface load around 1000 MPa (About 100kgf/mm²). When the bearing life below 5,000 hours (attach importance to rigidity), we take the preload of surface load around 1500 MPa (About 150kgf/mm²).

The above datas can conduct as a kind of approximately standard.

Conduct as a kind of simple estimating method according to the rated dynamical load:

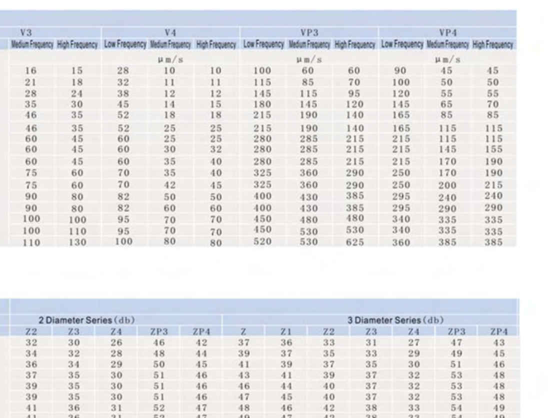
Bearing life exceeds 10,000 hours: 0.5/100~1/100 Cr
Bearing life between 5,000 to 10,000 hours: 0.5/100~1/100 Cr
Bearing life below 5,000 hours: 1.0/100~2/100 Cr

Besides, if the material is high-carbon chromium steel, the surface load exceed 2700MPa (About 270kgf/mm²), the ball bearing's generate plastic deformation. Therefore, even though the load is for a short time, if apply a average surface load 2700MPa (About 270kgf/mm²), in spite of it will not damage the bearing, but we consider the safety to recommend to control the applied load below 1600MPa (About 160kgf/mm²).

Preload and Rigidity

Preloading methods divide into fixed position preload (Fig. 9-2) and constant pressure preload (Fig. 9-3). Fixed position preload is a kind of method which obtain preload according to the relatation of mechanical position. The advantages of this method are structural component simple and higher rigidity, while the disadvantages are the variation amount of preload trigger according to the temperature variation, and the preload factor easy due to abrasion.

Constant pressure preload is a kind of method which through screw type spring, and loosen washer to provide preload to bearings. Its advantage is only having little influence from temperature variation, but it also have the disadvantages of the structural component complicated and the rigidity reduced. Generally, we have two kinds of preloading methods, we called Front Combination (DF) and Back Combination (DB). The rigidity of DB is higher than DF's.



Fixed position preload Fig. 9-2

Front Combination (DF) Fig. 9-4

Constant pressure preload Fig. 9-3

Back Combination (DB) Fig. 9-5

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10 Bearing Installation

1 Preparation before installation

Ball bearing is a kind of precision parts, in order to maintain its accuracy, it should be sure to prudent and carefully use. Maintain the cleanness, avoid bearing strongly impact and prevent rust, etc, are the attention matters when use bearings.
(1) Please do not open the packaging before using the bearing, and do not take up the bearings after open the packaging.
(2) To keep the operation environment cleaning.
(3) It should use the specified tools and fixtures for assembling and keep them cleaning.
(4) Please do not touch the bearing with hands and avoid oil and bearing, and do not allowed to use dirty cloth.
(5) It should be assembling bearing after cleaning the surrounding components.
(6) Don't touch bearings by hand.
(7) Don't add stock and high load to bearings.

When install bearings to the axle or housing, if the installation surface has rough selvedge or dust, the bearing will can not work normally and it will occur unusual vibration and noise when bearing in operation.

- Preparation before using

Raw Edge

Impurity

2 The installation schematic diagram of bearing

According to statistics, about 18% of bearing failure is due to improper installation method. When bearing installed to the shaft or the bearing housing, do not use a hammer directly attack, please refer to the following chart.

- The installation method of ball bearings

OK! OK! OK!

Press-in Shaft

Press-in Shell

Equipotent Press-in Shaft & Shell

- The considerations of ball bearings when installation

① To avoid strong impact force:
Since the contact surface bearing groove surface and the rolling elements is be similar to contact, excessive wallop will cause the contact interface creasing, so striking or drop must avoid happen.

Impact force

Crushed

Unusual noise

② To avoid dust entering into bearing
If bearings suffering dust invaded when bearing installation, which can be caused groove surface and roller surface damage, this will cause bearing strange noise and rotation not good.

Dust

Bite

Crushed

Strange noise

VS

11 Fitting

When use ball bearing, there is no occasion for using alone, it must be installed onto the spindle or inset onto the machine shell. So, fitting means the assembling and gomphosis's tightness degree of Spindle and inner ring and machine shell and outer ring. It divides into clearance fit, interference fit and transition fit.

The press-in type gomphosis of spindle and inner ring

Shaft

$$\Delta=\frac{2d/\delta}{(d^2-d_1^2)\left[\frac{d^2+d_1^2}{E_s(d^2-d_1^2)}-\frac{m_s}{E_s}+\frac{d_i^2+d^2}{E_i(d_i^2-d^2)}+\frac{m_i}{E_i}\right]}$$

According to the above formula, when press in the magnitude of interference I, the groove diameter's amplifying of inner ring Δ, so the radial clearance's decrescence is Δ. Among which:
- d: ID of inner ring
- d_1: ID of spindle (Solid shafting)
- d_i: Groove diameter of inner ring
- I: Magnitude of interference
- E_i: Young modulus of inner ring
- E_s: Young modulus of shaft
- m_i: Poisson's coefficient of inner ring
- m_s: Poisson's coefficient of shaft

The press-in type gomphosis of outer ring and machine shell

Bearing housing

$$\Delta=\frac{2D/\delta}{(D_o^2-D^2)\left[\frac{D_1^2+D^2}{E_h(D_1^2-D^2)}+\frac{m_h}{E_h}+\frac{D^2+D_o^2}{E_o(D^2-D_o^2)}-\frac{m_o}{E_o}\right]}$$

According to the above formula, when the machine shell and outer ring press in gomphosis according to the magnitude of interference, the diminution of radial clearance is Δ.
- D_o: Groove diameter of outer ring
- D: OD of outer ring
- D_1: OD of machine shell
- I: Interference degree
- E_h: Young modulus of machine shell
- m_h: Poisson's coefficient of machine shell

Bearing Fit Dimensions List

Bearing fit (Cylindrical Bore)

The fit of bearing inner bore and axle

Bearing Grade	Inner ring rotating load or direction variable load						Inner ring static load		
Grade 0, Grade 6	r6	p6	n6	m6 / m5	k6 / k5	js6 / js5	h5	h6 / g5	f6
Grade 5				m5	k4	js4	h4	h5	
Fitting	Interference Fit					Transition Fit			Clearance Fit

The fitting of bearing outer ring surface and bearing housing

Bearing Grade	Outer ring static load				Direction variable load or outer ring rotating load				
Grade 0, Grade 6	G7	H6	J6 / JS6	J7 / JS6	K7 / K6	M7 / M6	N7 / N6	P7	
Grade 5		H5	JS5		K5	M5			
Fitting	Loose Fit			Transition Fit				Interference Fit	

Permissible variation in dimension of common fitting spindle (Unit μm)

[illegible]
[illegible]

Permissible variation in dimension of common bearing housing bore (Unit μm)

[illegible]
[illegible]

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12 Friction Torque

The friction torque of ball bearing is dividing into starting friction torque and dynamic friction torque. Starting friction torque means, when the ball bearing start to rotate, the torque is what needed for overcoming the resistance which generated due to the steel ball and track groove's contact elastic deformation and overcoming the resistance which generated due to the steel ball and the lubricant on the raceway. Dynamic friction torque means the torque which needed for overcoming the resistance that generated from the friction of lubricant, steel ball and cage as well as the friction of steel ball and raceway groove when bearing in revolution. Ball bearings' friction torque is connected with calorification, rated rotational speed, current value at start up, rated current value, the variation of current value and revolution inequality ect.

Calorification

Ball bearing's revolution calorification is due to enclose too much high viscosity grease, and the sticky grease will suffer agitation when in rotating, and the bearings will start calorification because of agitation resistance. The countermeasure is to reduce the filling amount of grease, or to change to oriented type grease.

Fail to reach the rated revolution

Sometimes, it happens that bearing fail to reach the rated revolution after motor started, the reasons is possibly because of the grease filled too much or have used sticky type grease.

Current value at starting

The reasons of the higher current value at motor starting is possibly because of the grease filled too much or have used sticky type grease.

Rated current value

The oversize current value at motor rotating is possibly connected with the filling grease consistency and viscidity of grease.

Rotating inequality

The reason is because of the guidance quality of grease been destroyed in rotating, and then it will occur the lubricant's thickness unevenness and torque fluctuate in a moment, the improvement actions are to reduce the filling amount of grease, or change to grease with better guidancequality or the grease with good viscidity.

Rotational speed & dynamic friction torque

Generally, when the rotational speed increase, the dynamic friction torque will increase consequently.

Grease filling amount & dynamic friction torque

Generally, when the grease filling amount increase, the dynamic friction torque will increase consequently.

Temperature & torque

Normally, when the temperature steps down, the dynamic friction torque will increase consequently.

Influence of grease filling position

The value of dynamic friction torque will change due to the position of grease filling.

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13 Displacement

When ball bearing endures the external load, the deformation generated from the contact area of steel ball and raceway groove is called displacement.

Radial displacement

Suppose the radial load is F, the maximum load which exerted to the steel ball is Q, then:

$$Q=\frac{5}{Z}F$$

The radial displacement of steel ball and raceway groove's contact point is δ:

$$\delta=c_\delta\sqrt[3]{\Sigma\rho Q^2}$$

Of which:
$\Sigma\rho$: Sum of contact point's principal curvatures
c_δ: The function of auxiliary variable $f(\tau)$, which is a coefficient can be calculated.

Because the steel balls contact with both the inner raceway groove and outer raceway groove, the total displacement amount should be the sum of two kinds of displacement amount.

$\Delta t=\delta_i+\delta_e$

Of which:
Δt: Total displacement
δ_i: Displacement between steel ball and inner ring groove
δ_e: Displacement between steel ball and outer ring groove

Axial displacement

The axial displacement which generated when exert axial load Fa can be calculated by using below method.

Initial contact angle

When the basic clearance of bearing become a bearing with no clearance, the track circle move along with the axial direction, the contact angle which generated under this condition can be calculated by the following formula:

$$\alpha_0=\cos^{-1}\left(1-\frac{Gr}{2(r_i+r_e-D_w)}\right)$$

Relation of initial contact angle and contact angle

From the initial contact status to exert load along with the axial direction, the relation of contact angle which generated under this condition and the initial contact angle is shown as following, it can be calculated the contact angle under load by using this formula:

$$\frac{\cos\alpha_0}{\cos\alpha}=1+\frac{c}{(r_i+r_e-D_w)}\left(\frac{F_a}{Z\cdot D_w^2\cdot\sin\alpha}\right)^{2/3}$$

From the above figure, it can be known the amount of axial displacement is:

$$\delta_a=(r_i+r_e-D_w)\left(\sin\alpha-\sin\alpha_0\right)+c\left(\frac{F_a}{Z\sin\alpha}\right)^{2/3}\left(\frac{\sin\alpha_0}{\ldots}\right)$$

Of which:
Gr: Radial clearance
c: contact coefficient of elasticity

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14 Lubricant

For ball bearing, the selection of lubricant is very important. It has significant influence to bearing's performance, such as service life, friction torque, rotating uniformity, noise, dustproof, heat proof, cooling and antirust, etc. Normally, ball bearings adopt sealed lubrication, so it is rarely to change the lubricant. Lubricant is usually use oil or grease injection, the lubrication life of grease is usually longer than oil. Therefore, the standard form for sealed ball bearing is to use grease as the lubricant. The reason why the lubrication life of grease is longer than oil is because the thickening agent (fibrous's combination) of lubricant of grease not only can keep the oil content (base oil), but also can release oil content. Besides, for the purpose of torque very small or not allowed to have friction torque fluctuate, the better is to use oil as the lubricant. If there is a large of

It also contains the prevention oxidant which used for prevent base oil oxidation in the grease; improve the oiliness solvent of critical lubricity and avoid abrasion other additives of high pressure additives and rust stopping agent. After adding these additives makes various greases with different characters. Therefore, even with the same series of greases, due to the manufacturer is different, the performances are completely different. For the above reasons, regarding the calculation of sealed ball bearings' grease lifetime, the ratio of bearings' assembly parts use specific greases; and in recent years, the ratio of bearings' assembling parts use specific greases, chemical changes with grease is also increasing. So it is very necessary to consider the operating conditions and operating environment carefully when choose grease.

Grease Properties

Name	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

◎Excellent ○Good △Common ×Not Good

Manufacturer	Brand	Thickening Agent	Base Oil	Viscosity of Base Oil 40℃	100℃	Penetration
Kluber	[illegible]	Polyurea	[illegible]	[illegible]	[illegible]	[illegible]
Kyodo Yushi	[illegible]	Lithium Base	[illegible]	[illegible]	[illegible]	[illegible]
Shell	ALVANIA	Mineral Oil	[illegible]	[illegible]	[illegible]	[illegible]
Mobil	Mobil	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ESSO	POLYREX EM	Polyurea	[illegible]	[illegible]	[illegible]	[illegible]

Grease filling amount

Normally, the filling amount of grease for small size and miniature bearings take 30vol%, but in order to fit the performance of the used motor, so adopt the following filling amount:

K (35~10%)
L (10%~15%)
T (15%~20%)
No code (25%~35%)
H (10%~30%)

Drop Point	Operating Temperature Range (℃)	Property	Application
[illegible]	[illegible]	[illegible]	[illegible]

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15 Bearing Failure

Bearing failure analysis

Normally the bearing can work until its fatigue life if used correctly. However, the early failure of bearing may happen due to many reasons. The reasons for the spoilage are mostly related to the installation, use and lubrication of bearing, impurity penetration or insufficient knowledge of confirm approach. The early failure can be caused by wrong operation. Bearing's failure is a quite important factor in machinery. We will analyze the bearing's early failure; it can be divided into three kinds mainly. 1) Contact fatigue failure 2) Wearout failure 3) Breakage failure 4) Clearance change failure

Appearance | Causes | Preventive measures

Nonage flaking off

When bearing rotates under load, the materials of inner and outer raceway groove or the surface of rolling body take on unrepeatable dunghills to the raceway.

Indentation

The indent generated on the surface of raceway groove or roller after taking in foreign matter. Impurity ect.

Attrition

Attrition mostly occurs to sliding friction surfaces such as roller and surface rib surface, holder pocket surface as well as guide surface of holder and bearing race ect. The occurrence of these phenomena is with no directly related to fatigue of materials.

Burn

Bearing rings, rolling element as well as cage heat up quickly until occurrence of discoloration, softening, fusion and disrepair.

Creepage

Creepage refer to the condition that gap clearance exists in the matching surface of bearing, therefore the relative slackly occurs between the matching surfaces. The matching surface on which creepage exists on brightness of specular surface or dark face, and is accompanied by discoloration or scratch occasionally.

※The pictures refer to the famous bearing manufacturers' failure pictures at home and abroad.

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16 Steel Ball Gauge Value & Sorting Schematic Diagram

1 Gauge Value and Branch Gauge Value (See Fig. 1)
For example: P5 steel balls, the value of number used um.

Separation distance of Nominal Gauge Value

Nominal Diameter

Separation Distance of Gauge Value

(Fig. 1)

2 Batch and gauge value deviation (See Fig. 2)

The minimum ball in the batch

The maximum ball in the batch

Batch average diameter

Ball diameter variation

The batch S with the maximum gauge value of

The batch S with the minimum gauge value of

(Fig. 2)

Typical examples
Example:
S 610 -4 (-9.2) GB/T3082002
Indicate high-carbon chromium bearing steel which meet GB/T3082002, nominal diameter is 6mm, tolerance grade is grade 10, gauge value is -4 um, branch gauge value is -9.2 um.

Size Table 2

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Deep Groove Ball Bearing

Outline

Deep groove ball bearing is the most common rolling bearing, whose inner and outer raceways are both deep groove grooves. Deep groove ball bearings are mainly used for radial loading and even axial load. The friction coefficient of deep groove ball bearing is very low, and their limit speed is very high. The shielded ones can work without re-lubrication and maintenance.

The structure of deep groove ball bearing is simple. Compared with other types, they are easier to get higher manufacturing precision, able to be produced in enormous quantities, cost-efficient and convenient to use. Besides basic types, deep groove ball bearings have various derivative structures. Such as (see the examples in the right table for details):

Deep groove ball bearing with shield;
Deep groove ball bearing with rubber sealing ring;
Deep groove ball bearing with snap groove;
Deep groove ball bearing with filling slot
Double row deep groove ball bearing

1. Deep-groove ball bearing with shield

Shields can prevent the leakage of lubricating grease and the penetration of exterior foreign substances, and fall into single-sided shields and double-sided ones. Bearings with shields can be used where separate lubrication is difficult, playing lubrication ducts and checking lubricating conditions are inconvenient, while low friction torque and high operation are required. Bearings have been filled with a definite quantity of grease of a certain trademark before leaving the factory. The grease quantity for each bearing is usually make up 1/4 ~ 1/3 of the available space of the bearing bore, which can also be increased and decreased according to the customer's requirement. The filled lubricating grease can usually guarantee the bearing works at the temperature of -40~120℃. If customer has additional requirements for the bearing, other special lubricating grease can be filled according to the circumstances. Bearings with shield can work effectively for a long time after filled with grease, and there is no need to add lubricating grease during this period. Bearings with shield are normally used in small generators, two ends of the rotors of electric motors, automobiles, tractors, air conditioners, farmers, etc. as well as the situations where there are special requirements for the noise and vibration of the bearings.

The model and structure of deep groove ball bearing, showed in the picture

Open type	The most used basic structure is represented with basic code, e.g. 6204
Structure of shield on one side	Represented with a "Z" behind the model number, e.g. 6204-Z
Structure of shield on both sides	Represented with a "ZZ" behind the model number, e.g. 6204ZZ
Structure of seals on one side	An "RS" is added in front of the code of usual miniature bearing, e.g. F683
Structure of seals on both sides	Represented with a "2" behind the code, "-2RS" for double sided, e.g. 6204-2RS
Non-contact sealed structure	Represented with "RZ" behind the model number... e.g. 6204-2RZ
Contact sealed structure	Represented with a "RS" behind the model number, e.g. 6204-2RS
With snap groove	Represented with "N" behind, e.g. 6204N

2. Deep groove ball bearing with rubber sealing ring

Deep groove ball bearing with rubber sealing rings fall into contact type and non-contact type, also single-sided and double-sided. According to different use requirements, contact seal bearings can be designed and manufactured into light contact type, medium contact type and heavy contact type.

The performance, grease filling and usage of bearings with sealing rings are identical with those of deep groove ball bearings with shield. The difference is that the space between the shield and the inner race of the bearing with shield is large, while that between the sealing ring and inner race of the contact seal bearing is small. There is no space between the sealing lip and the inner race of the contact sealing ring bearing, which ensures a good sealing effect, but also increases the friction. Small-size deep groove ball bearings of 60 and 62 series are often used in situations where low noise is required. Requirements for low noise and low vibration can be raised for both open bearings and shielded bearings (bearings with shields or sealing rings) when they are ordered.

3. Deep groove ball bearings with snap grooves and stop rings

The structure with snap groove, stop ring or flange on the outer race can realize axial location and facilitate the mounting frame of housing. Deep groove ball bearings with snap grooves and stop rings are often used in the working positions of automobiles, tractors and etc.

4. Deep groove ball bearing with filling slot

The main dimensions of deep groove ball bearings are identical with those of the 62 or 63 series of deep groove ball bearings. There are filling slots in the inner and outer races, therefore, the number of steel balls are more than that of ordinary deep groove ball bearings and the dynamic load rating is 20 ~ 35% higher. Because this type of bearings have filling slots, they are not suitable for the situations where the axial load is high. When used in combined bearing especially radial loading, the condition and the dynamic equivalent radial load $P_r=0.5$ Cor should be met.

5. Double row deep groove ball bearing

In case of any requirement, please contact the technical center

Seal

Specifications	With shield	With sealing ring		
	Non-contact type	Non-contact type	Contact type	Light contact type
Features	2Z	2RZ	2RS	2RS
Friction torque	Small	Small	Large	Relatively small
High speed	Relatively good	Good	Restricted because of contact	Relatively good
Grease seal type	Relatively good	Better than 2Z type	Very good	Very good
Dustproof	Not very good	Better than ZZ type	Very good	Very good
Temperature	-30~110℃	-30~110℃		-30~110℃

Note: Here is the application temperature scope of standard bearings. Changes of lubricating grease type and sealing ring material may extend the application scope. Please contact the technical center.