3. ANGULAR CONTACT BALL BEARING COMBINATIONS

Angular Contact Ball Bearing Combinations Available

Normally, NSK supplies matched super precision angular contact ball bearings as 2, 3, and 4 row combinations. The combinations available for the fixed end of spindles are usually 2 rows (DB), 3 rows (DBD), and 4 rows (DBB) sets. However, in the case of 3 row combinations, since the preload distribution to each bearing is not equal, the optimum preload setting range is very limited, making them unsuitable for high speed applications.

Matched bearings are manufactured as sets, so when they are mounted adjacent to each other, a given preload is automatically obtained. The variation per pair of matched bearings for bore and outer diameters is adjusted to less than 1/3 of the permissible tolerance.

Table 3.1 Features of Each Combination

	DB	DF	DT	DBD	DBB
Load direction	⇔	⇔	→	⇔	⇔
Moment stiffness	◎	○	△	◎	◎
Speed capability	◎	◎	◎	△	○
Heat generation	◎	◎	◎	△	○
Stiffness	○	○	△	◎	◎

◎Excellent ◎Very good ○Good △Fair →One direction only ⇔Two directions

Features of Each Combination

● Back-to-back Arrangement, DB

Axial loads in both directions and radial loads can be sustained. Since the distance between the effective load centers is large, this type is suitable if moments are applied. However, if accuracy of housing is not enough and there is a misalignment in the spindle, internal loads of bearings could be large enough to possibly cause premature failure due to greater moment stiffness.

● Face-to-face Arrangement, DF

Compared with the DB type, the distance between the effective load centers is small, so the capacity to sustain moments is inferior to the DB type.
On the other hand, this type is suitable for using with housings that have less accuracy or larger shaft deflections due to low bending stiffness of shaft.

● Tandem Arrangement, DT

Axial loads in one direction and radial loads can be sustained. Since axial stiffness of this type is twice the value of a single row type, this arrangement is used when the axial load in one direction is heavy.

● 3 rows Arrangement, DBD

Axial loads in both directions and radial loads can be sustained.
However, the preload distribution to each bearing is not equal, and preload on the counter side (single side) is twice that of other side.
Consequently, this type is unsuitable for high speed operation because of the large increase of internal load of the single side which could lead to bearing failure.

● 4 rows Arrangement, DBB

Axial loads in both directions and radial loads can be sustained.
In situations that have the same axial clearance as DB arrangement, preload and stiffness are twice that of the DB arrangement. Also, the permissible axial load of a 4 row arrangement is larger than that of a DB arrangement.

Fig. 3.1 The Distance between the Effective Load Centers of Back-to-back and Face-to-face Arrangements

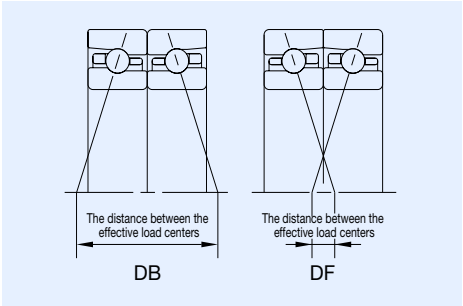


Fig. 3.2 Load Direction in Back-to-Back and Tandem Arrangements

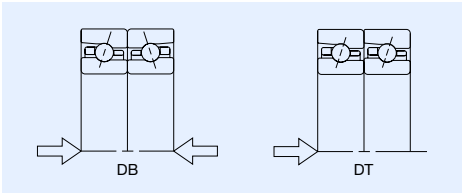
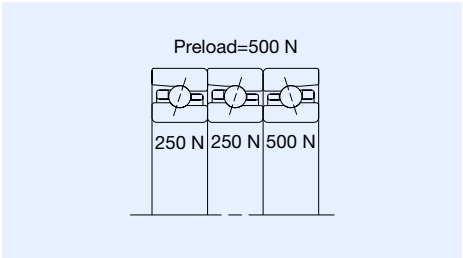


Fig. 3.3 Internal Preload in DBD Arrangement



Shaft Bending Comparison between Back-to-back and Face-to-face Arrangements

Moment stiffness is different between Back-to-back and Face-to-face arrangements as shown in the shaft bending comparison calculation example below. In this example, angular contact ball bearings (75BNR10XET) are used in the front side and the typical shaft deflections are shown for both DB and DF configurations. When 1 000 N of radial load is applied on the spindle nose, radial displacements on the spindle nose are calculated as follows.

$$\sigma_{DB} = 2.4079 \times 10^{-2}$$
$$\sigma_{DF} = 2.9853 \times 10^{-2}$$

This demonstrates the effect of the distance between effective load centers on spindle bending.

Mounting Instructions for Angular Contact Ball Bearings — Matching Method

Direction of Matching

For matched bearings, the mounting order and load application direction are very important.
A "V" is marked on the outer diameter surfaces of the bearings as shown in the figure on the right. When the bearings are mounted so their marks correctly form a "V", they are properly matched and aligned.
On the side surface or chamfered part of the inner rings, the symbol "○" is marked to indicate the position of maximum radial runout. Optimum accuracy is achieved when the bearing is mounted so the "○" symbol is placed just opposite the position of shaft maximum eccentricity.

Fig. 3.5 The Symbol for the Position of Maximum Radial Runout of Inner Ring

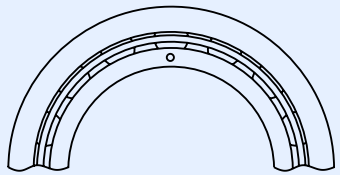


Fig. 3.4 Spindle Displacement Curve

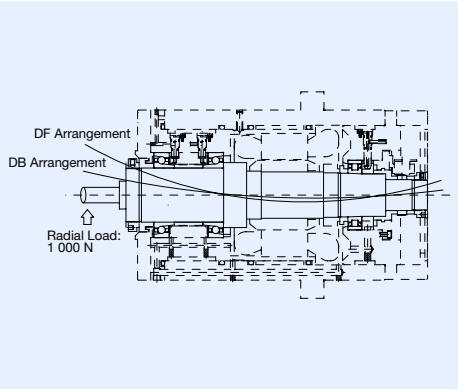
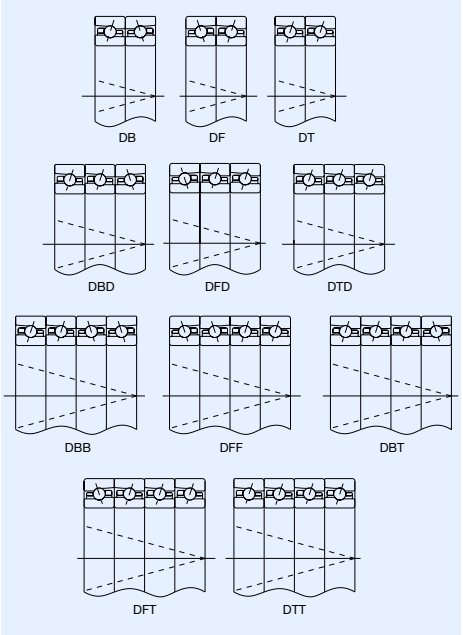


Fig. 3.6 Combinations of Angular Contact Ball Bearings



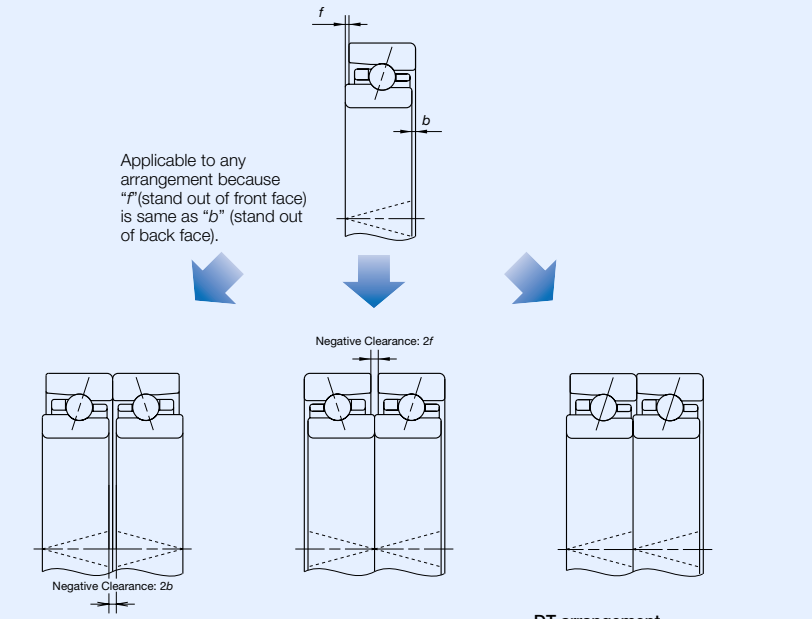
3. ANGULAR CONTACT BALL BEARING COMBINATIONS

Universal Combination

NSK supplies universal combination angular contact ball bearings that have the same amount of stand out on both the front and back face. This means that when bearings that have the same reference number are combined, they have the specified amount for each standard preload.

For universal combination bearings, the "V" combination marks on the outer diameter surface of outer ring prevent "direction" mistakes, ensure correct matching when they are mounted, and indicate the direction of the contact angle.

Fig. 3.7 Universal Combination



DB arrangement
Preload is "stand out of back face x 2 = 2*b* (=2*f*)" and it is the specified amount for each standard preload.

DF arrangement
Preload is "stand out of front face x 2 = 2*f* (=2*b*)" and it is the specified amount for each standard preload.

DT arrangement
There is no clearance on DT surface because stand out of front face "*f*" is same as stand out of back face "*b*". This situation is the same as bearings combined as DT.

Difference between SU and DU Bearings

There are 2 types of NSK universal combination bearings as shown in the table below.

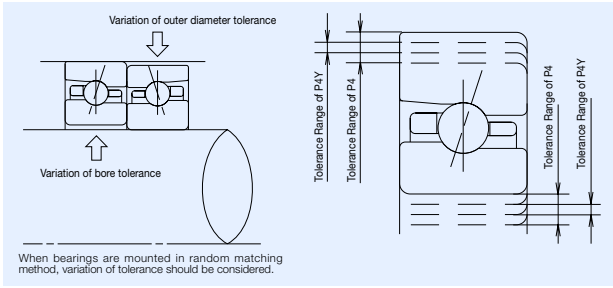
Table 3.2 Features of SU and DU Bearings

	SU	DU
Row of bearings	1	2
Variation of bore and outer diameter tolerance	–	Controlled in 1/3 of tolerance

Notice for Use of Single Universal (SU) Bearings

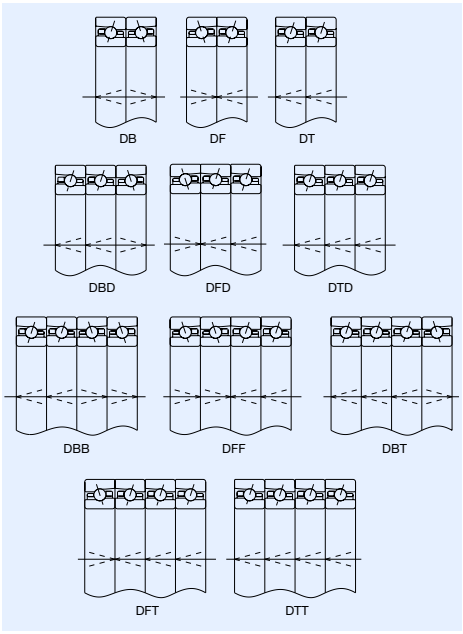
- When these bearings are used as part of multiple combined bearings, it is recommended that the variation of bore and outer diameter tolerance is within 1/3 of tolerance range.
- There are also special bearings with special accuracy "Class 4Y" that can accommodate small variations of bore and outer diameter tolerance. "Class 4Y" tolerance has the same running accuracy as Class 4 but has a narrower tolerance range of bore and outer diameter than Class 4. It is suitable for "random matching method" universal combination bearings.
- "Class 4Y" is suitable for use "random matching method" universal combination bearings. However, when these bearings are operated over 1 500 000 $d_m n$, there is a possibility that this very small variation of fits with either the shaft or the housing can cause bearing failure because of imbalance of internal load in each row. If these bearings are considered for such high speed applications, this issue should be taken into account.

Fig. 3.8 Tolerance of P4 and P4Y Accuracy



Combination Mark and Matching Method for Universal Combination Bearings

Fig. 3.9 Universal Bearings Combinations



Bore and Outer Diameter Tolerance (Class 4Y)

Table 3.3 Tolerance of Bore Diameter of Inner Ring Unit: μm

Bore diameter		Class 4		Class 4Y (Controlled to medium value)	
Over	Incl	High	Low	High	Low
30	**50**	0	– 6	–1	–3
50	**80**	0	– 7	–2	–5
80	**120**	0	– 8	–3	–6
120	**150**	0	–10	–3	–7

*Tolerances for bearings under 30 mm bore are the same as values quoted between 30–50 mm bore.

Table 3.4 Tolerance of Outer Diameter of Outer Ring Unit: μm

Outer diameter		Class 4		Class 4Y (Controlled to medium value)	
Over	Incl	High	Low	High	Low
50	**80**	0	– 7	–2	–6
80	**120**	0	– 8	–2	–6
120	**150**	0	– 9	–3	–7
150	**180**	0	–10	–3	–7
180	**200**	0	–11	–4	–9
200	**Under 215**	0	–11	–2	–9

*Tolerances for bearings under 50 mm outer diameter are the same as values quoted between 50–80 mm outer diameter.