

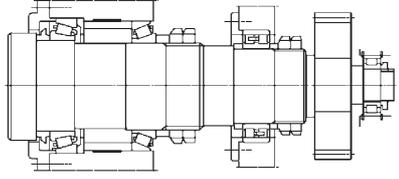
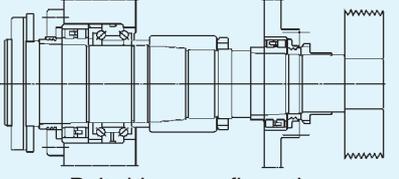
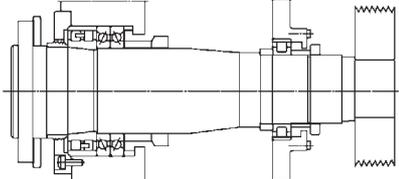
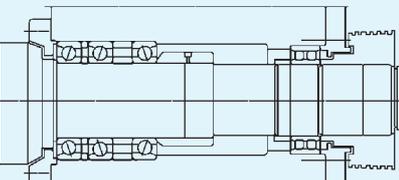
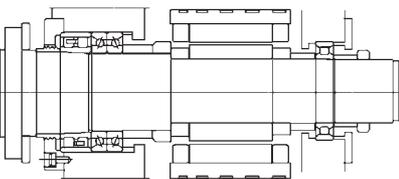
1. Precision Bearing Structure and Its Arrangement

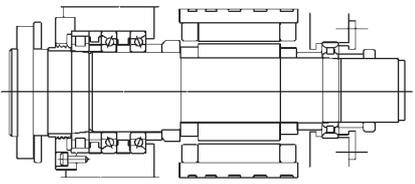
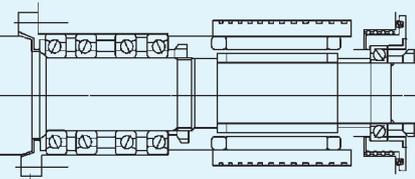
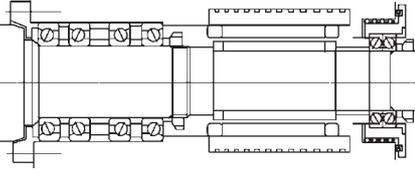
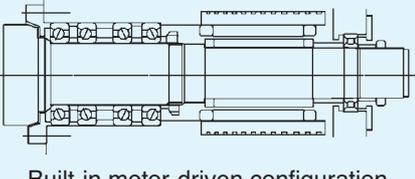
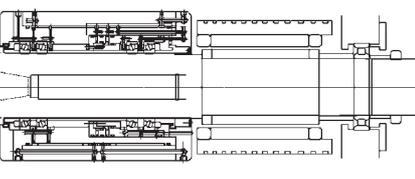
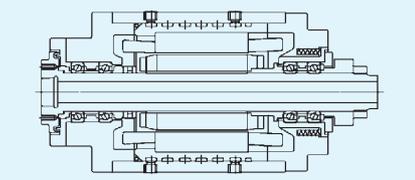
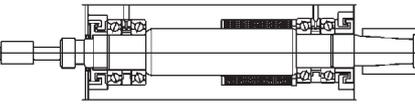
1.1 Bearing Arrangement for Main Spindles

Typical examples of bearing arrangements for main spindles of machine tools are summarized in Table 1.1. An optimal bearing arrangement must be determined through considerations about the properties required of

the main spindle in question (maximum speed, radial and axial rigidities, main spindle size, required accuracies, lubrication system, etc.). Recently, an increasing number of new machine tool models incorporate built-in motor type main spindles. However, heat generation on a built-in motor can affect the accuracy of the main spindle and performance of lubricant, so a main spindle bearing should be selected very carefully.

Table 1.1 Typical examples of bearing arrangements for main spindles

Type	Bearing arrangement for main spindle	Bearing type	Lubrication	Typical applications
1	 Gear-driven configuration	Tapered roller bearing + Tapered roller bearing + Double-row cylindrical roller bearing	Grease	Large turning machine Oil country lathe General-purpose turning machine
2	 Belt-driven configuration	Double-row cylindrical roller bearing + Double-direction angular contact thrust ball bearing + Double-row cylindrical roller bearing	Grease	CNC turning machine Machining center Boring machine Milling machine
3	 Belt-driven configuration	Double-row cylindrical roller bearing + High-speed duplex angular contact ball bearing for axial load + Single-row cylindrical roller bearing NOTE: high-speed variant of Type 2	Grease	CNC turning machine Machining center Milling machine
4	 Belt-driven configuration	Duplex angular contact ball bearing (DBT arrangement) + Double-row cylindrical roller bearing NOTE: high-speed variant of Type 2 & 3	Grease	CNC turning machine Machining center Milling machine
5	 Built-in motor-driven configuration	Double-row cylindrical roller bearing + High-speed duplex angular contact ball bearing for axial load + Single-row cylindrical roller bearing NOTE: high-speed variant of Type 3 with built-in motor-driven configuration	Grease/ Oil air	CNC turning machine Machining center Milling machine

Type	Bearing arrangement for main spindle	Bearing type	Lubrication	Typical applications
6	 <p>Built-in motor-driven configuration</p>	Single-row cylindrical roller bearing + High-speed duplex angular contact ball bearing for axial load + Single-row cylindrical roller bearing NOTE: high-speed variant of Type 5	Grease/ Oil air	CNC turning machine Machining center
7	 <p>Built-in motor-driven configuration</p>	Duplex angular contact ball bearing (DTBT arrangement) + Single-row angular contact roller bearing (w/ ball slide) NOTE: super high-speed variant	Grease/ Oil air	Machining center <vertical>
8	 <p>Built-in motor-driven configuration</p>	Duplex angular contact ball bearing (DTBT arrangement) + Duplex angular contact roller bearing (w/ ball slide) NOTE: super high-speed variant	Grease/ Oil air	Machining center <vertical>
9	 <p>Built-in motor-driven configuration</p>	Duplex angular contact ball bearing (DTBT arrangement) + Single-row cylindrical roller bearing NOTE: super high-speed variant	Grease/ Oil air	Machining center
10	 <p>Built-in motor-driven configuration</p>	Adjustable preload bearing unit + Duplex angular contact ball bearing (DBT arrangement) + Single-row cylindrical roller bearing NOTE: high-rigidity/super high-speed variant	Oil air	Machining center
11	 <p>Built-in motor-driven configuration</p>	Duplex angular contact ball bearing (DT arrangement) + Duplex angular contact ball bearing (DT arrangement)	Grease/ Oil air	Machining center Small turning machine Grinding machine
12	 <p>Belt-driven configuration</p>	(DT arrangement)	Oil mist	Grinding machine

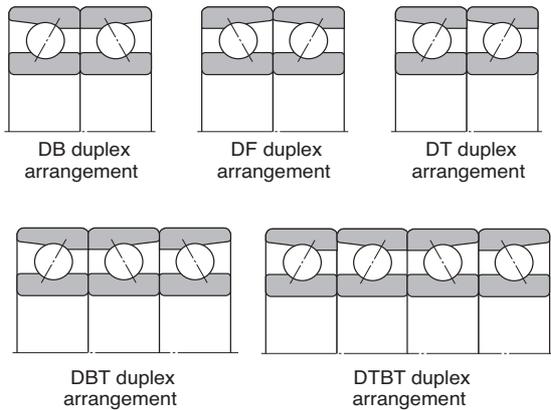
1.2 Structure of Spindle Bearings

1.2.1 Duplex Arrangement Bearings

Duplex angular contact ball bearings can be combined in rows of two, three or four bearings to accommodate required specifications. The back-to-back duplex (DB) arrangement and the face-to-face duplex (DF) arrangement allow for the application of both radial loads and axial loads in both directions. The DB arrangement has a wide space between load points and can handle large moment loads. For this reason, this type of duplex arrangement is preferable for use on the main spindles of machine tools.

The DF arrangement cannot handle large moment loads, but its allowable inclination angle is greater than that of the DB arrangement. The tandem duplex (DT) arrangement can handle both a radial load and large axial load, but this bearing can take the axial load in one direction only. The 4-row duplex (type DTBT) arrangement ensures high rigidity in the radial and axial directions and accommodates high-speed operation. For this reason, this type of duplex bearing is commonly used for the main spindles of machining centers.

Fig.1.1 Duplex arrangement codes



1.2.2 Marking of Bearings and Bearing Sets

A "V-shaped" marking on the outside surface of the outer rings of matched bearing sets indicates how the bearings should be mounted to obtain the proper preload in the set. The marking also indicates how the bearing set should be mounted in relation to the axial load. The "V" should point in the direction in which the axial load will act on the inner ring. In applications where there are axial loads in both directions, the "V" should point toward the greater of the two loads, refer to Fig. 1.2 °

For universal combination bearings described in 1.2.3, the "V" marking on the outside surface of the outer rings shown in Fig. 1.3, prevent "direction" mistakes, ensure correct matching when they are mounted.

Fig.1.2 A "V-shaped" marking on the outside surface of the outer rings of matched bearing sets

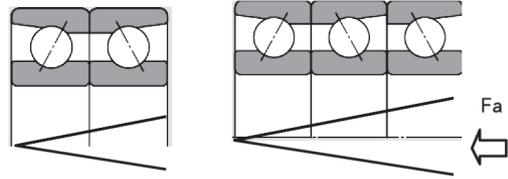
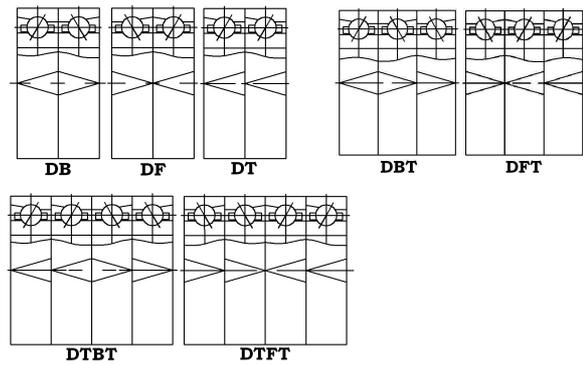


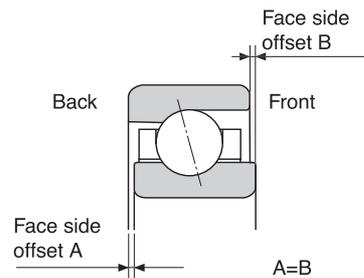
Fig.1.3 A "V-shaped" marking on the outside surface of the outer rings of universal combination bearings



1.2.3 Flush Grinding and Universal Matching

"Flush grinding" is a finishing technique in which the front and back faces of the inner and outer rings are aligned with each other to eliminate differences in face height (illustrated in Fig. 1.4). Such alignment can ensure the specified clearance and preload for DF, DB, and DT sets, but it is possible only if the combined bearings have the same clearance/preload symbols.

Fig.1.4 Flush grinding



If these combined 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. TPI bearings with special accuracy P4X that can accommodate small variations of bore and outer diameter tolerance. P4X bearings have the same running accuracy as P4 while has a narrower tolerance range. It is suitable for random matching on universal combination bearings. It also bring convenience for customers to optimize their inventory with more precision P4X bearings.

In addition to the flush grinding technique, universal matching is employed for duplex angular contact ball

bearings. Universal matching controls the bearing-to-bearing dimensional differences in the bore and outside diameters.

When ordering a bearing, specify the desired number of duplex bearings to be used in combination (“D2” for DB, DF or DT; and “D3” for DBT, DFT or DTT). Alternately, indicate the basic combination and specify universal matching. For specific needs for bore and outside diameter of bearings, please contact TPI for customized tolerance.

1.2.4 Special P4X Accuracy

P4X bearings can control the bearing-to-bearing difference in the bore and outside diameters to no more than one third the tolerance (a minimum of 2 μm) as shown in Table 1.2. Their bearing code normally comes with flushed grinding and universal matching as follows:

Example : 7014C G/GL P4X

Table 1.2 Tolerance of P4 and P4X Accuracy

Tolerance of bore diameter of inner ring unit: μm					
Bore diameter (mm)		P4		P4X	
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

Tolerance of outer diameter of outer ring unit: μm

Tolerance of outer diameter of outer ring unit: μm					
Outer diameter (mm)		P4		P4X	
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

1.2.5 Double-row cylindrical roller bearings

In a cylindrical roller bearing, the rollers and raceways are in linear contact. Consequently this type of bearing can support a larger radial load than a point-contact ball bearing. Also, its structure is suitable for high-speed operation.

Double-row cylindrical roller bearings are available in two types, NN and NNU, and two series, 30 and 49. The rollers in the NN type bearing are guided by the ribs of the inner ring. The rollers in the NNU type bearing are guided by the ribs of the outer ring. Bearings are available with either a tapered bore type (which allows adjustment of radial internal clearance of bearing) or a standard cylindrical bore. The bearings come in two types, standard type and high-speed type. For standard type, a set of machined brass cages are used while high temperature special molded resin cages for high-speed applications. They can be used for both grease lubrication and air-oil lubrication.

1.2.6 Angular Contact Thrust Ball Bearings

A range of thrust bearings used in machine tools for the main spindles. They includes 5629 and 5620 series for high axial rigidity (contact angle 60°) and HTA series high-speed duplex angular contact ball bearings for axial loads

with optimized internal design (contact angle 40°, 30°). These bearings are used in conjunction with NN30, NN49, or NNU49 series double-row cylindrical roller bearings (matched bearings must have the same bore and outside diameter).

These duplex angular contact ball bearing series have similar design to the double-row thrust angular contact ball bearing series, but are different in terms of their width. Since their contact angles are lower at 40° and 30°, the series boast high speed capability. However, their axial rigidity is less than double-row thrust angular contact ball bearings with 60° contact angle.

1.3 Ball Screw Support Bearings

The BS type incorporates the maximum possible number of small balls and has thicker inner and outer rings, and a larger contact angle of 60°. Thus, this type of bearing boasts greater axial rigidity. Additionally, since balls are used as the rolling elements, the starting torque of an angular contact thrust ball bearing is less than that of a roller bearing.

Side faces of BS type bearings are flush-ground to provide the same face height difference for both the front and back faces. As a result, bearings of the same part number can be freely combined into DB, DBT, DTBT configurations, and the adjustment for a relevant preload is no longer necessary. For improving in material on raceways, grease, and sealing, please contact TPI for further information.

The BS type is mainly installed on ball screws of machine tool feed systems, and two to four row arrangements are used in many cases. Both back-to-back and face-to-face duplex arrangement are used in this application. The face-to-face duplex arrangement may be used if misalignment is un-avoidable as shown in Fig.1.5.

Fig.1.5 Two to four row arrangements are used on ball screws of machine tool feed systems

