2. Bearing selection

NTN provides rolling bearings (hereinafter referred to as bearings) of various types and dimensions. When selecting the correct bearing for your application, it is important to consider several factors, and analyze using various means.

2.1 Bearing selection flow chart

An example of the procedure for selecting bearings is shown in the following flow chart. When special consideration is necessary, consult with **NTN** Engineering.

Procedure	Confirmation items
Confirm operating conditions and operating environment	●Function and construction of components to house bearings ●Bearing mounting location ●Bearing load (direction and magnitude) ●Rotational speed ●Vibration and shock load ●Bearing temperature (Ambient temperature/ temperature rise) ●Operating environment (potential for corrosion, degree of contamination, extent of lubrication)
Select bearing type and configuration	●Dimensional limitations (refer to page insert···A-46) ●Bearing load (magnitude,direction,vibration; presence of shock load) (refer to page insert···A-34) ●Rotational speed (refer to page insert···A-106) ●Bearing tolerances (refer to page insert···A-54) ●Rigidity (refer to page insert···A-101) ●Allowable misalignment of inner/outer rings (refer to page insert···A-149) ●Friction torque (refer to page insert···A-110) ●Bearing arrangement (fixed side, floating side) (refer to page insert···A-17) ●Installation and disassembly requirements (refer to page insert···A-150) ●Bearing availability and cost
Select bearing dimensions	●Design life of components to house bearings (refer to page insert···A-27) ●Dynamic/static equivalent load conditions (refer to page insert···A-41) ●Safety factor (refer to page insert···A-31) ●Allowable Speed (refer to page insert···A-106) ●Allowable axial load (refer to page insert···A-31) ●Allowable space (refer to page insert···A-46)
Select bearing tolerances	●Shaft runout tolerances (refer to page insert···A-54) ●Rotational speed (refer to page insert···A-106) ●Torque fluctuation
Select bearing's internal clearance	●Material and shape of shaft and housing (refer to page insert···A-146) ●Bearing Fits (refer to page insert···A-75) ●Temperature differential between inner/outer rings (refer to page insert···A-92) ●Allowable misalignment of inner/outer rings (refer to page insert···A-149) ●Load (magnitude, nature) (refer to page insert···A-34) ●Amount of preload (refer to page insert···A-100) ●Rotational speed (refer to page insert···A-106)
Select cage type and material	●Rotational speed (refer to page insert···A-106) ●Noise level ●Vibration and shock load ●Momentary load ●Lubrication type and method (refer to page insert···A-111)
Select lubricant, lubrication method, sealing method	●Operating temperature (refer to page insert···A-164) ●Rotational speed (refer to page insert···A-106) ●Lubrication type and method (refer to page insert···A-111) ●Sealing method (refer to page insert···A-124) ●Maintenance and inspection (refer to page insert···A-164)
Select any special bearing specifications	●Operating environment (high/low temperature, vacuum, pharmaceutical, etc.) ●Requirement for high reliability
Confirm handling procedures	●Installation-related dimensions (refer to page insert···A-148) ●Installation and disassembly procedures (refer to page insert···A-152)

Selection of bearing type and configuration

(1) Dimensional limitations
There is a wide range of standardized bearing types and dimensions. Typically, for bearing used in machines, it is necessary to select the optimal bearing type and dimension that fits the space allowed in the machine.

(2) Bearing load
There can be various directions, characteristics, and magnitudes of loading that act on bearings. However, in determining the appropriate bearing type, it is also necessary to consider whether the acting load is a radial load only or combined radial and axial load. In addition, it is necessary to determine what bearing type and size is appropriate based on the basic load rating, specified in the bearing dimension table, while considering the magnitude of the load being applied.

(3) Rotational speed
The allowable speed of a bearing will differ depending upon bearing type, size, tolerances, cage type, load, lubricating conditions, and cooling conditions.

The allowable speeds listed in the bearing tables for grease and oil lubrication are for normal tolerance **NTN** bearings. In general, deep groove ball bearings, angular contact ball bearings, and cylindrical roller bearings are most suitable for high speed applications.

(4) Bearing tolerances
The dimensional accuracy and operating tolerances of bearings are regulated by ISO and JIS standards.

For equipment requiring high tolerance shaft runout or high speed operation, bearings with Class 5 tolerance or higher are recommended.

Deep groove ball bearings, angular contact ball bearings, and cylindrical roller bearings are recommended for high rotational tolerances.

(5) Rigidity
Elastic deformation occurs along the contact surfaces of a bearing's rolling elements and raceway surfaces under loading. With certain types of equipment it is necessary to reduce this deformation as much as possible. In general, roller bearings exhibit less elastic deformation than ball bearings. Furthermore, in some cases, bearings are given a load in advance (preloaded) to increase their rigidity. This procedure is commonly applied to deep groove ball bearings, angular contact ball bearings, and tapered roller bearings.

(6) Misalignment of inner and outer rings
Shaft flexure, variations in shaft or housing accuracy, and fitting errors result in a certain degree of misalignment between the bearing's inner and outer rings. In situations where the degree of misalignment is liable to be relatively large, self-aligning ball bearings, spherical roller bearings, bearing units and other bearings with aligning properties are advisable.(Refer to **Fig. 2.1**)

(7) Noise and torque levels
Rolling bearings are manufactured and processed according to high precision standards, and therefore generally produce only slight amounts of noise and torque. For applications requiring particularly low-noise or low-torque operation, deep groove ball bearings and cylindrical roller bearings are most appropriate.

(8) Installation and disassembly
Some applications require frequent disassembly and reassembly to enable periodic inspections and repairs. For such applications, bearings with separable inner/outer rings, such as cylindrical roller bearings, needle roller bearings, and tapered roller bearings are most appropriate. Incorporation of adapter sleeves simplifies the installation and disassembly of self-aligning ball bearings and spherical roller bearings with tapered bores.

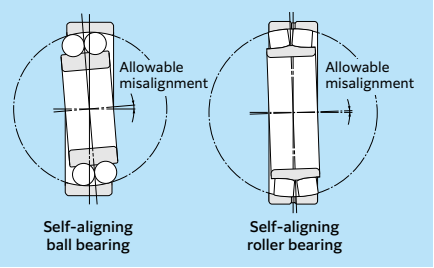


Fig. 2.1

2.2 Type and characteristics

Table 2.1 shows the main types and characteristics of rolling bearings.

Table 2.1 Main types of rolling bearings and performance comparison

Characteristics \ Bearing type		Deep groove ball bearings	Angular contact ball bearings	Double row angular contact ball bearings	Duplex angular contact ball bearings	Self-aligning ball bearings	Cylindrical roller bearings	Singleflange cylindrical roller bearings	Doubleflange cylindrical roller bearings	Double row cylindrical roller bearings	Needle roller bearings
Load capacity	Radial load	☆☆	☆☆	☆☆☆	☆☆☆	☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆☆	☆☆☆
	Axial load	☆☆ Both directions	☆☆☆ One direction	☆☆☆ Both directions	☆☆☆ Both directions	☆ Both directions	×	☆ One direction	☆ Both directions	×	×
	Combined load	☆☆	☆☆☆	☆☆☆	☆☆☆	☆	×	☆☆	☆☆	×	×
High speed rotation [1]		☆☆☆☆	☆☆☆☆	☆☆	☆☆☆	☆☆	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆
Accuracy under high speed [1]		☆☆☆	☆☆☆	☆☆	☆☆☆		☆☆☆	☆☆	☆	☆☆☆	
Low noise/vibration [1]		☆☆☆☆	☆☆☆		☆		☆	☆	☆	☆	☆
Low friction torque [1]		☆☆☆☆	☆☆☆		☆☆	☆	☆				
High rigidity [1]				☆☆	☆☆		☆☆	☆☆	☆☆	☆☆☆	☆☆
Vibration/shock resistance [1]				☆		×	☆☆	☆☆	☆☆	☆☆	☆☆
Allowable misalignment for inner/outer rings [1]		☆				☆☆☆	☆				
Stationary in axial direction [2]		◎	○	◎ For DB and DF arrangement	◎	◎		○	◎		
Movable in axial direction [3]		○		○ For DB arrangement	○	○	◎			◎	◎
Separable of inner and outer rings [4]						○	○	○	○	○	○
Tapered bore inner ring [5]							○			○	
Remarks			Duplex arrangement required				NU, N type	NJ, NF type	NUP, NP, NH type	NNU, NN type	NA type
Reference page		B-17	B-57	B-59	B-57	B-79	B-93	B-93	B-93	B-94	E-2

Characteristics \ Bearing type		Tapered roller bearings	Double-row, 4-row tapered roller bearings	Spherical roller bearings	Thrust ball bearings	Thrust cylindrical roller bearings	Thrust spherical roller bearings	Reference page
Load capacity	Radial load	☆☆☆	☆☆☆☆	☆☆☆☆	×	×	☆	
	Axial load	☆☆☆☆ One direction	☆☆☆☆ Both directions	☆☆ Both directions	☆☆☆ One direction	☆☆☆☆ One direction	☆☆☆☆ One direction	
	Combined load	☆☆☆	☆☆☆☆	☆☆☆	×	×	×	
High speed rotation [1]		☆☆☆	☆☆	☆☆	☆	☆	☆	A-106
Accuracy under high speed [1]		☆☆☆	☆		☆			A-54
Low noise/vibration [1]					☆			—
Low friction torque [1]								A-110
High rigidity [1]		☆☆	☆☆☆☆	☆☆☆		☆☆☆	☆☆☆	—
Vibration/shock resistance [1]		☆☆	☆☆☆	☆☆☆		☆☆☆	☆☆☆	A-34
Allowable misalignment for inner/outer rings [1]		☆		☆☆☆		×	☆☆☆	A-149
Stationary in axial direction [2]		○	◎	◎	○	○	○	A-17
Movable in axial direction [3]			○	○	○			A-17
Separable of inner and outer rings [4]		○	○		○	○	○	—
Tapered bore inner ring [5]				○				A-147
Remarks		Duplex arrangement required				Including thrust needle roller bearings		—
Reference page		B-127	B-128 C-36	B-211	B-253	E-2	B-254	

1) ☆☆☆☆ : Particularly excellent
☆☆☆ : Excellent
☆☆ : Highly possible
☆ : Possible
× : Poor

2) ◎indicates dual direction.
○indicates single direction axial movement only.

3) ◎indicates movement in the axial direction is possible for the raceway surface; ○indicates movement in the axial direction is possible for the fitting surface of the outer ring or inner ring.

4) ○indicates both inner ring and outer ring are separable.

5) ○indicates inner ring with tapered bore is possible.

2.3 Selection of bearing arrangement

In general, a shaft is supported by two bearings. A bearing that positions and fixes the shaft in the axial direction is called the "**fixed side bearing**" and a bearing that allows the axial movement is called the "**floating side bearing**." This allows expansion and contraction of the shaft due to temperature variation and absorbs errors in the bearing mounting clearance. Fixing two bearings without providing a floating side bearing applies an excessive load on bearings because of the expansion and contraction or the error, damaging the bearings at an early stage.

The **fixed side bearing** is able to support radial and axial loads. A bearing that can fix axial movement in both directions should therefore be selected. A **floating side bearing** that allows movement in the axial direction while supporting a radial load is desirable. Movement in the axial direction **occurs on the raceway surface** for bearings with separable inner and outer rings such as **cylindrical roller bearings**, and **occurs on the fitting surface** for those which are not separable, such as **deep groove ball bearings**.

When shaft expansion and contraction due to temperature fluctuations is slight, the same type of bearing may be used for both the fixed-side and floating-side bearing.

Table 2.2 (1) shows typical bearing arrangements where the bearing type differs on the fixed side and floating side.**Table 2.2 (2)** shows some common bearing arrangements where no distinction is made between the fixed side and floating side. Vertical shaft bearing arrangements are shown in **Table 2.2 (3)**.

Table 2.2 (1) Bearing arrangement (distinction between fixed and floating-side)

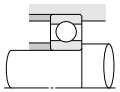
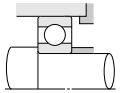
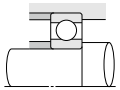
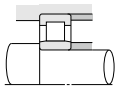
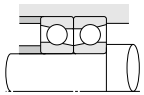
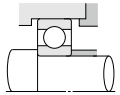
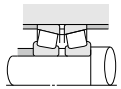
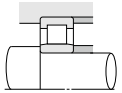
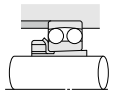
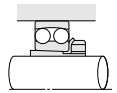
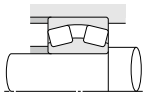
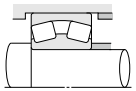
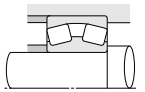
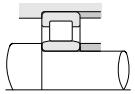
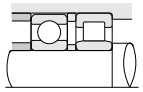
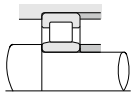
Arrangement		Remarks	Application (Reference)
Fixed side	Floating side		
		1. General arrangement for small machinery. 2. For radial loads, but will also accept axial loads in some degree.	Small pumps, auto-mobile transmissions, etc.
		1. Suitable when mounting error and shaft deflection are minimal or used for high rotational speed application. 2. Even with expansion and contraction of shaft, the floating side moves smoothly.	Medium-sized electric motors, ventilators, etc.
		1. Relatively heavy radial loading and dual direction of axial loading possible. 2. In place of duplex angular contact ball bearings, double-row angular contact ball bearings are also used.	Worm gears, reducers, compressors
		1. Heavy loading capable. 2. Shafting rigidity increased by preloading the two back-to-back fixed bearings. 3. Requires high precision shafts and housings, and minimal fitting errors.	Industrial machinery, large reducers
		1. Allows for shaft deflection and fitting errors. 2. By using an adapter on long shafts without screws or shoulders, bearing mounting and dismounting can be facilitated. 3. Self-aligning ball bearings are used for positioning in the axial direction, and not suitable for applications requiring support of axial load.	Conveyors
		1. Widely used in general industrial machinery with heavy and shock load demands. 2. Allows for shaft deflection and fitting errors in some degree. 3. Accepts radial loads as well as dual direction of axial loads in some degree.	Industrial machinery, large reducers
		1. Accepts radial loads as well as dual direction axial loads in some degree. 2. Suitable if an inner and outer ring tight fit is required.	Industrial machinery, large reducers
		1. Capable of handling large radial and axial loads at high rotational speeds. 2. Maintains clearance between the bearing's outer diameter and housing inner diameter to prevent deep groove ball bearings from receiving radial loads.	Diesel locomotives, carriage axles

Table 2.2 (2) Bearing arrangement (no distinction between fixed and floating-side)

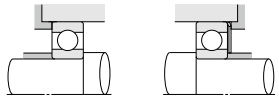
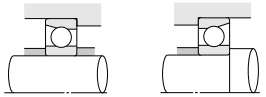
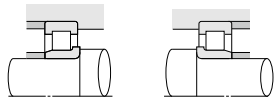
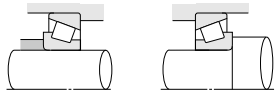
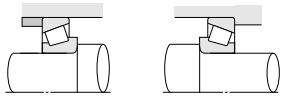
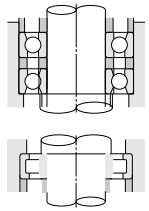
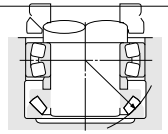
Arrangement	Remarks	Application (Reference)
	1. General arrangement for use in small machines. 2. Preload is sometimes applied by placing a spring on the outer ring side surface or inserting an adjusted shim. (can be floating-side bearings.)	Small electric motors, small reduction gears, etc.
	1. Back-to-back arrangement is preferable to face to face arrangement when moment load applied. 2. Able to support axial and radial loads; suitable for high-speed rotation. 3. Rigidity of shaft can be enhanced by providing preload.	Machine tool spindles, etc.
	1. Capable of supporting heavy loads and impact loads. 2. Suitable if an inner and outer ring tight fit is required. 3. Care must be taken so axial clearance does not become too small during operation.	Construction equipment, mining equipment sheaves, agitators, etc.
 Back-to-back arrangement  Face-to-face arrangement	1. Withstands heavy and shock loads. Wide range application. 2. Shaft rigidity can be enhanced by providing preload, but make sure preload is not excessive. 3. Back-to-back arrangement for moment loads, and face-to-face arrangement to alleviate fitting errors. 4. With face-to-face arrangement, inner ring tight fit is facilitated.	Reduction gears, front and rear axle of automobiles, etc.

Table 2.2 (3) Bearing arrangement (Vertical shaft)

Arrangement	Remarks	Application (Reference)
	1. When a fixing bearing is a duplex angular contact ball bearing, the floating bearing should be a cylindrical roller bearing.	Vertically mounted electric motors, etc.
	1. Most suitable arrangement for very heavy axial loads. 2. Shaft deflection and mounting error can be absorbed by matching the center of the spherical surface with the center of spherical roller thrust bearings.	Crane center shafts, etc.