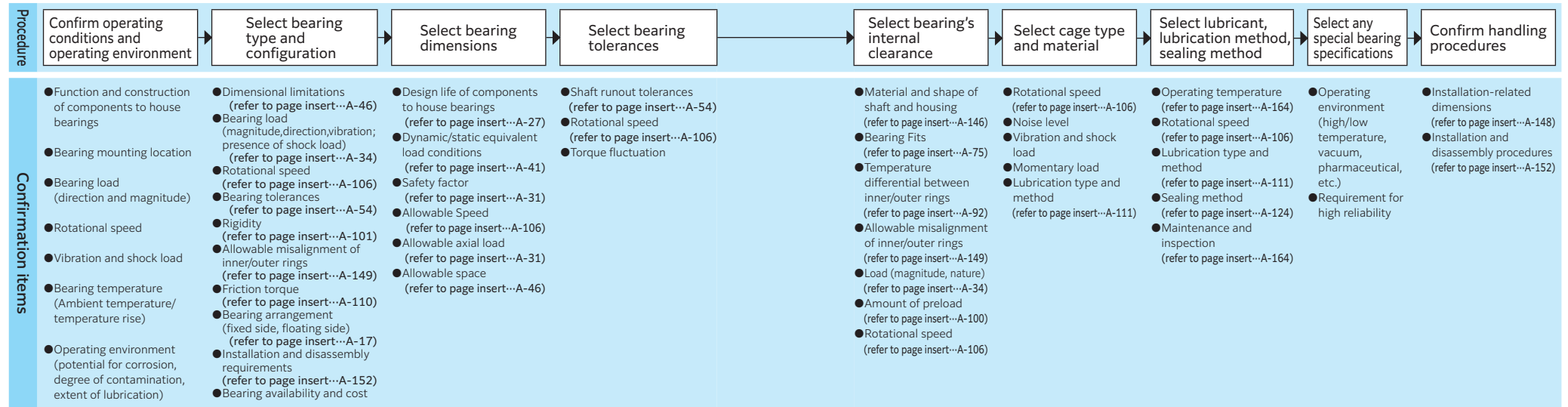


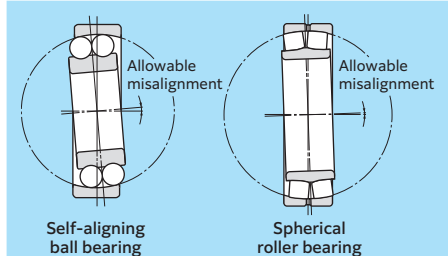
2. Bearing selection

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.



Selection of bearing type and configuration	<p>(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.</p>	<p>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.</p>	<p>than ball bearings. Furthermore, in some cases, bearings are given a load in advance (preload) to increase their rigidity. This procedure is commonly applied to deep groove ball bearings, angular contact ball bearings, and tapered roller bearings.</p>	<p>(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.</p>
	<p>(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.</p>	<p>(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.</p>	<p>(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 (see Fig. 2.1).</p>	
	<p>(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.</p>	<p>(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</p>	<p>(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.</p>	<p>Fig. 2.1</p>

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	Duplex angular contact ball bearings	Double-row angular contact ball bearings	Self-aligning ball bearings	Cylindrical roller bearings	Single-rib cylindrical roller bearings	Double-ribs cylindrical roller bearings	Double-row cylindrical roller bearings	Needle roller bearings
Load capacity	Radial load	☆☆	☆☆	☆☆☆	☆☆☆	☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆☆	☆☆☆
	Axial load	☆☆ ↔	☆☆☆ ←	☆☆☆ ↔	☆☆☆ ↔	☆☆ ↔	×	☆☆ →	☆☆ ↔	×	×
	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-57	B-59	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	Single direction thrust ball bearings	Thrust cylindrical roller bearings	Thrust spherical roller bearings	Reference page	Bearing type
Load capacity	Radial load	☆☆☆	☆☆☆☆	☆☆☆☆	×	×	☆☆		
	Axial load	☆☆☆☆ ←	☆☆☆☆ ↔	☆☆☆☆ ←	☆☆☆☆ ←	☆☆☆☆ ←	☆☆☆☆ ←		
	Combined load	☆☆☆	☆☆☆☆	☆☆☆☆	×	×	×		
High speed rotation ¹⁾	☆☆☆☆	☆☆	☆☆	☆☆	☆☆	☆☆	☆☆	A-106	High speed rotation ¹⁾
Accuracy under high speed ¹⁾	☆☆☆	☆☆						A-54	Accuracy under high speed ¹⁾
Low noise/vibration ¹⁾								—	Low noise/vibration ¹⁾
Low friction torque ¹⁾								A-110	Low friction torque ¹⁾
High rigidity ¹⁾	☆☆	☆☆☆☆	☆☆☆☆			☆☆☆☆	☆☆☆☆	—	High rigidity ¹⁾
Vibration/shock resistance ¹⁾	☆☆	☆☆☆☆	☆☆☆☆			☆☆☆☆	☆☆☆☆	A-34	Vibration/shock resistance ¹⁾
Allowable misalignment for inner/outer rings ¹⁾	☆☆		☆☆☆☆			×	☆☆☆☆	A-149	Allowable misalignment for inner/outer rings ¹⁾
Stationary in axial direction ²⁾	○	○	○	○	○	○	○	A-17	Stationary in axial direction ²⁾
Movable in axial direction ³⁾	○	○	○	○	○	○	○	A-17	Movable in axial direction ³⁾
Separable of inner and outer rings ⁴⁾	○	○						—	Separable of inner and outer rings ⁴⁾
Tapered bore inner ring ⁵⁾			○					A-147	Tapered bore inner ring ⁵⁾
Remarks						Including thrust needle roller bearings		—	Remarks
Reference page	B-127	B-128 C-36	B-211	B-253	E-2	B-254			Reference page

- ☆☆☆☆: Particularly excellent
☆☆☆☆: Excellent
☆☆: Highly possible
☆: Possible
×: Poor
- indicates dual direction.
○ indicates single direction axial movement only.
- 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.
- indicates both inner ring and outer ring are separable.
- 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)

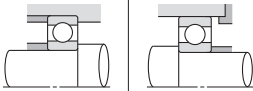
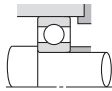
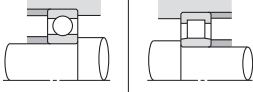
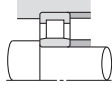
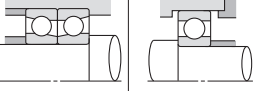
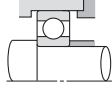
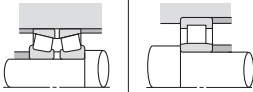
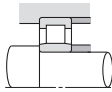
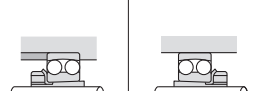
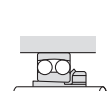
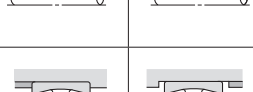


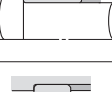
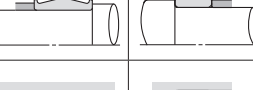

Arrangement		Remarks	Application (Reference)
Fixed side	Floating side		
		<ol style="list-style-type: none"> 1. General arrangement for small machinery. 2. For radial loads, but will also accept axial loads in some degree. 	Small pumps, auto-mobile transmissions, etc.
		<ol style="list-style-type: none"> 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.
		<ol style="list-style-type: none"> 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
		<ol style="list-style-type: none"> 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
		<ol style="list-style-type: none"> 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
		<ol style="list-style-type: none"> 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
		<ol style="list-style-type: none"> 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
		<ol style="list-style-type: none"> 1. Capable of handling large radial and axial loads at high rotational speeds. 2. Maintains clearance between the bearing's outside diameter and housing bore 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)

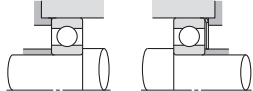
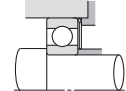
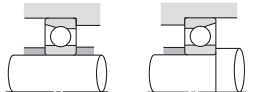
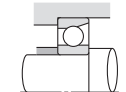
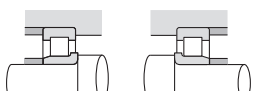
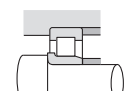
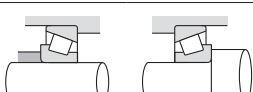
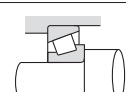
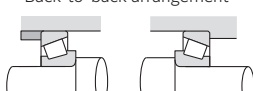
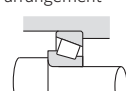
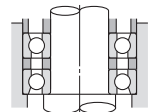
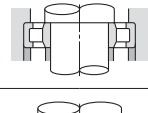
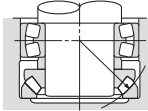
Arrangement		Remarks	Application (Reference)
			
		<ol style="list-style-type: none"> 1. Back-to-back arrangement is preferable to face to face arrangement when moment load applied. 2. Able to support axial and radial loads; suitable for high-speed rotation. 3. Rigidity of shaft can be enhanced by providing preload. 	Machine tool spindles, etc.
		<ol style="list-style-type: none"> 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.
		<ol style="list-style-type: none"> 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.
		<p>Back-to-back arrangement</p> <p>Face-to-face arrangement</p>	

Table 2.2 (3) Bearing arrangement (Vertical shaft)

Arrangement	Remarks	Application (Reference)
	<ol style="list-style-type: none"> 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.
		
	<ol style="list-style-type: none"> 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 thrust spherical roller bearings. 	Crane center shafts, etc.