2. Bearing Selection

Rolling bearings come in a wide variety of types, shapes and dimensions. The most important factor to consider in bearing selection is a bearing that will enable the machine or part in which it is installed to satisfactorily perform as expected.

To facilitate the selection process and to be able to select the most suitable bearing for the job, it is necessary to analyze the prerequisites and examine them from various standpoints. While there are no hard-and-fast rules in selecting a bearing, the following list of evaluation steps is offered as a general guideline in selecting the most appropriate bearing.

(1) Thoroughly understand the type of machine the bearing is to be used in and the operating conditions under which it will function.

(2) Clearly define all demand factors.

(3) Select bearing shape.

(4) Select bearing arrangement.

(5) Select bearing dimensions.

(6) Select bearing specifications.

(7) Select mounting method, etc.

2.1 Operating conditions and environment

When selecting a bearing, having an accurate and comprehensive knowledge of which part of the machine or equipment it is to be installed in and the operating requirements and environment in which it will function, is the basis for selecting just the right bearing for the job. In the selection process, the following data is needed.

(1) The equipment's function and construction.

(2) Bearing mounting location (point).

(3) Bearing load (direction and magnitude).

(4) Bearing speed.

(5) Vibration and shock load.

(6) Bearing temperature (ambient and friction generated).

(7) Environment (corrosion, lubrication, cleanliness of the environment, etc.).

2.2 Demand factors

The required performance capacity and function demands are defined in accordance with the bearing application conditions and operating conditions. A list of general demand factors to be considered is shown in Table 2.1.

Table 2.1 Bearing Demand Factors

Demand factor	Ref. page
Dimension limitations	A-16
Durabliity (life span)	A-40
Running accuracy	A-22
Allowable speed	A-77
Rigidity	A-74
Noise/vibration	—
Friction torque	A-78
Allowable misalignment for inner/outer rings	—
Requirements for mounting-dismounting	A-97
Bearing availability and economy	—

2.3 Design selection

By comparing bearing functions and performance demands with the characteristics of each bearing type, the most suitable bearing design can be selected. For easy reference, the characteristics of general bearing types are compared in Table 2.2 on page A-12.

2.4 Arrangement selection

Shaft assemblies generally require two bearings to support and locate the shaft both radially and axially relative to the stationary housing. These two bearings are called the fixed and floating bearings. The fixed bearing takes both radial and axial loads and "locates" or aligns the shaft axially in relation to the housing. Being axially "free", the floating bearing relieves stress caused by expansion and contraction of the shaft due to fluctuations in temperature, and can also allow for misalignment caused by fitting errors.

Bearings which can best support axial loads in both directions are most suitable for use as fixed bearings. In floating bearings the axial displacement can take place in the raceway (for example: cylindrical roller bearings) or along the fitting surfaces (for example: deep groove ball bearings). There is also the "cross location" arrangement in which both bearings (for example: angular contact ball bearings) act as fixing and non-fixing bearings simultaneously, each bearing guiding and supporting the shaft in one axial direction only. This arrangement is used mainly in comparatively short shaft applications.

These general bearing arrangements are shown in Table 2.3 on pages A-14 and A-15.

2.5 Dimension selection

Bearing dimension selection is generally based on the operating load and the bearing's life expectancy requirements, as well as the bearing's rated load capacity (P.A-40-A-53).

2.6 Specification determination

Specifications for rolling bearings which are designed for the widest possible use have been standardized. However, to meet the diversity of applications required, a bearing of non-standard design specifications may be selected. Items relating to bearing specification determination are given in Table 2.4.

Table 2.4 Bearing specifications

Specification item	Ref. page
Bearing tolerance (dimensional and running)	A-22
Bearing internal clearance and preload	A-64
Bearing material and heat treatment	A-92
Cage design and material	A-93

2.7 Handling methods

If bearings are to function as expected, appropriate methods of installation and handling must be selected and implemented. See Table 2.5.

When selecting a bearing, frequently all the data required for the selection of the bearing is not necessarily clearly specified. Thus, some elements governing selection must be "factored in" on an estimated basis. Also, the order of priority and weight of each factor must be evaluated. For this reason it is essential to have ample experience as well as abundant, integrated, data base upon which the bearing selection can be based.

Over the years, NTN has gained considerable expertise in bearings selection. Please consult NTN for advice and assistance with any bearing selection problem.

Table 2.5 Bearing handling

Treatment	Ref. page
Fitting methods	A-54
Lubrication methods and lubricants	A-79
Sealing methods and seals	A-88
Shaft and housing construction and dimensions	A-94

Table 2.2 Types and characteristics of rolling bearings

Bearing types / Characteristics	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	Single-flange cylindrical roller bearings	Double-flange cylindrical roller bearings	Double row cylindrical roller bearings	Needle roller bearings	Tapered roller bearings	Spherical roller bearings	Thrust ball bearings	Thrust ball bearings with seating ring	Double row angular contact thrust ball bearings	Cylindrical roller thrust bearings	Spherical roller thrust bearings	Reference page
Load Carrying Capacity (Radial load / Axial load)																		
High speed[1]	☆☆☆☆☆	☆☆☆☆☆	☆☆	☆☆☆	☆☆	☆☆☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆	☆	☆	☆☆☆	☆	☆	A-77
High rotating accuracy[1]	☆☆☆	☆☆☆	☆☆	☆☆☆		☆☆☆	☆☆	☆	☆☆☆		☆☆☆		☆		☆☆☆			A-22
Low noise/vibration[1]	☆☆☆☆☆	☆☆☆☆		☆		☆	☆	☆	☆	☆								A-77
Low friction torque[1]	☆☆☆☆☆	☆☆☆☆		☆☆	☆	☆												A-78
High rigidity[1]			☆☆	☆☆		☆☆	☆☆	☆☆	☆☆☆	☆☆	☆☆	☆☆☆			☆☆	☆☆☆	☆☆☆	A-74
Vibration/shock resistance[1]			☆		★	☆☆	☆☆	☆☆	☆☆	☆☆	☆☆	☆☆☆			★	☆☆☆	☆☆☆	—
Allowable misalignment for inner/outer rings[1]	☆				☆☆☆	☆					☆	☆☆☆	★	☆☆☆	★	★	☆☆☆	—
For fixed bearings[2]	◎	○	◎	◎ For DB and DF arrangment	◎		○	◎			○	◎	○	○	◎	○	○	A-94
For floating bearings[1]	○		○	○ For DB arrangment	○	◎			◎	◎		○						A-94
Non-separable or separable[4]						○	○	○	○	○	○		○	○	○	○	○	—
Tapered bore bearings[5]					○				○			○						A-99
Remarks		For duplex arrangment				NU, N type	NJ, NF type	NUP, NP, NH type	NNU, NN, type		For duplex arrangment					Including thrust needle roller bearings		
Reference page	B-6	B-44	B-68	B-44	B-74	B-84	B-84	B-84	B-85	B-112	B-118	B-186	B-218	B-218	B-218	B-218	B-218	

Note 1) ☆ The number of stars indicate the degree to which that bearing type displays that particular characteristic. ★ Not applicable to that bearing type.
2) ◎ Indicates dual direction. ○ Indicates single direction axial movement only.
3) ◎ Indicates movement at raceway. ○ Indicates movement at mated surface of inner or outer ring.
4) ○ Indicates both inner ring and outer ring are detachable.
5) ○ Indicates inner ring with tapered bore is possible.

Table 2.3 (1) Bearing arrangement (Fixed and Floating)

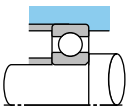
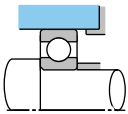
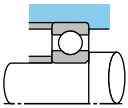
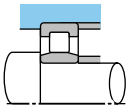
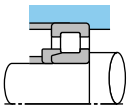
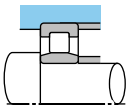
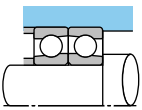
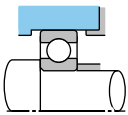
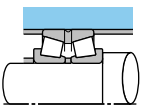
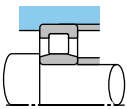
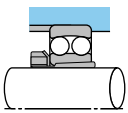
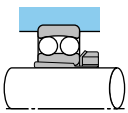
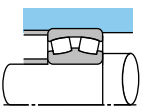
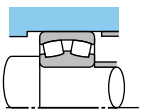
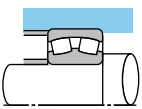
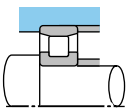
Arrangement		Comment	Application
Fixed	Floating		
		1. General arrangement for small machinery 2. For radial loads, but will also accept axial loads. 3. Preloading by springs or shims on outer ring face.	Small pumps, small electric motors, auto-mobile transmissions, etc.
		1. Suitable for high speed. Widely used. 2. Even with expansion and contraction of shaft, non-fixing side moves smoothly.	Medium-sized electric motors, ventilators, etc.
		1. Withstands heavy loading and some axial loading. 2. Inner and outer ring shrink-fit suitable. 3. Easy mounting and dismounting.	Railway vehicle electric motors, etc.
		1. Radial loading plus dual direction axial loading possible. 2. In place of duplex angular contact ball bearings, double-row angular contact ball bearings are also used.	Wormgear speed reducers, etc.
		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.	Machine tool spindles, etc.
		1. Allows for shaft deflection and fitting errors. 2. By using an adaptor on long shafts without screws or shoulders, bearing mounting and dismounting can be facilitated. 3. Not suitable for axial load applications.	Counter shafts for general industrial equipment, etc.
		1. Widely used in general industrial machinery with heavy and shock load demands. 2. Allows for shaft deflection and fitting errors. 3. Accepts radial loads as well as dual direction axial loads.	Reduction gears for general industrial equipment, etc.
		1. Widely used in general industrial machinery with heavy and shock loading. 2. Radial and dual directional axial loading.	Industrial machinery reduction gears, etc.

Table 2.3 (2) Bearing arrangement (Placed oppositely)

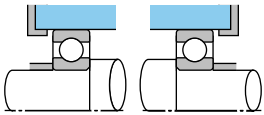
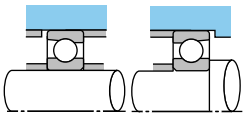
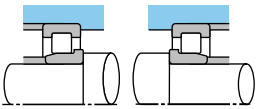
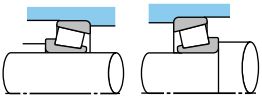
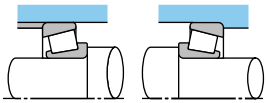
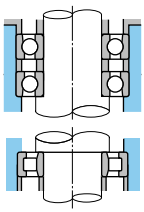
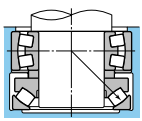
Arrangement	Comment	Application
	General arrangement for use in small machines.	Small electric motors, small reduction gears, etc.
	1. This type of back-to-back arrangement well suited for moment loads. 2. Preloading increases shaft rigidity. 3. High speed reliable.	Spindles of machine tools, etc.
	1. Accepts heavy loading. 2. Suitable if inner and outer ring shrink-fit is required. 3. Care must be taken that 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. Shafting rigidity increased by preloading. 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 shrink-fit is facilitated.	Reduction gears, automotive axles, etc.

Table 2.3 (3) Bearing arrangement (Vertical shaft)

Arrangement	Comment	Application
	When fixing bearing is a duplex angular contact ball bearing, non-fixing bearing is a cylindrical rollerbearing.	Machine tool spindles, vertical mounted electric motors, etc.
	1. Most suitable arrangement for very heavy axial loads. 2. Depending on the relative alignment of the spherical surface of the rollers in the upper and lower bearings, shaft deflection and fitting errors can be absorbed. 3. Lower self-aligning spherical roller thrust bearing pre-load is possible.	Crane center shafts, etc.