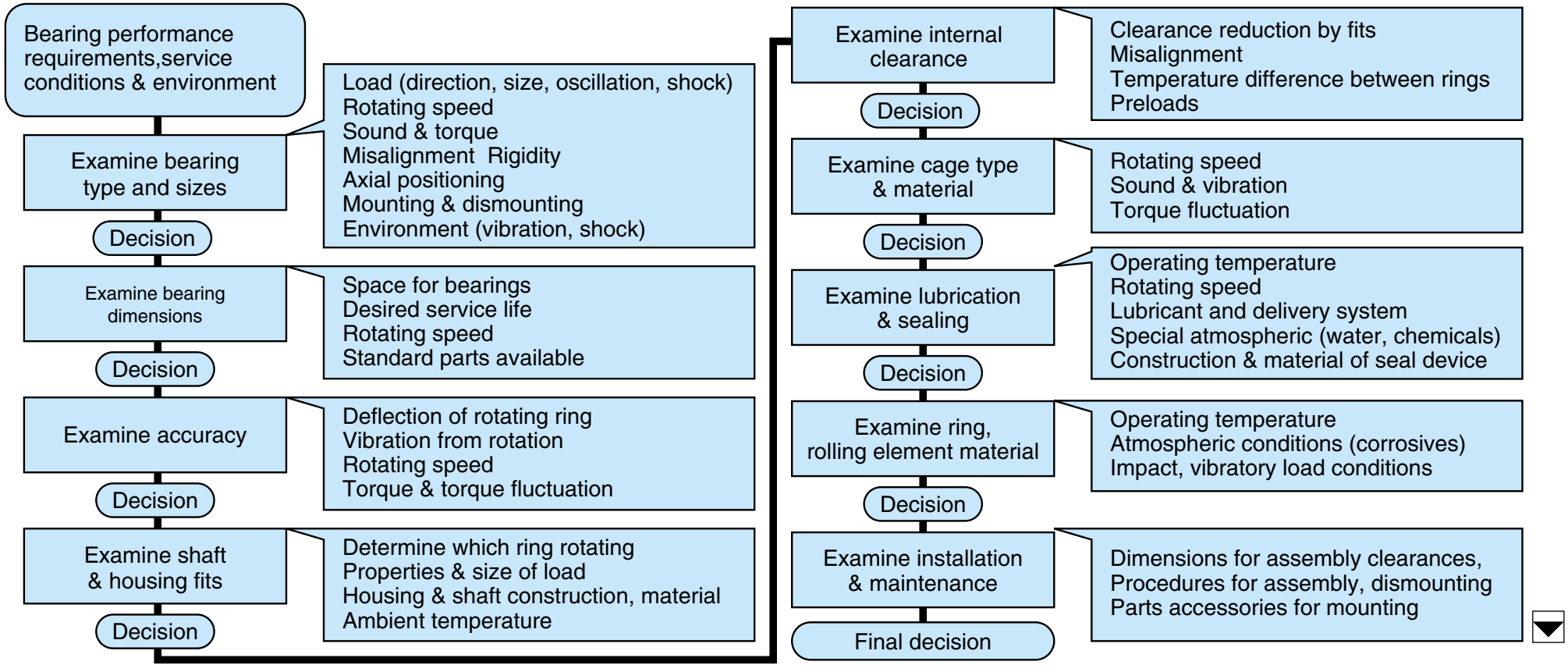
2. Selection of Bearings

2. Selection of Rolling Contact Bearings

Rolling contact bearings are important, often critical, components of machinery. To meet the demands of a large variety of applications, rolling contact bearings are manufactured in a wide variety of types, sizes, and configurations. While machine performance and service life depend on which bearings are selected, it is often difficult to select the optimal bearing from among the many available variations.
While there is no "best" procedure for selecting the optimal bearing, Figure 2.1 provides an example of a procedure based on the establishment of priorities for the required bearing characteristics.

Fig. 2.1 Bearing Selection Procedure



2.1 Bearing Type Selection Considerations

2.1.1 Load

Bearing types are selected according to the types of load (radial, axial, moment) and the magnitude of these loads on the bearing. Table 2.1 outlines the types of load and applicable bearing types. In bearings of identical dimensional series, a roller bearing will have a greater load rating capacity than a ball bearing.

Table 2.1 Applicable Bearings vs Load Type

Bearing type \ Load type		Radial	Axial	Moment			
		●	●	●	●	●	●
			●	●		●	●
					●	●	●
Ball bearings:	Single-row Deep Groove	○	△	○	○	△	○
	Single-row Angular Contact		○	○			
	Paired Angular Contact	○	○	○	○	○	○
	Double-row Angular Contact	○	△	○	○	△	○
Roller bearings:	Cylindrical	○		△			
	Single-row Tapered		○	○			
	Paired Tapered	○	○	○	○	○	○
	Multi-row Tapered	○	○	○	○	○	○
	Spherical radial	○		△			
	Spherical thrust		○			△	

Remarks: ○ Bearing type can meet the load type.
△ Bearing can meet the load type conditionally. (Contact NACHI for more information.)

2.1.2 Rotating Speed

Limiting speed of bearings is determined by bearing type, bearing dimensions, accuracy of work, construction of cages, load, lubricating system, and seal type and design. The bearing dimension tables show the rotating speed limits of standard rolling contact bearings as a criterion of bearing type selection.
Bearings used at high rotating speeds should generally have high accuracy. In applications over the limiting speed, please consult NACHI for assistance.

2.1.3 Noise and Torque

All NACHI rolling contact bearings are designed and manufactured to operate with low noise and torque levels. Of the many types of ball and roller bearings, single-row deep-groove ball bearings will tend to operate with the lowest noise and torque levels.

2.1.4 Alignment

If the accuracy of alignment of the shaft and bearing housing is poor or the shaft is deflected due to load, the inner and outer rings of the bearings will be misaligned.
Non-self-aligning rolling contact bearings are capable of tolerating only that amount of misalignment which can be handled by the assembled internal clearance. If inclination is expected to occur between the inner and outer rings, the choice of bearings should be from types such as thrust ball bearings with self-aligning washer, Self-aligning ball bearings, or Spherical roller bearings.
The permissible angle of inclination of bearings differs by bearing type, internal clearance, and load conditions. Table 2.2 outlines the permissible angles of mis-alignment by bearing type.
Internal bearing damage can occur if misalignment in the bearing is greater than the permissible angle. Please contact NACHI for assistance.

Table 2.2 Permissible Misalignment of Bearing Types

Bearing type	Permissible angle of misalignment
Single-row deep groove ball bearings	1/300
Single-row angular contact ball bearings	1/1000
Cylindrical roller bearings	1/1000
Tapered roller bearings	1/800
Thrust ball bearings	1/2000

2.1.5 Rigidity

When rolling contact bearings are loaded, the contact section between the bearing rings and rolling elements will elastically deform. The magnitude of this elastic deformation will differ depending on load, bearing type, and bearing dimensions.
If bearings of identical dimension series are compared, roller bearings will have a much higher level of rigidity than ball bearings, and if bearings of identical type are compared, bearings of larger dimensions will have higher rigidity than those of smaller dimensions. (Pre-loading combinations of units of two or more bearings will increase rigidity.)

2.1.6 Mounting, Dismounting

Rolling contact bearings can be divided into bearing types classed as separable or non-separable. Mounting and dismounting is facilitated if a separable bearing type is used.
Use of tapered-bore bearings and sleeves or hydraulic assist also makes bearing mounting and dismounting easier.
There is a possibility that noise and shortening of life occur due to poor mounting of bearings. When bearings are mounted, the following items should be noticed.

-Keep the bearings clean
-Rust prevention
-Protect bearings from external damage

2.1.7 Axial Location; Bearing Arrangement

Generally the shaft is supported by two units (or the equivalent to two units) of bearings. Generally, one of the bearings acts to hold (or fix) the axial position of the assembly and the other bearing acts to allow linear expansion.
The fixed side bearings must be firmly seated against both housing and shaft.
Table 2.3 shows representative examples of actual bearing arrangements according to service conditions.

Table 2.3 Examples of Bearing Arrangements

2.1.8 Bearing Environment

If there is a comparatively large source of vibration near the bearing mount, or if the bearing is to handle impact loading, the use of Spherical roller bearings or Spherical roller thrust bearings is recommended.
Standard bearings will be not suitable to be operated under severe condition (load, rotating speed, operating temperature, lubrication amount, vibrating environment).

Table 2.3 Examples of Bearing Arrangements

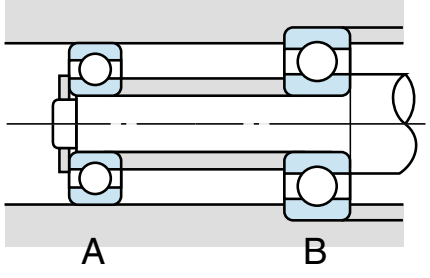
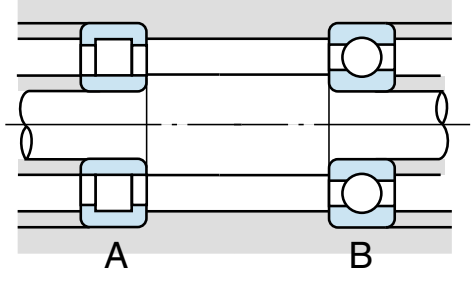
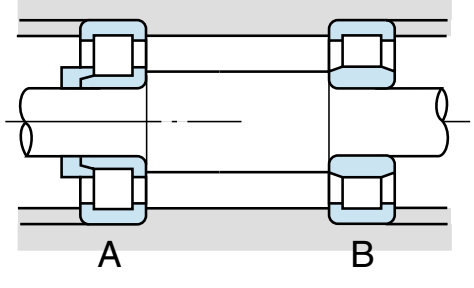
No.	Mounting examples	Applicable bearings		Application & design considerations
		A	B	
①		Deep Groove Ball	Deep Groove Ball	Popular mounting. Ball bearings can support light-to-moderate axial loads. Spherical roller bearings are good for heavy radial loads and light axial loads. One of the bearing outer ring must be free to move axially to handle thermal expansion.
		Spherical Roller	Spherical Roller	
②		Cylindrical Roller; N, NU configuration	Deep Groove Ball	Popular mounting. Axial expansion of shaft taken by inner ring of Cylindrical roller bearing. Use a Cylindrical roller bearing for the heavy load position. The Deep groove ball bearing carries the axial load. Not recommended for handling angular misalignment.
③		Cylindrical Roller; NH configuration	Cylindrical Roller; N, NU configuration	Easy mounting arrangement where interference fit is required for both inner and outer rings. Not recommended for handling angular misalignment. Thermal expansion taken internally. Suitable for light axial load applications.

Table 2.3 Examples of Bearing Arrangements

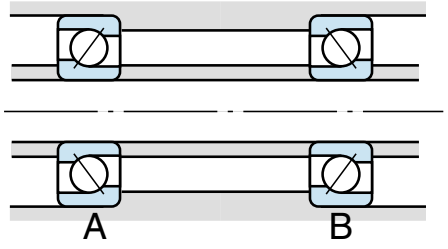
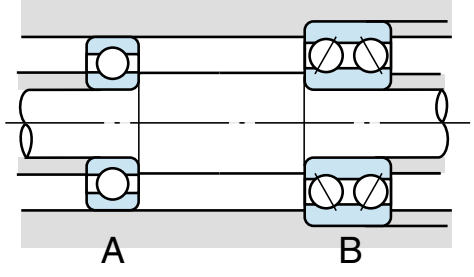
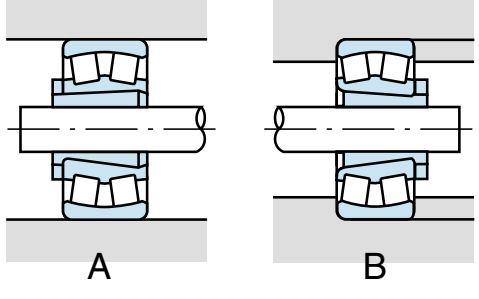
No.	Mounting examples	Applicable bearings A	Applicable bearings B	Application & design considerations
④		Deep Groove Ball	Deep Groove Ball	Preloading allows good rigidity. Care must be taken in design of preload amount. Angular contact ball bearings are better than Deep groove ball bearings for moderate axial laods and preload.
		Angular Contact Ball	Angular Contact Ball	
⑤		Deep Groove Ball	Double-Row Angular Contact Ball	Good for moderate, bidirectional axial loads. When using Deep groove ball bearings in position <A>, and double-row bearings in position <B>, the outer ring of one of the parts must be free to move axially for thermal expansion. If an N, or NU configuration bearing is used in position <A>, thermal expansion can be taken internally and a much greater radial load can taken on side <A>.
		Cylindrical Roller; N, NU configuration	Double-Row Angular Contact Ball	
⑥		Self-Aligning Ball	Self-Aligning Ball	Good for small angular misalignment. Use with adapter for long shafts which eliminates costly, shaft-weakening shaft shoulders and threading. Outer ring of one bearing must be free to move to compensate for thermal expansion or mouting error. Axial load capacity is light for ball bearing and moderate for Spherical roller bearing. Check with NACHI if Fa/Fr ratio is greater than 0.6 for Spherical roller bearings.
		Spherical Roller	Spherical Roller	

Table 2.3 Examples of Bearing Arrangements

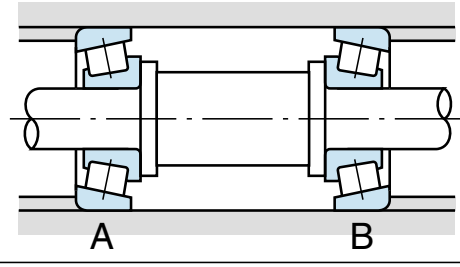
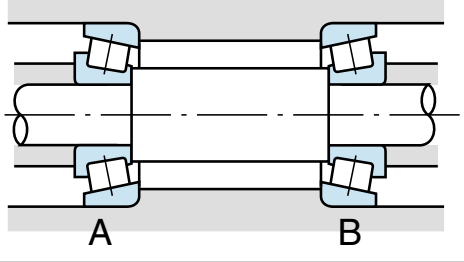
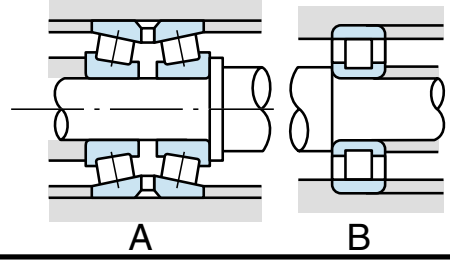
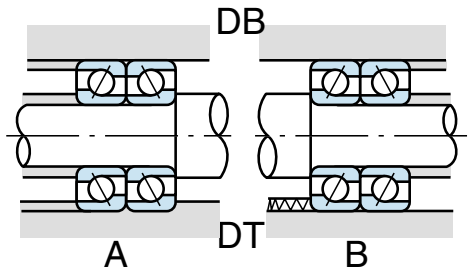
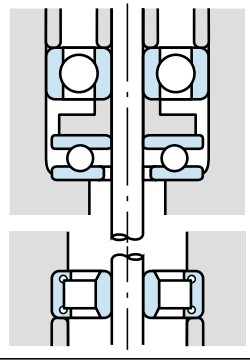
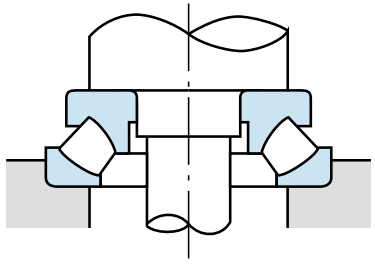
No.	Mounting examples	Applicable bearings		Application & design considerations
		A	B	
⑦		Tapered Roller	Tapered Roller	General application, direct mounting ("face-to-face"). Good for heavy axial loads. Clearance easily adjustable. Assembly is convenient where one or both inner ring are interference-fit to shaft.
⑧		Tapered Roller Angular Contact Ball	Tapered Roller Angular Contact Ball	Indirect mounting ("back-to-back"). Good shaft rigidity. Good for moment loading. Good for large axial and radial loads. Use care in establishing preload or clearance.
⑨		Tapered Roller	Cylindrical Roller; N, NU configuration	Good for heavy loads and radial and axial rigidity. Clearance on side <A> easy to adjust. Thermal expansion can be taken by Cylindrical roller bearing. Alignment must be accurate.

Table 2.3 Examples of Bearing Arrangements

No.	Mounting examples	Applicable bearings		Application & design considerations
		A	B	
⑩		Paired Angular Contact Ball	Paired Angular Contact Ball	Good for very accurate rotation and light loads. Two bearings are used in pairs with preload. Good shaft rigidity. Alignment must be accurate. Mounting example above the shaft center line is DB ("back-to-back") mount; below line is DT ("tandem") mount.
⑪		Deep Groove Ball & Thrust Ball	Cylindrical Roller	Thrust bearing should be close to radial bearing to reduce shaft deflection. When using Thrust ball bearing on a horizontal shaft, it is important to keep a load on the thrust bearing at all times. If there is shaft deflection at the thrust bearing location, use of a Thrust ball bearing with aligning washer arrangement is recommended.
		Cylindrical Roller & Thrust Ball	Cylindrical Roller	
⑫		Spherical Roller Thrust	Various Radial Types	Spherical roller thrust bearings are applicable if radial load is 55% or less than that of axial load. Suitable for heavy axial load. Good where there is shaft deflection and housing accuracy error. Axial load must be continuous. Used in conjunction with radial bearings at low-to-moderate speed.