



1. Types and Features of Bearings

1.1 Classification and Types

1.2 Designs and Feature

1.2.1 Deep Groove Ball Bearings

1.2.2 Single-row Angular Contact Ball Bearings

1.2.3 Double-row Angular Contact Ball Bearings

1.2.4 Self-aligning Ball Bearings

1.2.5 Cylindrical Roller Bearings

1.2.6 Tapered Roller Bearings

1.2.7 Spherical Roller Bearings

1.2.8 Thrust Ball Bearings

1.2.9 Spherical Roller Thrust Bearings

1. Types and Features of bearings

1.1 Classification and Types of Rolling Contact Bearings

In general, rolling contact bearings may be classified as radial or thrust bearings according to bearing design or they may be classified as ball or roller bearings according to the type of rolling element.

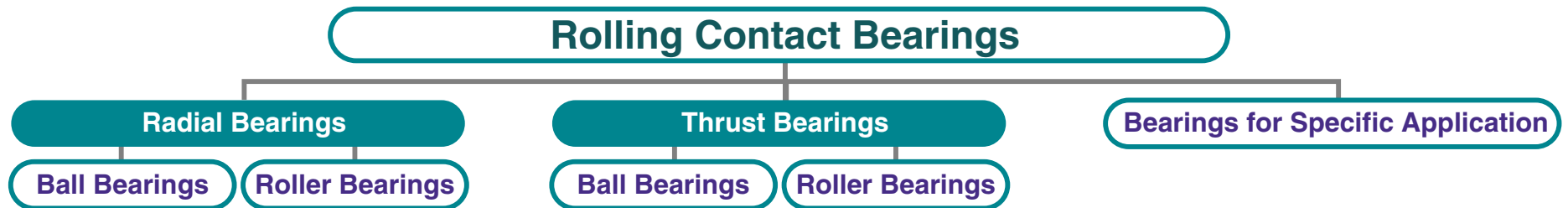
Radial bearings are mainly designed for supporting a load perpendicular to a shaft axis, whereas thrust bearings accept loads parallel to the shaft axis.

Using the BALL and ROLLER classification ROLLER bearings may be further divided according to the shape of the roller into the sub-classes; Cylindrical roller, Tapered roller, Spherical roller, or Needle roller bearings. BALL bearings can be further divided according to the number of rows into either single-row or double-row (for Thrust Ball bearings, single-direction and double-direction.) BALL Bearing may be still further sub-divided into smaller segments according to the relationship between the bearing rings and rolling elements; the shape of bearing rings; and use of accessories.

Bearings are also classified by specific application, such as Clutch-release ball bearings for automotive applications.

Table 1.1 indicates the principal types of radial and thrust bearings and a summary of their design. Table 1.2 summarizes the designs and features of rolling contact bearings.

Table 1.1 Classification and Types of Rolling Contact Bearings



[Table 1.2 Types and Features of Rolling Contact Bearings](#)



**Table 1.1 Classification and Types of Rolling Contact Bearings
Radial Bearings > Ball Bearings**


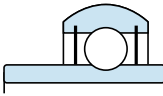





Bearing Types			Cross Sections	Bearing Series Symbols		
				JIS		Others
Deep Groove Ball Bearings	Single row	Without filling slot (JIS B 1521)		67 68 69	60 62 63	00B60 RLS RMS 16000
		Without filling slot [for unit ;JIS B 1558]		UC UWE UNE	UM UK	U B KH
		With filling slot		-	-	-
	Double row	Without filling slot		-	-	-
		With filling slot		-	-	42 43
	Counter-Bored Bearings	Single row	Non-Separable		-	-
Separable (JIS B 1538)				E EN	-	BM



Table 1.1 Classification and Types of Rolling Contact Bearings
Radial Bearings > Ball Bearings





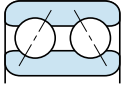
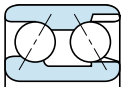
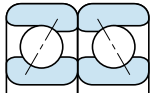

Bearing Types			Cross Sections	Bearing Series Symbols		
				JIS		Others
Angular Contact Ball Bearings	Single row	Non-Separable (JIS B 1522)		79 70	72 73	
		Separable		-		
	Double row	Without filling slot		-		52 53
		With filling slot		-		32 33
	Duplex mounting	DB mounting DF mounting DT mounting		-		
Self-Aligning Ball Bearings	Double row	Outer ring raceway : spherical		12 13	22 23	

Table 1.1 Classification and Types of Rolling Contact Bearings
Radial Bearings > Roller Bearings







Bearing Types				Cross Sections	Bearing Series Symbols		
					JIS	Others	
Cylindrical Roller Bearings	Single row	Inner ring with a rib	Without loose rib		NJ2 NJ23 NJ22 NJ4 NJ3		
			With loose rib		NH2 NH23 NH22 NH4 NH3		
		Inner ring without rib				NU10 NU3 NU2 NU23 NU22 NU4	
		Inner ring with ribs on both sides	Outer ring with a rib [JIS B 1533]			NF2 NF3 NF4	
	Outer ring without rib			N2 N3 N4	N10		
	Double row	Inner ring with ribs on both sides		Outer ring without rib		NN30	
		Inner ring without rib		Outer ring with ribs on both sides		NNU49	



Table 1.1 Classification and Types of Rolling Contact Bearings
Radial Bearings > Roller Bearings



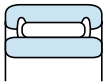
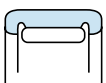

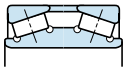
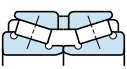
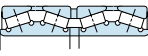


Bearing Types				Cross Sections	Bearing Series Symbols			
					JIS		Others	
Needle Roller Bearings	Single row	Inner ring without rib	Outer ring with ribs on both sides		NA48 NA49			
		Without inner ring			RNA48 RNA49			
Tapered Roller Bearings	Single row	Separable (JIS B 1534)			320 302 322	303 303D 323	329 331 313	330 332
	Double row	Separable (Inward)			-		KBD	
		Separable (Outward)			-		KBE KDE	
	Four row	Separable			-			
Spherical Roller Bearings	Single row	Outer ring raceway : spherical			-			
	Double row	Outer ring raceway : spherical			239 230 240	231 241 222	232 213 223	

Table 1.1 Classification and Types of Rolling Contact Bearings
Thrust Bearings > Ball Bearings

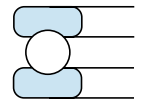
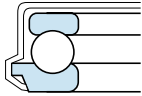
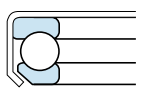
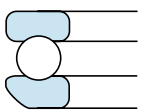
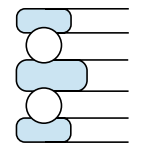
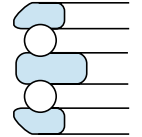
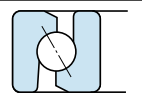
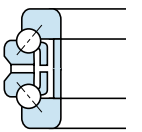
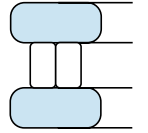
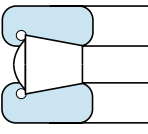
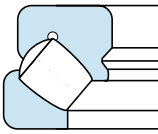
Bearing Types			Cross Sections	Bearing Series Symbols	
				JIS	Others
Thrust Ball Bearings	Single direction	Flat back face (JIS B 1532)		511 513 512 514	29 39 9 0
		Flat back face		-	TMN
		Flat back face		-	TG
		Spherical back face		-	532(U) 7(U) 533(U) 37(U) 534(U) OOT6(U)
	Double direction	Flat back face (JIS B 1532)		522 523 524	19
		Spherical back face		-	542(U) 543(U) 544(U)
Thrust Angular Contact Ball Bearings	Single direction	Non-Separable (DB, DF, DT)		-	TAB
	Double direction	Separable		-	TAD

Table 1.1 Classification and Types of Rolling Contact Bearings
Thrust Bearings > Roller Bearings

Bearing Types			Cross Sections	Bearing Series Symbols	
				JIS	Others
Thrust Cylindrical Roller Bearings	Single direction	Flat back face		-	TMP
Thrust Tapered Roller Bearings		Flat back face		-	
Spherical Roller Thrust Bearings	Single direction	Outer ring raceway : spherical		292 293 294	

**Table 1.1 Classification and Types of Rolling Contact Bearings
Bearings for Specific Application**

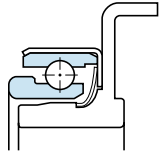
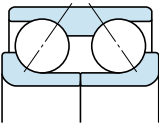
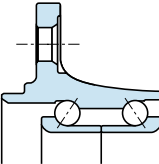
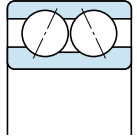
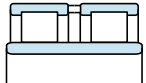
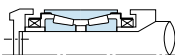
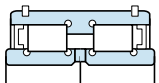
Bearing Types		Cross Sections	Bearing Series Symbols	
			JIS	Others
Automotive Bearings	Self-Aligning Clutch-Release Ball Bearings		-	SCRN
	Ball Bearings for Wheel (1st type)		-	BVV
	Ball Bearings for Wheel (2nd type)		-	F BVV
	Ball Bearings for Air Conditioner Clutch		-	BG
Journal Bearings for Rolling Stocks			-	FCD JC AP
			-	JT
Sheave Bearings			-	E50 RB48 RC48

Table 1.2 Classification and Types of Rolling Contact Bearings

Bearing Type	Features	Load carrying capacity	High speed rotation	Accuracy	Low noise • Low torque	Permissible aligning of inner ring • outer ring	Rigidity	Aligning action	Separable inner ring • outer ring	Applicable to "fix side"	Applicable to "free side" only	Inner ring with tapered bore
Deep Groove Ball Bearings		↑ ← →	● ● ● ●	● ● ●	● ● ●	● ●	●			○	□	○
Angular Contact Ball Bearings		↑ ←	● ● ● ●	● ● ●	● ● ●	●	●					
Double Row Angular Contact Ball Bearings		↑ ← →	● ● ●	●	●	●	●			○	□	
Duplex Mounting Angular Contact Ball Bearings		↑ ← →	● ● ●	● ● ●	● ●	●	● ●			○	□	
Self-Aligning Ball Bearing		↑ ← →	● ●	●	●	● ● ●	●	○			□	○
Cylindrical Roller Bearings		↑	● ● ●	● ● ●	● ●	●	● ●		○		○	○
Double Row Cylindrical Roller Bearings		↑	● ● ●	● ● ●	● ●	●	● ● ●		○		○	○

Remarks

- (1) ↑ and ← → show radial load and axial load respectively ← and ← → mean single direction and double directions respectively.
- (2) Mark "●" shows possibility for getting the characteristics. More number of "●" means much easier than less number. "X" mean "not applicable".
- (3) "○" means "applicable". "□" means "can be applicable", but shaft thermal expansion must be absorbed.
- (4) Thrust Ball/Roller Bearings can sustain axial loads ONLY.
- (5) This table is for reference only. Bearings should be selected for specific applications.



Table 1.2 Classification and Types of Rolling Contact Bearings



Bearing Type	Features	Load carrying capacity	High speed rotation	Accuracy	Low noise • Low torque	Permissible aligning of inner ring • outer ring	Rigidity	Aligning action	Separable inner ring • outer ring	Applicable to "fix side"	Applicable to "free side" only	Inner ring with tapered bore
Tapered Roller Bearings		↑ ←	●●	●●●	●	●	●●		○			
Double-row Multi-row Tapered Roller Bearings		↑ ← →	●●	●	●	●	●●●●		○	○	□	
Spherical Roller Bearings		↑ ← →	●●	●	●	●●●	●●●	○		○	□	○
Cylindrical Roller Bearings With One Rib Inner Ring		↑ →	●●●	●●	●●	●	●●		○			
Cylindrical Roller Bearings With L-shaped Thrust Collar		↑ ← →	●●●	●●	●●	●	●●		○	○		
Needle Roller Bearings		↑	●●	●	●	●	●●		○		○	

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Bearing Type	Features	Load carrying capacity	High speed rotation	Accuracy	Low noise - Low torque	Permissible aligning of inner ring* outer ring	Rigidity	Aligning action	Separable inner ring - outer ring	Applicable to "fix side"	Applicable to "free side" only	Inner ring with tapered bore
Single Direction Thrust Ball Bearings With Flat Back Face		←	●	●	●●	×	●		○			
Single Direction Thrust Ball Bearings With Spherical Flat Back Face		←	●	●	●●	●●●	●	○	○			
Double-row Thrust Angular Contact Ball Bearings		← →	●●●	●●●	●●	×	●●		○			
Thrust Cylindrical Roller Bearings		←	●	●	●	×	●●●		○			
Thrust Tapered Roller Bearings		←	●	●	●	×	●●●		○			
Spherical Roller Thrust Bearings		← ↑	●	●	●	●●●	●●●	○	○			

Remarks

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1.2 Rolling Contact Bearing Designs and Features

Rolling Contact Bearings usually consist of an inner ring, outer ring, and rolling elements (balls or rollers), and a cage which positions the rolling elements at fixed intervals between the ring raceways. (See Figure 1).

Standard materials for inner and outer rings, and for the rolling elements, are high carbon chromium bearing steel or case hardening steel. The steel is heat-treated to an appropriate hardness to attain optimum resistance to rolling fatigue. Bearing surfaces are ground to a very high accuracy using special machine tools.

While each of the various types of rolling contact bearings has special features, the following features are common to most rolling contact bearing types:

- Rolling contact bearings have relatively low starting resistance. There is little difference between the starting and running resistance of rolling contact bearings.
- Dimensions and accuracy are standardized. Ready-made products of high quality are easy to obtain.
- Compared to “sliding” bearings, rolling contact bearings are less prone to wear and help to maintain the accuracy of the machine in which they are used.
- Rolling contact bearings consume small amounts of lubricant and are far less costly to maintain than sliding-type bearings.
- While not common to all rolling contact bearings, many types can sustain both axial and radial loads.

To get optimum performance from a selected bearing, it is necessary to understand the design and features of the various bearing types and to then select bearings optimal to individual machine performance.

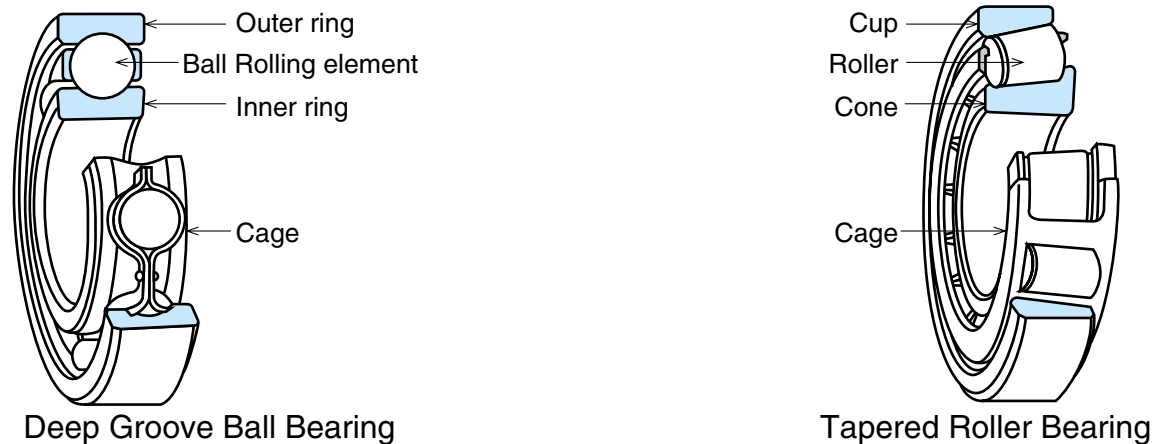


Fig 1. Rolling Contact Bearing Designs

1.2.1 Deep Groove Ball Bearings

Deep Groove ball bearings are the most popular of all the ball bearing types because they are available in a wide variety of seal, shield and snap-ring arrangements.

The bearing ring grooves are circular arcs made slightly larger than the radius of the ball. The balls make point contact with the raceways (elliptical contact when loaded). The inner ring shoulders are of equal height (as the outer ring shoulders).

Deep Groove ball bearings can sustain radial, axial, or composite loads and because of simple design, this bearing type can be produced to provide both high-running accuracy and high-speed operation.

Deep Groove ball bearings having an outside diameter less than 9 mm are known as Miniature ball bearings.

Deep Groove ball bearings having an outside diameter \geq 9 mm and a bore diameter $<$ 10 mm are known as Extra-small ball bearings.

Standard ball retainers (cages) are made from pressed steel. Machined cages are used in bearing operating at very high speed or for large diameter bearings.

Deep groove ball bearings with seals or shields are standardized. They contain proper amount of grease in advance.



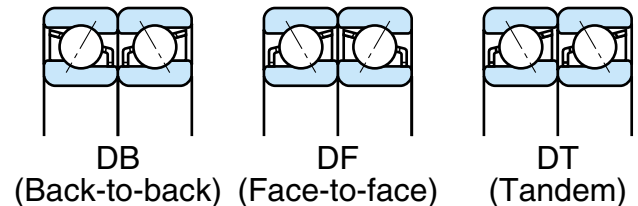
1.2.2 Single-row Angular Contact Ball Bearings

The raceways of both the inner and outer rings of this bearing type are made with a set contact angle. These bearings are non-separable. Since the balls are inserted utilizing counter-bore construction, a larger number of balls can be installed than in the case of Deep-groove ball bearings.

Standard cage materials may be pressed steel, high-strength brass, or synthetic resin. Cage material is dependent on the bearing series and or service condition.

Single-row Angular Contact ball bearings can sustain radial, axial or composite loads, however, any axial load must be in one direction.

This bearing type is generally used in pairs to handle the induced load resulting from the internal axial force generated by the applied radial load. When mounting two single bearings in adjacent positions, NACHI provides these combination parts (pairs) with preadjusted clearance. Paired combination bearings are matched sets. Combination or paired bearings can be arranged BACK-TO-BACK (DB), FACE-TO-FACE (DF), or in TANDEM (DT). DB or DF sets can sustain bidirectional axial loads.



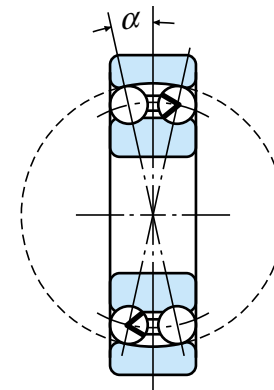
1.2.3 Double-row Angular Contact Ball Bearings

The construction of this type ball bearing is similar to the adjacent, BACK-TO-BACK mounting of two Single-row Angular Contact ball bearings. Because fewer balls can be inserted per row compared to Single-row Angular Contact ball bearings, a Double-row Angular Contact ball bearing will have less load capacity than an equivalent size/series BACK-TO-BACK set of two Single-row Angular Contact ball bearings. This bearing type can sustain radial, moment and bi-directional axial loads.



1.2.4 Self-aligning Ball Bearings

This type is constructed with the inner ring and ball assembly contained within an outer ring which has a spherical raceway. Due to the construction, this bearing type will tolerate a small angular misalignment from deflection or mounting error. Self-aligning Ball bearings are suitable for long shafts where accurate positioning of housing bores is difficult. This type is often used in conjunction with pillow blocks. Cages are made from pressed steel or polyamide resin. This bearing should only be used in light axial load applications due to the small axial support of the rolling elements by the outer ring raceway.



1.2.5 Cylindrical Roller Bearings

Construction of this roller bearing type is the simplest of all radial roller bearings. This bearing type is often used in high-speed applications.

Because the inner ring, outer ring, and rollers are in line contact, this bearing type has a large radial load capacity. Various Cylindrical roller bearing configurations are:

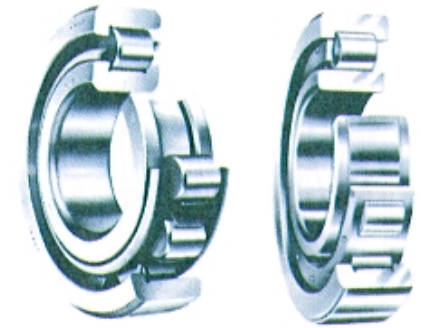
- N,NJ,NF,NU,RNU : integral ribs (flanges)
- NH,NP,NUP,NUH : integral and loose ribs
- NN,NNU : double-row bearings

[→Continue]

(See the Cylindrical roller bearing dimensional data section for description of configuration design).

Configurations having integral flanges or loose ribs on both the inner and outer rings can sustain a small amount of axial load. Since this bearing type supports axial loads as sliding action between the end of the rollers and flange faces, axial loading is limited.

Double-row Cylindrical roller bearings are used for high-speed, high-accuracy applications such as; main spindle support for lathes, milling machines, and machining centers. Radial clearance of tapered-bore bearings can be adjusted during mounting of the bearing(s) onto the mating journal. Standard cages are pressed steel or polyamide resin. Machined cages of high-strength brass are used for bearings of large dimension or for high-speed applications.



1.2.6 Tapered Roller Bearings

The inner and outer ring raceways and rollers of this type of bearing are made with a taper so that the planes of the surfaces of the raceways and roller axis meet at a point. The rollers are guided by the cone (inner ring) back-face rib.

A single-row Tapered roller bearing can support a combined radial and axial load. If either a radial load or bi-directional axial load is to be carried, a pair of bearings must be used in a “face-to-face” or “back-to-back” position.

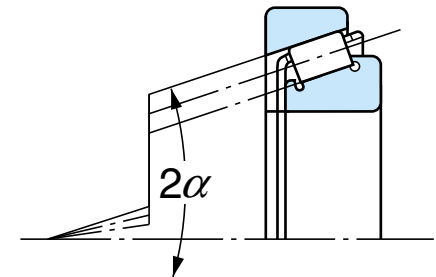
Tapered roller bearings are separable into the components: outer ring, inner ring and roller assembly. The non-separable inner ring and roller assembly is called the “cone”, and the outer ring is called the “cup”. Internal clearance is established during mounting by the axial positioning of the cone relative to the cup.

This bearing type can be used in a preload situation to obtain higher rigidity and better running accuracy of the shaft.

Double-row and four-row Tapered roller bearings are designed to carry radial, and bi-directional axial loads. Four-row Tapered roller bearings are used for the roll necks of rolling machines and for other applications where heavy or impact loads are present.

Multi-row Tapered roller bearings have the serial number and the combination symbol stamped on the faces of the rings for clearance adjustment and must be assembled according to this number and symbol.

Pressed steel cages are used for small bore bearings and machined, high-strength brass or mild-steel cages are used for bearings with larger bores. Heavy-duty pin-type cages are used for some large-bore bearings.



1.2.7 Spherical Roller Bearings

NACHI double-row Spherical roller bearings are available in bore sizes from 25 mm to over 1000 mm.

The raceways in the outer ring of this type bearing are designed with a spherical surface whose center coincides with the bearing center.

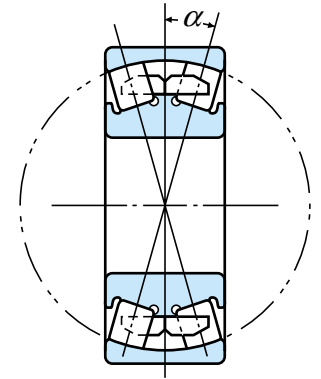
NACHI Spherical roller bearings are of an improved design having a modified line contact between the raceways and rollers. This construction enables very high radial and impact-load capacity.

This bearing type can carry a moderately-high level of bi-directional axial load and is self-aligning. This type is used extensively for large machines where shaft deflection or mounting error may occur.

Spherical roller bearings are used for paper mill equipment, rolling machines, rolling stock, shaker screens and general industrial machinery. The mounting and dismounting of Spherical roller bearings is facilitated through the use of tapered-bore bearings in conjunction with tapered journals, or adapters or withdrawal sleeves.

Internal clearance can also be precisely set using a tapered-bore bearing.

Pressed steel cages are used for small-bore bearings and machined, high-strength brass or mild-steel cages are used for bearings with larger bores.



1.2.8 Thrust Ball Bearings

Thrust ball bearings can handle axial loads only. Bearing rings mounted on the shaft are called shaft washers, and those mounted in the bearing housing are called housing washers. Both washers contain grooves for the balls.

Thrust Ball bearings are of two types: single type which can support axial loads in only one direction and double type that can support bi-directional loads. The central washer of double type thrust ball bearing is located in an axial direction by a shaft shoulder and sleeve.

Thrust Ball bearings are not suitable for high-speed rotation since lubricant is expelled by centrifugal force. When used on a horizontal shaft, a minimum axial load must be applied.

Pressed steel plate, polyamide resin, machined high-strength brass or mild steel are used for cages.

Care must be taken in handling to prevent damage to the separable rings and ball assembly.



1.2.9 Spherical Roller Thrust Bearings

The raceway of housing washer of this bearing type is spherical with the center of the radius located on the bearing axis. The design provides self-alignment capability to the bearing. The contact angle (see sketch below) is approximately 45° enabling the bearing to support axial load and a small to moderate amount of radial load.

NACHI Spherical Roller Thrust bearings can sustain high loads at low-to-moderate speeds.

Because of the large load capacity and self-aligning characteristics, this bearing type is often used for injection molding machines, crane hooks and other large machines.

Cages are made from machined, high-strength brass or pressed steel.

