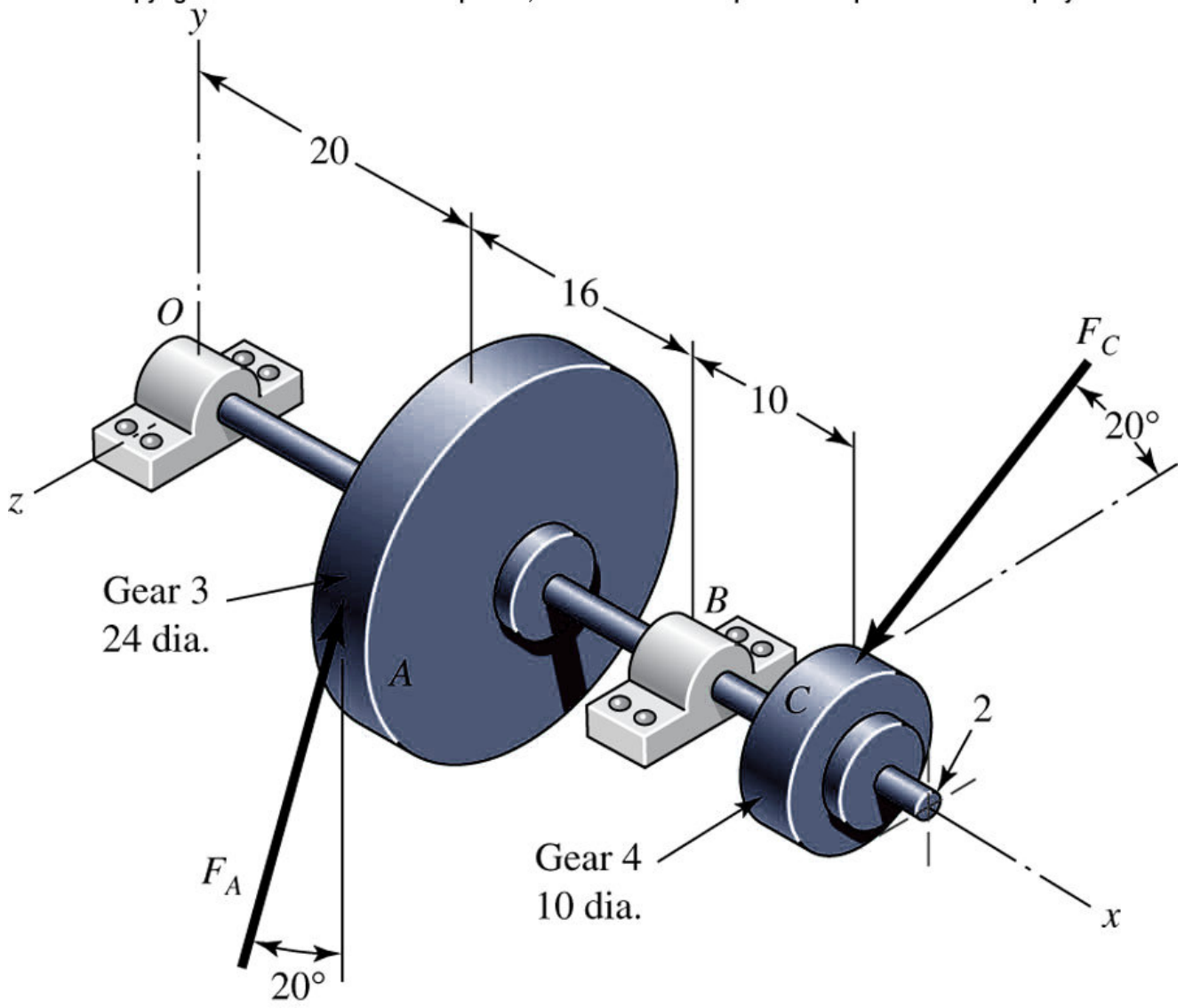
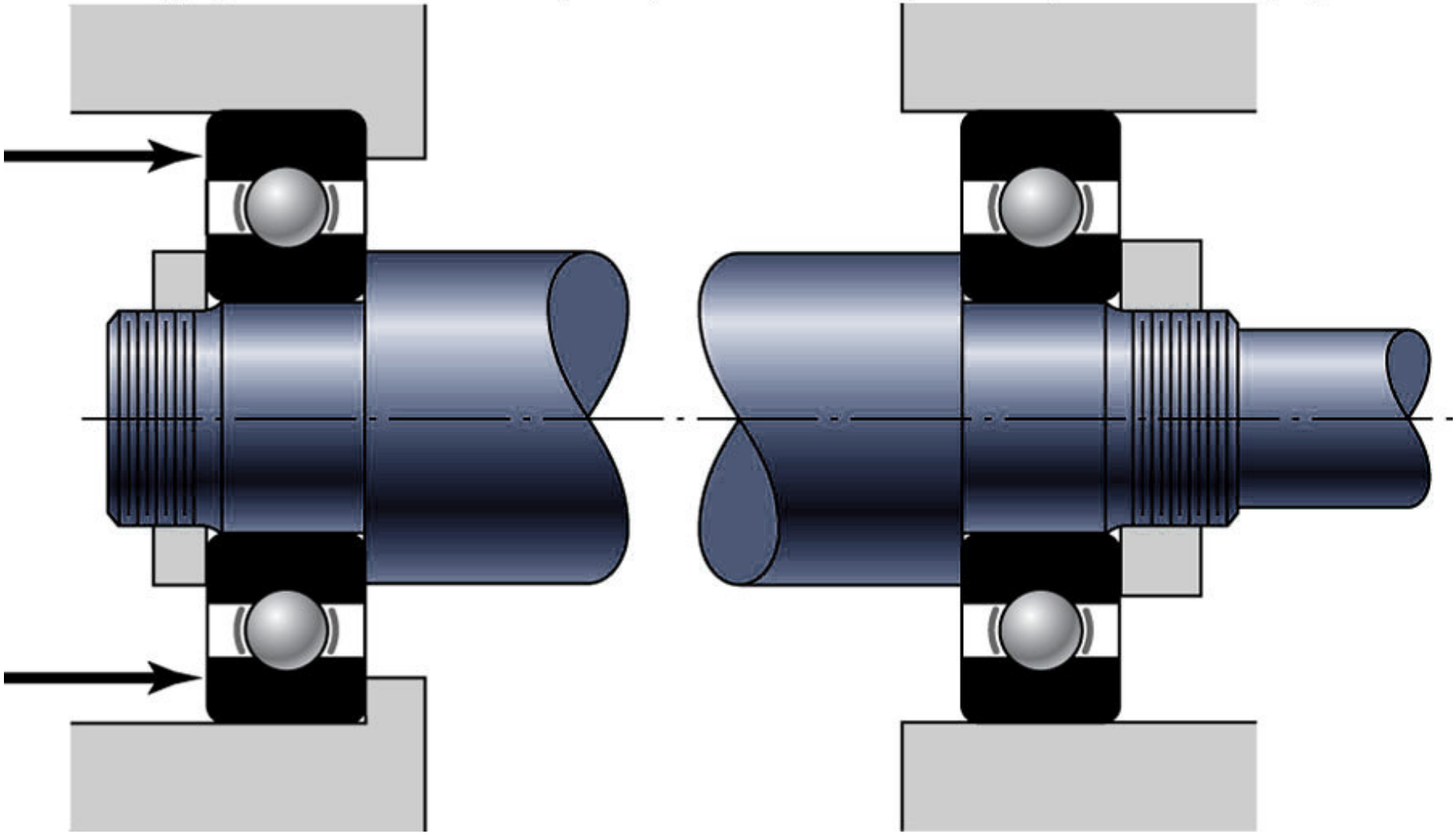
BEARINGS

BEARINGS

Are used to support shafts, axles and rotating machine members



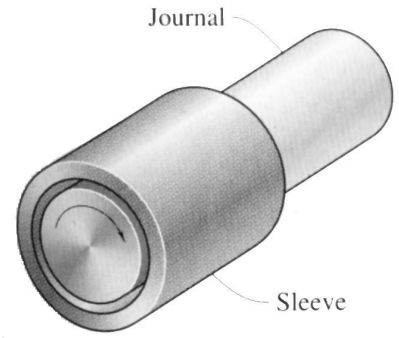


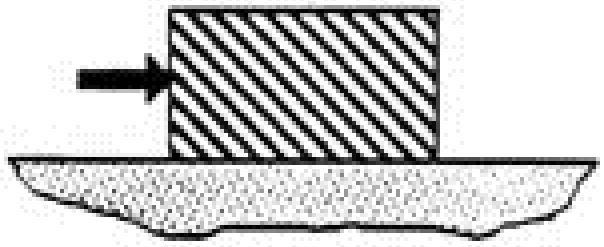
Classification of bearings:

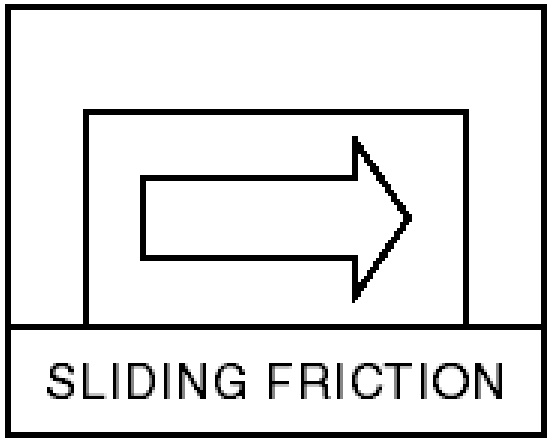
According to type of contact of shaft with bearing or according to the kind of friction generated in active surfaces, bearings can be classified into sliding bearings and antifriction bearings:

A- Sliding bearings:

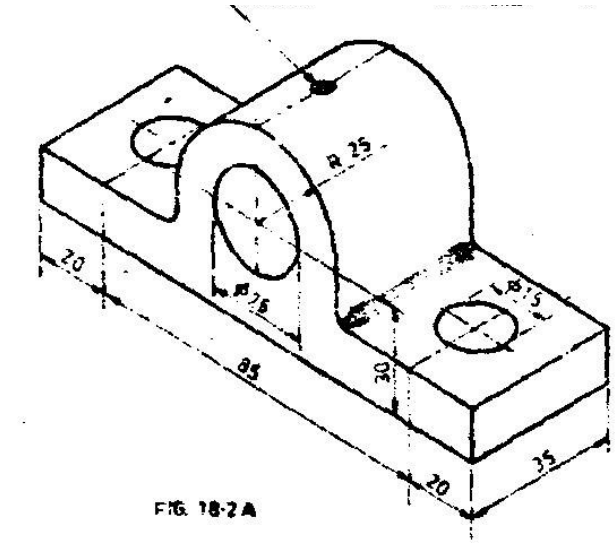
- Sliding bearings are those bearings where shaft is in direct contact with bearing and is sliding on its cylindrical surfaces.
- Because of the nature of contact, the friction between the mating parts is usually high, so these bearings require more lubrication.
- The lubrication does not totally eliminate contact between the surfaces.

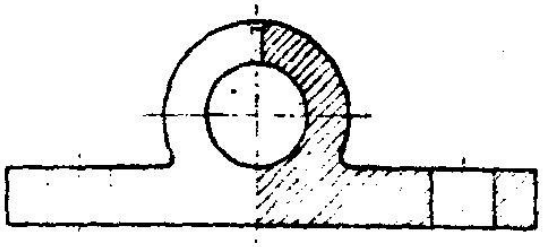


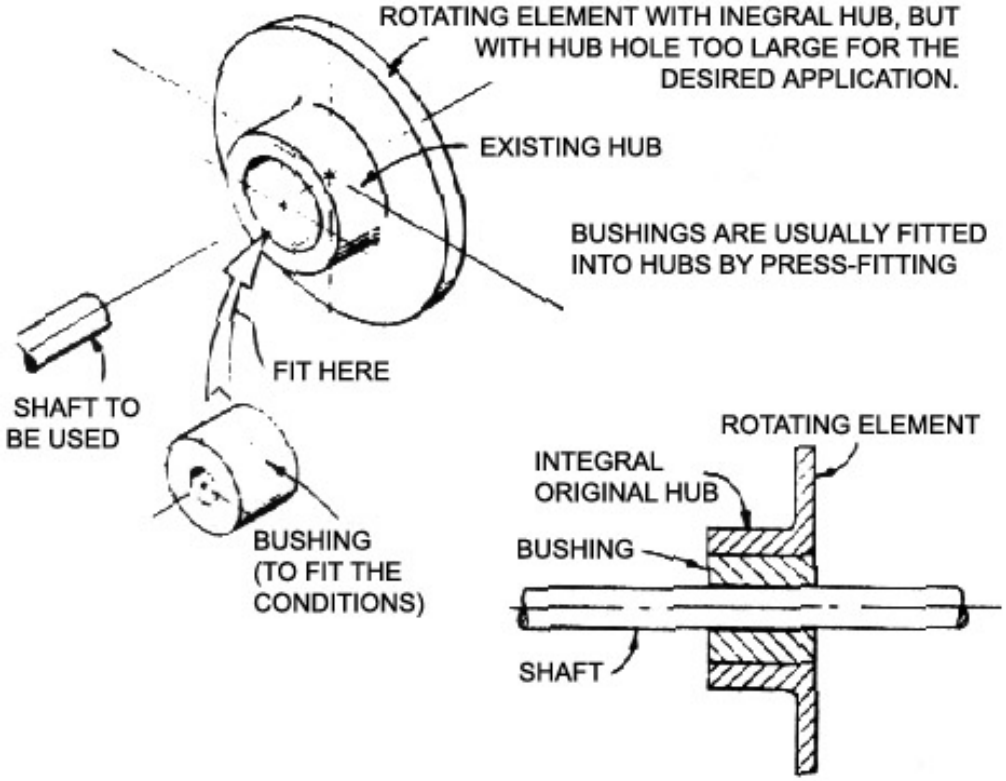




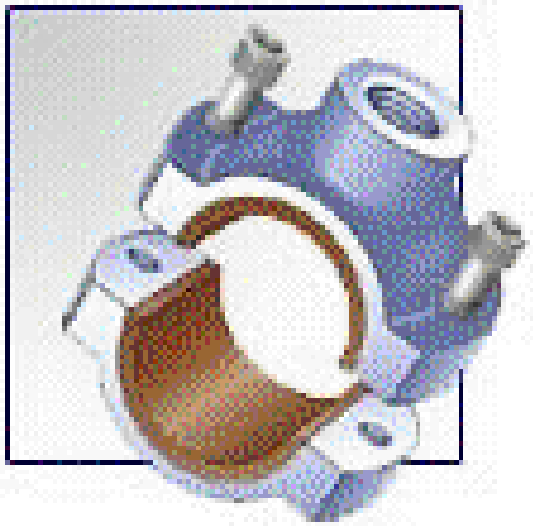
Sliding bearings

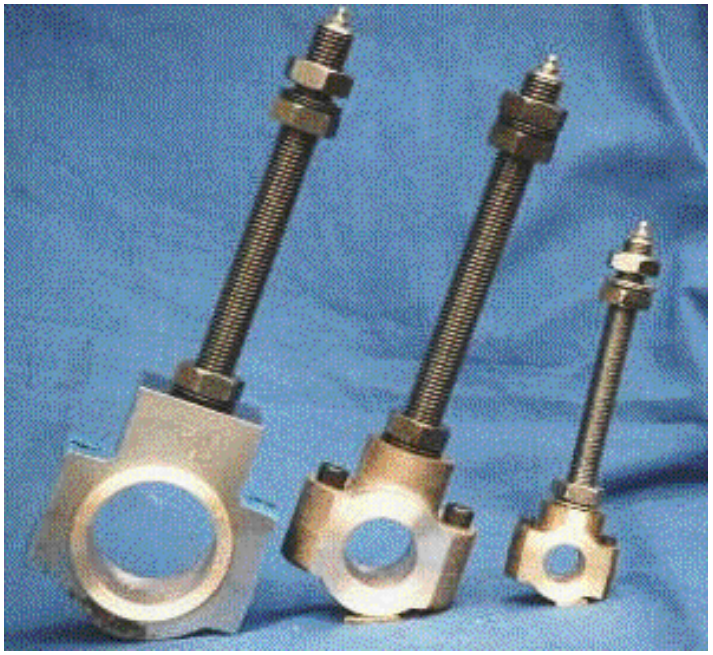


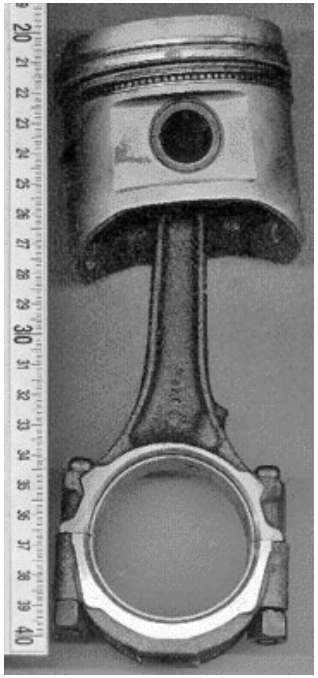


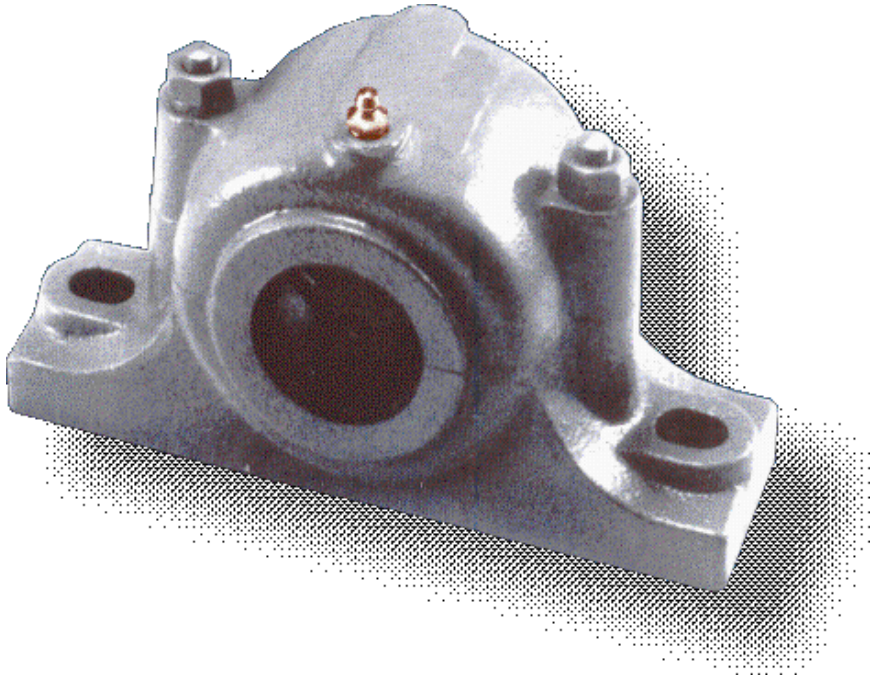


Bronze Bearings



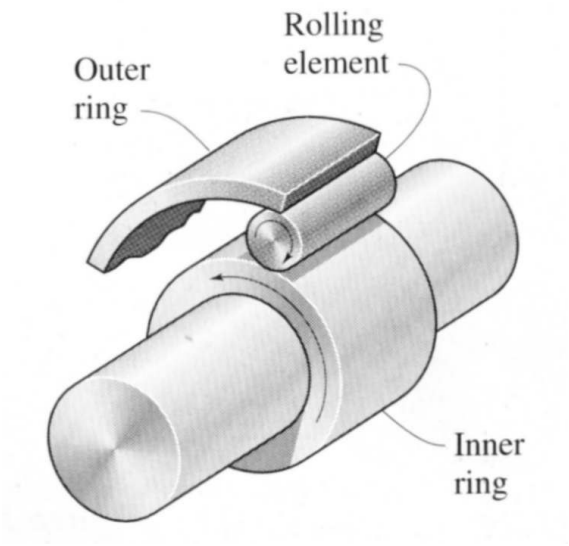


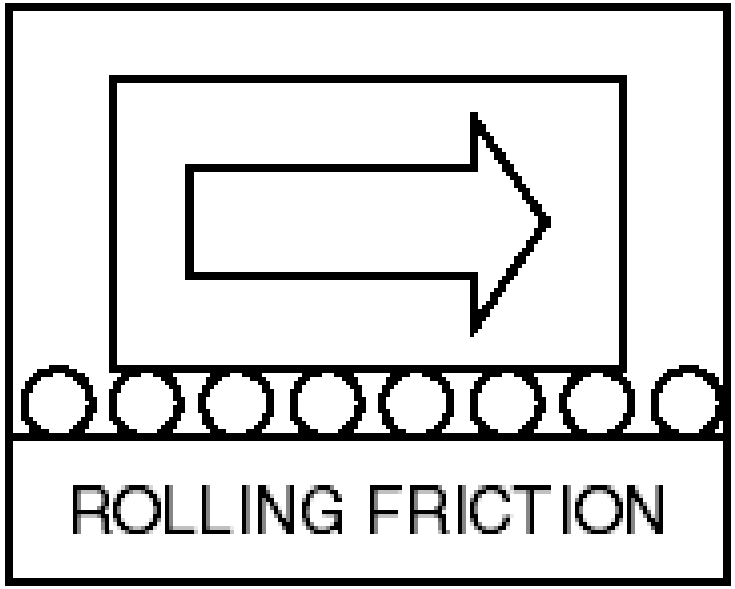


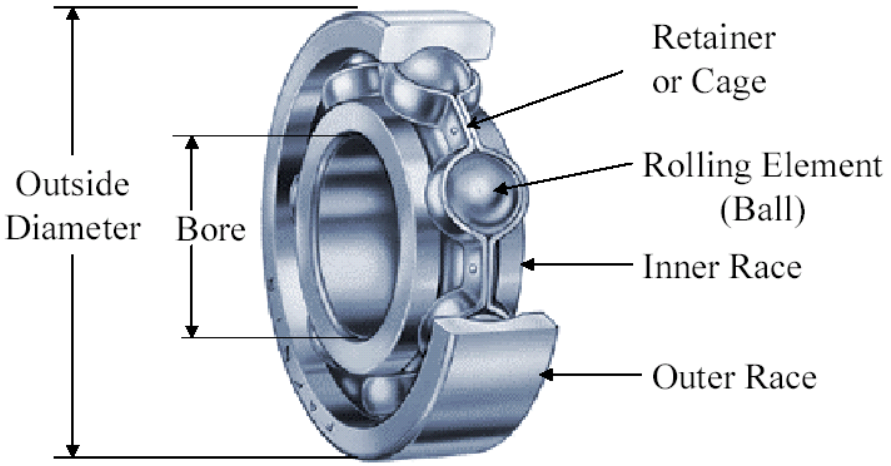


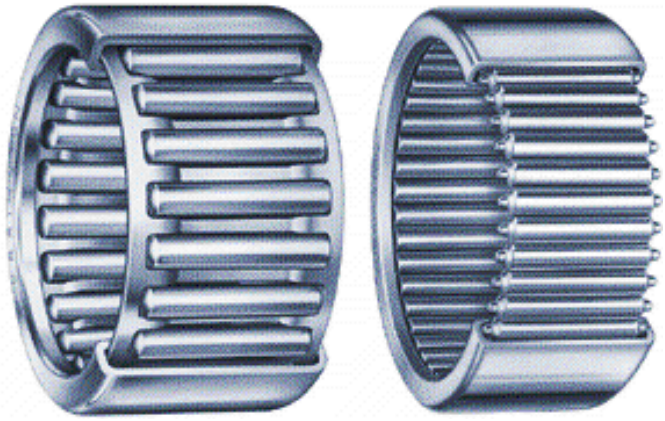
Anti-friction bearings:

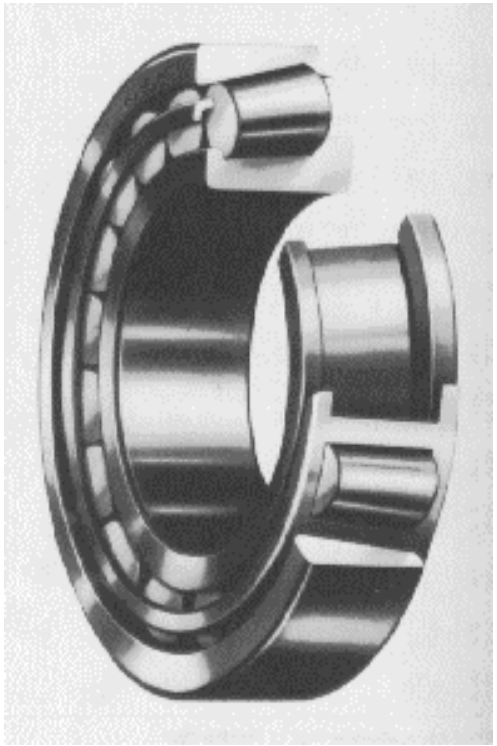
- These bearings are known as rolling bearings in which a pure rolling motion is achieved in place of the sliding motion which occurs in sliding bearings.
- As the rolling friction is much less than the sliding friction, rolling friction are called anti-friction bearings.
- Generally, both types of bearings (sliding bearings & anti-friction bearings) are divided according to the direction of the applied load.

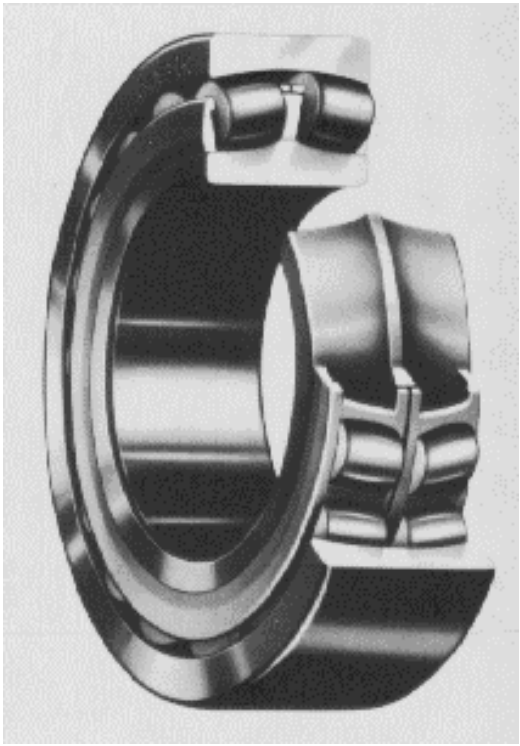





Retainer
or Cage
Rolling Element
(Ball)
Inner Race
Outer Race
Outside
Diameter
Bore







Advantages of sliding bearings:

1- They have a low coefficient of friction if properly designed and lubricated.

2- They have very high load-carrying capacities.

3- Their resistance to shock and vibration is greater than rolling-contact bearings.

4- The hydrodynamic oil film produced by plain bearings damps vibration, so less noise is transmitted.

5- They are less sensitive to lubricant contamination than rolling-contact bearings.

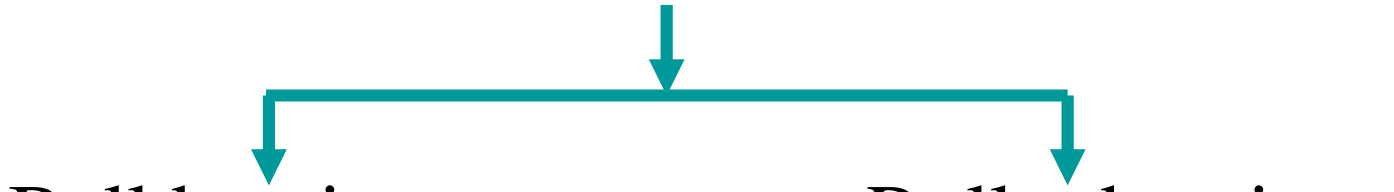
Advantages of rolling-contact bearings

1- At low speeds, ball and roller bearings produce much less friction than plain bearings.
2- Certain types of rolling-contact bearings can support both radial and thrust loading simultaneously.
3- Rolling bearings can operate with small amounts of lubricant.
4- Rolling-contact bearings are relatively insensitive to lubricant viscosity.
5- Anti-friction bearings have low wear rates and require little maintenance.

Rolling Contact Bearings

Types of rolling contact bearings:

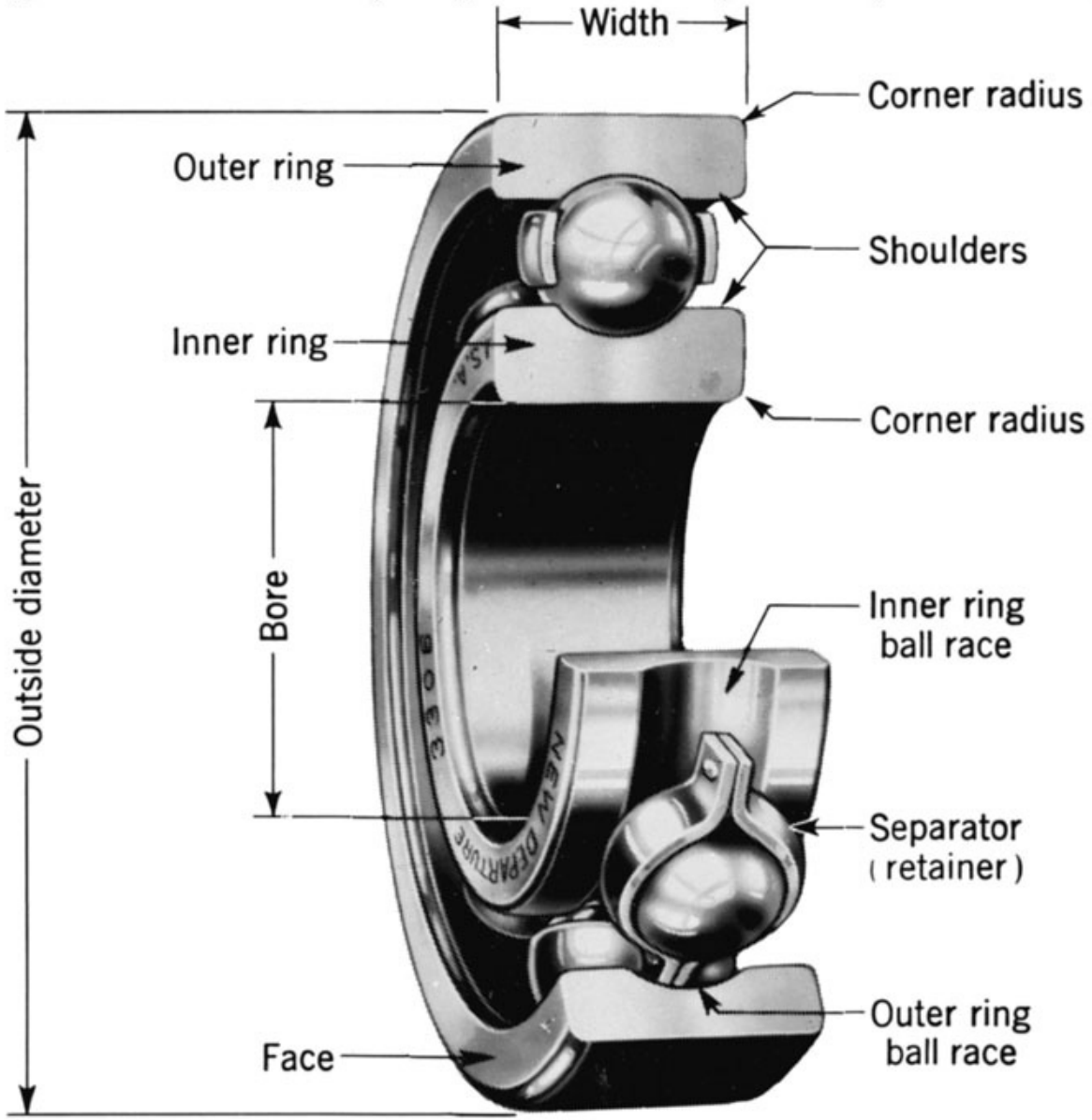
- As the rolling friction is much less than the sliding friction, rolling bearings are called 'antifriction bearings‘.



- Each of these may be subdivided into:
  - a- Radial bearings
  - b-Thrust bearings
  - c-Radial-Thrust bearings

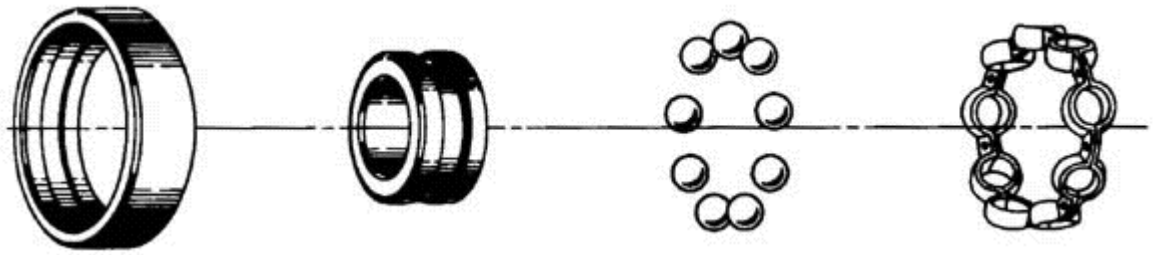
Ball Bearings:

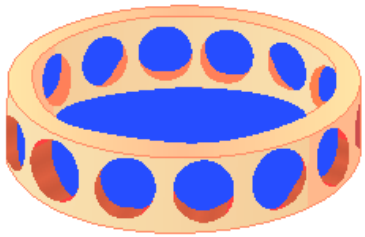
a- Radial Ball Bearings:



The rolling contact bearings consist as a rule of:

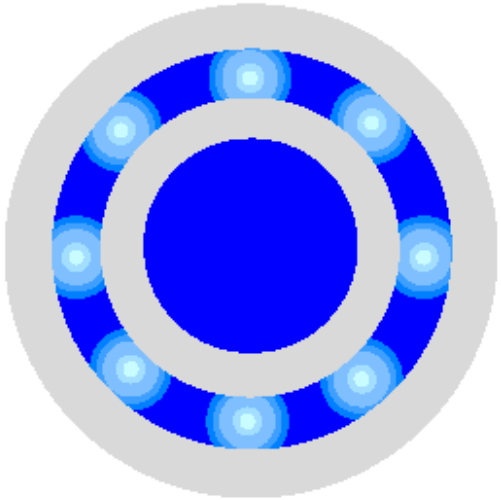
- Inner race
- Outer race (the inner race being pushed or pressed onto the shaft and the outer race being secured in the housing).
- The rolling elements (balls) at a certain distance from one another.
- Cage or separator (The rolling elements roll within a separator or a cage, to prevent the rolling elements from rubbing each other and to hold the rolling elements at a constant distance from each other).
- Running tracks of both races of these bearings are sufficiently deep to carry axial loads in addition to radial loads at high speeds.

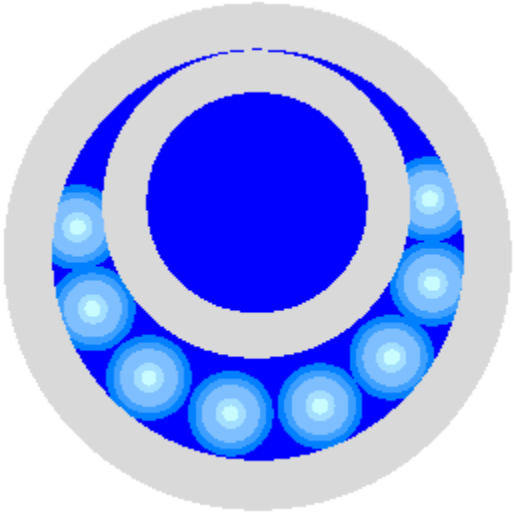


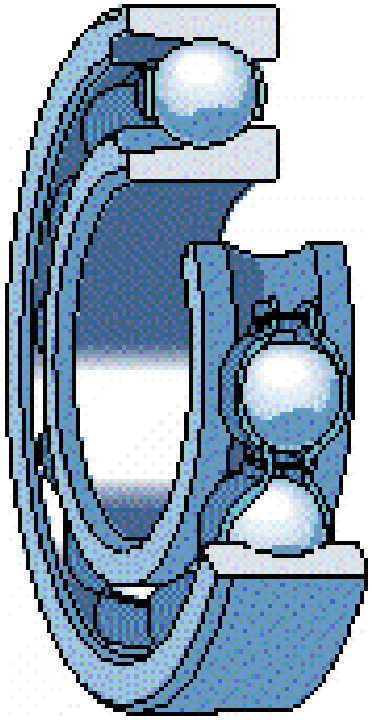


- Balls are inserted in bearings in such a way that the inner race is placed eccentrically against the outer race, after which the inner race is returned to a concentric position. Then the balls are uniformly spaced along periphery and the two parts separator (cage) are installed from either side to be riveted.

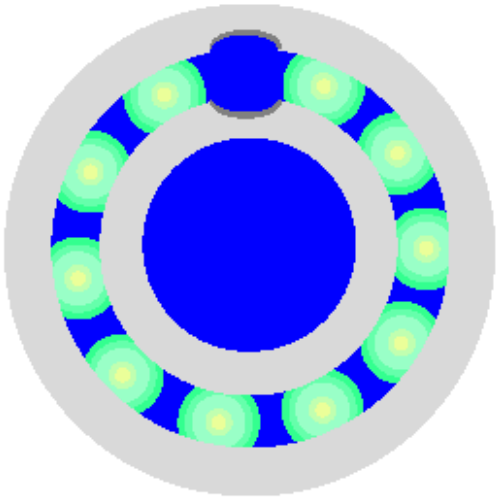
Conrad method

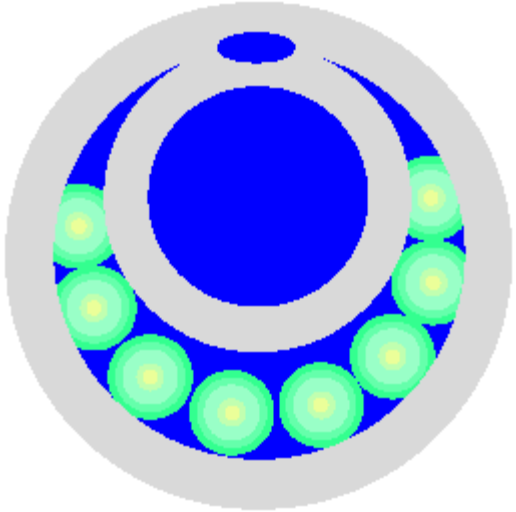






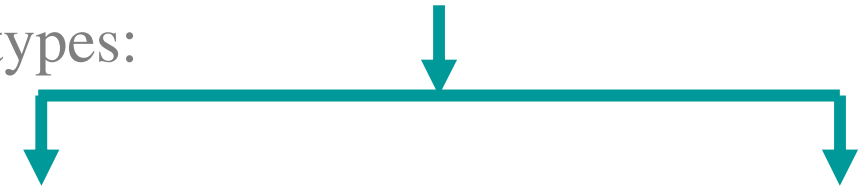
filling slot





b- Thrust Ball Bearings:

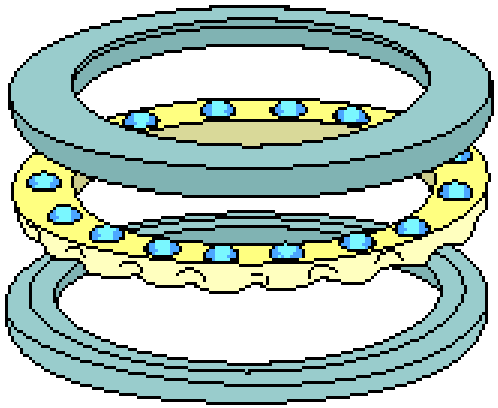
- Exist in two types:

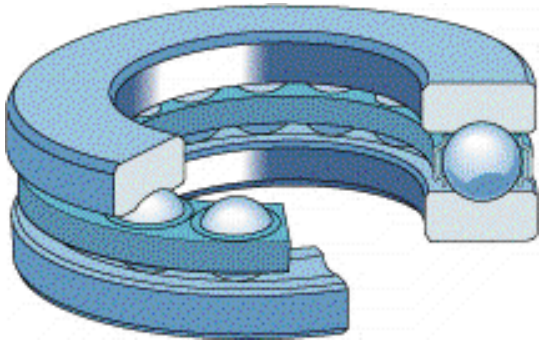


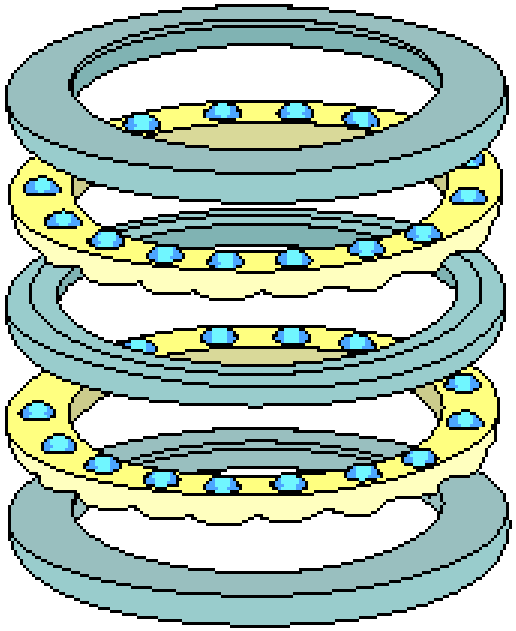
Single row thrust Ball bearings

Double row thrust Ball bearings

- They consist of 4 elements:
  - a- Shaft race.
  - b- Housing race.
  - c- Steel balls (Rolling elements).
  - d- Cage or separator.





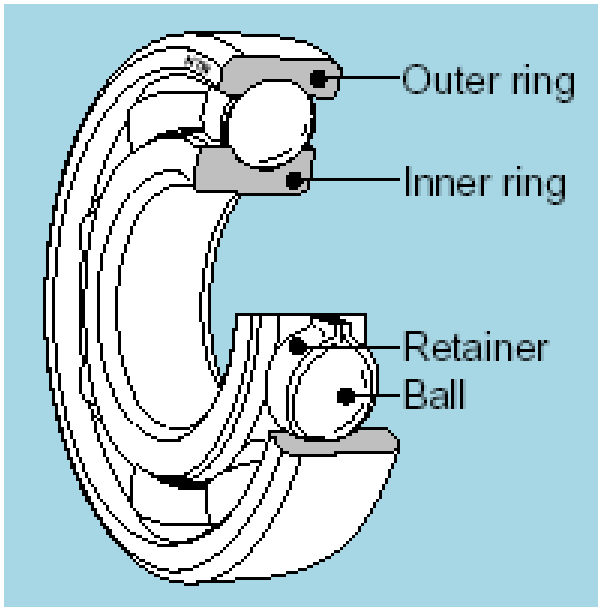


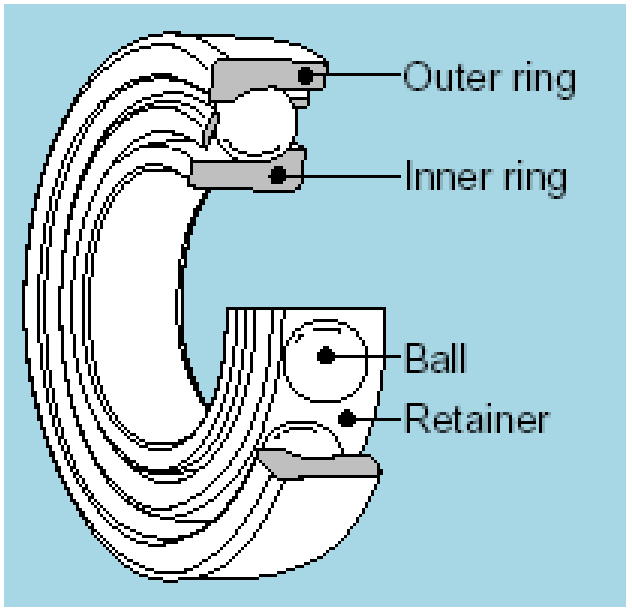
c- Radial-Thrust Ball Bearings:

There are many kind of Radial-Thrust Ball Bearings, the most common in industrial use are:

Deep groove Ball bearings

Angular contact ball bearings





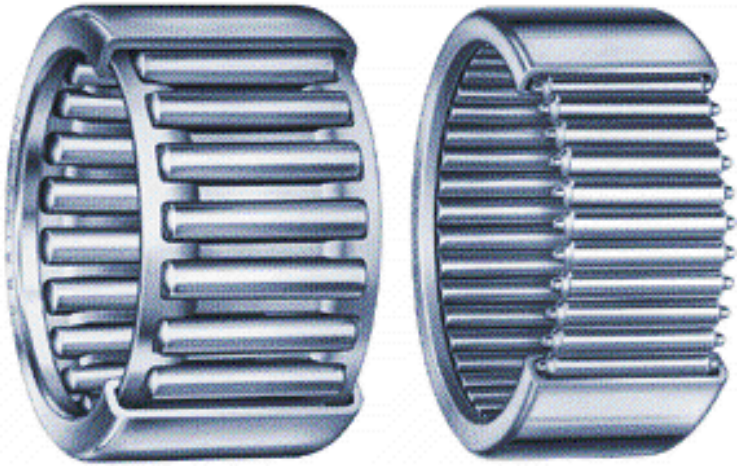
Roller Bearings:

a- Radial roller Bearings:

For radial roller bearing, the contact between the rolling elements and the run races is a line contact and not a point contact as in ball bearing. So, the load carrying capacity of roller bearing is higher than this is of the ball bearings with the same dimension. They are proper to be used for great impact loading.

Straight roller

Needle



b- Thrust Roller Bearings:

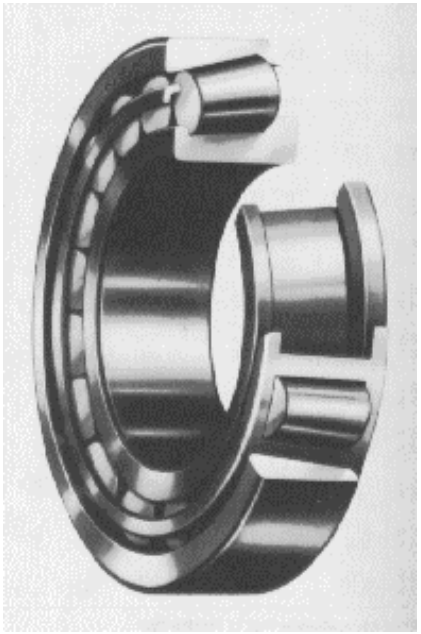
Cylindrical Roller

Taper Roller

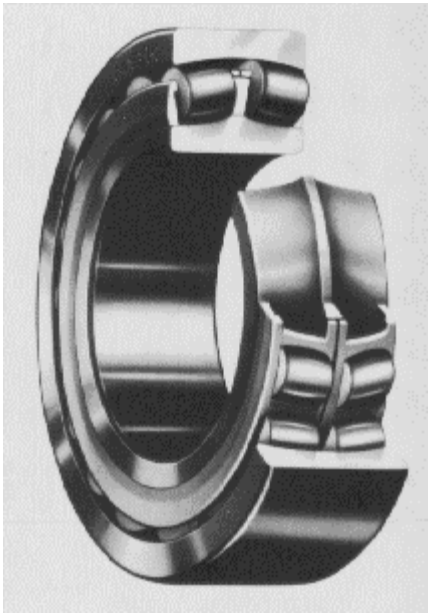
Spherical roller

c- Radial-Thrust roller Bearings:

Taper roller

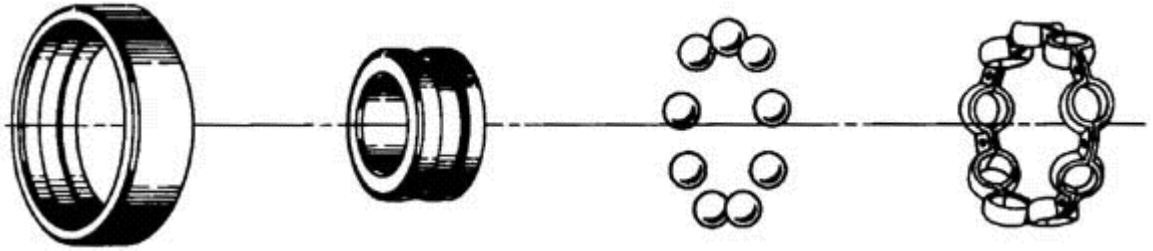


Spherical roller



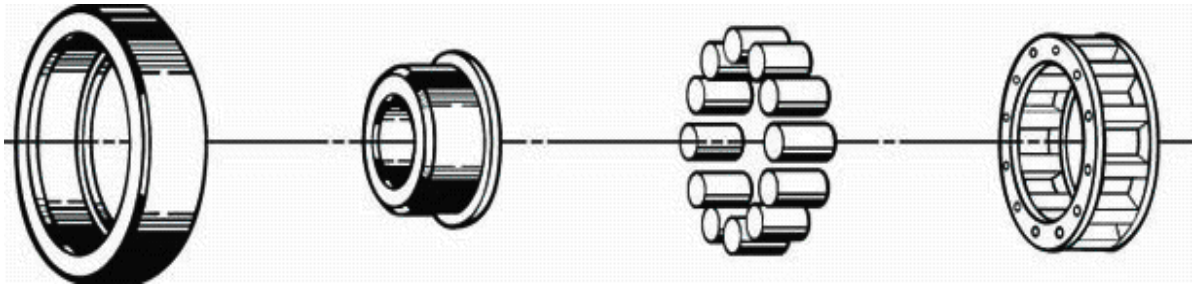
Rolling Elements:

Ball Bearing

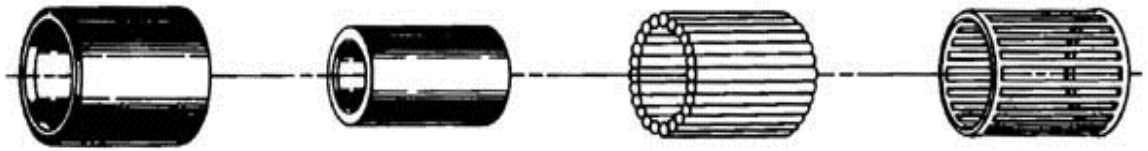


Roller Bearing

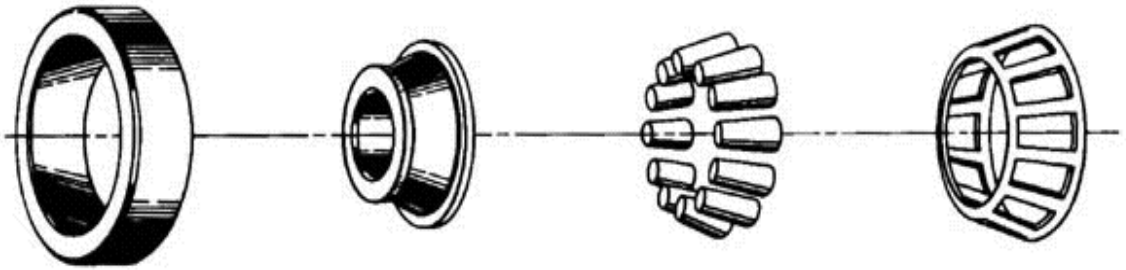
- Straight roller



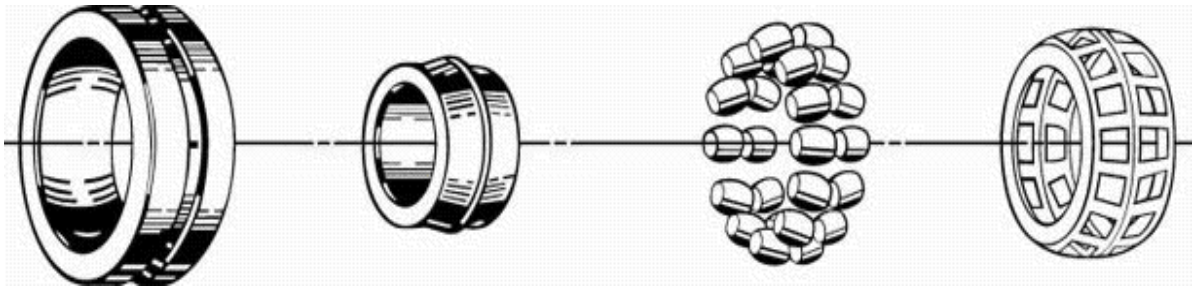
- Needle



- Taper roller



- Spherical roller



Bearing Life:

- The life of an individual bearing is defined as the total number of revolutions, or the number of hours at a given constant speed, of bearing operation required for the failure criteria to develop.
- Rating Life:

Is the number of revolutions or working hours of operation at a given constant speed, that 90% of a group of identical bearings will complete or exceed before failure. Rating life is termed as L_{10}.

Bearing load:

- If two groups of identical bearings tested under different loads F_1, F_2, they will have different respective lives L_1, L_2, then:

$$\frac{L_1}{L_2} = \left(\frac{F_2}{F_1}\right)^a$$

Where: a = 3 for ball bearings
= 10/3 for roller bearings

In general, if we define the basic dynamic load rating C as the load that will give a life of one million revolutions of inner race, then the relation

$$\frac{L_1}{L_2} = \left(\frac{F_2}{F_1} \right)^a$$

Will be

$$\frac{1}{L} = \left(\frac{F}{C} \right)^a \quad \text{or} \quad L = \left(\frac{C}{F} \right)^a$$

- In general:

$$\frac{L_1}{L_2} = \left(\frac{F_2}{F_1}\right)^a \longrightarrow F_2 = F_1\left(\frac{L_1}{L_2}\right)^{\frac{1}{a}} \rightarrow C_R = F_{eq}\left[\left(\frac{L_D}{L_R}\right)\left(\frac{n_D}{n_R}\right)\right]^{1/a}$$

Where, the subscripts:

- D → for designed or required values
- R → for rated values (from catalog)

- L_R (standard)
  - 500 hrs for ISO system
  - 3000 hrs for Timken
- n_R (standard)
  - 100/3 r.p.m for ISO system
  - 500 r.p.m for Timken

- L_D : Designed for L_{10} life (i.e, the reliability is 90%)

- ISO system → (SKF, ZKL, FAG…..)

- For a reliability greater than 90%:

$$C_R = F_{eq}\left[\left(\frac{L_D}{L_R}\right)\left(\frac{n_D}{n_R}\right)\frac{1}{6.84}\right]^{1/a}\frac{1}{\left[\ln(1/R)\right]^{1/1.17a}}$$

- Generally:

$$C_R = k_A F_{eq}\left[\left(\frac{L_D}{L_R}\right)\left(\frac{n_D}{n_R}\right)\frac{1}{6.84}\right]^{1/a}\frac{1}{\left[\ln(1/R)\right]^{1/1.17a}}$$

Where:

k_A : Application factor (usually is taken between 1.2 and 1.3)