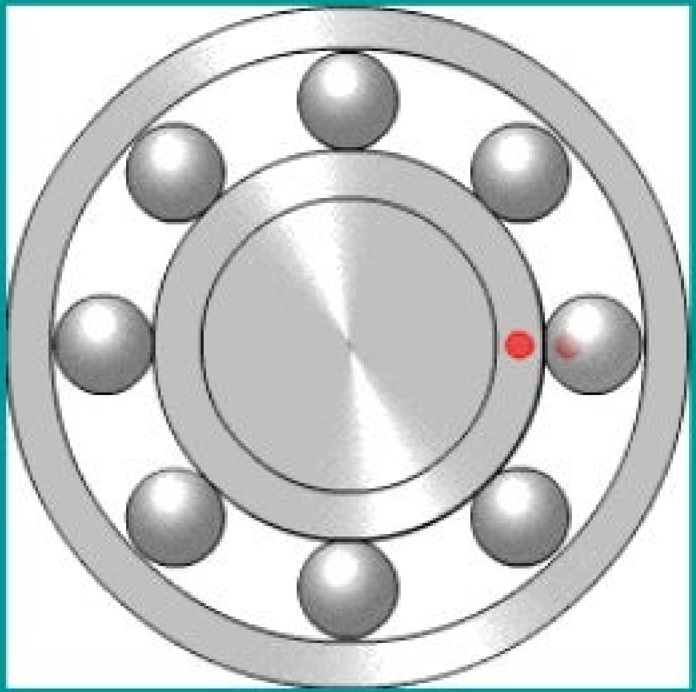
BEARING & LUBRICATION

BEARING



FUNCTION OF A BEARING

- The main function of a rotating shaft is to transmit power from one end of the line to the other.
  - It needs a good support to ensure stability and frictionless rotation. The support for the shaft is known as **“bearing”**.
- All bearing are provided some lubrication arrangement to reduced friction between shaft and bearing.

Bearings

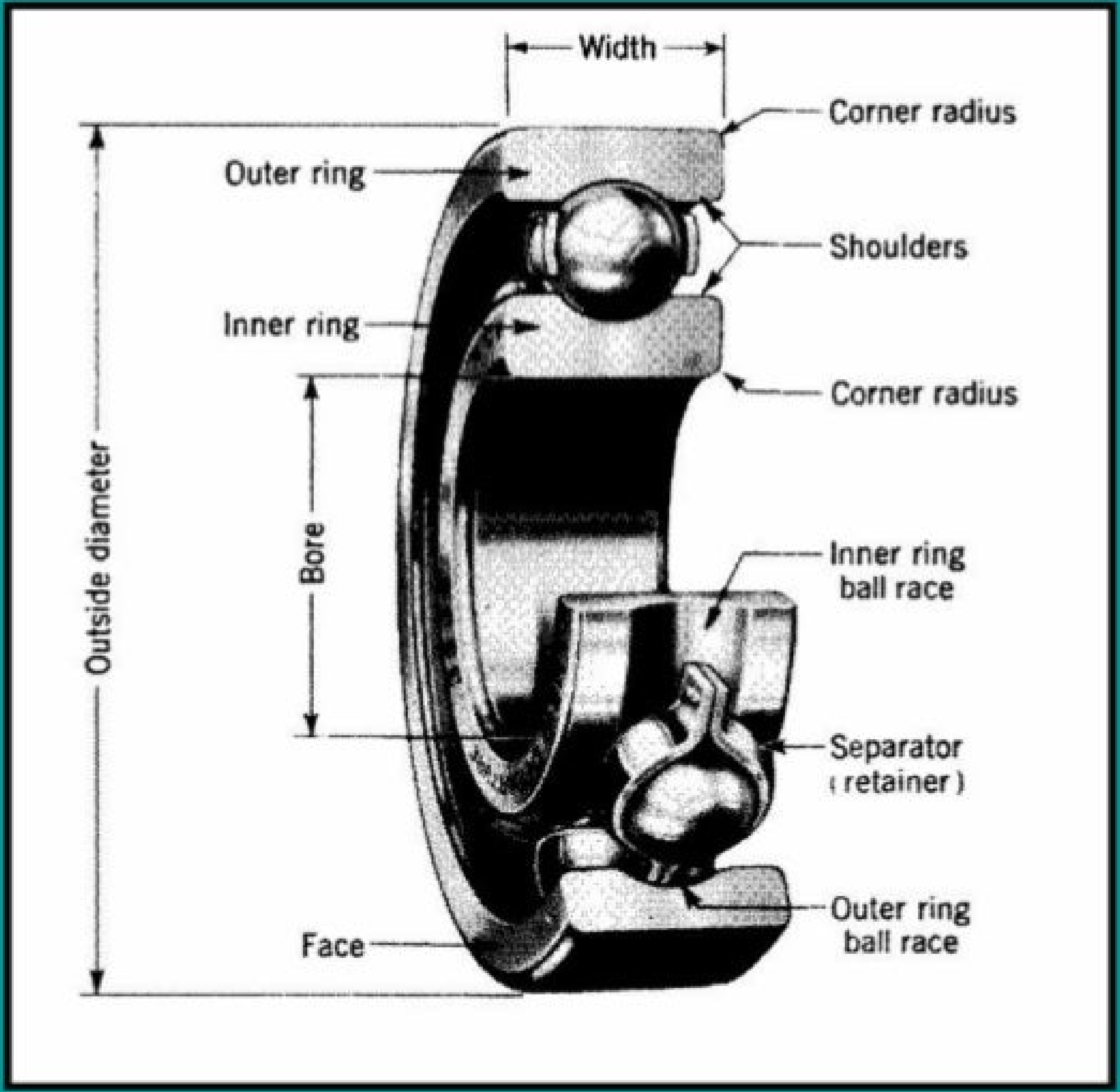
Rolling Contact Bearings – load is transferred through rolling elements such as balls, straight and tapered cylinders and spherical rollers.

Journal (sleeve) Bearings – load is transferred through a thin film of lubricant (oil).

Bearings

Rolling Contact Bearings

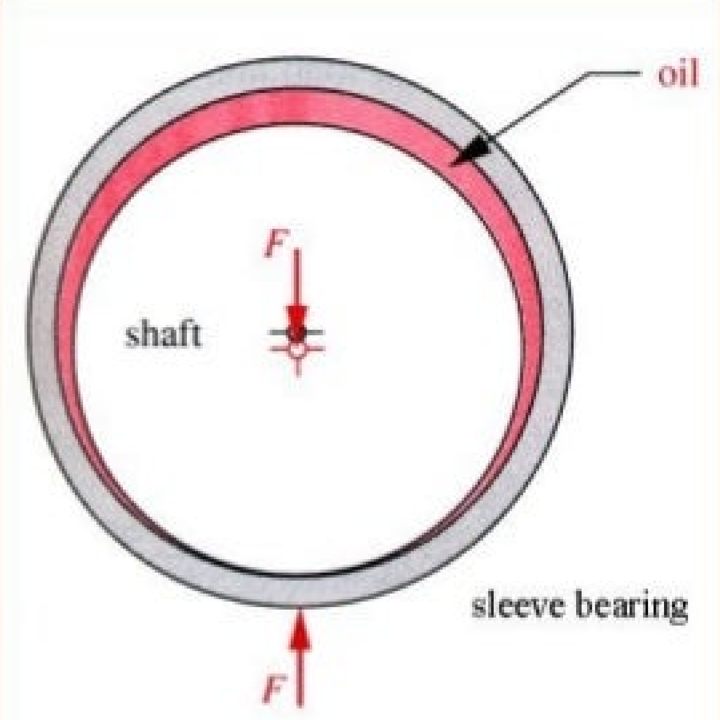
Load is transferred through elements in rolling contact rather than sliding contact.



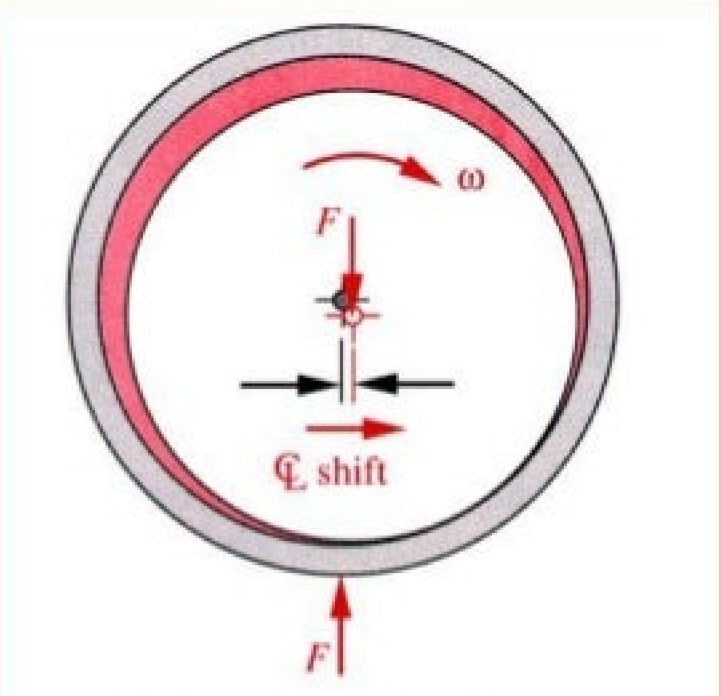
Bearings

Journal (Sleeve) Bearings

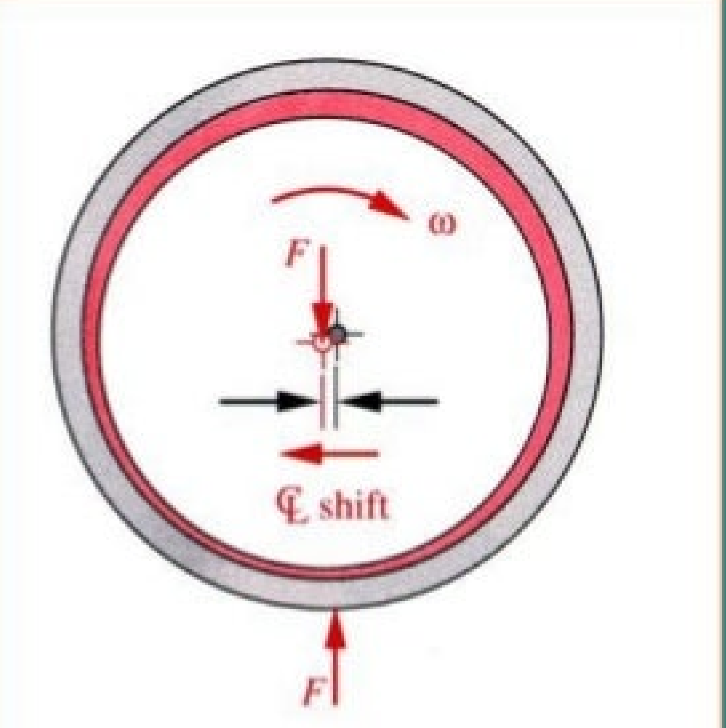
Load is transferred through a lubricant in sliding contact



(a) Shaft stationary - metal contact
- forces and centers in line



(b) Shaft rotating slowly
- boundary lubrication
- contact point leads centerline

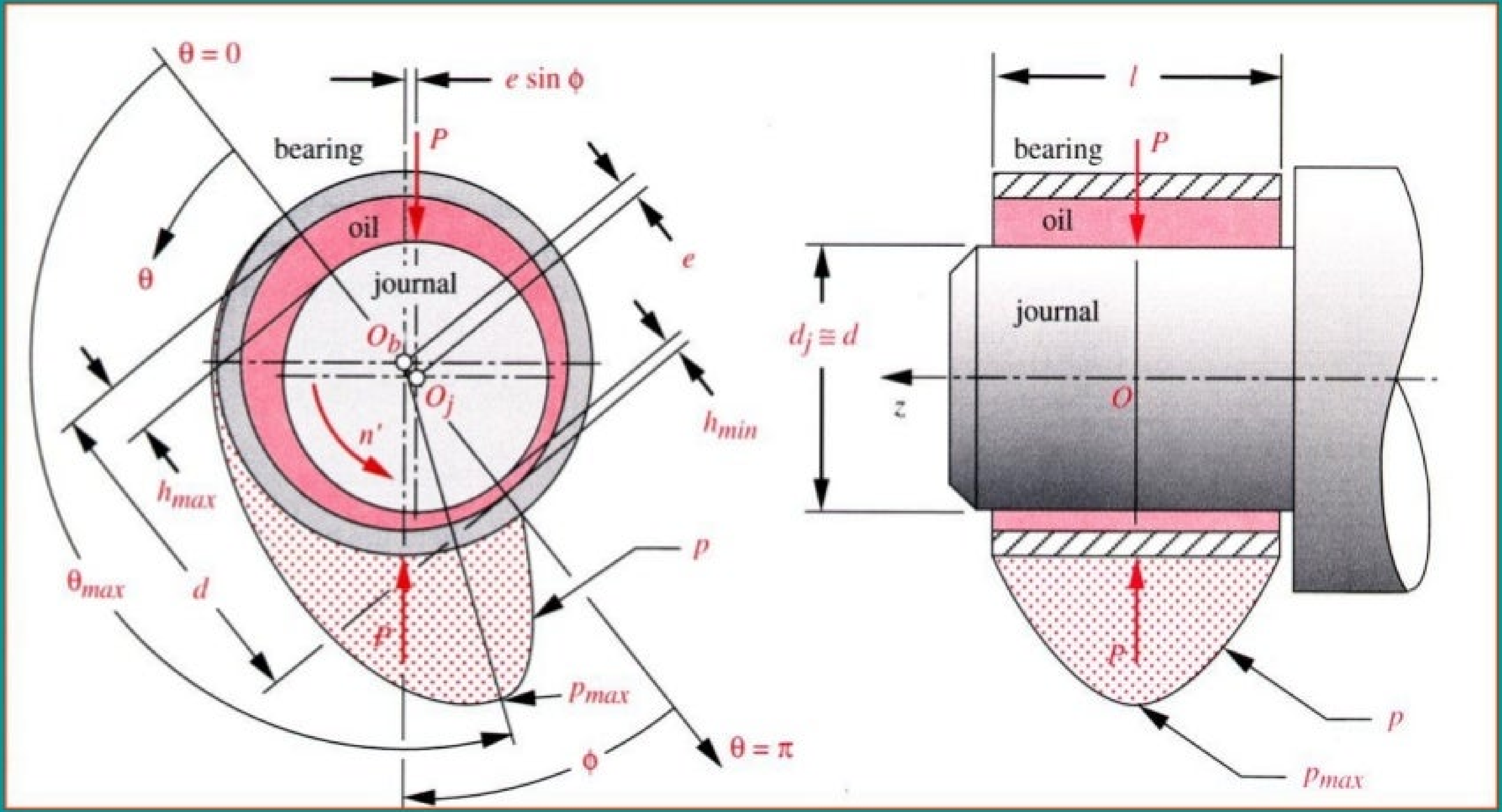


(c) Shaft rotating rapidly
- hydrodynamic lubrication
- no metal contact
- fluid is pumped by shaft
- shaft lags bearing centerline

Journal (Sleeve) Bearings

Thick-film lubrication (hydrodynamic), pressure distribution, and film thickness.

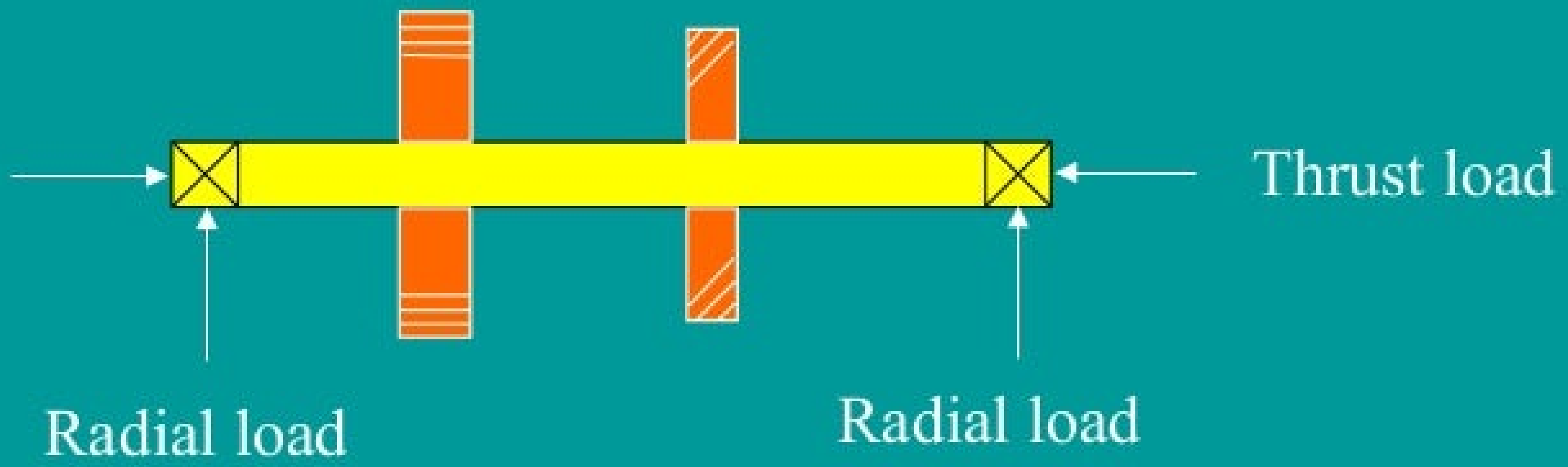
$\boldsymbol{h}_{\mathbf{min}}$ = minimum film thickness, c = radial clearance, e = eccentricity



Design Considerations

Bearings are selected from catalogs, before referring to catalogs you should know the followings:

- Bearing load – radial, thrust (axial) or both



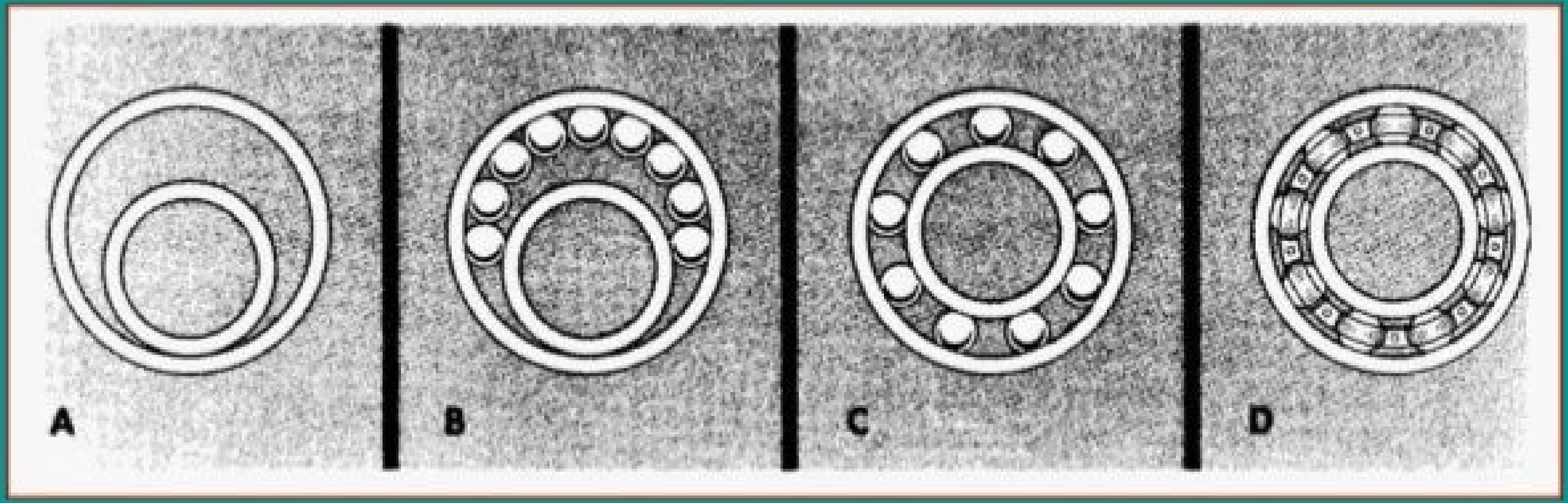
- Bearing life and reliability
- Bearing speed (rpm)
- Space limitation
- Accuracy

Rolling Contact Bearings

1. ***Ball bearings***
   - Deep groove (Conrad) bearing
   - Filling notch ball bearing or maximum capacity bearing
   - Angular contact bearings (AC)
2. ***Roller bearings***
   - Cylindrical bearings
   - Needle bearings
   - Tapered bearings
   - Spherical bearings
3. ***Thrust bearings***
4. ***Linear bearings***

Ball Bearings

1. Deep groove (Conrad) bearing

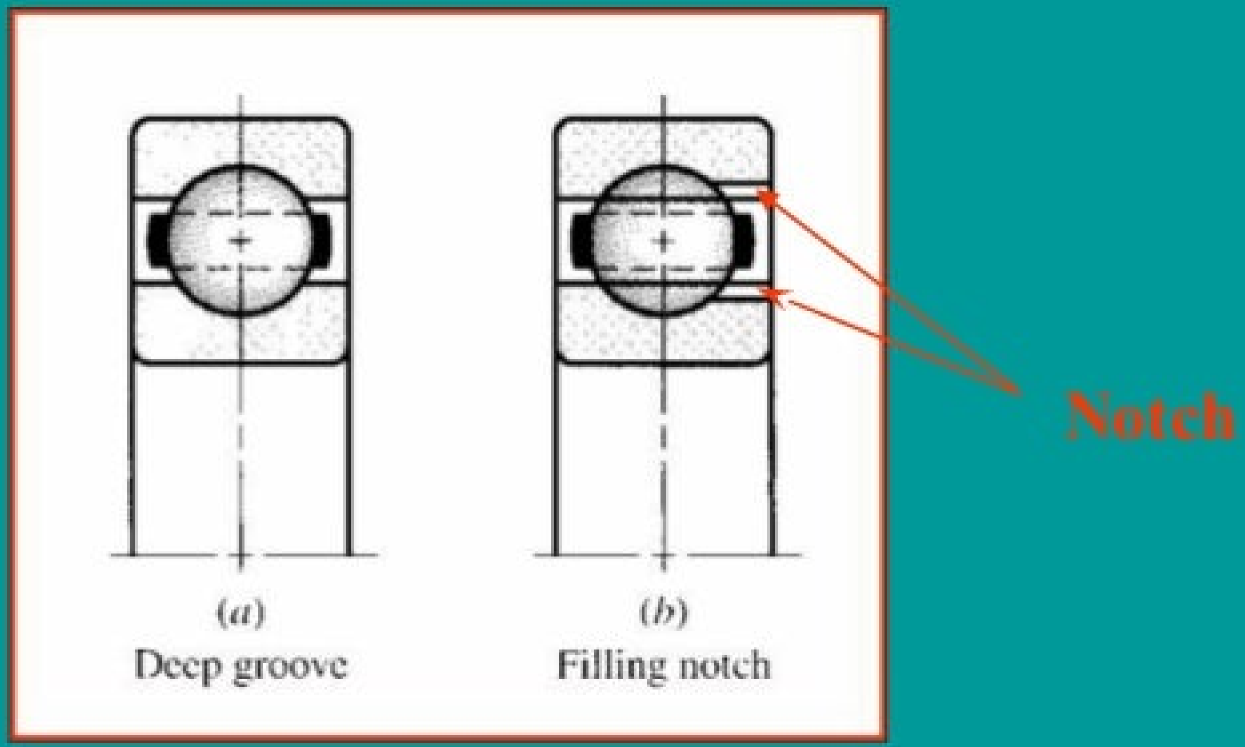


- Load capacity is limited by the number of balls
- Primarily designed to support radial loads, the thrust capacity is about 70% of radial load capacity

Ball Bearings

2. Filling notch or maximum capacity ball bearings

Bearings have the same basic radial construction as Conrad type. However, a ***filling notch*** (loading groove) permits more balls to be used.

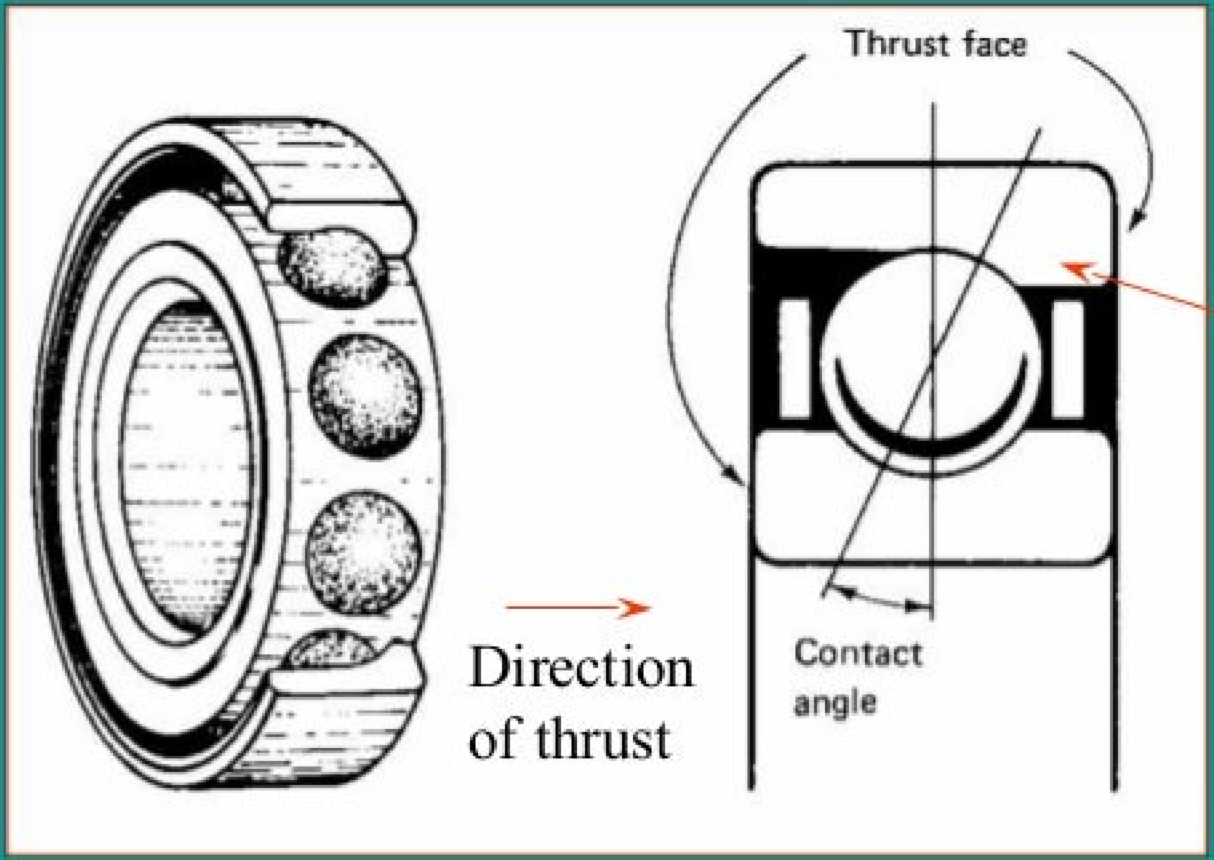


- Radial load capacity is 20 – 40% higher than Conrad type
- Thrust load capacity drops to 20% (2 directions) of radial load capacity.

Ball Bearings

3. Angular contact bearings (AC)

   The centerline of contact between the balls and the raceway is at an angle to the plane perpendicular to the axis of rotation.



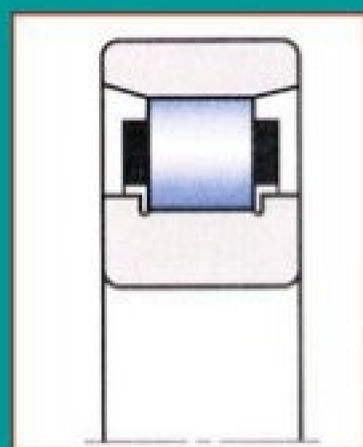
Extra support in the back

- Used for high radial and thrust load applications

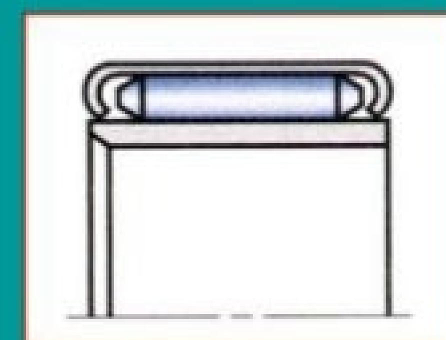
Roller Bearings

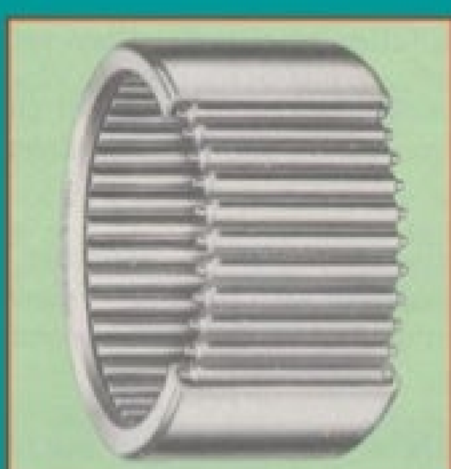
Roller bearings have higher load capacity than ball bearings, load is transmitted through line contact instead of point contact.

Straight cylindrical roller



Needle type





Mechanically retained rollers

Greased retained rollers

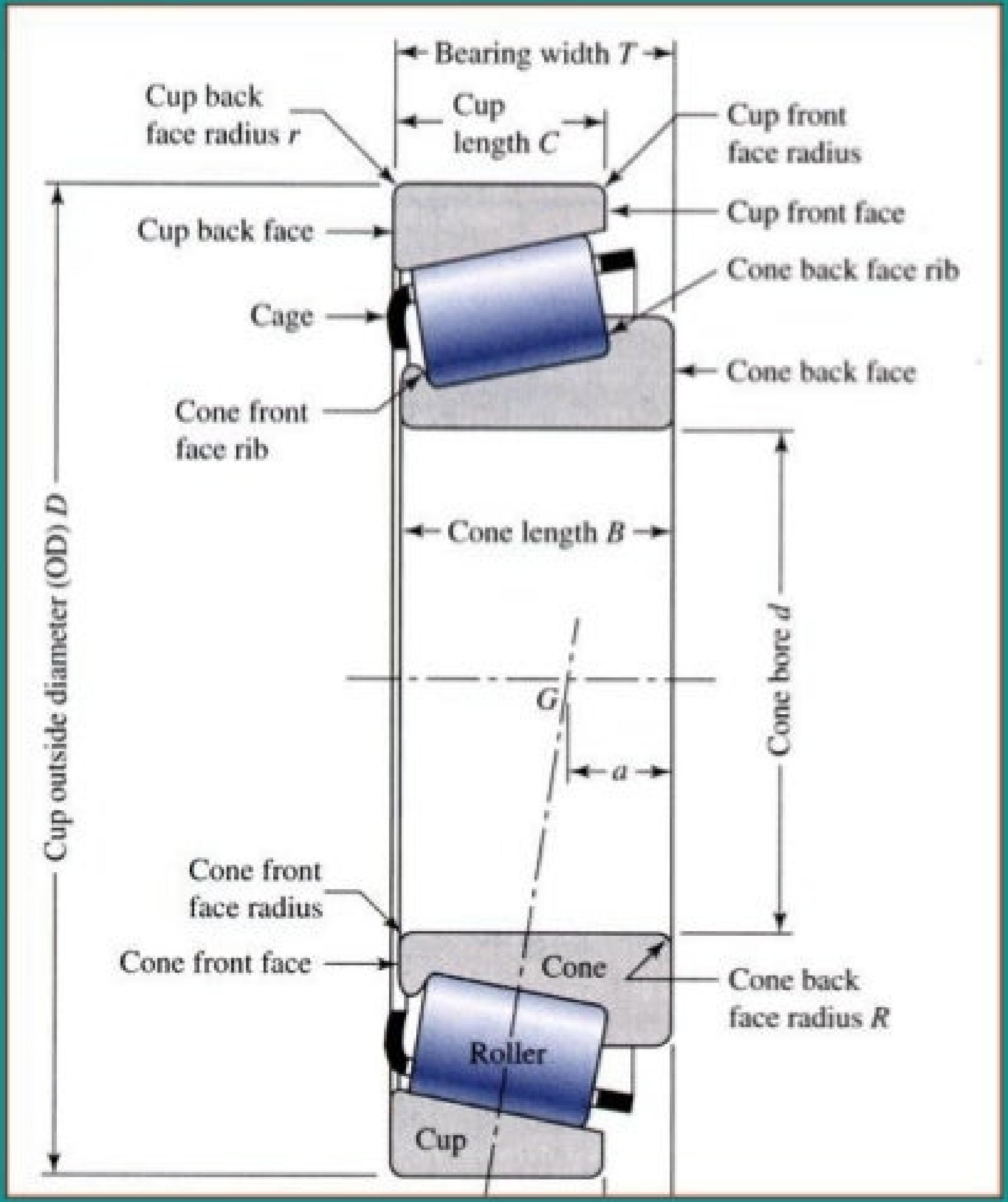
Caged

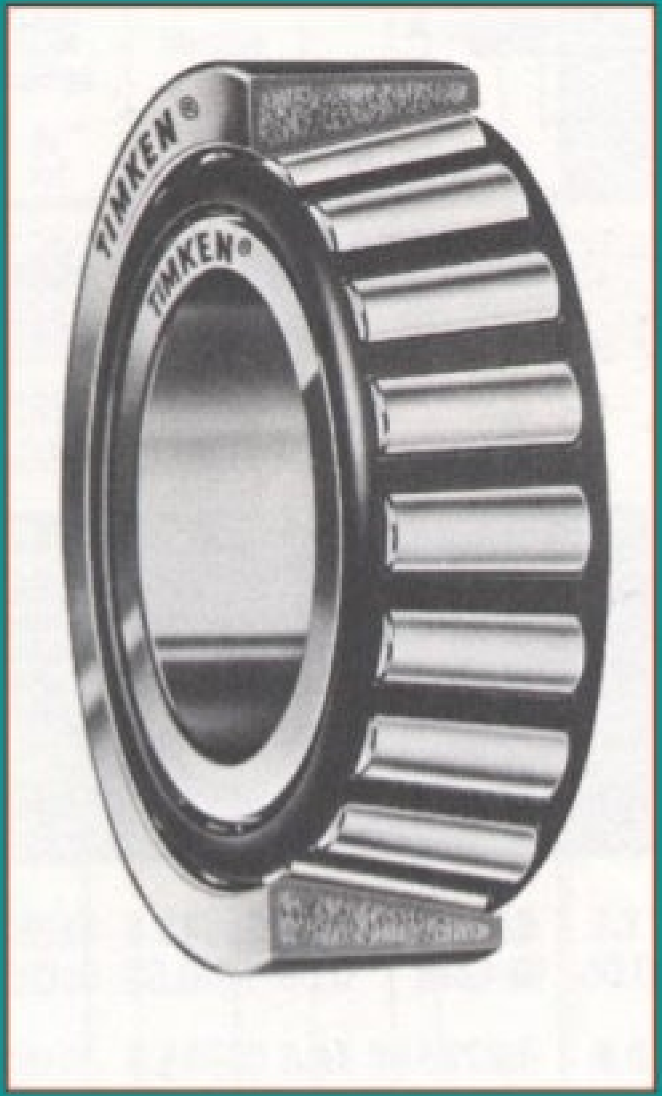
With inner race

Roller Bearings

Tapered bearings

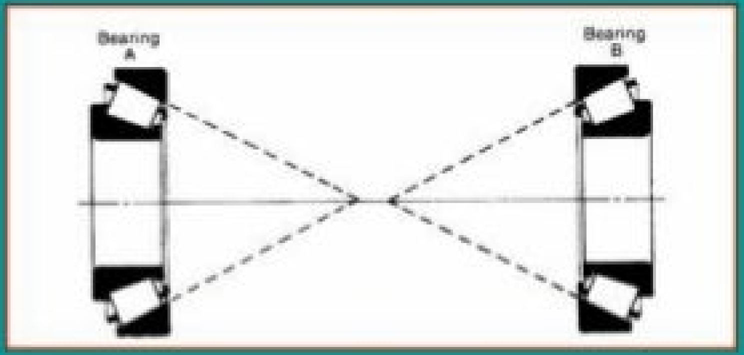
Designed to withstand high radial loads, high thrust loads, and combined loads at moderate to high speeds. They can also withstand repeated shock loads.





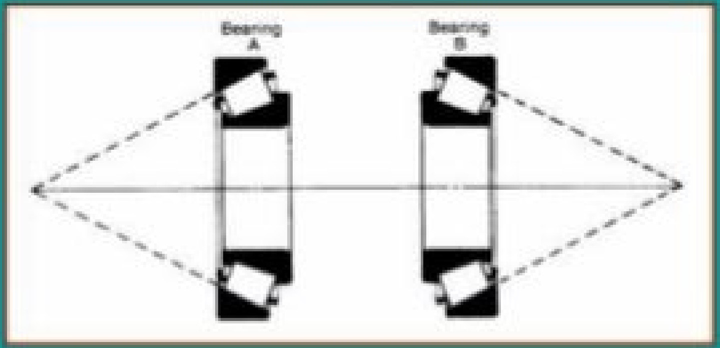
Tapered Bearings

Indirect and *Direct* mounting



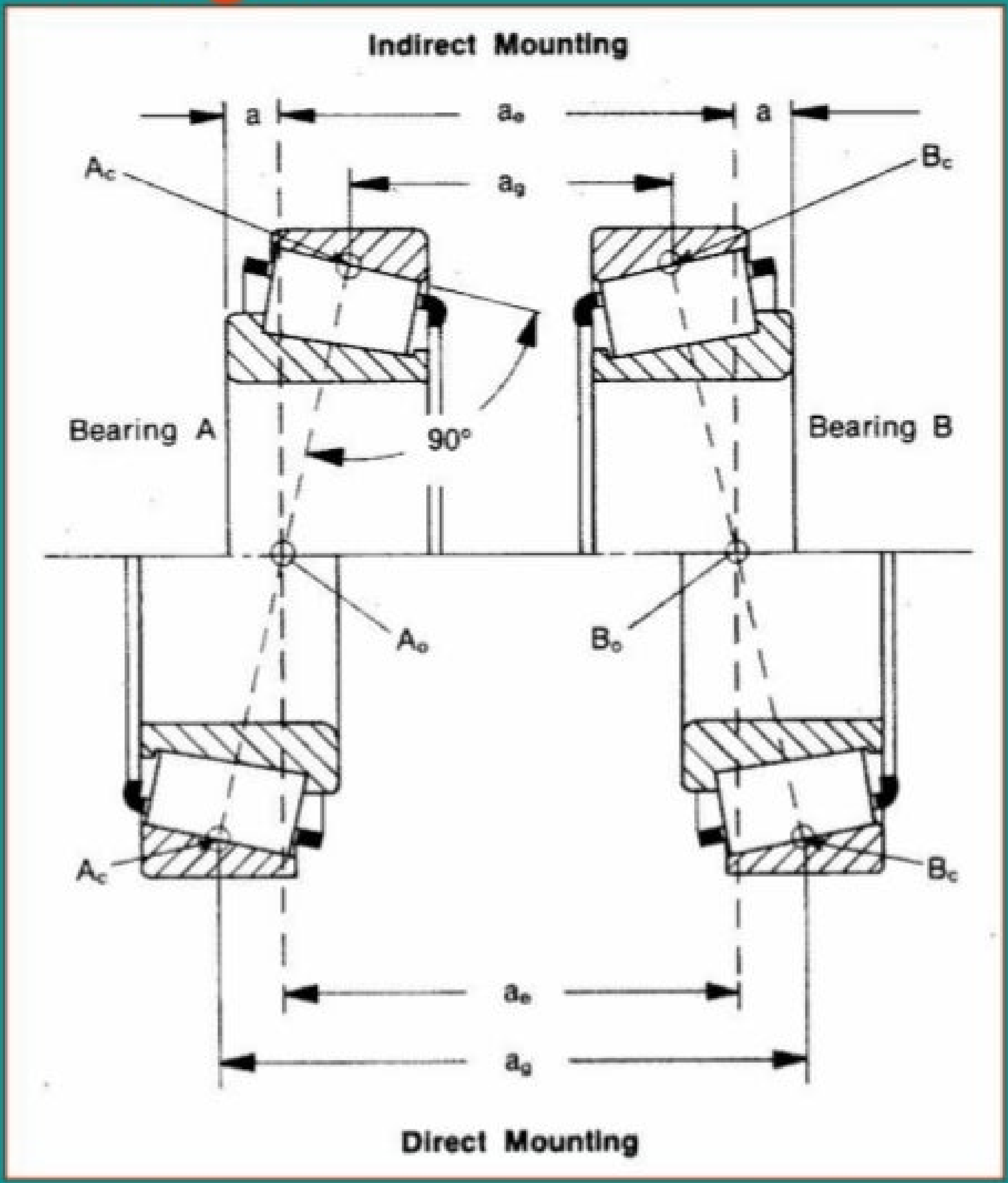
Indirect mounting

Indirect mounting provides greater rigidity when pair of bearings is **closely spaced**: front wheel of a car, drums, sheaves,..



Direct mounting

Direct mounting provides greater rigidity when pair of bearings is **not closely spaced**: transmission, speed reducers, rollers,..



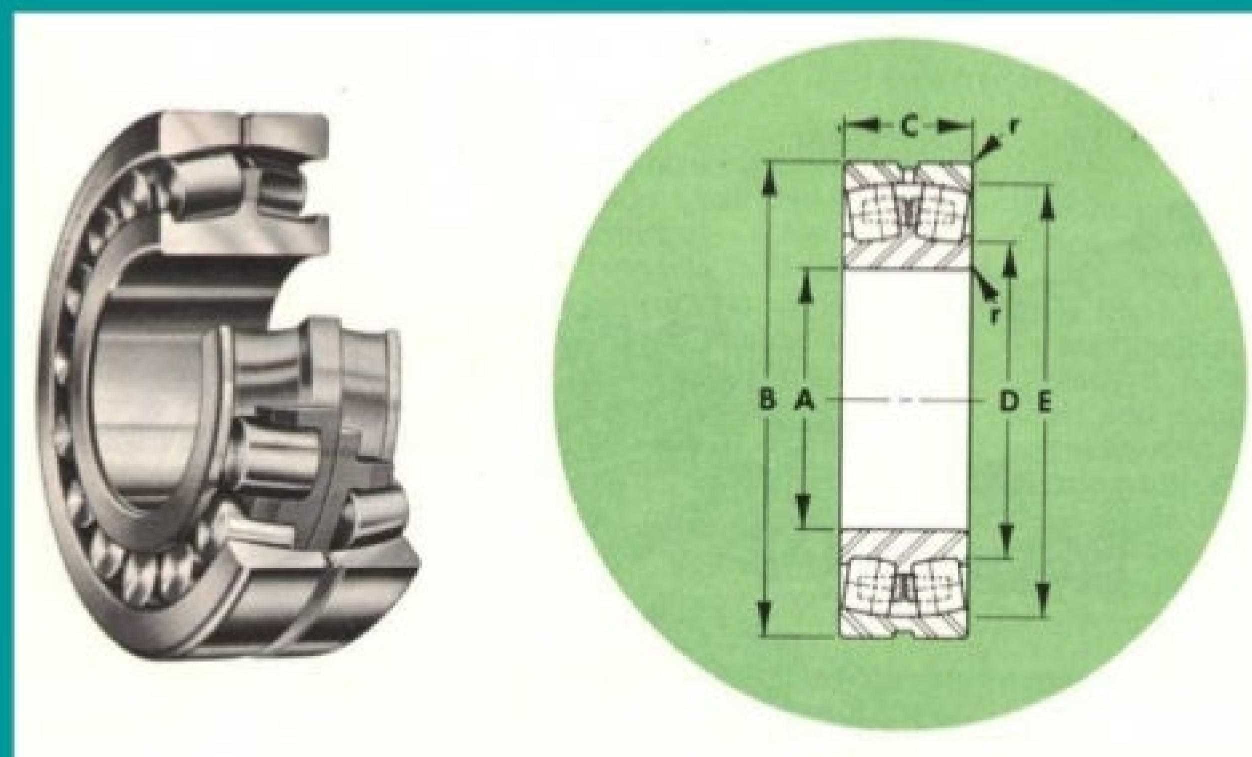
a_a = effective bearing spread

Measure of the rigidity of the bearing mounting

Roller Bearings

Spherical bearings

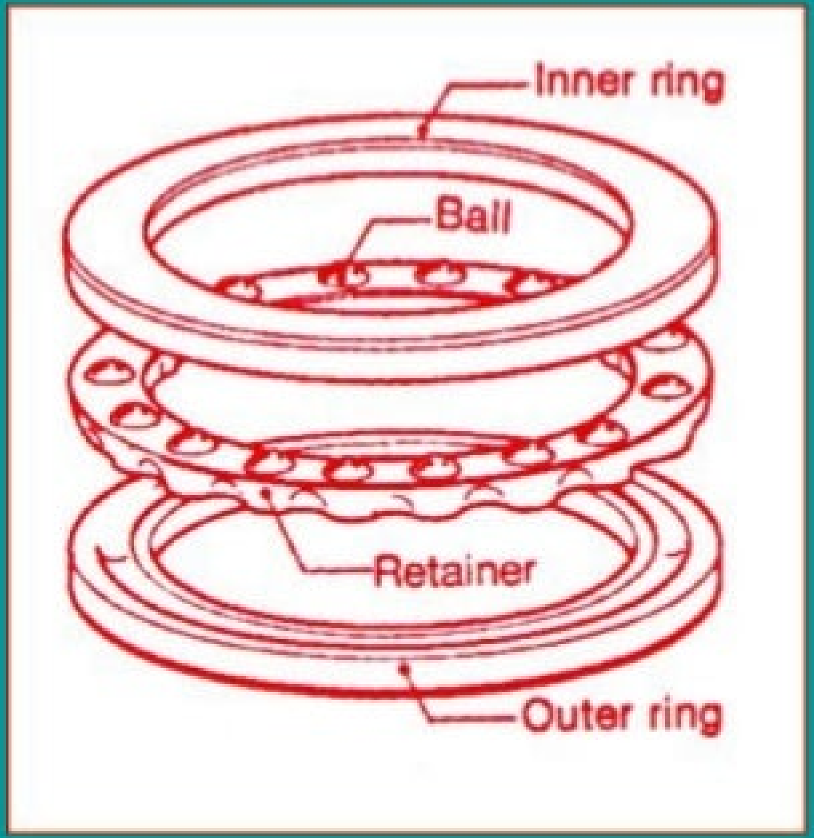
Bearing design uses barrel shaped rollers. Spherical roller bearings combine very high radial load capacity with modest thrust load capacity and *excellent tolerance to misalignment*.



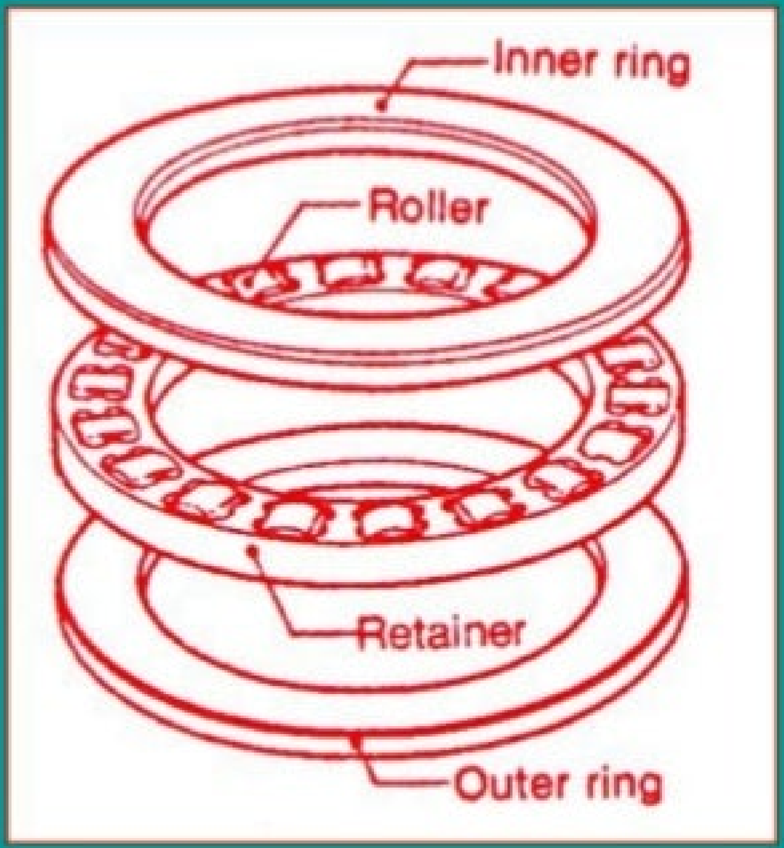
bearing number			nominal bearing dimensions							shoulder dimensions		weight lbs.	basic static capacity	§ approx. limiting speed	†basic dynamic capacity
series 222 straight bore	AFBMA reference number	series 222K tapered bore	A bore		B outside diameter		C width		*r	D max.	E min.	series 222 222K			
			mm	inch	mm	inch	mm	inch	inch	inch	inch		lbs.	rpm	lbs.
22207	35SD22	....	35	1.3780	72	2.8346	23	.9055	.04	1⅞	2 17/32	1.1	9500	5610	9100
22208	40SD22	....	40	1.5748	80	3.1496	23	.9055	.04	2	2¾	1.1	11500	5000	11000
22209	45SD22	22209 K	45	1.7717	85	3.3465	23	.9055	.04	2¾	3	1.2	12800	4610	12300

Thrust Bearings

Ball thrust bearing

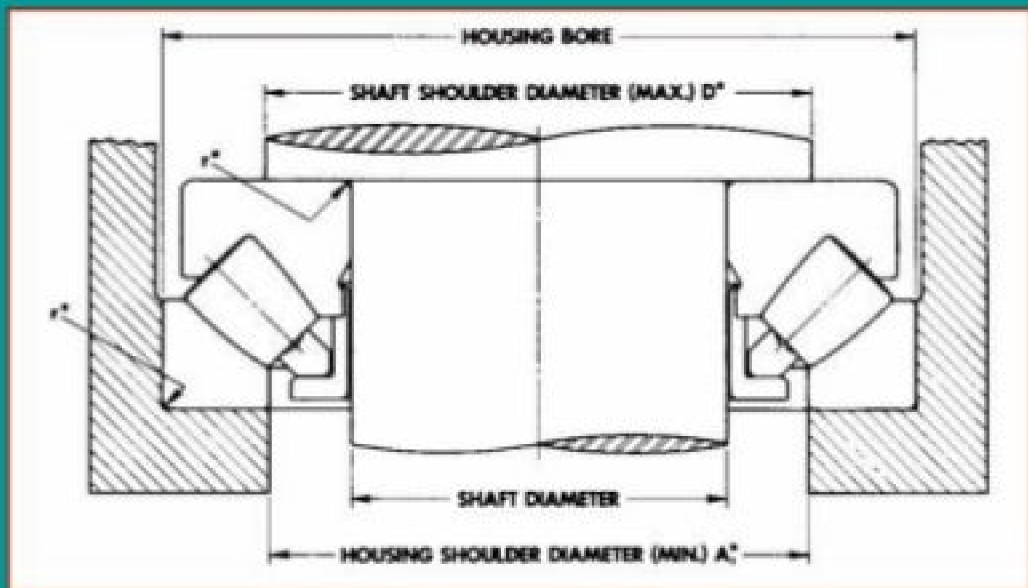


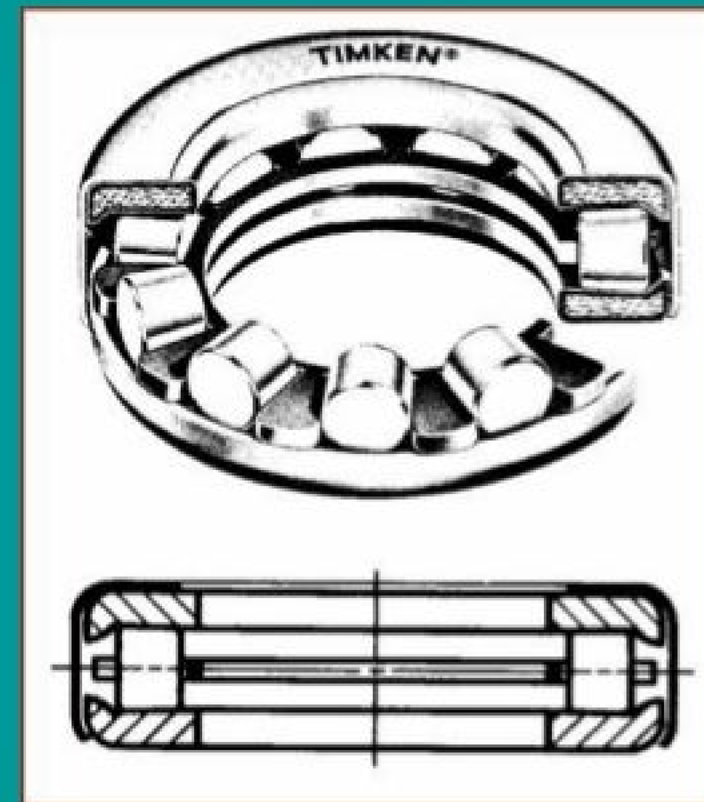
Roller thrust bearing



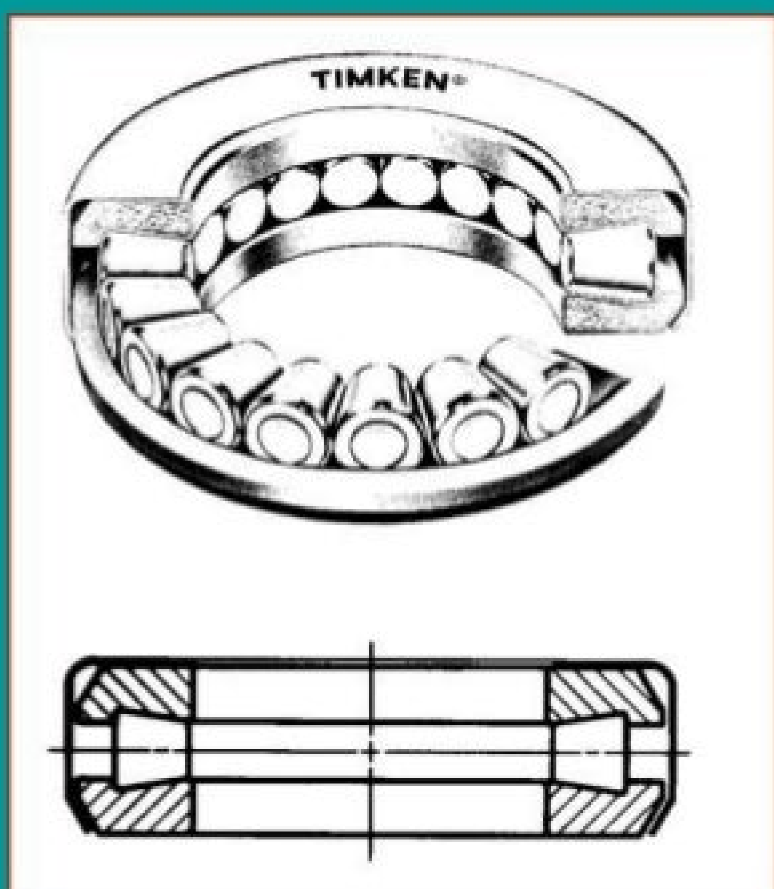
Roller Thrust Bearings

Spherical Thrust Bearings

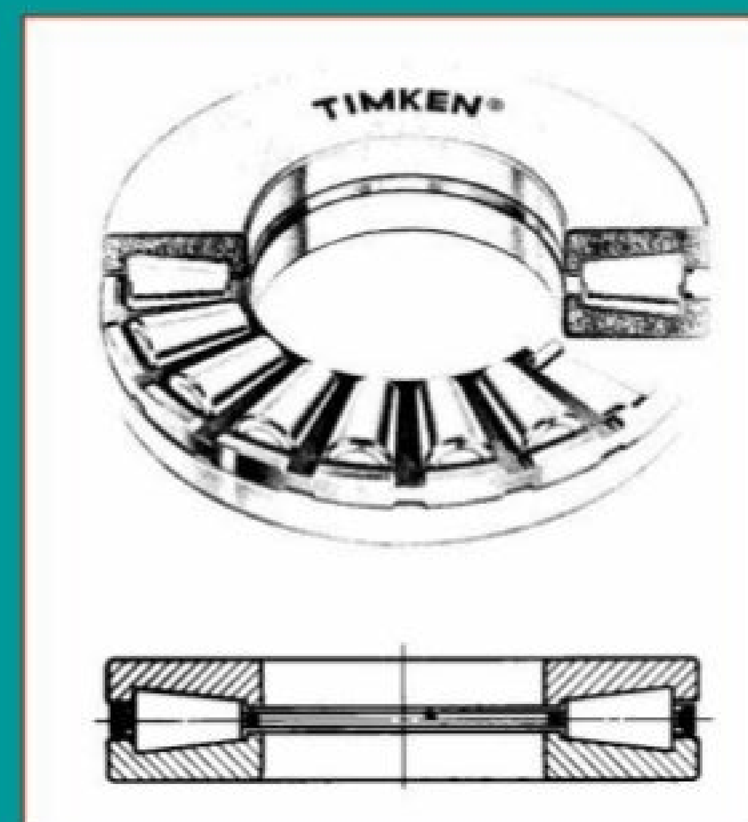




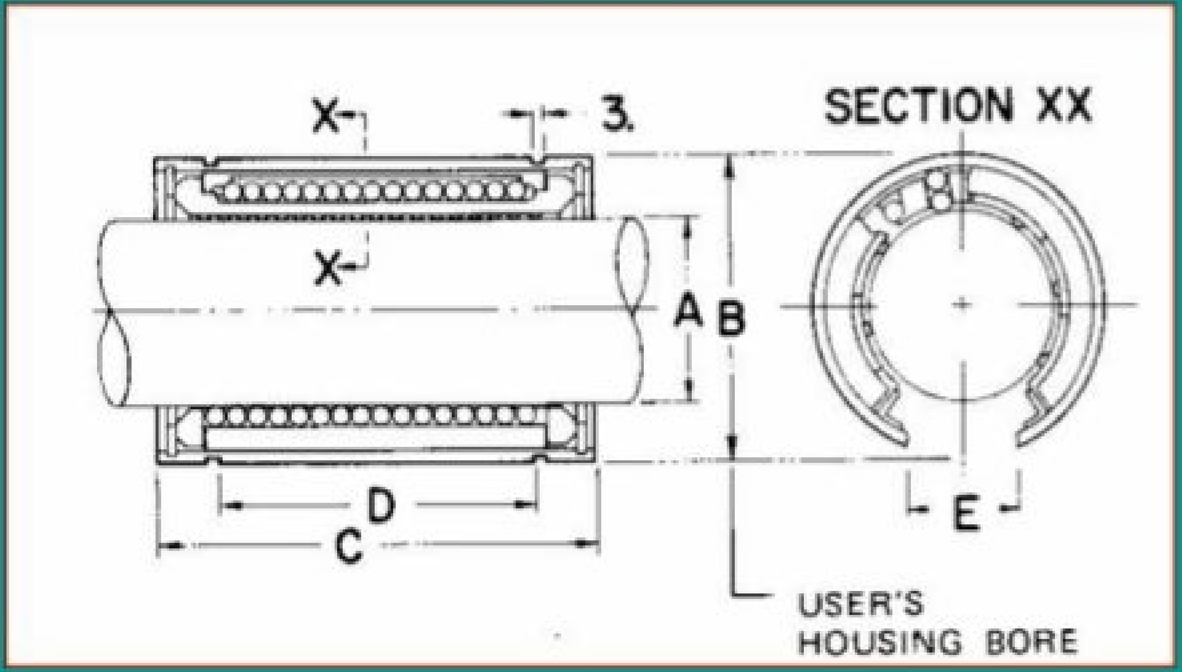
Cylindrical Thrust Bearings

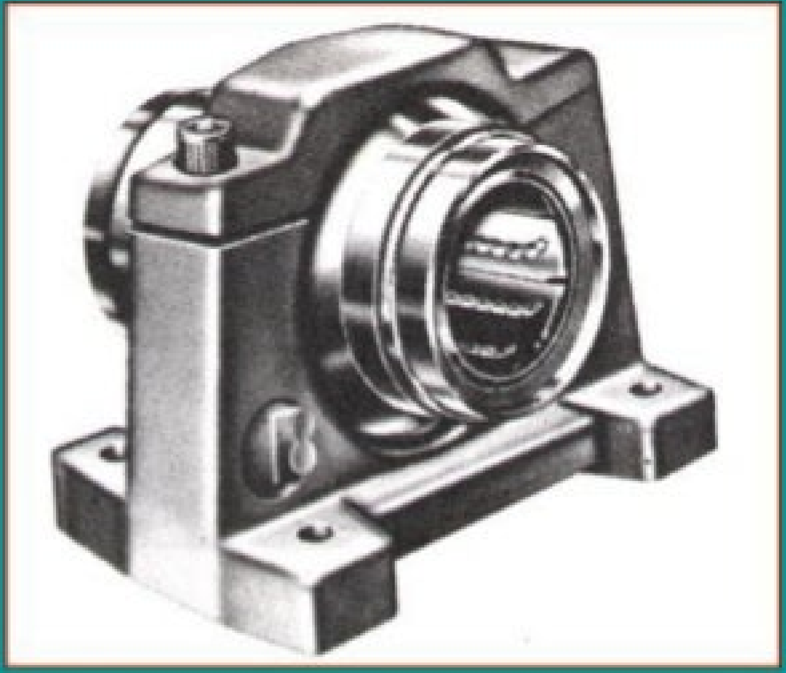


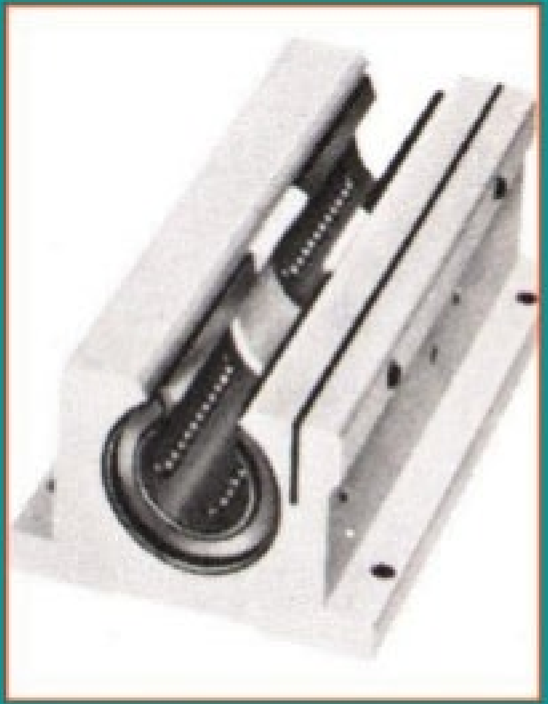
Tapered Thrust Bearings



Linear Bearings

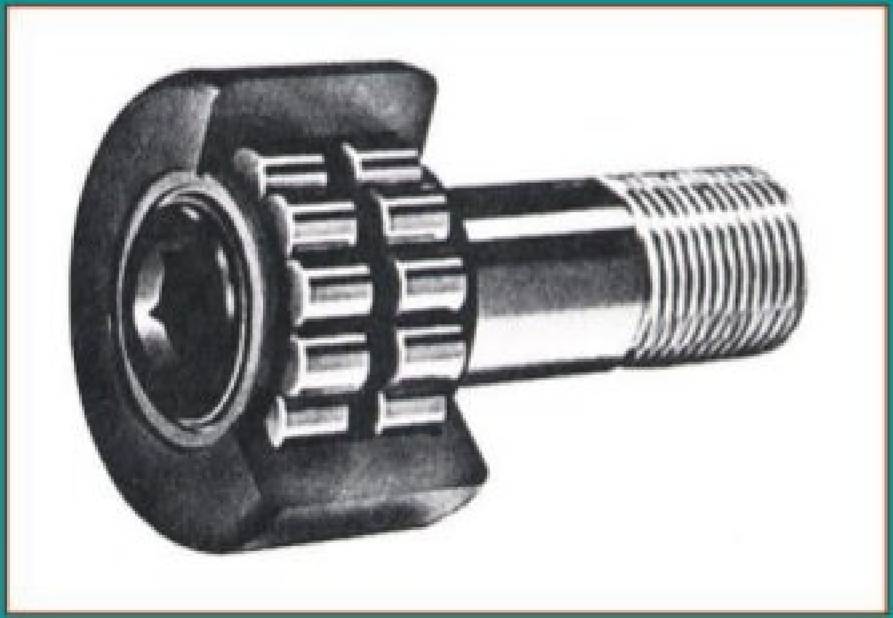




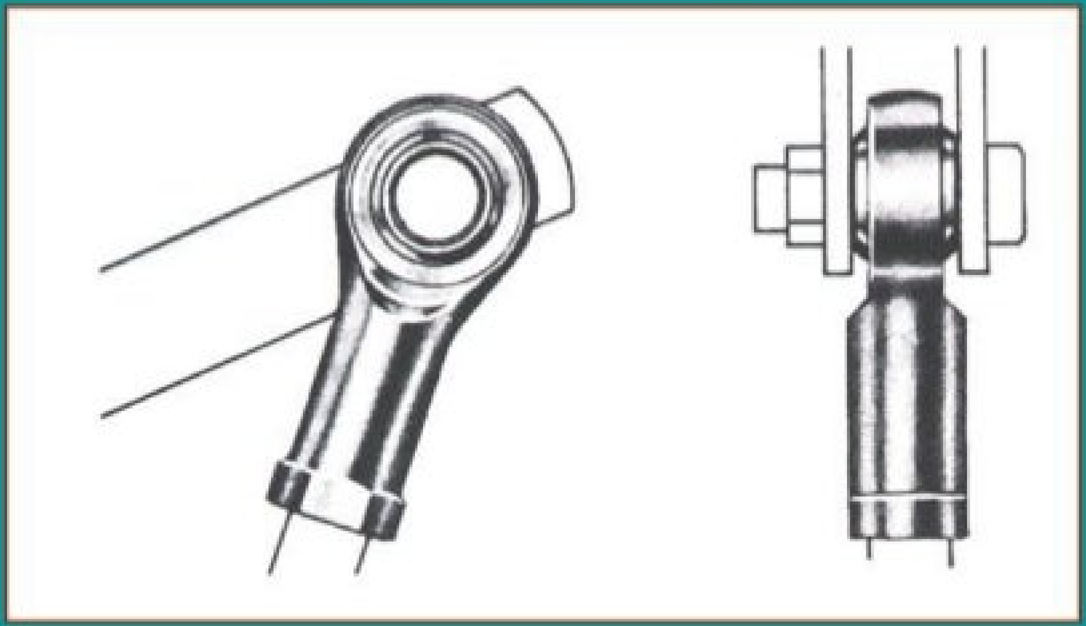


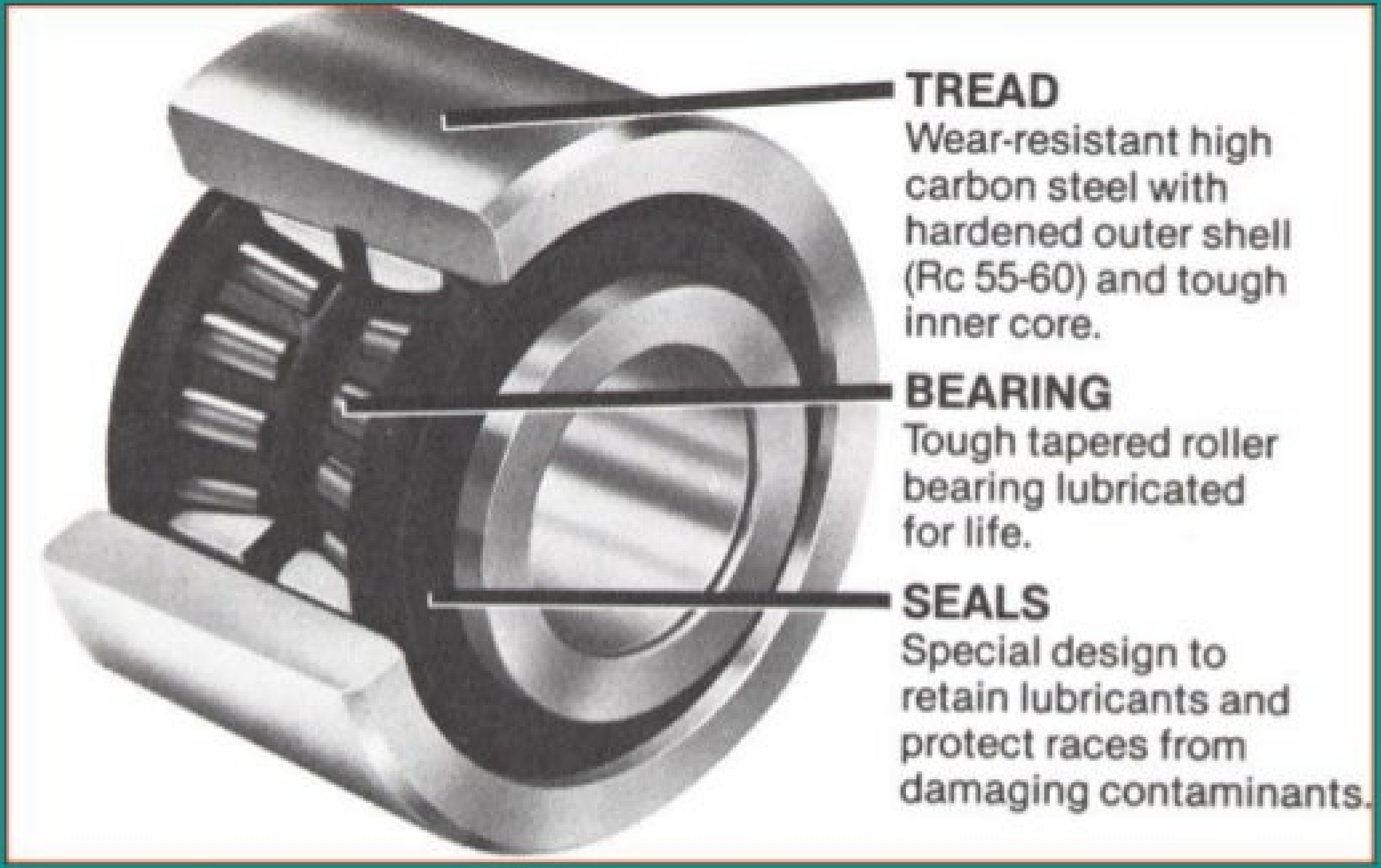
Bearings

Roller bearing cam follower



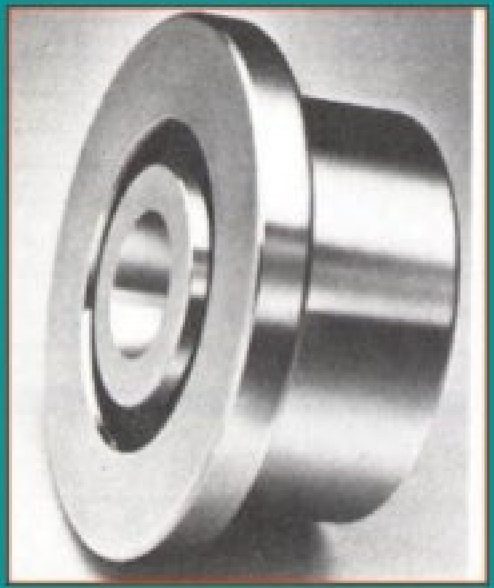
Spherical rod end





Load runners (idler-rollers)

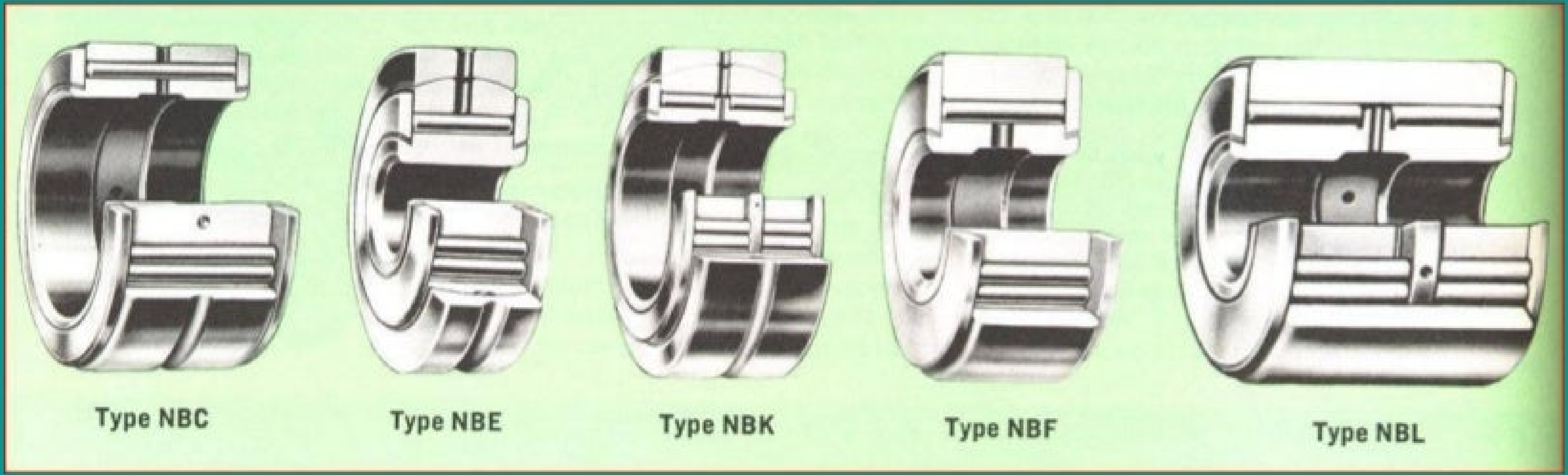
Flanged



V-Grooved

Bearings

Airframe control bearings – designed to meet the specific needs of the airframe industry, meets military and national standards.

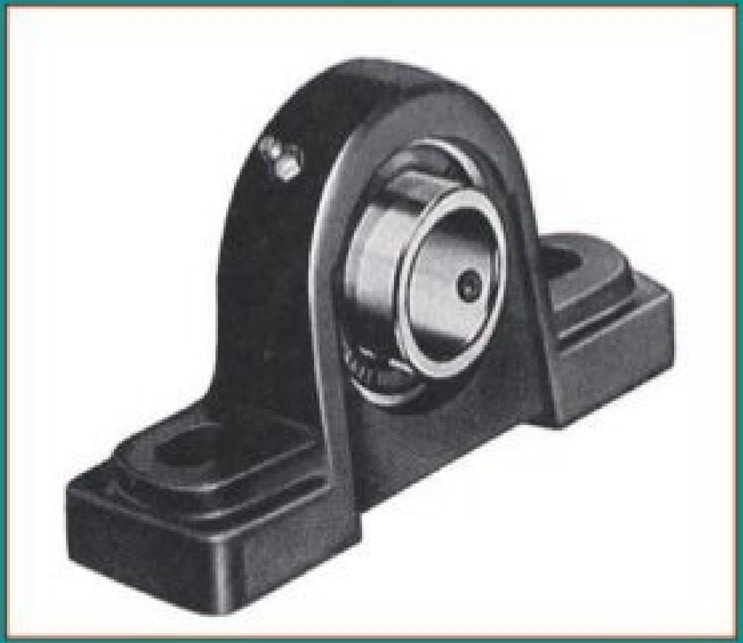


Designed to carry heavy static load and will also handle oscillation or slow rotation.

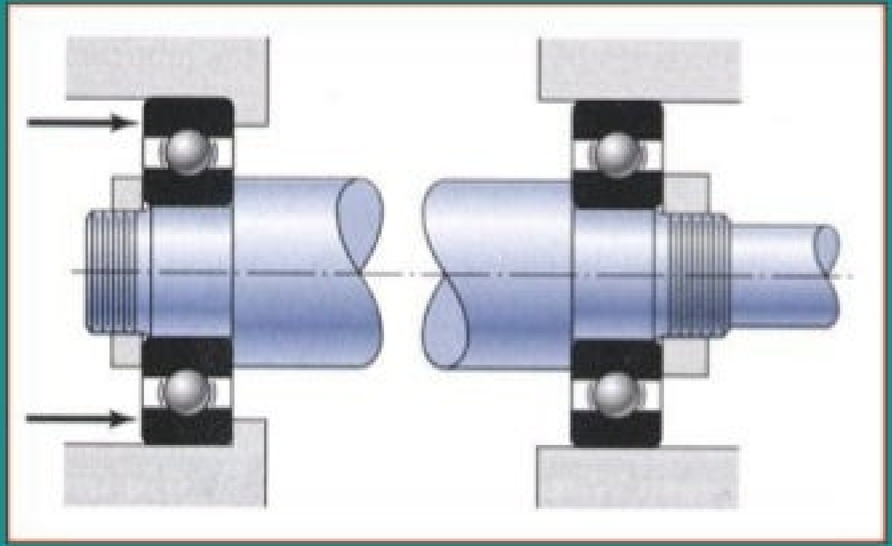
Track rollers, withstand heavy rolling loads.

Mounting Bearings

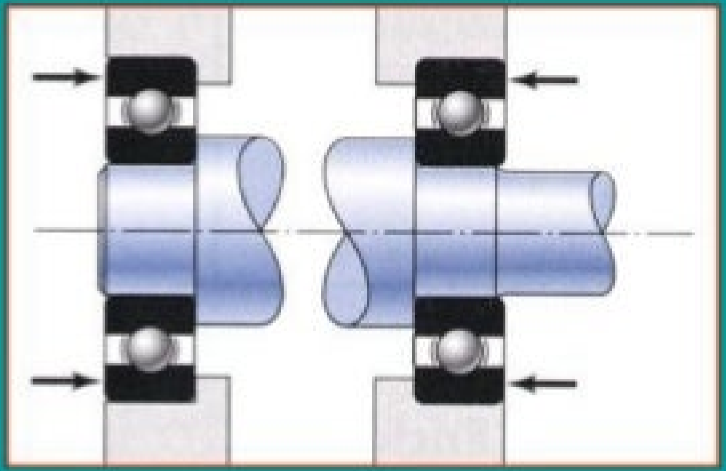
Pillow Block



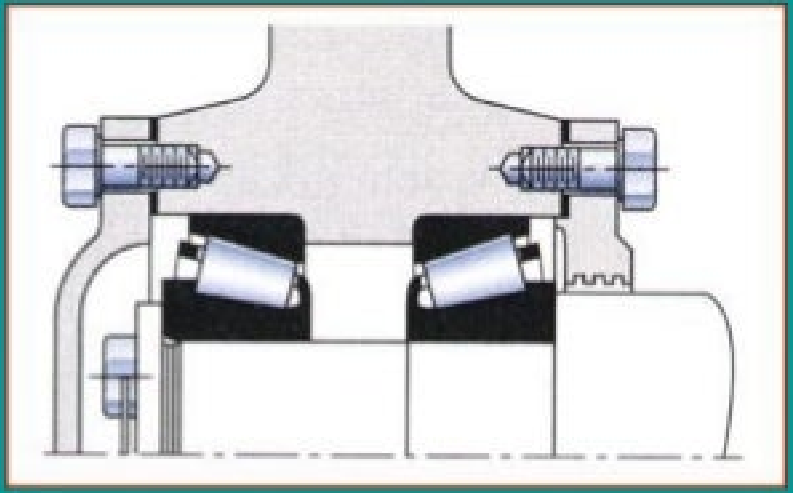
Flange



Common mounting, inner ring held in position by nuts threaded onto the shaft.



Alternative method, inner ring is press fitted onto the shaft.



Two-bearing mounting

Bearing Life

If a bearing is clean, properly lubricated and mounted and is operating at reasonable temp., failure is due to fatigue caused by ***repeated contact stresses*** (Hertzian stress)

Fatigue failure consists of a spalling or pitting of the curved surfaces

Spalling – crack initiates below the curved surface at the location of maximum shear stress, propagates to the surface causing surface damage.

Failure criterion – spalling or pitting of an area of 0.01 in^2, Timken company (tapered bearings)

Bearing Life

Life – number of revolution or hours of operation, at constant speed, required for the failure criterion to develop.

Rating Life – defines the number of revolution or hours of operation, at constant speed, in such a way that **90%** of the bearings tested (from the same group) will complete or exceed before the first evidence of failure develops. This is known as L_{10} life.

For ball bearings and spherical bearings:

L_{10} = 500 (hours) x 33.33 (rpm) x 60 = 10^6 = 1 million revolutions

For tapered bearings manufactured by Timken:

L_{10} = 3000 (hours) x 500 (rpm) x 60 = 90 x 10^6 = 90 million revolutions

Basic Dynamic Load Rating, C – constant radial load that a group of bearings can carry for L_{10} life.

Bearing Life

$L_{10} = (C / F)^a$, $a = 3$ for ball bearings and $a = 10/3$ for roller bearings

F = applied radial load

$$C_{10} (L_R n_R 60)^{1/a} = F_D (L_D n_D 60)^{1/a}$$

catalog rating

rating life in hours

rating speed

desired speed, r/min

desired life, hours

desired radial load, lb or kN

Solving for C_{10} gives

$$C_{10} = F_D \left(\frac{L_D n_D 60}{L_R n_R 60} \right)^{1/a}$$

Example

Select a deep groove ball bearing for a desired life of 5000 hours at 1725 rpm with 90% reliability. The bearing radial load is 400 lb.

$$C_{10} = F_D \left(\frac{L_D n_D 60}{L_R n_R 60} \right)^{1/a} = 400 \left[\frac{5000(1725)60}{10^6} \right]^{1/3} = 3211 \text{ lb } = 14.3 \text{ kN}$$

Bore, mm	OD, mm	Width, mm	Fillet Radius, mm	Shoulder Diameter, mm d_S	Shoulder Diameter, mm d_H	Load Ratings, kN Deep Groove C	Load Ratings, kN Deep Groove C_0	Load Ratings, kN Angular Contact C	Load Ratings, kN Angular Contact C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0

Bearing Reliability

If a machine is assembled with 4 bearings, each having a reliability of 90%, then the reliability of the system is $(.9)^4 = .65 = 65\%$. This points out the need to select bearings with higher than 90% reliability.

The distribution of bearing failure can be best approximated by ***two and three parameter Weibull distribution.***

$$\frac{1}{R} = \exp\left[\left(\frac{L/L_{10} - 0.02}{4.439}\right)^{1.483}\right] \Rightarrow L_{10} = \frac{L}{0.02 + 4.439[\ln(1/R)]^{1/1.483}}$$

$$C_{10} = F_D\left(\frac{L_D n_D 60}{L_R n_R 60}\right)^{1/a} \Rightarrow C_{10} = F_D\left\{\frac{(L_D n_D / L_R n_R)}{0.02 + 4.439[\ln(1/R)]^{1/1.483}}\right\}^{1/a}$$

$$C_{10} = F_D\left\{\frac{(L_D n_D / L_R n_R)}{4.48[\ln(1/R)]^{1/1.5}}\right\}^{3/10}$$

Two parameter Weibull distribution for tapered bearings

C_{10} is the catalog basic dynamic load rating corresponding to L_R hours of life at the speed of n_R rpm.

Example

Select a deep groove ball bearing for a desired life of 5000 hours at 1725 rpm ***with 99% reliability***. The bearing radial load is 400 lb.

For 90% reliability

$C_{10} = 14.3$ kN ⟹ 30 mm Bore deep groove bearing

Use 99% reliability, R = .99

$$F_R = F_D \left\{ \frac{(L_D n_D / L_R n_R)}{0.02 + 4.439[\ln(1/R)]^{1/1.483}} \right\}^{1/a} = 23.7 \text{ kN}$$

			Fillet	Shoulder		Load Ratings, kN			
						Deep Groove		Angular Contact	
Bore, mm	OD, mm	Width, mm	Radius, mm	Diameter, mm d_S	d_H	C	C_0	C	C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0

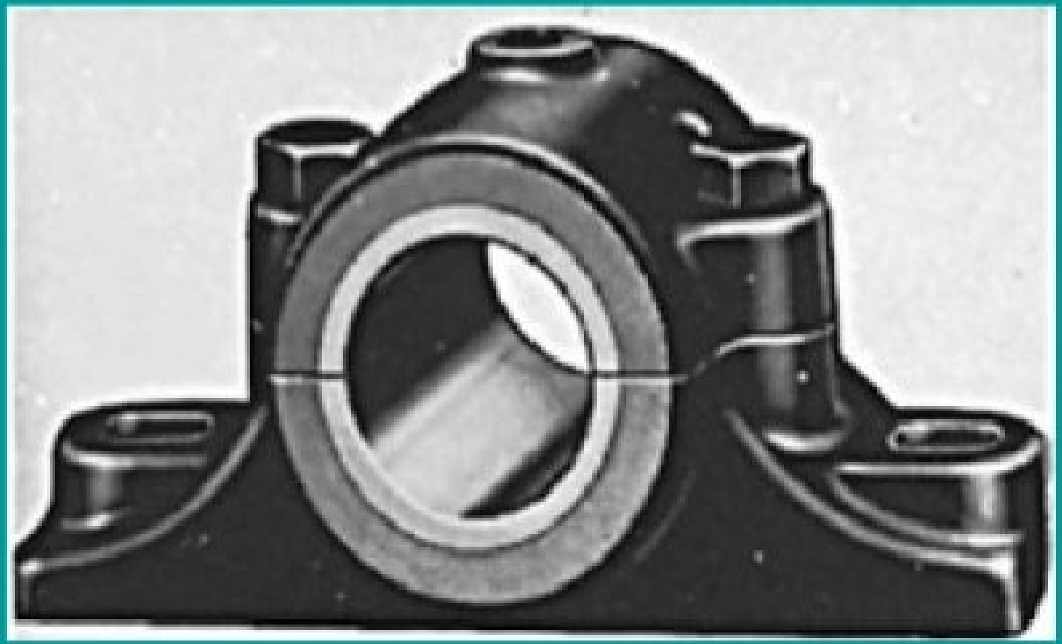
Select a 35 mm bearing instead of 30 mm for 90% reliability

$L_{new\ D} = L_D / .22 =$

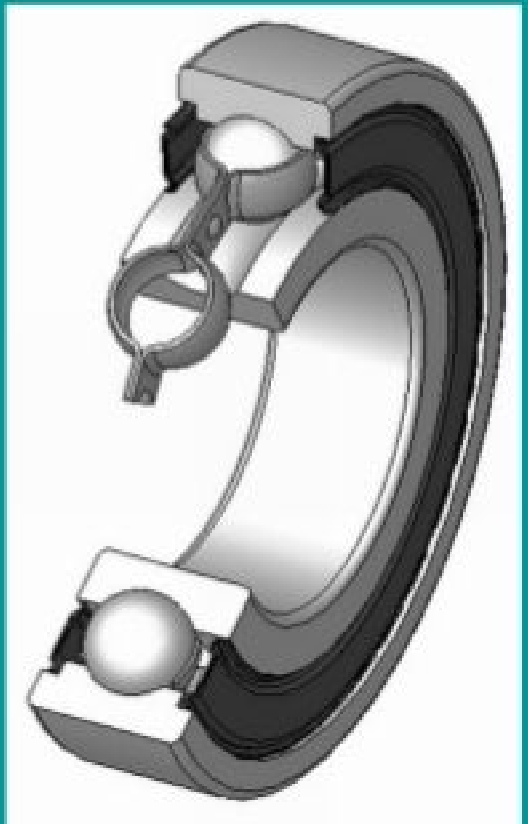
5000 / .22 = 22,770 hours

Bearings are classified under two main categories:

- **Plain or slider bearing** : -
  - In which the rotating shaft has a sliding contact with the bearing which is held stationary . Due to large contact area friction between mating parts is high requiring greater lubrication.

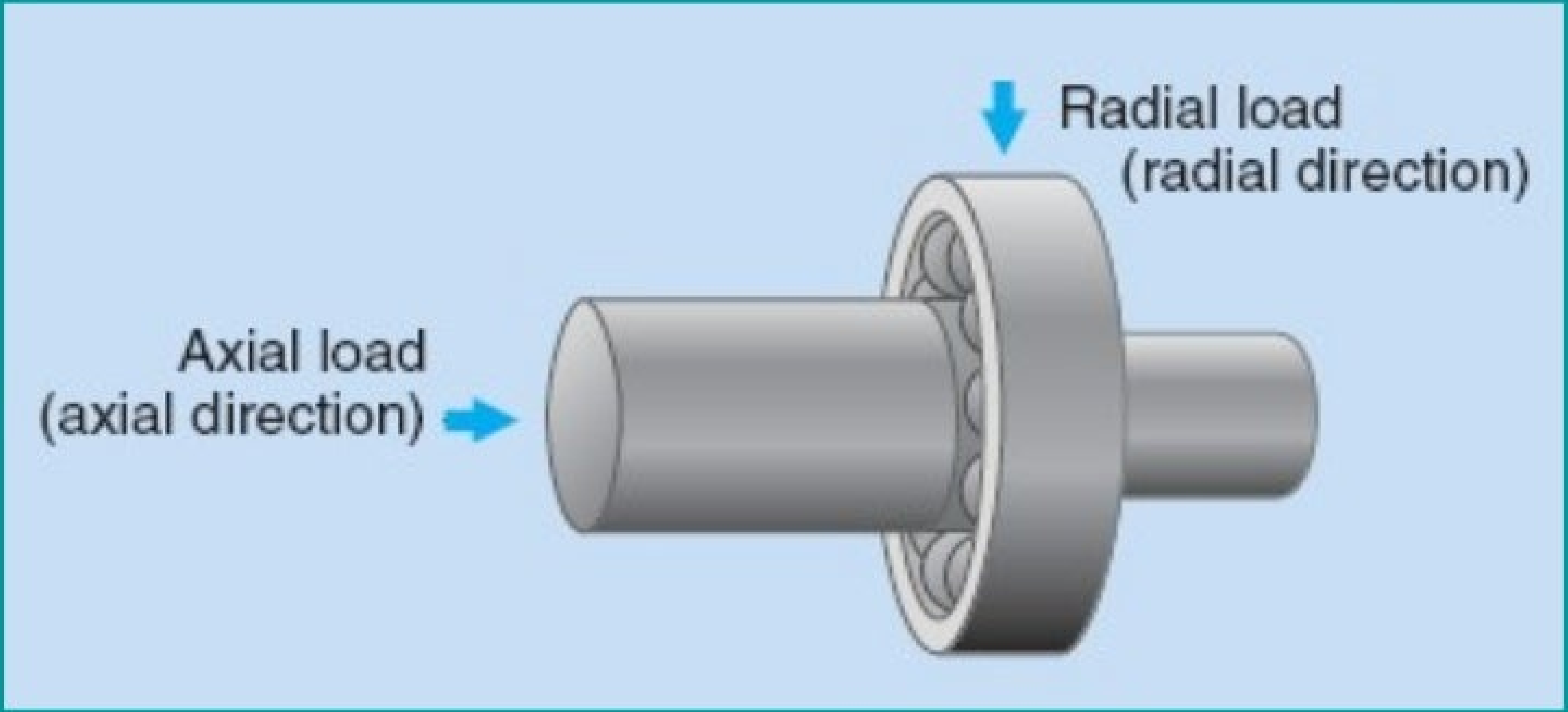


- **Rolling or anti-friction bearing** :
  - Due to less contact area rolling friction is much lesser than the sliding friction , hence these bearings are also known as **antifriction bearing**.



Rolling or anti-friction bearing

Load Direction and Name



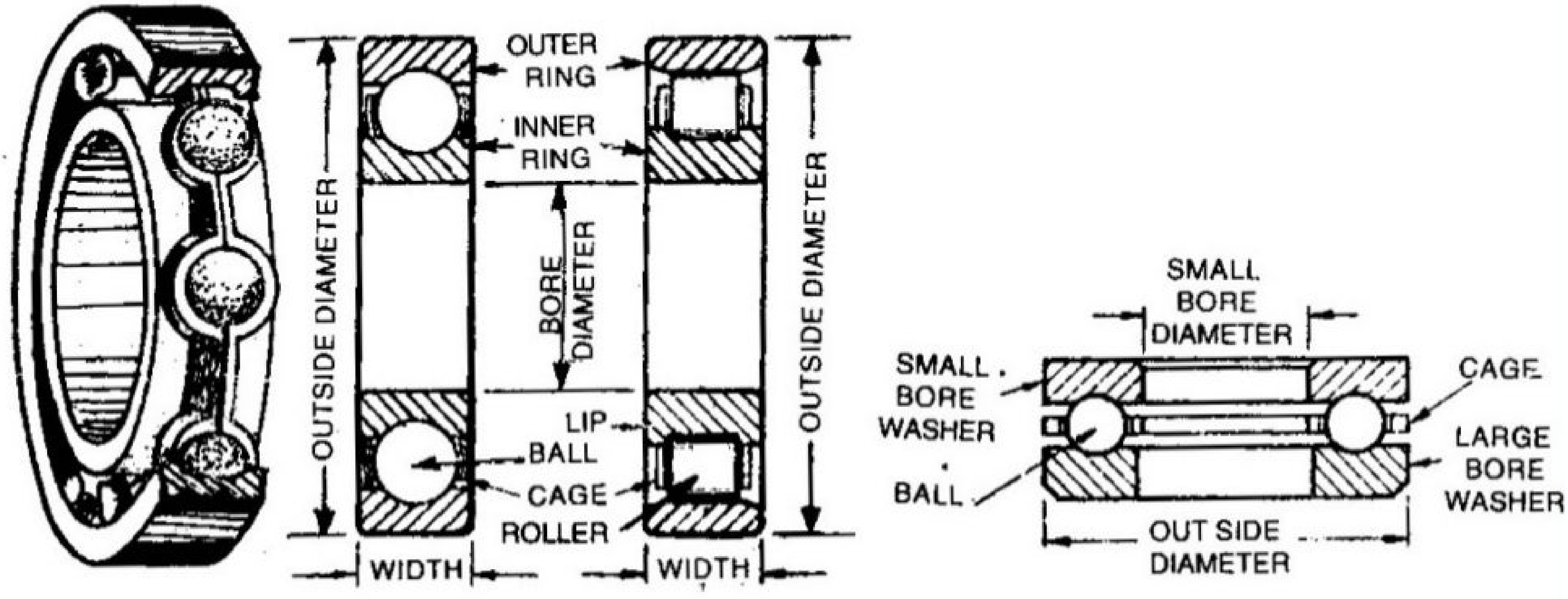
Ball and roller bearings (due to low rolling friction these bearings are aptly called "antifriction" bearing.)

- Frictional resistance considerably less than in plain bearings
- Rotating – non-rotating pairs separated by balls or rollers
- Ball or rollers has rolling contact and sliding friction is eliminated and replaced by much lower rolling friction.
- In plain bearing the starting resistance is much larger than the running resistance due to absence of oil film.
- In ball and rolling bearings the initial resistance to motion is only slightly more than their resistance to continuous running.
- Hence ball and rolling bearing are more suitable to drives subject to frequent starting and stopping as they save power.
- Owing to the low starting torque, a low power motor can be used for a line shaft running in ball bearing.

Types of rolling bearing

- Single row deep-groove ball bearing:
  - Incorporating a deep hardened raceway which makes them suitable for radial and axial loads in either direction, provided the radial loads are greater than the axial loads.
- Single row roller bearing:
  - Roller bearing have a greater load-carrying capacity than ball bearing of equivalent size as they make line contact rather than point contact with their rings.
    - Not suitable for axial loading, cheaper to manufacture, used for heavy and sudden loading, high speed and continuous service.

Ball and Roller bearing

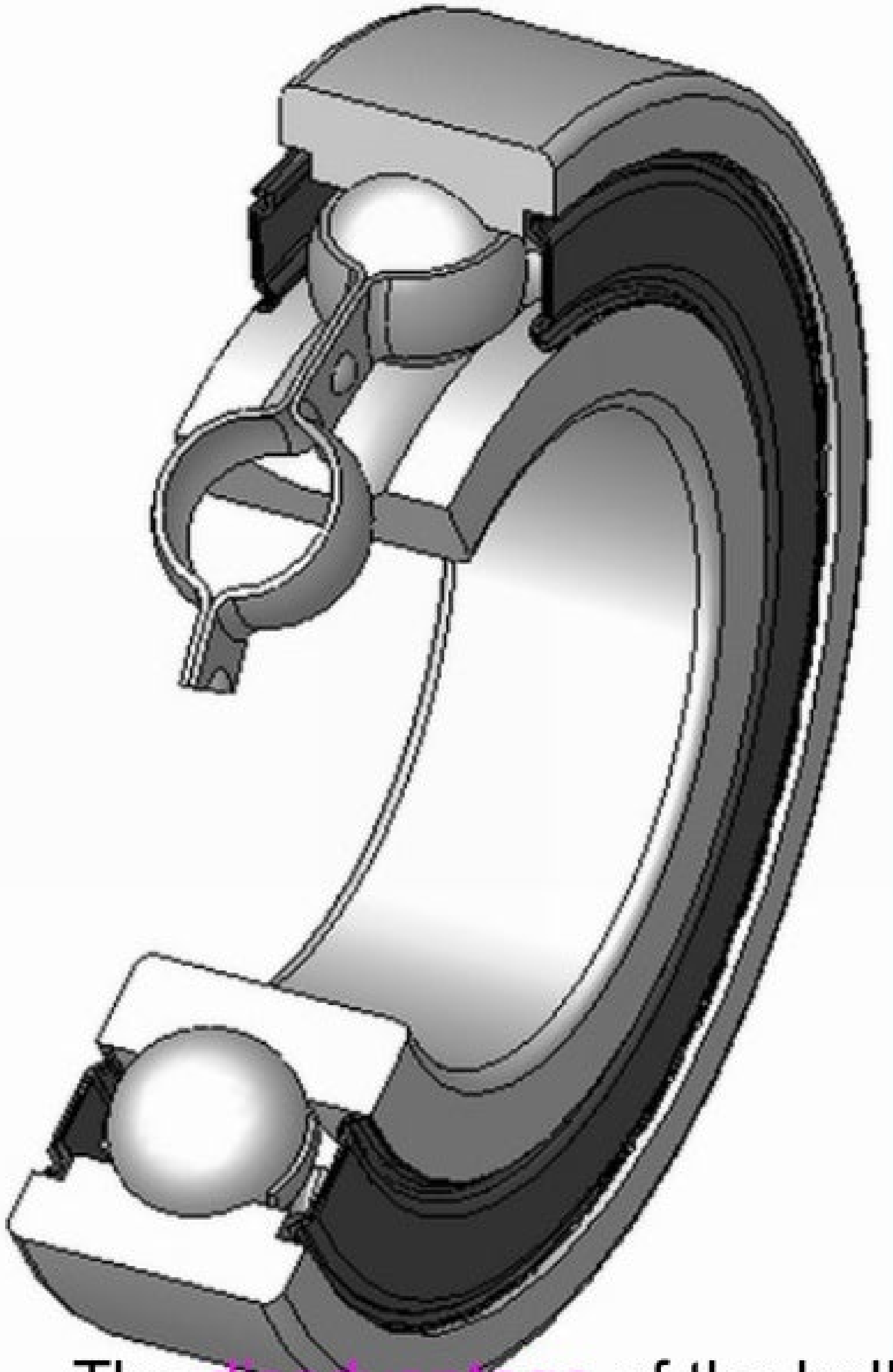


(a) Ball bearing (b) Rolled bearing (c) Thrust ball bearing

Ball and roller bearing

Races and balls are high carbon chrome steel (to provide resistance to wear) machined and ground to fine limits of 0.0025 mm, highly polished and hardened.

The cages are made of low-carbon steel, bronzes or brasses, though for high temperature application case-hardened and stainless steels are used.

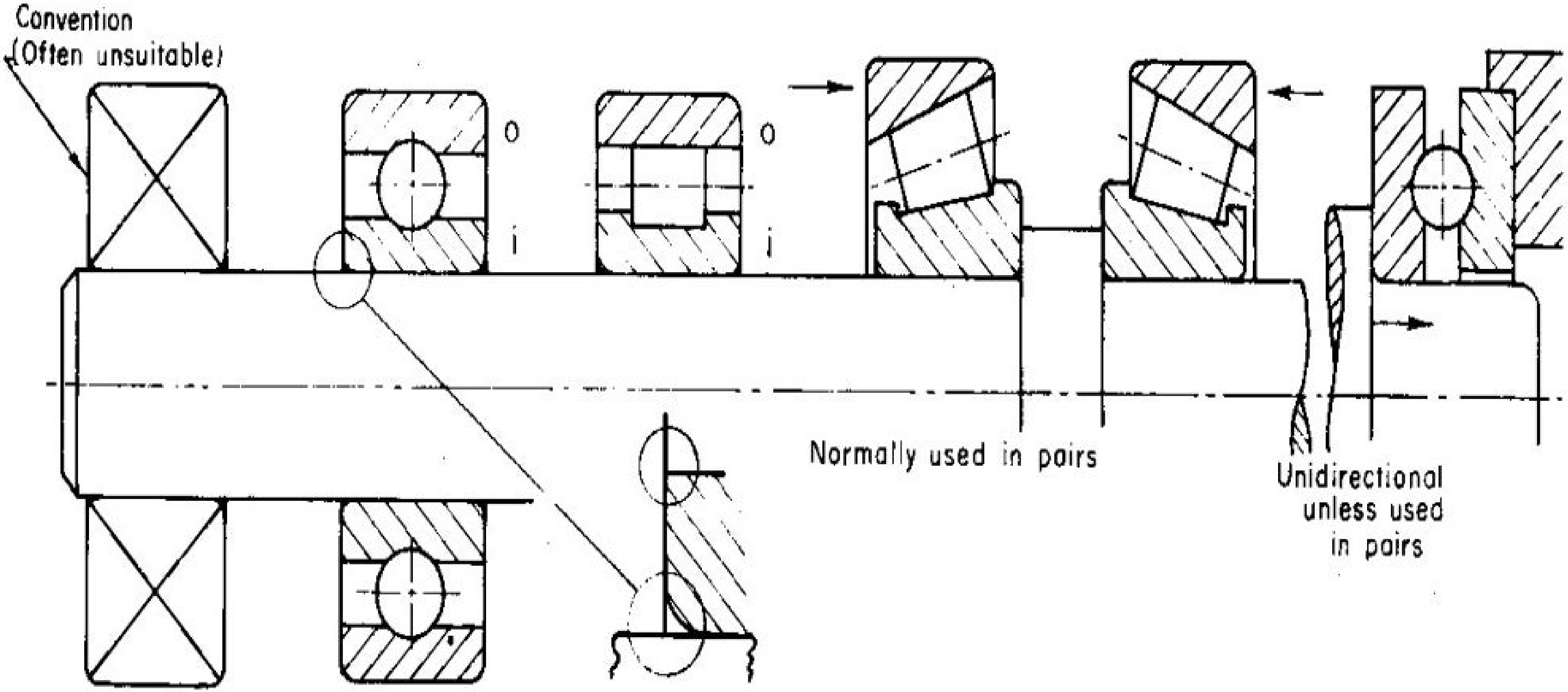


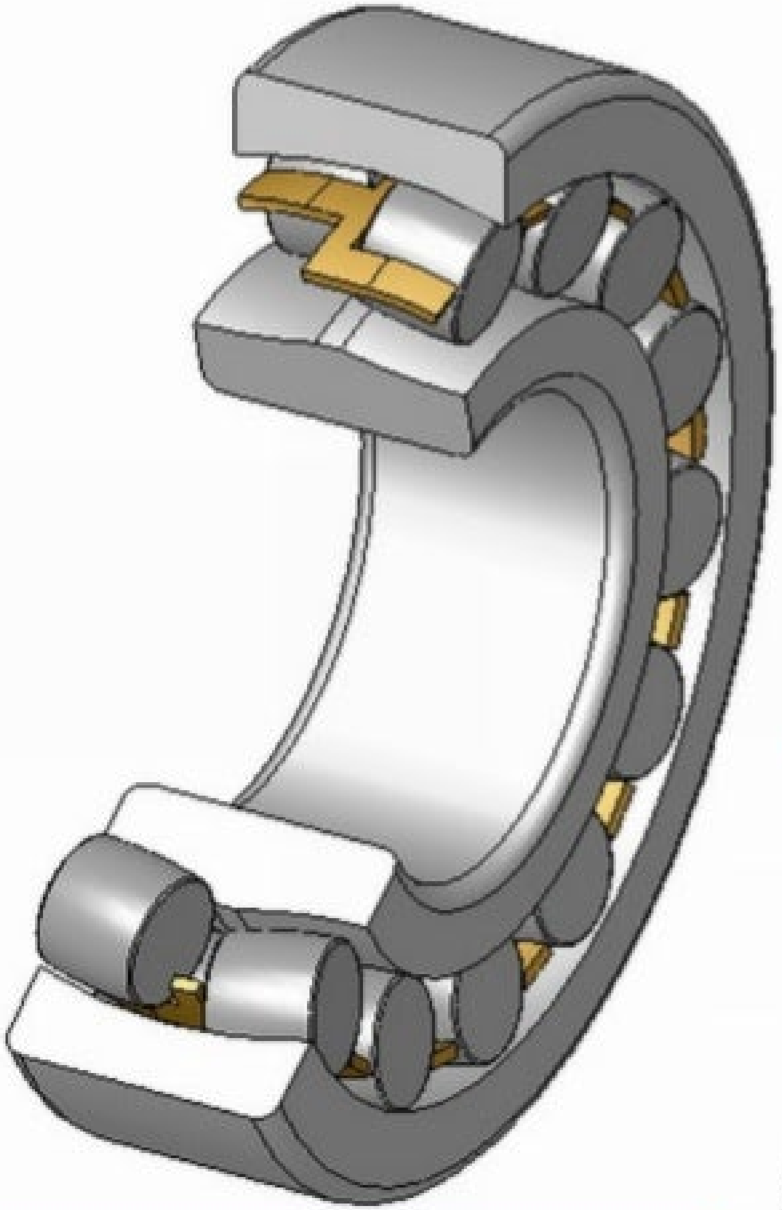
The ball and roller bearing consists of following parts:

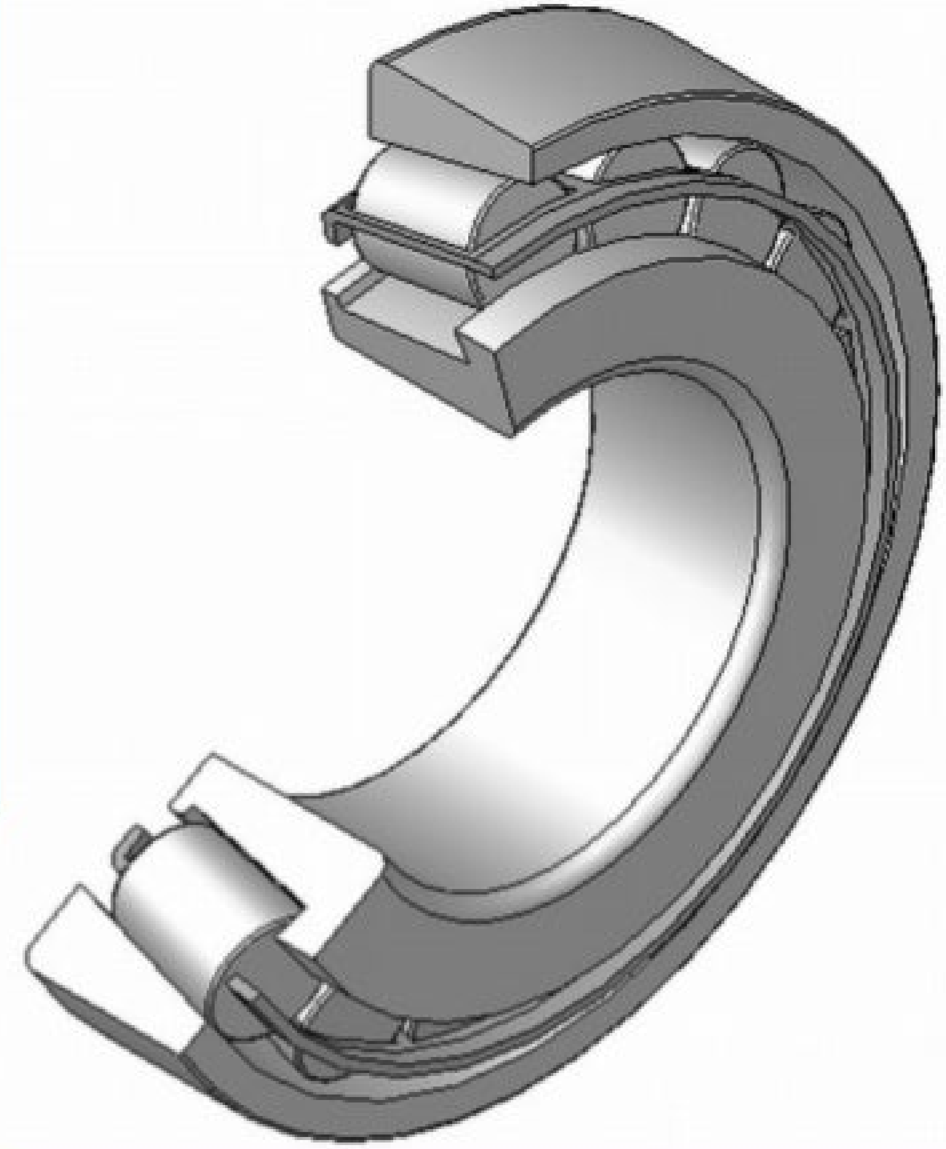
- Inner ring or race which fits on the shaft.
- Outer ring or race which fits inside the housing.
- Ball and roller arranged between the surfaces of two races. These provide rolling action between the races.
  - the radius of the track for balls is slightly greater 5 to 10 % than that of the ball themselves.
  - Note that the rotating surfaces rotate in opposite directions.
- Cage which separates the balls or rollers from one another.

The disadvantage of the ball and roller bearings are high cost, they cannot be used in half, and greater noise.

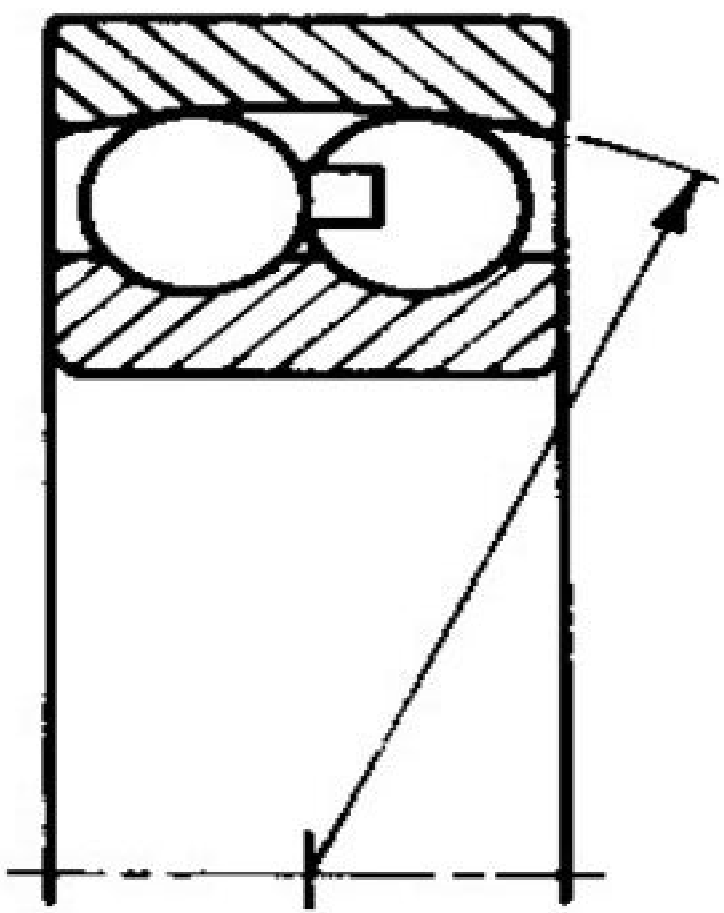
Types of bearing



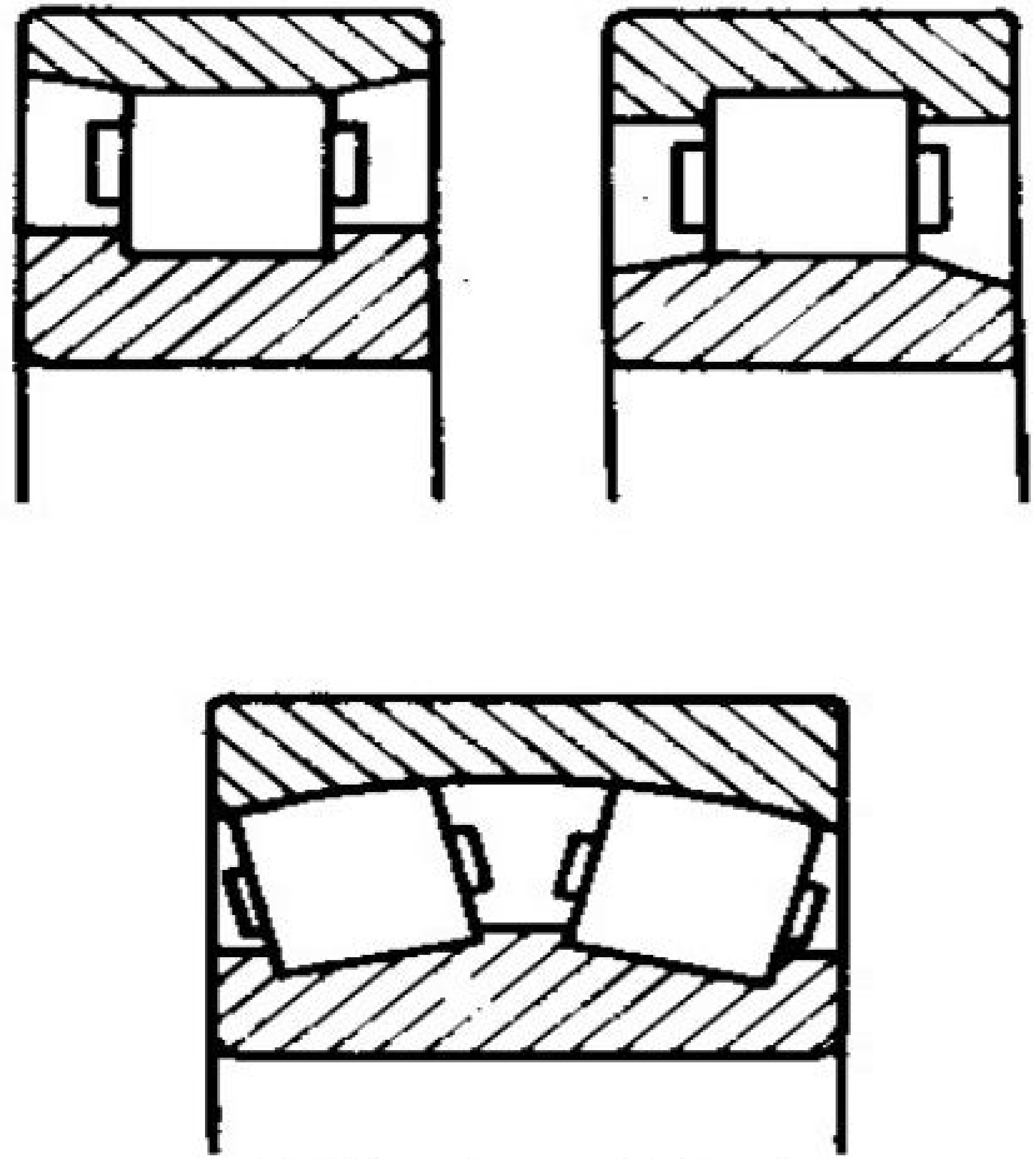




Types of ball bearings



(*a*) Double-row self-algning ball beaing



(*b*) Single and double-row roller bearing

Types of Bearings - Presentation Transcript

1. ROLLER BEARINGS

2. Bearings are used to support rotating shafts and are classified according to the direction of the main load. Axial bearings are designed to withstand axial thrust. Radial bearings are designed to withstand radial loads.

3. Bearings types: A bearing is constituted by an inner and an outer ring. Between them a series of rolling element is found. Sometimes a fourth element (cage) is present to keep the rolling elements in their position. Rolling elements can be spheres (ball bearing) or cylinders (cylindrical roller bearings).

4. Deep groove ball bearing
   Good capacity to withstand radial and axial loads
   May be of sealed type
   Available in a wide range of build precision
   Low cost
   Moderate tolerant towards misalignment

5. Angular contact ball bearing
   Increased capacity to withstand axial loads
   Coupled with another bearing of the same kind can withstand high bending torques

6. Self aligning ball bearing
   Very good capacity to tolerate misalignment
   Can't withstand axial loads

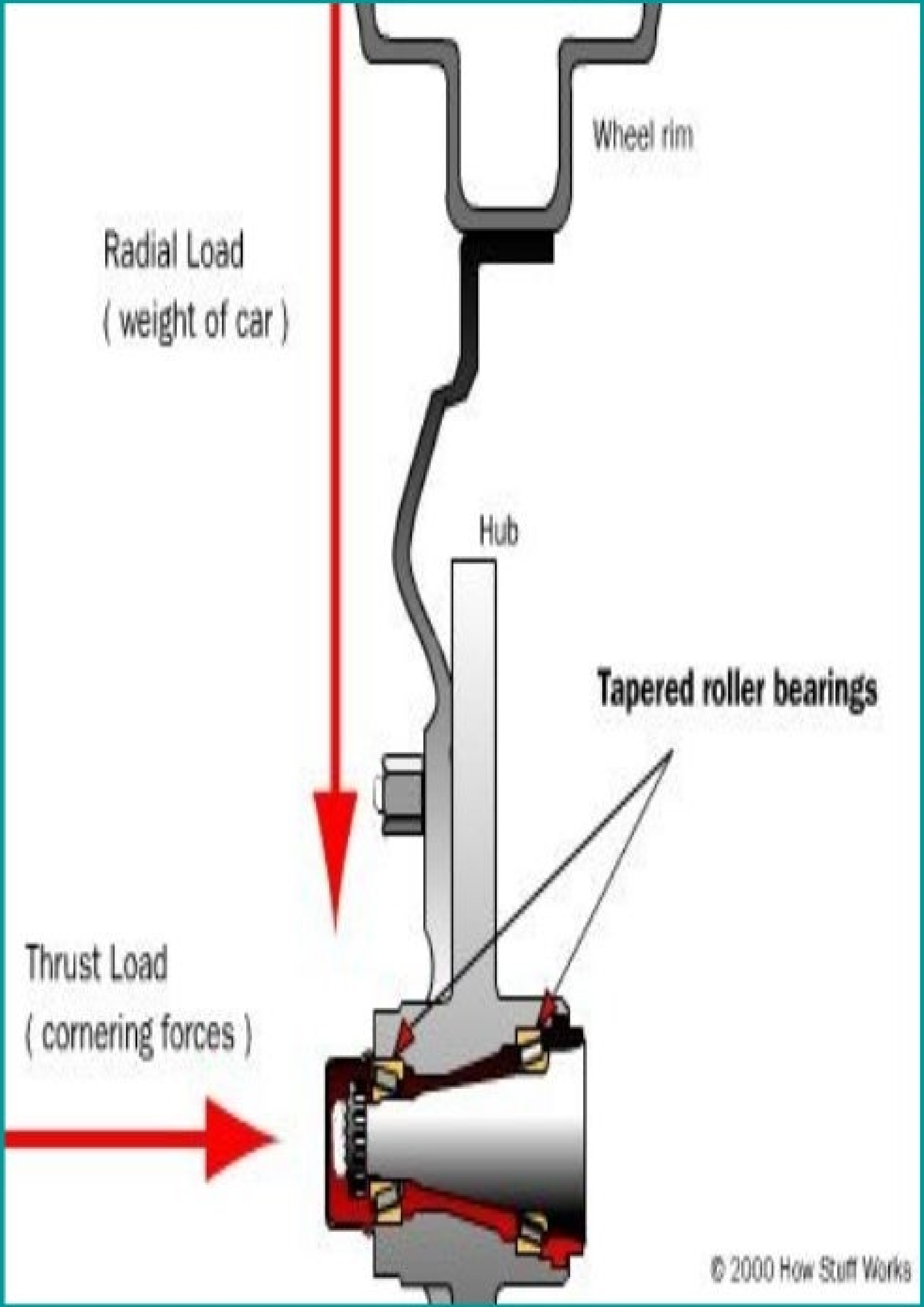
7. Cylindrical roller bearings
   High radial load
   Can't withstand axial loads

8. Needle roller bearings

9. Taper roller bearings
   High radial load
   High axial load in one direction

10. Thrust bearings Needle roller thrust bearing Taper roller thrust bearing Cylindrical roller thrust bearing Thrust ball bearing

Bearings reduce friction either by using hard smooth balls or rollers, and a smooth inner and outer surface for the balls to roll against or by introducing a low friction surface between the surfaces. These balls or rollers "bear" any loads which they may be subjected to thus allowing the bearing to rotate smoothly.



How bearings 'bear' load

Ball bearings are typically capable of dealing with two kinds of loading condition; radial load and thrust load. Depending on the type of application the bearing is used in, it may experience radial load only, thrust load only or a combination of both. A classic example being the car wheel as shown.

There are many different types of bearings used, all have benefits and disadvantages to them and so are used for different purposes and in different circumstances.

Ball Bearing

A ball bearing uses a ball to rotate and move the load. Ball bearings are cheaper than other bearings used such as cylinders in roller bearings and have high accuracy. When moving lighter loads ball bearings do not have as much friction as roller bearings, and can support radial and axel loads. Radial loads are perpendicular to the shaft and axel loads are parallel.

Roller Bearing

Roller bearings use cylinders instead of balls and usually have a larger diameter. Roller bearings can support radial loads, usually of a higher capacity than ball bearings can, but have higher friction with axial loads. Roller bearings are commonly used in rotary appliances and in machinery.

Thrust Ball Bearing

A thrust ball bearing consists of two steel washers with balls situated within them. They are mostly used for low speed appliances and can't handle heavy loads, for example they can be found in swivel bar stools and turn tables.

Taper Roller Bearing

Tapered roller bearings are used to support large radial and thrust loads. It consists of a series of tapered or conical rollers held in a cage between inner and outer bearing tracks. They are used in many car hubs. The disadvantages to taper roller bearings are that they are usually quite expensive and they add more friction than a ball bearing.

Needle Bearing

Needle bearings are similar to roller bearings but the cylinders are thinner and longer like needles. These are used sometimes as they reduce the friction of the rotating surface. Needle bearings are used in engines and engine parts and transmissions; the drive shaft of a rear wheel drive car has at least 8 needle bearings.

Different Bearing types

There are many types of bearings, each used for different purposes either singularly or in combinations. These include ball bearings, roller bearings, ball thrust bearings, roller thrust bearings and tapered roller thrust bearings.

Ball bearings

Ball bearings, as show are the most common type by far. They are found in everything from skate boards to washing machines to PC hard drives. These bearings are capable of taking both radial and thrust loads, and are usually found in applications where the load is light to medium and is constant in nature (i.e. not shock loading). The bearing shown here has the outer ring cut away revealing the balls and ball retainer.

Roller bearings

Roller bearings like the one shown to the left are normally used in heavy duty applications such as conveyer belt rollers, where they must hold heavy radial loads. In these bearings the roller is a cylinder, so the contact between the inner and outer race is not a point (like the ball bearing above) but a line. This spreads the load out over a larger area, allowing the roller bearing to handle much greater loads than a ball bearing. However, this type of bearing cannot handle thrust loads to any significant degree. A variation of this bearing design is called the needle bearing. The needle roller bearing uses cylindrical rollers like those above but with a very small diameter. This allows the bearing to fit into tight places such as gear boxes that rotate at higher speeds.

Thrust ball bearings

Ball thrust bearings like the one shown to the left are mostly used for low-speed non precision applications. They cannot take much radial load and are usually found in *lazy susan* turntables and low precision farm equipment.

Roller thrust bearing

Roller thrust bearings like the one illustrated to the left can support very large thrust loads. They are often found in gearsets like car transmissions between gear sprockets, and between the housing and the rotating shafts. The helical gears used in most transmissions have angled teeth, this can causes a high thrust load that must be supported by this type of bearing.

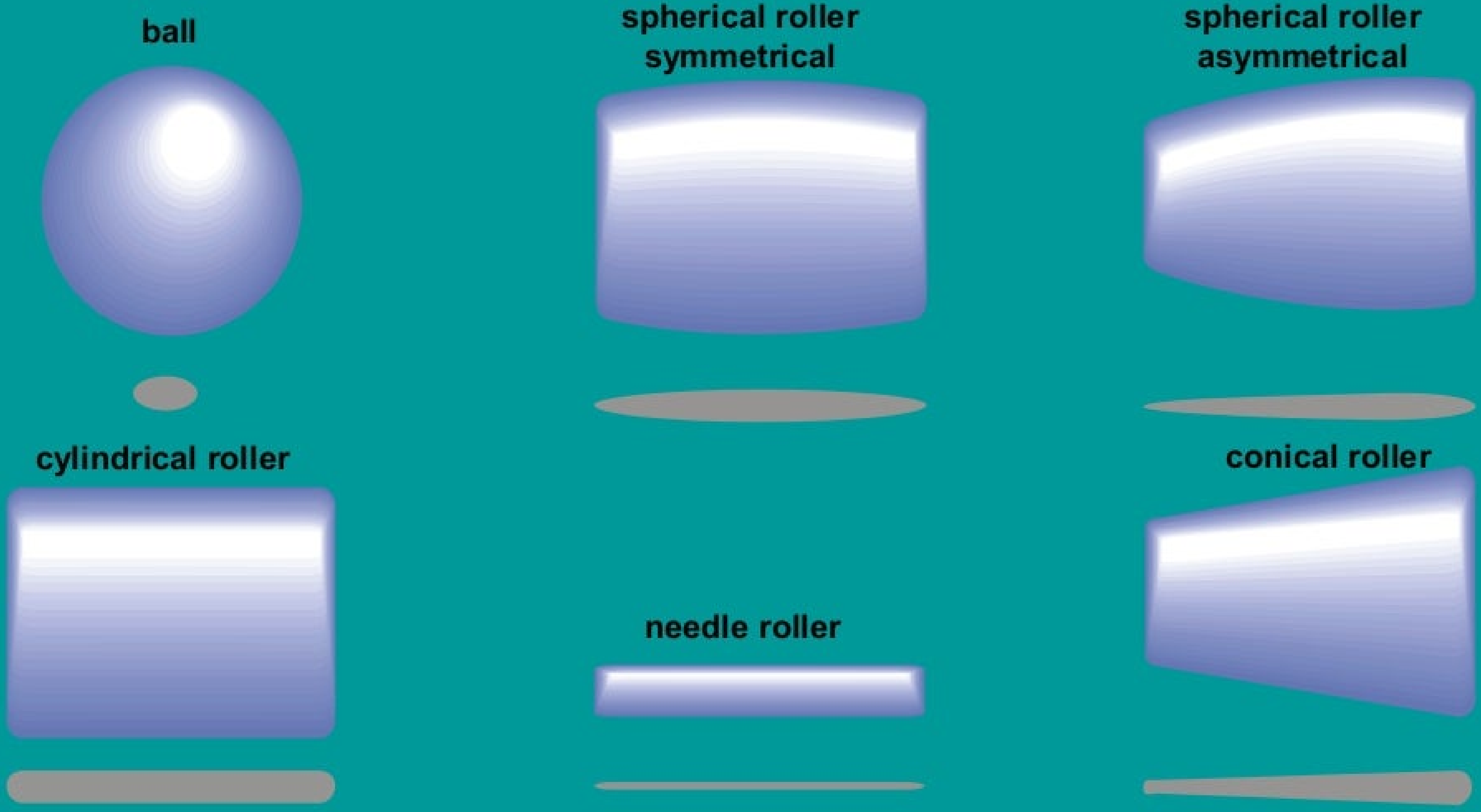
Taper roller bearing

Tapered roller bearings are designed to support large radial and large thrust loads. These loads can take the form of constant loads or shock loads. Tapered roller bearings are used in many car hubs, where they are usually mounted in pairs facing opposite directions. This gives them the ability to take thrust loads in both directions. The cutaway taper roller on the left shows the specially designed tapered rollers and demonstrates their angular mounting which gives their dual load ability.

Other bearing types..

The above bearing types are some of the most common. There are thousands of other designs, some standard and some specific applications but all perform the same basic function. Essentially further types of bearings usually take all or some of the characteristics of the above bearings and blend them into one design. Through the use of careful material selection and applying the correct degree of machining precision, a successful bearing solution can usually be found.

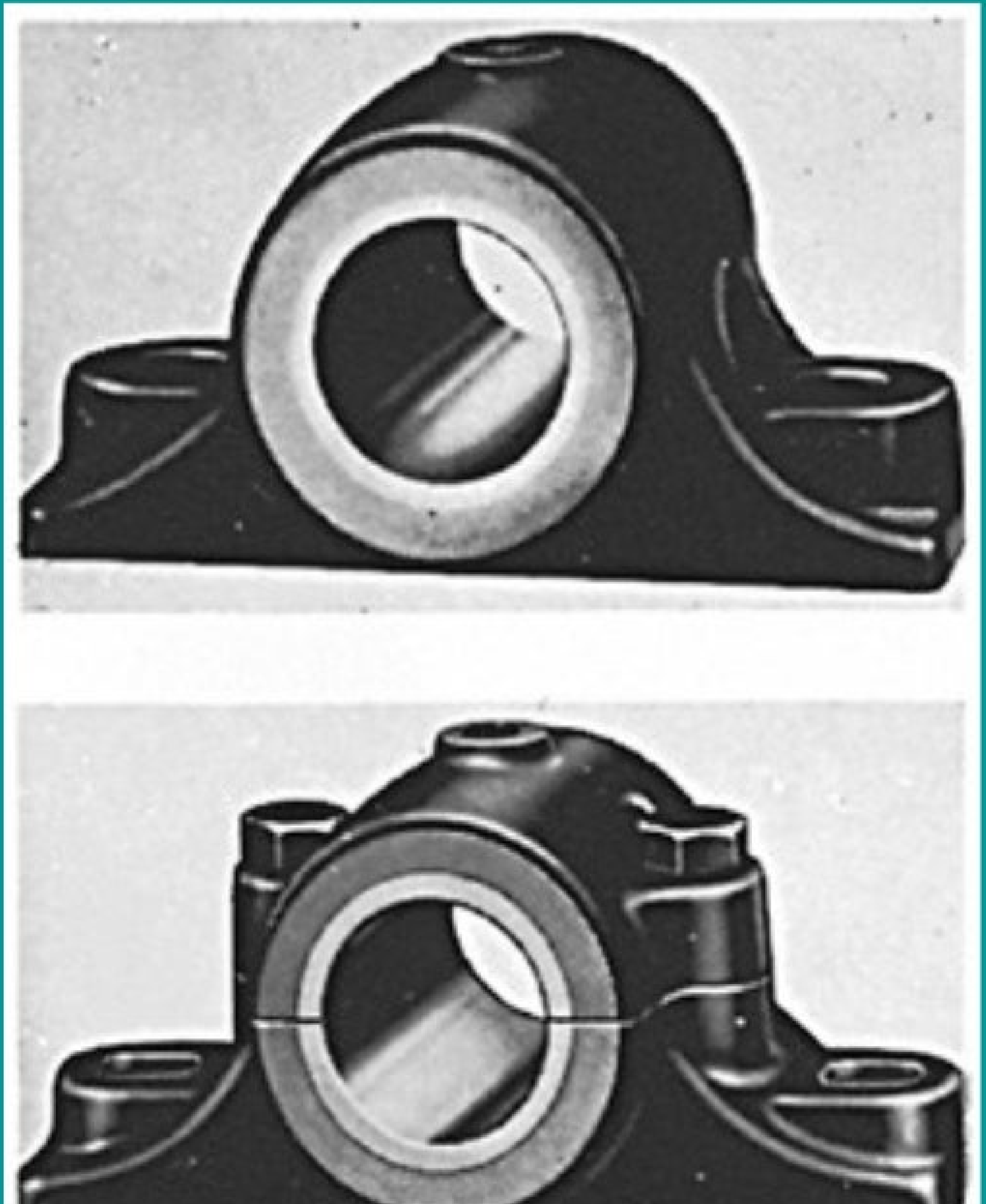
Roller Bearings are named after the Shape of their rolling Elements



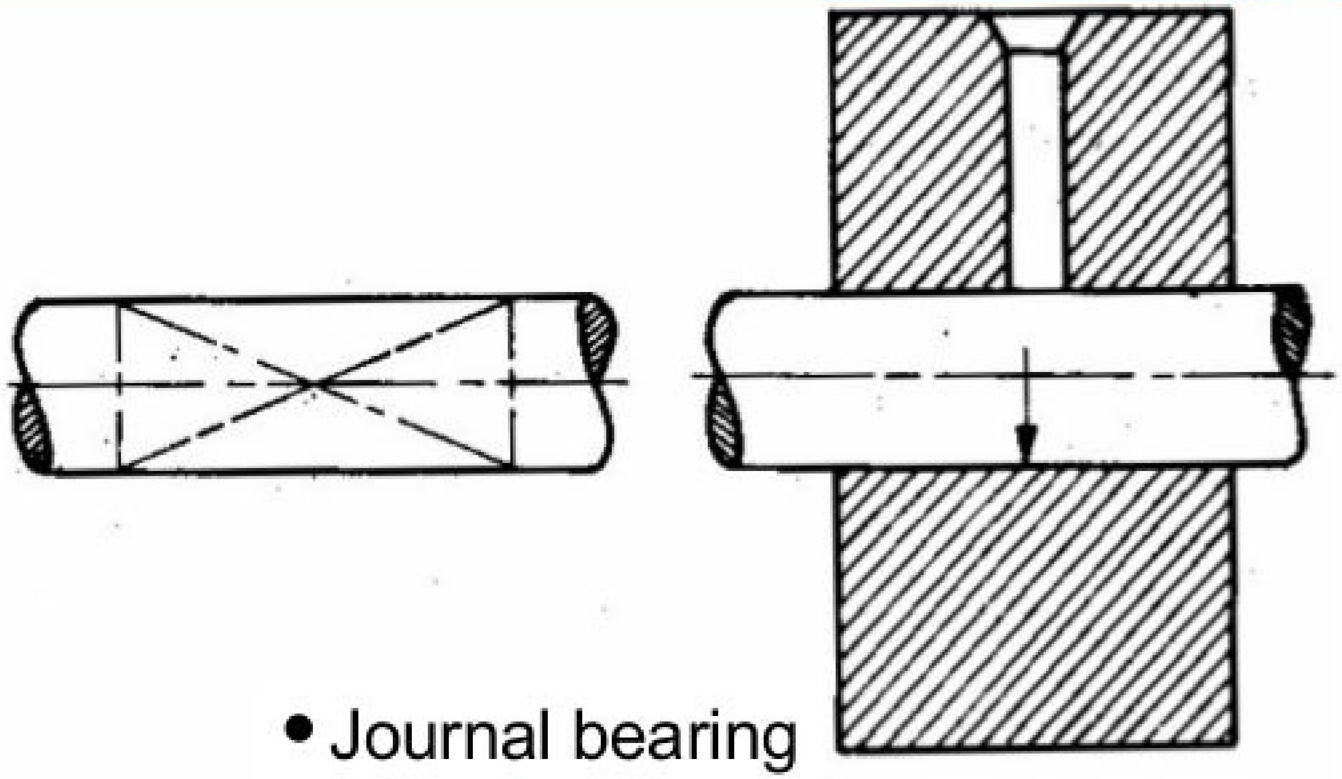
Advantages and disadvantages of the plain bearing

- **Plain bearing are cheap to produce and have noiseless operation. They can be easily machined, occupy small radial space and have vibration damping properties. Also they can cope with tapped foreign matter.**
- **Disadvantages are they require large supply of lubricating oil, they are suitable only for relative low temperature and speed; and starting resistance is much greater than running resistance due to slow build up of lubricant film around the bearing surface.**

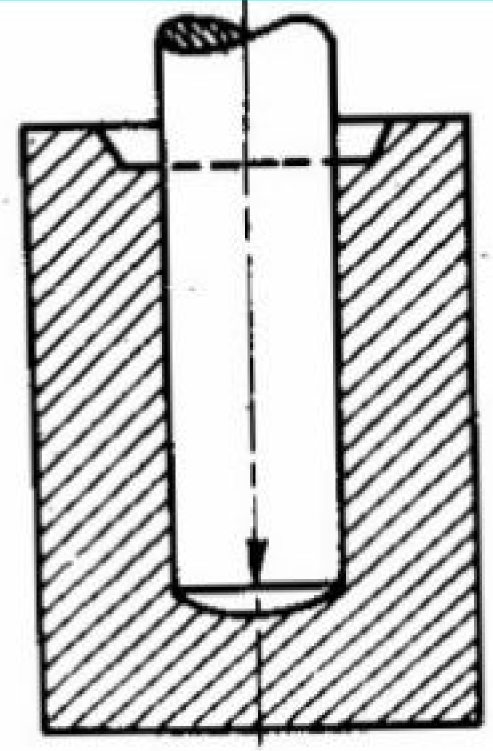
SLIDING CONTACT BEARING



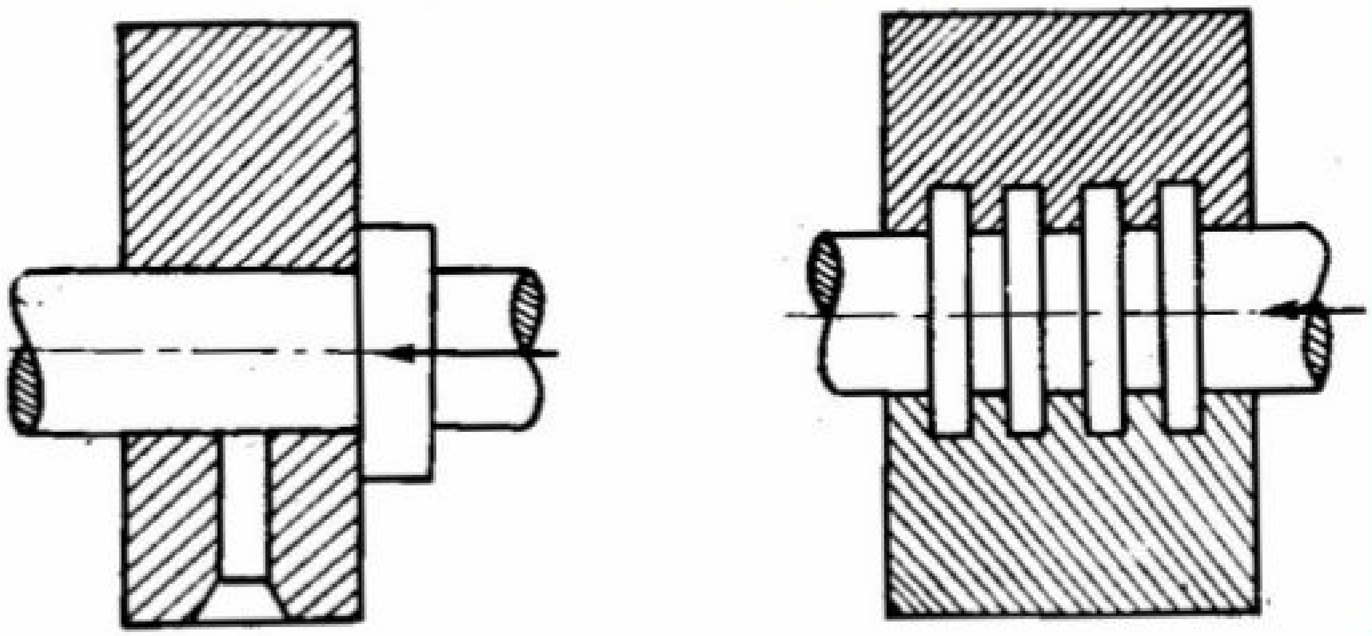
Classification of the sliding contact bearing



- Journal bearing



- Footstep bearing



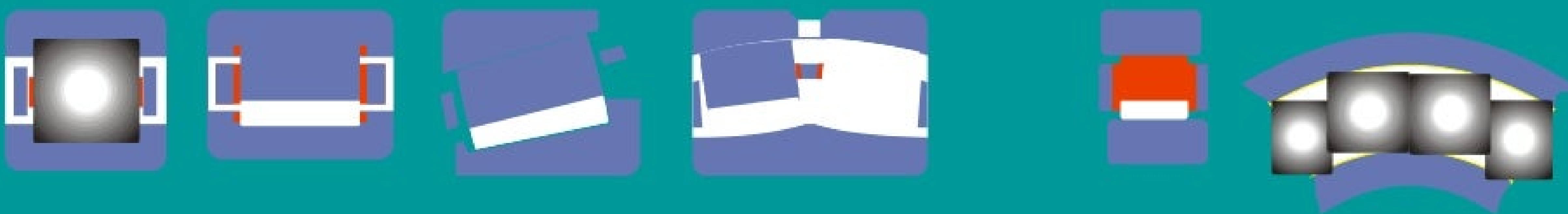
- Collar thrust bearing

- **Journal bearing** – in this the bearing pressure is exerted at right angles to the axis of the axis of the shaft. The portion of the shaft lying within the bearing in known as journal. Shaft are generally made of mild steel.
- **Foot step or pivot bearing** – in this bearing the bearing pressure is exerted parallel to the shaft whose axis is vertical. Note that in this case the end of the shaft rests within the bearing.
- **Thrust bearing** – in this bearing supporting pressure is parallel to the axis of the shaft having end thrust. Thrust bearing are used in bevel mountings, propeller drives, turbines, etc. note here the shaft ,unlike foot-strep bearing passes through and beyond the bearing.
  - Thrust bearings also known as "**collar bearing**".

Journal bearing

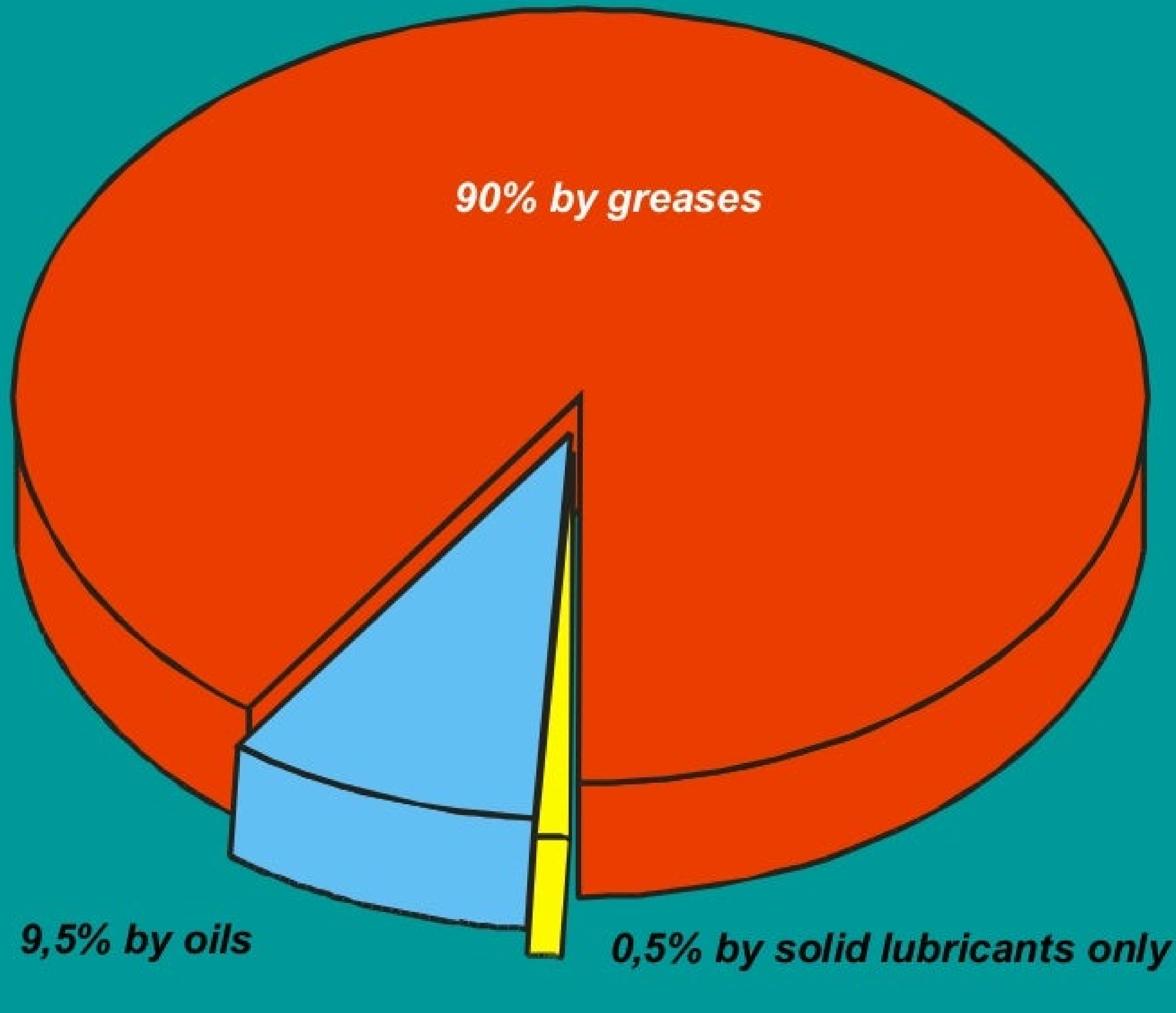
- Simple journal or solid bearing
  - It is simply a block of cast iron with a hole for the shaft providing running fit. An oil hole is drilled at the top for lubrication.
  - The main disadvantage of this type of bearing are
    - There is no provision for wear and adjustment on account of wear.
    - The shaft must be passed into the bearing axially, i.e. endwise.
    - Limited load on shaft and speed of shaft is low.

Friction in Roller Bearings

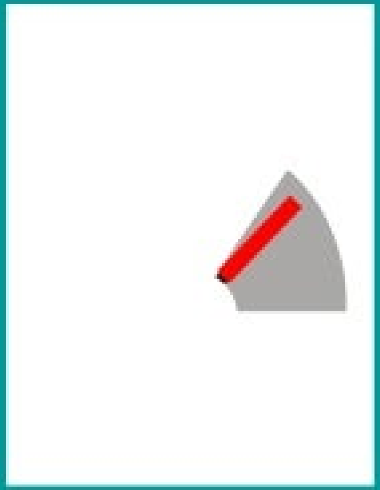


- ***small portion of rolling friction***
- ***but considerable share of sliding friction at:***
  - roller bearing rings
  - cages and / or
  - rolling elements against each other

Kinds of Lubrication of Roller Bearings



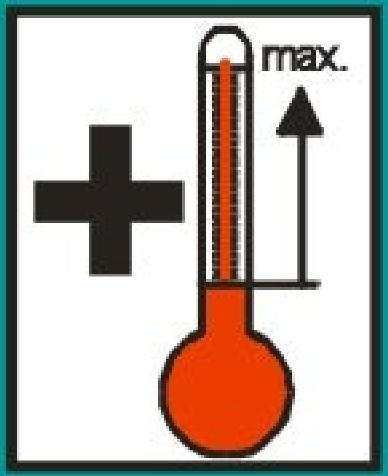
The most important Parameters for selecting the suitable Lubricant



revolution or DN - factor

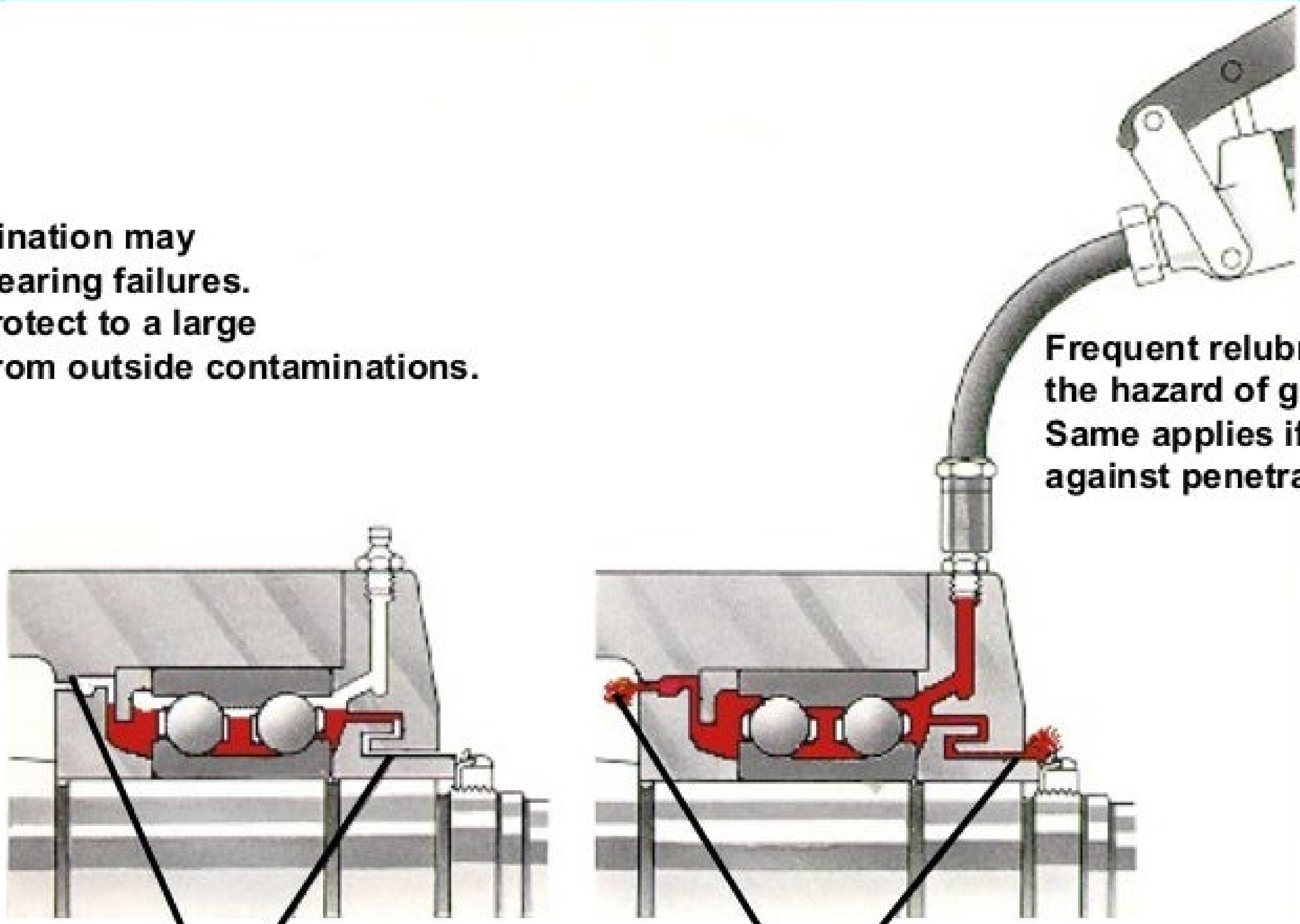
$$DN = \frac{D + d}{2} \cdot n$$

D = external bearing diameter [mm]
d = internal bearing diameter [mm]
n = revolution per minute [rpm]
d_m = medium bearing diameter [mm] = $\frac{D + d}{2}$



temperature range

Lubrication by greases



Relubrication Intervals for Grease lubricated Roller Bearings

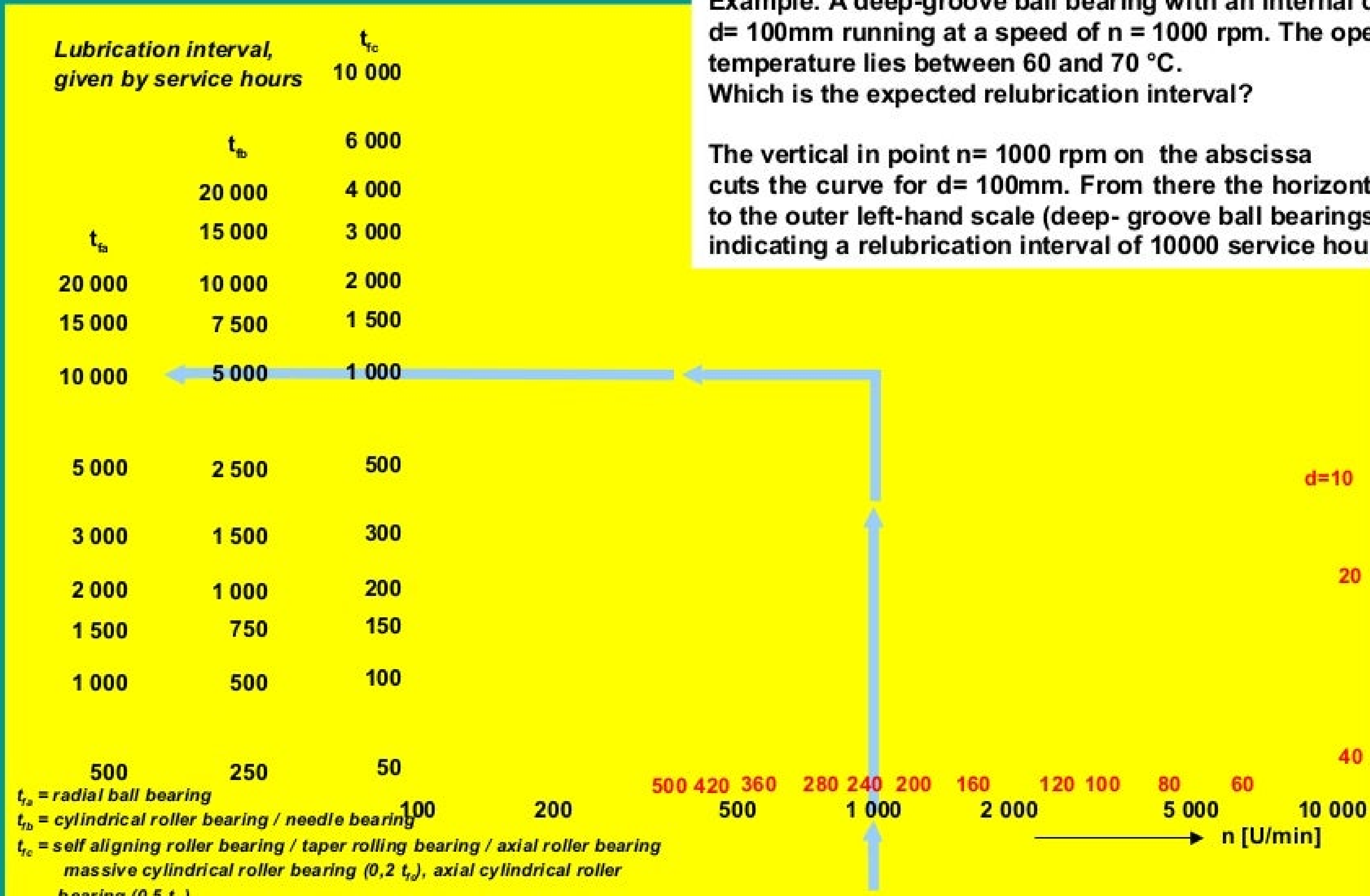
Small bearings with lateral seals or cover plates do not need any relubrication. They are already for - life lubricated.

For all other roller bearings relubrication intervals become valid.

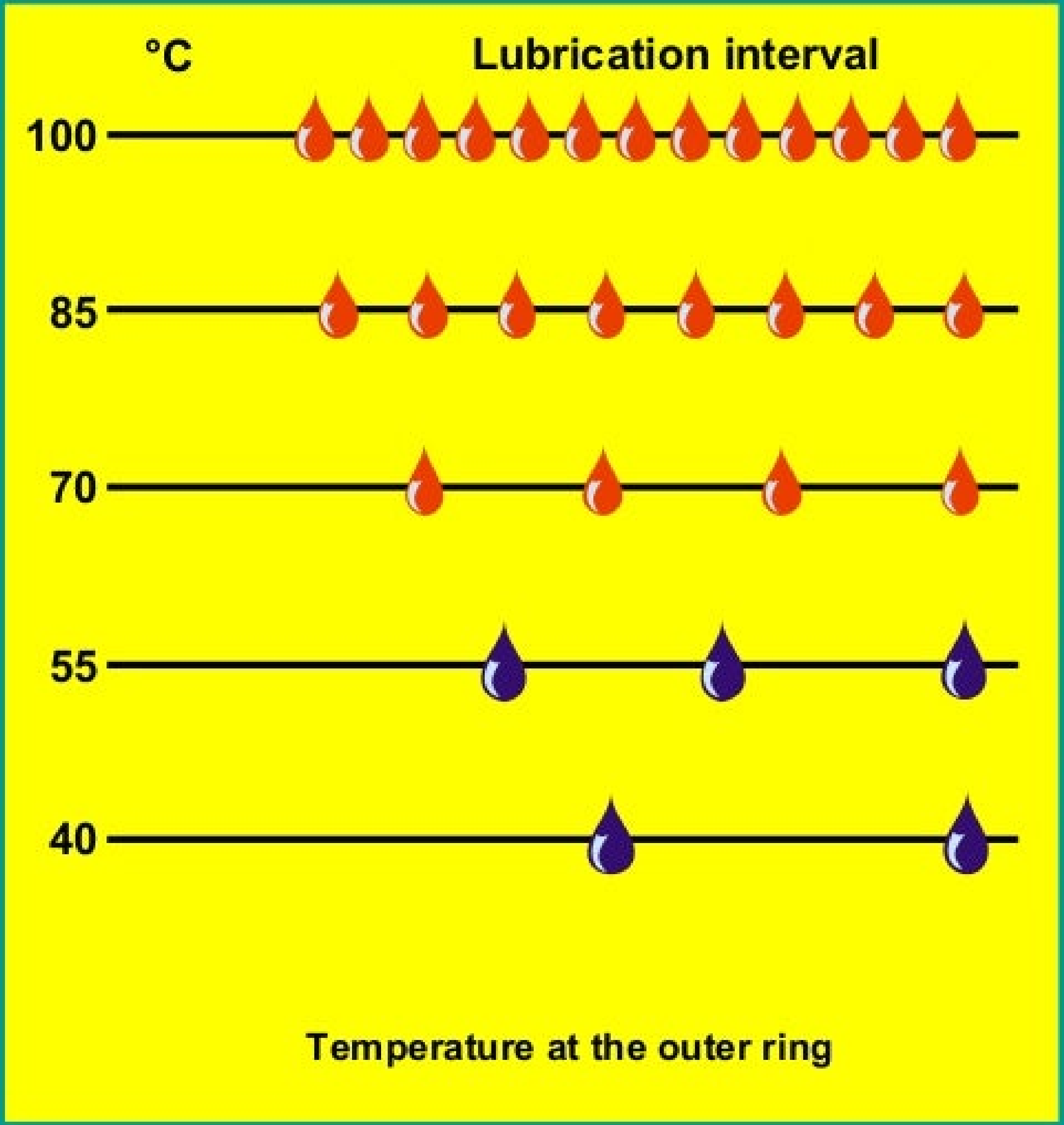
Guidelines for Relubrication Intervalls

Example: A deep-groove ball bearing with an internal diameter d= 100mm running at a speed of n = 1000 rpm. The operating temperature lies between 60 and 70 °C.
Which is the expected relubrication interval?

The vertical in point n= 1000 rpm on the abscissa cuts the curve for d= 100mm. From there the horizontal leads to the outer left-hand scale (deep- groove ball bearings) indicating a relubrication interval of 10000 service hours



Dependance of Relubrication Intervals on Tempearture



 above 70°C the factor 0,5 applies for each temperature rise of 15°C

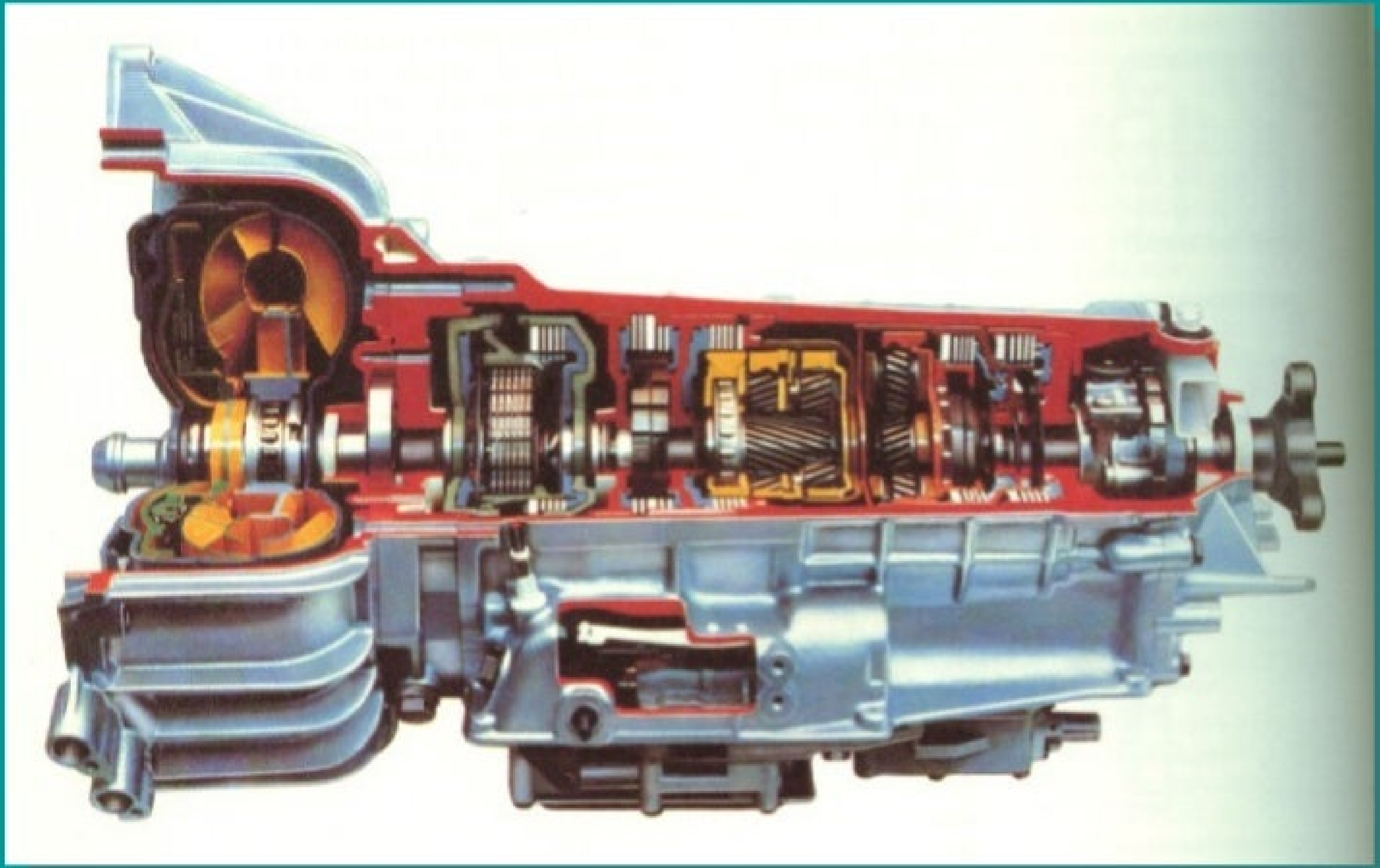
i.e. with a temperature rise from e.g. 70°C up to 85°C the service life of the grease is cut by half.

 below 70°C the factor 2 applies for each temperature drop of 15°C

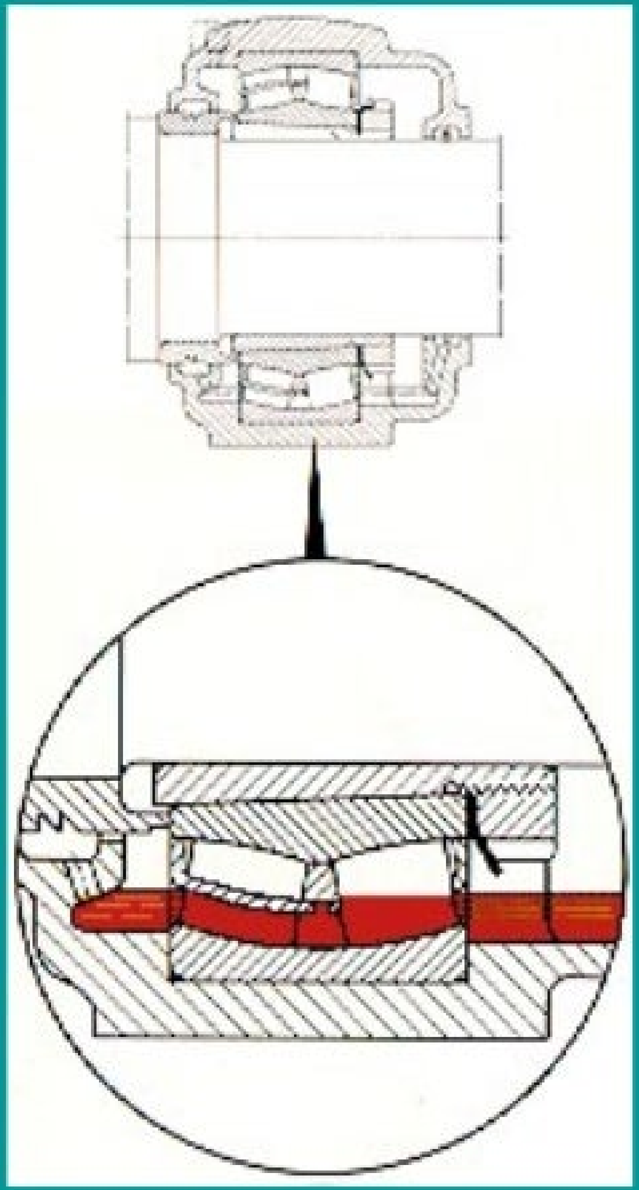
i.e. with a temperature drop from e.g. 70°C down to 55 °C the service life of the grease is doubled.

Lubrication by Oil

is used at high speeds resp. at DN-factors exceeding 1.000.000 and in case heat conduction is necessary.



Oil bath lubrication



Suitable only for bearings with low speeds.

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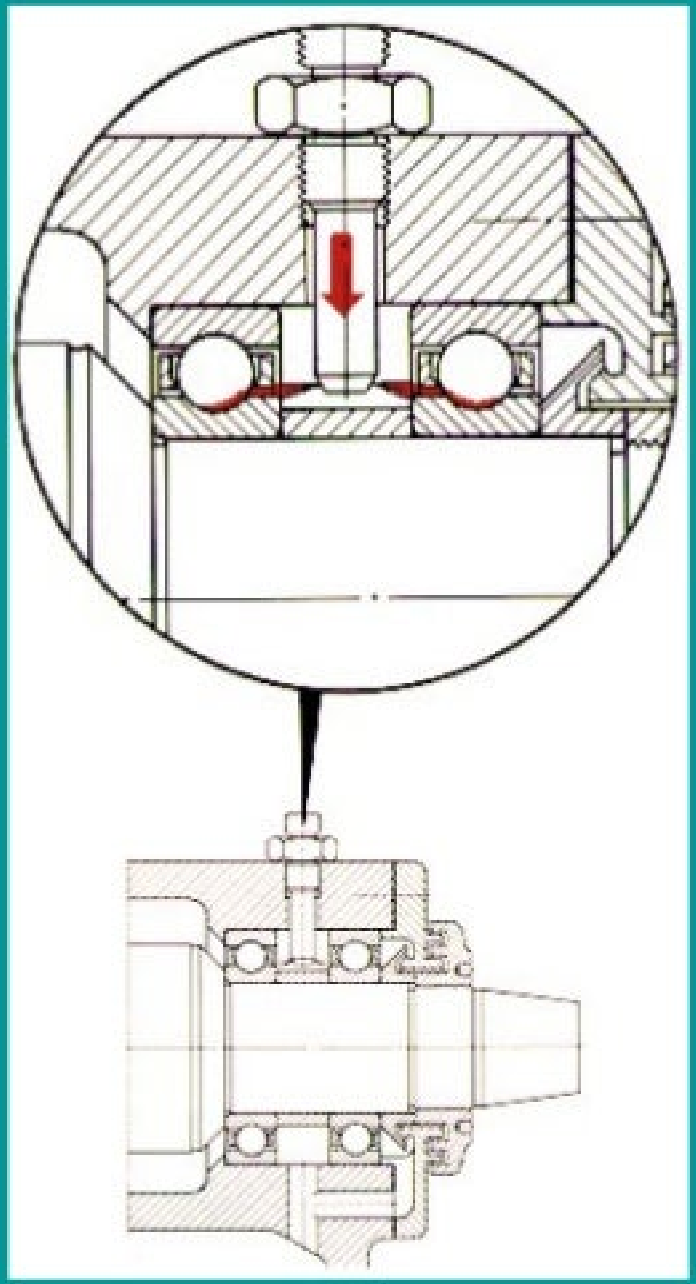
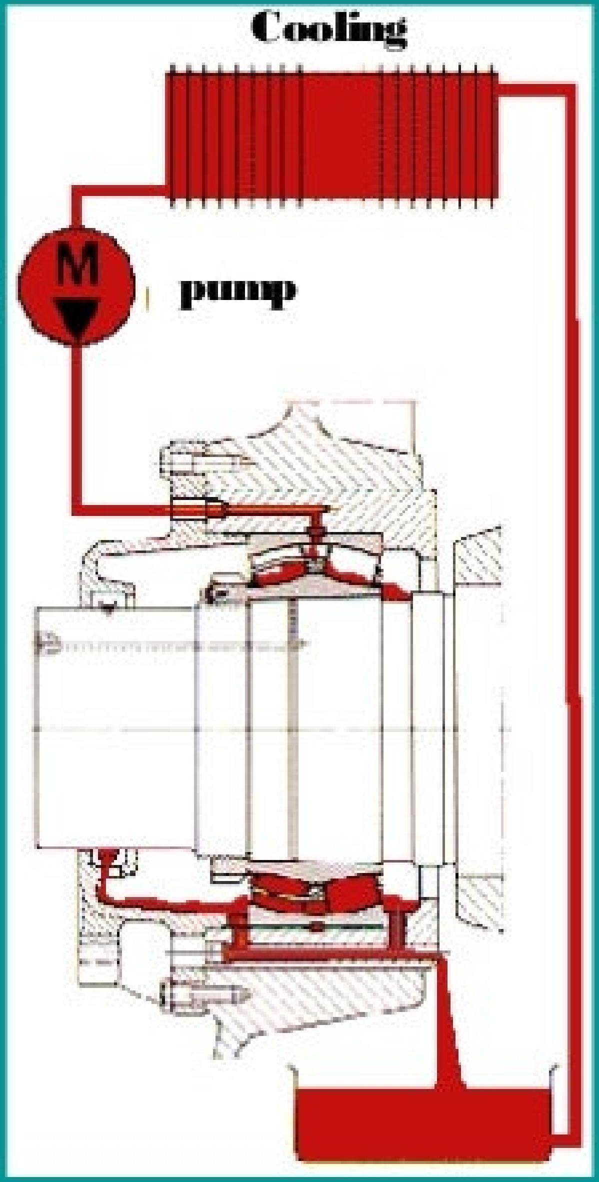
Oil injection lubrication



At high speed it becomes necessary, that the air turbulence circulating with the bearing is penetrated by the oil. This is ensured by injecting oil under high pressure (min.15 m/s) from the side into the bearing.

Circulatory oil lubrication



With increasing speed the service temperature rises and accelerates the ageing of the lubricating oil.

By circulatory lubrication the oil can be cooled and consequently the service temperature be reduced.

Lubrication with Solid Lubricants

Deep groove ball bearings with increased clearance required at:

- ***high temperatures > + 200 °C***
- ***high temperature variations***
- ***low speed***