

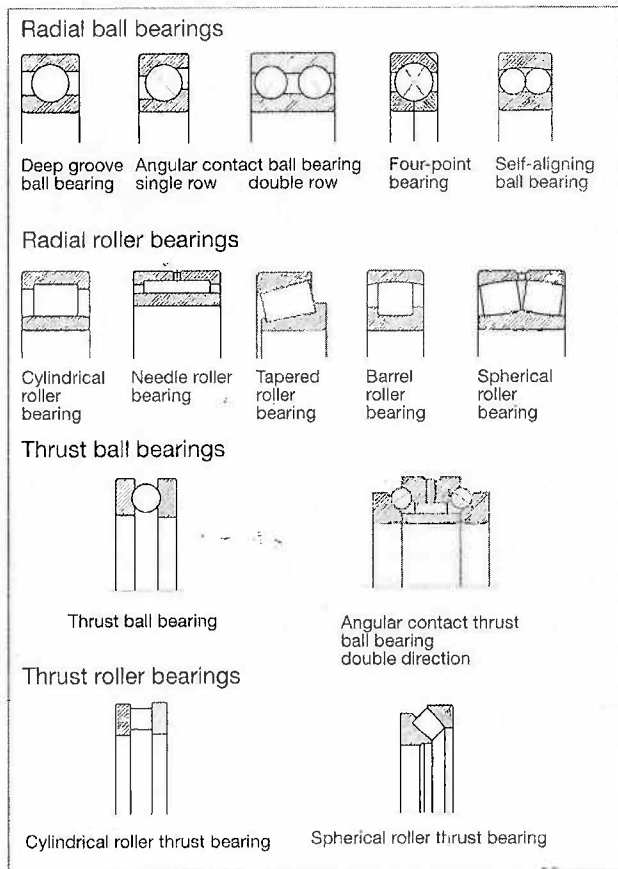
Rolling bearing types

Rolling bearing types

Numerous rolling bearing types with standardized main dimensions are available for the various requirements.

Rolling bearings are differentiated according to:

- the direction of main load: **radial bearings** and **thrust bearings**. Radial bearings have a nominal *contact angle* α_0 of 0° to 45° . Thrust bearings have a nominal contact angle α_0 of over 45° to 90° .
- the type of *rolling elements*: **ball bearings** and **roller bearings**.



The essential differences between ball bearings and roller bearings are:

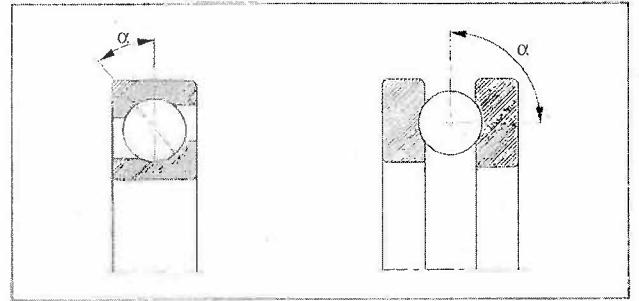
- Ball bearings: lower load carrying capacity, higher *speeds*
- Roller bearings: higher load carrying capacity, lower *speeds*

Other distinctive characteristics:

- *separable* or *non-separable*
- axial displaceability of the bearing rings relative to each other (*ideal floating bearings*)
- *self-aligning capability* of the bearing

Contact angle

The *rolling elements* transmit loads from one *bearing ring* to the other in the direction of the **contact lines**. The contact angle α is the angle formed by the contact lines and the radial plane of the bearing. α_0 refers to the nominal contact angle, i.e. the contact angle of the load-free bearing. Under axial loads the contact angle of deep groove ball bearings, angular contact ball bearings etc. increases. Under a *combined load* it changes from one *rolling element* to the next. These changing contact angles are taken into account when calculating the pressure distribution within the bearing.



Ball bearings and *roller bearings* with symmetrical rolling elements have identical contact angles at their inner rings and outer rings. In roller bearings with asymmetrical rollers the contact angles at the inner rings and outer rings are not identical. The equilibrium of forces in these bearings is maintained by a force component which is directed towards the lip.

Pressure cone apex

The pressure cone apex is that point on the bearing axis where the *contact lines* of an **angular contact bearing**, i.e. an angular contact ball bearing, a tapered roller bearing or a spherical roller thrust bearing, intersect. The *contact lines* are the generatrices of the pressure cone apex.



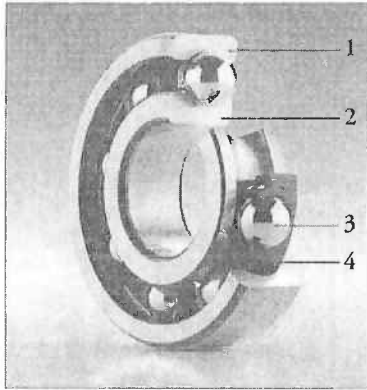
In *angular contact bearings* the external forces F act, not at the bearing centre, but at the pressure cone apex. This fact has to be taken into account when calculating the *equivalent dynamic load* P and the *equivalent static load* P_0 .

Rolling bearing components

Rolling elements

Rolling bearing components

Rolling bearings generally consist of *bearing rings* (inner ring and outer ring), *rolling elements* which roll on the raceways of the rings, and a *cage* which surrounds the rolling elements.



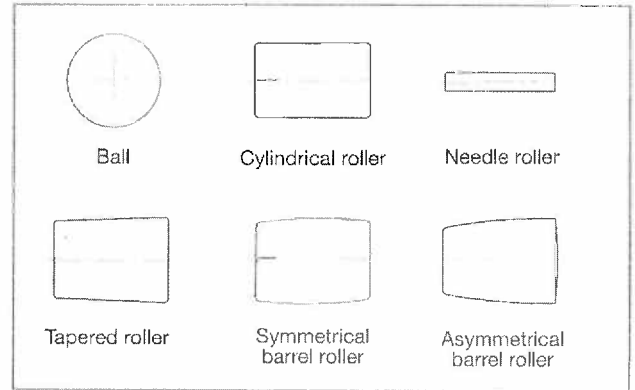
1 Outer ring, 2 Inner ring, 3 Rolling element, 4 Cage

The lubricant (usually *lubricating grease* or *lubricating oil*) also has to be regarded as a rolling bearing component as a bearing can hardly operate without a lubricant. *Seals* are also increasingly being integrated into the bearings.

The material of which rings and rolling elements for FAG rolling bearings are made is normally a low-alloyed, through-hardening chromium steel which is identified by the material number 1.3505, DIN designation 100 Cr 6.

Rolling elements

Rolling elements are classified, according to their shape, into balls, cylindrical rollers, needle rollers, tapered rollers and barrel rollers.



The rolling elements' function is to transmit the force acting on the bearing from one ring to the other. For a high load carrying capacity it is important that as many rolling elements as possible, which are as large as possible, are accommodated between the bearing rings. Their number and size depend on the cross section of the bearing.

It is just as important for loadability that the rolling elements within the bearing are of identical size. Therefore they are sorted according to grades. The tolerance of one grade is very slight.

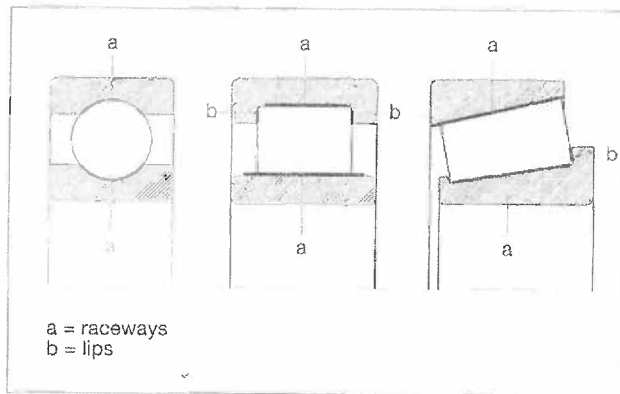
The generatrices of cylindrical rollers and tapered rollers have a logarithmic profile. The centre part of the generatrix of a needle roller is straight, and the ends are slightly crowned. This profile prevents edge stressing when under load.

Rolling bearing components

Bearing rings · Cages

Bearing rings

The bearing rings – inner ring and outer ring – guide the *rolling elements* in the direction of rotation. Raceway grooves, lips and inclined running areas guide the rollers and transmit axial loads in transverse direction. Design NU and N cylindrical roller bearings and needle roller bearings and needle roller bearings have lips only on one bearing ring; they can, therefore, accommodate shaft expansions as *floating bearings*.



The two rings of **separable** rolling bearings can be mounted separately. This is of advantage if both bearing rings have to be mounted with a tight *fit* (see page 28).

Separable bearings include, e.g. four point bearings, double-row angular contact ball bearings with a split ring, cylindrical roller bearings, needle roller bearings, tapered roller bearings, thrust ball bearings, cylindrical roller thrust bearings and spherical roller thrust bearings.

Non-separable bearings include, e.g. deep groove ball bearings, single-row angular contact ball bearings, self-aligning ball bearings, barrel roller bearings and spherical roller bearings.

Cages

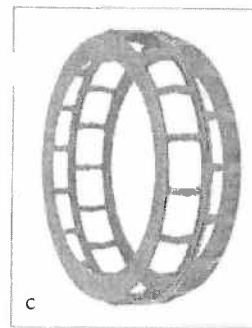
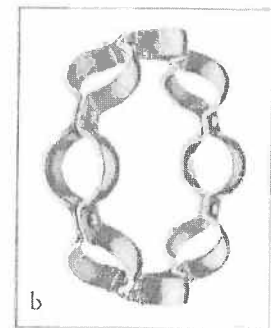
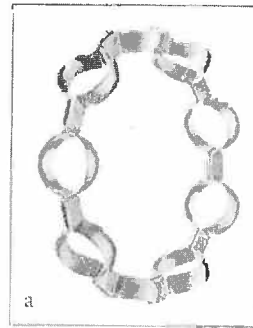
Functions of a cage:

- to keep the *rolling elements* apart so that they do not rub against each other
- to keep the rolling elements evenly spaced for uniform load distribution
- to prevent rolling elements from falling out of *separable bearings* and bearings which are swiveled out
- to guide the rolling elements in the unloaded zone of the bearing.

The transmission of forces is not one of the cage's functions.

Cages are classified into *pressed cages*, *machined cages* and *moulded cages*.

Pressed cages are usually made of steel, but sometimes of brass, too. They are lighter than machined metal cages. Since a pressed cage barely closes the gap between inner ring and outer ring, lubricant can easily penetrate into the bearing. It is stored at the cage.



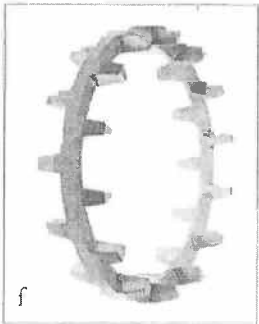
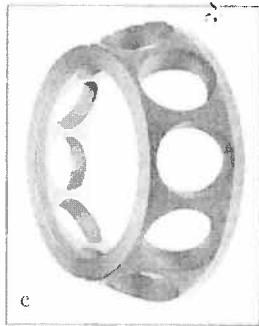
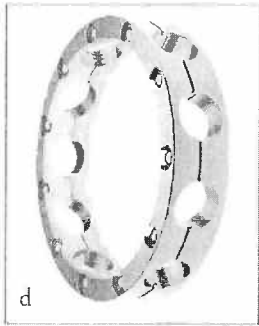
Pressed steel cages: prong-type cage (a) and rivet cage (b) for deep groove ball bearings, window-type cage (c) for spherical roller bearings

Machined cages of metal and textile laminated phenolic resin are made from tubes of steel, light metal or textile laminated phenolic resin, or cast brass rings.

These cages are mainly eligible for bearings of which small series are produced. To obtain the required strength, large, heavily loaded bearings are fitted with machined cages. Machined cages are also used where lip guidance of the cage is required. Lip-guided cages for high-speed bearings are in many cases made of light materials such as light metal or textile laminated phenolic resin to keep the forces of gravity low.

Rolling bearing components

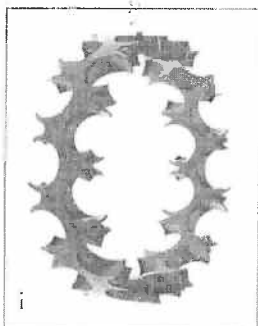
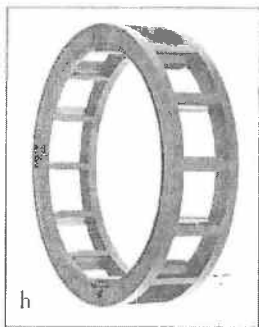
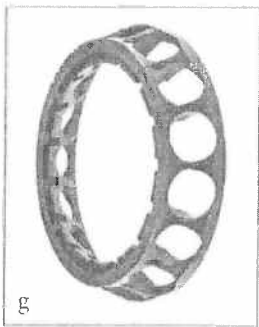
Cages



Machined brass cages: riveted machined cage (d) for deep groove ball bearings, window-type cage (e) for angular contact ball bearings, double prong type cage (f) for spherical roller bearings.

Moulded cages of polyamide 66 are produced by injection moulding and are used in many large-series bearings.

Injection moulding has made it possible to realize cage designs with an especially high-load carrying capacity. The elasticity and low weight of the cages are of advantage where shock-type bearing loads, great accelerations and decelerations as well as tilting of the bearing rings relative to each other have to be accommodated. Polyamide cages feature very good sliding and dry running properties.

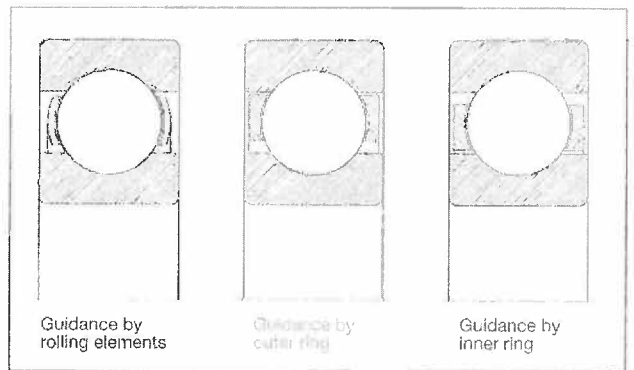


Moulded cages of glass fibre reinforced polyamide: window-type cage (g) for single-row angular contact ball bearings, window-type cage (h) for cylindrical roller bearings, double prong type cage (i) for self-aligning ball bearings

Cages of glass fibre reinforced polyamide PA66 can be used at operating temperatures of up to +120 °C for extended periods of time. In oil-lubricated bearings, *additives* contained in the oil may reduce the cage life. At increased temperatures, aged oil may also have an impact on the cage life so that it is important to observe the oil change intervals. The limits of application for rolling bearings with polyamide PA66-GF25 cages are indicated in the FAG catalogue WL 41 520EA, page 85. TI No. WL 95-4 contains a list of these cages.

Another distinctive feature of a cage is its type of guiding.

- The most frequent one: guidance by the *rolling elements* (no suffix)
- Guidance by the outer ring (suffix A)
- Guidance by the inner ring (suffix B)



Under normal operating conditions, the cage design specified as the standard design is usually suitable. Within a single bearing series the standard cages may differ depending on the bearing size, cp. section on "Spherical roller bearings". Where specific operating conditions have to be accommodated, a cage custom-tailored to these conditions has to be selected.

Rules determining the cage code within the bearing code:

- If a pressed cage is the standard cage: no code for the cage
- If the cage is a machined cage: code number for the cage whether normal or special cage
- If a pressed cage is not standard design: code numbers for cage

There are a number of special rolling bearing designs and some series of cylindrical roller bearings – so-called full complement bearings – without cages. By omitting the cage the bearing can accommodate more *rolling elements*. This yields an increased *load rating*, but, due to the increased friction, the bearing is *suitable for lower speeds* only.

