The Design of Rolling Bearing Mountings

FAG

Rolling Bearings

FAG Bearings Limited

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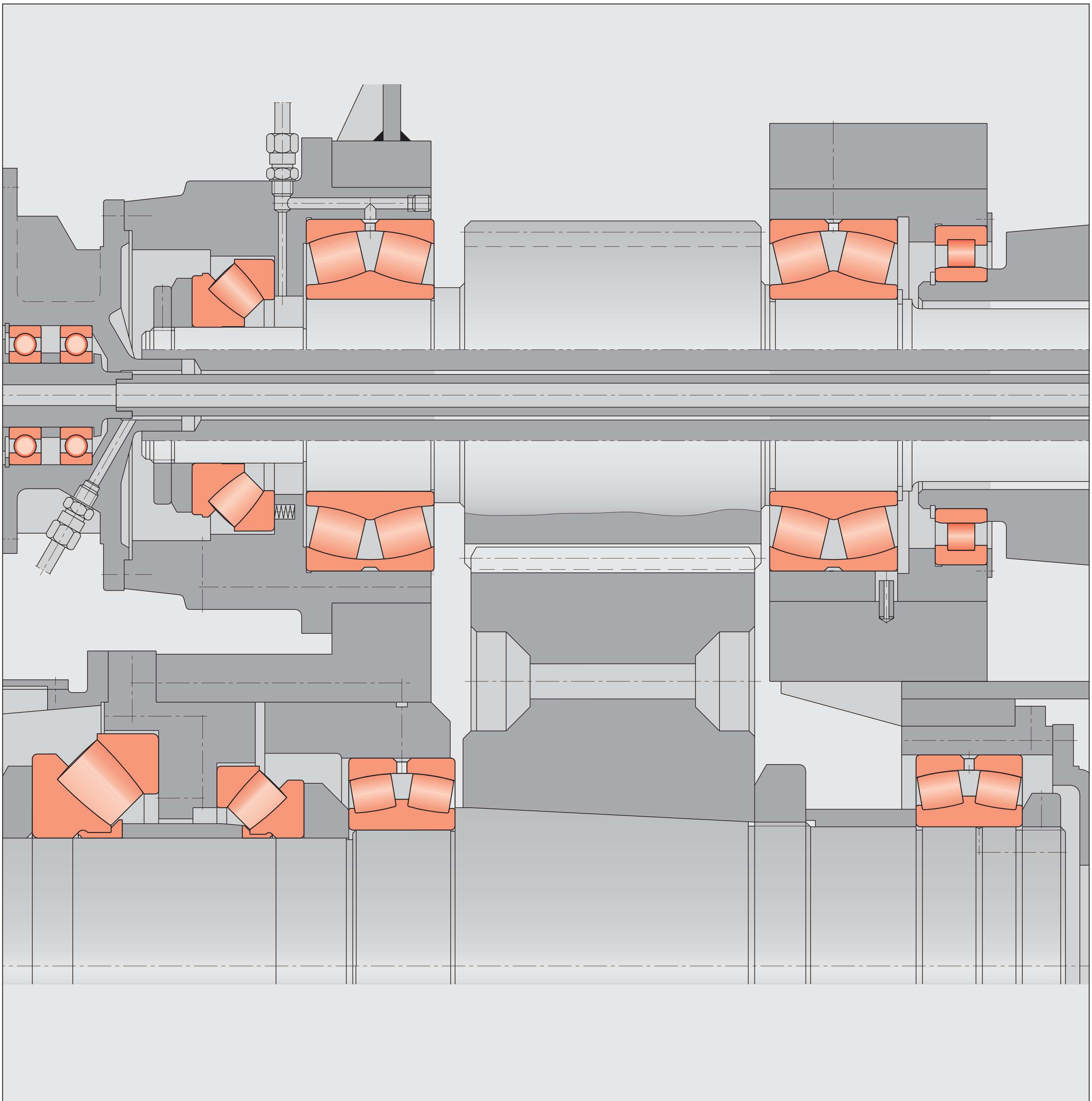

The Design of Rolling Bearing Mountings

Design Examples covering
Machines, Vehicles and Equipment

Publ. No. WL 00 200/5 EA

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Preface

This publication presents design examples covering various machines, vehicles and equipment having one thing in common: rolling bearings.

For this reason the brief texts concentrate on the rolling bearing aspects of the applications. The operation of the machine allows conclusions to be drawn about the operating conditions which dictate the bearing type and design, the size and arrangement, fits, lubrication and sealing.

Important rolling bearing engineering terms are printed in italics. At the end of this publication they are summarized and explained in a glossary of terms, some supplemented by illustrations.

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1 Traction motor for electric standard-gauge locomotives

Operating data

Three-phase current motor supplied by frequency converter.
Nominal output 1,400 kW, maximum speed 4,300 min^{-1} (maximum driving speed for transmissions with standard gear ratios is 200 km/h). One-end drive with herringbone gear pinion.

Bearing selection, dimensioning

Collective loads which cover representative load cases for the motor torque, speeds, and percentages of time for the operating conditions in question, are used to determine bearing stressing.

Load case	M_d N m	n min^{-1}	q %
1	6,720	1,056	2
2	2,240	1,690	34
3	1,920	2,324	18
4	3,200	2,746	42
5	2,240	4,225	6

The collective load is the basis for determining the average speeds (2,387 min^{-1}) and the average driving speed (111 km/h). For each of the load cases the tooth load acting on the pinion and the reaction loads from the bearings have to be calculated both for forward and backward motion (percentage times 50 % each).
In addition to these forces, the bearings are subjected to loads due to the rotor weight, the unbalanced magnetic pull, unbalanced loads and rail shocks. Of these loads only the rotor weight, G_L, is known; therefore, it is multiplied by a supplementary factor f_z = 1.5...2.5 – depending on the type of motor suspension. The bearing loads are determined from this estimated load. For the spring-suspended traction motor shown, a supplementary factor f_z = 1.5 is used.
The bearing loads from weight and drive allow the resultant bearing loading to be determined by vector addition. In this example only the critical transmission-end bearing will be discussed. The *attainable life* $L_{hna1...5}$ is determined for every load case using the formula $L_{hna} = a_1 \cdot a_{23} \cdot L_h$ [h], taking into account the *operating viscosity* ν of the transmission oil at 120 °C, the *rated viscosity* ν_1 as well as the factors K_1 and K_2. The basic *a_{23II} factor* is between 0.8 and 3. *The cleanliness factor* s is assumed to be 1. Then, L_{hna} is obtained using the formula:

$$L_{hna} = \frac{100}{\frac{q_1}{L_{hna1}} + \frac{q_2}{L_{hna2}} + \frac{q_3}{L_{hna3}} + \ldots}$$

When selecting the bearing it should be ensured that the nominal mileage is reached and that, due to the high speed, the drive-end bearing is not too large. With the bearings selected the theoretical mileage of 2.5 million kilometers required by the customer can be reached.

A cylindrical roller bearing FAG NU322E.TVP2.C5.F1 serves *as floating bearing* at the drive end; an FAG 566513 with an angle ring HJ318E.F1 serves as *the locating bearing.*
The cylindrical roller bearing FAG 566513 is an NJ318E.TVP2.P64.F1, but its inner ring is 6 mm wider. The resulting *axial clearance* of 6 mm is required in order to allow the herringbone gearing on the pinion to align freely.

Suffixes:

E	reinforced design
TVP2	*moulded cage* of glass fibre reinforced polyamide, *rolling element* riding
C5	*radial clearance* larger than C4
F1	FAG manufacturing and inspection specification for cylindrical roller bearings in traction motors which considers, among others, the requirements according to DIN 43283 "Cylindrical roller bearings for electric traction".
P64	*tolerance class* P6, *radial clearance* C4

Machining tolerances

Drive end: shaft r5; end cap to M6
Opposite end: shaft n5; end cap to M6

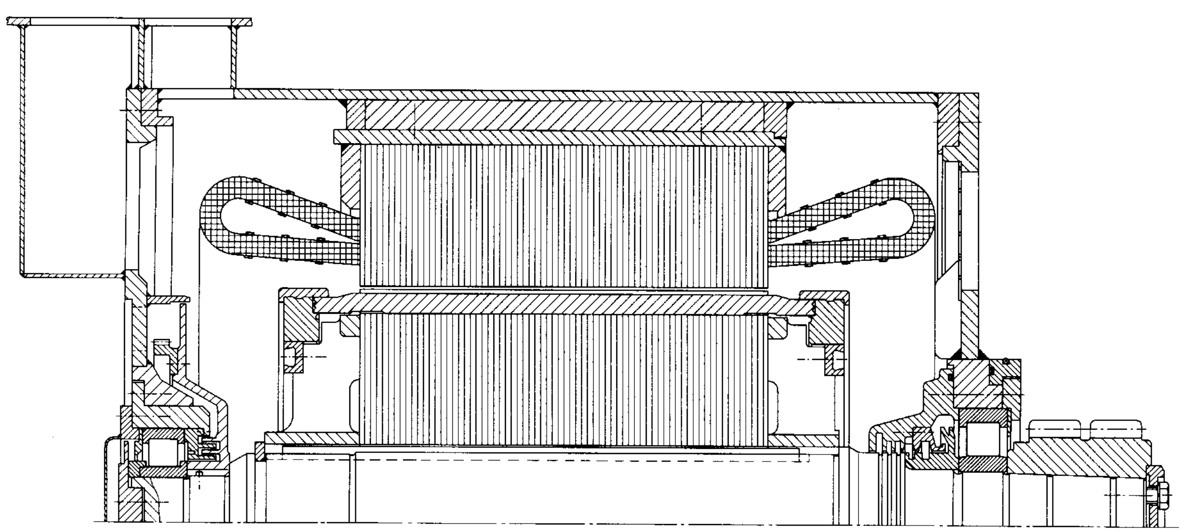
The bearings are fitted tightly on the shaft due to the high load, which is sometimes of the shock type. This reduces the danger of fretting corrosion, particularly at the drive end.

Bearing clearance

Due to the tight *fits,* the inner ring of the bearing is expanded and the outer ring with the roller-and-cage assembly is contracted. Thus the *radial clearance* of the bearing is reduced after mounting. It is further reduced during operation as the operating temperature of the inner ring is higher than that of the outer ring. For this reason bearings with an increased *radial clearance* (C4...C5) are mounted.

Lubrication, sealing

The drive-end bearing is lubricated, due to the high speeds, with transmission *oil* ISO VG 320 with *EP additives.* No *sealing* is required between pinion and bearing so that a shorter cantilever can be used, thus reducing the bearing loading. Flinger edges and oil collecting grooves prevent the *oil* from escaping in the direction of the coil.



1: Traction motor for electric standard-gauge locomotive

The bearing at the opposite end is lubricated with a lithium soap base *grease* of *NLGI penetration* class 3 (FAG rolling bearing grease *Arcanol* L71V).
The bearings should be relubricated after 400,000 kilometers or five years, respectively. Multiple labyrinths prevent contaminants from penetrating into the bearings.

Operating data

Self-ventilated converter current motor, permanent power 200 kW at a speed of 1,820 min^{-1} (driving speed 72 km/h), maximum speed 3,030 min^{-1} (maximum driving speed 120 km/h), one-end drive with herringbone gear pinion.

Bearing selection, dimensioning

The operating mode of commuter train motor vehicles is characterized by the short distances between stops. The periodic operating conditions – starting, driving, braking – can be recorded on an operating graph representing the motor torque versus the driving time. The cubic mean of the motor torque and an average speed, which is also determined from the operating graph, form the basis for the rolling bearing analysis. The mean torque is about 90 % of the torque at constant power.

The bearing loads are calculated as for traction motors for standard-gauge locomotives (example 1). They are made up of the reaction loads resulting from the gear force on the driving pinion and a theoretical radial load which takes into account the rotor weight, the magnetic pull, unbalanced loads and rail shocks. This theoretical radial load applied at the rotor centre of gravity is calculated by multiplying the rotor weight by the supplementary factor $f_z = 2$. The value 2 takes into account the relatively rigid motor suspension.

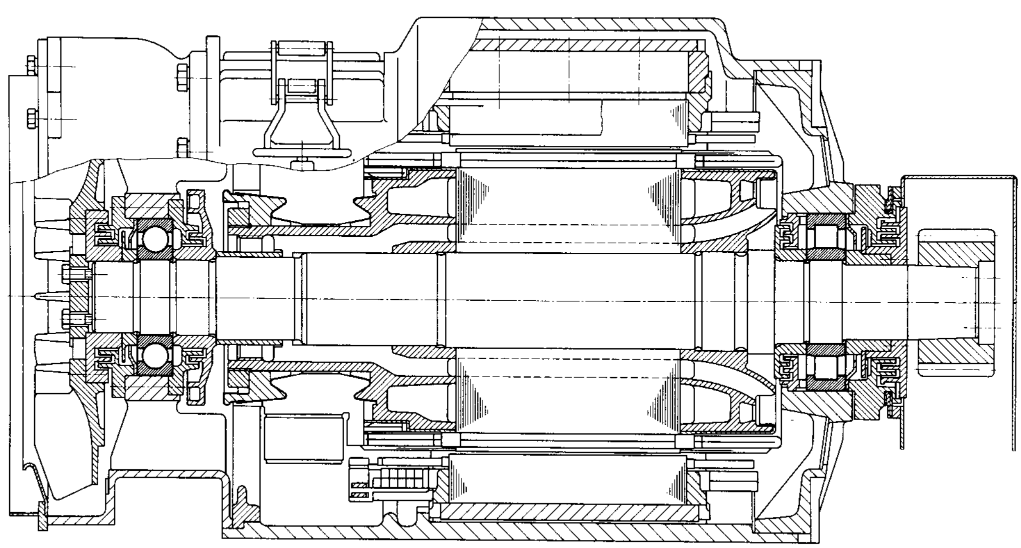
An overhung pinion provides the drive. At the pinion end a cylindrical roller bearing FAG NU320E.M1.P64.F1 is mounted as the *floating bearing.* At the commutator end a deep groove ball bearing FAG 6318M.P64.J20A very safely accommodates the thrust load resulting from the 7° helical gearing of the pinion, even at relatively high speeds.

Current insulation

Where converter current motors with an output of more than 100 kW are used, ripple voltages can be caused by magnetic asymmetries. As a result, an induced circuit is generated between rotor shaft and stator which can cause current passage damage in the bearing.

To interrupt the flow of current, one bearing (in this case the deep groove ball bearing) is provided with current insulation.

Current-insulated bearings feature an oxide ceramic coating on the outer ring O.D.s and faces.



2: Traction motor of an electric commuter train

3 Three-phase current standard motor

Operating data

Belt drive: Power 3 kW; rotor mass 8 kg; nominal speed 2,800 min^{-1}; size 100 L; totally enclosed fan-cooled according to DIN 42673, sheet 1 – design B3, type of protection IP44, insulation class F.

Bearing selection

Low-noise bearings in a simple, maintenance-free arrangement should be provided. These requirements are best met by deep groove ball bearings.
In DIN 42673, the shaft-end diameter specified for size 100 L is 28 mm. Consequently, a bore diameter of 30 mm is required. In this case a bearing of series 62 was selected for both bearing locations, i.e. an FAG 6206.2ZR.C3.L207. They guide the rotor shaft both at the drive side and at the ventilating side. The spring at the drive side provides clearance-free adjustment of the bearings and accommodates opposing axial loads on the rotor shaft.
By *adjusting* the deep groove ball bearings to zero clearance the adverse influence of bearing clearance on noise behaviour is eliminated.

Bearing dimensioning

The calculation of the bearings for this motor differs somewhat from the usual approach. As not even the motor manufacturer knows the amount of load at the shaft end, the permissible radial loading is indicated in the motor catalogues.
To determine the radial load carrying capacity, the drive-side deep groove ball bearing is calculated.
The calculation is based on an *attainable life* L_{hna} of 20,000 h and a *basic* a_{23II} *value* of 1.5. In addition, the rotor weight, the unilateral magnetic pull and the unbalanced load have to be taken into account. As the latter two criteria are not known the rotor weight is simply multiplied by a supplementary factor of $f_z = 1.5$.
With these values a permissible radial loading of 1 kN is calculated for the shaft-end middle.
Since the operating load in most applications is lower than the admissible load, an *attainable life* L_{hna} of more than 20,000 hours is obtained. The life of electric motor bearings, therefore, is usually defined not by material fatigue but by the *grease service life.*

Suffixes

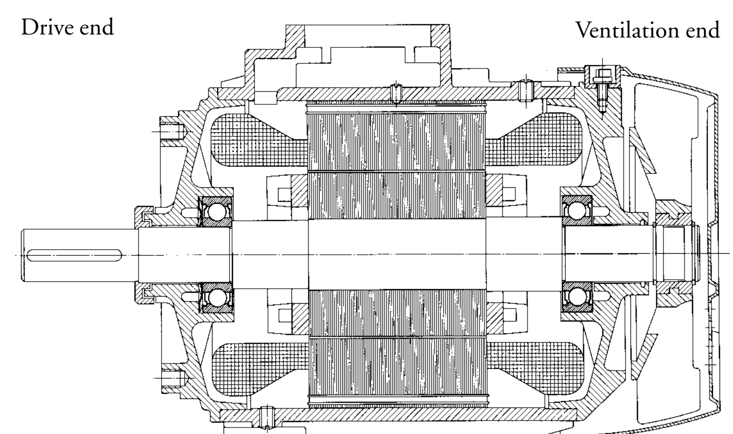
.2ZR	Bearing with two shields
C3	*Radial clearance* larger than PN (normal)
L207	*Grease* filling with *Arcanol* L207

Machining tolerances

Shaft to j5; end cap bore to H6.
The bore tolerance H6 ensures the slide fit required for free axial adjustment of both bearings.

Lubrication, sealing

The .2ZR design with shields on both bearing sides has been successful in small and medium-sized electric motors. The *grease* filling in these bearings is sufficient for their entire *service life.* Increased operating temperatures must be taken into consideration in the case in question due to the insulation class F provided. For this reason the FAG high-temperature grease *Arcanol* L207 is used. The shields prevent the grease from escaping and protect the bearings from contamination from the motor. Gap type *seals* protect the shaft opening at the drive side against dust and moisture. The requirements on insulation type IP44 are, therefore, met.



3: Three-phase current standard motor

4 Electric motor for domestic appliances

Operating data

Power 30 W; speed 3,500 min^{-1}.

Bearing selection

Quiet running is the prime requirement for domestic appliance motors. The noise level of a motor is influenced by bearing quality (form and running accuracy), bearing clearance and the finish of the shaft and end cap bore.
Today, the quality of standard bearings already adequately meets the common noise requirements.
Zero-clearance operation of the bearings is achieved by a spring washer lightly preloading the bearings in the axial direction.
The bearing seats on the shaft and in the end cap bores must be well aligned. To allow the spring washer to *adjust* the bearings axially, the outer rings have slide fits in the end caps.
A deep groove ball bearing FAG 626.2ZR is provided on the collector side, and an FAG 609.2ZR.L91 on the other side.

Suffixes

.2ZR Bearing with shields on both sides; they form a gap-type *seal*
L91 special *grease* filling (*Arcanol* L91)

Bearing dimensioning

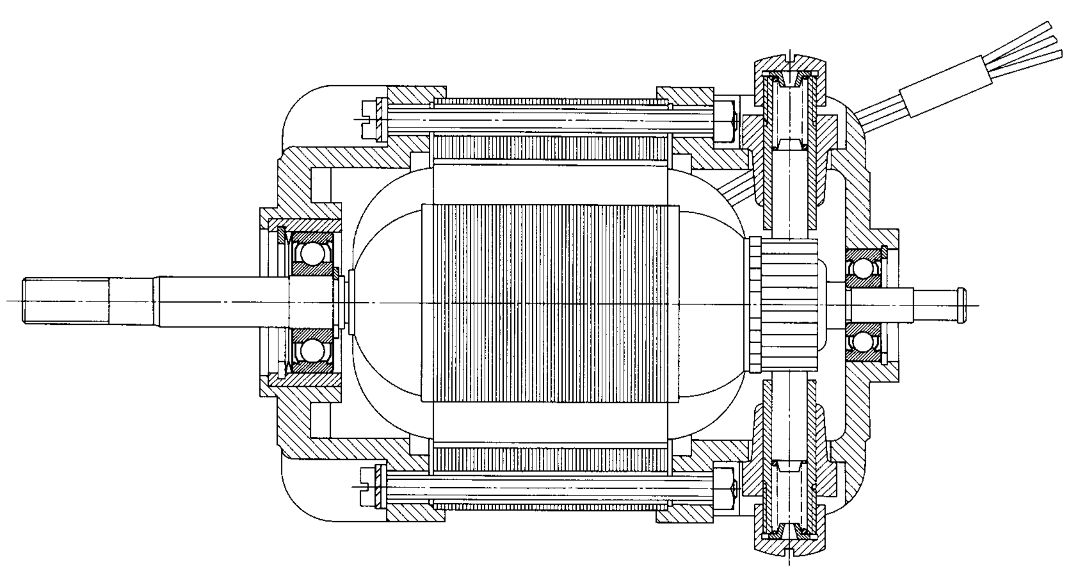
The shaft diameter is usually dictated by the machine design, and as a result the bearings are sufficiently dimensioned with regard to *fatigue life*. Fatigue damage hardly ever occurs; the bearings reach the required life of between 500 and 2,000 hours.

Machining tolerances

Shaft to j5; end cap bore to H5
The bore tolerance H5 provides the slide *fit* required to permit free axial alignment of both bearings.

Sealing, lubrication

Grease lubrication with lithium soap base grease of *consistency* number 2 with an especially high degree of cleanliness. It is characterized by its low friction. The overall efficiency of this motor is considerably influenced by the frictional moment of the ball bearings. The bearings with shields (.2ZR design) are prelubricated with *grease,* i.e. regreasing is not required. The gap-type *seal* formed by the shields offers adequate protection against contamination under normal ambient conditions.



4: Electric motor for domestic appliances

5 Drum of a domestic washing machine

Operating data

Capacity 4.5 kg dry mass of laundry
(weight G_w = 44 N);

Speeds:	when washing	50 min^{-1}
	when spinning after prewash cycle	800 min^{-1}
	when dry spinning	1,000 min^{-1}

Bearing selection

The domestic washing machine is of the front loading type. The drum is overhung and pulley-driven. Bearing selection depends on the journal diameter which is determined by rigidity requirements, and also on the weight and unbalanced loads. Very simplified data is assumed for bearing load determination, on which the bearing dimensions are based, since loads and speeds are variable.

Domestic washing machines generally have several, partly automatic, washing cycles with or without spinning. During the actual washing cycle, i.e. a cycle without spinning, the drum bearings are only lightly loaded by the weight resulting from drum and wet laundry. This loading is unimportant for the bearing dimensioning and is thus neglected. The opposite applies to the spinning cycle: Since the laundry is unevenly distributed around the drum circumference, an unbalanced load arises which, in turn, produces a large centrifugal force. The bearing dimensioning is based on this centrifugal force as well as on the weights of the drum, G_T, and the dry laundry, G_w. The belt pull is generally neglected.

The centrifugal force is calculated from:

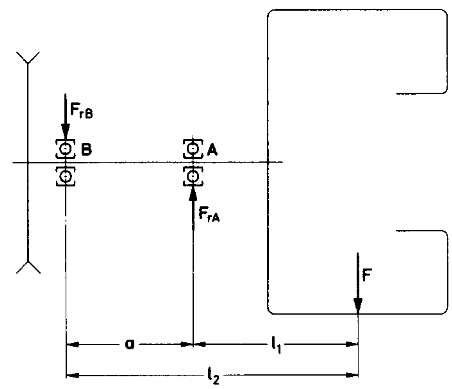
$$F_Z = m \cdot r \cdot \omega^2 \ \ [N]$$

where
$m = G_U/g \ [N \cdot s^2/m]$

G_U Unbalanced load [N]. 10...35 % of the dry laundry capacity is taken as unbalanced load.
g Acceleration due to gravity = 9.81 m/s^2
r Radius of action of unbalanced load [m]
Drum radius = d_T / 2 [m]
ω Angular velocity = $\pi \cdot n / 30$ [s^{-1}]
n Drum speed during spinning [min^{-1}]

The total force for determination of the bearing loads thus is: $F = F_Z + G_T + G_W$ [N]
This load is applied to the washing drum centre.

The bearing loads are:



Bearing A
$F_{rA} = F \cdot \frac{l_2}{a}$ [N]

Bearing B
$F_{rB} = F \cdot \frac{l_1}{a}$ [N]

Bearing dimensioning

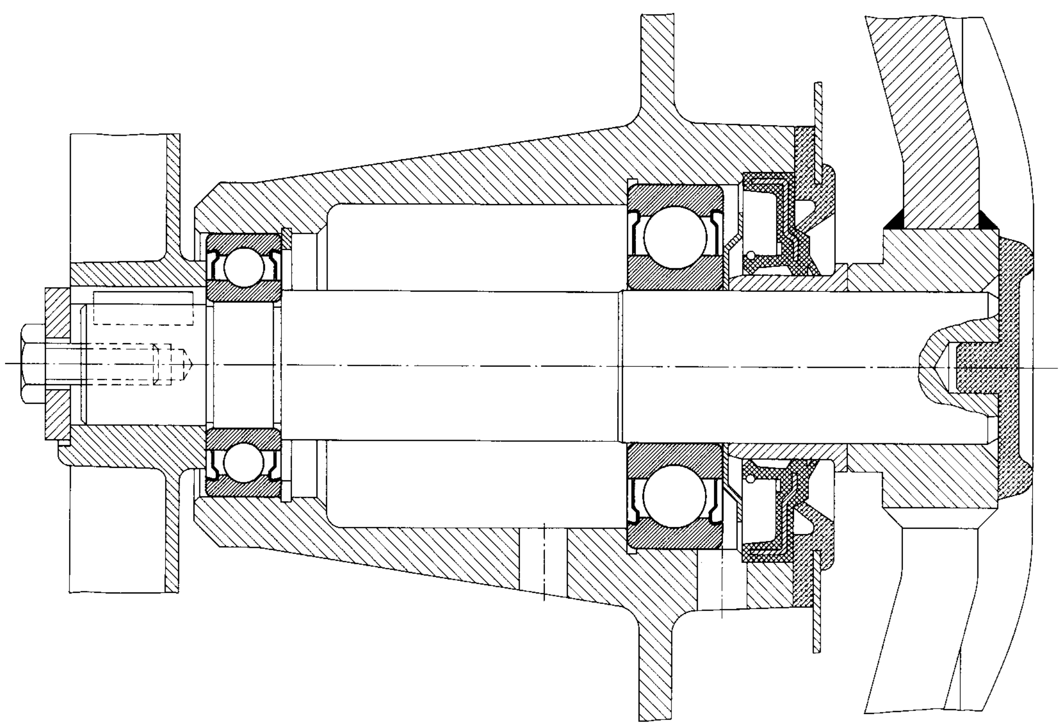
The bearings for domestic washing machines are dimensioned for an *index of dynamic stressing* f_L = 0.85...1.0.
These values correspond to a *nominal life* of 300...500 hours of spinning.
In the example shown a deep groove ball bearing FAG 6306.2ZR.C3 was selected for the drum side and a deep groove ball bearing FAG 6305.2ZR.C3 for the pulley side.
The bearings have an increased *radial clearance* C3 and are *sealed* by shields (.2ZR) at both sides.

Machining tolerances

Due to the unbalanced load G_U,the inner rings are subjected to *point load,* the outer rings to *circumferential load.* For this reason, the outer rings must have a tight *fit* in the housing; this is achieved by machining the housing bores to M6. The fit of the inner rings is not as tight; drum journal to h5. This ensures that the *floating bearing* is able to adjust in the case of thermal expansion. A loose fit also simplifies mounting.

Lubrication, sealing

The bearings, *sealed* at both sides, are prelubricated with a special *grease,* sufficient for the bearing *service life.* There is an additional rubbing-type *seal* at the drum side.



5: Drum mounting of a domestic washing machine

6 Vertical-pump motor

Operating data

Rated horsepower 160 kW; nominal speed 3,000 min^{-1}; Rotor and pump impeller mass 400 kg; pump thrust 9 kN, directed downwards; type V1.

Bearing selection

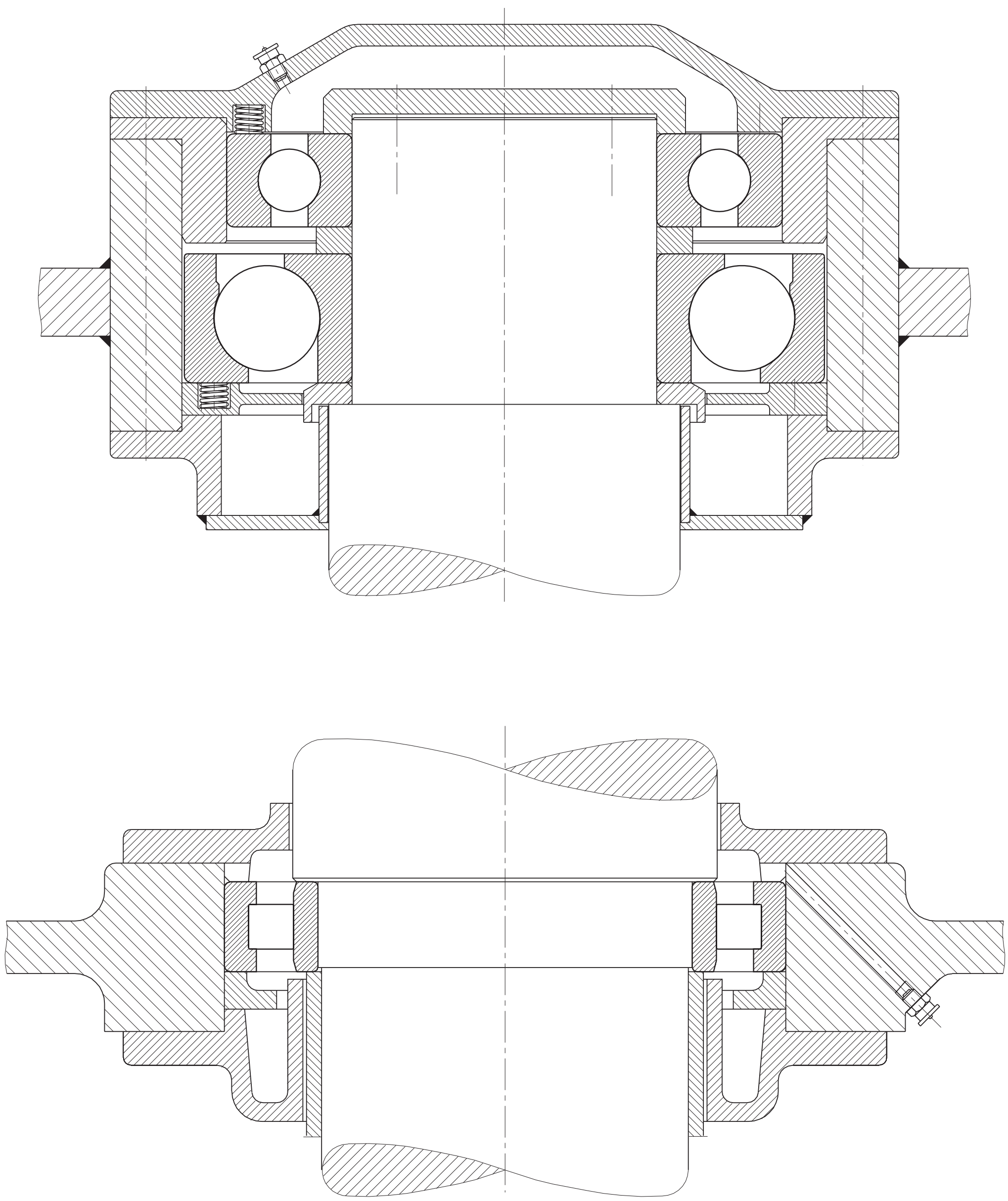
The selection of the bearings is primarily based on the main thrust, which is directed downwards. It is made up of the weight of the rotor and and pump impeller (4 kN), the pump thrust (9 kN) and the spring preload (1 kN). When the motor idles the pump thrust may be reversed so that the bearings have, briefly, to accommodate an upward axial load of 4 kN, as well.
The radial loads acting on the bearings are not exactly known. They are made up by the unbalanced magnetic pull and potential unbalanced loads from the rotor and pump impeller. However, field experience shows that these loads are sufficiently taken into account by taking 50 % of the rotor and pump impeller mass, which in this case is 2 kN.
In the example shown, the supporting bearing is an angular contact ball bearing FAG 7316B.TVP which has to accommodate the main thrust. To ensure that no radial force acts on the bearing this part of the housing is radially relieved to clearance *fit* E8.
In normal operation, the deep groove ball bearing FAG 6216.C3 takes up only a light radial load and the axial spring preload; in addition, the thrust reversal load of the idling motor has to be accommodated.
As a result, the rotor is vertically displaced in the upward direction (ascending distance) which is limited by the defined gap between deep groove ball bearing face and end cap. To avoid slippage during the thrust reversal stage, the angular contact ball bearing is subjected to a minimum axial load by means of springs.
On the pump impeller side a cylindrical roller bearing FAG NU1020M1.C3 acts as the *floating bearing*. As it accommodates the unbalanced loads from the pump impeller both the inner and the outer ring are fitted tightly.
The cylindrical roller bearing design depends on the shaft diameter of 100 mm, which in turn is dictated by strength requirements. Due to the relatively light radial load, the lighter series NU10 was selected.

Machining tolerances

Cylindrical roller bearing:	Shaft to m5; housing to M6
Deep groove ball bearing:	Shaft to k5; housing to H6
Angular contact ball bearing:	Shaft to k5, housing to E8

Lubrication

The bearings are lubricated with FAG rolling bearing grease *Arcanol* L71V and can be relubricated.
Replenishment quantity
– for the *floating bearing* 15 g
– for the *locating bearing* 40 g
The *relubrication interval* is 1,000 hours. The spent grease is collected in annular cover chambers provided below the bearing locations.



6: Rotor bearing arrangement of a vertical-pump motor

7 Mine fan motor

Operating data

Rated horsepower 1,800 kW; speed $n = 750\ min^{-1}$; Axial load $F_a = 130$ kN; radial load $F_r = 3.5$ kN; the bearings are vertically arranged.

Bearing selection

The axial load of 130 kN is made up of the weight of the rotor and the two variable top and bottom fan impellers as well as the thrust of these fan impellers. They are supported by the upper *thrust bearing.*

The radial loads on vertical motors are only guiding loads. They are very small and generally result from the unbalanced magnetic pull and the potential rotor unbalanced load. In the example shown, the radial load per bearing is 3.5 kN. If the exact values are not known, these loads can be sufficiently taken into account, assuming that half the rotor weight acts as the radial load at the rotor centre of gravity.

The upper supporting bearing is a spherical roller thrust bearing FAG 29260E.MB. Radial guidance is ensured by a deep groove ball bearing FAG 16068M mounted on the same sleeve as the supporting bearing and accommodating the opposing axial loads on the rotor. Axial guidance is necessary for transporting and mounting as well as for motor idling. In this operating condition the counterflow of air can cause reversal of rotation and thrust. The axial displacement is limited to 1 mm in the upward direction so that the spherical roller thrust bearing does not lift off. Springs arranged below the housing washer (spring load 6 kN) ensure continuous contact in the bearings.

Radial guidance at the lower bearing position is provided by a deep groove ball bearing FAG 6340M; it is mounted with a slide fit as the floating bearing. Since it is only lightly loaded, it is preloaded with springs of 3 kN.

Bearing dimensioning

Spherical roller thrust bearing FAG 29260E.MB has a *dynamic load rating* of C = 1430 kN. The *index of dynamic stressing* $f_L = 4.3$ is calculated with the axial load $F_a = 130$ kN and the *speed factor* for roller bearings $f_n = 0.393$ ($n = 750\ min^{-1}$). The *nominal life* $L_h = 65{,}000$ hours.
Based on the *operating viscosity* ν of the *lubricating oil* (viscosity class ISO VG150) at approx. 70 °C, the *rated viscosity* ν_1 and the *factors* K_1 und K_2, a *basic* a_{23II} *value* of about 3 is determined. The *cleanliness factor* s is assumed to be 1. The *attainable life* L_{hna} of the thrust bearing is longer than 100,000 hours and the bearing is therefore sufficiently dimensioned. The two radial bearings are also sufficiently dimensioned with the *index of dynamic stressing* $f_L > 6$.

Machining tolerances

Upper bearing location

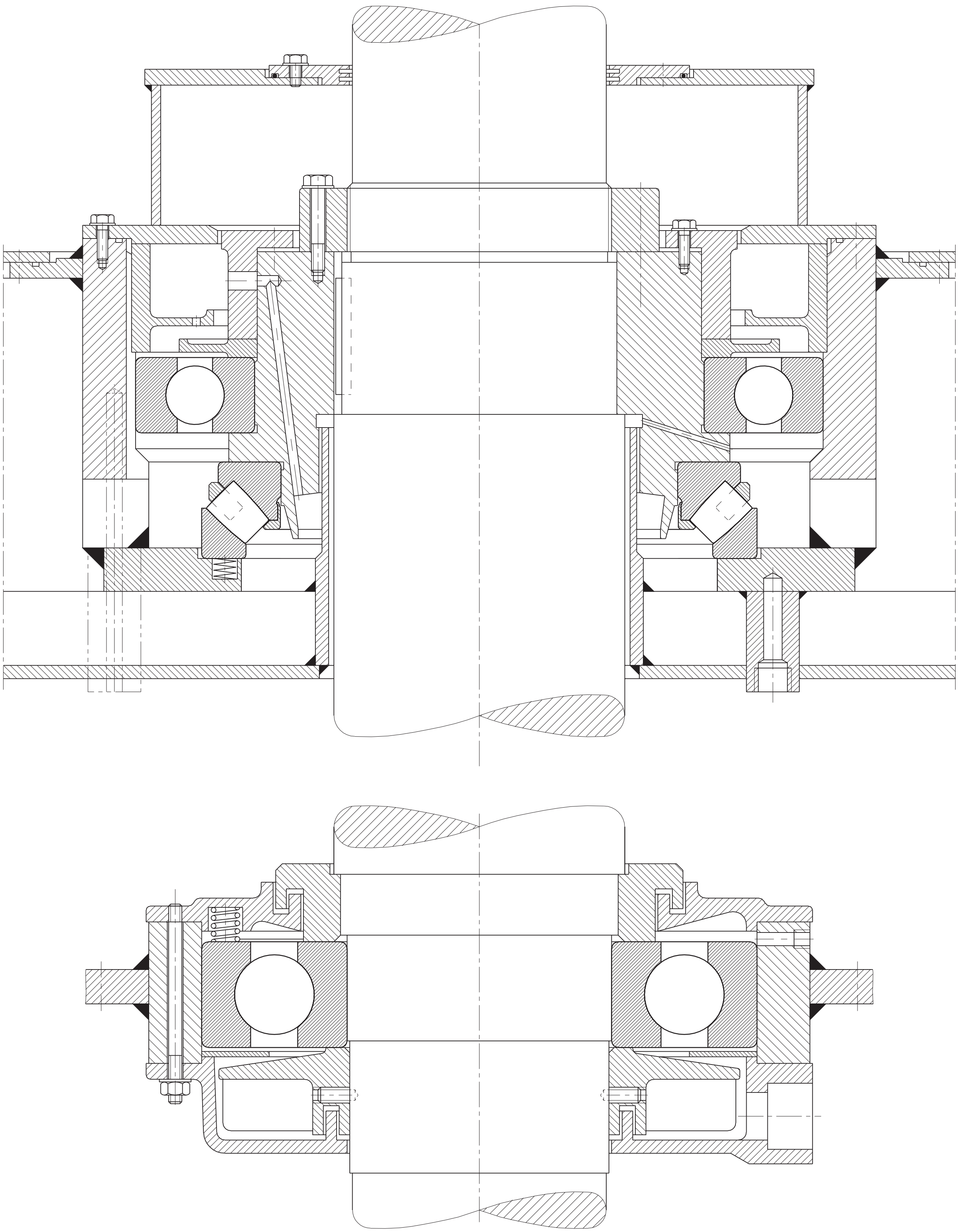
Spherical roller thrust bearing:	Shaft to k5; housing to E8
Deep groove ball bearing:	Shaft to k5; housing to H6

Lower bearing location

Deep groove ball bearing:	Shaft to k5; housing to H6

Lubrication, sealing

Thrust and *radial bearings* at the upper bearing location are *oil-lubricated.*
The spherical roller thrust bearing runs in an oil bath and, due to its asymmetrical design, provides automatic circulation from the inner to the outer diameter. A tapered oil feeder and angled oilways supply the upper bearing. A retaining and a flinger ring ensure oil supply during start-up.
The lower bearing is *grease-lubricated* with provision for relubrication and a grease valve. Both bearing locations are labyrinth-*sealed.*



7: Rotor bearing arrangement of a mine fan motor

8 Rotor of a wind energy plant

Wind energy plants are among the alternative and environmentally friendly energy sources. Today, they generate powers of up to 3,200 kW. There are horizontal-rotor systems and vertical-rotor systems. The wind energy plant WKA60 is 44 meters high and features a three-blade horizontal rotor with a diameter of 60 m.

Operating data

Nominal speed of the three-blade rotor = 23 min^{-1}; gear transmission ratio i = 1:57.4; electrical power 1,200 kW at a nominal rotor speed of the generator of n = 1,320 min^{-1}.

Bearing selection

A *service life* of 20 years was specified. To support the overhung blade rotor, spherical roller bearings FAG 231/670BK.MB (dimensions 670 x 1,090 x 336 mm) were selected for the *locating bearing* location and FAG 230/900BK.MB (dimensions 900 x 1,280 x 280 mm) for the *floating bearing* location.

Bearing dimensioning

The recommended value for dimensioning the main bearings of wind energy plants is P/C = 0.08...0.15. The varying wind forces, causing vibrations, make it difficult to exactly determine the loads to be accommodated by the bearings. A *nominal life* of L_h > 130,000 h was specified. For this reason, the mean equivalent load is, as a rule, determined on the basis of several load cases with variable loads, speeds and percentage times. The *locating bearing* of the WKA60 plant is subjected to radial loads of F_r = 400...1,850 kN and thrust loads of F_a = 60...470 kN. The *floating bearing* may have to accommodate radial loads of F_r = 800...1,500 kN.
For the *locating bearing,* the radial and axial loads to be accommodated yield a mean *equivalent dynamic load* of P = 880 kN. For the bearing FAG 231/670BK.MB with a *dynamic load rating* of C = 11,000 kN this yields a load ratio of P/C = 880/11,000 = 0.08.
The *floating bearing* FAG 230/900BK.MB accommodates a mean radial force of F_r = P = 1,200 kN. With a *dynamic load rating* of 11,000 kN a load ratio of 1,200/11,000 = 0.11 is obtained.
The *life* values calculated for the normally loaded spherical roller bearings (in accordance with DIN ISO 281) are far above the number of hours for 20-year continuous operation.

Mounting and dismounting

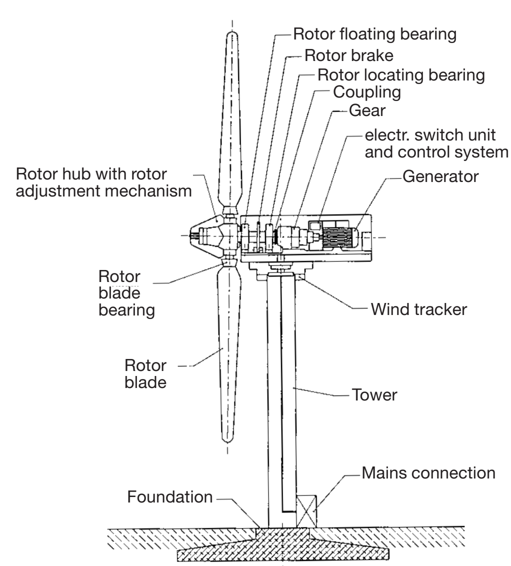
To facilitate mounting and dismounting of the bearings, they are fastened on the shaft by means of hydraulic adapter sleeves FAG H31/670HGJS and FAG H30/900HGS. Adapter sleeves also allow easier adjustment of the required *radial clearance.*
The bearings are supported by one-piece plummer block housing of designs SUB (*locating bearing*) and SUC (*floating bearing*). The housings are made of cast steel and were checked by means of the finite-element method.

Machining tolerances

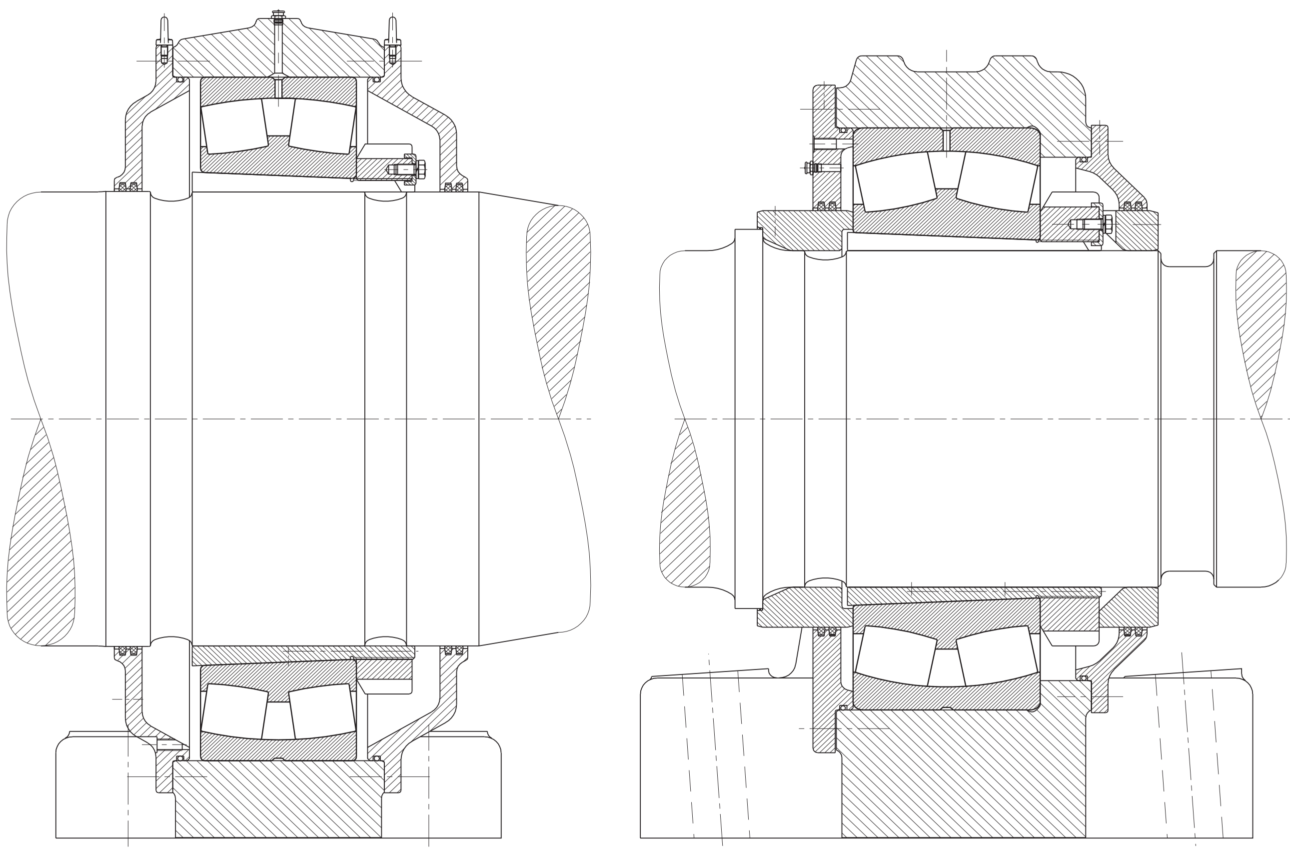
The withdrawal sleeve seats on the rotor shaft are machined to h9 and cylindricity tolerance IT5/2 (DIN ISO 1101).
The bearing seats in the housing bore are machined to H7; this allows the outer ring of the *floating bearin*g to be displaced.

Lubrication, sealing

The bearings are lubricated with a lithium soap base *grease* of *penetration* class 2 with *EP additives* (FAG rolling bearing grease *Arcanol* L186V).
The housings are sealed on both sides by means of a double felt *seal.* A grease collar around the sealing gap prevents ingress of dust, dirt and, possibly, splash water.



Wind energy plant, schematic drawing



8: Rotor shaft bearings of a wind energy plant

9–18 Work spindles of machine tools

The heart of every machine tool is its main or work spindle and its work spindle bearings. The main quality characteristics of the spindle-bearing system are cutting volume and machining precision. Machine tools are exclusively fitted with rolling bearings of increased precision; mainly angular contact ball bearings and spindle bearings (radial angular contact ball bearings with *contact angles* of 15° and 25°, respectively), double-direction angular contact thrust ball bearings, radial and thrust cylindrical roller bearings and, occasionally, tapered roller bearings.

Depending on the performance data required for a machine tool, the spindle bearing arrangement is designed with ball or roller bearings based on the following criteria: rigidity, friction behaviour, precision, *speed suitability,* lubrication and *sealing.*

Out of a multitude of possible spindle bearing arrangements for machine tools a few typical arrangements have proved to be particularly suitable for application in machine tools (figs. a, b, c).

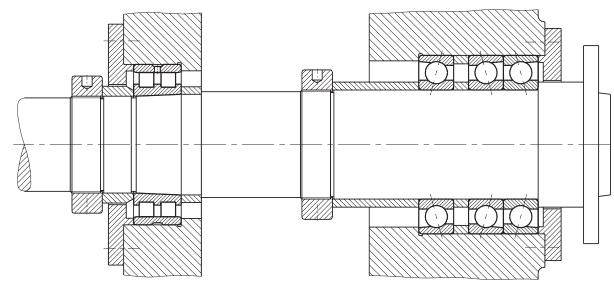
Dimensioning

Usually, a *fatigue life* calculation is not required for the work spindles since, as a rule, to achieve the required spindle and bearing rigidity, bearings with such a large bore diameter have to be selected that, with increased or utmost cleanliness in the lubricating gap, the bearings are failsafe. For example, the *index of dynamic stressing* f_L of lathe spindles should be 3...4.5; this corresponds to a *nominal life* of L_h = 15,000...50,000 h.

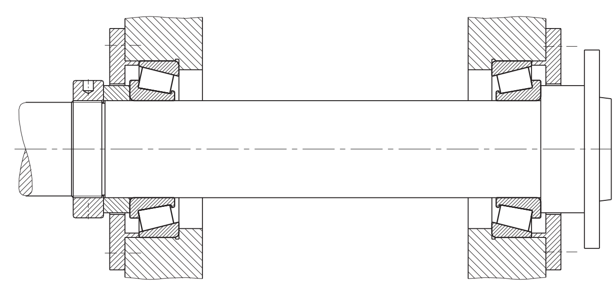
Example: The main spindle bearing arrangement of a CNC lathe (fig. a) is supported at the work end in three spindle bearings B7020E.T.P4S.UL in *tandem-O-arrangement* (*contact angle* α_0 = 25°, C = 76.5 kN, C_0 = 76.5 kN). At the drive end, the belt pull is accommodated by a double-row cylindrical roller bearing NN3018ASK.M.SP. The cutting forces cause 50 % each of the axial reaction forces for the two *tandem-arranged* spindle bearings. The front bearing at the work end accommodates 60 % of the radial forces. It is loaded with F_r = 5 kN, F_a = 4 kN at n = 3,000 min^{-1}.

If the bearings are lubricated with the lithium soap base grease FAG *Arcanol* L74V (*base oil viscosity* 23 mm^2/s at 40 °C), an *operating viscosity* of ν = 26 mm^2/s will be obtained at an operating temperature of 35 °C. With the mean bearing diameter d_m = 125 mm and the speed n = 3,000 min^{-1} a *rated viscosity* of ν_1 = 7 mm^2/s is obtained.

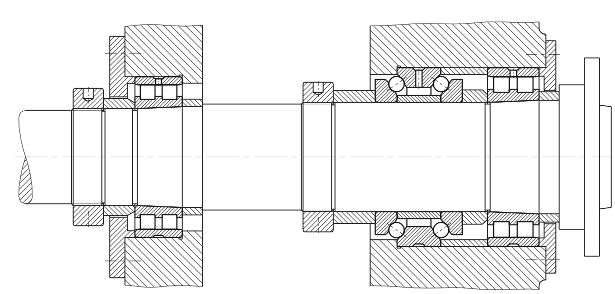
This yields a *viscosity ratio* $\kappa = \nu/\nu_1 \approx 4$; i. e. the rolling contact areas are fully separated by a lubricant film. With κ = 4, a *basic* a_{23II} *factor* of 3.8 is obtained from the a_{23} diagram. Since the bearings, as a rule, are relatively lightly loaded (f_{s*} > 8), a very good *cleanliness factor* (s = infinite) is obtained with increased (V = 0.5) and utmost (V = 0.3) cleanliness. Consequently, the *factor* a_{23} ($a_{23} = a_{23II} \cdot s$), and thus the *attainable life* ($L_{hna} = a_1 \cdot a_{23} \cdot L_h$) becomes infinite; the bearing is *failsafe.*
So, as long as $f_{s*} \geq 8$ and the main spindle bearings are lubricated well ($\kappa \geq 4$), only the cleanliness in the lubricating gap determines whether the bearing is *failsafe* or not.



a: Spindle bearing arrangement with universal-design spindle bearings (spindle bearing set), subjected to combined load, at the work end and a single-row or double-row cylindrical roller bearing at the drive end which accommodates only radial loads.



b: Spindle bearing arrangement with two tapered roller bearings in *O arrangement.* The bearings accommodate both radial and axial loads.



c: Spindle bearing arrangement with two double-row cylindrical roller bearings and a double-direction angular contact thrust ball bearing. Radial and axial loads are accommodated separately.

9 Drilling and milling spindle

Operating data

Input power 20 kW; range of speed 11...2,240 min^{-1}.

Bearing selection

Radial and axial forces are accommodated separately. The *radial bearings* are double-row cylindrical roller bearings – an FAG NN3024ASK.M.SP at the work end and an FAG NN3020ASK.M.SP at the opposite end. The double-direction angular contact thrust ball bearing FAG 234424M.SP guides the spindle in axial direction. This bearing has a defined preload and *adjustment* is, therefore, not required.

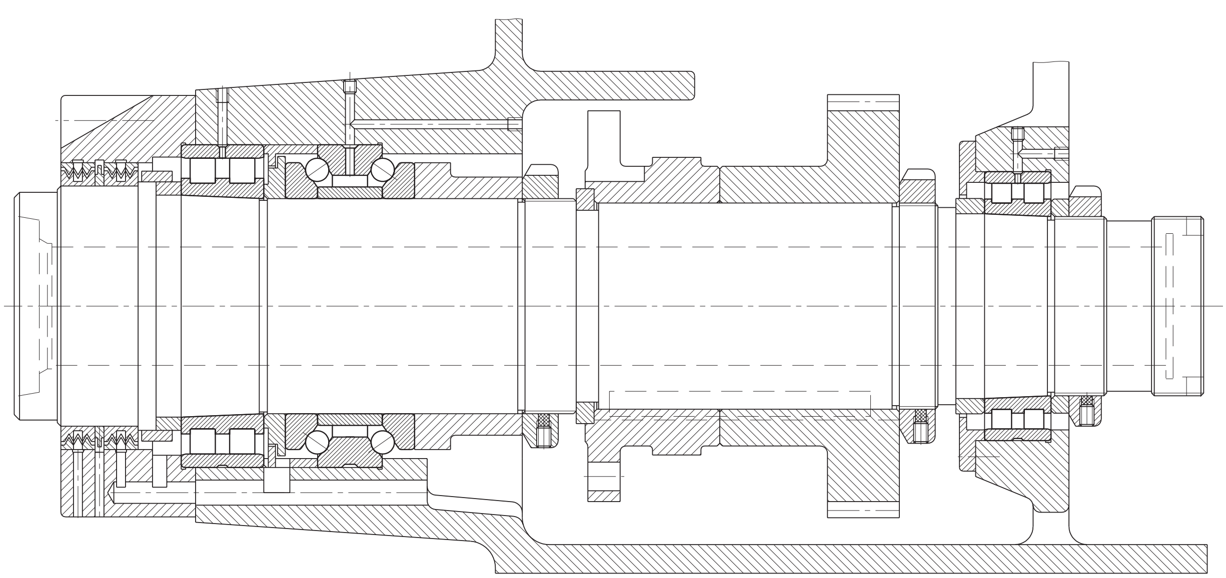
Machining of the housing bore is simplified in that the nominal outside diameters of the *radial* and *thrust bearings* are the same. The O.D. tolerance of the angular contact thrust ball bearing is such as to provide a loose *fit* in the housing.

Lubrication, sealing

Circulating *oil* lubrication.
The labyrinth *seal* at the work end consists of ready-to-mount, non-rubbing sealing elements. The inner labyrinth ring retains the *lubricating oil,* the outer labyrinth ring prevents the ingress of cutting fluid.

Machining tolerances

Bearing	Seat	Diameter tolerance	Form tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Cylindrical roller bearing	Shaft, tapered	Taper 1:12	IT1/2	IT1
	Housing	K5	IT1/2	IT1
Angular contact thrust bearing	Shaft	h5	IT1/2	IT1
	Housing	K5	IT1/2	IT1



9: Drilling and milling spindle

10 NC-lathe main spindle

Operating data

Input power 27 kW;
maximum spindle speed 9,000 min^{-1}.

Bearing selection

The main requirements on this bearing arrangement are an extremely good *speed suitability*, rigidity, and accurate guidance of the work spindle. At the work end, a spindle bearing set FAG B7017C.T.P4S.DTL in *tandem arrangement* is provided; at the drive end, a spindle bearing set FAG B71917C.T.P4S.DTL in *tandem arrangement.*
The bearings are lightly preloaded (UL) and have an increased precision (P4S).
The arrangement has no *floating bearing;* it is a rigid *locating bearing* system. Both bearing groups together form an *O arrangement.*

Bearing dimensioning

The size of the bearings is primarily based on the spindle rigidity required, i. e. on the largest possible spindle diameter. The *fatigue life* of the bearings is taken into account for dimensioning but it does not play a dominating role in practice.

Main spindle bearings do not normally fail due to material fatigue but as a result of *wear;* the *grease service life* is decisive.

Bearing clearance

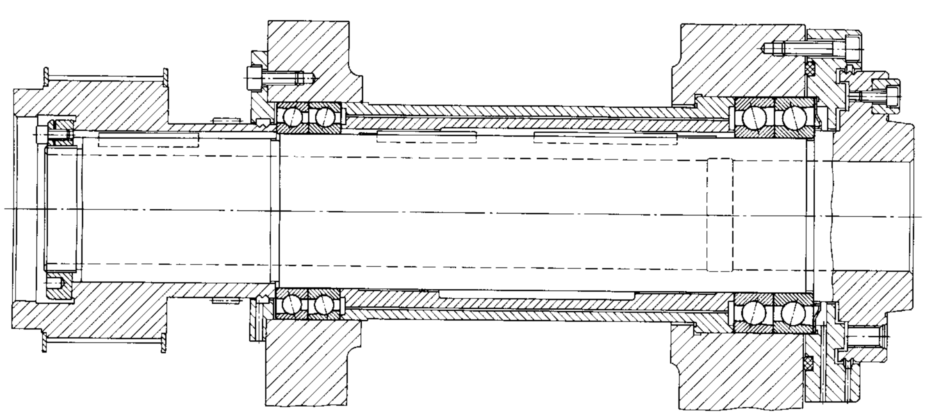
FAG spindle bearings of *universal design* are intended for mounting in *X, O or tandem arrangement* in any arrangement. When mounting in *X* or *O arrangement* a defined preload results. The light preload UL meets the normal requirements.
The original preload remains in the bearings due to outer and inner spacer sleeves of identical lengths.
With a good bearing distance, the axial and radial heat expansions of the work spindle compensate each other so that the bearing preload remains unchanged under any operating condition.

Lubrication, sealing

The bearings are greased for life with the FAG rolling bearing *grease Arcanol* L74V and about 35 % of the cavity is filled.
Sealing is provided by labyrinth *seals* with defined gaps.

Machining tolerances

Bearing	Seat	Diameter tolerance	Form tolerance (DIN ISO 1101)	Axial run-out tolerance of abutment shoulder
Spindle bearings	Shaft	+5/–5 µm	1.5 µm	2.5 µm
Drive end/work end	Housing	+2/+10 µm	3.5 µm	5 µm



10: NC-lathe main spindle

11 CNC-lathe main spindle

Operating data

Input power 25 kW;
Speed range 31.5...5,000 min^{-1}.

Bearing selection

The bearings must accurately guide the spindle radially and axially and be very rigid. This is achieved by selecting as large a shaft diameter as possible and a suitable bearing arrangement. The bearings are preloaded and have an increased precision.
At the work end a spindle bearing set FAG B7018E.T.P4S.TBTL in *tandem-O-arrangement* with a light preload is mounted as *locating bearing.*
At the drive end there is a single-row cylindrical roller bearing FAG N1016K.M1.SP as *floating bearing.*
This bearing arrangement is suitable for high speeds and for high cutting capacities.

Bearing dimensioning

The bearing size is primarily based on the spindle rigidity required, i.e. on the spindle diameter. The *fatigue life* of the bearings is taken into account for dimensioning but it does not play a dominating role in practice.
Apart from the Hertzian contact pressure, the *service life* of the bearings is mainly dictated by the *grease service life.* Main spindle bearings do not normally fail due to material fatigue but as a result of *wear.*

Bearing clearance

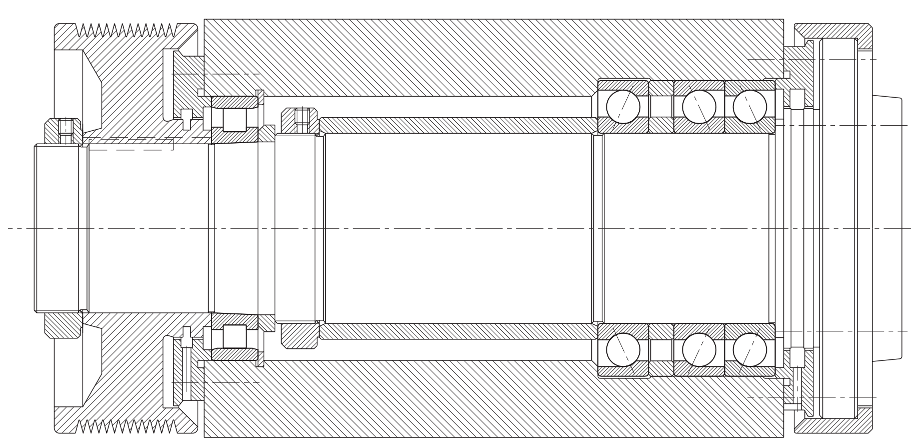
FAG spindle bearings of *universal design* are intended for mounting in *X, O* or *tandem arrangement* in any arrangement. When mounting in *X* or *O arrangement* a set preload results. The light preload UL meets the normal requirements.
The cylindrical roller bearing is adjusted with almost zero *radial clearance* by axially pressing the tapered inner ring onto the spindle.

Lubrication, sealing

The bearings are greased for life with the FAG rolling bearing *grease Arcanol* L74V.
Approximately 35% of the spindle bearing cavity and approximately 20% of the cylindrical -roller bearing cavity is filled with *grease.*
Sealing is provided by a labyrinth with set narrow radial gaps.

Machining tolerances

Bearing	Seat	Diameter tolerance	Form tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Spindle bearings	Shaft Housing	+5/–5 µm –4/+8 µm	1.5 µm 3.5 µm	2.,5 µm 5 µm
Cylindrical roller bearings	Shaft, tapered Housing	Taper 1:12 –15/+3 µm	1.5 µm 3.5 µm	2.5 µm 5 µm



11: CNC-lathe main spindle

12 Plunge drilling spindle

Operating data

Input power 4 kW;
maximum spindle speed 7,000 min^{-1}.

Bearing selection

Accurate axial and radial guidance of the drilling spindle is required. Consequently, bearing selection is based on the axial loads to be accommodated while providing the greatest possible axial rigidity. Another criterion is the available space which, e.g. in the case of multispindle cutter heads, is limited.
Work end:
1 spindle bearing set FAG B71909E.T.P4S.TTL
(three bearings mounted in *tandem arrangement*)
Drive end:
1 spindle bearing set FAG B71909E.T.P4S.DTL
(two bearings mounted in *tandem arrangement*).
The two bearing sets can also be ordered as a single set of five:
FAG B71909E.T.P4S.PBCL (*tandem* pair mounted against three *tandem-arranged* bearings in *O arrangement,* lightly preloaded). This bearing arrangement includes no *floating bearing;* it forms a rigid *locating bearing* system.

Bearing dimensioning

The bearing size is based on the spindle rigidity required, i.e. on as large a spindle diameter as possible.

As regards loading, the bearings usually have a *stress index* f_{s*} > 8 and are, consequently, *failsafe.* The *bearing life* is significantly influenced by a good *sealing* which allows the *grease service life* to be fully utilized.

Bearing clearance

FAG spindle bearings of *universal design* are intended for mounting in *X, O* or *tandem arrangement* in any arrangement. When mounting in *X* or *O arrangement,* a set preload results. The light preload UL meets the normal requirements.

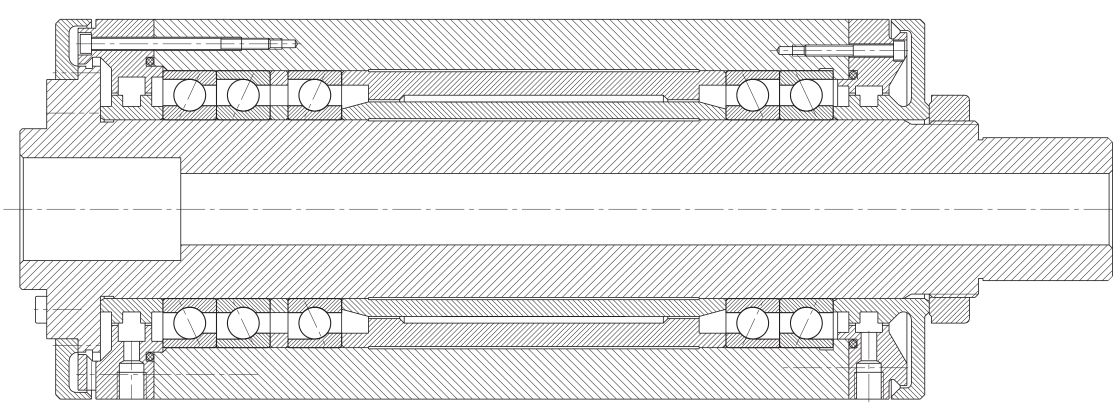
The original preload remains in the bearings due to outer and inner spacer sleeves of identical lengths. With a good bearing distance, the axial and radial heat expansions of the work spindle compensate each other so that the bearing preload remains unchanged under any operating condition.

Lubrication, sealing

The bearings are greased for life with the FAG rolling bearing grease Arcanol L74V and about 35 % of the cavity is filled.
Sealing is provided by labyrinth *seals* with a collecting groove and a drain hole where a syphon may be provided.

Machining tolerances

Bearing	Seat	Diameter tolerance	Form tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Spindle bearing (drive/work end)	Shaft	+3.5/–3.5 µm	1 µm	1.5 µm
	Housing	–3/+5 µm	2 µm	3 µm



12: Drilling spindle bearing arrangement

13 High-speed motor milling spindle

Operating data

Input power 11 kW;
maximum spindle speed 28,000 min^{-1}.

Bearing selection

The bearings must be suitable for very high speeds and for the specific thermal operating conditions in a motor spindle. Hybrid spindle bearings with ceramic balls are particularly suitable for this application.
Milling spindles must be guided extremely accurately both in the axial and in the radial direction.

Work end:
1 spindle bearing set FAG HC7008E.T.P4S.DTL in *tandem arrangement.*
Drive end:
1 spindle bearing set FAG HC71908E.T.P4S.DTL in *tandem arrangement.*

The bearing pairs at drive end and work end are mounted in *O arrangement* and elastically *adjusted* by means of springs (spring load 300 N), corresponding to a medium preload. The bearing pair at the drive end is mounted on a sleeve which is supported on a linear ball bearing with zero clearance so that axial length variations of the shaft can be freely compensated for.

Bearing dimensioning

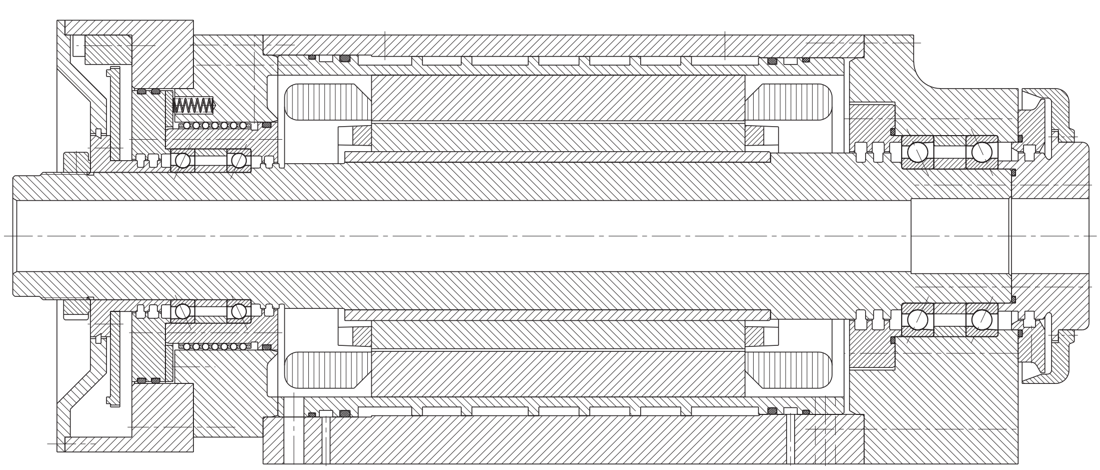
Bearing size and bearing arrangement are selected on the basis of the specified speed and on the spindle diameter.
Two other factors that have to be taken into account are the heat generated by the motor, which causes a major temperature difference between the inner ring and the outer ring of the bearing, and the ring expansion which makes itself felt by the centrifugal force resulting from the high speed. In a rigid bearing arrangement, this would considerably increase the preload. Due to the spring preload, both these influences are easily compensated for. As a result, the contact pressure in the rolling contact area of the bearing is relatively low ($p_0 \leq 2{,}000$ N/mm^2), and the bearings are *failsafe.* Consequently, the service life of the bearings is dictated by the *grease service life.*

Lubrication, sealing

The bearings are lubricated with rolling bearing *grease Arcanol* L207V which is particularly suitable for the greater thermal stressing and for high speeds.
To protect the *grease* from contamination, and consequently to increase the *grease service life,* the bearings are sealed by labyrinths consisting of a gap-type *seal* with flinger grooves and a collecting groove.

Machining tolerances

Bearing	Seat	Diameter tolerance	Form tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Spindle bearing (drive/work end)	Shaft	+6/+10 µm	1 µm	1.5 µm
	Housing	–3/+5 µm	2 µm	3 µm



13: Bearing arrangement of a high-speed motor milling spindle

14 Motor spindle of a lathe

Operating data

Input power 18 kW;
maximum spindle speed 4,400 min^{-1}.

Bearing selection

The bearings must be very rigid and accurately guide the spindle in the radial and axial direction. This is achieved by selecting as large a shaft diameter as possible and a suitable bearing arrangement. The bearings are preloaded and have an increased precision. Also, the specific thermal conditions found in a motor bearing arrangement have to be taken into account.

Work end: 1 spindle bearing set
FAG B7024E.T.P4S.QBCL
(*tandem-O-tandem arrangement*)
as *locating bearing*

Opposite end: 1 cylindrical roller bearing
FAG N1020K.M1.SP
as *floating bearing.*

Bearing dimensioning

As the bearing size primarily depends on the spindle rigidity (larger spindle diameter) bearing sizes are obtained whose load carrying capacity is more than adequate.
Consequently, the *service life* of the bearings is primarily dictated by the *grease service life.*

Bearing clearance

The spindle bearings are mounted with a light preload. The cylindrical roller bearing is *adjusted* to a *radial clearance* of a few µm by axially pressing the tapered inner ring onto the tapered shaft seat and reaches the required zero clearance at operating temperature.

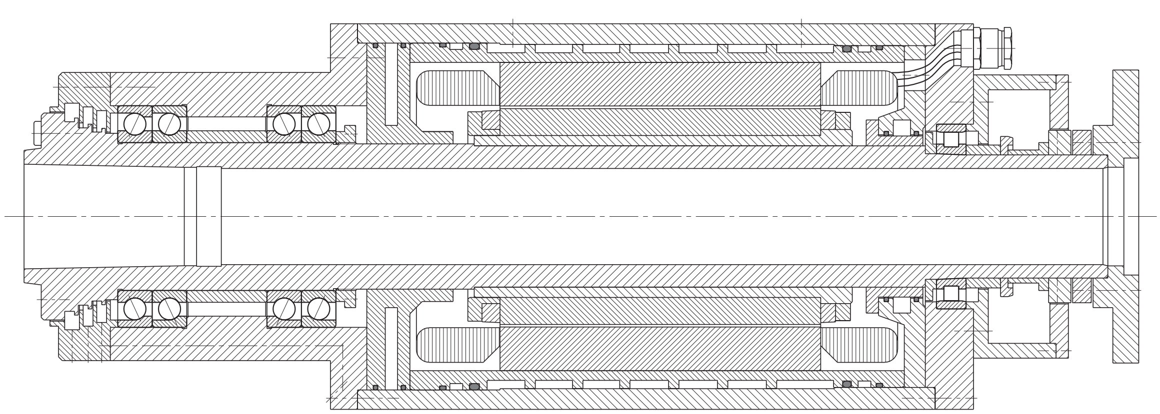
Lubrication, sealing

The bearings are lubricated for life with the rolling bearing *grease Arcanol* L207V. This *grease* is particularly suitable for increased temperatures and high speeds. Approximately 35 % of the spindle bearing cavity and approximately 20 % of the cylindrical-roller bearing cavity is filled with grease.

Sealing is provided by a stepped labyrinth with collecting grooves and drain holes. A gap-type *seal* protects the cylindrical roller bearing from external contamination.

Machining tolerances

Bearing	Seat	Diameter tolerance	Form tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Spindle bearing	Shaft Housing	–5/+5 µm –4/+10 µm	1.5 µm 3.5 µm	2.5 µm 5 µm
Cylindrical roller bearing	Shaft, tapered Housing	1:12 –15/+3 µm	1.5 µm 3.5 µm	2.5 µm 5 µm



14: Motor spindle bearing arrangement of a lathe

15 Vertical high-speed milling spindle

Operating data

Input power 2.6/3.14 kW;
Nominal speed 500...4,000 min^{-1}.

Bearing selection

The bearings must operate reliably over the entire speed range from 500 to 4,000 min^{-1}. For example, the spindle must be rigidly guided at 500 min^{-1} under heavy loads both in the radial and axial direction. On the other hand, at the maximum speed of 4,000 min^{-1}, the bearing temperature must not be so high as to impair accuracy.
At the milling spindle work end a spindle bearing set FAG B7014E.T.P4S.TBTM are mounted in *tandem-O-arrangement* with a medium preload. The bearing group is preloaded with 1.9 kN by means of a nut and a spacer sleeve.
The deep groove ball bearing FAG 6211TB.P63 guides the spindle at the drive end. To ensure clearance-free operation this bearing is lightly preloaded by means of Belleville spring washers.

Bearing dimensioning

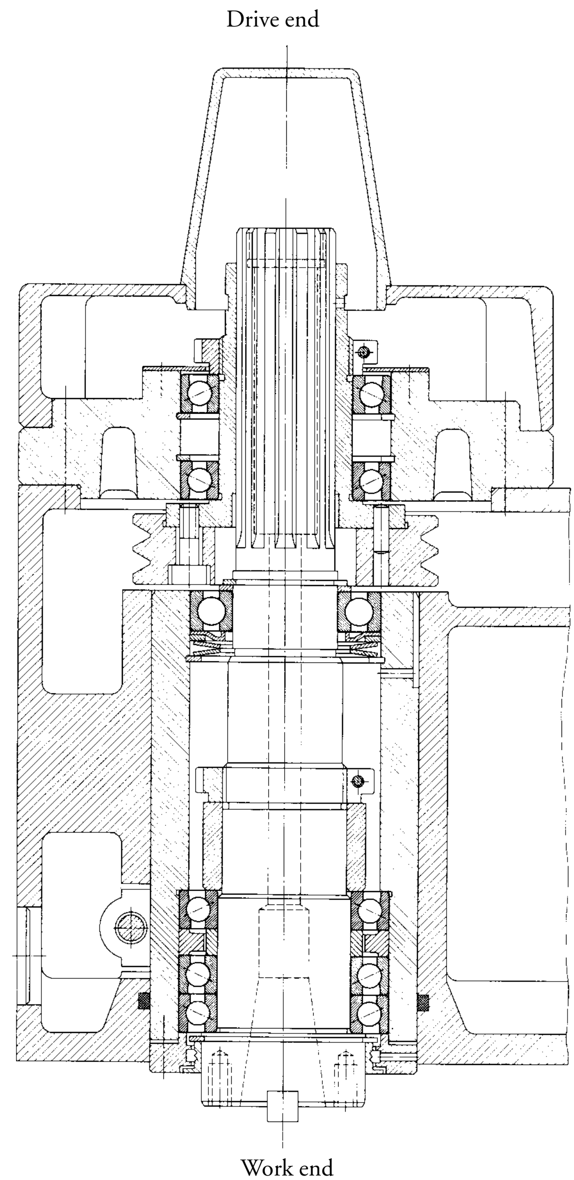
Milling spindles must be resistant to deflection and torsion. This requirement dictates the spindle diameter and the bearing size. The required bearing rigidity is obtained by the chosen bearing arrangement and preload. The two angular contact ball bearings arranged at the upper drive end accommodate the driving forces.

Machining tolerances

Seat	Diameter tolerance	Cylindricity tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Shaft	js4	IT1/2	IT1
Housing (work end)	JS5	IT2/2	IT2
Housing (drive end)	H6	IT3/2	IT3

Lubrication, sealing

The bearings are *grease lubricated* (FAG rolling bearing *grease Arcanol* L74V).
A gap-type *seal* with oil splash ring and collecting grooves protect the spindle bearings from contamination.



15: Bearing arrangement of a vertical high-speed milling spindle

16 Bore grinding spindle

Operating data

Input power 1.3 kW; spindle speed 16,000 min^{-1}. The spindle is radially loaded by the grinding pressure. The load depends on grinding wheel quality, feed and depth of cut.

Bearing selection

Due to the high speeds required during bore grinding, the spindle speeds must also be high. Sufficient rigidity and accurate guidance, especially in axial direction, are also required. The demands for high speed and high rigidity can be met with spindle bearings. As the spindle requires primarily a high radial rigidity, it is advisable to provide bearings with a *contact angle* of 15° (design C).

At the work end and at the drive end there is one spindle bearing set FAG B7206C.T.P4S.DTL in *tandem arrangement* each. The load is equally shared by these *O arranged* tandem bearing pairs. For this purpose the spacer rings must be identical in width and also flush ground.

The bearings are lightly preloaded by a coil spring for clearance-free operation under all operating conditions. The preload increases the rigidity of the bearing arrangement. It is, however, limited by the permissible bearing temperature and varies between 300 and 500 N depending on the spindle application.

The spindle diameter, which determines the bearing size, is based on the required rigidity.

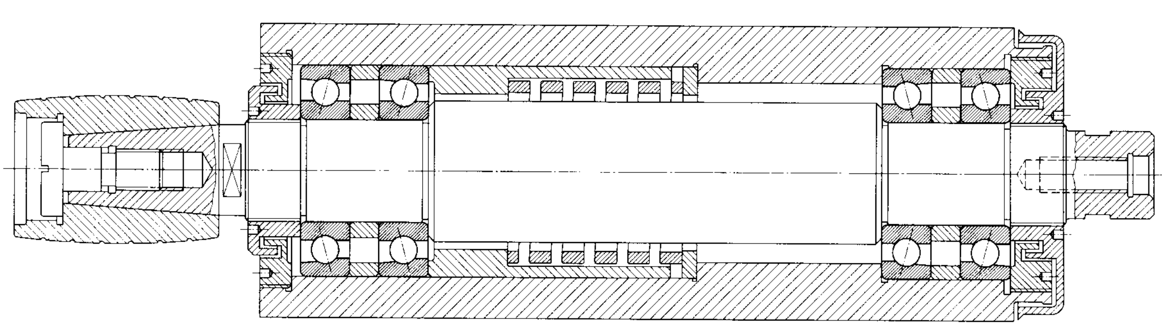
Lubrication, sealing

Grease lubrication for high-speed bearings (FAG rolling bearing *grease Arcanol* L74V). The bearings are lubricated for *life* during mounting and therefore no relubrication is required.

The high-speed bearings require the use of non-rubbing *seals,* in this case labyrinth *seals.*

Machining tolerances

Seat	Diameter tolerance	Cylindricity tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Shaft	js3	IT0/2	IT0
Housing (drive end)	+2/+6 µm	IT1/2	IT1
Housing (work end)	–1/+3 µm	IT1/2	IT1



16: Bearing arrangement of a bore grinding spindle

17 External cylindrical grinding spindle

Operating data

Input power 11 kW; speed n = 7,500 min^{-1}; running accuracy: radially 3 µm, axially 1 µm.

Bearing selection

During external cylindrical grinding a high cutting capacity is required (for rough grinding) and a high standard of form and surface quality (for fine grinding). A high degree of rigidity and running accuracy as well as good damping and *speed suitability* form the main criteria for the bearing arrangement. These requirements are met by *precision bearings.*
Sealed universal spindle bearings with small steel balls (HSS) are used:

- at the work end: 1 spindle bearing set FAG HSS7020C.T.P4S.QBCL in double-*O arrangement* as *locating bearing*
- at the drive end: 1 spindle bearing set FAG HSS7020C.T.P4S.DBL in *O arrangement* as *floating bearing*

Where even higher speeds have to be accommodated, it is advisable to use sealed hybrid spindle bearings HCS with small ceramic balls (lower centrifugal forces).

Bearing dimensioning

The required spindle diameter or the specified outside diameter of the quill determines the bearing size. The *contact angle* of 15° is suitable for high radial rigidity. Damping and running accuracy are improved by arranging four bearings at the work end.

Bearing clearance

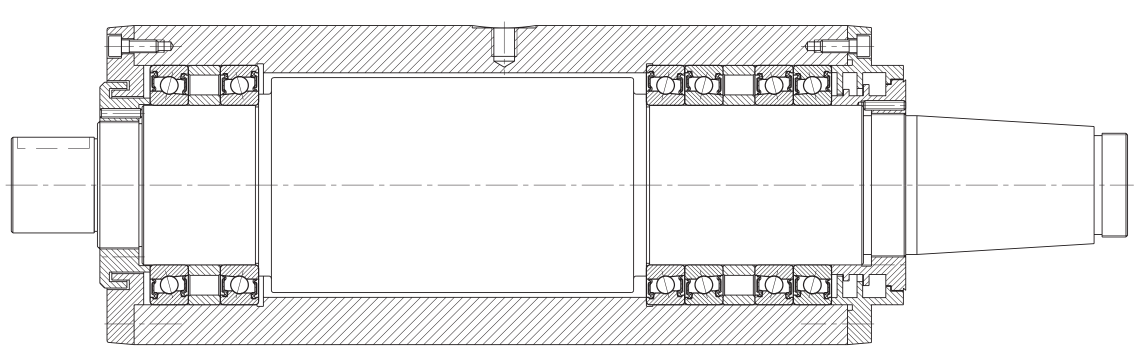
All UL *universal design* bearings are lightly preloaded when mounted in *O arrangement.* Spacers improve the thermal conditions and provide a larger *spread* at the bearing location. To ensure that the defined bearing preload is not altered by the spacers, the latter must be identical in width and flush ground.

Lubrication, sealing

The sealed FAG HSS spindle bearings require no maintenance and are lubricated for life with the FAG rolling bearing *grease Arcanol* L74.
Additional *sealing* is provided at the grinding wheel end by a labyrinth with defined narrow axial gaps of 0.3 ... 0.8 mm. A plain labyrinth *seal* is sufficient at the drive end.

Machining tolerances

Bearing	Seat	Diameter tolerance	Form tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Spindle bearing (work end)	Shaft Housing	+3/–3 µm -3/+5 µm	1 µm 2 µm	1.5 µm 3.5 µm
Spindle bearing (drive end)	Shaft Housing	+3/–3 µm +5/+13 µm	1 µm 2 µm	1.5 µm 3.5 µm



17: Bearing arrangement of an external cylindrical grinding spindle

18 Surface grinding spindle

Operating data

Grinding motor power 220 kW; maximum speed 375 min^{-1}; weight of spindle, rotor and grinding spindle head 30 kN; maximum grinding pressure 10 kN.

Bearing selection

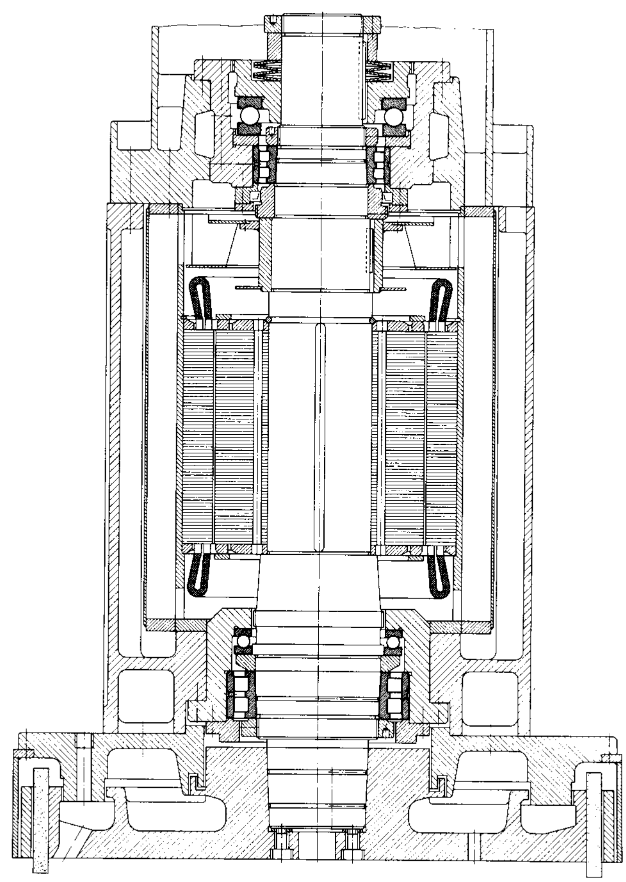
The spindle is supported at the grinding spindle head by a double-row cylindrical roller bearing FAG NN3060ASK.M.SP. The thrust ball bearing FAG 51164MP.P5 arranged above this bearing absorbs the thrust component of the grinding pressure. The upper end of the spindle is fitted with a double-row cylindrical roller bearing FAG NN3044ASK.M.SP and a thrust ball bearing FAG 51260M.P6. The cylindrical roller bearing provides radial guidance; the thrust ball bearing carries the weight of the rotor, spindle, and spindle head. To increase axial rigidity this bearing is adjusted with Belleville spring washers against the lower thrust ball bearing.

Bearing dimensioning

Rigid spindle guidance in the radial direction is ensured by accurately dimensioned mating parts, tight *fits* of the rings, and a light preload of the cylindrical roller bearings. The inner rings are pushed along the tapered bearing seat until the roller-and-cage assembly runs under a light preload (5 µm). Surface finish and dimensional accuracy of the workpiece mainly depend on the axial rigidity of the spindle headstock and of the rotary table. Therefore, the rigidity of the *thrust bearings* is especially important. To increase the rigidity, the thrust bearings are preloaded to 40 kN by Belleville spring washers at the upper end of the spindle. Since the combined weight of spindle, rotor, and spindle head is 30 kN, the lower *thrust bearing* is preloaded to 10 kN. Rigid, clearance-free spindle guidance also in the axial direction is, therefore, guaranteed. The nominal rigidity is 2.5 kN/µm; the spindle deviates axially by only 4 µm with the maximum grinding pressure of 10 kN.

Lubrication, sealing

The headstock bearings are lubricated for life with FAG rolling bearing *grease Arcanol* L74V. A gap-type *seal* suffices at the upper spindle end since the headstock is protected by a cap.
A shaft seal prevents *grease* from penetrating into the motor. The lower bearings are sealed at the motor end with a gap-type *seal* and at the spindle head with a gap-type *seal* preceded by a labyrinth.



18: Bearing arrangement of a surface grinding spindle

19 Rotary table of a vertical lathe

Operating data

Input power 100 kW; speeds up to n = 200 min^{-1}; rotary table O.D. 2,000, 2,200 or 2,500 mm; maximum workpiece diameter 2,800 mm, maximum workpiece height 2,700 mm, maximum workpiece weight 250 kN; maximum radial and axial runout 5 µm.

Bearing selection

The face plate bearings must provide a high running accuracy and rigidity. As the thrust load predominates and eccentric load application causes a great tilting moment, a thrust ball bearing of increased precision (main dimensions 1,250 x 1,495 x 150 mm) is installed. Radial guidance is provided by an angular contact ball bearing of increased precision, FAG 7092MP.P5 (30° *contact angle*). Both bearings are preloaded against each other with 50 kN.

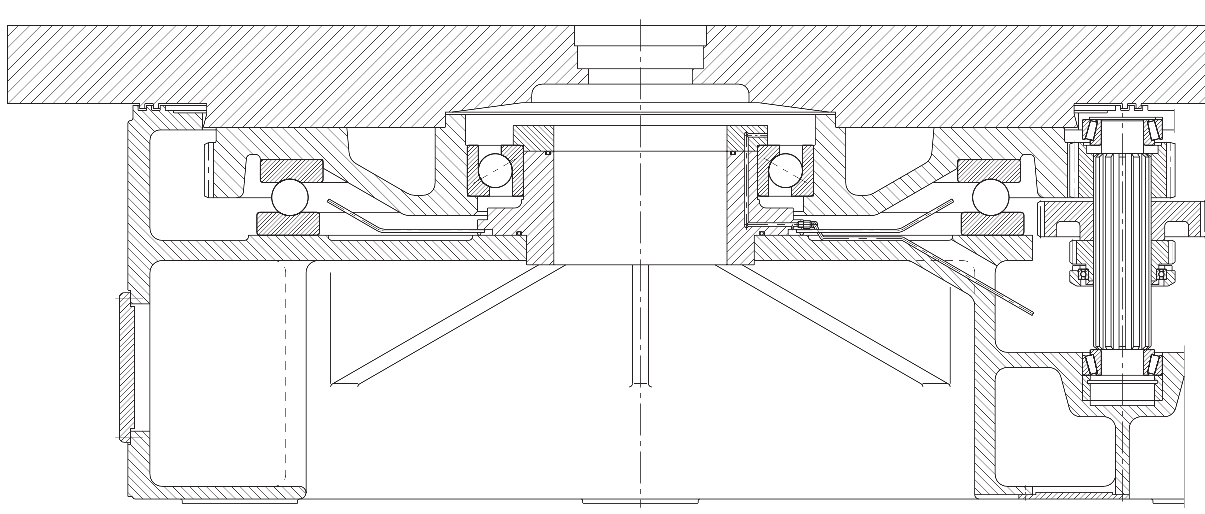
The high preload guarantees a high running accuracy while ensuring a high radial and axial moment or tilting rigidity and keeping internal heating relatively low. By taking special measures during mounting and after final grinding of the rotary table a maximum axial runout of 5 µm is obtained.

Machining tolerances

Thrust ball bearing: gearing to j5
Angular contact ball bearing: kingpin to j5/gearing to K6

Lubrication, sealing

The bearings have circulating *oil* lubrication.
The oil is fed directly to the various bearings through oil feed ducts. After flowing through the bearings, the oil passes through a filter and into an oil collecting container from where it returns to the bearings.
The labyrinth *seal* prevents the *oil* from escaping from the bearings and protects them from contamination.



19: Bearing arrangement of a rotary table of a vertical lathe

20 Tailstock spindle

Operating data

Maximum speed $n = 3{,}500\ min^{-1}$

Cylindrical roller bearings have a high radial load carrying capacity, and angular contact ball bearings with a 40° *contact angle* have a high axial load carrying capacity.

Bearing selection, dimensioning

The bearing arrangement must be particularly rigid and have a high load carrying capacity. Other requirements such as precision and high-*speed suitability* are met by bearings of *precision design.*

At the work end the high radial load is accommodated by a double-row cylindrical roller bearing FAG NN3014ASK.M.SP. The high axial load is accommodated at the opposite end by four angular contact ball bearings FAG 7210B.TVP.P5.UL. Three of these bearings are mounted in *tandem arrangement;* the fourth bearing is merely for axial *counter guidance.*

The maximum bearing O.D. is dictated by the size of the quill.

Bearing clearance

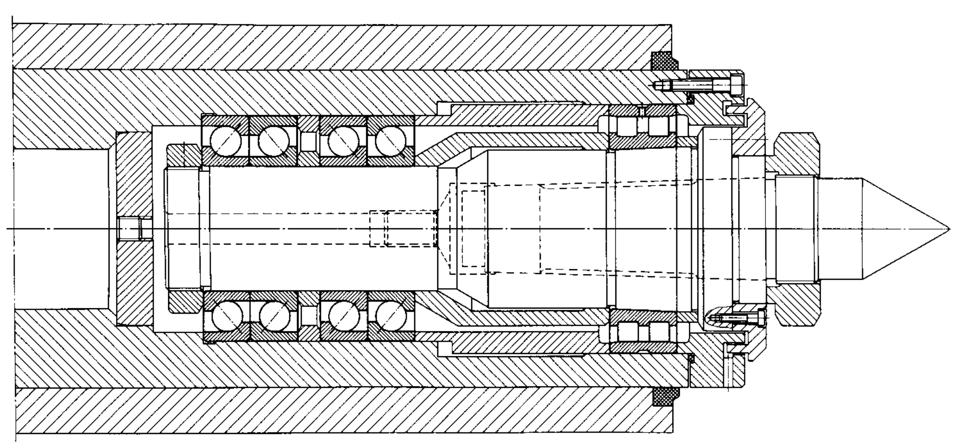
The cylindrical roller bearing with a tapered bore is preloaded with 2...3 µm by pressing the inner ring on to the tapered shaft seat (taper 1:12).
The angular contact ball bearings of *universal design* UL have a light preload in the *O arrangement.* The two spacers are identical in width and exclusively serve to provide a cavity which can accommodate the excess *grease* escaping from the bearings.

Lubrication, sealing

The bearings are lubricated for life with FAG rolling bearing *grease Arcanol* L135V. A labyrinth *seal* prevents dirt from penetrating into the bearings.

Machining tolerances

Bearing	Seat	Diameter tolerance	Form tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Cylindrical roller bearing	Shaft, tapered Housing	Taper 1:12 –13 / +2 µm	1.5 µm 2.5 µm	2 µm 4 µm
Angular contact ball bearings	Shaft Housing	–4 / +4 µm –4 / +6 µm	1.5 µm 2.5 µm	2 µm 4 µm



20: Bearing arrangement of a tailstock spindle

21 Rough-turning lathe for round bars and pipes

Rough-turning lathes are used for particularly economical production of bars and pipes to tolerance class h9 with a wide range of diameters. In this process, the stationary round stock is moved against rotating lathe tools at a certain feed rate. In this machine four cutting tool carriages are attached to the circumference of the turrethead which are radially adjustable.

Operating data

Input power 75 kW; speed n = 300...3,600 min^{-1}; material O.D. 11...85 mm; feed rate 1...40 m/min.

Bearing selection

The main bearing arrangement is formed by two spindle bearings FAG B7036E.T.P4S.UL and accommodates the cutting forces transmitted by the four cutting tools. The bearings are mounted in *O arrangement* and preloaded with 14.5 kN (2 % of C_0/Y_0) by means of springs.
C_0 *static load rating*
Y_0 thrust factor (*static loading*)
Two angular contact ball bearings FAG 71848MP.P5.UL in *O arrangement* accommodate the guiding loads from the axially displaceable hollow cone in which the four tool carriages are radially guided and adjusted.

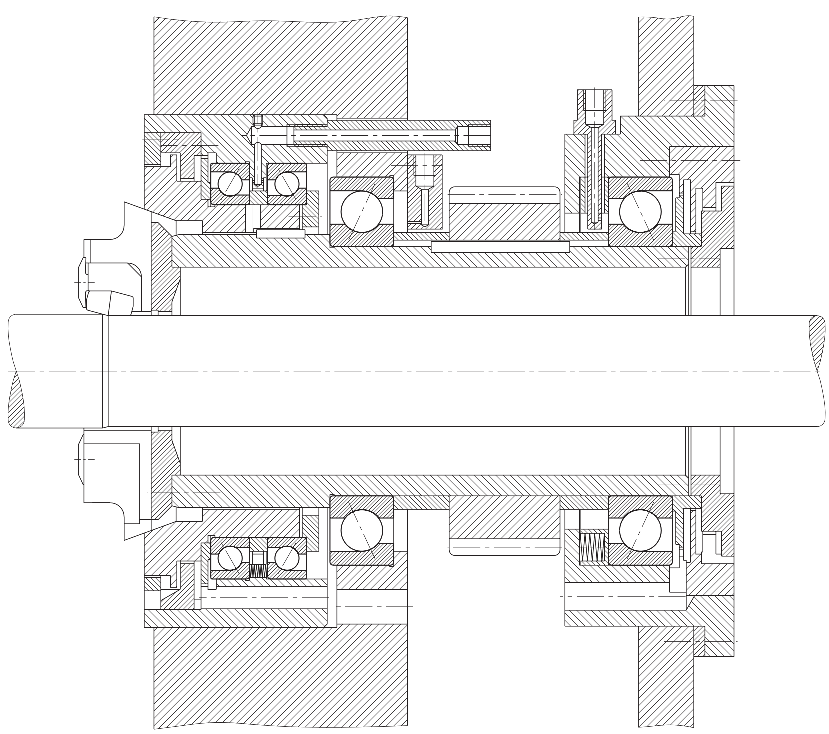
These bearings are also *adjusted* against each other with a spring preload of 5 kN (1 % of C_0/Y_0). Experience shows that with these preloads no slippage damage results, even if the rough-turning lathe is slowed down from 3,600 min^{-1} to zero within a second.

Machining tolerances

The inner rings of both bearings are subjected to *circumferential loads* and are fitted with a tolerance of js5.The bearing seats for the outer rings are machined to G6. The spring preload remains effective in all operating conditions as the expansion of the rotating parts due to the effects of heat and centrifugal force do not cause jamming of the outer rings in the housing.

Lubrication, sealing

The bearings are lubricated by *oil* injection lubrication with ISO VG 32 (32 mm^2/s at 40 °C). At 80 °C the *oil* has an *operating viscosity* of ν = 8 mm^2/s.
An elaborate labyrinth *seal* protects the bearings from the ingress of cutting fluid and chips (rubbed-off particles) and from *oil* escape.



21: Bearing arrangement of a rough-turning lathe for round bars and pipes

22 Flywheel of a car body press

Operating data

Input power 33 kW; flywheel speed 370 min^{-1}; radial load from flywheel weight and belt pull approximately 26 kN.

Bearing selection

Both rings must be tightly fitted to their mating parts due to the heavy loads and the *circumferential load* on the outer ring. Nevertheless, mounting and dismounting should be simple. These requirements can be met with cylindrical roller bearings. They feature a high load carrying capacity, and they are *separable,* i.e. inner and outer rings can be mounted separately.

The flywheel is supported on the hollow trunnion protruding from the press frame by two cylindrical roller bearings FAG NU1048M1A. The suffix M1A indicates that the bearings are fitted with an outer ring riding *machined* brass *cage.* Two angle rings HJ1048, one at each of the outer sides of the cylindrical roller bearings, are provided for axial location of the flywheel. Spacer J is arranged between the bearing inner rings and spacer A between the outer rings. Spacer J is $0.6^{+0.2}$ mm longer than spacer A, which ensures adequate *axial clearance.* After the bearing has been mounted, the *axial clearance* is checked (minimum 0.4 mm).

Bearing dimensioning

The trunnion diameter, which is determined by the design, determines in turn the bearing size.

Machining tolerances

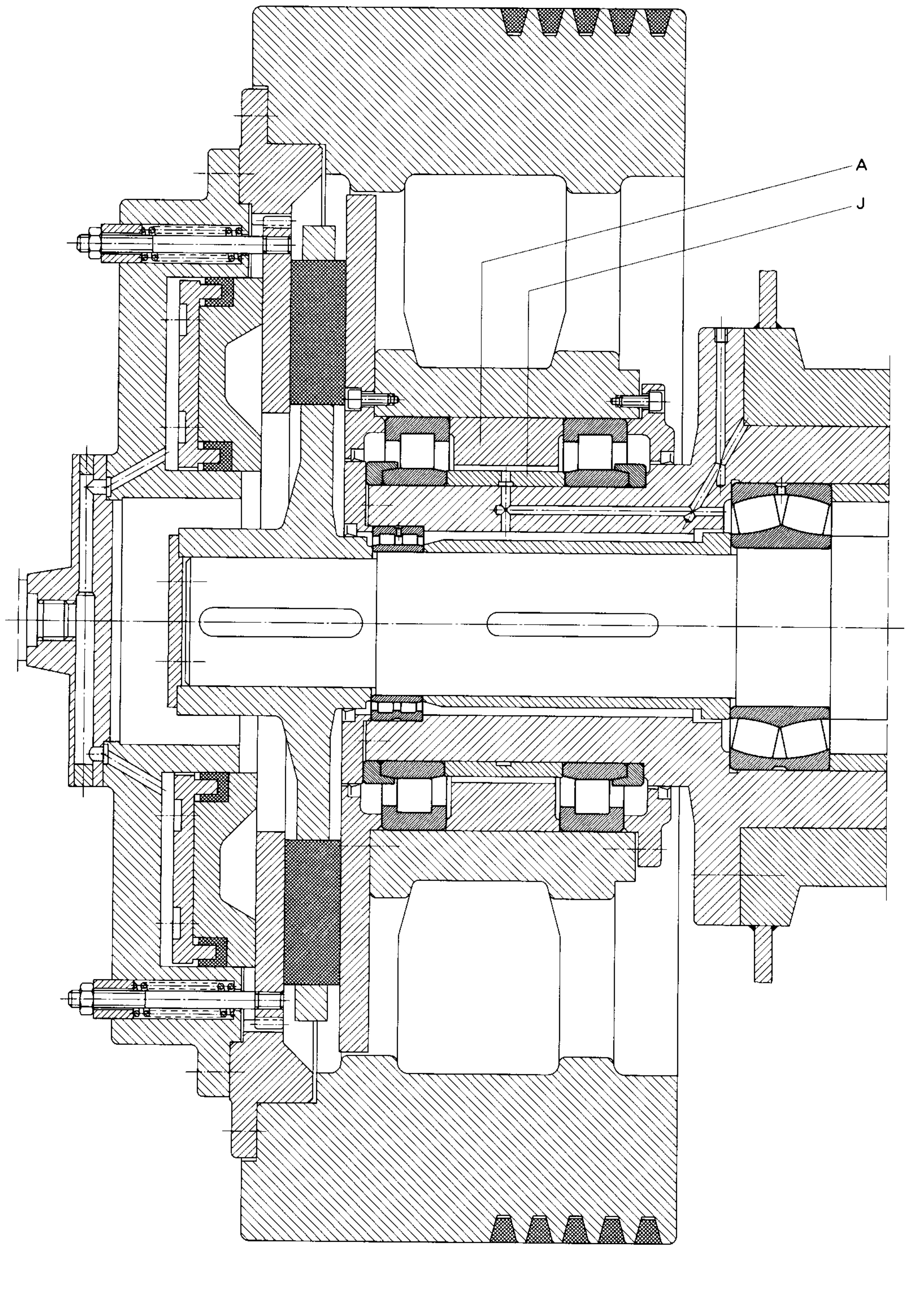
The outer rings are subjected to *circumferential load* and therefore require tight *fits;* the hub bore is machined to M6. The inner rings are *point-loaded.* The trunnion is machined to j5.

Bearing clearance

Calculations show that the *radial clearance* is reduced after mounting, due to outer ring contraction and inner ring expansion (probable interference), by only 20 µm from the value measurable prior to mounting (value indicated in table). Bearings of normal *radial clearance* (CN = 110...175 µm) can, therefore, be used.

Lubrication, sealing

Grease lubrication (FAG rolling bearing *grease Arcanol* L71V).
Shaft *seals* prevent the ingress of dirt.



22: Flywheel bearing arrangement of a car body press

23 Vertical wood milling spindle

Operating data

Input power 4 kW; nominal speed 12,000 min^{-1}.
Maximum load on the work end bearing:
radial – maximum cutting load of 0.9 kN,
axial – shaft weight and spring preload of 0.2 kN.
Maximum load on the drive end bearing:
radial – maximum belt pull of 0.4 kN,
axial – spring preload of 0.5 kN.

Bearing selection

Since a simple bearing arrangement is required the bearing is not *oil-lubricated* as is normally the case for such high-speed applications. Experience has shown that *grease lubrication* is effective if deep groove ball bearings of increased precision with textile laminated phenolic resin *cages* are used. Where very high speeds have to be accommodated, angular contact ball bearings with a small *contact angle* (spindle bearings) are often provided. These bearings are interchangeable with deep groove ball bearings and can, therefore, be employed without modifying the spindle design.
The work end features a deep groove ball bearing FAG 6210TB.P63 and the drive end a deep groove ball bearing FAG 6208TB.P63. Two Belleville spring washers preload the bearings to 500 N. Clearance-free operation and high rigidity of the spindle system is, therefore, ensured. In addition to this, the spring preload ensures that both bearings are loaded under all operating conditions, thus avoiding ball skidding which may occur in unloaded bearings at high speeds, which in turn may cause roughening of the surfaces (increased running noise).

Bearing dimensioning

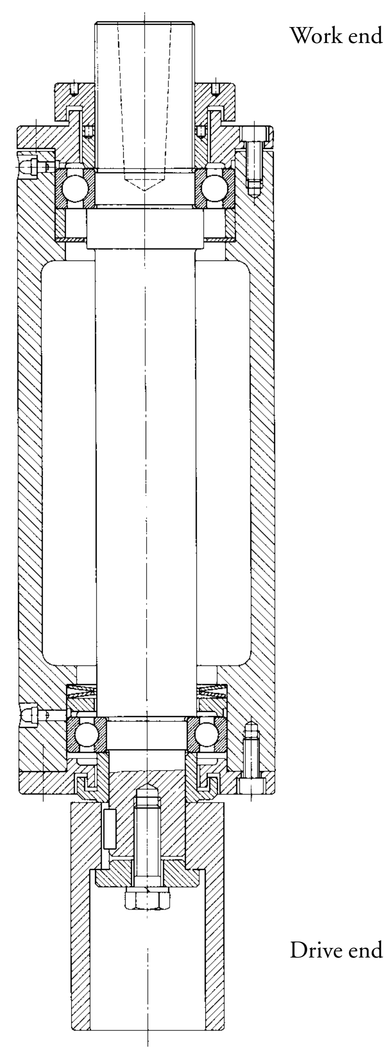
The size of the bearings is dictated by the shaft diameter, which in turn is based on the anticipated vibrations. The bearing sizes thus determined allow a sufficient *bearing life* to be achieved so that a *contamination factor* V = 0.5...0.3 can be assumed if great care was taken to ensure cleanliness during mounting and maintenance (relubrication). With this very good to utmost cleanliness the bearings even can be failsafe.

Lubrication, sealing

Grease lubrication with FAG rolling bearing grease *Arcanol* L74V. The bearings are packed with *grease* and replenished at the required intervals. In view of the high speeds the grease quantities should not, however, be too large (careful regulation) so that a temperature rise due to working of the grease is avoided.
As a rule, the bearings have to be relubricated every six months, and for high speeds even more often.
Non-rubbing labyrinth *seals* are used instead of rubbing-type *seals* in order to avoid generation of additional heat.

Machining tolerances

Seat	Diameter tolerance	Cylindricity tolerance (DIN ISO 1101)	Axial runout tolerance of the abutment shoulder
Shaft	js5	IT2/2	IT2
Housing (work end)	JS6	IT3/2	IT3
Housing (drive end)	H6	IT3/2	IT3



23: Vertical milling cutter spindle

24 Double-shaft circular saw

Operating data

Input power max. 200 kW;
max. speed 2,940 min^{-1}.

Bearing selection

A simple bearing arrangement is required with standardized bearings which are suitable for very high speeds and allow accurate shaft guidance. The required high shaft rigidity determines the bearing bore diameter.
The *locating bearing* is at the work end in order to keep heat expansion in the axial direction as small as possible at this end. The two spindle bearings FAG B7030E.T.P4S.UL are mounted in *O arrangement.* The bearings of the UL *universal design* are lightly preloaded by clamping the inner rings axially. The bearing pair is suitable for high speeds.

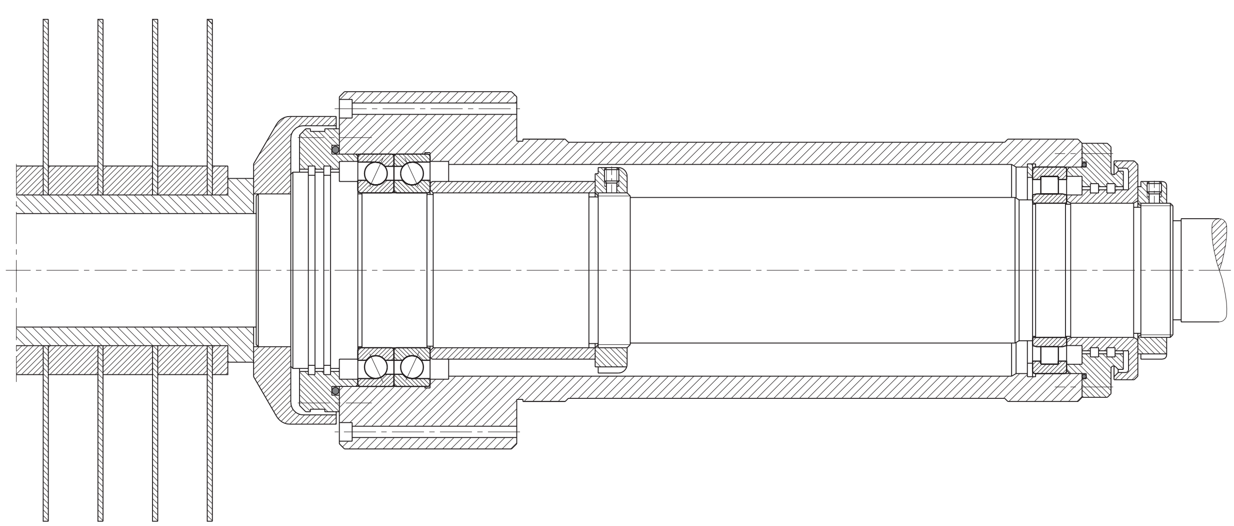
The cylindrical roller bearing FAG NU1026M at the drive end is the *floating bearing.* Heat expansion in the axial direction is freely accommodated in the bearing. The cylindrical roller bearing also accommodates the high belt pull tension forces.

Machining tolerances

Shaft tolerance js5
Housing tolerance JS6

Lubrication, sealing

The bearings are *greased for life,* e.g. with FAG rolling bearing *grease Arcanol* L74V.
Good *sealing* is required due to the dust arising during sawing. Non-rubbing *seals* are used due to the high speed. Flinger disks prevent the penetration of coarse contaminants into the gap-type *seals.*



24: Double-shaft circular saw

25 Rolls for a plastic calender

Plastic foils are produced by means of calenders comprising several rolls made of chilled cast iron or steel with polished surfaces which are stacked on top of each other or arranged side by side.
Hot oil or steam flows through the rolls, heating the O.D.s, depending on the material, to up to 220 °C (rigid PVC), which ensures a good processibility of the material. Rolls 1, 2 and 4 are subjected to deflection under the high loads in the rolling gap. In order to still achieve the thickness tolerances of the sheets in the micrometer range, the deflection is compensated for by inclining of rolls 1 and 3 and by counterbending of rolls 2 and 4. Moreover, the narrow tolerance of the foil thickness requires a high radial runout accuracy of the bearings and adequate radial guidance of roll 3 which is only lightly loaded; this is achieved by preloading the main bearing arrangement by means of collaterally arranged, separate preloading bearings.

Operating data

Type: four-roll calender, F-shaped
Useful width 3,600 mm
Roll diameter 820 mm
Rolling gap 1st step 1.5...2 mm
2nd step 1...1.5 mm
3rd step 0.25...1 mm
Roll speed n = 6...24 min^{-1}
Inner ring temperature 170 °C
Roll mass 18 t (weight ≈ 180 kN)

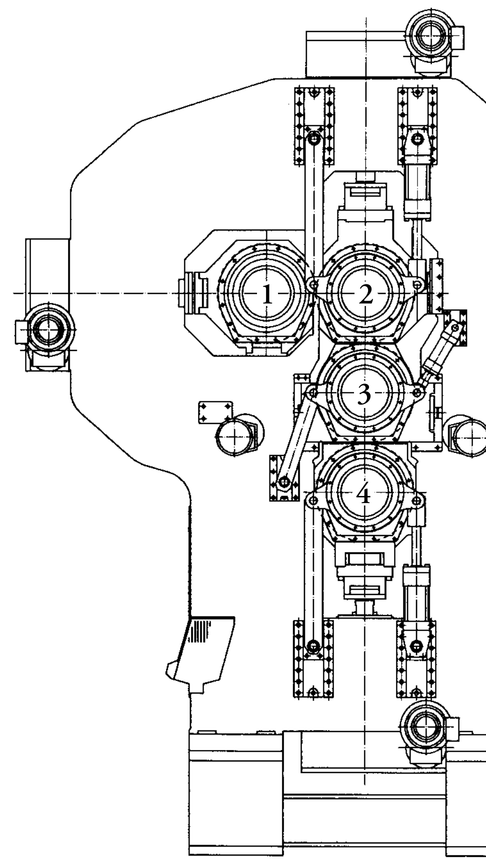
Bearing system

To accommodate the radial and thrust loads, the four rolls are supported at both ends by the same type of main bearing arrangement. It consists of two double-row cylindrical roller bearings forming the *floating bearing* and of two double-row cylindrical roller bearings plus one deep groove ball bearing forming the *locating bearing* at the drive end. In addition, rolls 2 and 4 have to accommodate counterbending forces, and roll 3 has to accommodate preloading forces. These counterbending and preloading forces are supported at both roll ends in spherical roller bearings.

Bearing selection

Main bearing arrangement
The radial pressure by load of 1,620 kN resulting from the maximum gap load of 4.5 kN/cm, as well as the counterbending and preloading forces, are accommodated by the main bearing arrangement at each end of rolls 1, 2 and 4. The radial loads and the axial guiding loads are accommodated by double-row FAG cylindrical roller bearings (dimensions 500 x 650 x 130 mm) and deep groove ball bearings FAG 61996M.P65.
At the *locating bearing* end the radially relieved deep groove ball bearing accommodates only axial guiding loads.
At the *floating bearing* end, heat expansions are compensated by cylindrical roller bearings. Misalignments resulting from shaft deflections and roll inclination are compensated for by providing a spherical recess for the bearing housings in the machine frame. The bearings must be dimensionally stable up to 200 °C as their inner rings may heat up to 180 °C as a result of roll heating.
The high radial runout accuracy (≤ 5 µm) is achieved by grinding the bearing inner rings and the roll body to finished size in one setting at a roll surface temperature of 220 °C.The inner rings and the roll body can be ground together due to the fact that the inner rings of the cylindrical roller bearings – in contrast to those of spherical or tapered roller bearings – can be easily removed and mounted separately.
The dimension of the inner ring raceway after grinding has been selected such that no detrimental radial preload is generated even during the heating process when the temperature difference between outer and inner ring is about 80 K.

Roll arrangement 1 to 4



Rollbending bearings
A counterbending force is generated by means of hydraulic jacks. The counterbending force (max. 345 kN per bearing location) is transmitted to the roll neck by spherical roller bearings FAG 23980BK.MB.C5. The bearings ensure low-friction roll rotation and accommodate misalignments resulting from shaft deflection.

Preloading bearings
The main bearings of roll 3 have to accommodate the difference from the rolling forces from rolls 2 and 4. In order to avoid uncontrolled radial roll movements, the main bearings are preloaded with 100 kN via spherical roller bearings FAG 23888K.MB.C5.

Bearing dimensioning

Two cylindrical roller bearings FAG 522028.. mounted side by side have a *dynamic load rating* of 2 x 2,160 kN. The load accommodated by the bearings is calculated, depending on the load direction, from (roll weight + press-on force + counterbending force)/2. The dimensioning calculation is carried out for the most heavily loaded roll 2 which rotates at an average speed of 15 min^{-1}.
The *nominal life* is approx. 77,000 hours. Due to the high bearing temperature, the *attainable life,* which takes into account the amount of load, lubricant film thickness, lubricant *additives,* cleanliness in the lubricating gap and bearing type, is only 42,000 hours. The required *bearing life* of 40,000 h is reached.

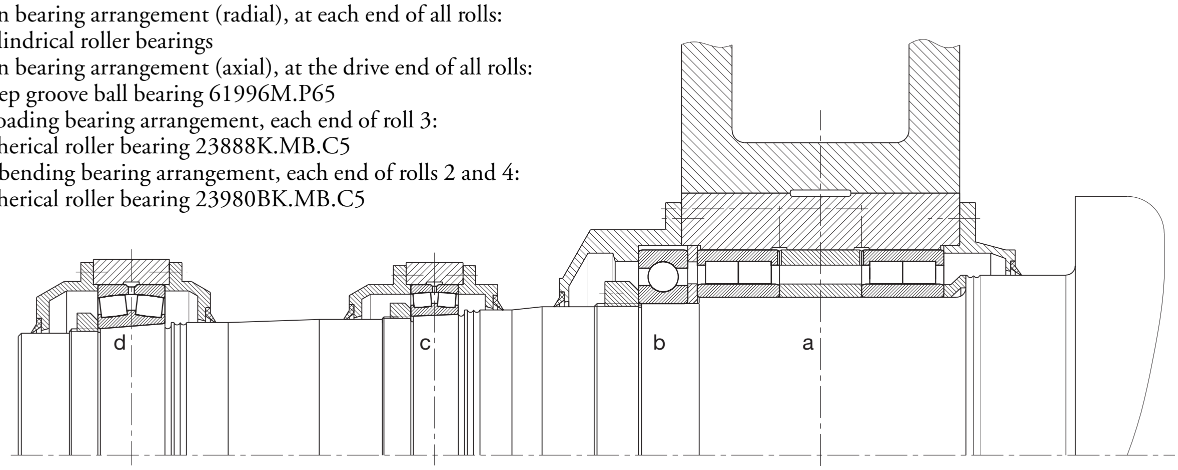
Machining tolerances

Main bearings:	Shaft to r6/housing to H6
Guiding bearing:	Shaft to g6/housing radially relieved
Preloading bearing:	Shaft tapered/ housing H7
Rollbending bearing:	Shaft tapered/ housing to H7

Lubrication

The bearings are lubricated with *oil.* The lubricant has to meet very stringent requirements. Due to the low speed and the high operating temperature, no elastohydrodynamic lubricant film can form. As a result, the bearings always operate in the mixed-friction range and are exposed to the risk of increased *wear.* This condition requires particularly suitable and tested *lubricating oils.*
A central circulation lubrication system with recooling supplies all bearings with *oil.* Holes in the bearing housings, circumferential grooves in the bearing outer rings and in the spacers as well as radial grooves in the outer faces feed the *oil* directly into the bearings.
Lip *seals* in the housing covers prevent dirt particles from penetrating into the bearings.

a Main bearing arrangement (radial), at each end of all rolls: 2 cylindrical roller bearings
b Main bearing arrangement (axial), at the drive end of all rolls: 1 deep groove ball bearing 61996M.P65
c Preloading bearing arrangement, each end of roll 3: 1 spherical roller bearing 23888K.MB.C5
d Rollbending bearing arrangement, each end of rolls 2 and 4: 1 spherical roller bearing 23980BK.MB.C5



25: Bearing arrangement of a plastic calender

26 Infinitely variable gear

The main components of this infinitely variable gear are two shafts linked by a chain which is guided by two bevelled drive disks at each of the shafts. By varying the distance between the bevelled drive disks the running circle of the chain increases or decreases, providing an infinitely variable transmission ratio.

Bearing selection

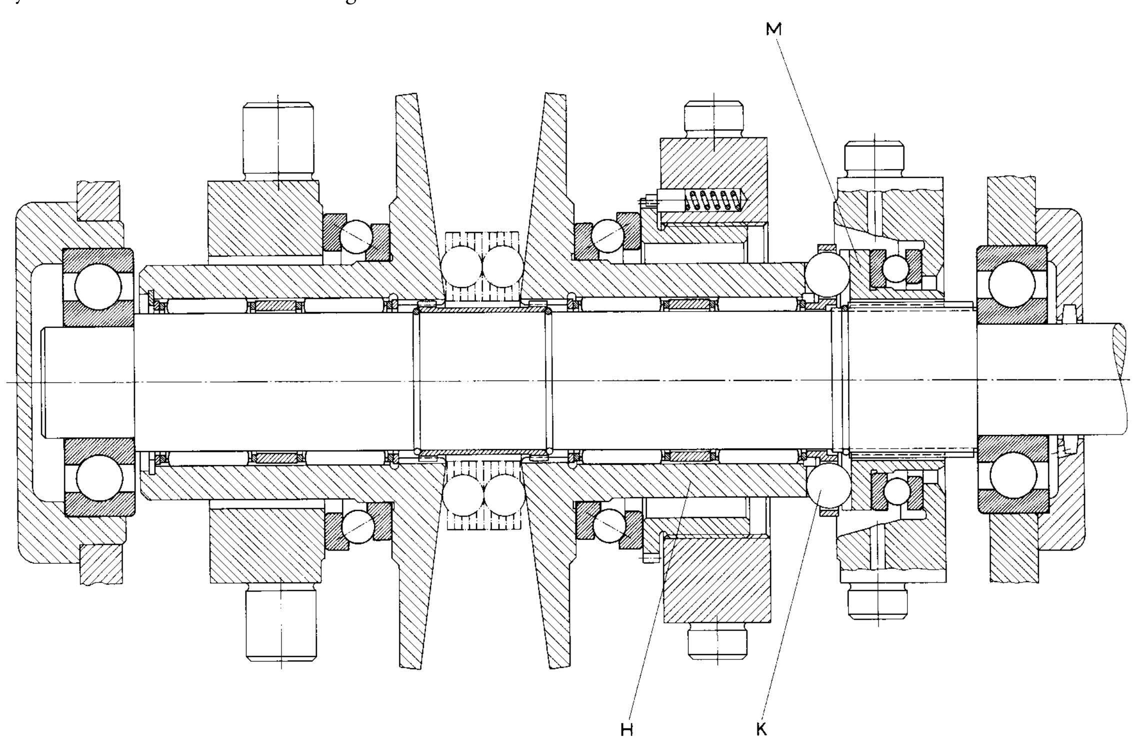
The two variator shafts are each supported by two deep groove ball bearings FAG 6306.
The driving torque is transmitted by sleeve M via balls to the bevelled disk hub H. The ball contact surfaces of coupling K are wedge-shaped. Thus, sleeve and bevelled disk hub are separated depending on the torque transmitted, and subsequently the contact pressure between chain and disks is adapted to the torque.
Two angular contact thrust ball bearings FAG 751113M.P5 and one thrust ball bearing FAG 51110.P5 accommodate the axial loads resulting from the contact pressure.
Torque variations are associated with small relative movements between shaft and drive disks; for this reason the two parts are separated by needle roller and cage assemblies (dimensions 37 x 45 x 26 mm).

Lubrication

Oil bath lubrication provides for ample *oil* supply to variator components and bearings.

Machining tolerances

Bearing	Seat	Diameter tolerance	Cylindricity tolerance (DIN ISO 1101)	Axial runout tolerance of abutment shoulder
Deep groove ball bearing	Shaft Housing	k5 J6	IT3/2 IT3/2	IT3 IT3
Angular contact thrust ball bearings and thrust ball bearing	Bevelled disk hubs/ Sleeve	k5	IT2/2	IT2 IT3
Needle roller and cage assembly	Shaft Housing	h5 G6	IT3/2 IT3/2	IT3 IT3



26: Infinitely variable gear

27 Spur gear transmission for a reversing rolling stand

Operating data

The housing contains two three-step transmissions. The drive shafts (1) are at the same level on the outside and the output shafts (4) are stacked in the housing centre.

Input speed 1,000 min^{-1}; gear step-up 16.835:1; input power 2 x 3,950 kW.

Bearing selection

Input shafts (1)
One cylindrical roller bearing FAG NU2336M.C3 and one four-point bearing FAG QJ336N2MPA.C3 form the *locating bearing.* The *floating bearing* is a cylindrical roller bearing FAG NJ2336M.C3. The four-point bearing is mounted with clearance in the housing (relieved) and, therefore, takes up just the axial loads. The two cylindrical roller bearings only take up the radial loads.

Intermediate shafts (2, 3)
The intermediate shafts have a *floating bearing* arrangement with FAG spherical roller bearings: 22348MB.C3 and 24160B.C3 for shafts 2. 23280B.MB and 24164MB for shafts 3.

Output shafts (4)
A spherical roller bearing FAG 24096B.MB is used as *locating bearing.* A full-complement single-row cylindrical roller bearing as a *floating bearing* compensates for the thermal length variations of the shaft.

Machining tolerances

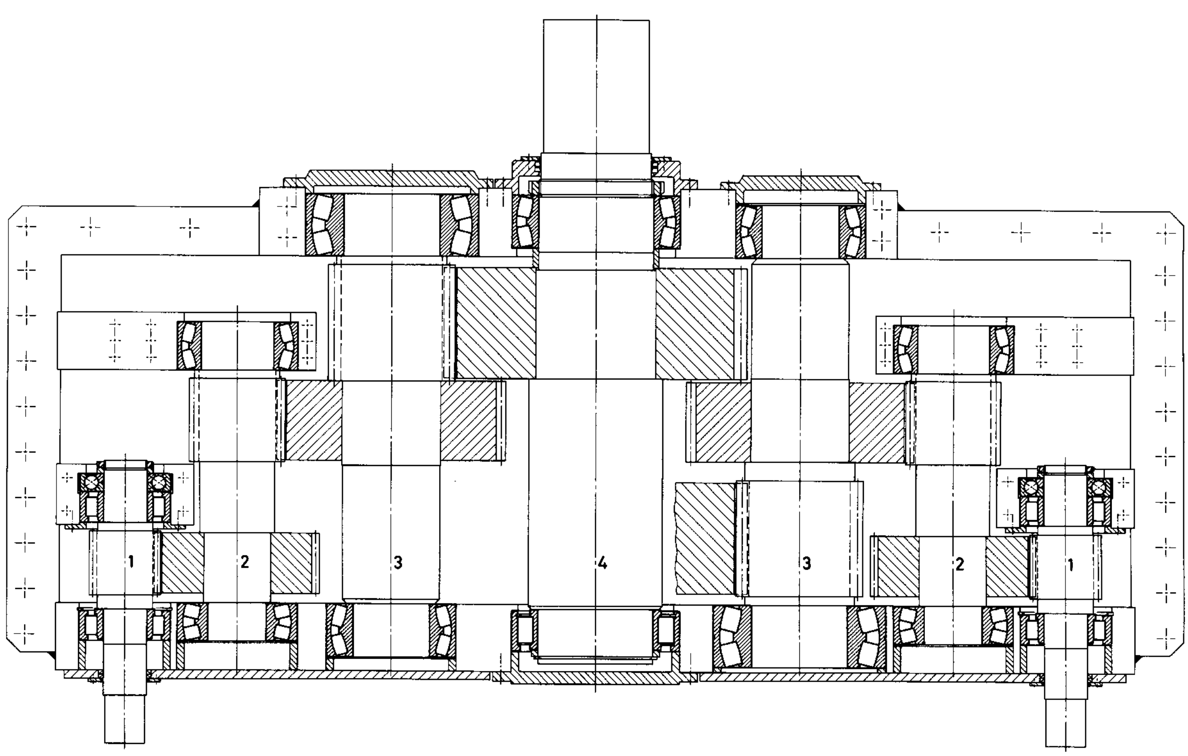
Input shafts (1):
Cylindrical roller bearing: – Shaft n6; housing J6
Four-point bearing: – Shaft n6; housing H7

Intermediate shafts (2 and 3):
Spherical roller bearing: – Shaft n6; housing relief-turned.

Output shafts (4):
Cylindrical roller bearing: – Shaft p6; housing JS6
Spherical roller bearing: – Shaft n6; housing JS6

Lubrication

The bearings are also connected to the *oil* circulation system for the transmission wheels. The *oil* (ISO VG320) is fed directly to the bearing positions from the oil filter.



27: Spur gear transmission for a reversing rolling stand

28 Marine reduction gear

The hardened and ground gearings of marine gears transmit great torques.

Operating data

Input power P = 5,475 kW; input speed 750 min^{-1}; output speed 209 min^{-1}; operating temperature ca. 50 °C.

Bearing selection

Coupling shaft

The coupling shaft (upper right) is supported at the drive end by a spherical roller bearing 23248B.MB (*locating bearing*) and at the opposite end by a cylindrical roller bearing NU1056M (*floating bearing*). The shaft transmits only the torque. The bearings have to accommodate only the slight deadweights and minor gearwheel forces from a power take-off system. The bearing dimensions are determined by the design; as a result larger bearings are used than needed to accommodate the loads. Consequently, a *life* calculation is not required.

Input shaft

At the input shaft the radial loads from the gearing are accommodated by two spherical roller bearings 23248B.MB. The thrust loads in the main sense of rotation during headway operation are separately accommodated by a spherical roller thrust bearing 29434E. The bearing 23248B.MB on the left side also accommodates the smaller axial loads in the opposite direction. It is *adjusted* against the spherical roller thrust bearing with a slight clearance and preloaded by springs. The preload ensures that the *thrust bearing* rollers do not lift off the raceways when the load changes but keep rolling without slippage. The housing washer of the spherical roller thrust bearing is not radially supported in the housing to ensure that this bearing can transmit no radial loads.

Output shaft

At the output shaft, radial and axial loads are accommodated separately. The radial loads are accommodated by two spherical roller bearings 23068MB. In the *locating bearing* position at the output end a spherical roller thrust bearing 29464E accommodates the difference from the propeller thrust during headway operation and the axial tooth loads. The smaller axial loads during sternway operation are taken up by the smaller spherical roller thrust bearing 29364E. These two thrust bearings are also *adjusted* against each other with a slight *axial clearance,* preloaded by springs and not radially supported in the housing.

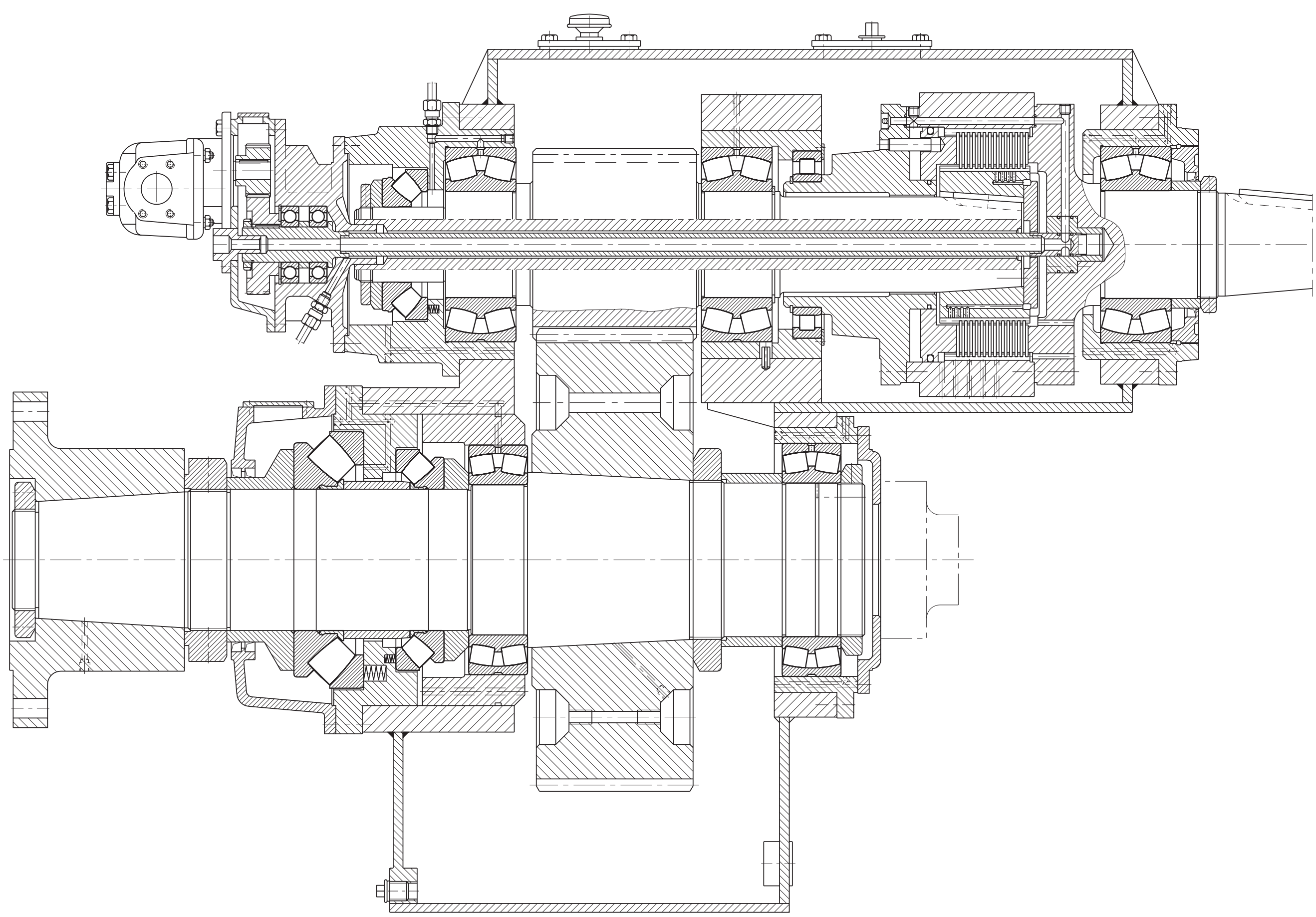
Bearing dimensioning

Based on the operating data, the following *nominal fatigue lives* are obtained for the different bearings. The minimum value of L_h = 40,000 hours required for classification was not only reached but far exceeded.

Shaft	Bearing location	Rolling bearing	Equivalent dynamic load P [kN]	Index of dynamic stressing f_L	Nominal fatigue life L_h [h]	Viscosity ratio $\kappa = \nu/\nu_1$	Factor $a_{23} = a_{23II} \cdot s$	Attainable life at utmost cleanliness L_{hna} [h]
Coupling shaft								
Locating bearing	1	23248B.MB	only slightly loaded by deadweight					
Floating bearing	2	NU1056M	only slightly loaded by deadweight					
Input shaft								
Radial bearings	3	23248B.MB	242	3.98	49,900	6.3	>114	»200,000
	3 new	23048B.MB	242	1.88	4,100	5.8	>114	»200,000
	4	23248B.MB	186	5.18	120,000	6.3	>114	»200,000
Thrust bearings	5	29434E	80	>6.03	>200,000	5.2	>114	»200,000
	5 new	29334E	80	4.91	102,000	5.0	>114	»200,000
Output shaft								
Radial bearings	6	23068MB	158	>6.03	>200,000	2.4	>84	»200,000
	7	23068MB	293	4.64	83,500	2.4	>84	»200,000
	7 new	23968MB	293	2.70	13,600	2.3	39	»200,000
Thrust bearings	8	29364E	only briefly loaded during sternway operation					
	9	29464E	650	3.81	43,300	2.5	> 87	»200,000
	9 new	29364E	650	2.35	8,600	2.3	> 84	»200,000

The effects of basing the bearing dimensions on *attainable life* become evident in the case of the two bearings dimensioned for the least load carrying capacity: the spherical roller bearing 23248B.MB (bearing location 3) at the coupling end of the input shaft and the spherical roller thrust bearing 29464E (bearing location 9) at the output end of the output shaft.

Based on the *index of dynamic stressing* f_L a *nominal life* L_h = 49,900 h is calculated for spherical roller bearing 3 and L_h = 43,300 h for spherical roller thrust bearing 9. Due to the required minimum *life* of 40,000 h the transmission bearings would thus be sufficiently dimensioned.



28: Bearing arrangement of a marine gear

Attainable life

The actually *attainable life* L_{hna} is considerably longer than the *nominal life* L_h.
$L_{hna} = a_1 \cdot a_{23} \cdot L_h$ is calculated with the following data:
Nominal *viscosity* of the *oil:* $\nu_{40} = 100$ mm²/s
Operating temperature: t = 50 °C
Operating viscosity: $\nu = 58$ mm²/s
Spherical roller bearing 23248B (no. 3):
C = 2,450 kN; C_0 = 4,250 kN; n = 750 min^{-1};
$d_m = (440 + 240)/2 = 340$ mm
Rated viscosity: $\nu_1 = 9.2$ mm²/s
Viscosity ratio: $\nu/\nu_1 = 6.3$

Spherical roller thrust bearing 29464E (no. 9):
C = 4,300 kN; C_0 = 15,600 kN; n = 209 min^{-1};
$d_m = (580 + 320)/2 = 450$ mm
Rated viscosity: $\nu_1 = 23$ mm²/s
Viscosity ratio: $\kappa = \nu/\nu_1 = 2.5$

A *stress index* $f_{s*} = C_0/P_{0*} > 14$ is obtained for both bearings; consequently, $K_1 = 1$ and $K_2 = 1$; therefore, K = 1 + 1 = 2.
From the *viscosity ratio* κ and the *factor* K the following *basic factors* are obtained:
– for the radial spherical roller bearing $a_{23II} = 3.8$
– for the spherical roller thrust bearing $a_{23II} = 2.9$

Factor a_{23} is obtained from $a_{23} = a_{23II} \cdot s$.
The *cleanliness factor* s is determined on the basis of the *contamination factor* V. Both bearings operate under utmost cleanliness conditions (V = 0.3). Cleanliness is utmost if the particle sizes and filtration ratios of *contamination factor* V = 0.3 are not exceeded.
Taking into account the *viscosity ratio* κ and the *stress index* f_{s*}, a *cleanliness factor* of s > 30 and consequently an a_{23} *factor* = $a_{23II} \cdot s > 114$ and > 87, respectively, is obtained for the bearings under consideration. The *attainable* life is in the *endurance strength* range.

This means that smaller bearings could be provided for bearing locations 3, 5, 7 and 9 to accommodate the same shaft diameter (see table: 3 new, 5 new, 7 new, 9 new) and would, in spite of the now higher bearing loads, still be in the *endurance strength* range.

Machining tolerances

As all bearing inner rings in this application are subjected to *circumferential load* they are fitted tightly onto the shaft seats:
– *Radial bearings* to n6
– *Thrust bearings* to k6.
If the *radial bearing* outer rings are subjected to *point load,* the bearing seats in the housings are machined to H7.
As the spherical roller thrust bearings are to accommodate exclusively thrust loads they are fitted with clearance, i.e. radially relieved, into the housing seats which are machined to E8.

Lubrication, sealing

To meet the high requirements on safety and reliability, adequate lubrication and cleanliness conditions are provided for marine gears. The circulating *oil* ISO VG 100, which is used to lubricate both gear wheels and rolling bearings, is cooled and directly fed to the bearings. By-pass filters with filter condition indicators and with an adequate filtration ratio ensure an oil condition where no particles bigger than 75 µm are found and where, consequently, cleanliness is usually utmost (*contamination factor* V = 0.3).
For this reason, the *oil* cleanliness class should be 14/11 or 15/12 (ISO 4406).
Radial shaft *seals* protect the transmission from contamination.

29 Bevel gear – spur gear transmission

Operating data

Input speed 1,000 min^{-1}; gear ratio 6.25:1; input power 135 kW.

Bearing selection, dimensioning

Pinion shaft
The pinion is an overhung arrangement. Two tapered roller bearings FAG 31315.A100.140.N11CA in *X arrangement* are mounted at the *locating end.* Spacer A between the cups adjusts the bearing pair to achieve an *axial clearance* of 100...140 µm prior to mounting.
The *floating bearing,* a cylindrical roller bearing FAG NUP2315E.TVP2, has a tight *fit* on the shaft and a slide *fit* in the housing.
Axial pinion adjustment is achieved by grinding the spacers B and C to suitable width.

Crown wheel shaft
The crown wheel shaft is supported by two tapered roller bearings FAG 30320A (T2GB100 - DIN ISO 355). The bearings are mounted in *X arrangement* and are *adjusted* through the cups. For axial adjustment and adjustment of the *axial clearance* the spacers D and E are ground to suitable width.

Output shaft
The output shaft is supported by two spherical roller bearings FAG 23028ES.TVPB in *floating bearing arrangement.*

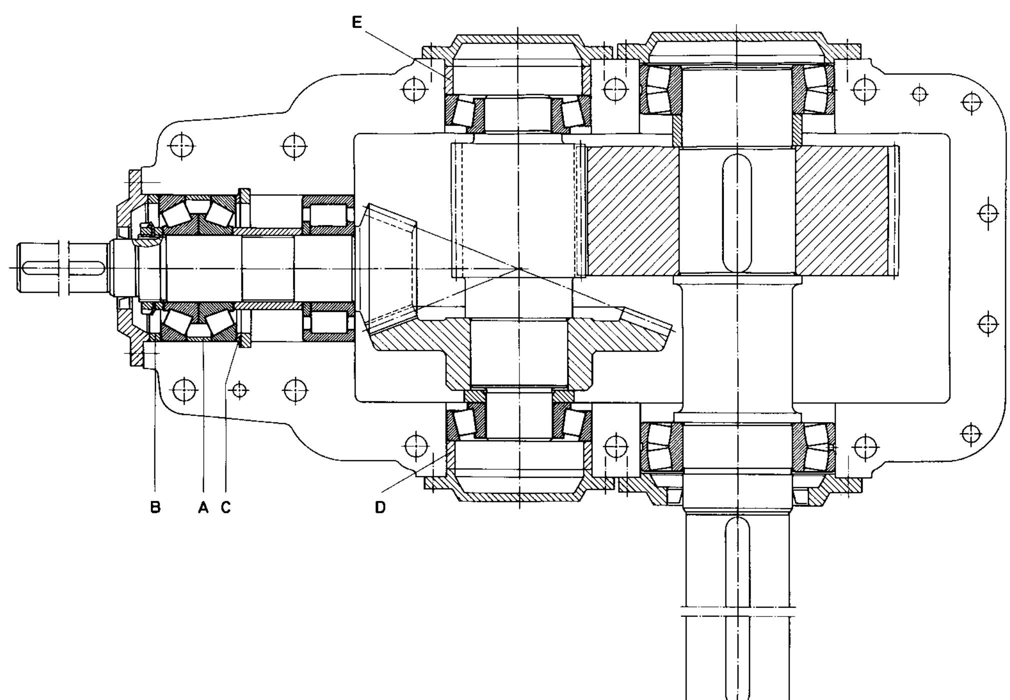
Detrimental axial preloads are avoided by means of a gap between the covers and outer rings.
For the *floating bearing* of the pinion shaft an *index of dynamic stressing* f_L = 2.88 is calculated. This value corresponds to a *nominal life* of L_h = 17,000 hours. Taking into account the operating conditions such as:
– *oil* ISO VG220 with suitable *additives,*
– a good degree of cleanliness in the lubricating gap,
– max. operating temperature 80 °C,
a *factor* a_{23} = 3 is obtained with the *adjusted life calculation.* Therefore, the *attainable life* L_{hna} = 50,700 hours.

Machining tolerances

The bearing inner rings are subjected to *circumferential loads* and consequently have to be fitted tightly on the shaft. The bearing seats for the pinion bearings must be machined to the following tolerances: Shaft to m5 / housing to H6.

Lubrication, sealing

All bearings are sufficiently lubricated with the splash *oil* from the gears. The tapered roller bearing pair is supplied with *oil* which is fed through ducts from collecting pockets in the upper housing part.
Shaft *seals* are fitted at the shaft openings.



29: Bevel gear-spur gear transmission

30 Double-step spur gear

Operating data

Max. input speed 1,500 min^{-1}; gear ratio 6.25:1; output power 1,100 kW at a maximum speed of 1,500 min^{-1}.

Bearing selection

The bearings supporting the three gear shafts are *adjusted*. Two tapered roller bearings FAG 32224A (T4FD120)*, two tapered roller bearings FAG 30330A (T2GB150)* and two tapered roller bearings FAG 30336 are used. The *X arrangement* chosen means that the cups are adjusted and the adjusting shims inserted between the cup and housing cover determine the *axial clearance*. The same gear housing is also used for gears transmitting higher power. In such a case larger bearings are used without sleeves.

Machining tolerances

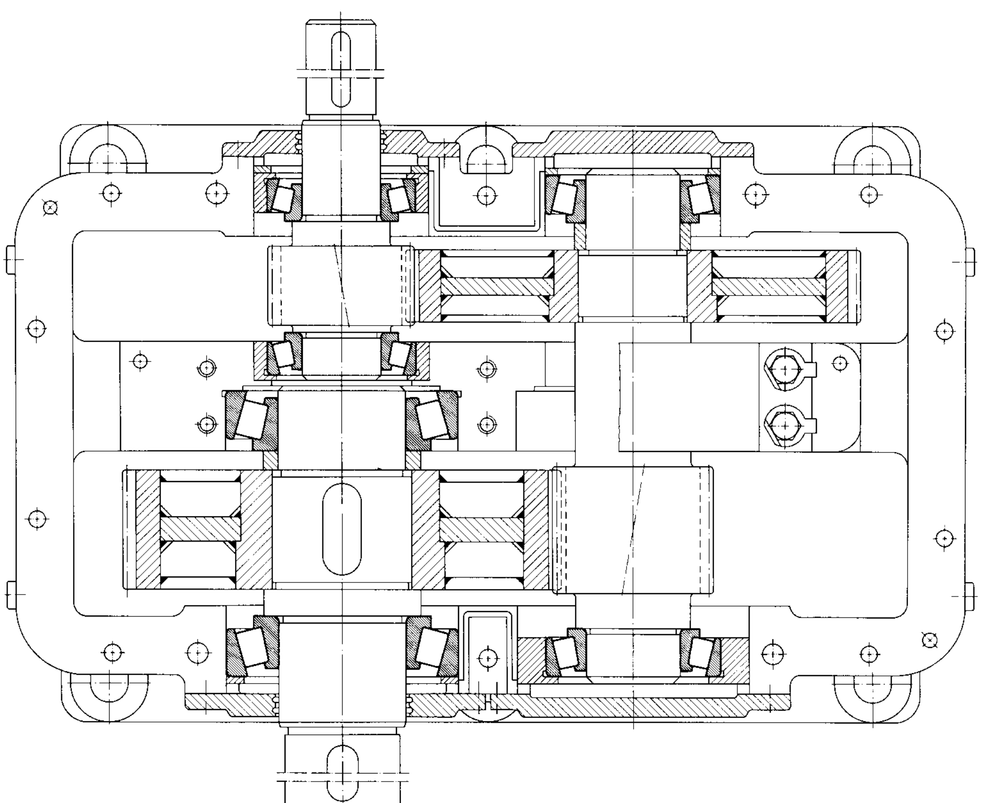
The cones are subjected to *circumferential load* and are, therefore, fitted tightly on the shaft. The cups are subjected to *point load* and can, therefore, have a loose *fit*. The bearing seats on the shafts are machined to m6, the housings to J7.

The relatively loose *fit* in the housing simplifies cup *adjustment*.

Lubrication, cooling, sealing

The lubrication system selected depends on the gear speed, power, operating time and ambient temperature. For low power and low gear circumferential speeds, *oil* splash lubrication without extra cooling is sufficient. Medium power often requires some extra cooling. For high power and high gear circumferential speeds circulating *oil* lubrication (possibly with oil cooler) is provided. Detailed information on the range of application of lubrication system and *oils* in question is available from gear manufacturers.
The rolling bearings are lubricated with the same *oil* as the gears; for this purpose baffle plates and collecting grooves are provided in the transmission case to trap the oil and feed it through the channels to the bearings.
Gap-type *seals* with grooves and oil return channels in the end covers provide adequate *sealing* at the shaft openings. More sophisticated *seals* such as shaft *seals* (with dust lip, if necessary) are provided where ambient conditions are adverse.

*) Designation according to DIN ISO 355



30: Double-step spur gear

31 Worm gear pair

Operating data

Input power 3.7 kW; input speed 1,500 min^{-1}; overall gear ratio 50:1.

Bearing selection

Worm shaft
The worm shaft bearings are primarily axially loaded, the load direction changing with the direction of rotation of the worm. The radial loads acting on the bearings are relatively small. *A locating-flating bearing arrangement* is selected.
The *locating bearing* comprises two universal angular contact ball bearings FAG 7310B.TVP.UA. Suffix UA indicates that the bearings can be mounted in any *tandem, O* or *X arrangement.* When the bearings are paired in *O* or *X arrangement* and the shaft is machined to j5 and the housing to J6, the bearings feature a small *clearance.* The two angular contact ball bearings are mounted in *X arrangement.* Depending on the direction of rotation of the worm shaft, either one or the other bearing accommodates the axial load.

A cylindrical roller bearing FAG NU309E.TVP2 is mounted as the *floating bearing.*

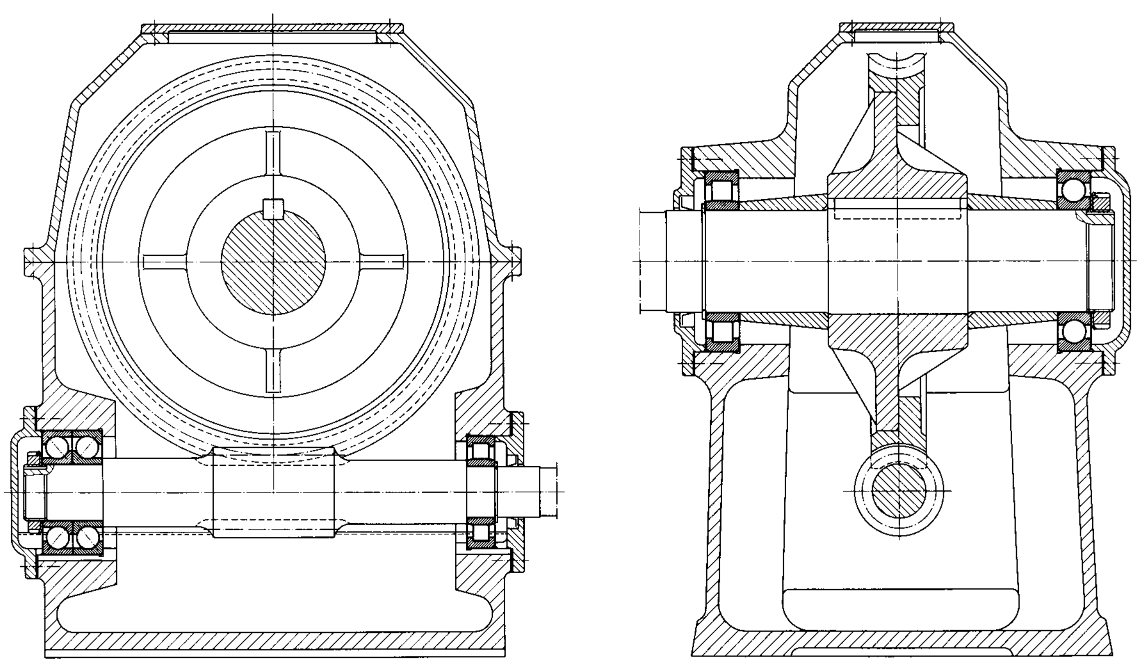
Worm gear shaft
The bearings of the worm gear shaft are mainly radially loaded; the axial loads are relatively low in comparison. A deep groove ball bearing FAG 6218 is therefore provided at the *locating bearing* end and a cylindrical roller bearing FAG NU218E.TVP2 at the *floating bearing* end.

Machining tolerances

Angular contact ball bearings:	Shaft to j5; housing to J6
Cylindrical roller bearings:	Shaft to k5; housing to J6
Deep groove ball bearing:	Shaft to k5; housing to K6

Lubrication, sealing

The worm gear and the bearings are *oil*-lubricated. The *oil* level should coincide with the lowest point of the worm teeth pitch circle diameter.
The *sealing* rings at the shaft openings prevent oil from escaping and offer adequate protection against contamination.



31: Worm gear pair

Design

The rolling bearings used in torque converters in vehicles (manual transmissions and transfer boxes) are custom-tailored to this application. Depending on the load accommodation and speed requirements, deep groove ball bearings – both unshielded and dirt-protected ("clean bearings") –, cylindrical roller bearings, combined bearings and tapered roller bearings have proven themselves in the main bearing locations. The idlers are generally supported on needle roller and cage assemblies. The main bearing locations have *locating-floating* bearing designs, *adjusted* bearing or *floating bearing arrangements.*

Locating-floating bearing arrangement
Radial loads are accommodated by both bearings while the axial load is taken up by the *locating bearing.* With extreme axial loads the radial and axial loads may be taken up separately (*axial bearing* e. g. deep groove ball bearing or four-point bearing) at the *locating bearing* end.

Adjusted bearing arrangement
The angular contact ball bearings or tapered roller bearings are mounted in opposition to one another. The bearings, when running at operating temperature, should have zero clearance or even preload (narrow axial guidance). Regulation of the *axial clearance* by axial displacement of the bearing rings. Both bearings accommodate radial and axial loads.

Floating bearing arrangement
The bearings (except for *angular contact bearings,* all bearing types may be used) accommodate both radial and axial loads, permitting, however, axial displacement of the shaft. This axial displaceability is such that the bearings are never preloaded, not even under adverse thermal conditions.

Lubrication

The gear wheels of vehicle transmissions are all *oil*-lubricated almost without exception. For this reason *oil lubrication* is usually also provided for the rolling bearings in the transmission.
Since the rolling bearings require only very little lubricant, the *oil* splashed from the gear wheels is normally sufficient for bearing lubrication. Only in cases where the splash oil does not reach the bearings may it be necessary to provide collecting pockets and feed ducts. On the other hand it is advisable to protect those bearings which run directly beside the gear wheel from excessive *oil* supply, for example by means of a *seal* or a baffle plate.
However, with joint lubrication of gear wheels and bearings care must be taken that the *life*-reducing contaminants are filtered out of the *oil* circulation (costly).

Dirt-protected bearings

In order to keep these contaminants (rubbed-off particles from the gears) out of the bearings as long as possible, manual transmissions for cars are fitted today with sealed, *grease*-lubricated deep groove ball bearings or angular contact ball bearings (so-called dirt-protected or "clean bearings").
Since roller bearings are less affected by cycled particles, the dirt-protected design is not required in automotive gearboxes.

Bearing selection and dimensioning

The bearing calculation is based on the maximum input torque with the corresponding speed, the gearing data and the proportionate running times for the individual gear steps.

Determination of the tooth loads
Based on the tangential load $F_t = M_d / r$ a radial load ($F_r = F_t \cdot \tan \alpha_E$) and an axial load ($F_a = F_t \cdot \tan \beta$) are calculated. Based on the distances at the individual shafts, the forces acting on the teeth are distributed over the individual bearing locations, also taking into account the tilting moment caused by the tooth load component F_a.

Index of dynamic stressing f_L
Unsealed transmission bearings in medium-weight to heavy cars should have an f_{Lm} value of 1.0...1.3, whereas the f_{Lm} value for dirt-protected bearings should be 0.7...1.0.
The bearing loads in the individual speeds and the transmission bearings are calculated in detail by means of computer programs.

Attainable life
The lubricant in open ball bearings must be assumed to be moderately (*contamination factor* V = 2) to heavily contaminated (V = 3) .
With the usual transmission bearing *stress indexes* of $f_{s*} \approx 2...8$, depending on the gear, a *cleanliness factor* of s = 0.6...0.7 is obtained with V = 2, and s = 0.3...0.5 with V = 3.
Consequently, due to the effects of contamination by the transmission *oil,* the reserve capacities of the unsealed ball bearings (higher f_{Lm} value) cannot be utilized. On the other hand, if dirt-protected ball bearings are used,

at least normal cleanliness (*contamination factor* V = 1), in most cases improved cleanliness (V = 0.5) or even utmost cleanliness (V = 0.3) can be achieved. Thus, with a *viscosity ratio* of $\kappa = 1$, a *cleanliness factor* s is obtained which is between 1 and 3.
So dirt-protected transmission bearings (deep groove ball bearings or angular contact ball bearings) reach *lives* which are up to six times longer than those of unsealed bearings running in the "contaminated" transmission *oil.*

Machining tolerances

At all bearing locations the inner rings are subjected to *circumferential load* and the outer rings to *point load.* The bearing seats on the shafts are machined to j6...m6 and those in the housings to M6...P6 (light metal) and to J6...K6 (grey-cast iron), respectively. The tighter bearing *fits* in light-metal housings take into account the differences in the thermal expansion of light metal and steel.

32 Passenger car transmission

Operating data

Five-speed transmission for passenger cars for a maximum input torque of 170 N m at 4,500 min^{-1}; the 5th speed is an overdrive gear; light-metal housing.
Gear ratios: 3.717 – 2.019 – 1.316 – 1.0 – 0.804

Bearing selection

Input shaft
Combined bearings (deep groove ball bearing + roller and cage assembly) as *locating bearing* for accommodating radial and axial loads. The roller and cage assembly runs directly on the input shaft. The outer ring is axially located via the housing cover in pull operation and via a snap ring in push operation.

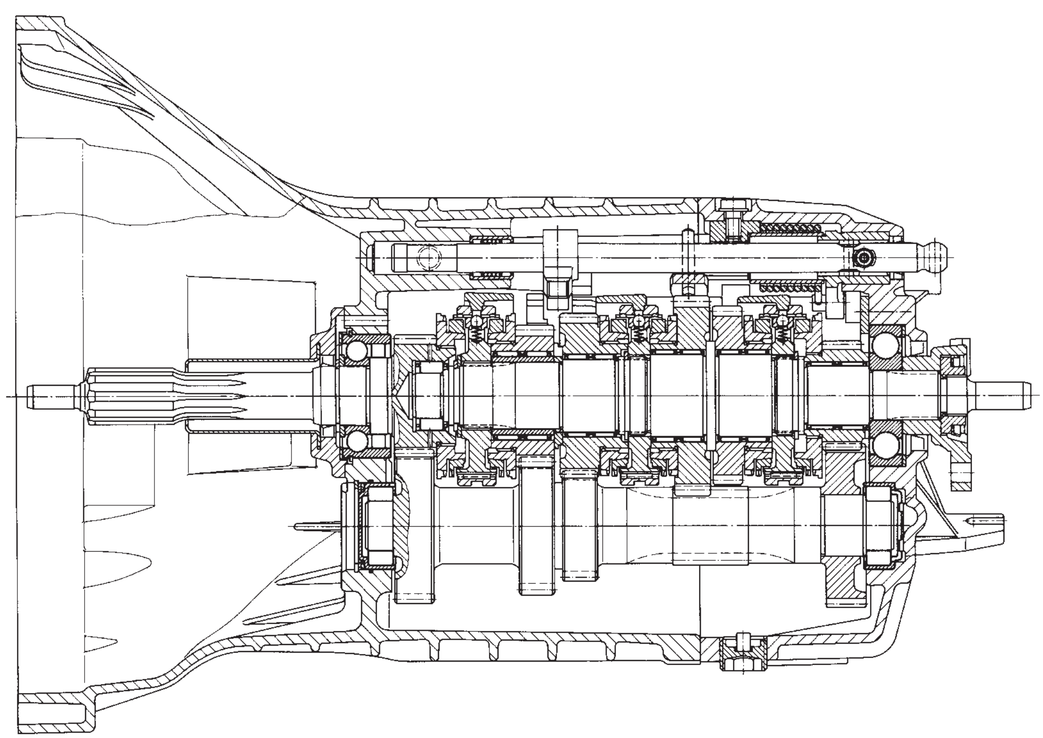
Lay shaft
Floating bearing arrangement with roller sleeves. The *axial clearance* is adjusted by means of fitting washers at the roller sleeve of the input end. Axial location is provided by a snap ring. The transmission is *sealed* to prevent *oil* escape. There is an opening at the closed end of the output-side roller sleeve to facilitate dismounting.

Output shaft
Engine-end bearing:
The roller and cage assembly runs directly on the output shaft and in the bore of the input shaft. The *cage* is guided by the *rolling elements.* The logarithmic profile of the rollers is especially adapted to the stress resulting from shaft deflection. Lubricating holes in the gear wheel of the input shaft provide for a better *oil* supply to the roller and cage assembly.

Output end:
Deep groove ball bearing as *locating bearing,* axial location of the outer ring by means of the housing shoulder and retaining washer. The idlers on the output shaft are directly supported by double-row needle-roller-and-cage assemblies.

Machining tolerances

Bearing location	Tolerance Shaft	Housing
Input shaft	k6	N6
Direct bearing arrangement roller and cage assembly	g6	
Lay shaft		
Drive end/output end	h5	N6
Output shaft		
Engine-end bearing	g6	G6
Output end	k6	N6
Idlers (1st – 5th gear, reverse gear)	h5	G6



32: Passenger car transmission

33 Manual gearbox for trucks

Operating data

16-speed-transmission for heavy trucks in the power range from 220 to 370 kW. The 4-speed component is extended to 16 gears by means of a split group and a range group.
Gear ratios: 13.8 — 0.84 and 16.47 — 1.0.

Bearing selection

Input and output shafts, main bearings
Adjusted tapered roller bearings in boxed *X arrangement. Adjustment* of these bearings via the cup of the tapered roller bearing at the input end. The cup is machined to K6.

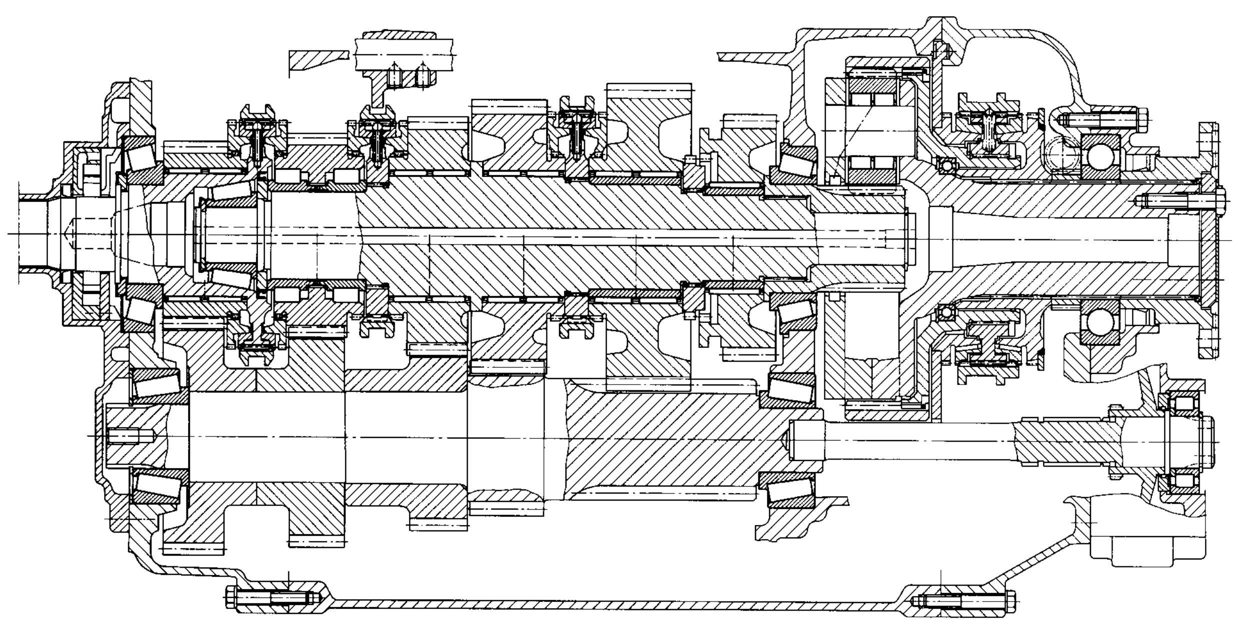
Lay shaft
Tapered roller bearings in *X arrangement;* machining tolerances: shaft to k6 / housing to K6.
The idler gears are supported by needle-roller-and-cage assemblies.

First split constant
Bearing arrangement with two single-row needle-roller-and-cage assemblies. Shaft tolerance g5; housing tolerance G5.

Second split constant
Bearing arrangement with two cylindrical roller bearings, both outer ring raceways integrated in the gearwheel bore. The cylindrical roller bearings accommodate radial and axial loads.

Range group
The planet wheels are supported by full-complement, double-row cylindrical roller bearings.
The lubricant is supplied via bores between the roller rows and collecting pockets in the cage. A deep groove ball bearing supports the cage versus the ring gear.

At the output end of the output shaft a deep groove ball bearing accommodates the radial and axial loads resulting from the joint shaft.



33: 16-speed truck transmission

Automotive differentials

Design

Spiral bevel-gear drives – with or without intersecting axes – are now almost always used for front and rear axle drives. Very high axial loads arise which, with non-intersecting axes, may be several times the tangential load at the pinion. Due to the limited space and the elevated torque values, the pinion bearings are very heavily loaded. The pinion bearings should provide for even meshing of pinion and crown wheel under load; therefore, the pinion bearing arrangement should be as rigid as possible. The pinion is either an overhung or a straddled arrangement. The overhung arrangement is usually fitted with two tapered roller bearings *adjusted* against one another. Compact bearing arrangements (double-row tapered roller bearings with an unsplit cup or a cup with a flange) are common.
The crown wheel is mounted in common with the differential. The meshing accuracy of the teeth should vary as little as possible and mounting should, therefore, be provided with sufficient rigidity. The rigidity requirements are easier to meet than with the pinion since more mounting space is available for this application and the axial loads are generally lower.

Bearing adjustment

Rigid pinion and crown wheel guidance is achieved by *adjusting* the bearings against each other with a preload. With grey-cast iron housings, thermal expansion of the shaft increases the preload in nearly all cases after operating temperature is reached; the preload must, however, never be such as to exceed the elastic limit of the bearing material.
The opposite applies to aluminium housings, which are being used more and more because of their lightness. So, the preload has to be selected such as to achieve the required rigidity, but the additional bearing loading must not significantly reduce the *bearing life*. This is the case if the axial preload does not exceed about half the external axial force F_a applied.

Lubrication

Differentials rely exclusively on *oil* lubrication. Bearings and gears are lubricated with the same *oil*. Since the lubricant is subjected to severe stressing in the spiral gearing, hypoid oils with *EP additives* are used. While the splash *oil* sufficiently lubricates the crown wheel shaft bearings, which have to accommodate lower loads, inlets and outlets must be provided for the *oil* for the pinion shaft particularly for the bearing on the flange side. Attention should be paid to the oil flow direction which is always from the small end to the large end of the tapered rollers. The oil ducts have to be arranged and dimensioned such as to ensure that *oil* circulates in every speed range.

The pinion shaft is normally sealed by means of radial shaft *seals*, in some cases in combination with a flinger sheet.

Bearing dimensioning

Fatigue life analysis of the bearings mounted in differentials is based on maximum torque and corresponding speed as is the case with automotive gearboxes. The percentage times at the individual speeds are based on experience. This information is then used to determine the mean index of *dynamic stressing*. The rolling bearings mounted in cars should have an average f_{Lm} value of 1...1.3.

Wear of these bearings should be minimal since differential drives require a high guiding accuracy and as quiet running as possible. With today's bearing dimensioning the *service life* of differential bearings is either terminated by fatigue or *wear*.

A detailed calculation of the *attainable life* is usually not necessary as these bearings have proved their worth sufficiently in the automotive sector. Bearing dimensioning based on a comparison calculation with the *index of dynamic stressing* f_L is sufficient.

34 Final drive of a passenger car

Operating data

Maximum engine torque 160 N m at 3,000 min^{-1}.

Bearing selection

Pinion shaft
The pinion shaft is fitted with FAG inch-dimensioned tapered roller bearings mounted in *O arrangement.* Dimensions: 34.925 x 72.233 x 25.4 mm (*dynamic load rating* C = 65.5 kN) and 30.163 x 68.263 x 22.225 mm (C = 53 kN).
The pinion is accurately positioned relative to the crown wheel by means of shims inserted between housing shoulder and bearing cup. The cones are *circumferentially loaded.* But only the cone of the larger bearing can be press-*fitted.* The cone of the smaller bearing is slide-fitted because the bearings are *adjusted* through this ring.

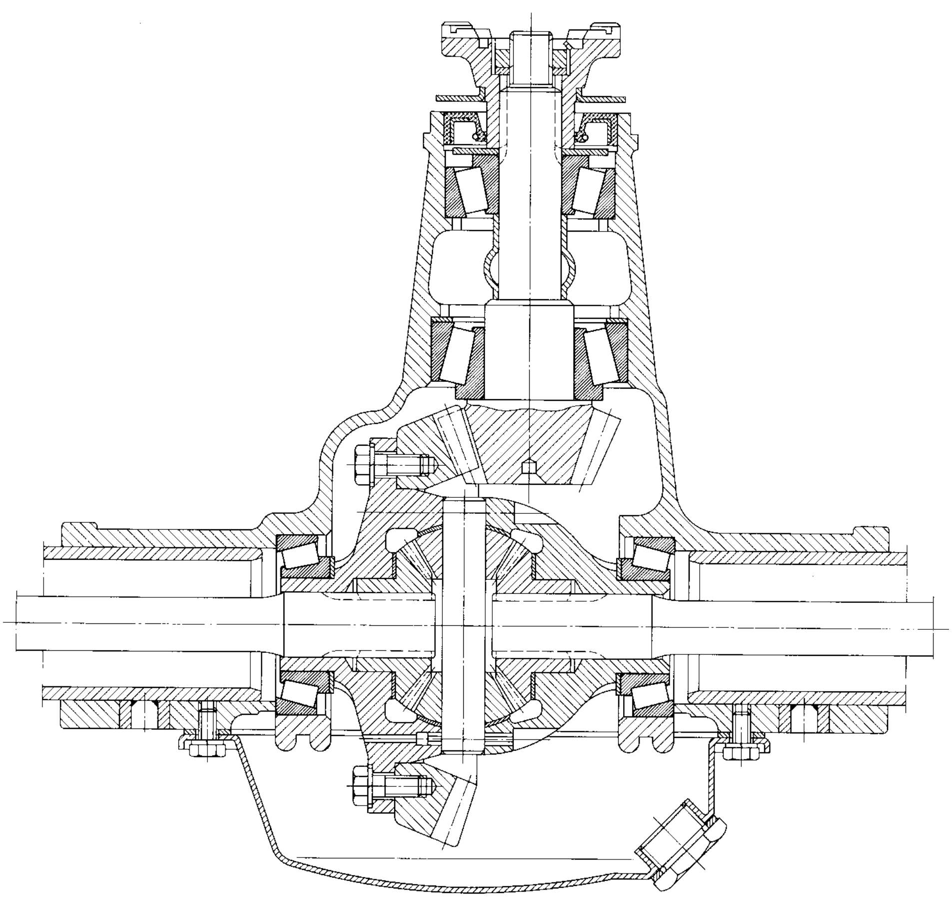
Crown wheel
Crown wheel and differential are mounted on the same shaft. Fitted are two FAG inch-dimensioned tapered roller bearings of 38.1 x 68.288 x 20 mm; C = 39 kN.
Both bearing and gear mesh *adjustment* are achieved by means of shims.

Machining tolerances

Pinion shaft: m6 (larger-size bearing)
h6 (smaller-size bearing)
housing P7

Crown wheel: hollow shaft to r6
housing to H6.

To allow the pinion to be *adjusted* to a certain torque and to avoid expensive fitting work (for instance machining of a solid spacer), a thin-walled preformed sleeve is provided between the bearing cones. The sleeve is somewhat longer than the maximum distance between the two bearing cones. Depending on the width tolerance values of the bearings there will be some elastic deformation of the sleeve (a few microns at most).



34: Final drive of a passenger car

35–39 Automotive wheels

Differences exist between driven and non-driven wheels for automobiles; the bearings can be either steerable or non-steerable. Basically, all wheels must be guided as accurately and clearance-free as possible for driving control reasons. This is in most cases achieved by using angular contact ball bearings or tapered roller bearings which are *adjusted* against each other.

Front wheels

Where steered, non-driven front wheels are concerned, the axle or shaft journal are relieved of torque transmission and can, consequently, be given relatively small dimensions. The tendency towards compact wheel bearing units is encouraged by the wish for the smallest roll radius possible as well as the pressure to reduce weight and to simplify series mounting.
Double-row angular contact ball bearings are almost always selected where the ratio of the mounting space for the wheel bearings axial width to the radial cross section height is less than 2.5. The following advantages can then be felt:

– little space is required in the axial direction, a large spread and, therefore, a high moment load carrying capacity due to a large *contact angle,*
– total weight of the bearings is low,
– suitable for integration in bearing units,
– flanges can be more easily integrated – particularly at the inner ring – than with tapered roller bearings.

Rear wheels

With non-steered rear wheels, the radial mounting space is generally limited not only in the case of conventional drum brakes but also in vehicles with disc brakes since an extra drum brake is usually mounted at the rear wheels as a parking brake. The actuation mechanism is inside the drum near the axle and limits, as a result, the maximum outside diameter of the hub. In comparison, the axial mounting space is normally not as restricted so the wheel bearings do not have to be particularly short.
Today's standard bearing arrangement for such wheels, therefore, consists of two relatively small single radial tapered roller bearings which are mounted at a larger distance. The bearings have small *contact angles* so that the highest *load rating* possible is reached in a small mounting space. The necessary *spread* to accommodate tilting forces is achieved with the large bearing distance.
With the wide range of standard tapered roller bearings, this simple bearing arrangement, which is inexpensive where solely the bearing costs are concerned, offers diverse variations for all vehicle types and sizes.

There are, however, also some disadvantages particularly with large series:

– Numerous single parts must be purchased, stored and mounted.
– The bearings have to be greased and *sealed* during mounting.
– The bearing system must be *adjusted* and the adjusting elements secured in the correct position.

Therefore, for rear wheels there is also a tendency to use double-row angular contact ball bearings which do not have to be *adjusted* when mounting and which can easily be integrated in bearing units.

Machining tolerances

The outer rings or cups of non-driven wheel bearings (hub bearings) are subjected to *circumferential load* (interference *fit*) whereas the inner rings or cones accommodate *point load* (loose, sliding or wringing *fit*); this facilitates mounting and bearing adjustment.
The the inner rings or cones of driven wheel bearings are *circumferentially loaded,* and the outer rings or cups are *point-loaded;* this has to be taken into account when selecting the machining tolerances.
Non-driven front or rear wheels with two angular contact ball bearings or two tapered roller bearings:
inner bearing: shaft to k6 (h6)
hub to N6, N7 (P7 for light-metal hubs)
outer bearing: axle journal to g6...j6
hub to N6, N7 (P7 for light-metal hubs)
Driven front or rear wheels with double-row angular contact ball bearings (bearing unit):
shaft to j6...k6
hub to N6, N7 (P7 for light-metal hubs)

Bearing dimensioning

For the *fatigue life* calculation of wheel bearings, the static wheel load, the dynamic tyre radius r_{dyn} and its coefficient of adhesion, as well as the speeds of the vehicle in the operating conditions to be expected, are taken into account. The loads on the individual bearings or – for double-row bearings on the individual *rolling element* rows – are determined with the forces and moments calculated. The calculation results can only be taken as reference values. Normally the ideal f_L values for passenger cars are approximately 1.5 and for commercial vehicles approximately 2.0.

Lubrication, sealing

Wheel bearings are almost exclusively lubricated with *grease.* Bearings which have no integrated *seals* are normally sealed with spring-preloaded shaft *seals* with special dust lips. Sealed bearings such as the double-row angular contact ball bearings with for-life lubrication, which are widespread in passenger cars, normally have a combination of dust shield and seal. Experience has shown that these *seals* are satisfactory if the design provides an additional gap-type seal. Collecting grooves and baffles are also required to protect the bearings against dust and splash water.

35 Driven and steered front wheel of a front drive passenger car

Operating data

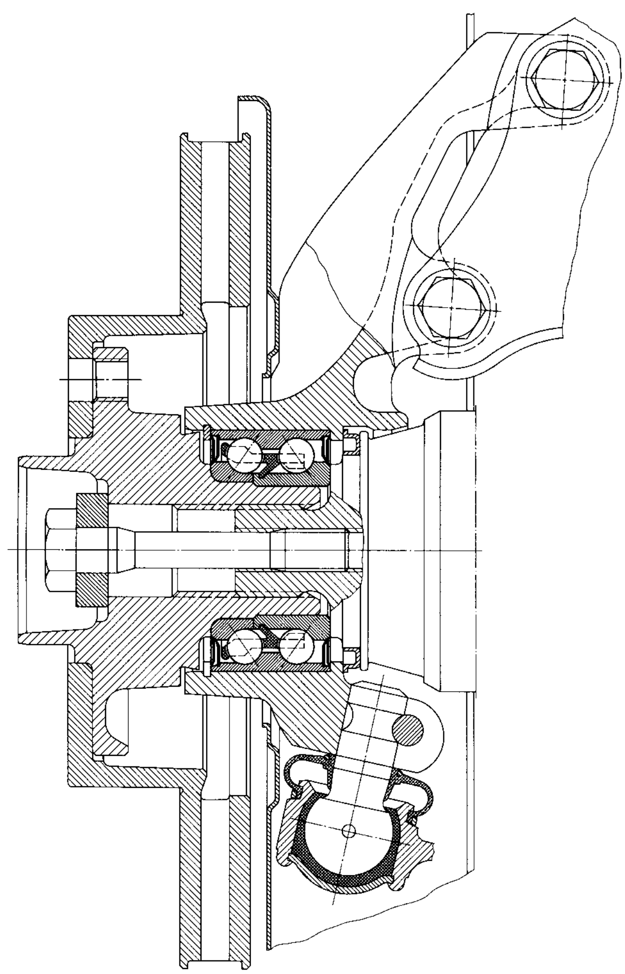
Wheel load 4,600 N; tyre size 175/70 R14; r_{dyn} = 295 mm; maximum speed 180 km/h.

Bearing selection

The bearing arrangement is made up of a *sealed* double-row FAG angular contact ball bearing.

The bearing is greased for *life* with FAG rolling bearing *grease.*

The bearing arrangement of a driven and non-steered rear wheel of a rear drive passenger car may also be designed like this.



35: Passenger-car front wheel

36 Driven and non-steered rear wheel of a rear drive passenger car

Operating data

Wheel load 4,800 N; tyre size 195/65 VR15; r_{dyn} = 315 mm; maximum speed 220 km/h.

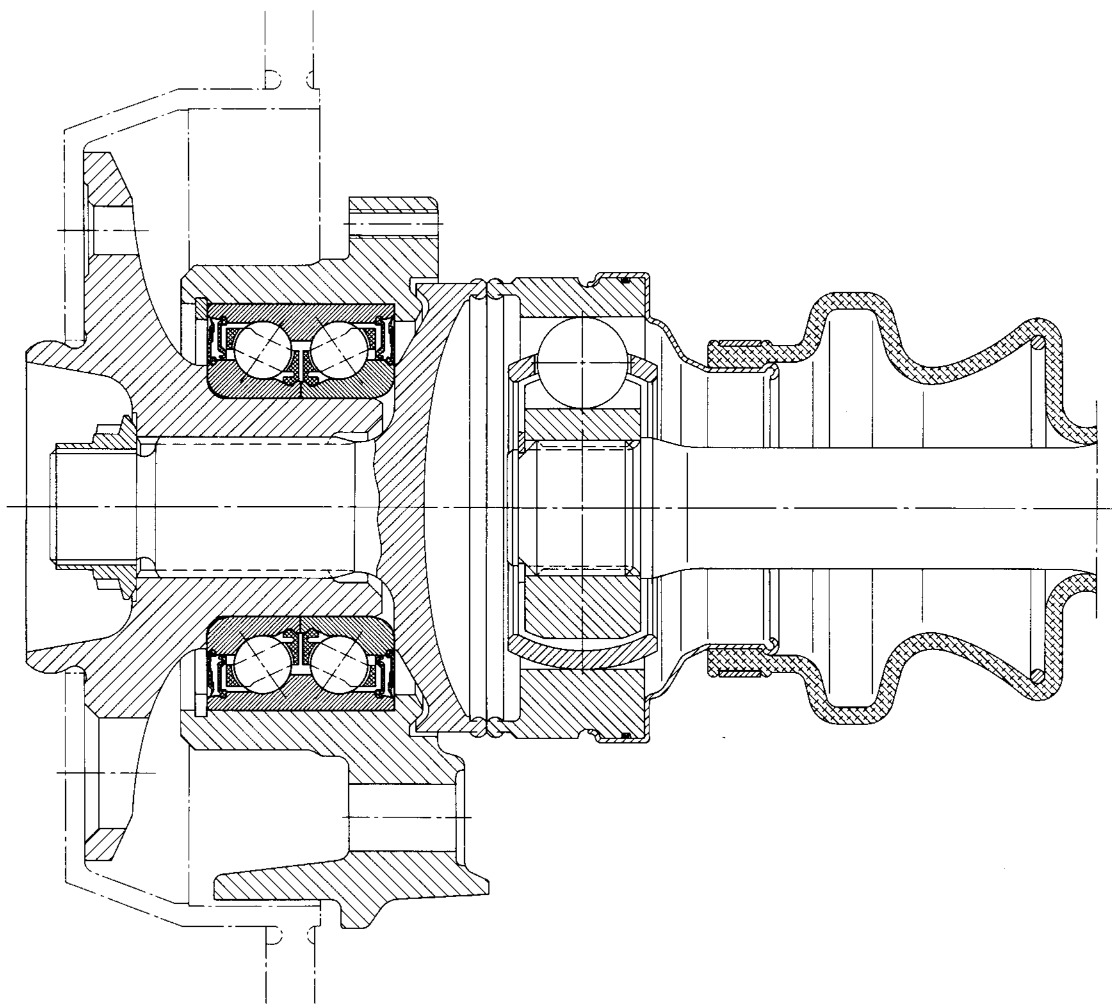
Bearing selection

The wheel bearing arrangement consists of a double-row FAG angular contact ball bearing which is *greased for life.*

Seals and flinger rings provided on both sides protect the bearing from contamination.

Machining tolerances

The inner rings and the outer ring of the bearing are tightly *fitted.*



36: Passenger-car rear wheel

37 Driven and non-steered rear wheel of a rear drive truck

The rear wheel hubs of heavy trucks often feature a planetary gear. This type of drive provides a relatively high gear ratio in a limited space. As the high driving torque is generated directly at the wheel, small differential gears and light drive shafts are possible.

Operating data

Wheel load 100 kN; tyre size 13.00-20; r_{dyn} = 569 mm; permissible maximum speed 80 km/h.

Bearing selection

Wheel bearings
Tapered roller bearings FAG 32019XA (T4CC095 according to DIN ISO 355) and FAG 33021 (T2DE105 according to DIN ISO 355). Since these bearings have a particularly low section height they require only a small radial mounting space thus allowing light-weight constructions. The relatively large bearing width and long rollers result in a high load carrying capacity.

The bearings are *adjusted* against each other in *O arrangement* (large *spread*).

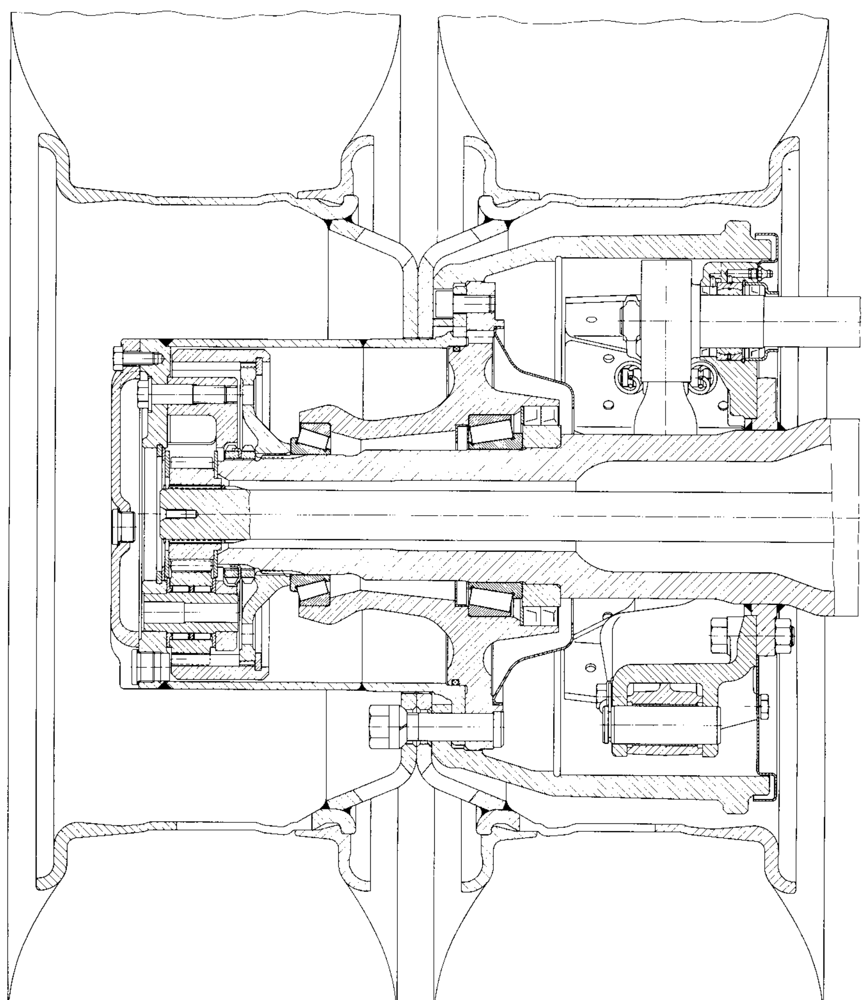
Planetary gears
The outer planet drive increases the driving torque in a minumum space. The planet gear bearing arrangement is of the full-complement type, i.e. it features two rows of needle rollers. Axial guidance is provided by thrust washers.

Machining tolerances

Direct bearing arrangement with needle rollers:	shaft to h5; housing to G6
Tapered roller bearing:	shaft to j6; housing to N7

Lubrication

Common *oil* lubrication for planet drive and wheel bearings. An oiltight, welded housing protects gear and bearings against contamination.



37: Rear wheel of a truck

38 Steering king pin of a truck

A variety of steering king pin mounting arrangements are possible. The bearing arrangement with two *adjusted* tapered roller bearings for accommodating the axial loads is generally used in driven truck front wheels. In other cases the axial loads are accommodated by thrust ball bearings or tapered roller thrust bearings. Since the radial mounting space for king pin bearing mounting arrangements is usually very limited the radial loads (steering and guiding forces) are accommodated by a plain bearing made of bronze and drawn cup needle roller bearings which provide for easy steering.

Mounting with a tapered roller thrust bearing

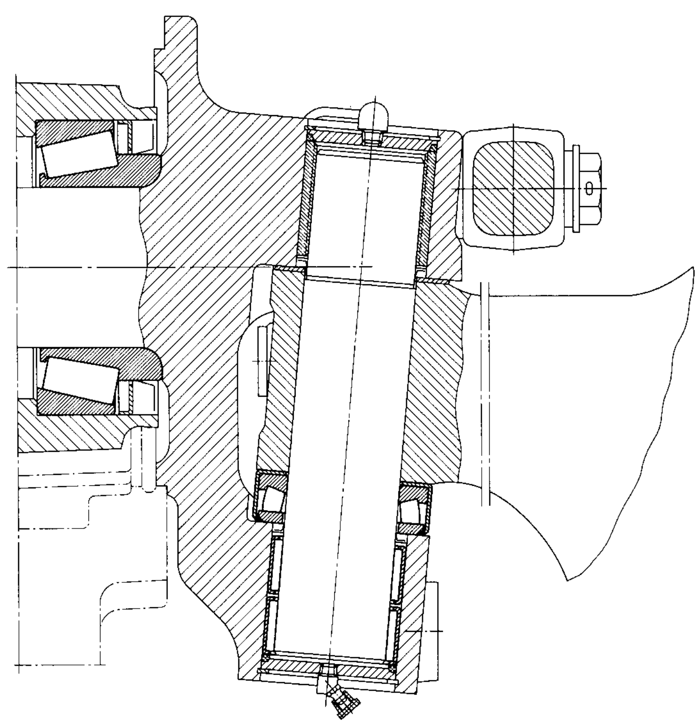
The shock loads on the steering king pin are very high. Therefore, the *thrust bearing* must have a high load carrying capacity and be mounted with zero clearance or preload. As the king pin performs only slight slewing motions no *cage* is required so that the number of *rolling elements* and, consequently, the load carrying capacity can be increased.

The example features a full-complement tapered roller thrust bearing as the *thrust bearing.* It has a profiled shaft-washer raceway and a flat housing-washer raceway. The sealed bearing is held together by a pressed steel cap, which simplifies mounting.

The bearing is filled with special *grease;* it can be relubricated if necessary. Openings in the *sealing* lip and the elasticity of the sealing material ensure the escape of the spent *grease.*

The clearance between the knuckle and the cross member is compensated for by shims. In this way, the thrust bearing can have zero clearance at best, which means higher shock-type loads. Experience has shown that this can be taken into account by means of an impact factor of f_z = 5...6, in the case of adjusted tapered roller bearings with an impact factor of f_z = 3...5.

The shaft washer of tapered roller thrust bearings is located by a relatively loose *fit* on the steering kin pin (g6); the housing washer has no radial guidance.



38: Steering king pin of a truck

39 Shock absorbing strut for the front axle of a car

Front axles are being equipped more and more frequently with McPherson shock absorbing struts. When driving, the coil spring and the damping unit of the McPherson strut cause movements relative to the body which are due to spring deflection and the degree of lock. For comfort reasons and for easy handling, these slewing motions are supported either by rolling bearings or rubber elements. Deep groove ball bearings best meet all requirements.

Bearing selection

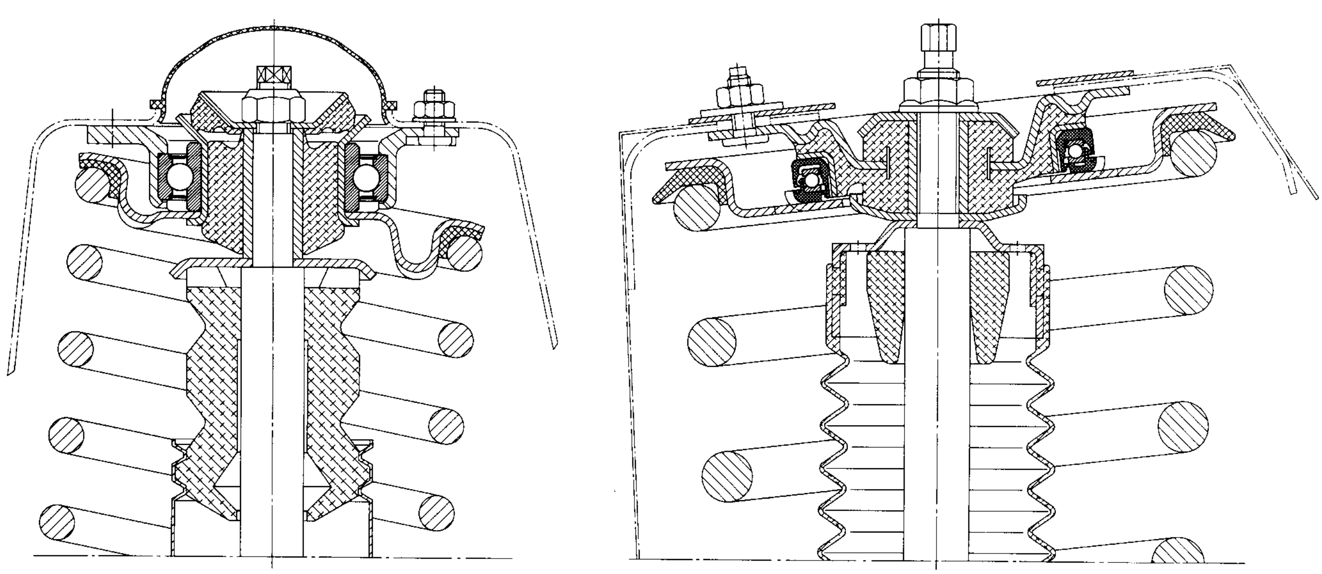
Requirements

- Accommodation of weights and high shock loads
- Maintenance-free design

Variants

- Damping unit and spring coil rotate together – single path solution (fig. a). The spring coil loads and the pulsating loads from the piston rod act on the strut bearing.
  Possible bearing designs: Deep groove ball bearings loaded axially (with *cage* or full-complement variants with a fracture-split outer ring) or thrust ball bearings.
- Movements of the shock absorber's piston rod and of coil spring are independent of each other – dual path solution (fig. b).
  Direct connection of shock absorber's piston rod to the body via a rubber element; coil spring supported by a special thrust ball bearing or angular contact ball bearing (spring seat bearing).

Both variants meet all requirements concerning *sealing*, *for-life* lubrication and economic efficiency.



a b

39: Shock absorbing strut for the front axle of a car; a: single path solution; b: dual path solution

40 Water pump for passenger car and truck engines

The water pump provides for circulation of the cooling water in the engine. Smaller and lighter pump designs are possible with ready-to-mount bearing units.

Bearing selection

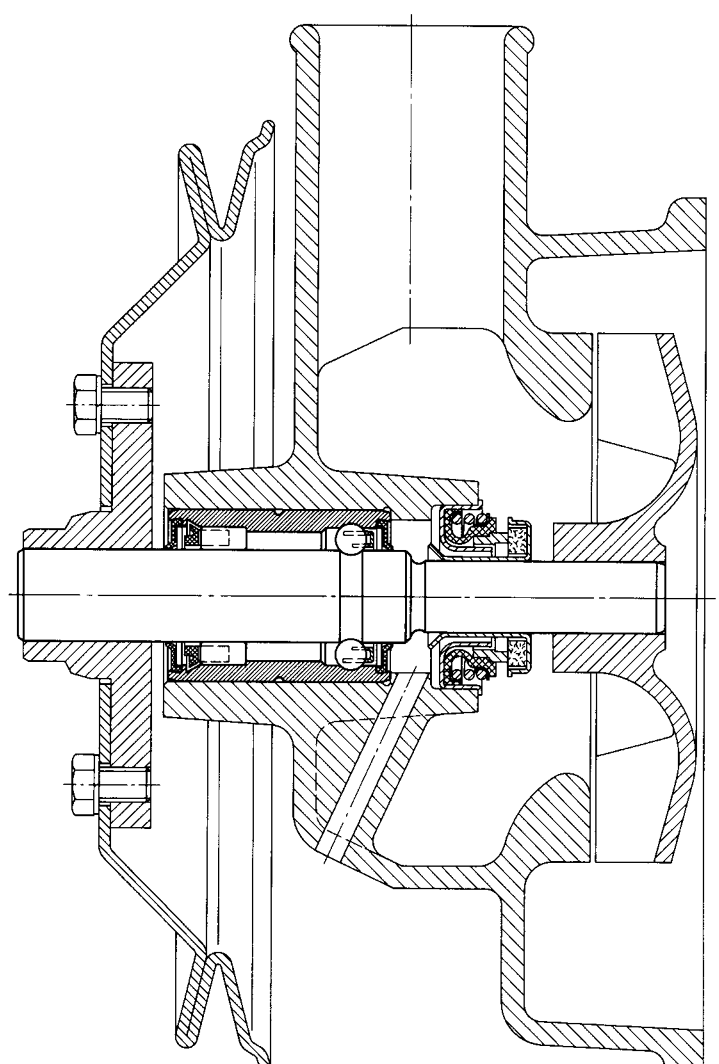
The water pump bearing unit consists of the shaft and a common outer ring with raceways *for rolling-element-and-cage* assemblies. The example features one ball-and-cage assembly and one roller-and-cage assembly each mounted in a *locating-floating bearing arrangement.* The roller-cage assembly is designed as the *floating bearing* at the side that is most heavily loaded by the belt pull. The ball-cage assembly is the *locating bearing:* in addition to the radial loads it also accommodates the thrust of the pump impeller.

Machining tolerance, bearing clearance

The outer ring is mounted into the housing with an R7 interference *fit.* The bearing clearance of the unit is selected to allow for a small *operating clearance.*

Lubrication, sealing

For-life lubrication with a special rolling bearing *grease.* Lip *seals* in the outer ring are provided on both sides against grease escape. A spring loaded axial face *seal* is fitted at the impeller end. Unavoidable water leakage is drained to the outside through the outlet bore.



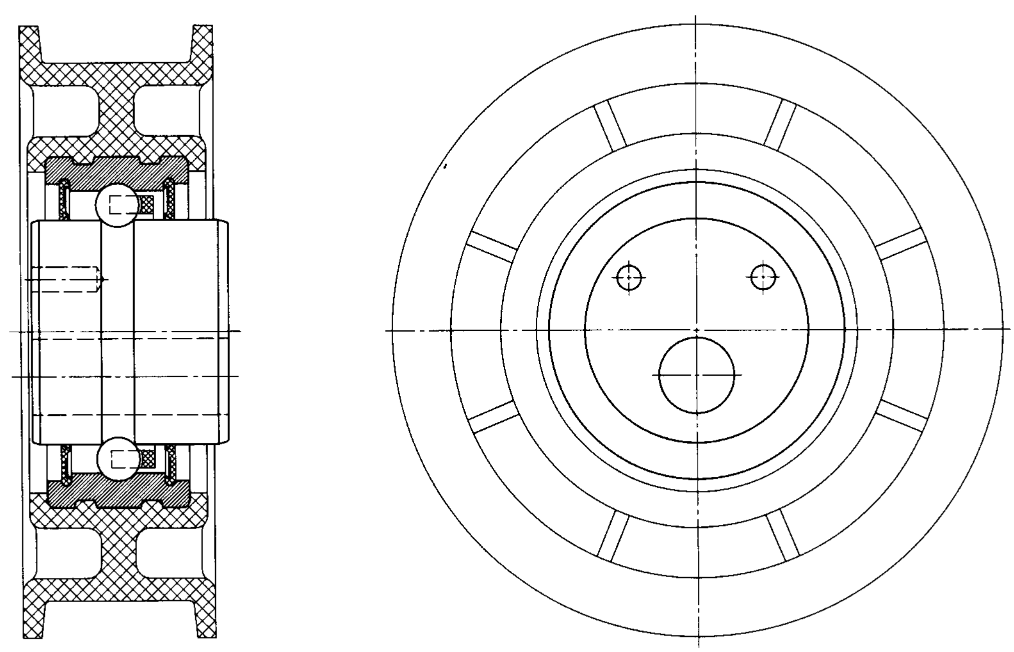
40: Water pump bearing unit for a truck engine

41 Belt tensioner for passenger car engines

The cam shafts of many four-cycle engines are driven with toothed belts from the crankshaft.
The belt tension necessary for quiet running is provided by an FAG bearing unit. This tensioning pulley unit consists of a journal with integral raceways, a ball-cage assembly and an outer ring with the plastic injection-moulded tensioning pulley.

The screw bore for fastening the tensioning pulley to the engine housing is eccentrically located so that the belt tension can be applied by rotating the journal.

The bearing unit is *sealed* on both sides and packed with grease for *life*. Speed is approximately 7,000 min^{-1}.



41: Belt tensioner for passenger car engines

42 Axle box roller bearings of an Intercity train carriage

The type of axle box roller bearings presented here is used for Intercity traffic in Europe.
The bogie frame is supported on the bearing housing by a central coil spring, arranged above the bearings. The wheelsets are guided by plate-type guiding arms which are bolted on one side.

Operating data

Deadweight of the carriage plus maximum payload: 64,000 kg; two bogies, each with two wheelsets, implies 4 wheelsets per car.
Resulting axle weight per wheelset: A = 64,000/4 = 16,000 kg; weight of wheelset G_R = 1,260 kg; acceleration due to gravity g = 9.81 m/s^2; supplementary factor for dynamic loads occurring during operation f_z = 1.3;
thrust factor for cylindrical roller bearings f_a = 1;
number of bearings per wheelset i_R = 4.

Thus the *equivalent dynamic load* per bearing is:
$P = (A - G_R)/i_R \cdot g \cdot f_z \cdot f_a$

$P = (16{,}000 - 1{,}260)/4 \cdot 9.81 \cdot 1.3 \cdot 1 = 46{,}990$ N
P = 46.99 kN

Wheel diameter D_R = 890 mm;
maximum speed v_{max} = 200 km/h (possible speed 250 km/h).

Bearing selection

Cylindrical roller bearings installed as axle box roller bearings offer important advantages:

Mounting is simple and they are easy to check and maintain in main inspections.

Axial clearance is irrelevant for *radial clearance.* Cylindrical roller bearings are pure *radial bearings,* but the lips allow the safe accommodation of all thrust loads (guiding forces) occurring in operation.

Of all the roller bearing types cylindrical roller bearings have the lowest friction. Their *speed suitability* is therefore greater than in the case of other roller bearings.

Cylindrical roller bearings do not, however, compensate for misalignment between axle and bogie frame. Therefore misalignment must be corrected by angular freedom of the housing.

The same cylindrical roller bearings are used for passenger cars and freight cars. This simplifies stockkeeping.

Each axle box accommodates two cylindrical roller bearings, one FAG WJ130x240TVP and one FAG WJP130x240P.TVP.

The bearing dimensions (d x D x B) are 130 x 240 x 80 mm; the *dynamic load rating* C of one bearing is 540 kN.

The *nominal rating life* (L_{h10}) is checked in kilometres when dimensioning the axle box bearings:

$L_{h10km} = (C/P)^{3.33} \cdot D \cdot \pi = (540/46.99)^{3.33} \cdot 890 \cdot \pi = 3{,}397 \cdot 2{,}497.6 \approx 9.5$ million kilometres.

Under these conditions the bearings are sufficiently dimensioned. 5 million kilometres (lower limit) applies today as a basis for dimensioning axle box bearings for passenger train carriages.

Machining tolerances

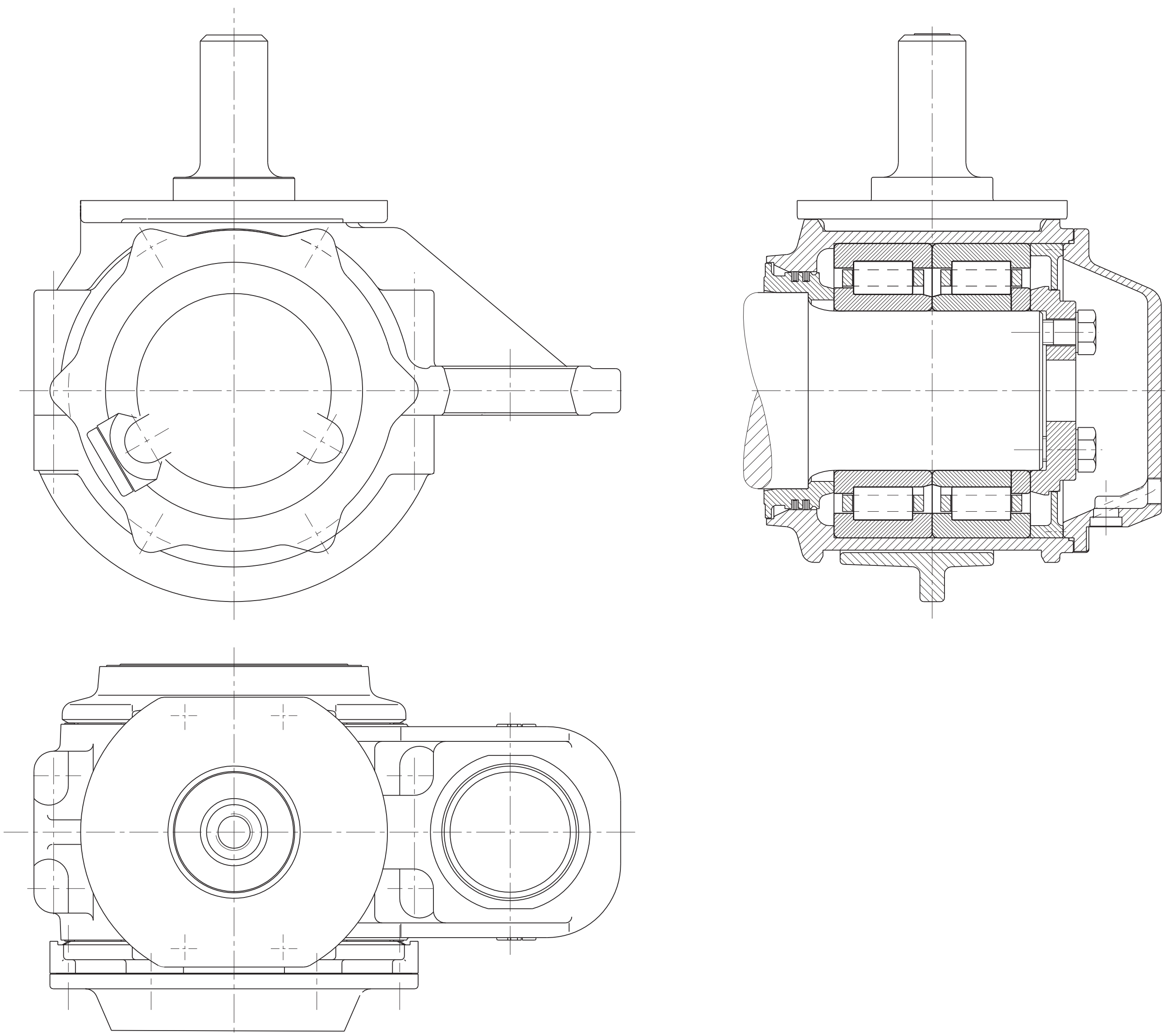
Bearing inner rings carry *circumferential load;* therefore they are press-*fitted:* axle journal p6, housing H7.

Bearing clearance

The tight *fit* expands the bearing inner rings which reduces *radial clearance.* The air stream cools the outer rings to a greater extent than the inner rings during travel which leads to a further reduction in *radial clearance.* Therefore the bearings have a *radial clearance* of 120 to 160 microns.

Lubrication, sealing

The bearings are lubricated with a lithium soap base *grease.* Lamellar rings at the wheel side provide for effective non-rubbing *sealing.* A baffle plate at the cover end keeps the grease close to the bearing. Despite the small amount of grease (≈ 600 g) high running efficiency (800,000 km and more) can be reached due to the *polyamide cages* without changing the lubricant.



42: Axle box roller bearings of an Intercity train carriage

43–44 UIC axle box roller bearings for freight cars

The car body is supported by laminated springs on the wheelset. The laminated springs have the additional job of guiding the wheelset. To limit the swaying motion of the car body and to accommodate the thrust peaks, the housing features guiding surfaces in which the axle support of the frame is engaged. Cylindrical or spherical roller bearings are used as axle box roller bearings. The housing boundary dimensions of the UIC bearing are standardized. According to the latest UIC conditions 130 mm diameter journals are specified for cylindrical and spherical roller bearings. In some cases 120 mm journals are used for cylindrical roller bearings.

Clearance

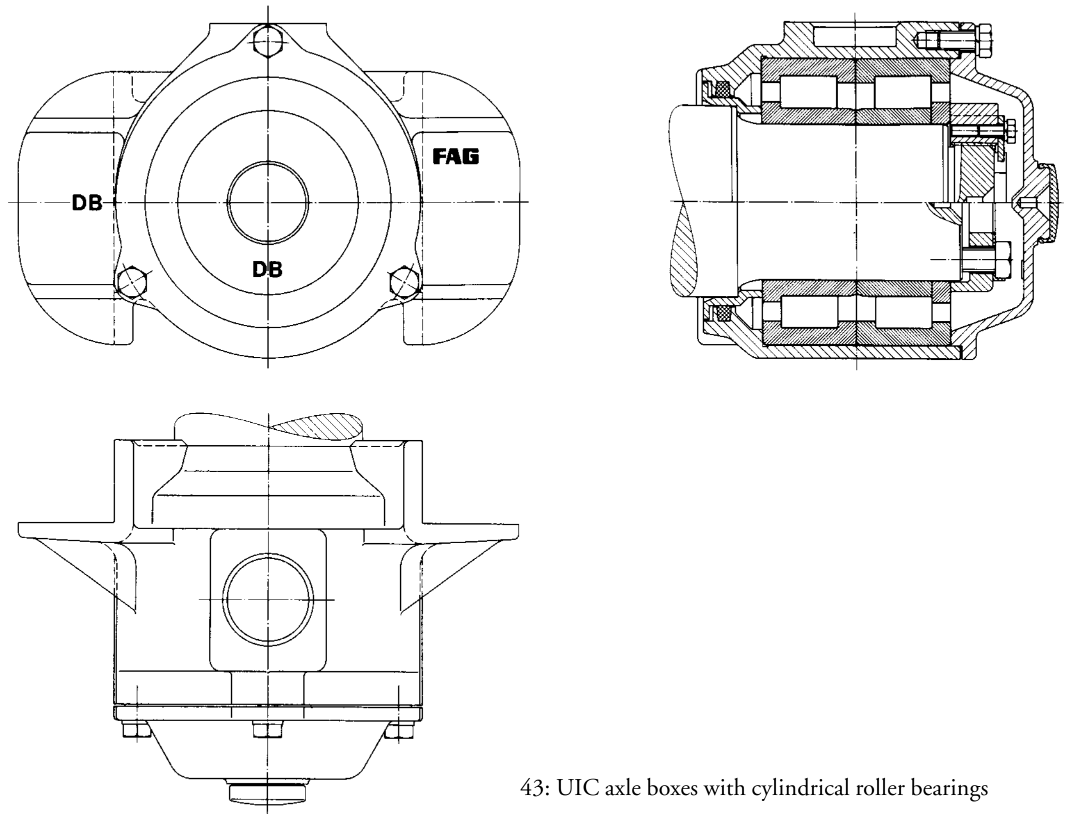
The tight *fit* expands the inner ring thus reducing *radial clearance*. A further clearance reduction results from the air stream developed during travel which cools the outer ring more than the inner ring. Therefore, cylindrical roller bearings with a *radial clearance* of 130 to 180 microns and spherical roller bearings with increased *radial clearance* C3 are chosen.

Lubrication, sealing

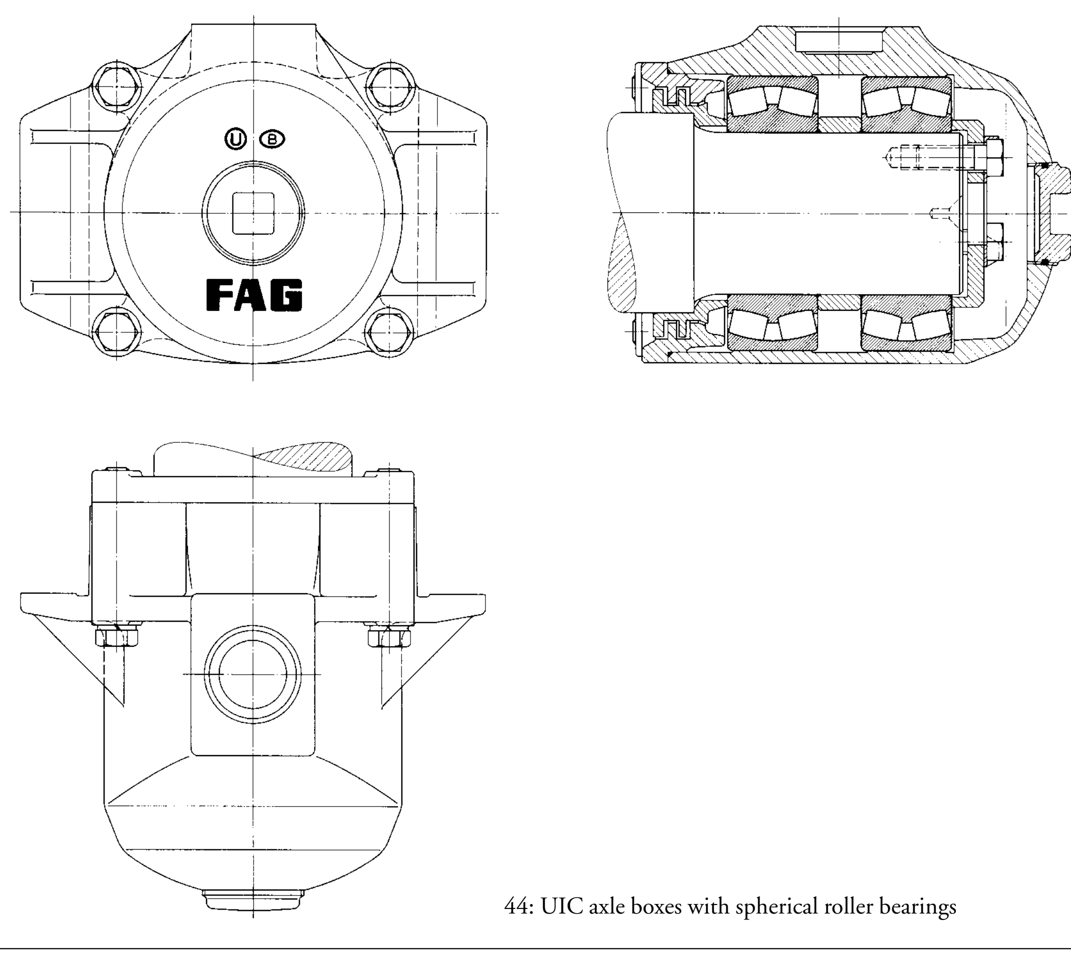
The axle box roller bearings are lubricated with a lithium soap base *grease*. Felt seals combined with a labyrinth have proved most effective for cylindrical roller bearings.
UIC axle boxes with spherical roller bearings invariably use only labyrinth *seals*.

Dimensioning, bearing selection

Operating data	43: UIC axle boxes with cylindrical roller bearings	44: UIC axle boxes with spherical roller bearings
Deadweight with max. payload G_{max}	40,000 kg	40,000 kg
Top speed v_{max}	100 km/h	100 km/h
Wheel diameter D_R	1 m	1 m
Number of wheelsets	2	2
Wheelset weight G_R	1,300 kg	1,300 kg
Weight on axle A	20,000 kg	20,000 kg
Number of bearings per wheelset i_R	4 cylindrical roller bearings	4 spherical roller bearings
Supplementary factor $f_z \cdot f_a$ (f_a = 1 for cylindrical roller bearings where thrust loads are taken up by the lips; f_a = 1.25 for spherical roller bearings where thrust loads are taken up by the raceways.)	$1.3 \cdot 1 = 1.3$	$1.3 \cdot 1.25 = 1.625$
Equivalent load: $P = (A - G_R) \cdot g \cdot f_z \cdot f_a / i_R$ ($g = 9.81$ m/s^2)	59.6 kN	74.5 kN
Average travelling speed ($v_{Fm} = 0.75 \cdot v_{max}$)	75 km/h	75 km/h
Average wheelset speed $n = 5{,}310 \cdot v_{Fm}$ (km/h)/D_R (mm)	400 min^{-1}	400 min^{-1}
Speed factor f_n	0.475	0.475
Index of dynamic stressing f_L	3.5	3.5
Required *dynamic load rating* of one bearing: $C = f_L/f_n \cdot P$	439 kN	549 kN
Bearings mounted:	Cylindrical roller bearings FAG WJ130x240TVP and FAG WJP130x240P.TVP	2 spherical roller bearings FAG 502472AA
Bore x outside diameter x width	130 x 240 x 80 mm	130 x 220 x 73 mm
Dynamic load rating	540 kN	585 kN
Machining tolerances of journals	p6	p6
Machining tolerances of housing bores	H7	H7
Radial clearance	130...180 μm	Clearance group C3



43: UIC axle boxes with cylindrical roller bearings



44: UIC axle boxes with spherical roller bearings

45 Axle box roller bearings of series 120's three-phase current locomotive

The frame is supported by coil springs and spring seats which are integrated in the bearing housing. The spring seats are arranged at different heights. The bearing is guided by an arm on each side which is linked diagonally to the housing. The arms are supported by elastic damping springs.

Technical data

Vehicle weight: 84,000 kg
Number of wheelsets: 4
Wheelset weight: 2,250 kg
Axle load: 22,000 kg
Supplementary factor f_z = 1.5
The locomotive reaches top travelling speeds up to 200 km/h.

Bearing selection

Please refer to example number 42 to determine the *equivalent dynamic load* P.
Cylindrical roller bearings of the type NJ and NJP with the dimensions 180 x 320 x 75 mm are mounted. *Dynamic load rating* of one bearing: C = 735 kN. The outer and inner rings of both bearings are separated by spacer rings. The inner spacer ring is 2 mm wider than that of the outer rings.
The *axial clearance* which arises thereby, is necessary to compensate for bogie production tolerances. The bearing can always be mounted without preload.

Machining tolerances

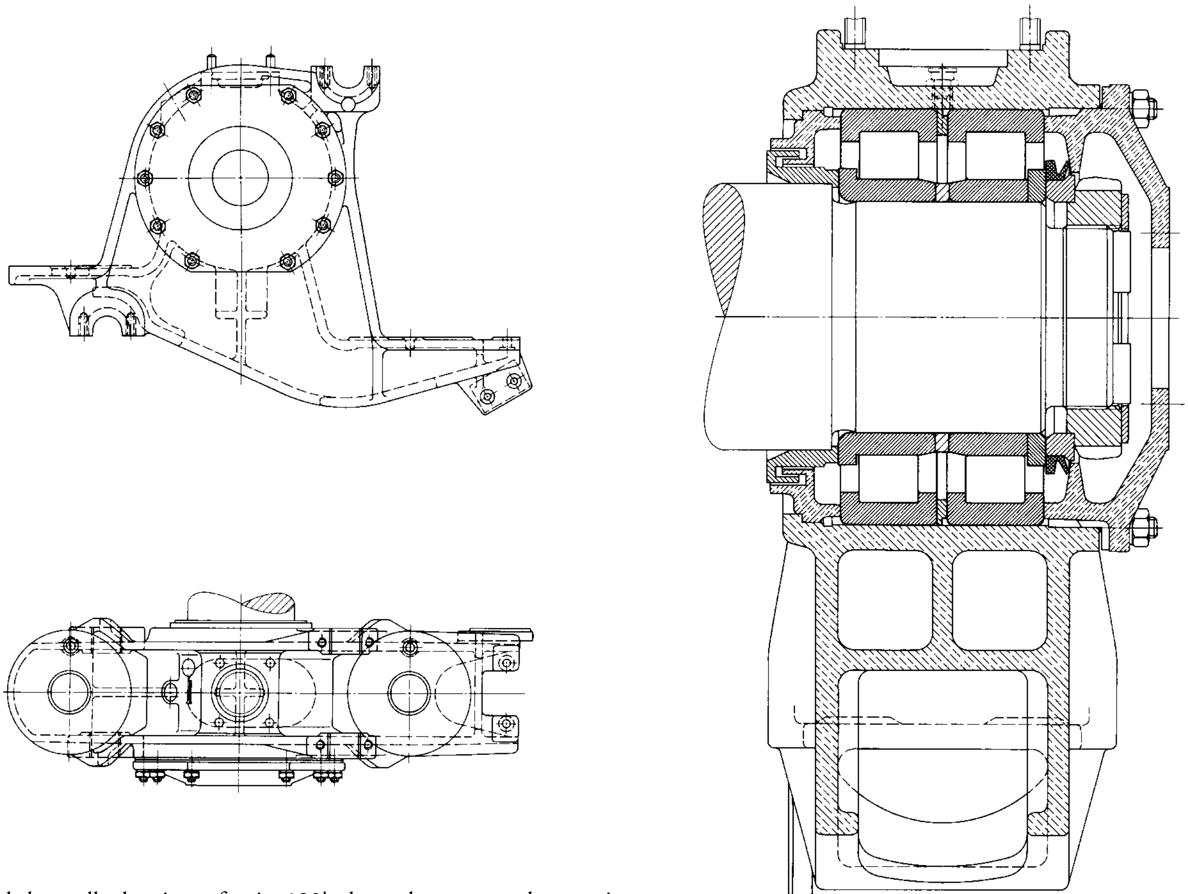
The bearing inner rings have *circumferential load* and are therefore given a tight *fit:* Journals to p6. The housing material, an aluminium cast alloy, has a greater coefficient of expansion than cast steel which is why the tolerance field J7 was selected and not the housing tolerance H7 usually taken for cast steel housings.

Bearing clearance

Due to the tight *fit* the bearing inner rings expand; the *radial clearance* becomes smaller. The outer ring is cooled more than the inner ring by the wind resistance during travel which leads to a further reduction of clearance. For this reason bearings with increased *radial clearance* C4 have been selected.

Lubrication, sealing

A lithium soap base *grease* is used for lubrication. On the wheel side the bearing is sealed by a two-web labyrinth *seal.* A V ring seal protects from contaminants on the opposite side.



45: Axle box roller bearings of series 120's three-phase current locomotive

46 Axle box roller bearings for the ICE driving unit

The bogie frame is supported by 2 coil springs each on the bearing housings. The wheelset with the housings is connected to the bogie by an arm. A setting mechanism enables the mounting of the wheelsets in the bogies without preload. The bearing units are axially located by a cover.

Operating data

Axle load: 19,900 kg
Weight of unsprung weight: 2,090 kg
Diameter of wheel 1,040 mm
Maximum speed 250 to 280 km/h.

Bearing selection

FAG tapered roller bearing units TAROL 150/250 are mounted in the wheelset housings of the series vehicles with the designation ET 401. The main component of these units is a double row tapered roller bearing with the dimensions: 150 x 250 x 160 mm.

Machining tolerances

The cones carry *circumferential load* and therefore have a tight *fit:* journal to p6.

Housing to: H7 (for GGG material)
J7 (for aluminium alloys).

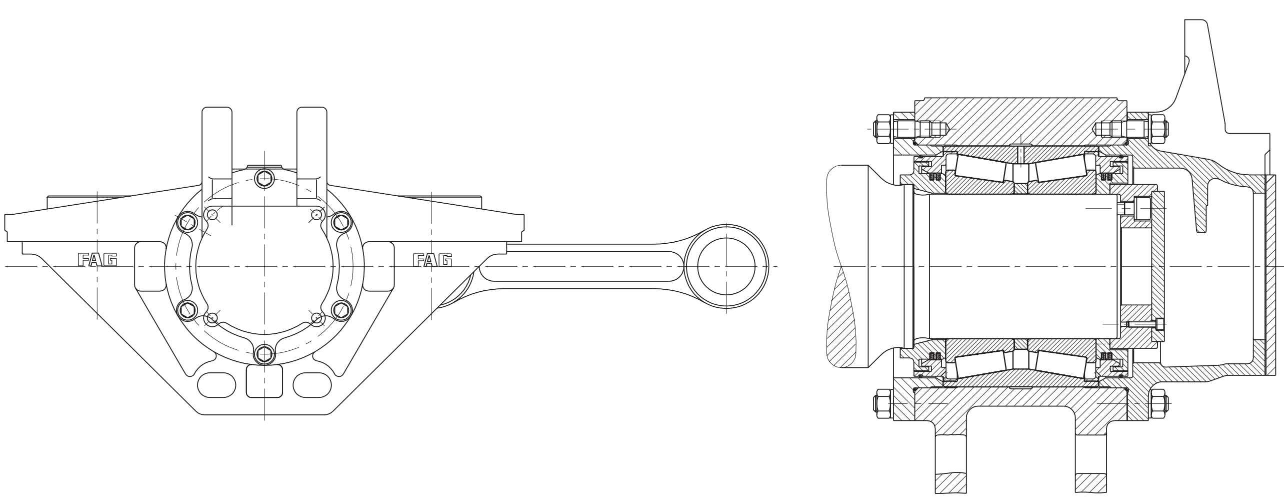
Bearing clearance

A slight *axial clearance* is required for ideal running behaviour of the bogies at top speeds. It is between 0.2 and 0.5 mm after mounting.

Lubrication, sealing

The TAROL 150 is supplied as a complete unit which is sealed. The *sealing* system consists of two parallel outer diameter seated lamellar rings and one single-web labyrinth acting as a pre-seal. The labyrinth is shaped as a *seal* cap and pressed into the cup.

The *seal* caps are each provided with four discharge holes through which excess *grease* escapes. This is particularly important directly after relubrication. O rings protect the bearing unit from the penetration of water in the seating area of the cup.



46: Axle box roller bearings of the ICE driving unit

47 Axle box roller bearings of the Channel tunnel's freight engine, class 92

Class 92 is used for freight traffic in the Euro tunnel between Great Britain and the Continent. It is a two-system engine which means it can be operated on direct current (750 V) as well as on alternating current (25 kV). The engine with six axles (CoCo) draws loads weighing up to 1,600 t.

The vertical loads of the bogie are accommodated by two lateral coil springs on the housing of the axle box bearings. All lateral and longitudinal forces act via the guiding journals and sleeves which are attached to the bogie frame and the housing.

The middle axle of each triple axle bogie is designed as a floating axle box to insure trouble-free operation in narrow curves. The two outer axles are designed as standard axles as customary.

Operating data

Vehicle weight 126,000 kg; two bogies each with three axles; wheel diameter 1,120 mm; top speed v_{max} = 140 km/h;
Power P = 5,000 kW at 25 kV AC
4,000 kW at 750 V DC

Bearing selection

Tapered roller bearing units TAROL 150/250 with *pressed cages* (JP) are mounted to the outer standard axles of the vehicles. The bearings are clearance-adjusted, greased and *sealed* by the manufacturer. Fey lamellar rings provide for sealing on the side facing the wheel. A gap-type seal prevents rough dirt from penetrating the bearings.

The floating axle is accommodated in two cylindrical roller bearings whose dimensions are 150 x 250 x 80 mm. The extended inner ring allows axial displacement within the bearing of ± 20 mm at a maximum.

Sealing is achieved at the wheel end by means of long-webbed labyrinths.

Machining tolerances

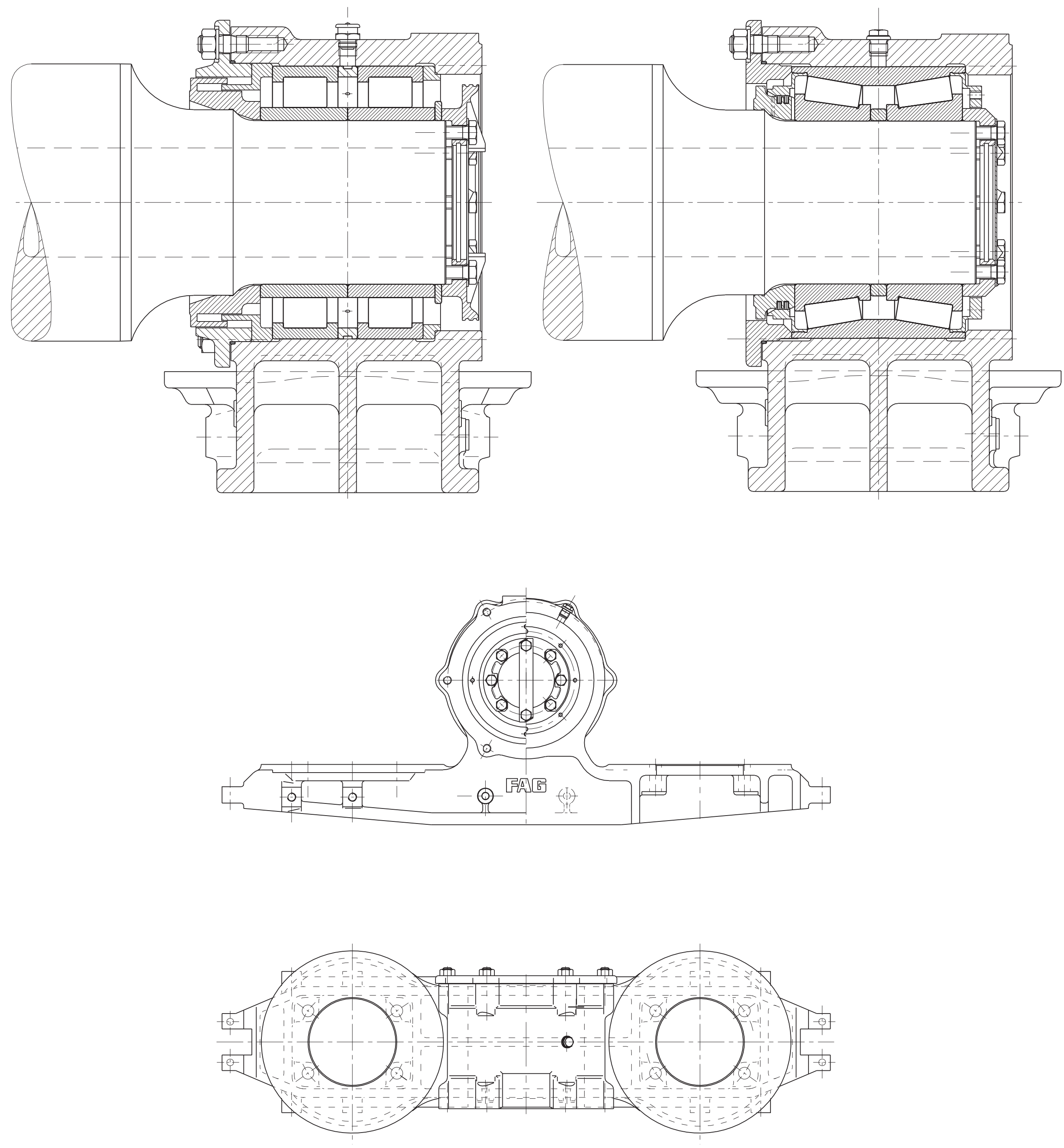
The inner rings carry *circumferential load* and have a tight *fit* to p6 on the journal.
The housing bores (*point load*) are machined according to H7.

Bearing clearance

Prior to mounting, the TAROL units of the standard axle have an *axial clearance* of 0.665...0.740 mm and the cylindrical roller bearing units a *radial clearance* to C4 in order to compensate for heat expansion.

Lubrication

Both bearing types are lubricated with a lithium soap base *grease.* While the lubricant in the TAROL bearings is only changed during the main inspections, the floating axle bearings must be relubricated in between. Due to the constant right to left displacement of the axle lubricant is removed from the bearing area and therefore has to be replaced regularly.



47: Axle box roller bearings of the Channel tunnel's freight engine, class 92

48 Axle box roller bearings for an underground train

A car has two bogies. Each axle box roller bearings is cushioned and guided by rubber-metal silent blocks. These are arranged between the axle box roller bearing and the frame opening. They are inclined to the vertical and have an angular cross-section.

Operating data

Weight and maximum payload of one car: 34,000 kg.
Number of wheelsets per bogie: 2.
Wheelset weight G_R: 1,400 kg.
Supplementary factor f_z: 1.3.
Equivalent dynamic load P = 22.6 kN.
Wheel diameter D_R = 900 mm.
Top speed v_{max} = 80 km/h.

Bearing selection

Two cylindrical roller bearings are mounted per axle box: One FAG NJ2318E.TVP2.C3.F2.H25 and one FAG NJP2318ED.TVP2.C3.F2 (*dynamic load rating* C = 430 kN).

Machining tolerances

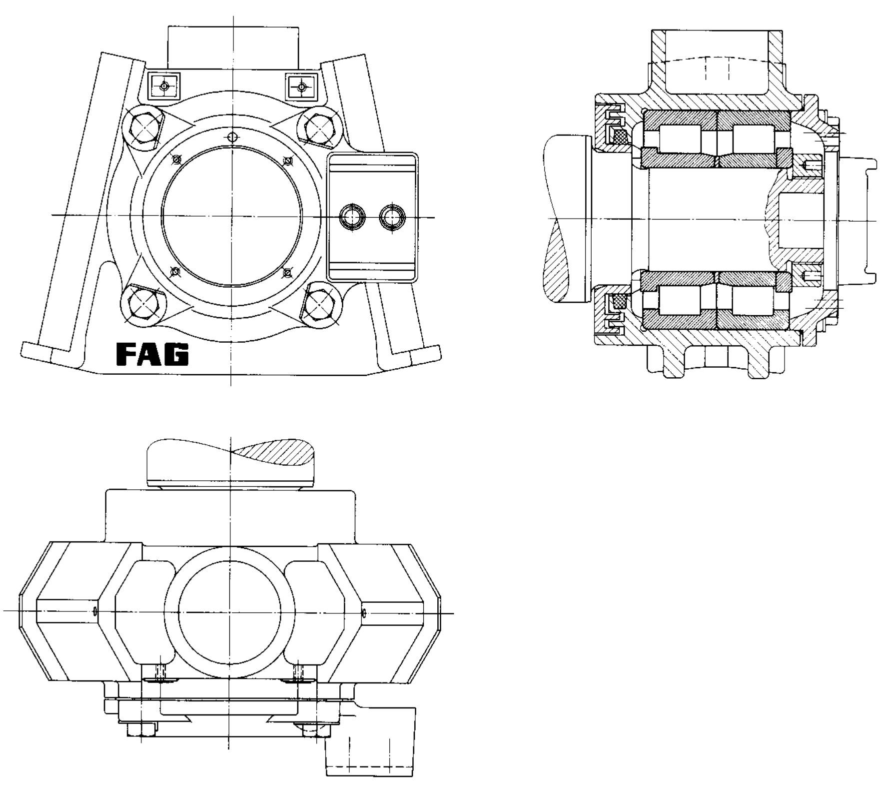
The bearing inner rings carry *circumferential load* and are therefore given a tight *fit:* journal to m6, housing to H7.

Bearing clearance

The inner rings increase due to the tight *fit:* the *radial clearance* decreases. The outer rings are cooled more than the inner rings due to the air stream during travel. This leads to a further reduction in clearance and therefore a *radial clearance* C3 was selected.

Lubrication, sealing

A lithium soap base *grease* is used for lubrication. A combination of a felt ring and a labrinth was selected as a means of *sealing.*
The labyrinth is provided with two axial webs since the axle boxes are subjected to extreme dirt.



48: Axle box roller bearings for an underground train

49 Axle box roller bearings for a city train

The bogie frame is supported by Chevron springs on the axle boxes.

Operating data

The *equivalent dynamic load* P_m = 37 kN (calculated from the various load conditions).
Mean wheel diameter 640 mm.
Maximum speed v_{max} = 80 km/h.

Bearing selection

The main component of the FAG bearing units TAROL 90 used here is a double row tapered roller bearing whose main dimensions are (d x D x B overall widths cones/cup) 90 x 154 x 106/115 mm.

Bearing clearance

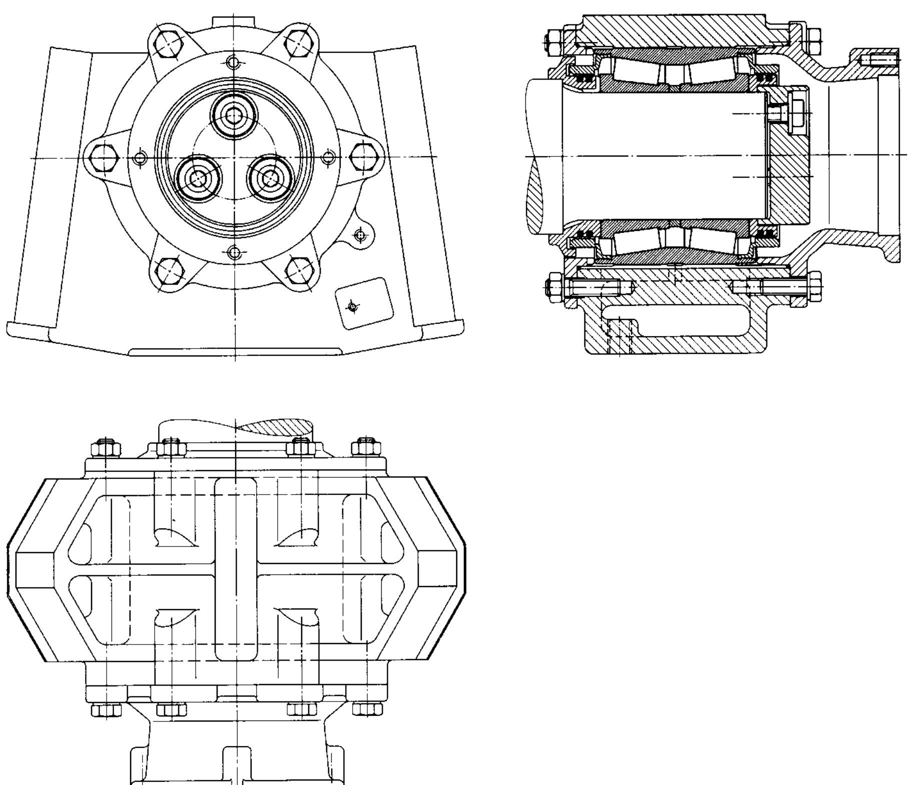
Prior to mounting, the *axial clearance* of the bearing unit TAROL 90 is 530 – 630 microns.

Machining tolerances

The bearing cones carry *circumferential load* and are therefore given a tight *fit:* journal n6.

Lubrication, sealing

Lubrication is with a lithium soap base *grease.* The TAROL 90 is sealed at both ends with lamellar rings. The backing ring also has a collar which forms a gap-type seal with the lid on the wheel side.



49: Axle box roller bearings for a city train

50 Axle box roller bearings according to AAR standard*) and modified types

The FAG TAROL unit according to AAR standards is a compact bearing unit with a double row tapered roller bearing as the main component. *Seals* at both sides of the bearing, accessories and the *grease* filling make the FAG TAROL a ready-to-mount unit. Neither is the *adjustment* of the bearing clearance required. The so-called NFL design (no field lubrication) is considered standard today. These TAROL units are no longer relubricated during operation. The bearing grease is only renewed during a main inspection.

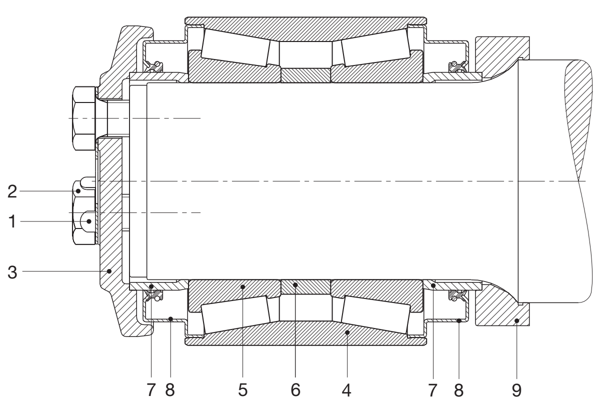
TAROL units do not have to be mounted into a housing. An adapter is attached between the TAROL unit and the bogie frame to transmit the loads and support the bearing cup on the loaded part of the circumference.

FAG supply NARROW and WIDE adapters according to the AAR standards as well as special adapters designed for the particular cases of application.

AAR has stipulated the admissible loads for the various sizes of TAROL units.

Components of the FAG tapered roller bearing unit TAROL

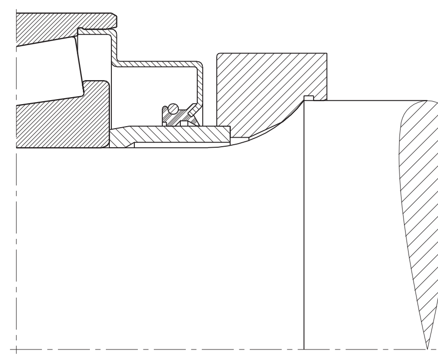
1 Locking plate
2 Cap screw
3 End cap
4 Bearing cup
5 Bearing cone with roller set
6 Spacer
7 Seal wear ring
8 Seal
9 Backing ring



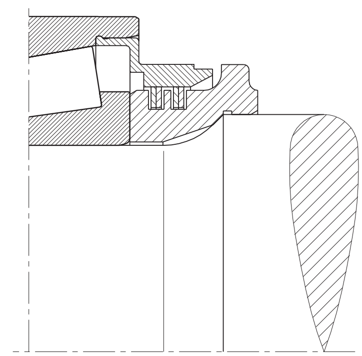
50: TAROL units
with a double-row tapered roller bearing

*) Association of American Railroads

FAG use two types of *seals:* the rubbing radial shaft seal (fig. a) corresponds to the design used by AAR. The non-rubbing lamellar *seal* ring (fig. b) was developed by FAG and tested and approved by AAR.

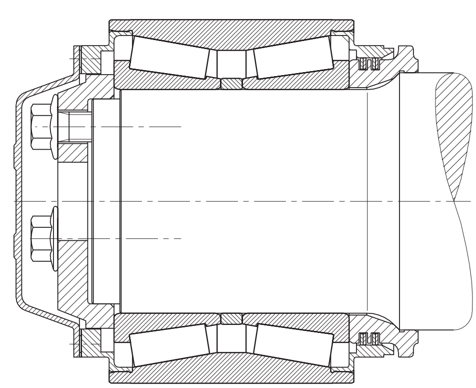


a: Rubbing radial shaft seal



b: Non-rubbing lamellar seal

FAG also supply TAROL units in metric dimensions. They (fig. c) have narrower tapered roller bearings and smaller *sealing* and retaining components than the AAR design. The relevant journals are also shorter resulting in lower bending stresses with the same shaft diameter than in the case of the AAR arrangement. Higher wheel loads are therefore admissible.



c: TAROL units in metric dimensions and with short journal (SK design)

51 Kiln trucks for sand lime brick works

Operating conditions

In sand lime brick autoclaves the wheelset bearings of the kiln trucks are exposed for many hours to hot steam of approximately 200 °C at 16 to 22 bars. Due to corrosion hazard the bearing location should be protected against penetration of the steam which is strongly alkaline.

Bearings

Sealing requires major attention when designing the bearing arrangement. The best solution is the use of pulverized *synthetic* FAG sealing agent and solid lubricant *Arcanol* DF. This lubricant is suitable for temperatures ranging between –200 °C and +300 °C and resists almost any chemical even at high temperatures. It is non-ageing and water repellent. The powder is packed into the bearing location penetrating into all cavities of the arrangement and forming a lubricating film between balls and raceways, balls and *cage* and also between outer ring and housing bore. The film in the housing bore ensures easy bearing displaceability, even after prolonged operation. This protects the bearing against detrimental axial preload.
In addition to lubrication *Arcanol* DF also acts as a sealing agent. It settles in the sealing gaps of the axle passage and protects the inside of the bearings against the ingress of alkaline condensate.

The bearings are designed for a truck with two wheelsets accommodating a total weight F_r of 43 kN.
The bearing load for each bearing is relatively low at $F_r/4$ allowing the use of inexpensive FAG 6208.R200.250.S1 deep groove ball bearings.
Considering the high operating temperatures the bearings have a particularly large *radial clearance* (200...250 or 250...350 microns), are heat-treated according to S1 (200 °C) and are dimensionally stable.

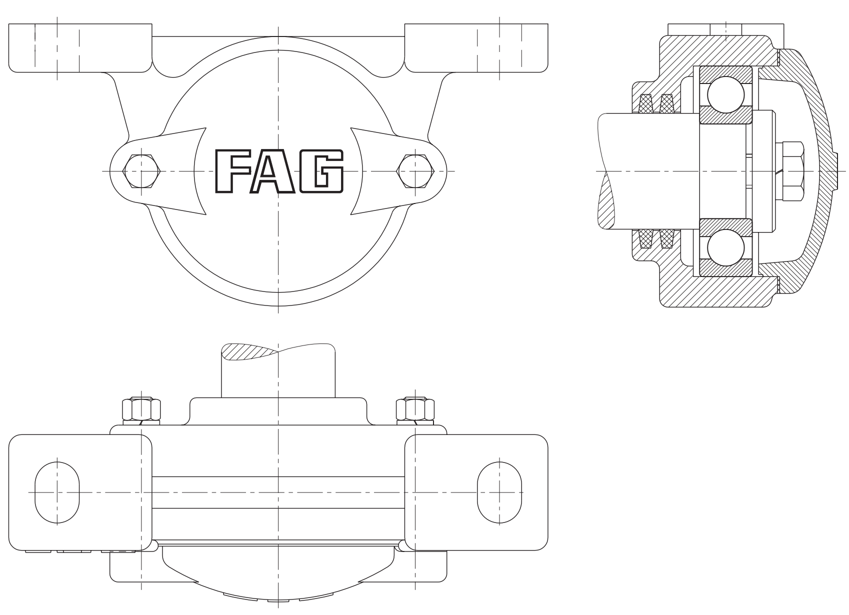
The bearings of the kiln trucks are mounted on the shaft as far as its shoulder by means of a punching cap and fastened securely with a shaft end washer and screw. They have a loose *fit* in the housing bore of the FAG series housing SUB6208. Two bolts attach the housings to the frame of the trucks. Strips inserted between housing and frame compensate for any differences in height due to warping of the truck frame.

Machining tolerances

Shaft: bearing seat j6.
Housing: the diameter of bearing seat is between 0.5 mm and 0.8 mm larger than the bearing O.D.

Sealing

Heat-resistant aramide stuffing box packings seal the bearing area at the axle passage. The cover flange is also provided with a heat-resistant *seal.*



51: Kiln trucks for sand lime brick works

52 Universal quill drive for threephase current locomotives of series 120

All four wheelsets of series 120's threephase current locomotives are driven. The traction motor arranged transversely to the direction of travel is connected to the bogie at three points. The torque of the traction motor acts via pinion and bullgear on a universal quill drive which is linked to the bullgear and driving wheel by the articulated lever coupling. The driving wheel transmits the tractive force to the rails.

Operating data

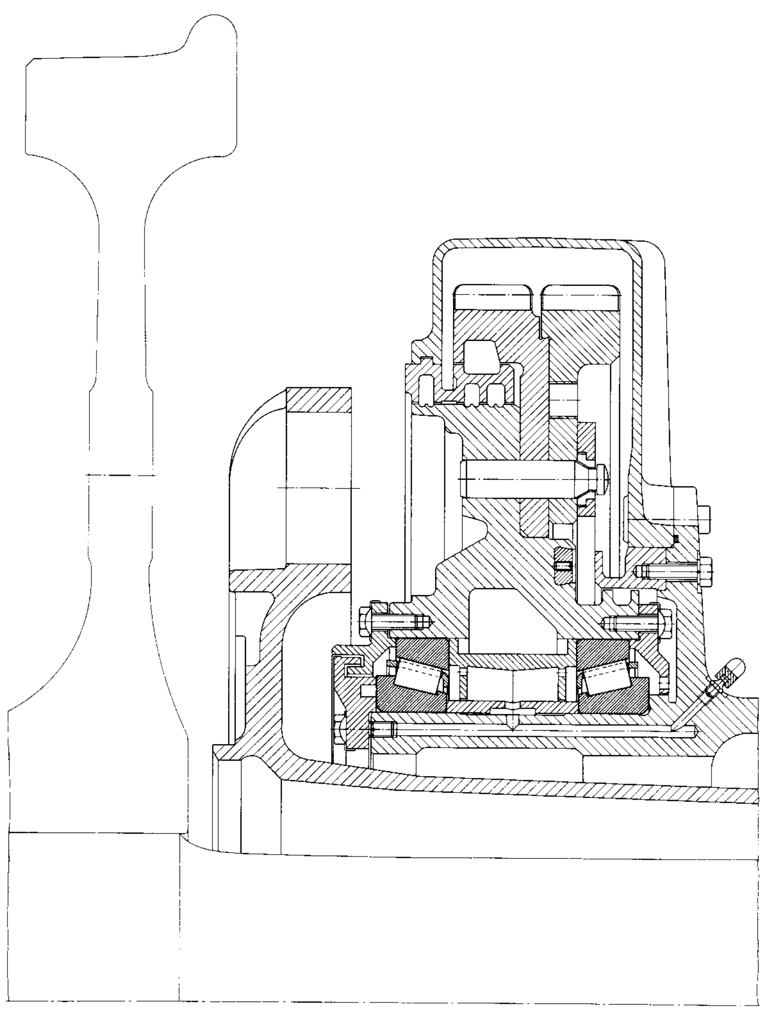
Top speed: 200 km/h; number of motors: 4; nominal power per motor: 1,400 kW; motor speed: max. 4,300 min^{-1}.

Bearing selection

The bullgear is supported on the universal quill drive in two tapered roller bearings FAG 534052 (dimensions: 381.03 x 479.475 x 49.213 mm) which are mounted in *O arrangement.* Even with a small bearing distance there is a relatively large *spread* and as a result tilting rigidity is high.
The quill drive housing is stationary. The cones, which carry *point load,* have a loose *fit.* The cups carry *circumferential load* and have therefore a tight *fit* in the rotating bullgear.
The *axial clearance* of the bearing pair depends on the machining tolerances of the bearing seats and the operating conditions. With inner and outer spacer sleeves bearing *adjustment* is not necessary when mounting.

Lubrication

During mounting the bearings and the space between the webs of the outer spacer sleeves are completely filled with a lithium soap base *grease* of the *NLGI class* 2. They are relubricated after every 150,000 km. The *grease* is fed through the holes of the sleeve's web.



52: Bullgear bearing arrangement for a universal quill drive

53 Suspension bearing arrangement for electric goods train locomotive

The torque of the traction motor is transmitted to the wheelset axle via pinion and bullgear. The traction motor arranged transversely to the direction of travel is supported directly on the wheelset axle in two bearing locations. The reaction torque is taken up by another support point at the bogie frame.

Operating data

Six driven wheelsets, power per traction motor: 500 kW. Max. speed: 100 km/h.

Bearing selection, dimensioning

For a suspension bearing to have a long *service life* (*nominal life* over 2 million kilometres) roller bearings with a high load carrying capacity are selected. A medium drive torque and a medium speed are taken as a basis for dimensioning. The *index of dynamic stressing* f_L should be 3.5 at least. Usually it is well above it.

Two FAG tapered roller bearings are mounted their dimensions being 230.188 x 317.5 x 47.625 mm and 231.775 x 336.55 x 65.088 mm. They are abundantly dimensioned because of the large shaft diameter. High loads due to vibrations and shocks are accommodated by special tapered roller bearings with reinforced *pressed cage* (reduced number of rollers).

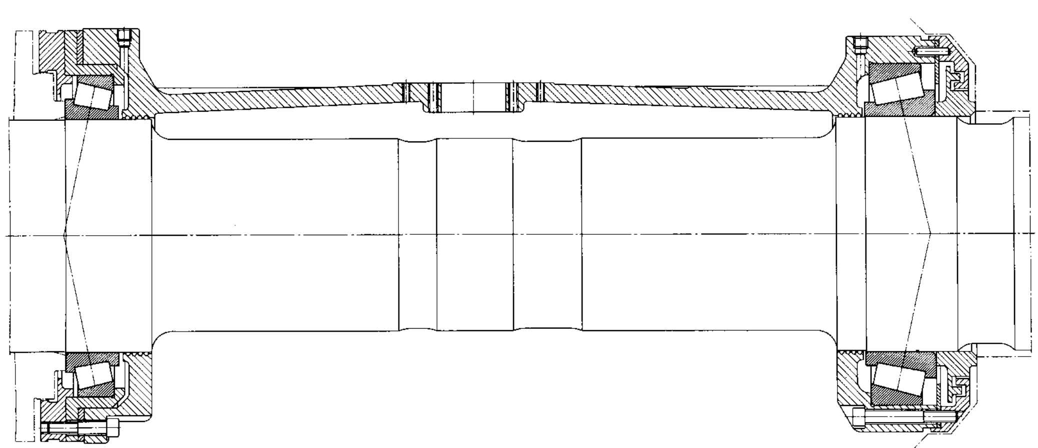
Both tapered roller bearings are mounted in *O arrangement* with little *axial clearance* (0.2...0.3 mm). When the shaft has a maximum load the cups and cones are tilted by up to 3' against each other. The profile of the tapered rollers or raceways are modified (slightly crowned) in order to avoid edge stressing.

Machining tolerances

The cups have *circumferential load* and an interference *fit* on the shaft. The cup or the angle sleeve in the housing is given a tight *fit* (perhaps a drive seat).

Lubrication, sealing

The suspension bearings are lubricated with a lithium soap base *grease* of *penetration* class 3 with anti-corrosion *additives.* Baffle plates hold the grease at the bearing (grease storage).
The *relubrication interval* is about 200,000 to 300,000 km depending on the type of operation. Labyrinth gap-type *seals* protect the bearing from contaminants.



53: Suspension bearing arrangement for electric goods train locomotive

54 Spur gear transmission for the underground or subway

The drive of modern suburban vehicles should provide for a high degree of travel comfort, low noise, and be economical at the same time. These requirements are fulfilled by a new compact drive package which is completely supported on springs in the bogie.

Operating data

Two step parallel shaft drive, helical/double helical gearing. Drive speed (input shaft) n_{max} = 5,860 min^{-1}, step-up i = 11.025.

The drive motor is flanged on to the transmission. A universal joint coupling transmits the torque directly to the wheelset from the transmission. The gearbox case, which is split at axis height, is made of high-strength cast aluminium. This is 25 % lighter than spheroidal graphite cast iron.

Bearing selection

Input shaft

The rotor of the drive motor is firmly attached to the input shaft of the transmission. An elastic coupling which can be subject to bending, avoids constraining forces in the shaft line which is supported in three positions by a *locating-floating bearing arrangement.* The *floating bearing* in the motor is a cylindrical roller bearing FAG NU212E (not illustrated). A second *floating bearing,* a cylindrical roller bearing FAG NJ215E, is at the motor end of the input shaft. The *locating bearing* arrangement of the input shaft is an angular contact ball bearing pair FAG 7215B.UA70 in *X arrangement.* Both angular contact ball bearings are fitted in an angle sleeve made of steel. Therefore different heat expansion coefficients of steel and light metal cannot have a direct effect on the bearings.
The bearings accommodate high speeds with a close axial guidance at the same time. This means tight *fits* for the bearing rings on the shaft and in the bore of the angle sleeve. The demand for a sufficient axial *operating clearance* in addition to the tight *fit* is met with angular contact ball bearings in *universal design.* The *axial clearance* of the bearing pair prior to mounting is 70 microns.

Intermediate shaft

A spherical roller bearing FAG 22218E is mounted as the *locating bearing* of the intermediate shaft. Its outer ring is in a steel angle sleeve. The spherical roller bearing accommodates chiefly axial forces from the gearing. The *floating bearing,* a cylindrical roller bearing FAG NJ2216E.C3, is directly in the light-metal housing with the outer ring. The very tight *fit* in the housing necessitates a bearing with increased *radial clearance* (C3).

Output shaft

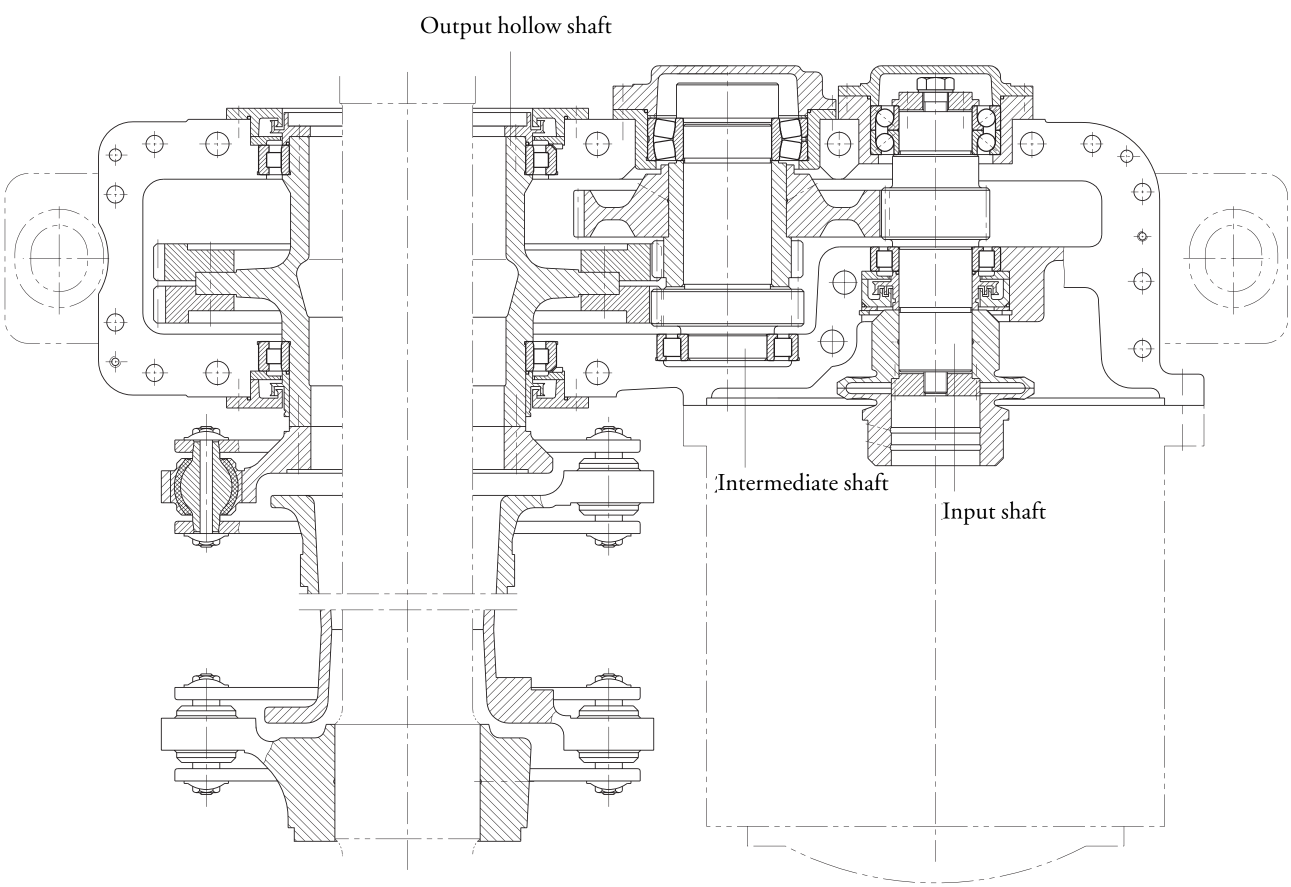
The output shaft whose large spur gear has a double helical gearing, is axially guided by the spherical roller bearing of the intermediate shaft. The *floating bearing arrangement* with two cylindrical roller bearings FAG NUZ1848 is therefore sufficient for the output shaft. The NUZ design with an extended inner ring raceway allows a large axial displacement of the hollow shaft.

Machining tolerances

Angular contact ball bearing pair	Shaft k5; pair housing K6
Spherical roller bearing	Shaft m5; housing K6
Cylindrical roller bearing/ intermediate shaft	Shaft m5; housing N6
Cylindrical roller bearing/ output shaft	Shaft n5; housing N6...P6

Lubrication

All the bearings of the transmission are lubricated by the *oil* circuit of the gearings.



54: Spur gear transmission for the underground or subway

55 Bevel gear transmission for city trains

With a so-called two-axled longitudinal drive in underground and metropolitan vehicles the traction motor (usually direct current motor) is arranged in the bogie in the direction of travel. A bevel gear transmission is flanged onto both sides of the motor's face. The drive unit firmly attached to the bogie frame is elastically supported by the wheel sets. The drive power is transmitted from the pinion shaft to the hollow ring gear shaft and then via rubber couplings to the driving wheel shaft. This drive design leads to good running behaviour and moderate stressing for the traction motor, transmission and track superstructure.

Machining tolerances

Cylindrical roller bearing:	Shaft m6, housing M6
Tapered roller bearing/ motor end:	Shaft m6, sleeve M6
Tapered roller bearing with mantle ring:	Shaft m6, ring R6 (S7)
Tapered roller bearing of ring gear shaft:	Shaft n6 – p6 housing K6 – M6

The *axial clearance* of the tapered roller bearing pair depends on gearing and the operating conditions.

Dimensioning, bearing selection

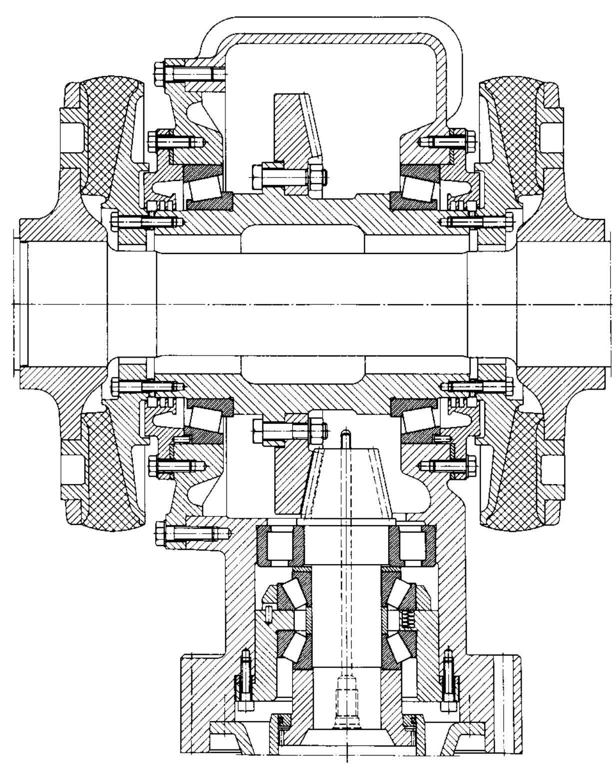
Mean torques and speeds (hourly torque, hourly speed) are calculated from the tractive force – surface speed diagram and the time shares for the various running conditions. By means of the gearing data the tooth loads of the hypoid bevel gear step are calculated and, depending on the lever arms, are distributed to the bearing locations.
A *life* of 20,000 to 30,000 hours is assumed for bearing dimensioning. Assuming an average travel speed this corresponds to 1.2 – 1.3 million kilometers.
To check the static safety of the bearings the maximum torque (slippage torque) is taken as a basis.

Pinion shaft
A single-row cylindrical roller bearing FAG NJ2224E.M1A.C3 (120 x 215 x 58 mm) is mounted as a *floating bearing* at the pinion end. It accommodates the high radial loads. The *machined cage* of the bearing is guided at the outer ring. The bearing has the increased *radial clearance* C3 since the bearing rings have a tight *fit* on the shaft and in the housing. Two tapered roller bearings FAG 31316 (80 x 170 x 42.5 mm) are used as *locating bearings.* They are mounted in pairs in *O arrangement.* The bearing at the motor end accommodates the radial loads as well as the axial loads from the gearing; the other tapered roller bearing only accommodates the axial loads arising during a change in direction of rotation. A minimum bearing load is a requirement in order to avoid harmful sliding motion (slippage) and premature *wear.* The cups of the tapered roller bearings are therefore preloaded with springs.

Ring gear shaft
There is a tapered roller bearing with the dimensions 210 x 300 x 54.5 mm at each side of the ring gear. Both bearings are *adjusted* in *X arrangement.*

Lubrication

Oil sump lubrication provides the transmission bearings with lubricant. The flinger oil is conveyed via the ring gear from the oil sump and fed directly to the transmission bearings via oil collecting bowls and supply ducts. The special driving conditions for city trains demand highly doped *oils* which are resistant to heat and corrosion.

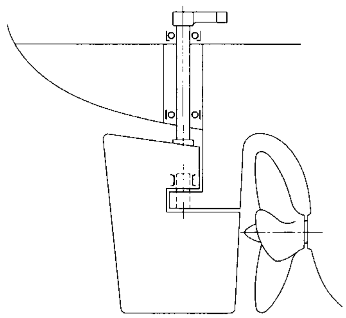


55: Bevel gear transmission for city trains

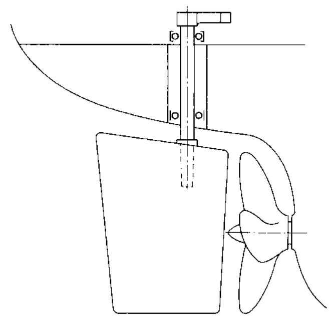
56–60 Rudder shafts

The rudders of ships make slow intermittent slewing motions. The maximum slewing angle is about 35° to both sides. The rudder shaft bearings accommodate the radial and axial loads arising from the rudder and the steering engine. The bearings are also subjected to the vibrations created by the propeller jet. There are numerous types of rudders the most common of which are illustrated in figs. a to c.

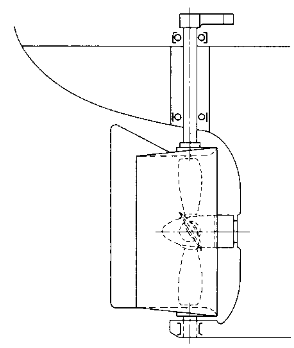
Rolling bearings are only used for the bearing positions of the rudders inside ships. They are not suitable for the bearing positions located outside the ship due to mounting difficulties and problems with *sealing* and lubricating. For such locations, plain bearings made of stainless steel, bronze, plastic etc. are used and water or a mixture of *grease* and water is used for lubrication.



a) Semi-spade rudder



b) Spade-type rudder



c) Steering nozzle

56–57 Spherical roller bearings as rudder shaft bearings

Operating data

Axial load 115 kN (weight of rudder and shaft), radial load 350 kN (driving force of steering engine and rudder).

Bearing selection, dimensioning

Due to the heavy loads and unavoidable misalignment spherical roller bearings are used. They have a high load carrying capacity and are *self-aligning.* The rudder shaft diameter depends on size and speed of the ship as well as on the type and size of the rudder used. The bearing bore and the size of the bearing are determined by the shaft diameter specified. A spherical roller bearing FAG 23052K.MB.R40.90 or FAG 23052K.MB.C2 (*radial clearance* 150...220 microns) is mounted. During mounting the bearing inner ring is pressed onto the tapered shaft seat so that the bearing operates under a light preload. Vibrations can thus be adequately accommodated. The hydraulic method facilitates dismounting particularly in the case of bearings with C2 bearing clearance. For this purpose the shaft must have oil ducts and the tapered seat a circular groove.

The housings of rudder shaft bearings FAG RS3052KS.1..... or FAG RS3052KW.1..... are made of welded shipbuilding steel plates.

The static safety of a rudder shaft bearing is checked because of the few slewing motions. An *index of static stressing* f_s between 4 and 5 is suitable for spherical roller bearings.

Machining tolerances

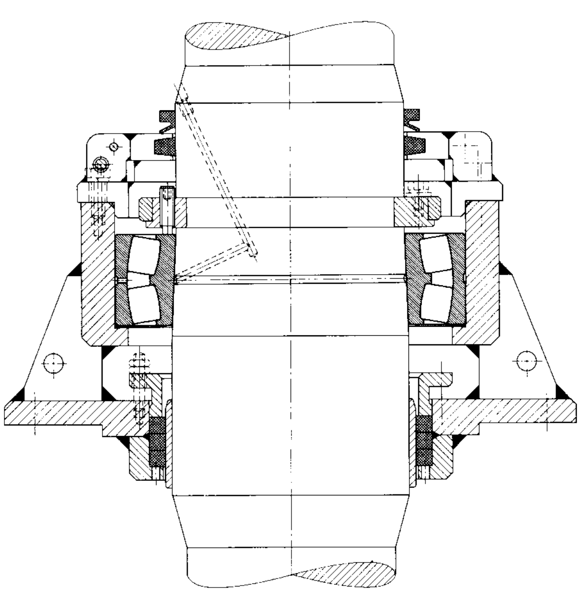
Shaft taper 1 : 12, housing H7.

Lubrication, sealing

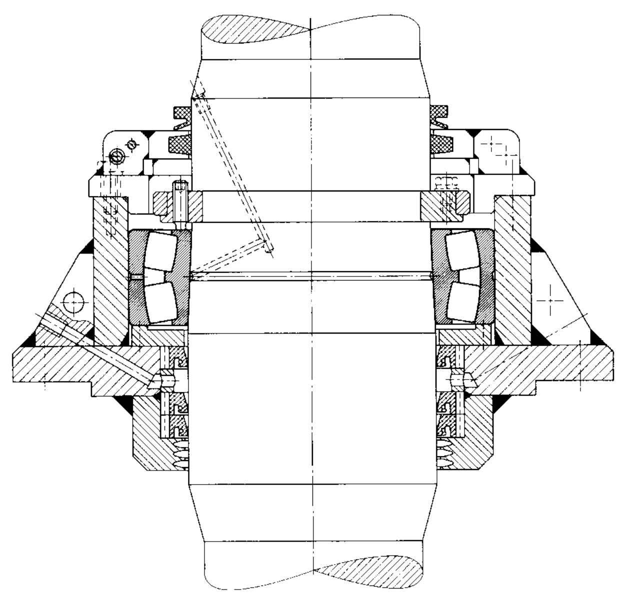
During mounting, the cavities of the spherical roller bearings and housings are completely filled with lithium soap base *grease* of *consistency* number 2 which contains *EP additives.*

Rudder shaft bearing FAG RS3052KS.1.....
The bearing is *grease* lubricated. It sits in the pot-like housing which is attached to the housing base plate by sturdy webs. A stuffing box *seal* is mounted in this base plate. Its packing runs on a sleeve of seawater-resistant steel.
Due to the separation between the upper half and the base any spray water which could penetrate runs along the side and does not get into the rolling bearing. The stuffing box can be inspected at any time during operation and if necessary readjusted. The bottom end of the bearing is provided with a spring seal. A felt seal and V ring suffice for *sealing* at the top end. This bearing arrangement with stuffing box *seal* is maintenance-free.

Rudder shaft bearing FAG RS3052KW.1.....
Bearing and seal are in one and the same housing and are lubricated with *grease.* The bearing arrangement can also be below the waterline. *Sealing* consists of three seawater-proof shaft sealing rings with an intermediate *grease* chamber. An automatic grease pump holds the latter under permanent pressure.



56: Rudder shaft bearing FAG RS3052KS.1.....



57: Rudder shaft bearing FAG RS3052KW.1.....

58–59 Spherical roller thrust bearings as rudder carriers

Spherical roller thrust bearings are used when the top bearing mainly has to take up the weight of the rudder and shaft. This is the case for all rudder drives not loaded by lateral forces, such as for rotary vane steering gears and four-cylinder engines, which do not operate spade-type rudders.
The two designs, N and W, for rudder carriers, differ only in their *sealing.*

Bearing selection, dimensioning

The shaft diameter is determined according to formulae of the Classification Societies. Thus the bore diameter of the rolling bearing is fixed. Due to the high axial load carrying capacity a spherical roller thrust bearing FAG 29284E.MB with the dimensions 420 x 580 x 95 mm is mounted directly on the shaft. The bearing's *index of static stressing* $f_s \geq 10$.

The welded housings are extraordinarily flat – they protrude just slightly beyond the deck or mounting base. This provides advantages especially for larger steering engines, since the rudder shaft extension can be kept short due to the low mounting and dismounting height.

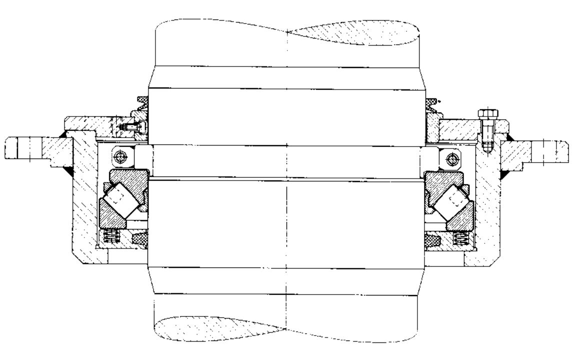
Powerful springs under the bearing outer ring provide a permanent positive contact of rollers and raceways. The supplementary plain bearing also accommodates radial forces, if for example a cylinder in a four-cylinder steering engine fails.

Machining tolerances

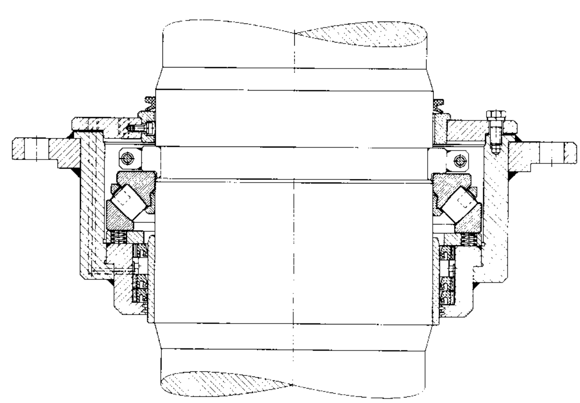
Shaft h7. The housing is relief turned to ensure axial spring preload via the housing washer.

Lubrication, sealing

During mounting, the cavities of the spherical roller thrust bearings and housings are completely filled with lithium soap base *grease (consistency* number 2 with *EP additives).* As with radial spherical roller rudder bearings, there are also two designs (N and W) in the case of rudder carrier bearings. Only the *seal* differs: FAG RS9284N.1..... rudder carrier bearings have felt seals, the rudder carrier bearings FAG RS9284W.1..... are sealed with seawater-proof shaft sealing rings. Both designs have a V-ring *seal* at the housing cover.



58: Rudder carrier bearing FAG RS9284N.1.....



59: Rudder carrier bearing FAG RS9284W.1.....

60 Spade-type rudder

Design

The slewing motion is accommodated by a top bearing and a bottom bearing. Both bearing locations are equipped with rolling bearings since they are inside the ship's hull. The top bearing or rudder carrier is designed as the *locating bearing* due to the locating ring between cover and bearing outer ring. The bottom bearing is the floating bearing. Spherical roller bearings are used at both locations and the bearing arrangement is therefore statically defined and not affected by misalignment of housing bores, warping of the ship's hull and rudder shaft deformation. Both spherical roller bearings are mounted on adapter sleeves which are mounted and dismounted by means of the hydraulic method. The relevant adapter sleeves (HG design) have connecting holes and grooves for the pressure oil.

Operating data

Top bearing:
Axial load 380 kN (weight of rudder and shaft).
Radial load 1,700 kN (load from rudder and steering engine).

Bottom bearing:
Radial load 4,500 kN (load from rudder and steering engine).

Bearing selection, dimensioning, sealing

Bearing selection is based on the specified shaft diameter and the given loads. Since the bearings only make slewing motions they are selected according to their static load carrying capacity. An *index of static stressing* $f_s \geq 4$ is a must.

The bottom spherical roller bearing, an FAG 230/750K.MB.R60.210 (or 230/750K.MB.C2), is located on an adapter sleeve FAG H30/750HG. Since this bearing is permanently below the waterline, special *sealing* must be provided for the shaft passage.

The radial *sealing* rings run on a sleeve made of seawater-resistant steel. The lips form a grease chamber permanently pressurized by an automatic grease pump. Some of the *grease* (lithium soap base grease of the *consistency* number 2 with *EP additives*) penetrates into the housing keeping the initial grease packing under constant pressure.

The *seal* above the bearing (shaft sealing ring and V ring) protects it against water which may either run down the shaft or collect in the rudder trunk.

The top spherical roller bearing, an FAG 23188K.MB.R50.130 (or 23188K.MB.C2), is mounted on the shaft with an adapter sleeve FAG H3188HG. The adapter sleeve is fixed axially; below by the shaft shoulder and above by a split holding ring which is bolted into a circular groove in the shaft. This upper bearing also takes up the weight from rudder and shaft as well as the radial loads. A shaft sealing ring is fitted at the upper and at the lower shaft diameter for *sealing* purposes. There is also a V ring at the upper shaft passage.

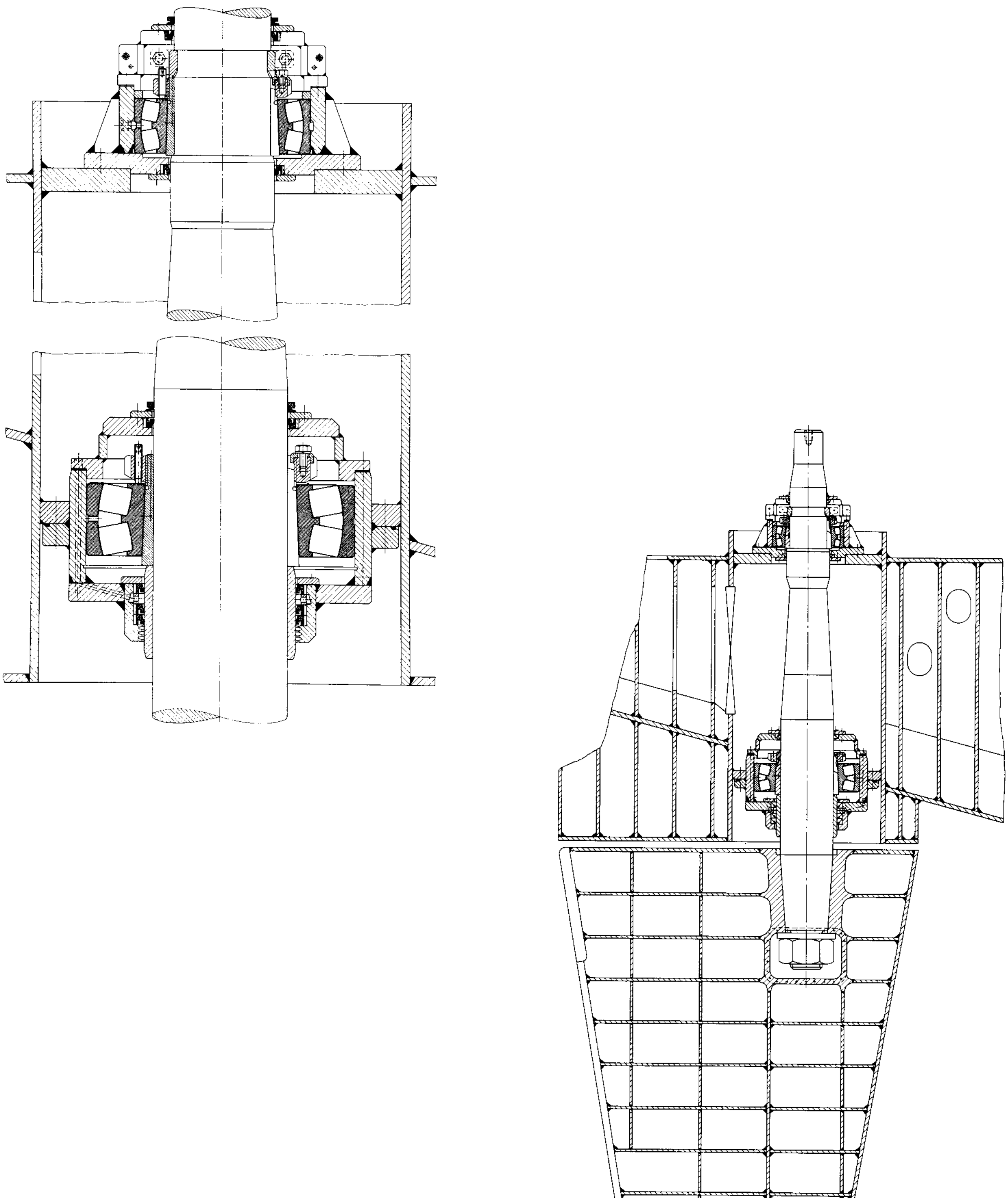
When relubricating with an automatic grease press, the initial *grease* filling is kept under pressure and the seal rings are lubricated at the same time.

Machining tolerances

Rudder shaft h8, cylindricity tolerance IT5/2 (DIN ISO 1101). Housing H7.

Bearing clearance

The bearings have a particularly small *radial clearance:* the lower bearing has 60 to 210 microns or 390 to 570 microns and the upper bearing has 50 to 130 microns or 230 to 330 microns. During mounting, the bearings are pressed onto the adapter sleeve so far that they obtain a preload of 20 to 30 microns. With these preloaded bearings vibrations are easily accommodated.



60: Spade-type rudder bearings

61–62 Ship shaft bearings and stern tube bearings

The propeller shaft of a ship is carried by so-called support bearings. Since length variations of the shaft are considerable, particularly with long shafts, the bearings must have axial freedom. The last part of the shaft supporting the propeller, runs in the so-called stern tube or tail shaft bearings.

Operating data

Shaft diameter 560 mm; nominal speed of propeller shaft 105 min^{-1}.
Radial load from shaft and coupling 62 kN, no axial load – the propeller thrust is taken up by the propeller thrust block (figs. 63 and 64). With a supplementary factor of 100 % on the radial load (f_z = 2), shocks or other dynamic forces are sufficiently taken into consideration when determining the bearing stress.

Bearing selection, dimensioning, sealing

Since the diameter of the ship shaft is specified, the bearings are overdimensioned for the loads to be accommodated. Thus the *index of dynamic stressing* f_L ranges from 4 to 6 and therefore a high *nominal life* (L_h) is obtained. With very good cleanliness in the lubricating gap, *endurance strength* is reached in the *adjusted life calculation* (L_{hna}) for ship shaft and stern tube bearings.

A spherical roller bearing FAG 239/600BK.MB (dimensions 600 x 800 x 150 mm, *dynamic load rating* C = 3,450 kN) is used as ship shaft bearing. By means of the hydraulic method the bearing is attached to the shaft with an adapter sleeve FAG H39/600HG and is located in a plummer block housing FAG SUC39/600H.1..... (fig. 61a). The housing is made of grey cast iron GG-25 and consists of a unsplit housing body with two split covers.

The housing's *sealing* is provided for by the radial shaft sealing rings in the cover. For small quantities, welded housings are generally more economical than cast housings. Fig. 61b is an alternative ship shaft bearing arrangement made up of a spherical roller bearing FAG 23048K.MB with adapter sleeve H3048 and a split plummer block housing S3048KBL.1..... (material GG-25).

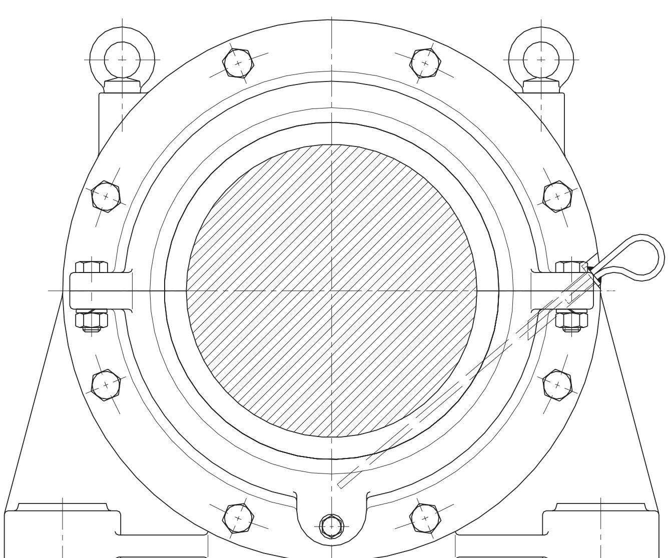
The ship shaft is surrounded by the stern tube at the stern. Fig. 62 shows a stern tube bearing arrangement, both bearings are designed as *floating bearings.* The tail bearing is also loaded by propeller weight and wave action. Spherical roller bearings are applied here also whose inner rings, with adapter sleeves, are attached to the shaft. A special stern tube *sealing* protects the bearings from seawater.

Machining tolerances

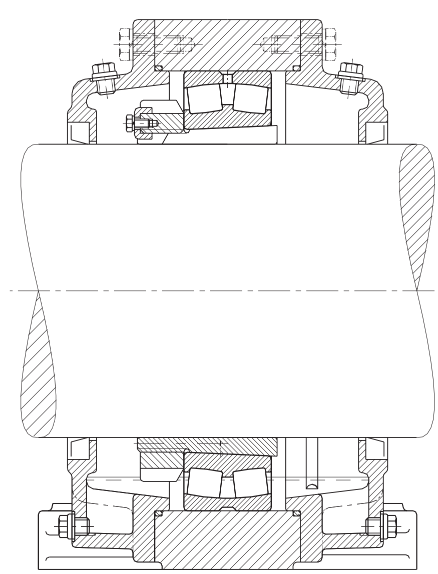
The inner rings carry *circumferential load.*
Adapter sleeve seat on the shaft h8. Cylindricity tolerance IT5/2 (DIN ISO 1101); housing bore H7.
Flanged housings are used for the tail shaft bearings.

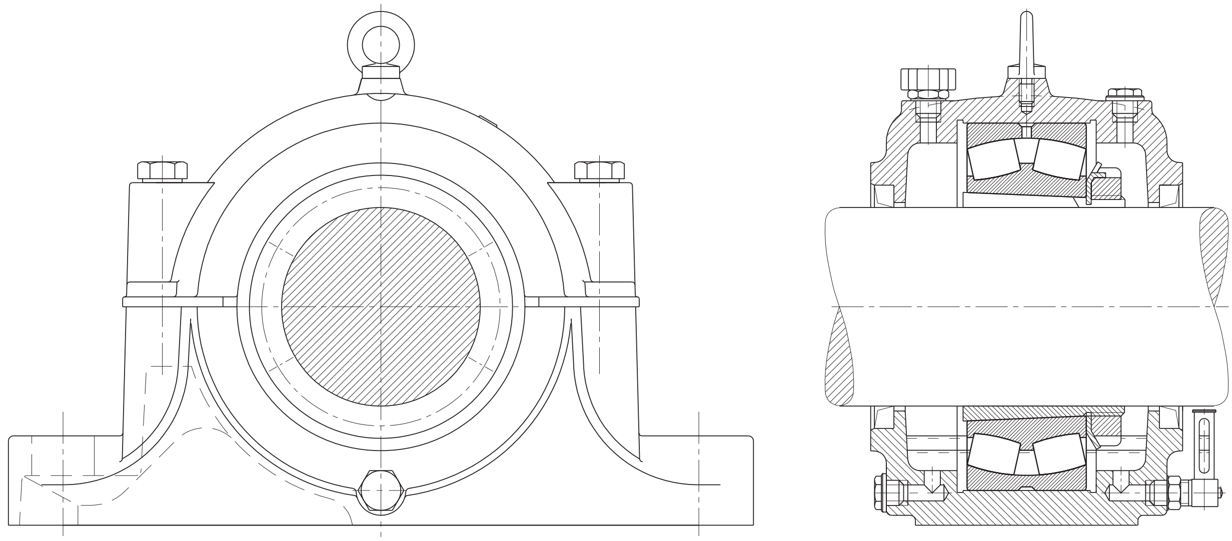
Lubrication

The bearings are lubricated with a non-aging *oil* with *EP additives* (*viscosity* 150 to 300 mm^2/s at 40°C). The lower parts of the support bearing housings have viewing glasses or oil dip sticks on which the permissible maximum and minimum oil levels are marked. The stern tube is filled with *oil.* The oil pressure is kept a little higher than that of the surrounding water.

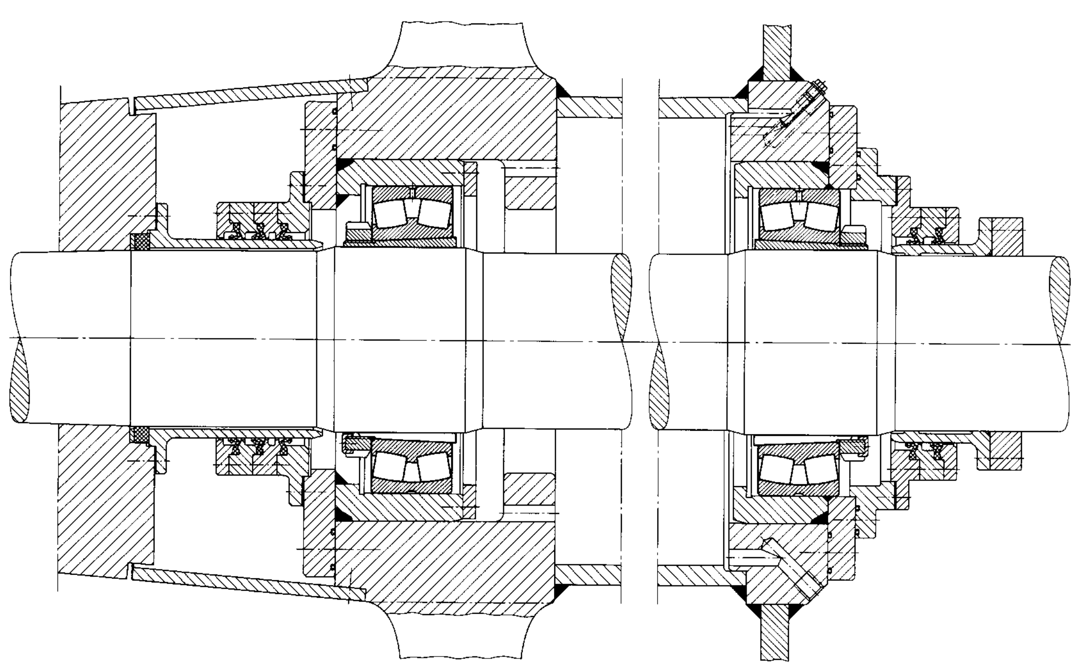


61a: Ship shaft bearing; spherical roller bearing in SUC housing





61b: Ship shaft bearing. Spherical roller bearing in S30.K housing



62: Stern tube or tail shaft bearing arrangement

63–64 Ship shaft thrust blocks

The thrust block is located directly behind a ship's engine. It transmits the propeller thrust to the ship. Apart from a small radial load from the shaft weight the bearing is loaded by a purely concentric thrust load. Depending on the direction of rotation of the propeller, it acts either forward or backward. During sternway the thrust load is lower and usually occurs only seldom. Three bearing arrangements are commonly used for these requirements:

Fig. 63a illustrates a thrust block arrangement with two spherical roller thrust bearings for small shaft diameters in a SGA plummer block housing.

Fig. 63b illustrates a thrust block arrangement with two spherical roller thrust bearings and one radial spherical roller bearing in an FKA flanged housing.

Both bearing arrangements are used when the axial load carrying capacity of a radial spherical roller bearing is insufficient when sternway is very frequent. The spherical roller thrust bearings accommodate the propeller thrust during forward motion and the propeller pull during sternway. In 63a the *thrust bearings* accommodate the weight also while in 63b the weight of shaft and propeller is supported by a radial spherical roller bearing.

Fig. 64 shows ship shaft thrust blocks each with a spherical roller thrust bearing and a radial spherical roller bearing:
a: – in SGA housing, b: – in SUB housing

The curvature centres of the outer ring raceways of the radial and axial bearings coincide. The bearings are therefore *self-aligning* and thus misalignment and bending of the shaft and hull are compensated for. In these thrust blocks only the propeller thrust is accommodated by the spherical roller thrust bearing during forward motion. The radial spherical roller bearing transmits the weight of the shaft and the propeller pull during sternway. The spherical roller thrust bearing not under stress is preloaded by springs so that it does not lift during sternway. A constant axial minimum load is thus ensured.

Machining tolerances

Fig. 63a:
Spherical roller thrust bearing Shaft m6; housing H7
Fig. 63b:
Spherical roller thrust bearing Shaft n6; housing relief turned
Radial spherical roller bearing Shaft n6; housing F7
Fig. 64a, 64b:
Spherical roller thrust bearing Shaft m6; housing relief turned
Radial spherical roller bearing Shaft m6; housing H7

Dimensioning of bearings

The diameter of the thrust block shaft is determined according to the guidelines of the Classification Societies. Taking the power output into account the *nominal life* L_h [h] and the resulting *index of dynamic stressing* f_L are calculated. An f_L value of 3 – 4 is recommended for the rolling bearings in ship shaft thrust blocks. Particularly with utmost cleanliness in the lubricating gap, ship shaft thrust blocks reach *endurance strength* according to the *adjusted life calculation.*

Design

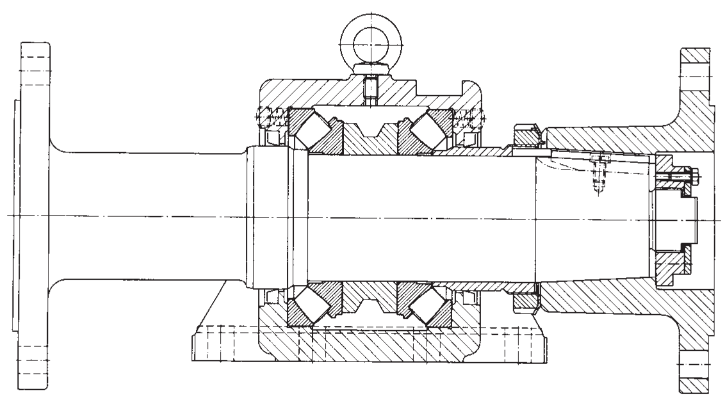
Ship shaft thrust blocks are supplied as complete units FAG BEHT.DRL. The unit includes bearings, housing with *sealing* and thrust block shaft with loose flange. The FAG thrust block housings are supplied either in split design SGA (figs. 63a and 64a) or in unsplit design FKA (fig. 63b) or SUB (fig. 64b).

Order example for unit
FAG BEHT:GRL:110.156680, consisting of:
1 Plummer block housing FAG SGA9322.156678
1 Thrust block shaft with loose flange
FAG DRW110 x 610.156678
2 Spherical roller thrust bearings FAG 29322E
1 Locknut FAG KM26
1 Lock washer FAG MB26
Oil lubrication

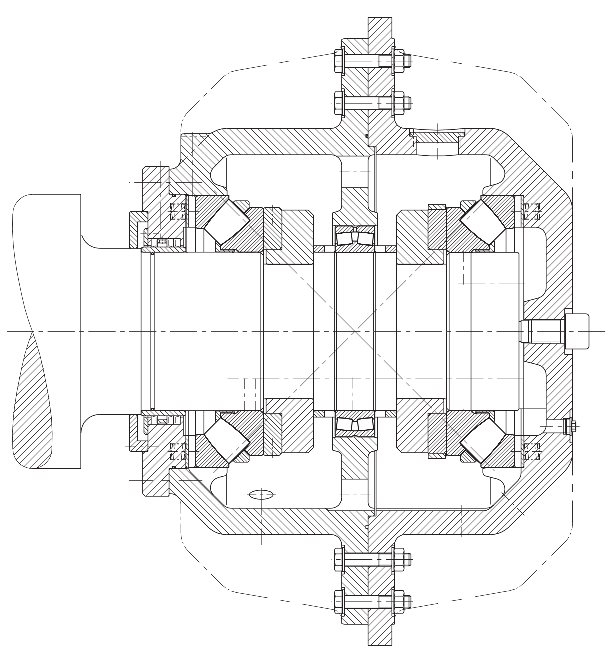
Operating data

	63a: Ship shaft thrust block FAG BEHT.DRL110.1..... with 2 spherical roller thrust bearings	63b: Ship shaft thrust block housing FAG FKA94/600.1 2 spherical roller thrust bearings 1 radial spherical roller bearing	64a, b: Ship shaft thrust block FAG BEHT.DRL.200.1..... with 1 spherical roller thrust bearing 1 radial spherical roller bearing
Diameter of thrust block shaft	110 mm	600/510 mm	200 mm
Power	320 kW	11,400 kW	1,470 kW
Speed	800 min^{-1}	150 min^{-1}	500 min^{-1}
Thrust	55 kN	1,625 kN	170 kN
Forward motion	50 %	50 %	95 %
Sternway	50 %	50 %	5 %
Bearings mounted	**2 x FAG 29322E**	**1 x FAG 239/600B.MB.C3** **2 x FAG 294/600E.MB**	**1 x FAG 23140B.MB** **2 x 29340E**
Lubrication	*Oil* sump lubrication[1])	*Oil* sump lubrication[1])	*Oil* sump lubrication[1])
Sealing	Shaft sealing rings	Shaft sealing rings	Shaft sealing rings

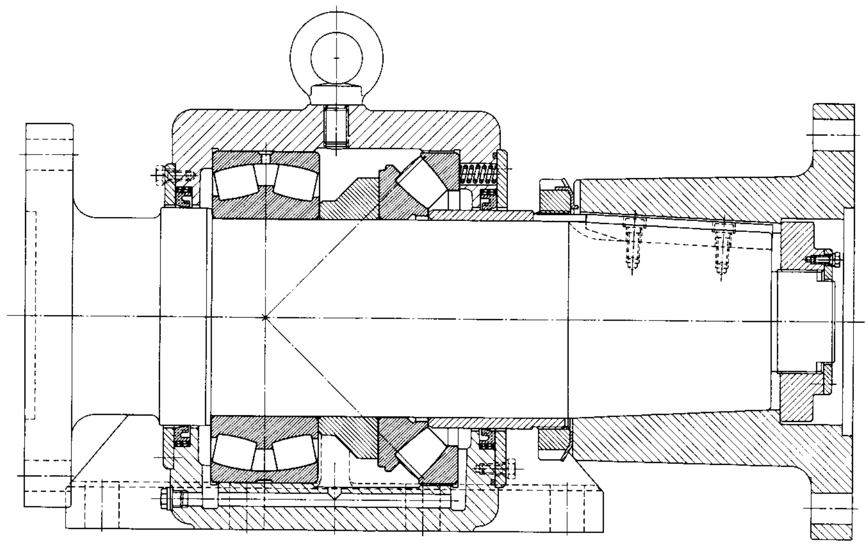
[1]) Non-aging *oil* with pressure *additives* (*viscosity* 150 to 300 mm^2/s at 40°C)



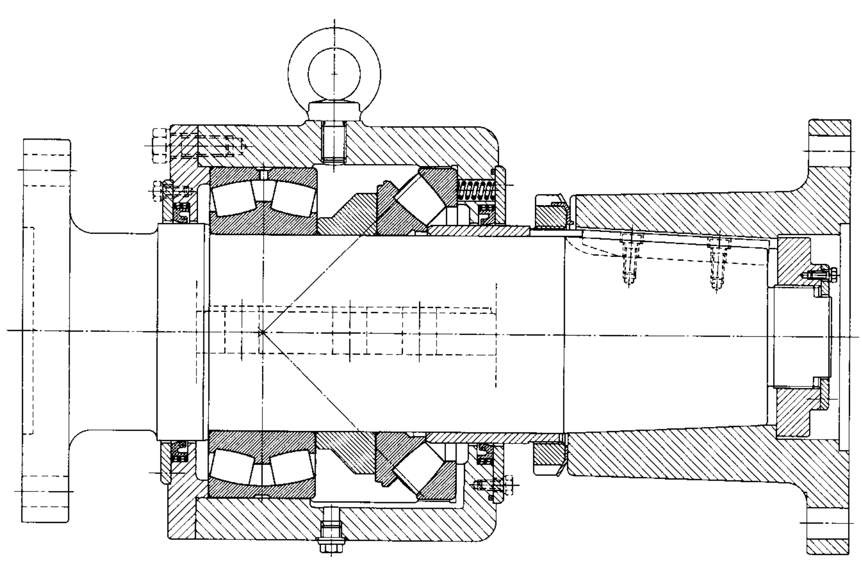
63a: Complete ship shaft thrust block FAG BEHT.DRL.110.1..... (SGA plummer block housing)



63b: Ship shaft thrust block with FKA flanged housing



64a: Complete ship shaft thrust block FAG BEHT.DRL.200.1..... (SGA plummer block housing)



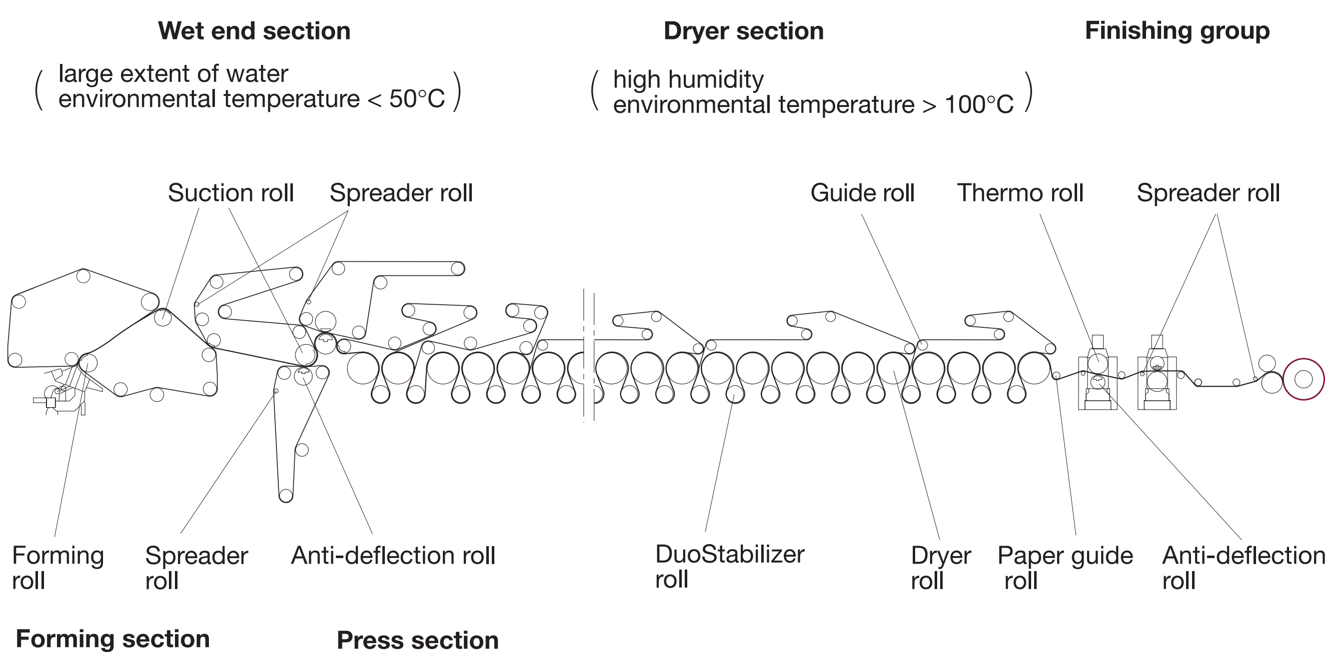
64b: Complete ship shaft thrust block FAG BEHT.DRL.200.1..... (SUB pot-shaped housing)

65–72 Paper Machines

Modern paper machines are extensive plants which frequently stretch well beyond 100 m in length and have numerous rolls. The demand for utmost operational reliability is priority number one when designing and dimensioning bearing locations: if trouble arises at just one roll the whole plant has to be shut down. For this reason the bearings are designed for a far longer *nominal life* (*index of dynamic stressing* f_L = 5...6) than in other industrial equipment. A high degree of cleanliness in the bearings is decisive for a long *service life.* This demands utmost *sealing* reliability, particularly against moisture, and design diversity based on the type of roll in question.

Lubrication also influences the *bearing life* greatly. All roll bearings in modern paper machines are connected to an *oil* circulation system for operational reliability and maintenance purposes. The bearings in the wet end section of older paper machines are still lubricated with *grease* (lower environmental temperatures).

In the dryer section, bearings for rope sheaves, spreader rolls and sometimes guide rolls are still lubricated with *grease.*
Due to high temperatures in the area of the dryer roll, bearing lubrication is particularly critical. Therefore *oils* of the *viscosity class* ISO VG 220 or 320 are used. Lightly doped *mineral oils* and *synthetic oils* are suitable (high ageing stability), which correspond to the requirements for dryer roll oils and have proven themselves in the field or successfully stood dynamic testing on the FAG test rig FE8.
Lubrication can be improved considerably (increasing the *operating viscosity*) by insulating the hollow journals of the dryer rolls and thus reducing the bearing temperature.
The following examples show the structure of some main bearing locations in the paper industry, for example refiners, suction rolls, press rolls, dryer rolls, guide rolls, calender thermo rolls, anti-deflection rolls and spreader rolls.



A modern paper machine

65 Refiners

Wood chips from the wood chopper which have been softened and steamed by water are broken down and crushed in the refiner by means of crushing wheels rotating in reverse motion with knife sections. Temperatures up to 160 °C result from this process (steamed wood chips, crushing) and can lead to increased operating temperatures in bearings depending on their construction.

Operating data

Axial load from crushing process 400 kN;
Radial load (rotor/shaft) 15 kN per bearing;
Speed 600 min^{-1};
Temperature in locating bearing 80 °C, in floating bearing 70 °C.

Bearing selection, dimensioning

With the high axial loads which have to be accommodated, an *attainable life* $L_{hna} \geq$ 80,000 hours is required. A second thrust bearing is necessary since the axial load acts mainly in the direction of the *locating bearing* but can also be acting in the opposite direction. Thus the *locating bearing* arrangement is made up of two symmetrically arranged spherical roller thrust bearings FAG 29460E. For the rollers to remain undisturbed when the axial load is "reversed" both bearings must be preloaded with springs (minimum load) at the outer rings.
A spherical roller bearing FAG 23052K.MB is mounted as a *floating bearing* and can easily accommodate shaft deflection. Thermal length variations of the shaft are compensated for in between bearing outer ring and housing (sliding *fit*). The bearing is mounted directly on the tapered shaft seat and fastened with a locknut HM3052.
The *floating bearing* reaches a *nominal life* L_h of well over 200,000 hours. Excellent bearing lubrication is required due to slippage hazard when loads are low ($P/C \approx 0.02$).
A *nominal life* of L_h = 50,600 h is calculated for the left *locating bearing* 29460E. With *oil* circulation lubrication, good cleanliness and a bearing temperature of 70 °C, *factor* a_{23} is 3.2. An *attainable life* L_{hna} = 162,000 h results from the *adjusted life calculation.*

The right *locating bearing* only has a slight axial load (spring preload). The *attainable life* L_{hna} is over 200,000 h for this bearing.

Machining tolerances

Floating bearing: The inner ring has *circumferential load* and is attached to the tapered bearing seat of the shaft.
Roundness tolerance IT5/2 (DIN ISO 1101);
Taper angle tolerance AT7 (DIN 7178).
Bearing seat of housing bore according to G7.

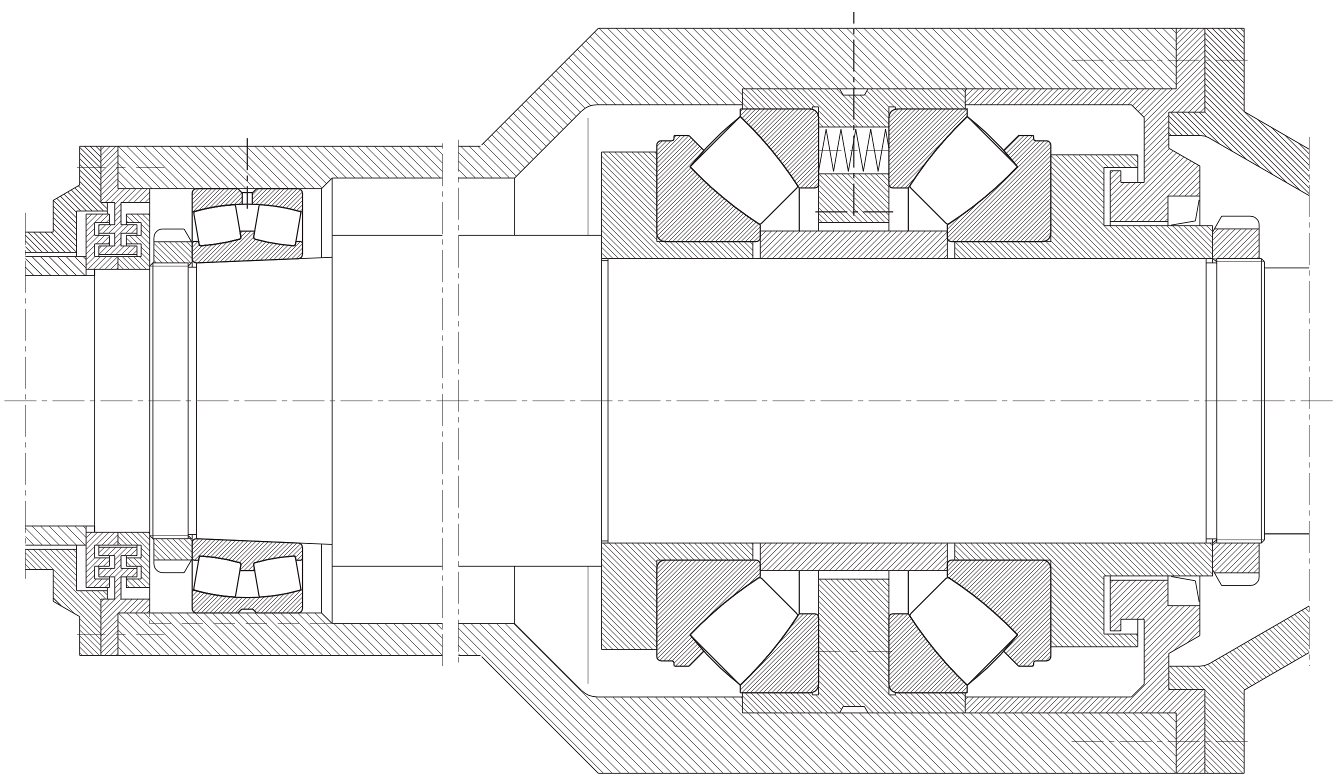
Locating bearing: For mounting reasons, both shaft and housing washer are in sleeves. The bearing seats are machined according to k6 and G7 for the shaft sleeves and housing sleeves respectively.

Lubrication

A *lubricating oil* ISO VG 150 with *EP additives* is used for *locating* and *floating bearings.*
The radial spherical roller bearing has oil circulation lubrication with 0.8 l/min. Oil jet lubrication is provided for the spherical roller thrust bearings. This ensures adequate *oil* constantly at the highly-stressed contact areas between roller face and lip. The *oil* is supplied through the side of the bearing via the spacer sleeve. The minimum *oil* flow rate for both bearings is 8 l/min (good heat dissipation from bearing). The oil is filtered in cirulation and cooled back to a temperature of 40 °C.

Sealing

There are two labyrinths on the side of the crushing wheel connected to one another and filled with grease which protect the bearings from water and contamination and prevent *oil* escaping from the bearings. On the outer side of the *locating bearing* a shaft sealing ring prevents *oil* escape.



65: Refiner bearings

66 Suction rolls

Suction rolls are found in the wire or press section of a paper machine. They are hollow cylinders up to 10 m in length which have several small holes all around their circumference. Some water is removed from the web due to the rotating roll shell and the vacuum inside the roll. The suction box, as interior axle, is stationary. The roll shell is driven by planet wheels in modern paper machines.

Operating data

Roll length 7,800 mm; roll diameter 1,600 mm; rotation 278 min^{-1} (speed 1,400 m/min); roll weight 270 kN; wire tension 5 kN/m.

Bearing selection, dimensioning

The diameter of the suction box is decisive for the size of the bearing. We recommend bearings with a *dynamic load rating* as low as possible; the higher specific bearing load reduces the danger of slippage. *Self-aligning bearings* are necessary as misalignment could arise. Roll weight, wire tension and rotational speed are the main criteria for dimensioning the bearings.
FAG spherical roller bearings FAG 239/850K.MB.C3 with tapered bore (K 1:12) and increased *radial clearance* are used. The bearings are mounted directly on the tapered shaft seats for running accuracy reasons. The hydraulic method is applied to facilitate mounting.
The *locating bearing* provides axial guidance for the rolls while the *floating bearing* compensates for any length variations caused by displacement of the outer ring in the housing bore.
The *nominal life* for both bearings is L_h > 100,000 h. The *attainable life* reaches over 200,000 h when the operating temperature is 60 °C and *oil* ISO VG 68 (*viscosity ratio* $\kappa > 2$; *factor* $a_{23} = 2.2$) is used.

Machining tolerances

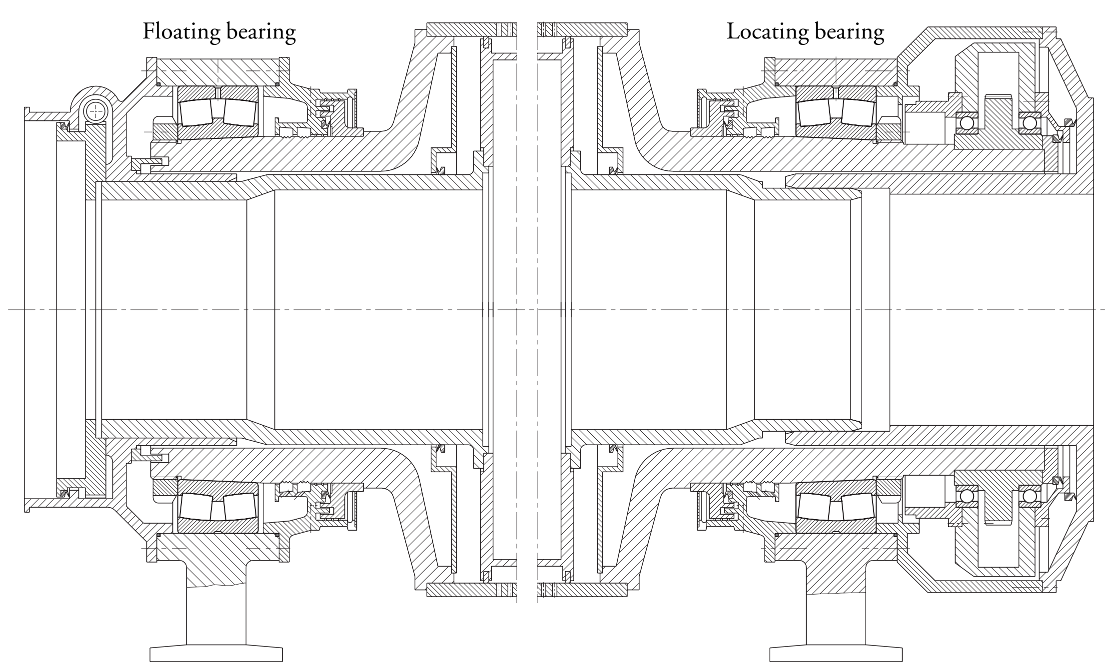
The inner ring has *circumferential load* and is attached to the tapered bearing seat of the shaft.
Roundness tolerance IT5/2 (DIN ISO 1101); taper angle tolerance AT7 (DIN 7178).
Housing bores according to G7 due to *point load* at the outer ring.

Lubrication

The spherical roller bearings are supplied by circulation lubrication with a *mineral oil* quantity of 8 l/min. A *mineral oil* with sufficient *viscosity* and *EP additives* is selected. *Additives* with good anti-corrosive properties and water separation ability are also required. An effective lubrication is achieved with an oil supply to the centre of the bearing.

Sealing

Any *oil* which escapes is thrown off via splash grooves into oil collecting chambers and directed back. At the roll side a baffle plate and multiple grease-filled labyrinth with integrated V ring prevent water penetrating from the outside.



66: Suction roll bearings

67 Central press rolls

The paper web runs through the press rolls on a felt cloth and a large amount of water is pressed out of it. Modern press sections consist of one central press roll against which one or more (suction) press rolls are pressed. The central press roll is solid, made of granite/steel or steel with a protective coating.

Operating data

Roll length 8,800 mm; roll diameter 1,500 mm; speed 1,450 m/min; roll weight 750 kN. Pressure by 3 rolls at 30°, 180° and 210°; bearing temperature about 60 °C. Direct drive.

Bearing selection, dimensioning

Self-aligning spherical roller bearings of the series 231 or 232 with a very high load carrying capacity are chosen due to the high radial load and the misalignment which is possible between the bearing locations. A low cross section height is also important for these bearings since the height of the housing is restricted by the roll diameter. The roll weight and the load components of the pressure rolls yield a resulting bearing load F_r = 300 kN.
A spherical roller bearing FAG 231/600K.MB.C3 is mounted at every bearing location. The bearings with tapered bore (taper 1:12) are pressed directly onto the tapered shaft seat by means of the hydraulic method. The *floating bearing* at the operator's end permits temperature-depending length variations of the roll by shifting the outer ring in the housing. The *locating bearing* is at the drive end.

The *nominal life* calculated is L_h > 100,000 h with a speed of 308 min^{-1}. With good lubrication (*viscosity ratio* $\kappa \approx 3$, *basic factor* $a_{23II} = 3$) and improved cleanliness (*contamination factor* V = 0.5) in the lubricating gap $L_{hna} \gg 100{,}000$ h according to the *adjusted rating life calculation.*

Machining tolerances

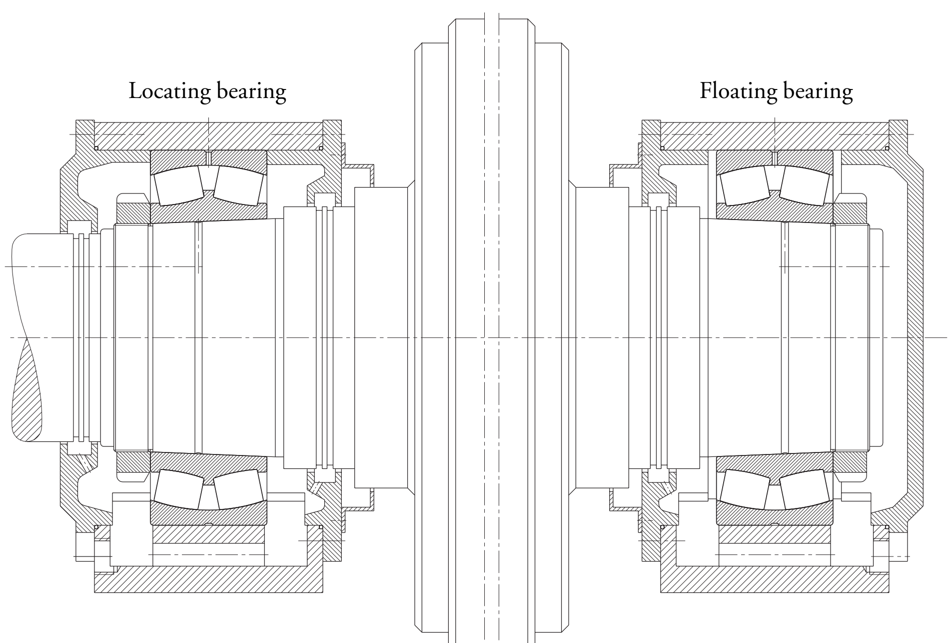
The inner ring has *circumferential load* and is attached to the tapered bearing seat of the shaft.
Roundness tolerance IT5/2 (DIN ISO 1101); taper angle tolerance AT7 (DIN 7178).
Housing bores according to G7 since there is *point load* at the outer ring.

Lubrication

The spherical roller bearings are supplied with a minimum *oil* quantity of 7 l/min by circulation lubrication. A *mineral oil* of sufficient *viscosity* (ISO VG 100) and *EP additives* is used. *Additives* with good anti-corrosive properties and water separation ability are also required. An effective lubrication is achieved with an oil supply to the centre of the bearing.
Oil returns to both sides of the bearing via oil collecting pockets and connecting holes.

Sealing

Oil splash grooves in the roll journal prevent *oil* escaping at the cover passage.
Non-rubbing and maintenance free gap-type *seals* protect the bearings from environmental influences.



67: Central press roll bearings

68 Dryer rolls

The remaining water in the dryer section is evaporated. The paper runs over numerous heated dryer rolls guided by endless dryer wires (formerly dryer felts). The dryer rolls are steam heated (temperature depends on the type of paper, its thickness and speed, and on the number of dryer rolls). The high temperatures of the heating steam transfer to the bearing seats stressing the rolling bearings accordingly. Today, the journals through which the steam flows are insulated in order to keep bearing temperatures low.

Operating data

Working width 5,700 mm; roll diameter 1,800 mm; paper speed 1,400 m/min (rotational speed 248 min^{-1}); heating temperature 165 °C (7 bar); roll weight 90 kN. Felt pull 4.5 kN/m; wrap angle 180°; environmental temperature under the dryer section hood approx. 95 °C; insulated journal bores.

Bearing selection

The bearing load is calculated from the roll weight, felt pull and temporary water fill. *The floating bearing* is loaded with 75 kN, the *locating bearing* with 83 kN taking into account the drive force. Heating the dryer roll leads to heat expansion which in turn leads to considerable changes in length with such long rolls. *Self-aligning* rolling bearings are necessary due to the misalignment arising between both bearing locations.
A double-row cylindrical roller bearing of the dimension series 31 is provided as *floating bearing* at the operator's end. It easily compensates for length variations in the bearing between the rolls and the inner ring raceway. With its spherical sliding surface a plain spherical bearing's seating ring accommodates any alignment inaccuracy of the journal. A double-row self-aligning cylindrical roller bearing FAG 566487K.C5 with the dimensions 200x340x112 mm is mounted. A spherical roller bearing FAG 23140BK.MB.C4 is mounted as *locating bearing* on the drive end.
Both bearings have about the same *operating clearance* in order to avoid any detrimental preload during the heating-up stage which may lead to a maximum temperature difference of 50 K. The spherical roller bearing has an increased *radial clearance* according to C4 (260...340 microns), the cylindrical roller bearing an increased *radial clearance* according to C5 (275...330 microns).

Both bearings have a tapered bore (K 1:12) and are mounted by the hydraulic method directly onto the tapered journals.

Since the cylindrical roller bearing and the spherical roller bearing have the same dimensions unsplit PMD plummer block housings (FAG PMD3140AF or BF) are applied both at the drive end and at the operator's end.

Due to increased operating temperature, both bearings are given special heat treatment (isotemp) and are thus dimensionally stable up to 200 °C.

Bearing dimensioning

An *attainable life* $L_{hna} \geq$ 250,000 hours is required for dryer roll bearings. Lubrication decisively influences the *adjusted rating life.* Under an average operating temperature of 100°C the *operating viscosity* $\nu \approx$ 16 mm^2/s for a *mineral oil* with a nominal *viscosity* of 220 mm^2/s (ISO VG 220).
The *rated viscosity* is determined from the speed and the mean bearing diameter $d_m = (200 + 340)/2 =$ 270 mm to $\nu_1 = 25$ mm^2/s.
The *viscosity ratio* is then:
$\kappa = \nu/\nu_1 = 16/25 = 0.64$.
With the *value* K = 1 a *basic factor* $a_{23II} = 1.1$ is obtained for the spherical roller bearing.
The values K = 0 and $a_{23II} = 1.4$ apply to the cylindrical roller bearing.
With normal cleanliness (*cleanliness factor* s = 1) the *factor* $a_{23} = a_{23II} \cdot s$
1.1 for the spherical roller bearing,
1.4 for the cylindrical roller bearing.
The *attainable life* $L_{hna} = a_1 \cdot a_{23} \cdot L_h$ is therefore well over 250,000 h for both bearings.

Machining tolerances

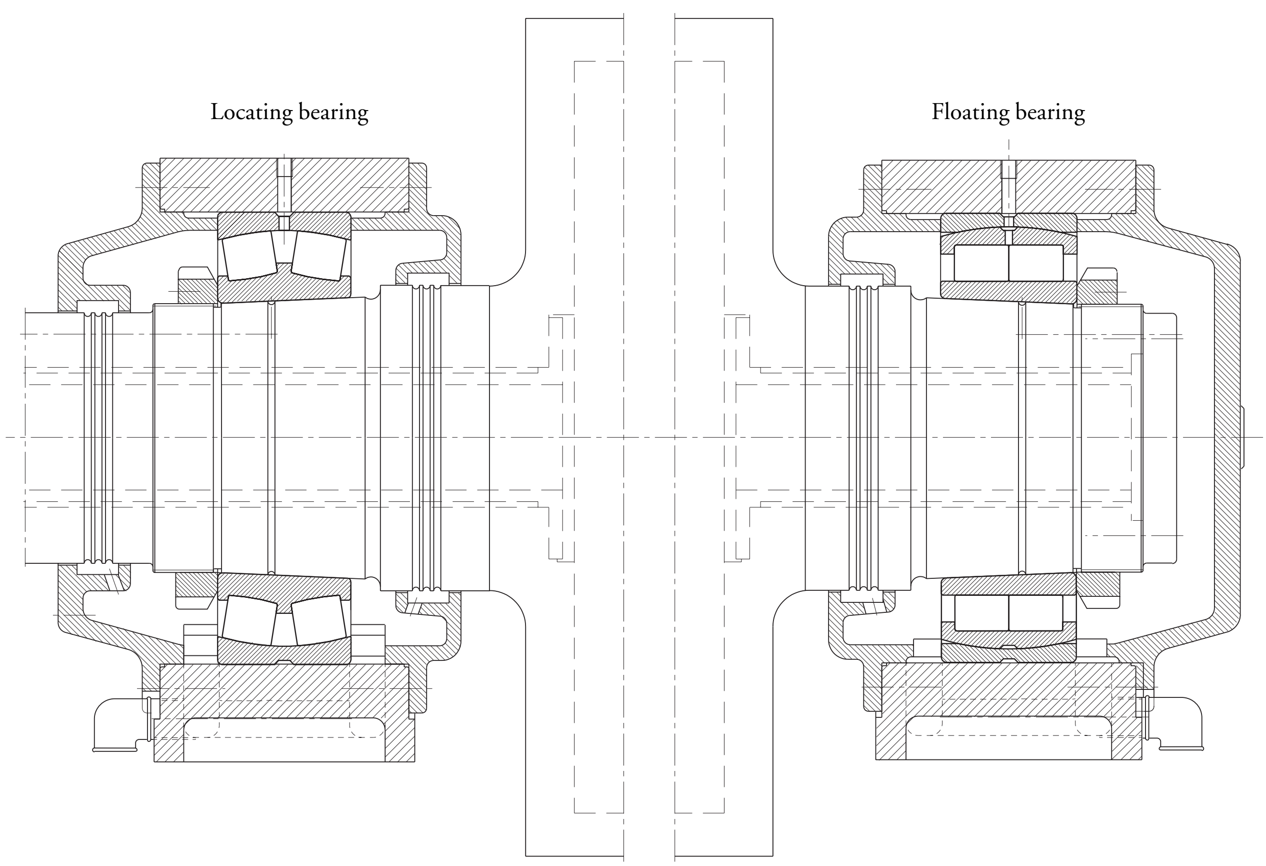
The inner rings have *circumferential load* and have a tight *fit* on the tapered roll journal. The journals have oil ducts so the bearings can be mounted and dismounted by means of the hydraulic method. Roundness tolerance IT5/2 (DIN ISO 1101), taper angle tolerance AT7 (DIN 7178). Bearing seats in the housing bore according to G7.

Lubrication

The bearing housings are connected to a central *oil* circulation lubrication system so that heat is constantly dissipated from the bearing. High-grade *mineral oils* ISO VG 220 or 320 are used which must have a high *operating viscosity,* thermal stability, good protection against *wear,* good water separation ability and a high degree of cleanliness. A minimum *oil* quantity of 1.6 l/min is guided directly to the centre of the bearing via a lubricating groove and lubricating holes in the outer ring.
The oil can be carried off at both sides of the bearing with the central oil system. The danger of oil retention and leakage is minimized considerably. Any contaminants or *wear* particles which might penetrate the bearing are immediately washed out of it with this method of lubrication.

Sealing

Gap-tape *seals,* which are non-rubbing and maintenance-free, are provided as *sealing* for the journal passages. The *oil* is thrown off via splash grooves and *oil* collecting chambers and flows back through return holes to the two *oil* cavities on the housing floor. Cover *seals* make the housing of the paper machine *oil* proof.



68: Dryer roll bearings

69 Guide rolls

Guide rolls guide, as the name indicates, and turn the wire and felt cloth in the wet end and dryer sections of a paper machine. The same bearings are used for the guide rolls in both areas. Lubrication and *sealing* differ, however, depending on the place of application.
In older machines the wet end section is usually lubricated with grease, and the dryer section with *oil.*
In modern machines both sections have *oil* circulation lubrication. Due to different operating conditions separate oil circuits are necessary for the wet end and dryer sections.
The larger the machine the more often it is found to be faster. For this reason the bearing inner rings are mounted with a tapered bore directly on the tapered roll journal.

Wet end section
Depending on the positions of the bearings in the machine they are subject to a small or large degree of moisture. Water must not penetrate the housing particularly when machines are being high-pressure cleaned.

Dryer section
Environmental temperatures of about 95 °C lead to great length variations and place high demands on lubrication. The operating temperature of the bearings can be 115 °C.

Operating data

Useful width 8,800 mm
Roll diameter 700 mm
Paper speed 1,650 m/min ($n = 750\ min^{-1}$)
Roll weight $F_G \approx 80$ kN
Paper pull 1 kN/m (tensile load $F_z \approx 9$ kN)
Wrap angle 180°
Bearing temperature approx. 105 °C

Bearing selection, dimensioning

The bearings must be able to accommodate loads and compensate for misalignment at the same time (misalignment, bending). An increased *radial clearance* according to C3 is necessary due to temperature differences. Spherical roller bearings FAG 22330EK.C3 are mounted.

Bearing load:

$P = (F_G + F_z)/2 = (80 + 9)/2 = 44.5$ kN

The diameter of the roll journal is determined by the roll rigidity required. As a result there is a high *index of dynamic stressing* f_L corresponding to a *nominal life* L_h of well over 200,000 hours. The *attainable life* is even higher with such good lubrication conditions.

The housings can be in standing or suspended position or can be laterally screwed on. They are designed for *oil* circulation lubrication.

Machining tolerances

The inner rings have *circumferential load* and are directly fitted to the tapered roll journal. The roll journal have oil ducts so the bearings can be mounted and dismounted with the hydraulic method.
Roundness tolerance IT5/2 (DIN ISO 1101); taper angle tolerance AT7 (DIN 7178).

Bearing seats in the housing bore according to G7.

Lubrication

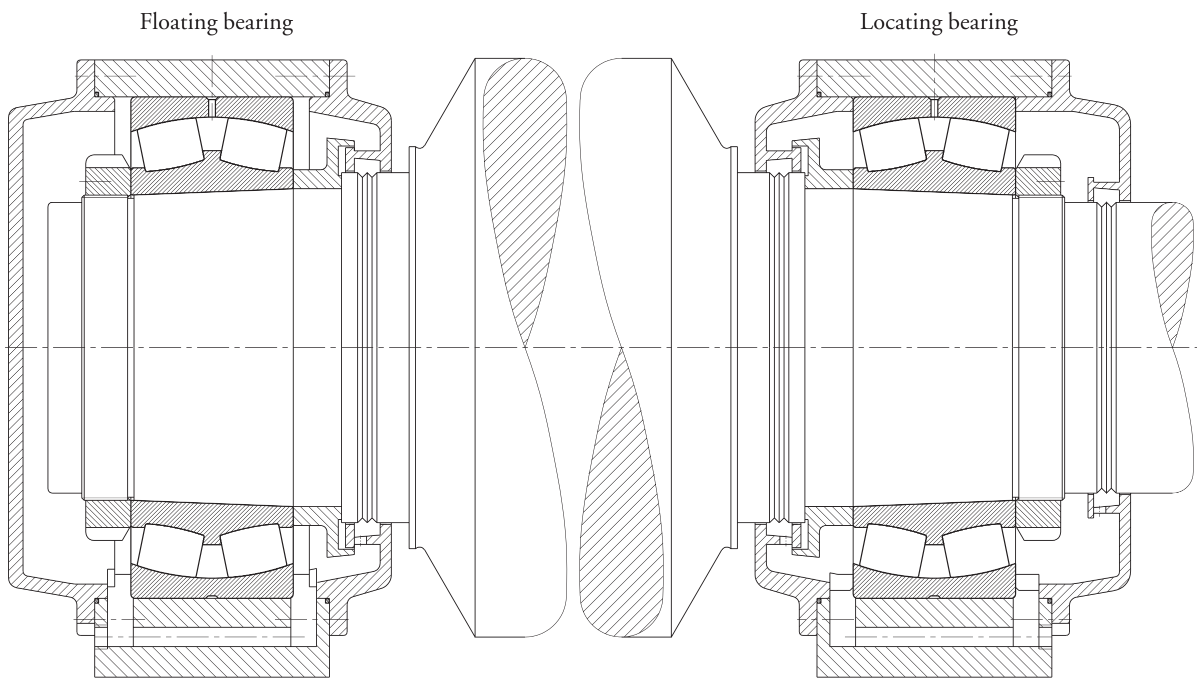
In the dryer section: see example 68 (Dryer rolls) since the bearings are connected to the *oil* circuit of the dryer rolls. Minimum flow rate 0.9 l/min.

In the wet end section: see example 66 (Suction rolls) and 67 (Central press rolls), since the bearings are connected to the *oil* circuit of the wet section rolls. Minimum flow rate 0.5 l/min.

Sealing

Gap-type *seals,* which are non-rubbing and maintenance-free, prevent *oil* from escaping through the cover passages in the dryer section.

The bearings in the wet end section must have relubricatable labyrinth *seals* to prevent water from penetrating. Remaining *oil* is thrown off by splash grooves into collecting chambers and directed back. Cover *seals* make the housing oilproof.



69: Guide roll bearings (dryer section)

70 Calender thermo rolls

The paper passes through the so-called calender stack after leaving the dryer section. Soft calenders smooth the surface of the paper thus improving its printability. The calender consists of two pairs of rolls. One calender roll (steel) lies above a counter roll, another below one. The counter roll is the so-called anti-deflection roll (elastic material). Soft calender rolls can be heated by water, steam, or oil. The gap or the "nip" pressure depends on the type of paper.

Operating data

Useful width approx. 7 m
Rotation 350 min^{-1} (speed 1,100 m/min)
Heated by oil at 200...250 °C
Insulated roll journal
Operating temperature at bearing inner ring 130 °C.

Bearing selection, dimensioning

The radial bearing load depends on the application of the calender roll as lower or upper roll, on the weight F_G and the variable pressure load with percentage of time.

$P_1 = F_G + F_{nip\,min}$ = 600 kN
$P_2 = F_G + F_{nip\,med}$ = 990 kN
$P_3 = F_G + F_{nip\,max}$ = 1,260 kN
$P_4 = F_G - F_{nip\,min}$ = 60 kN
$P_5 = F_G - F_{nip\,med}$ = 390 kN
$P_6 = F_G - F_{nip\,max}$ = 720 kN

Percentages of time: P_1, P_4 : 10 % each
P_2, P_3, P_5, P_6 : 20 % each

The sum of the roll weight and the nip load acts for the application as bottom roll whereas their difference acts for the application as top roll.

Taking the maximum load for designing the bearing would lead to overdimensioning (*equivalent dynamic load* $P < 0.02 \cdot$ *dynamic load rating* C) in the case of application in the top roll. Slippage may occur with such a low load which in turn can lead to bearing damage when lubrication is inadequate. In order to avoid this problem, smaller bearings with a smaller *dynamic load rating* C should be selected so that $P/C > 0.02$. The risk of breaking through the lubricating film drops with the smaller roller mass.

Requirements with respect to load carrying capacity and *self-alignment* are met by spherical roller bearings. The cross section height of the bearing is limited by the diameter of the roll journal and roll shell. The relatively wide spherical roller bearings FAG 231/560AK.MB.C4.T52BW are mounted.
The *nominal life* L_h = 83,000 h with given loads and percentages of time.

With a *lubricating oil* ISO VG 220 the viscosity ratio is $\kappa = 0.71$ under an operating temperature of 130 °C. An *attainable life* L_{hna} > 100,000 h is obtained with the *adjusted rating life calculation* (where $f_{s*} > 12$; a_{23II} = 1.2; V = 0.5; s = 1.6).

The increased *radial clearance* C4 is required due to the danger of detrimental radial preload in the bearing during the heating up phase when the temperature difference is great. With a *speed index* $n \cdot d_m$ = 224,000 $min^{-1} \cdot mm$ we recommend bearings with increased running accuracy according to specification T52BW.

Machining tolerances

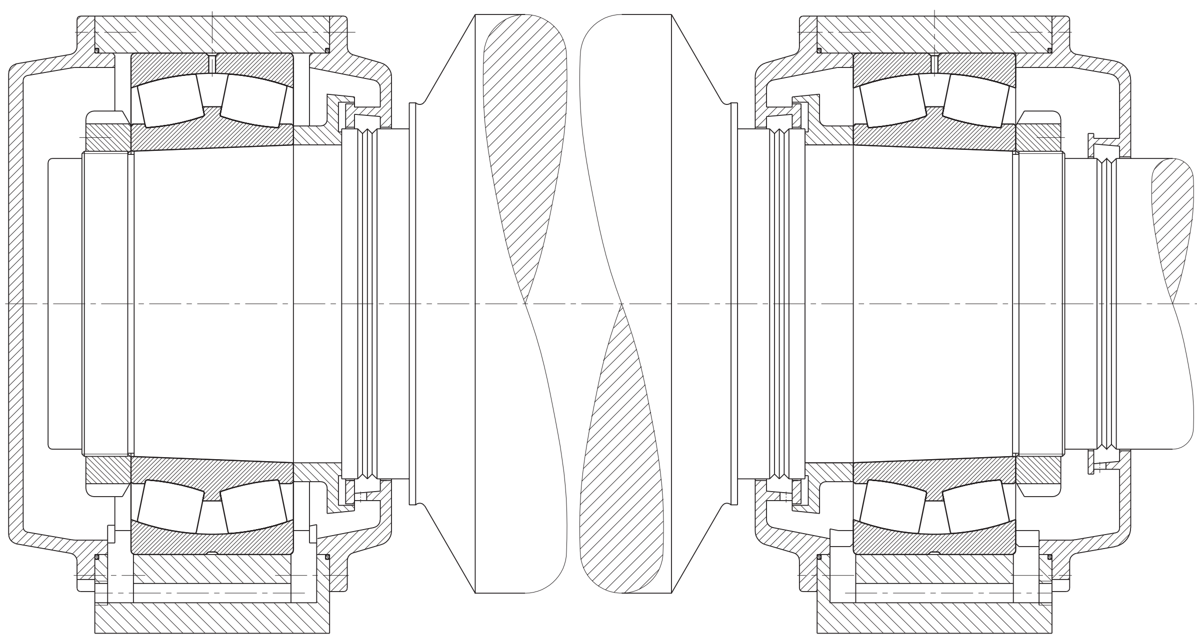
The inner rings have *circumferential load* and are directly fitted on the tapered roll journal. The roll journals have oil ducts so that the hydraulic method can be applied for mounting and dismounting the bearings. Roundness tolerance IT5/2 (DIN ISO 1101), taper angle tolerance AT7 (DIN 7178).
Bearing seats in the housing boring according to F7.

Lubrication

Oil circulation lubrication with a *synthetic oil* ISO VG 220, suitable in quality, which has stood dynamic testing on the FAG test rig FE8.
By supplying a large amount of *oil* to the centre of the bearing (minimum flow rate 12 l/min) heat dissipation is achieved as well as a low thermal stress of the oil. Any contaminants or wear particles are washed out of the bearing. Oil returns at both sides of the bearing via oil collecting pockets and connecting holes.

Sealing

Angle rings at the roll side prevent direct oil escape at the cover holes. Remaining oil is thrown off by splash grooves into collecting chambers and directed back. Cover *seals* make the housing oilproof.



70: Calender thermo roll bearings

71 Anti-deflection rolls

Anti-deflection rolls are found in both the press section and in calenders. They provide for an even paper thickness across the web and a consistently high paper quality. The drive is at the *locating bearing* end. Its power is transmitted via gearing and the hypoid teeth coupling to the roll shell.
The adjustment roll is pressed against the mating roll (calender roll) under very high pressure. As a result the mating roll is bent and the form of the roll shell changed. The shell of the adjustment roll must adjust to this form.
The anti-deflection roll consists of a stationary axle and a rotating roll shell. Control elements which can be pressure-balanced separately are provided on the axle. They support the roll shell hydrostatically and effect its adjustment. The roll shell is shaped like the bent mating roll by the changing pressure giving the paper an even thickness.

Operating data

Roll length 9,300 mm; roll diameter 1,025 mm; roll weight 610 kN; shell weight 210 kN; pressure 700 kN; circumferential velocity 1,500 m/min ($n = 470\ min^{-1}$); bearing temperature 55 °C.

Bearing selection, dimensioning

A *service life* of > 100,000 h is required. The bearing only has a guidance function when in operation (with pressure and closed gap).
Spherical roller bearings FAG 23096MB.T52BW (*dynamic load rating* C = 3,800 kN) are used.
Due to the danger of slippage bearings of the series 239 with a low *load rating* should be selected.
The bearings are produced with a reduced radial runout (specification T52BW), since running inaccuracy of the rotating roll shell influences the quality of the paper web.

Machine tolerances

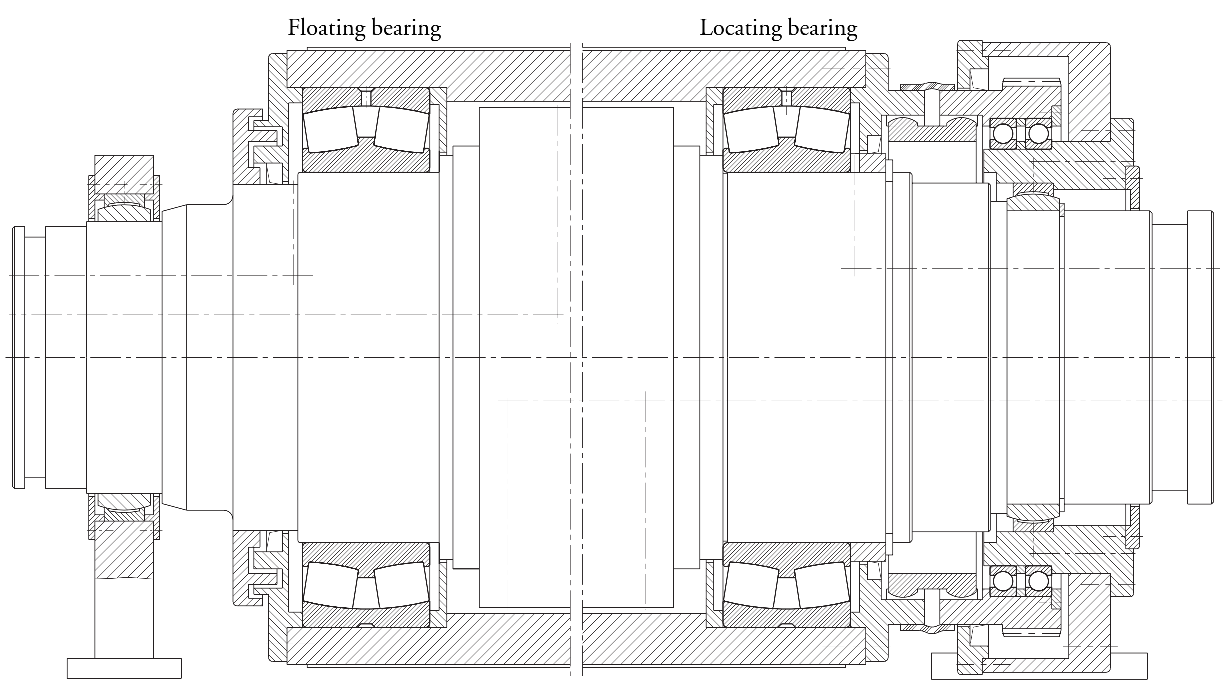
Bearing seats on the axle according to f6 due to *point load* for the inner rings.
The outer rings have *circumferential load* and a tight *fit;* the bearing seats in the housings are machined to P6.

Lubrication

When dynamic misalignment and/or slippage may occur, a very good lubrication system must always provide a load-carrying lubricating film. The bearings are supplied with the *lubricating oil* used for the hydraulic system (ISO VG 150 with *EP additives*). The oil is fed laterally to the bearings via holes. In new designs and particularly with heated rolls, the *lubricating oil* is fed via lubricating holes in the inner ring directly to the bearing contact areas.
The deep groove ball bearings of the transmission arranged at the *locating bearing* side are supplied with *oil* via a separate oil circuit.

Sealing

The bearings are *sealed* externally with a shaft seal. To the roll side a baffle plate provides for an *oil* reservoir in the bearing area.



71: Anti-deflection roll bearings

72 Spreader rolls

Paper webs transported in lengthwise direction tend to creasing. Spreader rolls stretch or expand in cross direction the webs running over them. They flatten creases and any middle or end parts of the web which are loose. Spreader rolls consist of a stationary axle which is bent symmetric to its longitudinal axis, and around which the roll shell rotates. Tube-shaped sections make up the roll shell and are arranged to rotate freely and have angular freedom. The sections adjust to one another in such a way that the bending form of the axle is reflected on the shell surface. Depending on the case of application – wet end section, dryer section, or subsequent processing – the sections are made of stainless steel or provided with a flexible coating (e.g. rubber).

Operating data

Roll length 8,300 mm, consisting of 22 sections; weight/section plus wire or paper web pull at 30° wrap angle 2 kN/m; a radial load of just 0.5 kN per bearing results therefrom.
Rotation of roll shell 1,160 min^{-1}.
Operating temperature in the wet end section 40 °C; in the dryer section and in subsequent processing with infrared drying temperatures can reach 120 °C.

Bearing selection, dimensioning

With rotating outer ring, extremely smooth running is required from the bearings since the sections in the wet end section and in the dryer section or subsequent processing are only driven by the wire tension and the paper web respectively.
High operational reliability is also necessary since the failure of one bearing alone means that the whole spreader roll has to be dismounted.

FAG 61936.C3 deep groove ball bearings are selected. The increased *radial clearance* C3 permits easy adjustment of the sections. With the low load, the bearings have a *nominal life* L_h of well over 100,000 hours.

Machining tolerances

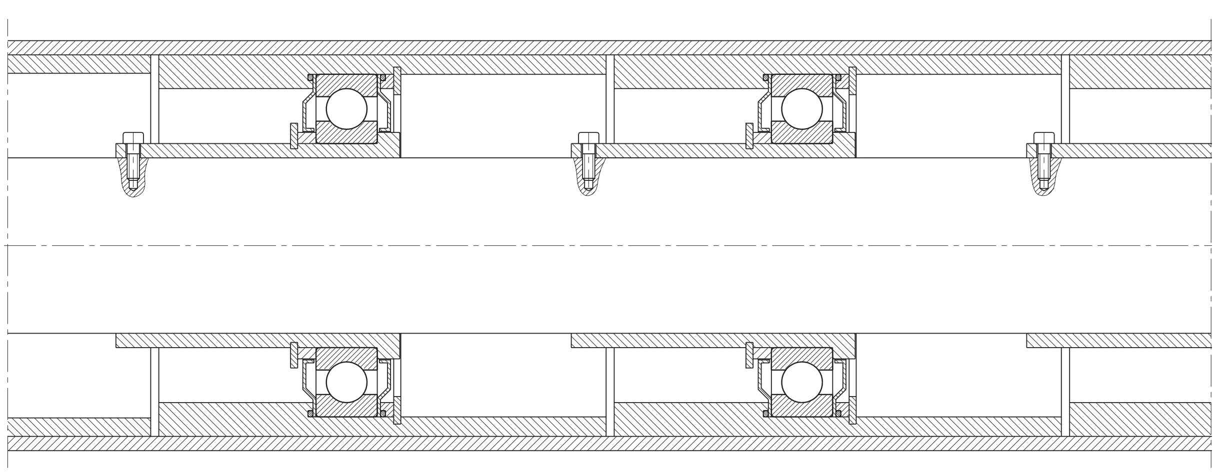
As the outer ring of the bearing rotates with the roll shell it is given a tight *fit* with M6 tolerance and is secured axially by a snap ring.
The inner ring has *point load* and is fitted to the shaft sleeve with h6. Due to the bent roll axle and for assembly reasons the sleeve is loosely fitted and axially attached with a screw.

Lubrication

The bearings are greased for life, i.e. no relubrication is provided for. The selection and filling quantity of *lubricating grease* is determined by the demand for smooth running as well as a *service life* of up to five years (8,000 operating hours per year). Low-friction *greases* (e.g. greases of class LG10 for the wet end section) are advantageous with high speeds and low loads.

Sealing

Non-rubbing dust shields are used for *sealing* due to the smooth running required. They are stuck to the bearing outer ring on both sides so the *base oil* centrifuged from the *lubricating grease* cannot escape. Round cord seals also provide for oil tightness.



72 Spreader roll bearings

73 Run wheel of a material ropeway

Operating data

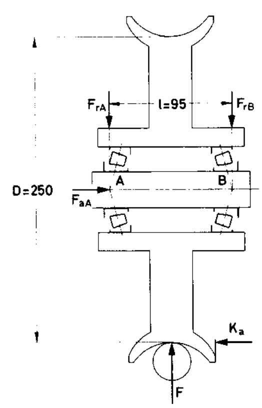
Speed $n = 270\ min^{-1}$; radial load $F_r = 8$ kN. Thrust loads as guidance loads only, considered by 20 % of the radial load: $K_a = 1.6$ kN.

Bearing selection

Each run wheel is supported by two tapered roller bearings FAG 30306A. The bearings are assembled in *O arrangement* which provides for a wider bearing *spread* than an *X arrangement.* The wider the spread, the lower the additional bearing load from thrust load K_a.

Bearing dimensioning

As thrust load K_a acts at the wheel circumference, it generates radial reaction forces at the bearing locations.



Bearing A:
$F_{rA} = F_r/2 + K_a \cdot (D/2)/l = 4 + 1.6 \cdot 125/95 = 6.1$ kN
The thrust load $K_a = 1.6$ kN acts toward bearing A.
Bearing B:
$F_{rB} = F_r/2 – K_a \cdot (D/2)/l = 4 – 1.6 \cdot 125/95 = 1.9$ kN

Radial loads acting on a shaft supported on two tapered roller bearings generate axial reaction loads which have to be considered in the calculation of the *equivalent dynamic load.* These internal loads together with the external thrust loads should, therefore, be taken into account for *life* calculation (see FAG catalogue WL 41 520, chapter "Tapered roller bearings").

Data for tapered roller bearings FAG 30306A (designation to DIN ISO 355: T2FB030):
dynamic load rating C = 60 kN,
Thrust factor $Y = Y_A = Y_B = 1.9$.

Thus,
$F_{rA}/Y = 6.1/1.9 = 3.2$; $F_{rB}/Y = 1.9/1.9 = 1$ and consequently $F_{rA}/Y > F_{rB}/Y$

The second condition proven is
$K_a > 0.5 \cdot (F_{rA}/Y – F_{rB}/Y) = 0.5\ (3.2 – 1) = 1.1$
For calculation of bearing A the following thrust load F_{aA} must, therefore, be taken into account:
$F_{aA} = K_a + 0.5 \cdot F_{rA}/Y = 1.6 + 0.5 \cdot 1.9/1.9 = 2.1$ kN

Consequently, the *equivalent dynamic load* P_A of bearing A is:

$P_A = 0.4 \cdot F_{rA} + Y\ F_a = 0.4 \cdot 6.1 + 1.9 \cdot 2.1 = 6.45$ kN
With this load, the indicated *dynamic load rating* and the *speed factor* $f_n = 0.534$ ($n = 270\ min^{-1}$) the i*ndex of dynamic stressing.*

$f_L = C/P_A \cdot f_n = 60/6.45 \cdot 0.534 = 4.97$

This value corresponds to a *nominal rating life* of more than 100,000 hours. Since this calculation is based on the most unfavourable load conditions, the thrust load acting constantly at its maximum and only in one direction, the bearing is adequately dimensioned with regard to *fatigue life.* The *service life* will probably be terminated by *wear,* especially under adverse operating conditions (high humidity, heavy contamination). The load carrying capacity of bearing B does not need to be checked since its loading is much less than that of bearing A.

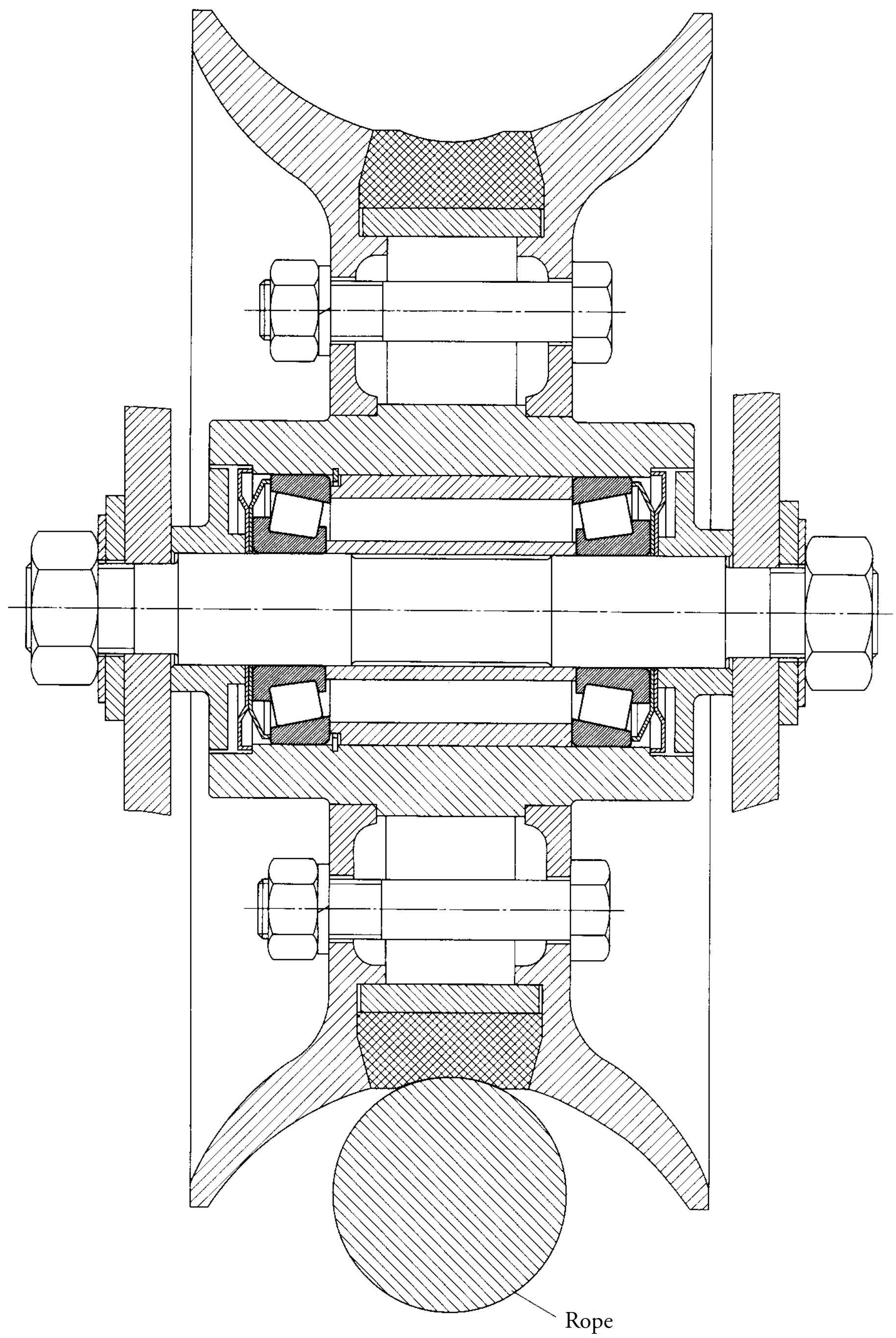
Machining tolerances

The run wheel mounting is a so-called hub mounting, i.e. the run wheel, with the two cups, rotates about a stationary shaft. The cups carry *circumferential load* and are thus tight-fitted. The shaft is machined to h6, the hub bore to M6.

Lubrication, sealing

The bearings and the free spaces have to be filled during mounting with *grease,* e. g. FAG rolling bearing *grease Arcanol* L186V. The grease filling will last for approximately one year.

In the example shown, the bearings are sealed by spring steel seals (Nilos rings).



73: Run wheel of a material ropeway

74 Rope return sheaves of a passenger ropeway

In this example of a passenger ropeway, eight sheaves are installed at the mountain station and another eight at the valley station including the sheaves in the valley station tensioning weight pit. The sheave diameters are 2.8 and 3.3 meters.

Bearing selection, dimensioning

The valley station sheaves and the tensioning weight sheaves are fitted with spherical roller bearings FAG 22234E. The sheaves at the mountain station are supported by spherical roller bearings FAG 22240B.MB.

The load on the bearings FAG 22234E installed in the tensioning weight sheaves is P = 65 kN each; with a *dynamic load rating* C = 1,100 kN and a *speed factor* f_n = 0.838, corresponding to a speed of 60 min^{-1}, the *index of dynamic stressing:*

$f_L = C/P \cdot f_n = 1{,}100/65 \cdot 0.838 = 14.2$.

This shows that the bearings are more than adequately dimensioned with regard to *fatigue life.*

The one-piece sleeve carrying the bearings allows convenient changing of the rope sheaves.

Machining tolerances

The outer rings carry *circumferential load* and require, therefore, a tight *fit.* To safeguard the spherical roller bearings against detrimental axial preloading, the design is of the *floating mounting* type. The outer rings are securely locked via the two covers by means of a spacer ring. The centre lip of sleeve H is slightly narrower than the spacer so that the sheave can float axially on the sleeve via the loosely fitted inner rings. The sleeve is locked to prevent it from rotating with the inner rings.

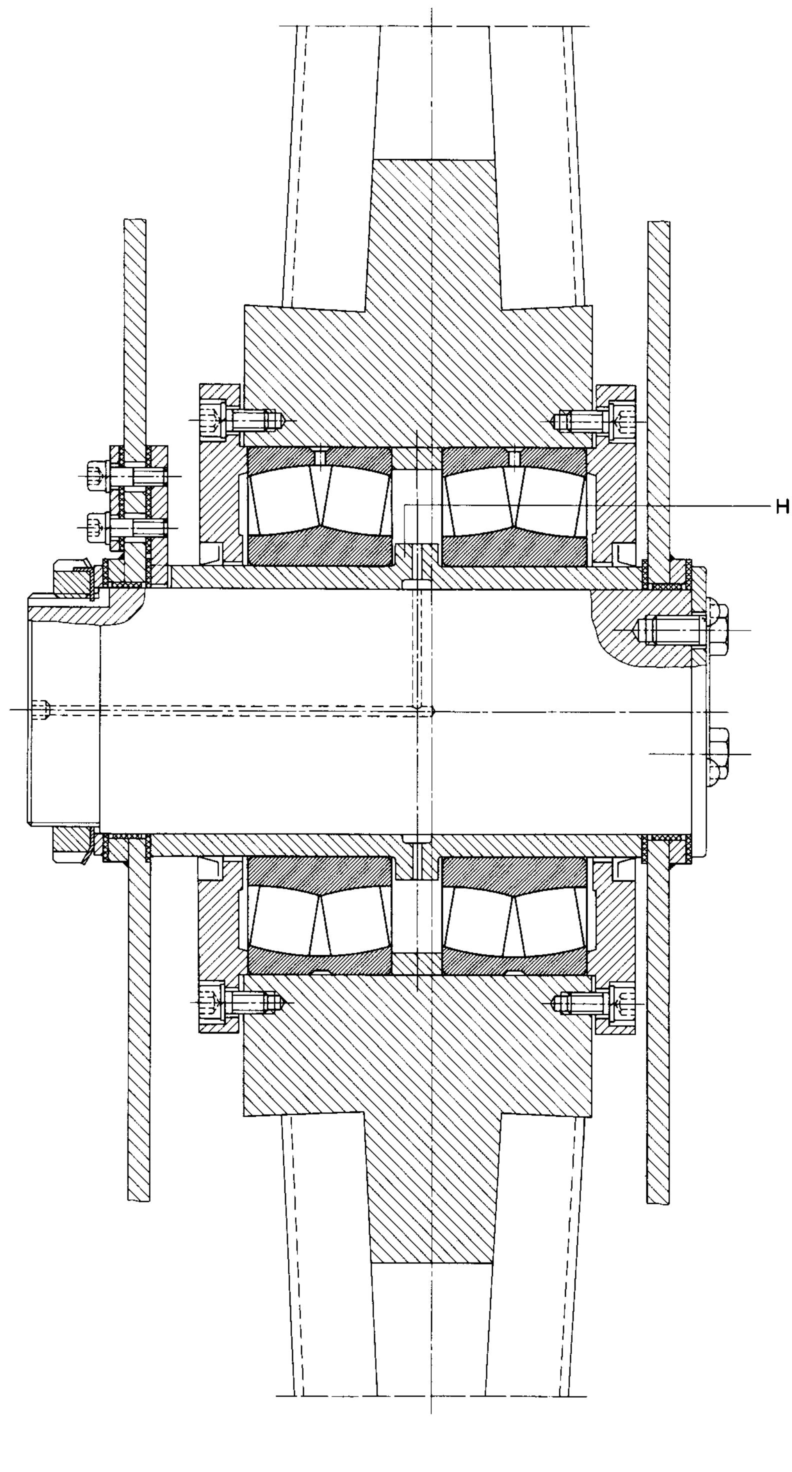
Sleeve to g6; hub bore to M6;

The sleeve has a sliding *fit* on the shaft.

Lubrication, sealing

Grease lubrication with FAG rolling bearing grease *Arcanol* L186V. Relubrication by means of lubricating holes in the shaft.

A shaft *seal* ring in the covers provides adequate protection against contamination.



74: Rope return sheaves of a passenger ropeway

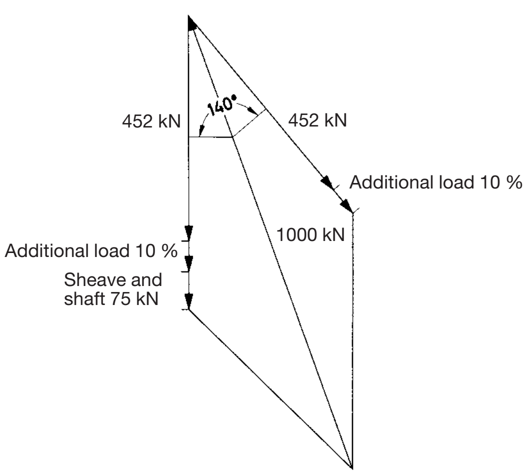
75 Rope sheave (underground mining)

These sheaves are arranged in the head frames of the pits. The rope fastened to the cage runs from the drive sheave or the drum of the hoist into the mine by passing over the rope sheaves.

Operating data

Static rope load 452 kN; weight of rope sheave and shaft 75 kN; rope sheave diameter d_S = 6.3 m; haulage speed v = 20 m/s; wrap angle 140°.

Acceleration forces are taken into account by assuming 10 % of the static rope load.



Bearing selection, dimensioning

From the parallelogram of forces the resultant load is approximately 1,000 kN. Since the two bearings are symmetrically arranged, the radial load per bearing is P = 500 kN.

Speed $n = v \cdot 60/(d_S \cdot \pi) = 20 \cdot 60/(6.3 \cdot 3.14) =$ 60 min^{-1}; this yields a *speed factor* $f_n = 0.838$.

The recommended *index of dynamic stressing* f_L is 4...4.5. With 4.5, the *nominal rating life* is about 75,000 hours. It should be borne in mind that only in rare cases the rope sheave bearings fail due to material fatigue; usually their *service life* is terminated by *wear.*

Thus, the required *dynamic load rating* C for the spherical roller bearing is calculated as follows:

$C = f_L/f_n \cdot P = 4.5/0.838 \cdot 500 = 2{,}680$ kN

Spherical roller bearings FAG 23252BK.MB with a *dynamic load rating* C = 2,900 kN were chosen.

The bearings feature a high load carrying capacity and compensate for potential housing misalignments, shaft deflections and deformations of the head frame.

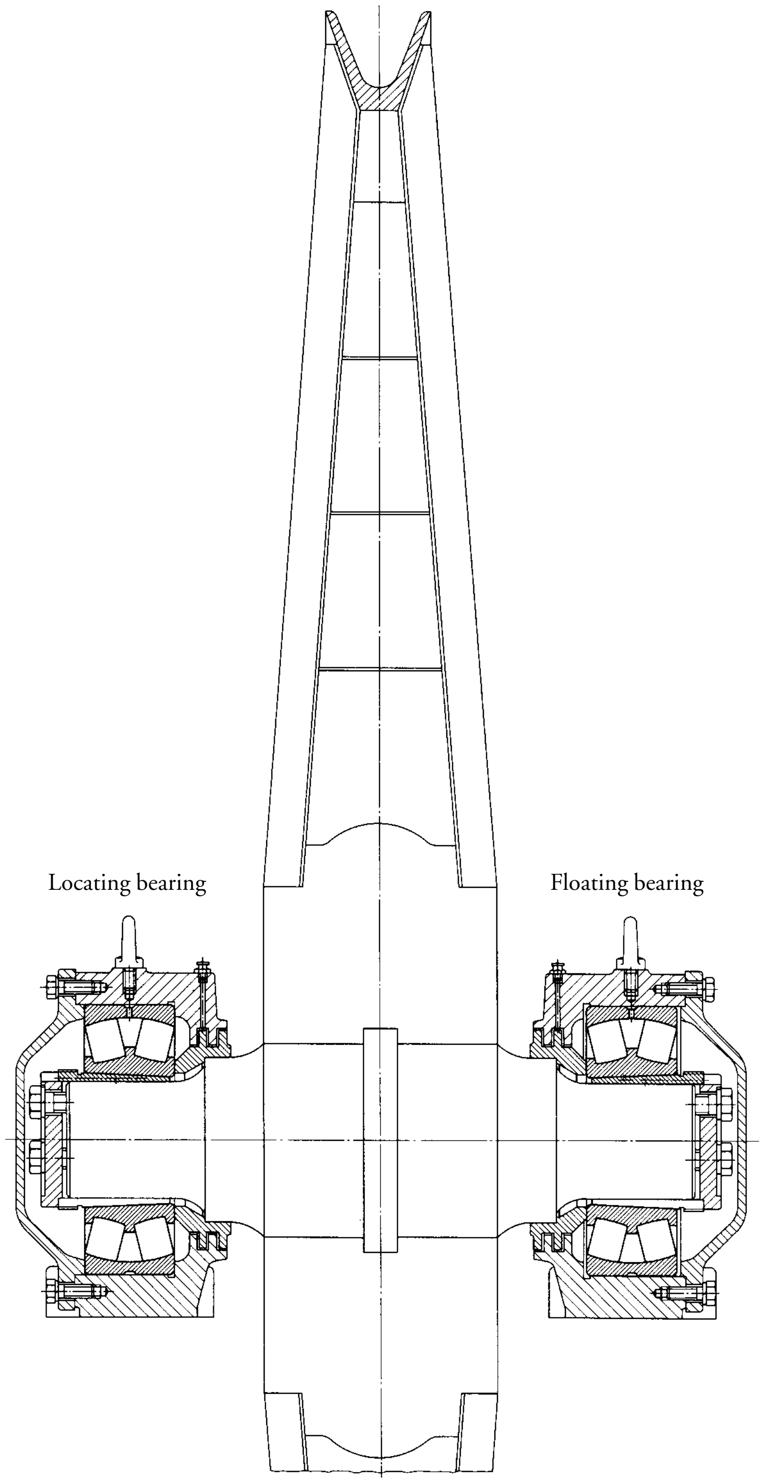
Machining tolerances

One bearing acts as the *locating bearing,* the other one as the *floating bearing.* Both bearings have a tapered bore (K 1:12). They are mounted on the shaft journal with withdrawal sleeves (FAG AH2352H). Mounting and dismounting is simplified by using the hydraulic method. For this purpose the withdrawal sleeves feature oil grooves and ducts. The spherical roller bearings are supported by FAG plummer block housings FS3252AHF and FS3252AHL.

Shaft journal to h6, cylindricity tolerance IT5/2 (DIN ISO 1101).
Housing to H7.

Lubrication, sealing

Grease lubrication with FAG rolling bearing grease *Arcanol* L186V.
A multiple labyrinth protects the bearings against contamination. Replenishment of labyrinth *grease* is effected about every 4...6 weeks.



75: Rope sheave (underground mining)

76 Rope sheave of a pulley block

In pulley blocks it is customary to arrange several sheaves on a common shaft. To achieve minimum overall pulley block width, the sheaves and their bearings should, therefore, be as compact as possible.

Bearing selection

For the rope sheaves of pulley blocks the wrap angle is 180°. Thus the radial load on the bearing is twice the rope pull. Thrust loads, resulting from a possible inclined rope pull, and the moments caused by them are low and can be neglected for *bearing life* calculation. Adequate bearing *spread* for load accommodation is achieved by mounting either two bearings or one double-row bearing. Deep groove ball bearings are satisfactory for accommodating the loads in this application.
The bearings are mounted on a sleeve, forming a ready-to-mount unit with the sheave which can be easily replaced.

Operating data and bearing dimensioning

Rope pull S	40 kN
Bearing load	
F = 2 · S	80 kN
Speed n	30 min^{-1}
Speed factor f_n	1.04
Bearings mounted	2 deep groove ball bearings FAG 6220
Dynamic load rating	C = 2 x 122 kN
Equivalent dynamic load	P = F/2 = 40 kN
Index of dynamic stressing	$f_L = C/P \cdot f_n$ = 122/40 · 1.04 = 3.17
Nominal rating life	L_h = 16,000 h

Usually, an *index of dynamic stressing* f_L = 2.5...3.5 is used for rope sheaves. This corresponds to a *nominal rating life* of 8,000 to 20,000 hours.
Thus the bearings are adequately dimensioned compared with established field applications.

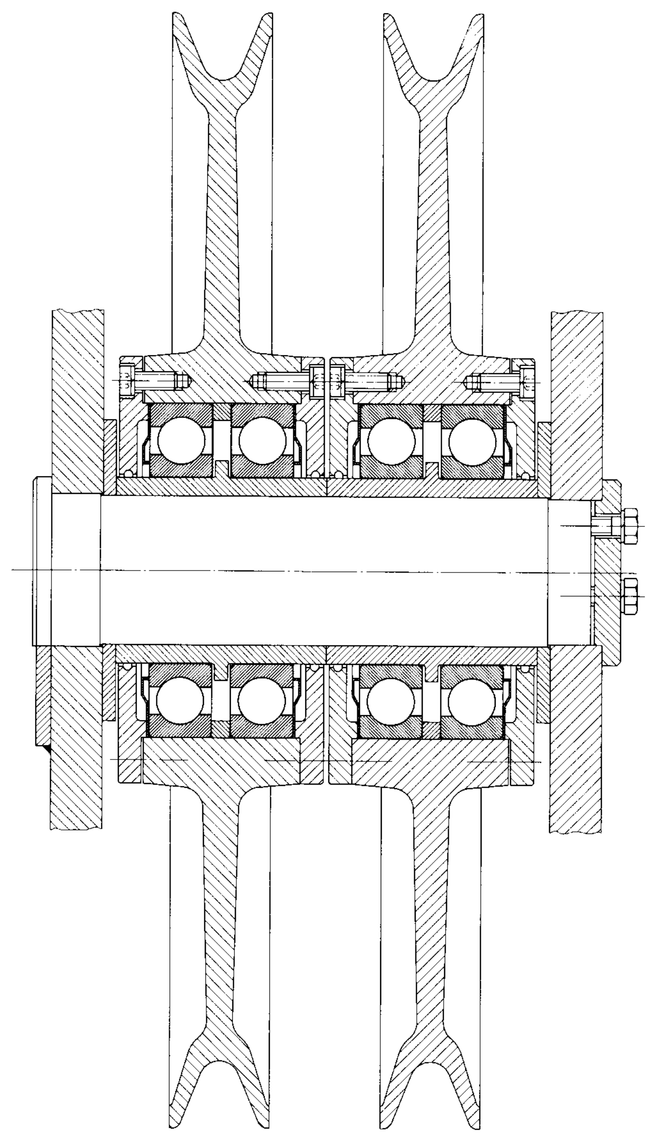
Machining tolerances

The mounting is a so-called hub mounting, i.e. the pulley, with the outer rings, rotates about a stationary shaft. The outer rings carry *circumferential load* and are press-fitted: hub to M7.
The inner rings carry *point load* allowing a loose *fit* or sliding fit: shaft sleeve to g6 or h6.

Lubrication, sealing

The sheave bearings are lubricated with lithium soap base *grease* of *penetration* class 3 (*Arcanol* L71V). High loads (load ratio P/C > 0.15) require a lithium soap base *grease* of *penetration* class 2 and *EP-additives* (*Arcanol* L186V). One *grease* filling normally lasts for several years.

The rope sheave in this example is sealed by spring steel *seals* (Nilos rings).



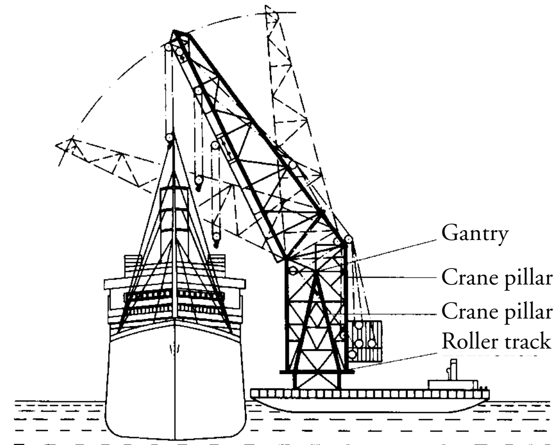
76: Rope pulleys with deep groove ball bearings

77–78 Gantry of a floating crane

Floating cranes are used in harbours for transportation of heavy and bulky goods, in shipyards for repair work and for ship outfitting. Due to their mobility they are an ideal complement to stationary cranes.

The pillar of the crane described is attached to the ship. The slewing gantry with the crane superstructure is supported on the crane pillar. The bearing mounting has to take up the weight of the superstructure and the payload. Since the common centre of gravity of payload and gantry is outside the pillar axis, a tilting moment is produced causing horizontal reaction forces in the bearings at the upper and lower pillar end.

At the upper pillar end the gantry runs on the so-called pillar bearing mounting. It consists either of one single spherical roller thrust bearing or one spherical roller bearing combined with one spherical roller thrust bearing, depending on the amount of radial loading.



At the pillar foot the gantry is supported on a roller-track assembly (see example no. 79).

77 Crane pillar mounting with a spherical roller thrust bearing

Operating data

Thrust load (crane superstructure and payload) F_a = 6,200 kN; radial load (reaction forces resulting from tilting moment and wind pressure) F_r = 2,800 kN; speed n = 1 min^{-1}.

Bearing selection, dimensioning

The thrust load, consisting of the weight of the slewing superstructure and the payload, is much higher than the radial load resulting from the tilting moment and wind pressure. Therefore, the crane pillar bearing must have a high thrust load carrying capacity. Moreover, the bearing must be *self-aligning* to compensate for misalignment and elastic deformation unavoidable on these crane structures. Due to the low speed of 1 min^{-1} the bearing is chosen with regard to its static load carrying capacity.
A spherical roller thrust bearing FAG 294/630E.MB with a *static load rating* of C_0 = 58,500 kN; factor X_0 = 2.7 is selected.

For spherical roller thrust bearings under *combined load* the ratio F_r/F_a must be small in order to ensure that most of the rollers transmit loads. Condition: $F_r/F_a \leq 0.55$.

In this example

$F_r/F_a = 2{,}800/6{,}200 = 0.45$

Thus the *equivalent static load*

$$P_0 = F_a + X_0 \cdot F_r = F_a + 2.7 \cdot F_r = 6{,}200 + 2.7 \cdot 2{,}800 = 13{,}800 \text{ kN}$$

The *index of static stressing*

$f_s = C_0/P_0 = 58{,}500/13{,}800 = 4.24$

Thus, the requirement $f_s \geq 4$ for spherical roller thrust bearings (FAG catalogue WL 41 520) whose housing and shaft washers – as in this example – are fully supported is met.

With f_s values $\geq 4 ... \leq 6$ the shaft washer and the housing washer must be fully supported axially, and good radial support of the housing washer must also be provided.

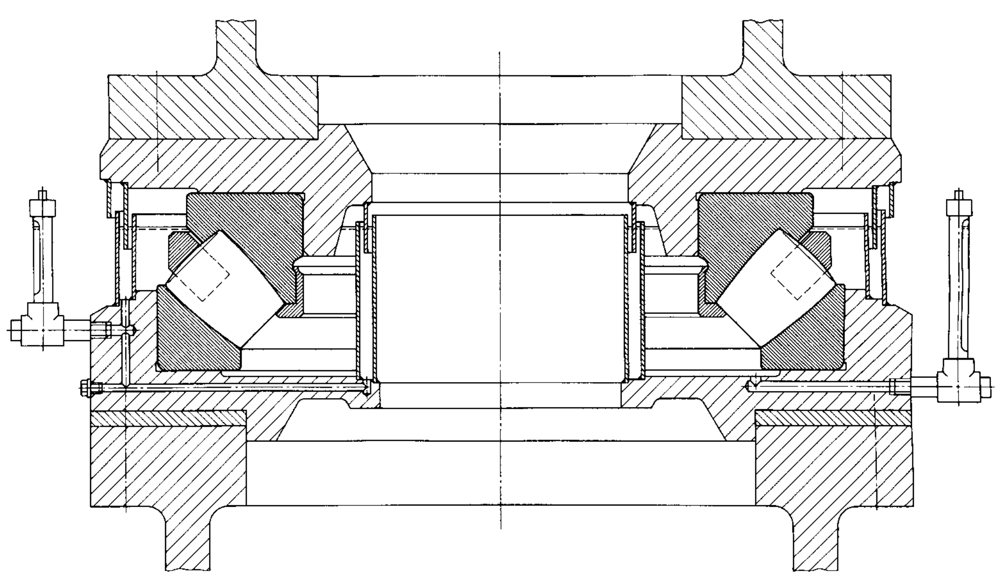
Machining tolerances

Shaft washer to j6; housing washer to K7

Lubrication, sealing

Oil bath lubrication, with the rollers fully immersed in *oil*. The *oil* level should be maintained to the upper edge of the shaft washer and is controlled by means of an *oil* level indicator.

Due to adverse ambient conditions existing for floating crane applications, high-efficiency *seals* must be provided (*oil*-filled labyrinths). The inner and the outer labyrinth are interconnectd by oil holes. The *oil* level in the labyrinths is also checked with an *oil* level indicator.



77: Crane pillar mounting with a spherical roller thrust bearing

78 Crane pillar mounting with a spherical roller thrust bearing and a spherical roller bearing

Operating data

Thrust load (crane superstructure and payload) F_a = 1,700 kN; radial load (reaction forces resulting from tilting moment and wind pressure) F_r = 1,070 kN; speed n = 1 min^{-1}.

Bearing selection, dimensioning

In this case $F_r/F_a > 0.55$. The radial load is relatively high. Therefore, it is accommodated by an additional radial bearing, a spherical roller bearing. The two bearings are mounted so that their pivoting centres coincide. Thus angular alignability is ensured. A thrust washer inserted between the two bearings prevents excessive radial loading on the *thrust bearing*. The spherical roller bearing size depends on that of the spherical roller thrust bearing. The outside diameter of the *radial bearing* must be larger than the housing washer of the *thrust bearing*. To ensure close guidance of the crane superstructure, the reduced *radial clearance* C2 is provided for the *radial bearing*.
Crane pillar mountings with one spherical roller bearing and one spherical roller thrust bearing provide compact designs. They require, however, a wider mounting space than mountings with one single spherical roller thrust bearing.
The mounting features a spherical roller thrust bearing FAG 29440E with the *static load rating* C_0 = 8,500 kN and a spherical roller bearing FAG 23056B.MB.C2 with the *static load rating* C_0 = 3,000 kN.
For calculating the *equivalent static load* for the spherical roller thrust bearing it is assumed that the friction at the thrust washer, acting as a radial load, is 150 kN. Thus $F_r/F_a < 0.55$ for the spherical roller thrust bearing.

Equivalent static load:

$$P_0 = F_a + X_0 \cdot F_r = F_a + 2.7 \cdot F_r \quad \text{for } F_r \leq 0.55\, F_a$$
$$= 1{,}700 + 2.7 \cdot 150 = 2{,}100 \text{ kN}$$

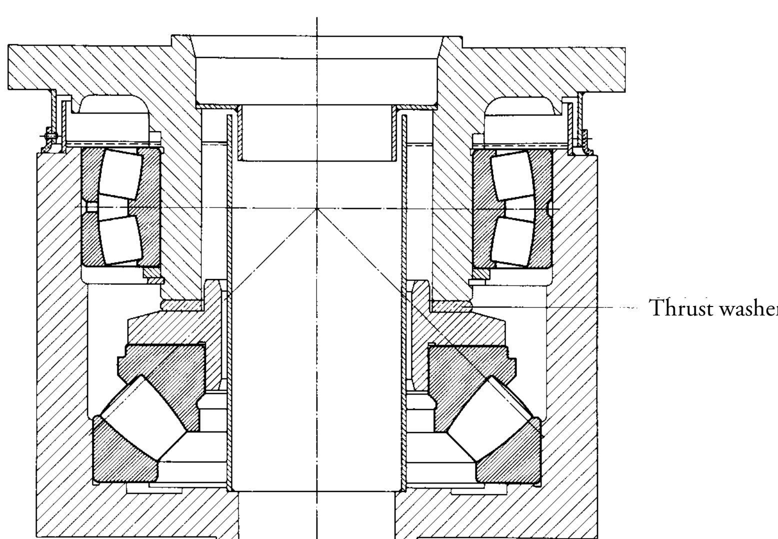
For the spherical roller bearing:
$P_0 = F_r$ = 1,070 kN
Hence the *indices of static stressing* $f_s = C_0 / P_0$ are:
Spherical roller thrust bearing = 8,500 / 2,100 = 4.05
Spherical roller bearing = 3,000 / 1,070 = 2.8
These values show that the bearings are safely dimensioned.
The shaft washer and housing washer of spherical roller thrust bearings with f_s values of ≥ 4...≤ 6 must be fully supported axially; good radial support of the housing washer is also required.

Machining tolerances

Spherical roller thrust bearing:
Shaft washer to j6,
housing washer to K7
Spherical roller bearing:
shaft to j6; housing to J7

Lubrication, sealing

The bearing housing is filled with *oil* beyond the upper edge of the spherical roller bearing, i.e. the bearings run in an oil bath. Thus they are well protected against condensation water and corrosion.
Outer *sealing* is provided by labyrinths. In view of the adverse ambient conditions an additional, rubbing *seal* with elastic lip is provided. Inner sealing is effected by the tube communicating with the housing, and a labyrinth.



78: Crane pillar mounting with a spherical roller thrust bearing and a spherical roller bearing

79 Roller track assembly

The radial bearing mounting at the pillar foot consists normally of several rollers travelling on a circular track. Each of these rollers is supported by two bearings, the upper bearing being the *locating bearing*, the lower one the *floating bearing*.

Operating data

The maximum load on one roller is 2,200 kN. Thus, each bearing is loaded with P_0 = 1,100 kN.

Bearing selection, dimensioning

The rollers transmit only the horizontal loads resulting from the tilting moment. To cater for the misalignment conditions inherent in structural steelwork and for wheel axle deflection, *self-aligning bearings* have to be provided.

Spherical roller bearings FAG 23230ES.TVPB with *static load rating* C_0 = 1,630 kN are mounted. With an *equivalent static load* P_0 = 1,100 kN an *index of static stressing*

$f_s = C_0/P_0$ = 1,630 / 1,100 = 1.48

is calculated.

This value meets the requirements for smooth running of the bearing.

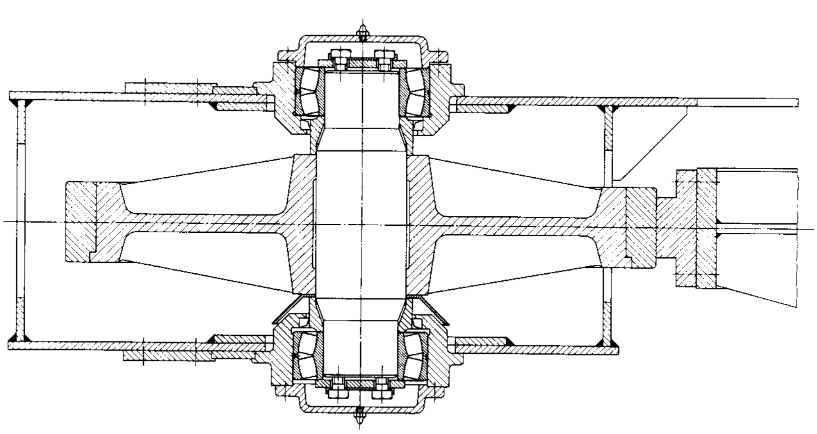
Machining tolerances

The inner rings carry *circumferential load* and are fitted tightly.
Shaft to k6; housing to H7.

Lubrication, sealing

The bearings and housing cavities are packed to capacity with a lithium soap base *grease* with *EP additives* (FAG rolling bearing grease *Arcanol* L186V). Relubrication is possible through lubricating nipples in the housing cover.

Outer *sealing* is provided by the housing cover, inner sealing by a shaft seal ring. A flinger ring between roller and lower bearing additionally protects the lower shaft seal ring against dirt and rubbed-off particles.



79: Roller-track assembly

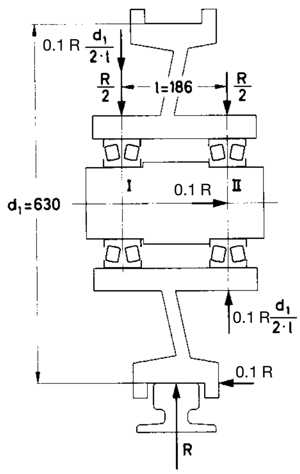
Crane run wheels

Bearings in crane run wheels have to accommodate the heavy loads resulting from the deadweight of the crane and the payload, and axial and radial reaction loads resulting from the axial guiding loads between wheel flange and rail.

80 Crane run wheel

Operating data

Wheel load R = 180 kN; operating speed $n = 50\ min^{-1}$; wheel diameter d_1 = 630 mm; bearing centres l = 186 mm.



Bearing selection

The bearings fitted in run wheels are often designed as hub mountings. The run wheel rotates, together with the bearing outer rings, about a stationary shaft. Spherical roller bearings are used because of their very high load carrying capacity.

The bearings fitted are two spherical roller bearings FAG 22220E. The distance between the two bearings should not be too small in order to keep the bearing reaction loads resulting from the wheel-rail contact within reasonable limits.
This bearing arrangement is standardized by DIN 15 071. The two spherical roller bearings run on a sleeve to allow for rapid replacement of the complete run wheel unit. It is a *floating bearing arrangement,* the inner rings being displaceable on the sleeve. Depending on the thrust load direction, either the left-hand or the right-hand bearing abuts the sleeve collar. This arrangement allows optimum bearing loading, since the bearing which accommodates the additional thrust loads is relieved of radial load due to the tilting moment from the thrust load.

Bearing dimensioning

The weight of the crane and the maximum payload are known. The thrust acting between wheel and rail can, however, only be estimated. The *equivalent dynamic load* P acting on the bearings is calculated in accordance with DIN 15 071; this standard specifies the thrust resulting from friction between wheel and rail to be 10 % of the radial load. The bearing loads P_I (bearing I) and P_{II} (bearing II) are:

$$P_I = X \cdot [R/2 + 0.1 \cdot R \cdot d_1 / (2 \cdot l)]$$

$$P_{II} = X \cdot [R/2 - 0.1 \cdot R \cdot d_1 / (2 \cdot l)] + Y \cdot 0.1 \cdot R$$

With the radial factor X = 1 and e = 0.24 for $F_a/F_r \le e$ the thrust factor Y = 2.84.

Thus $P_I = 90 + 18 \cdot 630/372 = 120.5\ kN = P_{max}$

$P_{II} = 90 - 30.5 + 2.84 \cdot 18 = 110.6\ kN = P_{min}$

Assuming that the bearing loads vary linearly between P_{min} and P_{max},

$$P = (P_{min} + 2 \cdot P_{max})/3 = (110.6 + 241)/3 = 117.2\ kN$$

With the *dynamic load rating* C = 360 kN and the *speed factor* f_n = 0.885 ($n = 50\ min^{-1}$) the *index of dynamic stressing*

$$f_L = C/P \cdot f_n = 360/117.2 \cdot 0.885 = 2.72$$

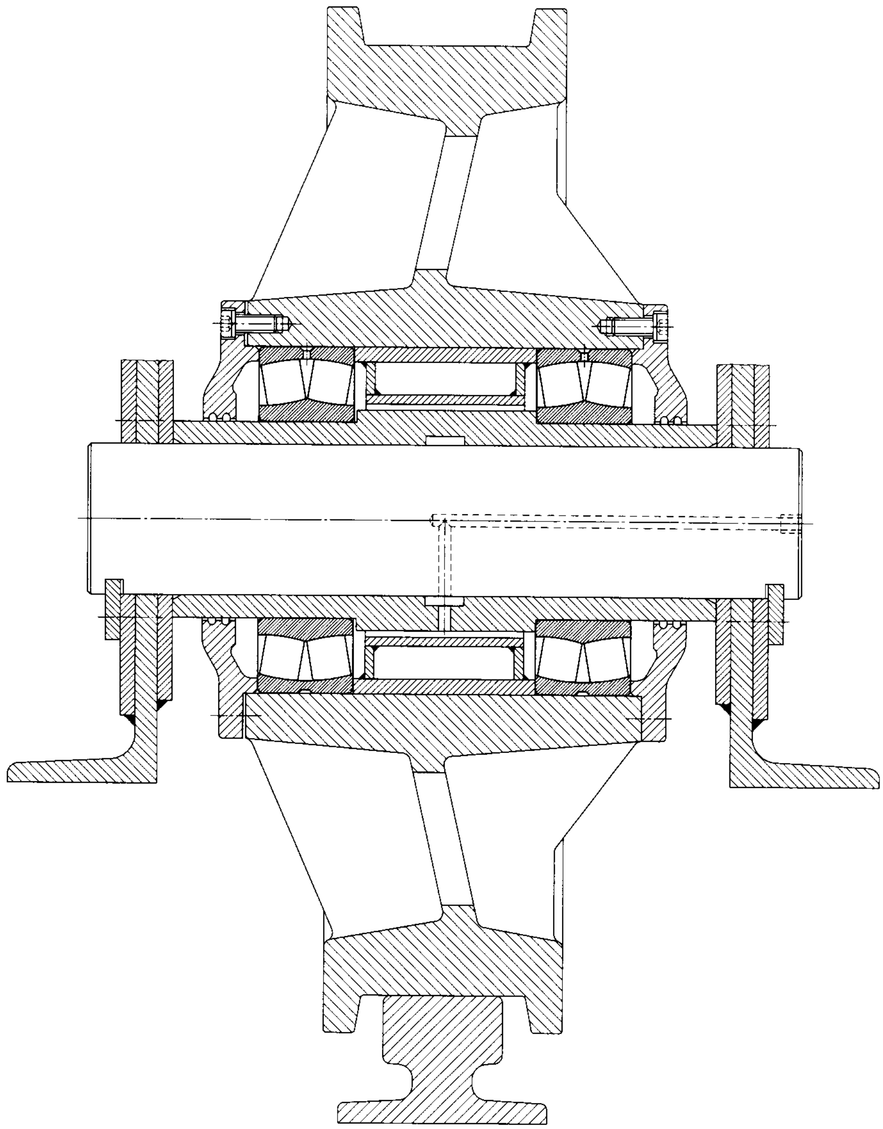
With the generally recommended value for crane run wheels f_L = 2.5...3.5, the bearing mounting is adequately dimensioned.

Machining tolerances

The bearing outer rings, which carry *circumferential load,* are tight *fits.* The hub is machined to M7, the sleeve to g6, thus providing for a slide *fit* for the inner rings. This prevents detrimental axial preloading and simplifies bearing mounting and dismounting.

Lubrication, sealing

The bearings are lubricated with a lithium soap base *grease* with *EP additives* (FAG rolling bearing grease *Arcanol* L186V). The *relubrication interval* is approximately one year.
Gap-type *seals* or simple rubbing *seals* are in most cases satisfactory.



80: Crane run wheel with spherical roller bearings

81 Crane hook

The load suspended from a crane hook often has to be swivelled before being lowered. Therefore, the hooks of heavy-duty cranes are designed for these swivelling motions.

Bearing selection, dimensioning

Since the weight of the payload acts vertically downward, the load is pure thrust. Therefore, loose radial guidance of the shaft in the crosshead is satisfactory.

The load carrying capacity of the bearing is based on its *static load rating*. A thrust ball bearing FAG 51152FP with a *static load rating* C_0 = 1,020 kN is mounted. Based on the maximum hook load of 1,000 kN plus a safety margin of 10 %, the *index of static stressing* $f_s = C_0/P_0$ = 1,020 / 1,100 = 0.93; i. e., permanent deformation occurs at maximum load. However, it is so small that it does not interfere with the swivelling of the load.

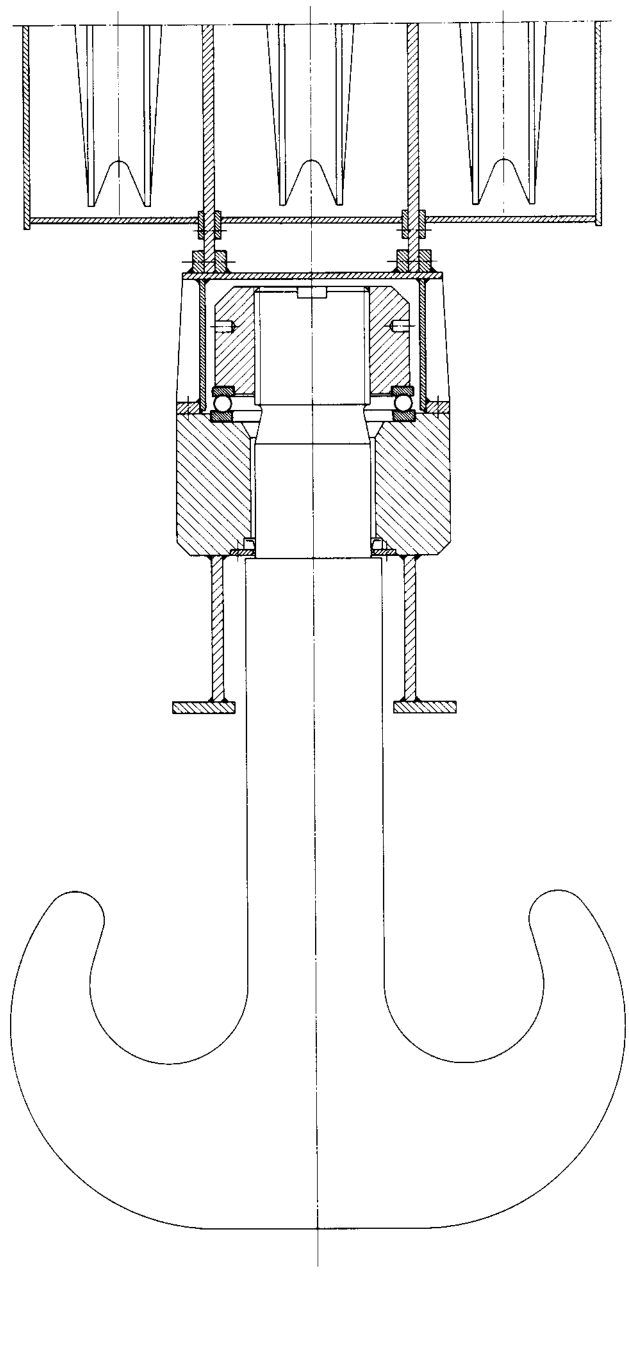
The bearing is *adjusted* against the collar at the hook shaft by means of a locknut. This prevents the shaft washer from separating when the crane hook is set on the ground.

Machining tolerances

The bearing seats are machined to j6 (washer) and to H7 (housing).

Lubrication, sealing

The bearing assembly is packed to capacity with lithium soap base *grease* with *EP additives* (FAG rolling bearing grease *Arcanol* L186V). Maintenance of the bearing is not required. Above the crane hook nut a sheet steel cap is provided which protects the bearing against contamination.



81: Crane hook mounting

82 Mast guidance bearings of a fork lift truck

The fork lift carriage must run smoothly in order to handle the live loads efficiently. This requirement is satisfied by mast guide rollers and chain return sheaves.
Mast guide rollers (HMFR) and chain sheaves (KR) of modern fork lift trucks are largely fitted with double-row angular contact ball bearings.

Bearing selection, bearing design

Mast guide rollers
FAG HMFR30x75x20.75 are preferably used for fork carrier and lifting frame. They can accommodate radial loads, thrust loads and the moments resulting from these. The mast guide rollers feature thick-walled outer rings and can, therefore, accommodate even high, shock-type loads.
The profile and dimensions of the outer ring are largely dictated by the standardized U-beam dimensions.

Chain sheaves
Chain sheaves FAG KR30x75x28/27 are attached to the hydraulically actuated upper section of the mast and serve to deflect the pull chain.

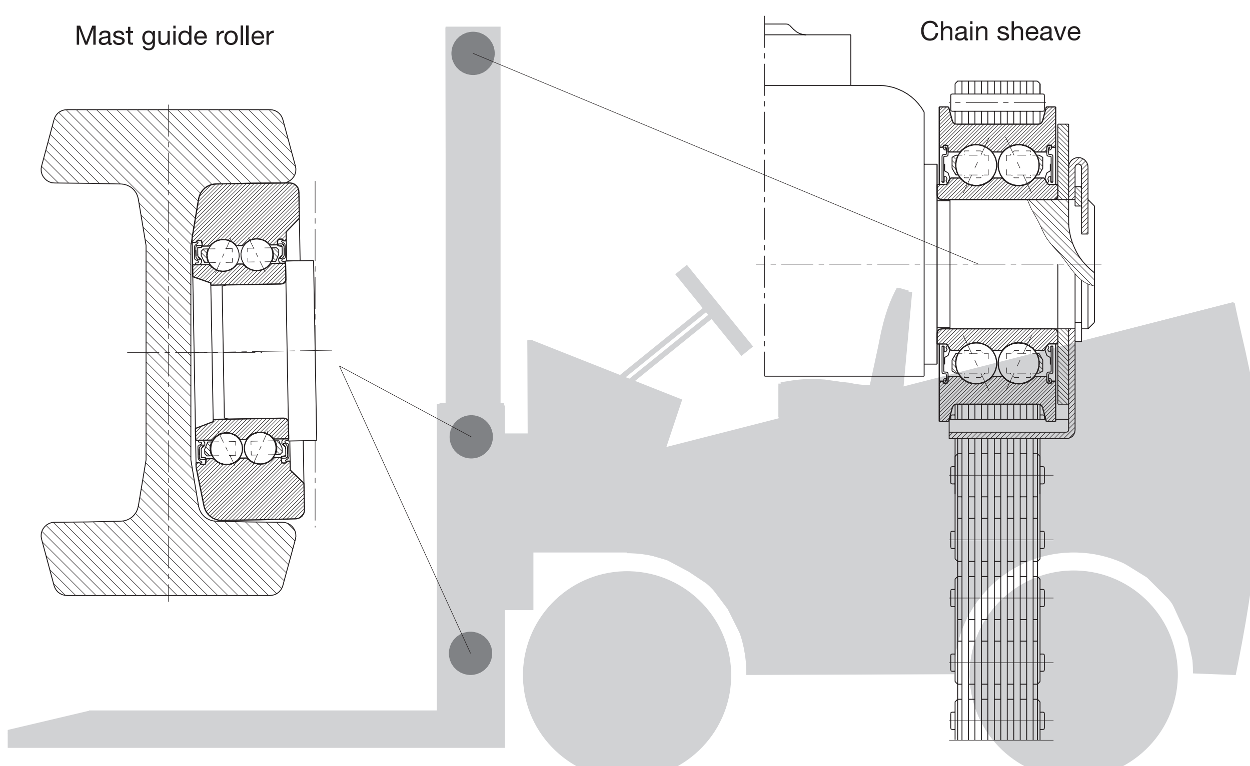
Due to their relatively thick-walled outer ring, the bearings can accommodate high radial loads made up of the deadweight of the fork lift carriage, including fork and live load. The outer ring profile is dictated by the pull chain used; lateral guidance is provided by the two lips. The distance between the two ball rows, together with the *contact angle,* provides for a wide *spread* so that the return sheaves can also accommodate tilting forces and axial guiding forces.
Roller mounting is simple; they are simply placed on the pin; axial preloading by a screw is not required. Chain return sheaves are axially locked.

Machining tolerances

The inner rings of der mast guide rollers and return sheaves carry *point load,* thus a loose *fit* is satisfactory. The pin is machined to j6.

Lubrication, sealing

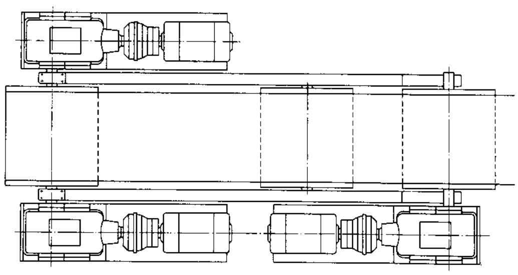
The bearings are lubricated for *life* with a lithium soap base *grease* (*EP additives*).
Sealing is provided by single- or double-lip RSR *seals.*



82: Mast guide roller and chain return sheave for a fork lift truck

83 Head pulley of a belt conveyor

One head pulley is not sufficient for very long belts, steeply inclined belts or heavily loaded belts. In such cases several head pulleys are mounted in tandem. In this application, two head pulleys are arranged at the drive station. Three identical driving motors are used: the first pulley is driven from both ends, the second one from one end only.



Operating data

Power consumption 3 x 430 kW; belt width 2,300 mm; belt speed 5.2 m/s; conveying capacity 7,500 m^3/h; pulley diameter 1,730 mm.

Bearing selection, dimensioning

The shaft of the head pulley is supported on plummer blocks. The shaft diameter is dictated by strength considerations, thus determining the bearing bore and housing size. Spherical roller bearings FAG 23264K.MB are mounted. The one-piece plummer block housings FAG BND3264K are made of cast steel GS-45. One of the plummer blocks acts as the *locating bearing,* the other one as the *floating bearing.* To simplify mounting and dismounting hydraulic sleeves are used.

With an *index of dynamic stressing* $f_L \approx 4$ the bearings are adequately dimensioned compared to field-proven bearing arrangements. Often the *bearing life* is limited by wear on *rolling elements* and raceways and is generally shorter than the *nominal rating life* (approx. 50,000 h), calculated with the *index of dynamic stressing* f_L. Improved cleanliness during mounting and operation, and a suitable lubricant, reduce *wear,* thus increasing the *bearing life.* These influences are taken into account in the *adjusted rating life calculation* by the *factor* a_{23}.

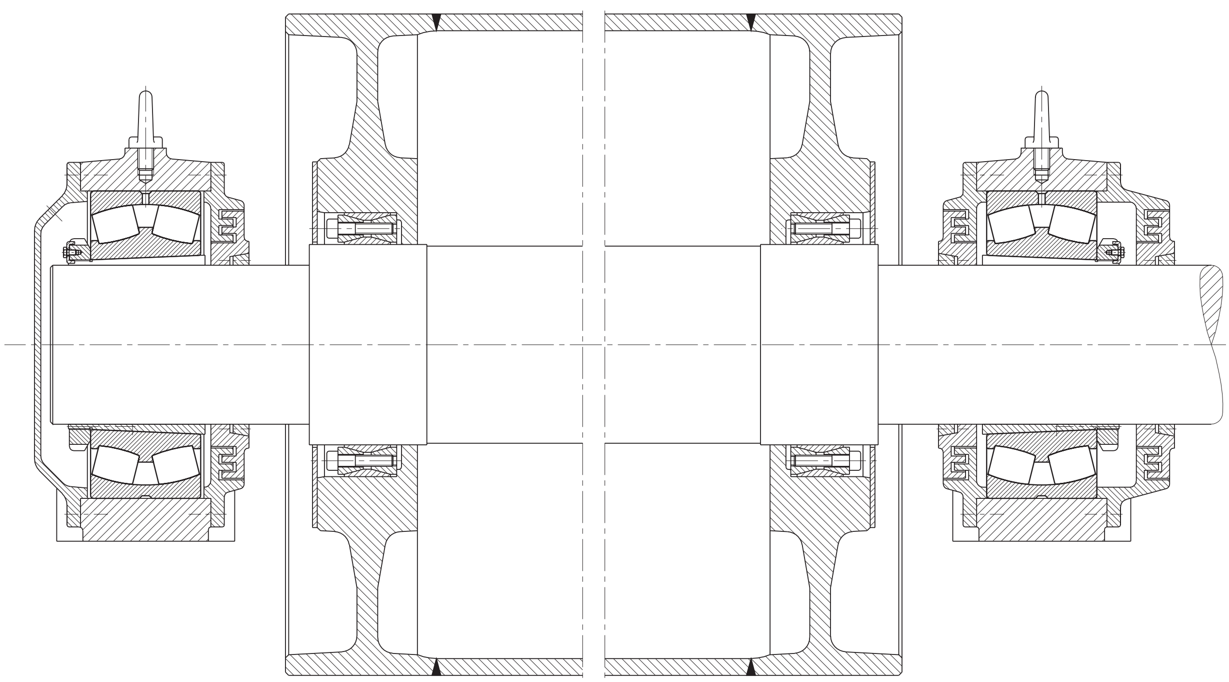
Machining tolerances

The bearing inner rings carry *circumferential load.* They are fitted on the shaft with adapter sleeves FAG H3264HG.
Shaft to h8 and cylindricity tolerance (DIN ISO 1101) IT5/2; housing bore to H7.

Lubrication, sealing

Grease lubrication with a lithium soap base grease of *penetration* class 2 with *EP additives* (FAG rolling bearing grease *Arcanol* L135V or L186V).

The housing covers and rings on the shaft form non-rubbing labyrinth *seals.* These multiple labyrinths are filled with the same *grease* as the bearings and prevent penetration of foreign matter. In very dusty environments relubrication at short intervals is required. *Grease* is injected into the bearing until some of the spent grease escapes from the labyrinths.



83: Head pulley bearing arrangement of a belt conveyor

84 Internal bearings for the tension/ take-up pulley of a belt conveyor

Non-driven pulleys in belt conveyors are frequently fitted with internal bearings. The bearings are integrated into the pulley so that the pulley body revolves about the stationary shaft.

Operating data

Belt width 3,000 mm; belt speed 6 m/s; pulley diameter 1,000 mm; pulley load 1,650 kN.

Bearing selection, dimensioning

These pulleys are supported either in two spherical roller bearings (fig. a) or in two cylindrical roller bearings (fig. b). The internal design of the cylindrical roller bearings allows the *rolling elements* to accommodate load-related shaft deflections without edge running.

In a spherical roller bearing arrangement, an FAG 23276BK.MB with an adapter sleeve FAG H3276HGJ is used as *locating bearing* and an FAG 23276B.MB is used as *floating bearing.*

In a cylindrical roller bearing arrangement, the *floating bearing* is an FAG 547400A and the *locating bearing* an FAG 544975A. Both cylindrical roller bearings have the main dimensions 360 x 680 x 240 mm and are interchangeable with spherical roller bearings FAG 23276BK.MB with an adapter sleeve FAG H3276HGJ.

The bearings must feature the required *dynamic load rating* C/the required bore diameter. With an *index of dynamic stressing* $f_L > 4$, the bearings are sufficiently dimensioned with regard to *fatigue life.*

Often, the actual *bearing life* is considerably shorter than the *nominal rating life* determined on the basis of the f_L value. The cause is *wear* in raceways and on *rolling elements* as a result of adverse ambient conditions. Improved cleanliness during mounting and in operation as well as the utilization of a suitable lubricant have a positive effect on the *bearing life.* These influences are taken into account in the a*djusted rating life calculation* and in the *modified life calculation* in accordance with DIN ISO 281. It is used for example to compare the effects of different lubricants. The *fatigue life* calculated for pulley bearings with this method in most cases is not equivalent to the *attainable life* as the *service life* is mainly limited by *wear.*

Machining tolerances

In view of the *circumferential load* and the relatively high amount of load the outer rings must be a very tight *fit* in the pulley bore. Tolerances, see table below.

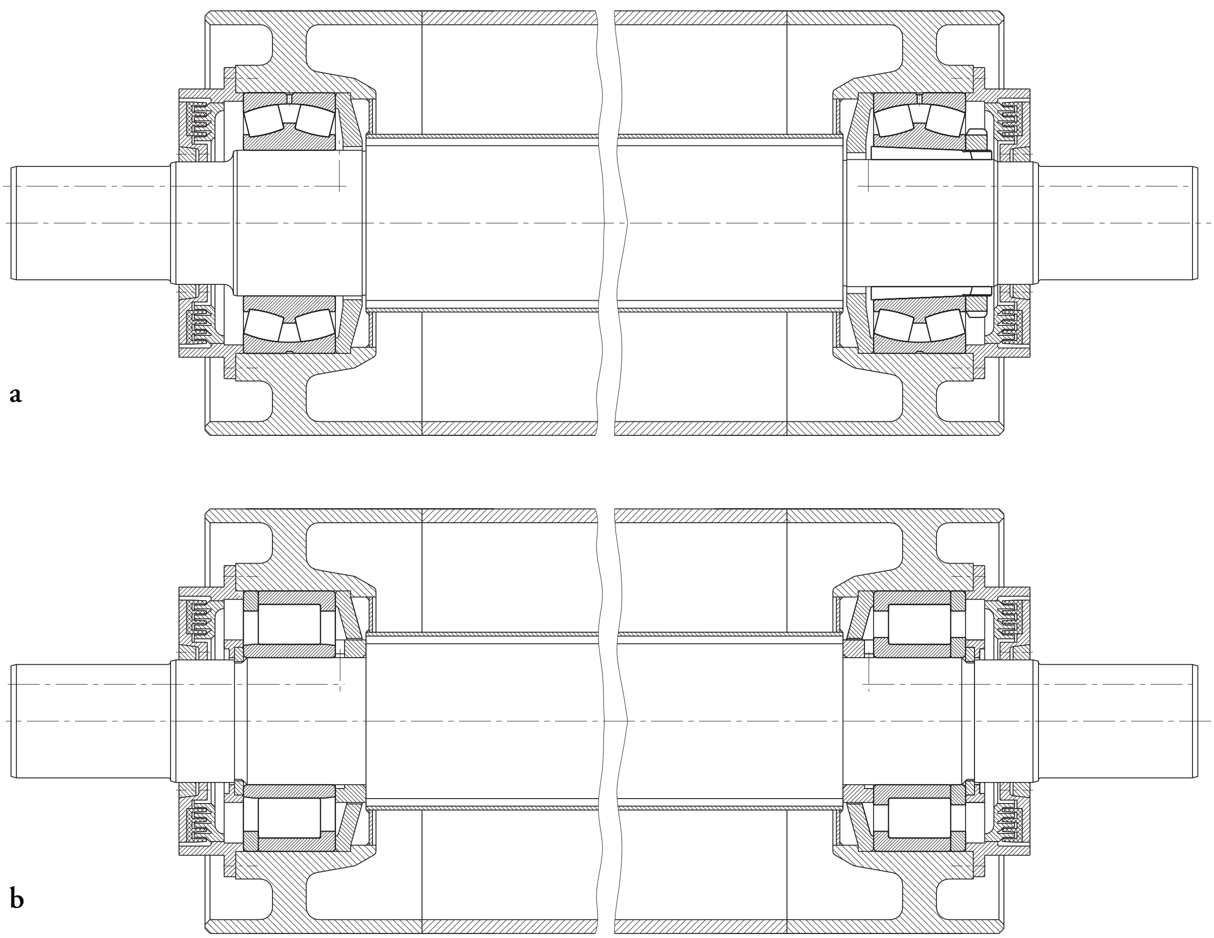
Lubrication, sealing

The bearings are lubricated with a lithium soap base *grease* of *penetration* 2 with *EP additives* (FAG rolling bearing grease *Arcanol* L186V).

External *sealing* of the bearings is provided by non-rubbing labyrinth *seals* or multi-collar rubbing seals. In both cases the labyrinths are filled with the same *grease* as the bearings. To supply the bearings with fresh grease and to increase the sealing effect, relubrication is effected at short intervals (depending on the amount of dirt) via the stationary shaft.

Machining tolerances

Bearing	Seat	Diameter tolerance	Cylindricity tolerance
Spherical roller bearing as *locating bearing*	Shaft Pulley bore	h8 M7	IT5/2 IT5/2
Spherical roller bearing as *floating bearing*	Shaft Pulley bore	g6 M7	IT5/2 IT5/2
Cylindrical roller bearing *locating bearing, floating bearing*	Shaft Pulley bore	g6 N7	IT5/2 IT5/2



84: Internal bearings for the tension / take-up pulley of a belt conveyor

Belt conveyor idlers

Many industries use belt conveyors for transporting bulk materials. The conveyors run on idlers and may extend over many miles; thus the number of idlers needed may be very large. Consequently, bearing mounting design is dictated by cost-saving considerations.

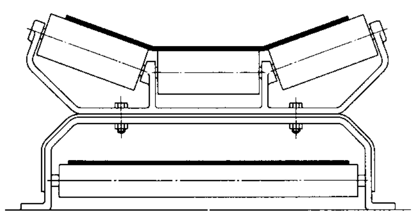
Idler arrangement

Small belt conveyor systems feature idlers rigidly linked to a frame. Large belt conveyor systems feature idler garlands linked to each other by flexible joints.

85 Rigid idlers

Operating data

Capacity I_m = 2,500 t/h; Design: troughed belt with three idlers per station; the two outer idlers are arranged at an angle of 30° to the horizontal; distance between two idler stations l_R = 1,200 mm; idler diameter d = 108 mm, belt weight G_G = 35 kg/m, deadweight per roller G_R = 6 kg; belt speed v = 3 m/s; acceleration due to gravity g = 9.81 m/s².



Bearing selection

Idler mountings are usually internal bearing arrangements (hub mountings), i.e. the idler rotates about a stationary shaft.
Since a belt conveying plant requires a large number of roller bearings, deep groove ball bearings, which are produced in large quantities at low cost, are preferably used. This allows a simple and economical idler design.

Bearing dimensioning

Idler speed $n = \dfrac{v \cdot 60 \cdot 1{,}000}{d \cdot \pi} = 530 \text{ min}^{-1}$

For ball bearings, the *speed factor* f_n = 0.4.

Load per idler station:

$$F = g \cdot l_R \cdot \left(\frac{I_m}{3.6 \cdot v} + G_G\right) =$$

$$= 9{,}81 \cdot 1{,}2 \cdot \left(\frac{2{,}500}{3.6 \cdot 3} + 35\right) = 3{,}137 \text{ N}$$

For a trough angle of 30° the horizontal centre idler takes up approximately 65 % of this load. Thus the load on the centre idler is

$$F_R = 0.65 \cdot F + g \cdot G_R = 0.65 \cdot 3{,}137 + 9.81 \cdot 6 =$$
$$= 2{,}100 \text{ N} = 2.1 \text{ kN}$$

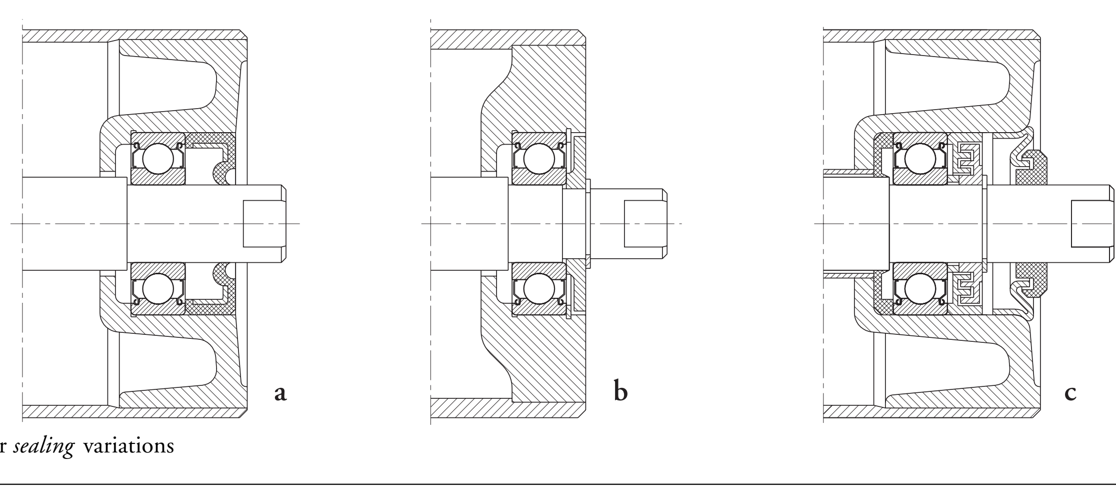
Equivalent dynamic bearing *load:*

$P = F_r = F_R/2 = 1.05$ kN

The usual *index of dynamic stressing* for idler bearings f_L = 2.5...3.5. With f_L = 3, the required *dynamic load rating* C of a bearing

$C = f_L \cdot P/f_n = 3 \cdot 1.05/0.4 = 7.88$ kN

Deep groove ball bearings FAG 6204.2ZR.C3 having a *dynamic load rating* C = 12.7 kN are mounted.



85a...c: Idler *sealing* variations

86 Idler garland

Generally, the *service life* of a bearing is not terminated by fatigue but by *wear* in raceways and on *rolling elements* as a result of contamination. Increased cleanliness during mounting and efficient *sealings* increase the *bearing life.* The *ajdusted rating life calculation* is used for comparing different *seal* designs.
New idler bearings feature utmost cleanliness (V = 0.3). However, in the course of operation the lubricant gets heavily contaminated by particles (V = 3).
As the bearings in belt conveyor systems fail as a result of *wear,* the values obtained by the *adjusted rating life calculation* (L_{hna}) usually are not equivalent to the actually attainable lives.

Machining tolerances

The two deep groove ball bearings are mounted onto the idler shaft in a *floating bearing arrangement.* As the inner rings are subjected to *point load* the shaft is machined to h6 or js6. The outer rings are subjected to *circumferential load* and are pressed, therefore, into the idler end with an M7 interference *fit.*

Lubrication, sealing and maintenance

The deep groove ball bearings FAG 6209.2ZR.C3 are packed, at the manufacturing plant, with a lithium soap base *grease* of *penetration* class 2 which is sufficient for the entire *bearing service life.* Such a *grease* is also used for the *sealing.*
With idler bearings, both the *attainable life* and the lubricant *service life* may be considerably reduced by *grease* contamination during operation so that the *sealing* selected is decisive. Figs. 85a...c show various types of *sealing* for belt conveyor idlers.
Simple *seals* (figs. 85a and b) are used for clean environments. Fig. 85c shows an idler *seal* for brown coal open pit mining.

In addition to the rigidly troughed belt conveyors the garland type belt conveyors are being increasingly used. The idlers of each station are linked to each other by flexible joints. These joints may consist of a wire rope, a chain link (flat chain, round chain), hinge or similar.
Idler garlands accommodate impacts elastically; in the event of problems with a roller the individual garland is lowered and can be replaced relatively easily if necessary.

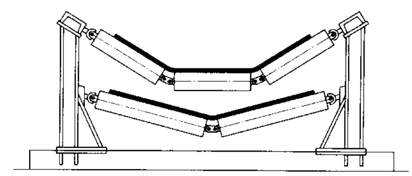


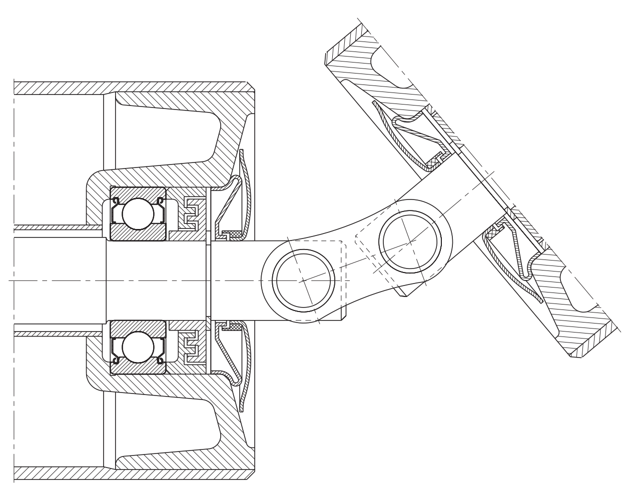
Fig. 86 shows idler garlands connected by chain links. These idlers are part of a conveying installation for rock phosphate. The bearings fitted are deep groove ball bearings FAG 6303.2ZR.C3.

Machining tolerances

Idler ends to M7, shaft to h6 or js6.

Lubrication, sealing, maintenance

The deep groove ball bearings (design .2ZR) are *sealed* by dust shields on both sides and filled with FAG rolling bearing *grease,* a lithium soap base grease of *penetration* class 2. The grease filling suffices for idler *service life.* A grease chamber with a non-rubbing labyrinth seal is provided at the outboard end. The second, adjacent chamber is closed by a shield pressed into the hub bore. A baffle plate protects the bearing against coarse particles.



86: Idlers connected by chain link

87 Bucket wheel shaft of a bucket wheel excavator

Bucket wheel excavators are mainly used for brown coal open pit mining. The bucket wheel shaft carries the bucket wheel, the bull gear and the transmission housing. It is supported in the boom ends.

Operating data

Input power 3 x 735 kW; theoretical conveying capacity 130,000 m^3 / day; bucket wheel speed 3 min^{-1}.

Bearing selection

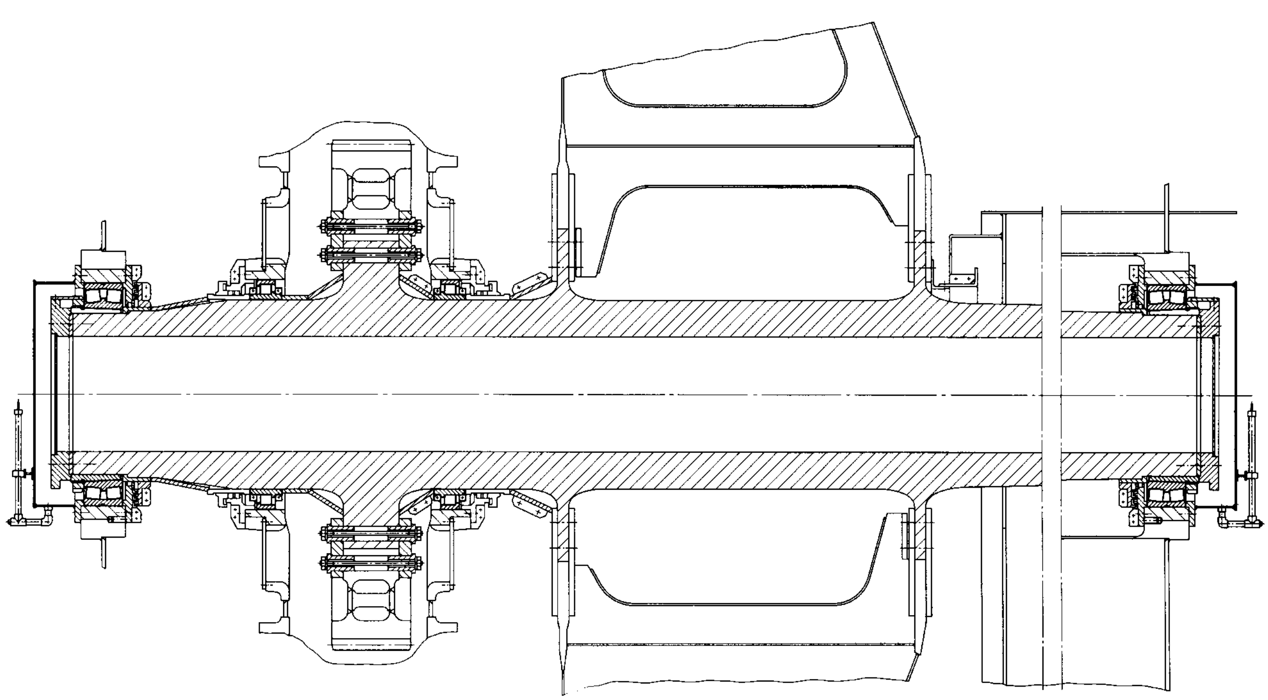
The bearings of the bucket wheel shaft are subjected to high shock-type loads. Moreover, shaft deflections and misalignments must be expected. For this reason, only *self-aligning* roller bearings are suitable for supporting the shaft. At both shaft ends, spherical roller bearings FAG 239/900K.MB with withdrawal sleeves FAG AH39/900H are mounted as *locating bearings.* Thermal length variations of the shaft are compensated for by the elastic surrounding structure. The *radial clearance* of the spherical roller bearings is eliminated during mounting by pressing in the withdrawal sleeves. Only a split bearing can be provided on the bucket wheel side of the transmission box due to the solid forged shaft flange to which the bull gear is attached. If an unsplit bearing were to be provided on the opposite side of the transmission box it could only be replaced after dismounting the spherical roller bearing first. For this purpose the entire bucket wheel shaft would have to be removed from the boom. This is avoided by using a split FAG cylindrical roller bearing of dimensions 1,000 x 1,220 x 170/100 mm on this side as well. The increased *axial clearance* of the two cylindrical roller bearings yields a *floating bearing arrangement.* Each bearing accommodates axial guiding loads in only one direction. The inner ring halves are attached to the shaft by means of separate locking rings. The calculated *nominal rating life* of all bearings is over 75,000 hours.

Machining tolerances

All inner rings are subjected to *circumferential load.* The spherical roller bearings FAG 239/900K.MB are hydraulically fastened to the shaft (machined to h8) by means of withdrawal sleeves FAG AH39/900H. The split cylindrical roller bearings sit directly on the shaft which is machined to m6 in this place. All outer ring seats are toleranced to H7.

Lubrication, sealing

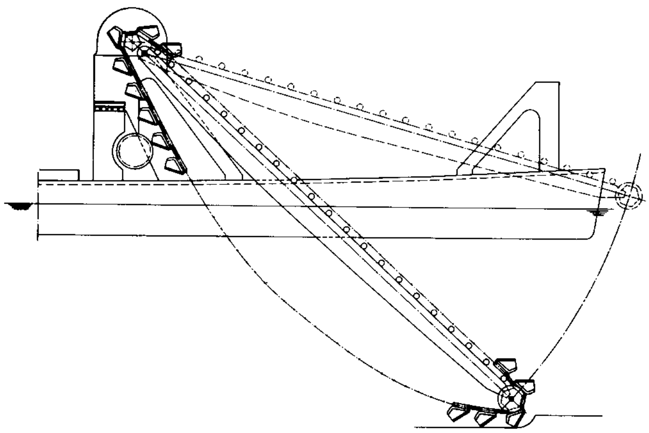
The spherical roller bearings are *oil*-bath lubricated. The split cylindrical roller bearings are supplied by the draining *oil* from gearwheel lubrication.
The *sealing* is a combination of labyrinth and rubbing *seal.* The labyrinths at the spherical roller bearings can be relubricated.



87: Bucket wheel mounting

88 Bottom sprocket of a bucket chain dredger

Bucket chain dredgers perform dredging work in waterways. The buckets are carried by a continuous chain from the bottom sprocket to the top sprocket over a large number of support rolls and back.



Operating data

Ladder length 32 m; number of buckets 44; maximum dredging depth approximately 14 m; radial load on bottom sprocket approximately 250 kN.

Bearing selection

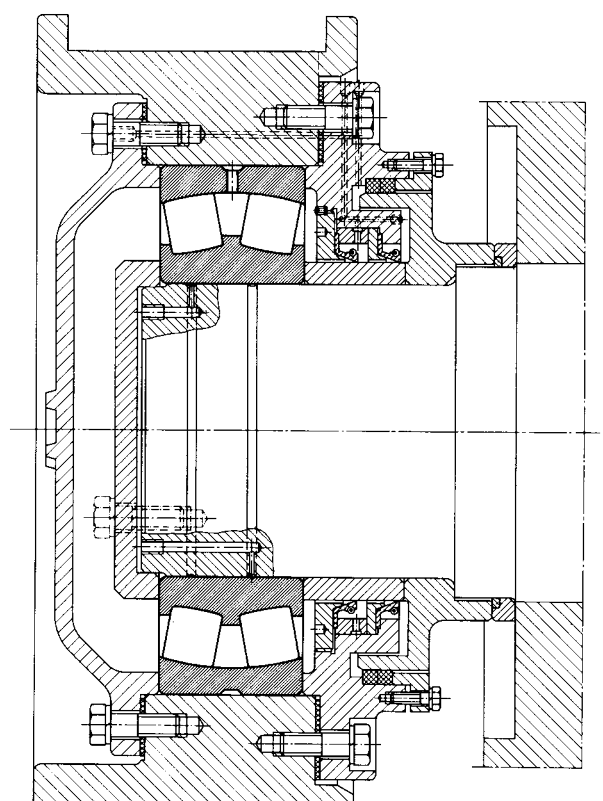
Rugged operation and unvoidable misalignment between the housings at both ends of the sprocket shaft call for *self-aligning bearings.* The bearings used are spherical roller bearings FAG 22240B.MB. Both bottom sprocket shaft bearings are designed as *locating bearings.* However, the bearings are not nipped axially, the housing being mounted with clearance in its ladder yoke seat. For easier bearing dismounting the shaft journal is provided with oilways and grooves for hydraulic dismounting.

Machining tolerances

Circumferential load on the inner ring.
Shaft journal to m6; housing to J7.

Lubrication, sealing

The *grease* in the bearing (FAG rolling bearing *grease Arcanol* L186V) is renewed at intervals of 1 1/2 to 2 years coinciding with the general overhaul period of the dredger.
The bottom sprocket is constantly immersed in water. This requires waterproof *sealing.* Each bearing location is, therefore, fitted with two rubbing *seals* (shaft seals with bronze garter spring) and, in addition, with two packing rings (stuffing box). The shaft seals run on a bush of seawater-resistant material. The stuffing box can be retightened by means of a cover. *Grease* is regularly pumped into the labyrinth between the shaft seals and packing rings.



88: Bottom sprocket of a bucket chain dredger

89 Drive unit of a finished goods elevator

Finished-goods elevators are used, for example, for charging salt granulating plants. The material is conveyed in buckets attached to a chain. The chain is driven by the tumbler situated at the upper end.

Operating data

Input power 22 kW; speed 13.2 min^{-1}; radial bearing load 90 kN.

Bearing selection

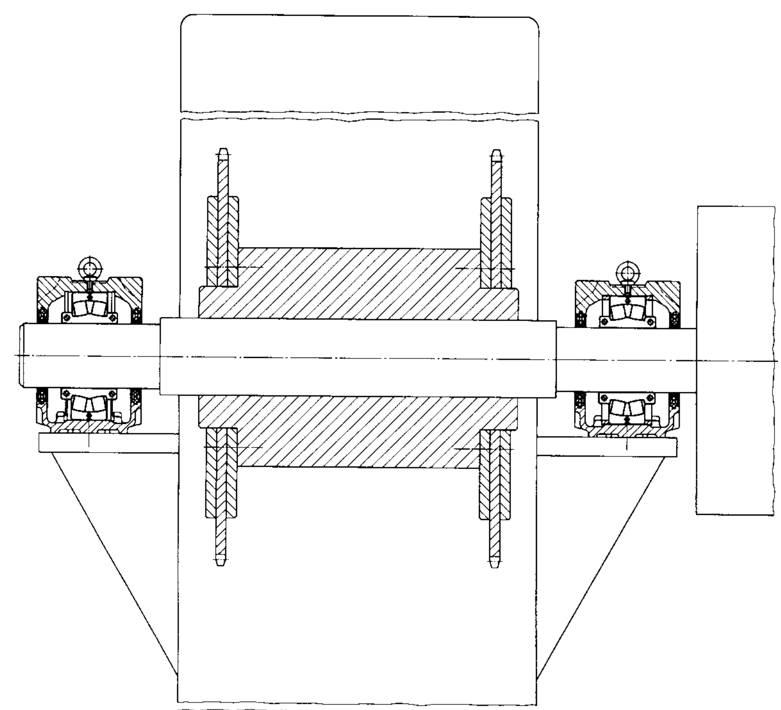
As shaft deflections and misalignments have to be expected the drive shaft is supported on *self-aligning bearings.* Selecting split spherical roller bearings FAG 222SM125T ensures that the heavy drive unit with the torque arm does not have to be dismounted in the event of repair.
As a result, the downtimes of the plant and the cost of production loss are considerably lower than they would be with one-piece bearings. To limit the variety of bearings used, a split spherical roller bearing was provided at the free shaft end as well.
Split spherical roller bearings have a cylindrical bore. Inner ring, outer ring and *cage* with roller set are split into halves.
The split inner ring halves are braced together by means of four dowel screws and attached to the shaft. Both outer ring halves are fitted together without a gap by means of two dowel screws.
The drive-end bearing is mounted with two locating rings and acts as the *locating bearing;* the bearing at the opposite end is the *floating bearing.* Split spherical roller bearings FAG 222SM125T are designed in such a way that they can be mounted into split series housings FAG SNV250 instead of one-piece spherical roller bearings with an adapter sleeve. Outside diameter, outer ring width and shaft seat diameter are identical.
The theoretical *fatigue life* L_h of the bearings is over 100,000 hours.

Machining tolerances

Shaft to h6...h9;
housing to H7

Lubrication, sealing

The bearings are lubricated with *grease.* The housings are connected to a central lubricating system so that continuous relubrication is ensured.
The shaft openings on both sides of the housing are each sealed by a two-lip *seal.*



89: Drive unit of a finished goods elevator

90 Driving axle of a construction machine

Modern construction machines feature planetary gears in the wheel hub. This yields a considerable step-down ratio in a limited space, in the example shown i_g = 6.35. As the considerable drive torque is generated immediately at the wheel, a light drive shaft is sufficient.

Planet wheel bearing arrangement

The planet wheel bearings must provide a high load carrying capacity in a limited space. This is achieved by means of assemblies where the outer ring raceway is integrated in the planet wheel. The *self-aligning* spherical roller bearing selected in the example smoothly compensates for small misalignments resulting from the deflection of the cantilever bearing journal under load. This yields a uniform contact pattern for the gearing, which is indicative of an optimal gear mesh. In the example shown the internal design of spherical roller bearing FAG 22309E.TVPB is used.

Wheel mounting

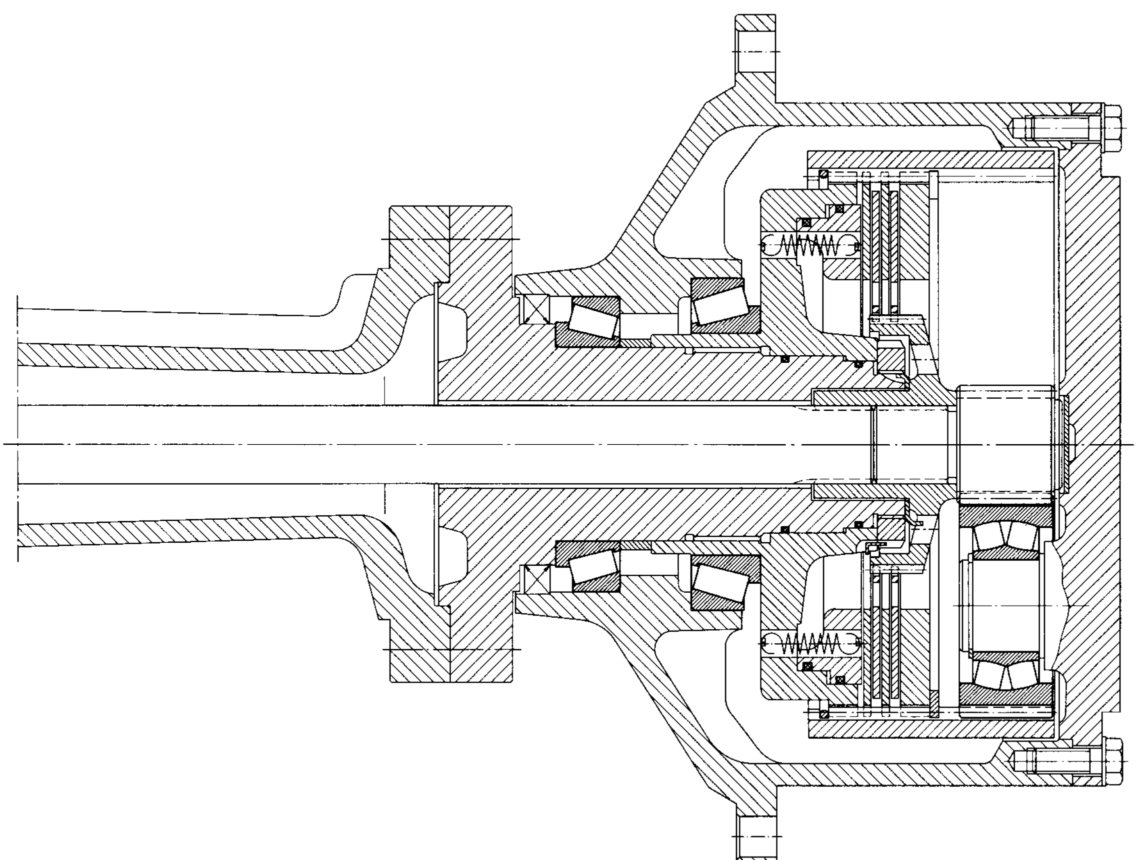
As a rule, the wheel mounting on rigid axles of construction machines consists of two tapered roller bearings which are axially *adjusted* against each other in *O arrangement* (larger *spread*) and with preload. In this way, deformations and tilting of the planetary gear are minimized and impermissible plastic deformations (brinelling marks) resulting from adverse operating conditions avoided.
The wheel bearings are tapered roller bearings FAG 32021X (in accordance with DIN ISO 355: T4DC105) and FAG 32024X (T4DC120).

Machining tolerances

The rotating outer rings of the wheel mounting are subjected to *circumferential load,* the stationary inner rings to *point load,* therefore: journal to k6; hub to N7.

Lubrication, sealing

Rolling bearings and gearing are washed around in the revolving wheel hub by the transmission *oil.*
Radial shaft *seals* protect the bearings from dirt and splash water.



90: Driving axle of a construction machine

91 Vibrating road roller

The vibrations of such road rollers are produced by an eccentric shaft.

Operating data

Speed of eccentric shaft $n = 1{,}800\ min^{-1}$; radial load $F_r = 238$ kN; number of bearings $z = 4$; required *nominal rating life* $L_h \geq 2{,}000$ hours.

Bearing selection, dimensioning

The centrifugal force from the imbalance weights on both sides of the roll are accommodated by two bearings each. The *equivalent dynamic load* per bearing is:

$P = 1/z \cdot F_r = 1/4 \cdot F_r = 59.5$ kN

For the above conditions, an *index of dynamic stressing* $f_L = 1.52$ and a *speed factor* of $f_n = 0.302$ are obtained. The adverse *dynamic stressing* is taken into account by introducing a supplementary factor $f_z = 1.2$. Thus, the required *dynamic load rating* of one bearing

$C = f_L/f_n \cdot P \cdot f_z = 1.52/0.302 \cdot 59.5 \cdot 1.2 = 359.4$ kN

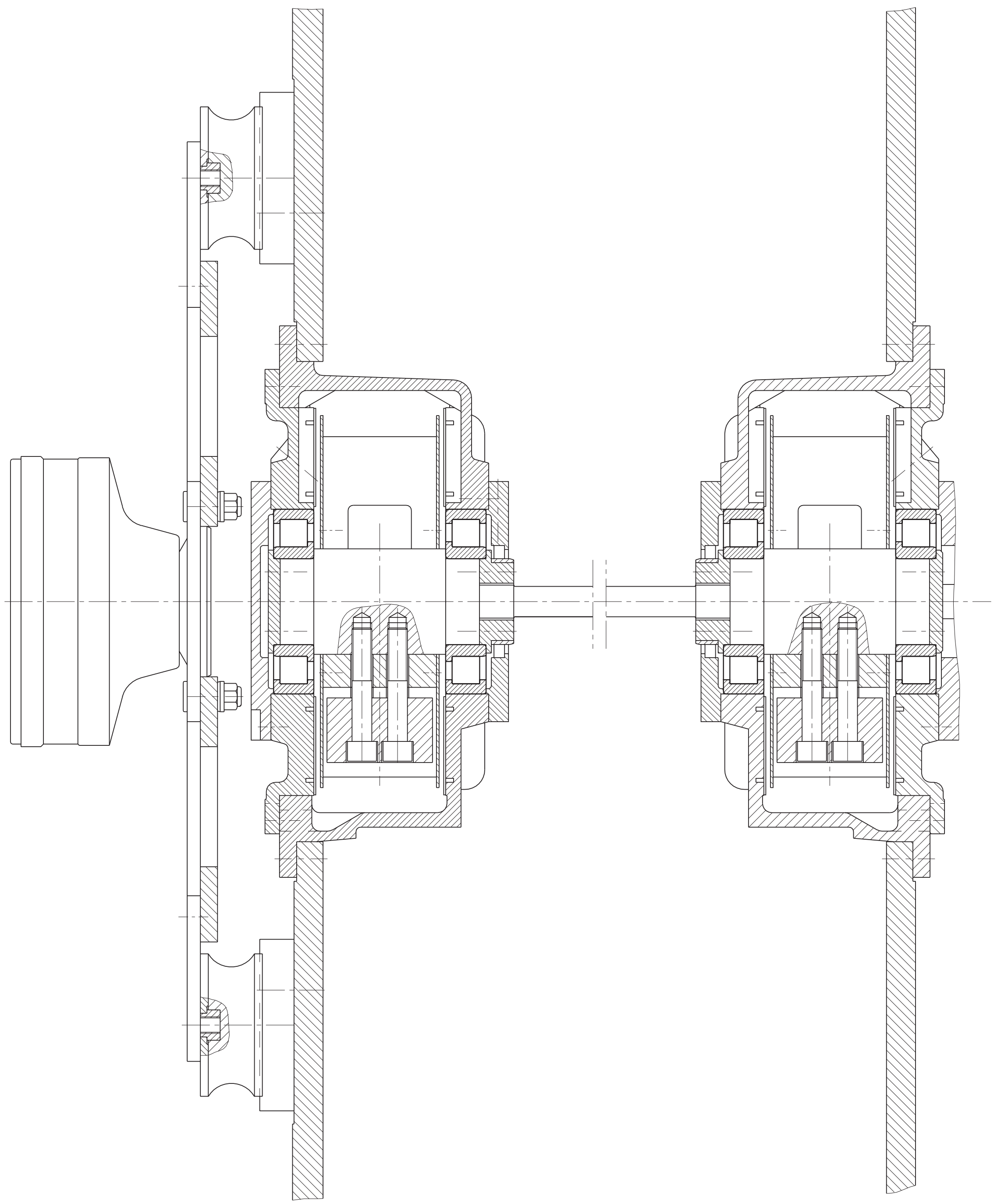
On each side of the imbalance weights a cylindrical roller bearing FAG NJ320E.M1A.C4 (*dynamic load rating* C = 380 kN) is mounted. Due to the vibratory loads the bearings are fitted with an outer ring riding *machined* brass *cage* (M1A). The misalignment between the two bearing locations from housing machining inaccuracies is less than that permissible for cylindrical roller bearings.

Machining tolerances

In view of the vibrations it is advisable to provide tight *fits* for both the bearing inner and outer rings. Axial guidance of the eccentric shaft is provided by the lips of the cylindrical roller bearings.
Eccentric shaft to k5, housing bore to M6.

Lubrication, sealing

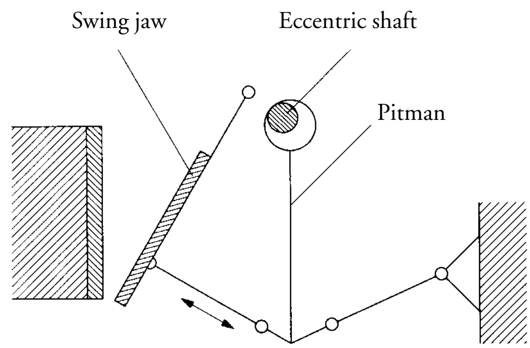
The bearings are lubricated by the *oil* splashed off from the imbalance weights. Additional guide plates improve lubricant supply to the bearings. *Mineral oils* with *EP additives* and anti-corrosion *additives* have proved to be suitable.
Internal *sealing* is provided by shaft seals, external sealing by O-ring seals.



91: Vibrating road roller

92 Double toggle jaw crusher

Double toggle jaw crushers have a large mouth opening. They are used, for example, as primary crushers to prepare ballast for road building. The coarse crushing is followed by further crushing operations until an aggregate of the size and shape required, e.g. gravel or grit, is obtained.



Operating data

Input power 103 kW; speed of eccentric shaft $n = 210 \text{ min}^{-1}$; mouth opening 1,200 x 900 mm; eccentric radius 28 mm.

Bearing selection, dimensioning

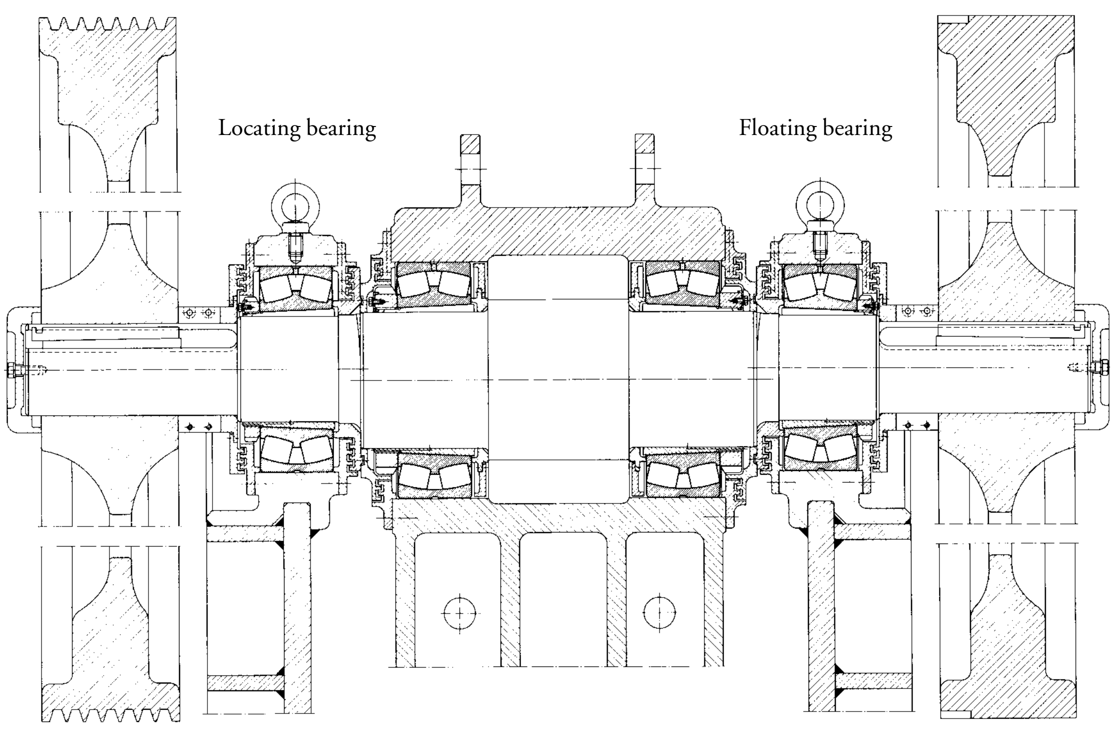
The pitman is fitted to the eccentric part of the horizontal shaft and actuates the swing jaw through a double toggle lever system. The inner bearings supporting the pitman must accommodate heavy crushing loads. The outer bearings transmit, in addition to these loads, the flywheel weight and the circumferential loads resulting from the drive. Due to the high loading and the rugged operation, spherical roller bearings are chosen. Spherical roller bearings FAG 23260K.MB are mounted as outer bearings and FAG 23176K.MB as inner bearings. The pitman bearing arrangement is of the *floating bearing* type. The outer bearing arrangement features a *locating bearing* at the drive side and the *floating bearing* at the opposite side. With an *index of dynamic stressing* $f_L \approx 4.5$ the bearing arrangement is safely dimensioned with regard to *nominal rating life.*

Machining tolerances

The bearings are mounted on the shaft with adapter sleeves FAG H3260HGJ and FAG H3176HGJ, respectively. The bearing seats on the shaft are machined to h7 with a cylindricity tolerance IT5/2 (DIN ISO 1101), and the bores of housing and pitman to H7.

Lubrication, sealing

Grease lubrication with a lithium soap base grease of *penetration class* 2 wit *EP additives* (FAG rolling bearing grease *Arcanol* L186V). The *relubrication interval* for the bearings is 2...3 months.
The bearings are *sealed* by multiple labyrinths. Once or twice a week, fresh *grease* is injected into the labyrinths.



92: Bearing mounting of a double-toggle jaw crusher

93 Hammer mill

Hammer mills are mainly used for crushing ores, coal, and stone.

Operating data

Hourly throughput 90...120 t of iron ore; input power 280 kW; rotor speed 1,480 min^{-1}, rotor weight including hammers approximately 40 kN; bearing centre distance 2,000 mm.

Bearing selection

Due to the high loads and rugged operation, hammer mill rotors are mounted on spherical roller bearings. This *self-aligning bearing* type can compensate for misalignments of the two plummer block housings, and possible rotor deflections. Two spherical roller bearings FAG 23228EASK.M.C3 are mounted, one acting as the *locating bearing,* the other one as *floating bearing.* The increased *radial clearance* C3 was selected because of the high speed. The bearing inner rings heat up more than the outer rings, causing the bearing clearance to be reduced during operation.

Bearing dimensioning

The rotor weight imposes a radial load on the bearings. Added to this are unbalanced loads and shock loads whose magnitude can only be estimated. These loads are introduced in the *nominal rating life* calculation by multiplying the rotor weight G_R with a supplementary factor f_z of 2.5...3, depending on the operating conditions. The thrust loads acting on the bearings are so small they need not be taken into account in the *life* calculation.
With the *dynamic load rating* C = 915 kN, the s*peed factor* $f_n = 0.32$ (n = 1,480 min^{-1}) and the rotor weight $G_R = 40$ kN, the *index of dynamic stressing* f_L for one bearing:

$$f_L = C \cdot f_n / (0.5 \cdot G_R \cdot f_z) = 915 \cdot 0.32 / (20 \cdot 3) = 4.88$$

An f_L value of 3.5...4.5 is usually applied to hammer mills. Thus the bearings are adequately dimensioned with regard to *nominal rating life* (L_h approximately 100,000 h).

Bearing mounting

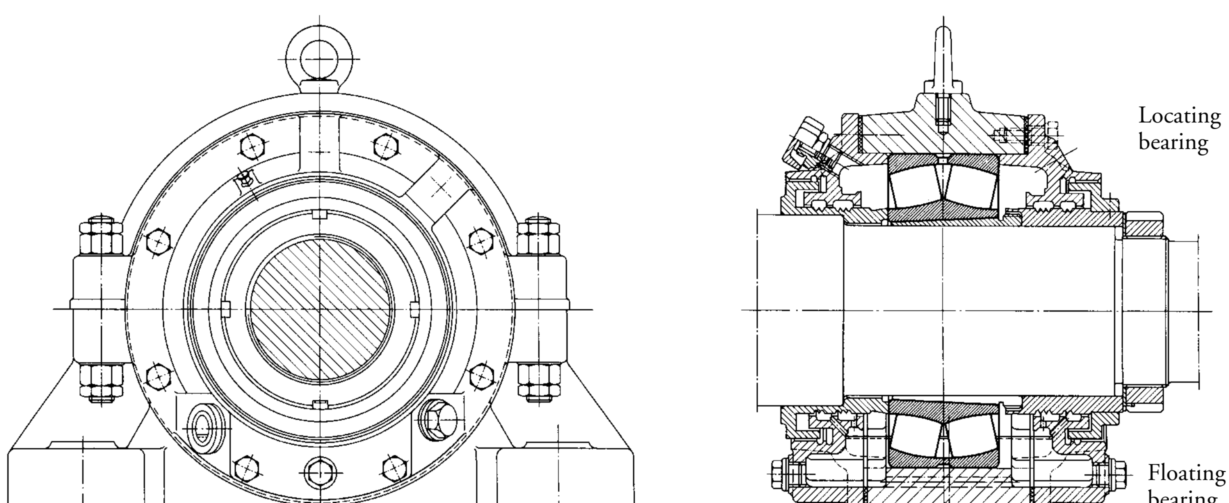
The bearings are mounted on the rotor shaft with withdrawal sleeves FAG AHX3228. They are fitted into plummer block housings MGO3228K. Both housings (open design) are available for *locating bearings* (design BF) and for *floating bearings* (design BL). The split housings of series MGO were especially developed for mill applications. They are designed for *oil* lubrication and feature particularly effective *seals.*

Machining tolerances

For mounting with sleeves, the shaft seats are machined to h7, with a cylindricity tolerance IT5/2 (DIN ISO 1101). The housing bores are machined to G6. Thus the requirement that the outer ring of the *floating bearing* must be displaceable within the housing is met.

Lubrication, sealing

For reliable operation at high speeds, the bearings are oil bath lubricated. *Grease*-packed labyrinths prevent the ingress of foreign matter. To increase the *sealing* efficiency, grease is replenished frequently. Flinger grooves on the shaft, and *oil* collecting grooves in the housing covers retain the oil within the housing.



93: Hammer mill mounting

94 Double-shaft hammer crusher

Double-shaft hammer crushers are a special type of hammer crushers or hammer mills. They feature two contra-rotating shafts to which the hammers are attached. This type is especially suitable for crushing large-sized material with a high hourly throughput and optimum size reduction.

Operating data

Hourly thoughput 350...400 t of iron ore; input power 2 x 220 kW; rotor speed 395 min^{-1}, rotor weight including hammers 100 kN; bearing centre distance 2,270 mm.

Bearing selection

Due to the rugged operation, spherical roller bearings are mounted which can compensate for misalignment between the two plummer blocks and for shaft deflections.

Bearing dimensioning

In addition to the loads resulting from the rotor weight, the bearings have to accommodate loads resulting from imbalances and shocks. They are taken into account by multiplying the rotor weight G_R by the supplementary factor $f_z = 2.5$. Small thrust loads need not be taken into account in the *life* calculation. The shaft diameter at the bearing locations determines the use of one spherical roller bearing FAG 23234EASK.M at each side. For the moderate speeds of this application normal *radial clearance* CN is satisfactory.
With the *dynamic load rating* C = 1,370 kN, the *speed factor* $f_n = 0.476$ (n = 395 min^{-1}) and the rotor weight $G_R = 100$ kN, the *index of dynamic stressing* f_L per bearing:

$$f_L = C \cdot f_n/(0.5 \cdot G_R \cdot f_z) = 1,370 \cdot 0.476/(50 \cdot 2.5) = 5.2$$

With this f_L value, which corresponds to a *nominal rating life* L_h of approximately 120,000 hours, the bearings are very adequately dimensioned.

Bearing mounting

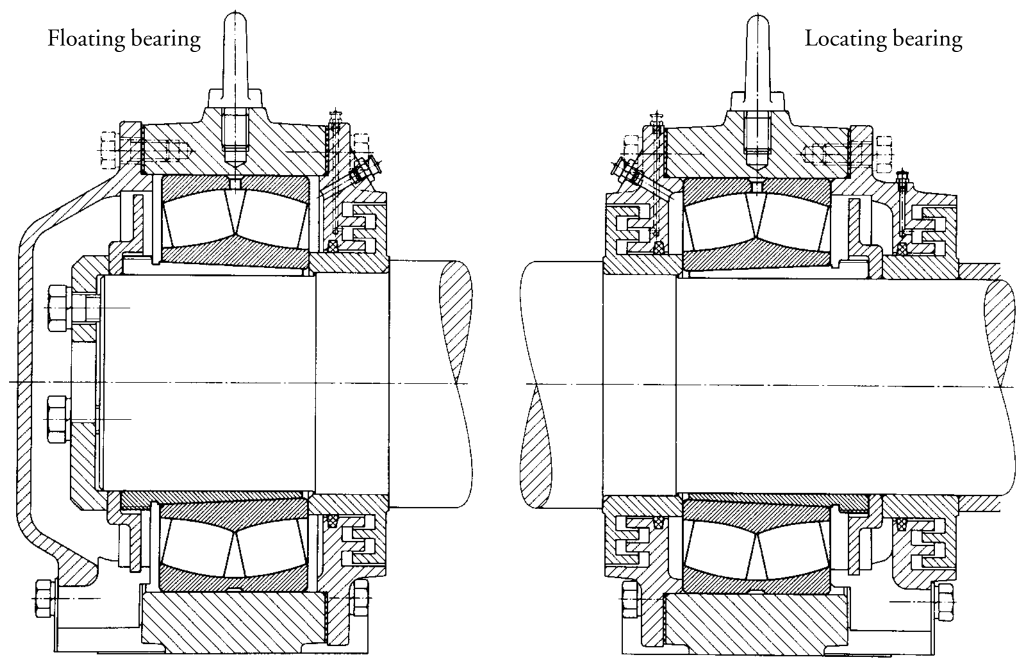
The bearings are mounted on the rotor shaft with withdrawal sleeves FAG AH3234 and mounted in FAG plummer block housings BNM3234KR.132887. One of the plummer blocks is designed as the *floating bearing* (closed on one side, design AL), the other one as the *locating bearing* (continuous shaft, design BF). The unsplit housings of series BNM were developed especially for hammer mills and crushers. They were designed for *grease lubrication* (grease valve) and feature particularly effective *seals.*

Machining tolerances

The shaft seats are machined to h7, with a cylindricity tolerance IT5/2 (DIN ISO 1101).
The housing bores are machined to H7; this allows the outer ring of the *floating bearing* to be axially displaced.

Lubrication, sealing

Grease lubrication with FAG rolling bearing grease *Arcanol* L71V is satisfactory for the speeds in this example. Relubrication is required at certain intervals. A *grease* valve protects the bearing against over-lubrication. Due to the adverse ambient conditions a double-passage labyrinth *seal* is provided. Frequent *grease* replenishment to the labyrinths improves sealing efficiency.



94: Double-shaft hammer crusher

95 Ball tube mill

Tube mills are mostly used in the metallurgical, mining and cement industries. The tube mill described is used in an Australian gold mine for grinding auriferous minerals (grain sizes 4...30 mm) into grit by means of grinding bodies (balls). The grain size of the material depends on the number of balls and the quantity of added water. The grinding drum, which revolves around its horizontal axis, is lined with chilled-cast iron plates. Charged with the grinding stock, it is very heavy.

Operating data

Drum: diameter 5,490 mm, length 8,700 mm; input power 3,850 kW; speed 13.56 min^{-1}; drum mass when loaded 400 t; maximum radial load per bearing F_r = 1,962 kN; maximum thrust load F_a = 100 kN; bearing distance 11,680 mm, throughput 250 t/h.

Bearing selection

Trunnion bearings

As the drum rotates, the bearings have to accommodate, in addition to the heavy weight, constant shock-type loads caused by the grinding bodies. Both drum trunnions are supported on spherical roller bearings of series 239, 248 or 249. The bearings compensate for static and dynamic misalignments that can be caused by misalignments of the bearing seats (large bearing distance) or drum deflections. In this example, spherical roller bearings with a tapered bore (K 1:30), FAG 248/1500BK30MB are mounted both as the *locating bearing* at the drive end and as the *floating bearing* at the feed end. The bearings are mounted on the trunnion with a wedge sleeve.

Drive pinion bearings

The drive pinion is supported on two spherical roller bearings FAG 23276BK.MB with adapter sleeve FAG H3276HG, in plummer block housings with Taconite-*seals* FAG SD3276TST.

Bearing dimensioning

The dimensioning of the drum bearings is based on half the weight of the loaded drum

$(400/2 \cdot 9.81 = 1{,}962 \text{ kN})$.

The shock loads are taken into account by a shock factor f_z = 1.5. The required *nominal rating life* is 100,000 h; this corresponds to an *index of dynamic stressing* f_L = 4.9.

The *equivalent dynamic load*

$P = f_z \cdot F_r + Y \cdot F_a = 2 \cdot 1.5 \cdot 1{,}962 + 4.5 \cdot 100 = 3{,}393 \text{ kN}$

With a *dynamic load rating* C = 12,900 kN the *index of dynamic stressing:*

$f_L = C/P \cdot f_n = 12{,}900/3{,}393 \cdot 1.31 = 4.98 \; (L_h > 100{,}000 \text{ h})$.

The bearings are very safely dimensioned with regard to *nominal rating life.*

The bearings are mounted in split FAG plummer block housings SZA48/1500HF (*locating bearing*) and SZA48/1500HL (*floating bearing*). The outer rings are tightly fitted into shell sleeves (e.g. made of grey-cast iron) in the lower housing half. They facilitate compensation of axial length variations. The sliding effect is enhanced by *grease* injected into the shell sleeve/housing joint.

Machining tolerances

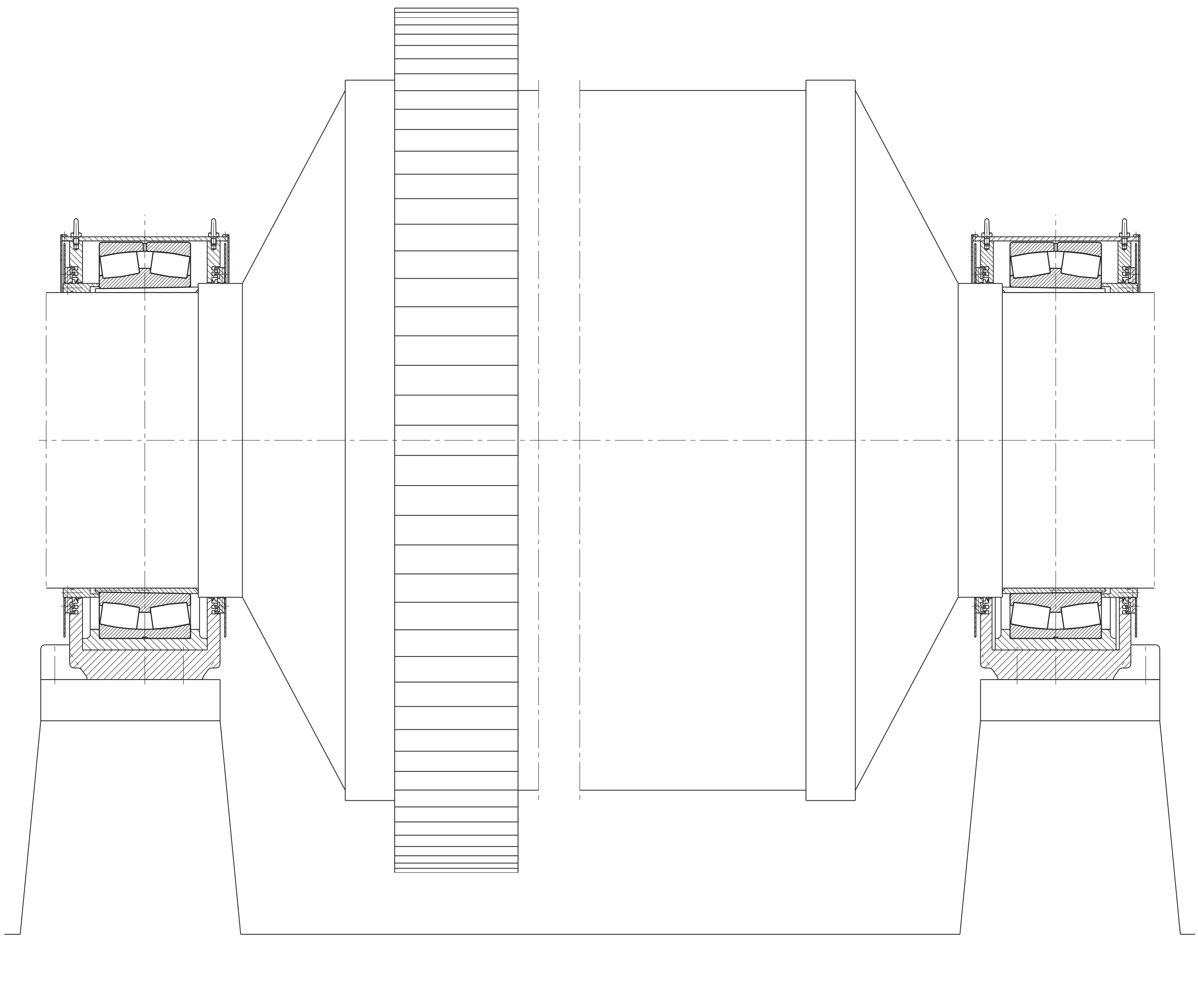
The *circumferentially loaded* inner rings are press-fitted on the trunnion. This is easily achieved by mounting them hydraulically on wedge sleeves. The *radial clearance* reduction and the *radial clearance* of the mounted bearing have to be observed (see table in FAG catalogue WL 41 520, chapter on spherical roller bearings).

The trunnions are machined to h9, with a cylindricity tolerance IT5/2 (DIN ISO 1101); the housing bores to H7.

Lubrication, sealing

Grease lubrication with a lithium soap base grease of *penetration class* 2 with *EP additives,* e. g. FAG rolling bearing grease *Arcanol* L186V. Continuous replenishment (approx. 5 g/h per bearing) ensures adequate lubrication.

The bearings are *sealed* by multiple labyrinths. Due to the extreme ambient conditions, the labyrinths are preceded by dirt baffle plates and rubbing seals (V-rings). This combination is also referred to as Taconite *sealing.* The labyrinths are also continuously replenished with approx. 5 g/h per labyrinth.



95: Ball tube mill mounting

96 Support roller of a rotary kiln

Rotary kilns for cement production can extend over a length of 150 m or more. The support rollers are spaced at about 30 m intervals.

Operating data

Kiln outside diameter 4.4 m; support roller diameter 1.6 m; support roller width 0.8 m; radial load per support roller 2,400 kN; thrust load 700 kN. Speed 5 min^{-1}; mass of support roller and housing 13 t.

Bearing selection, dimensioning

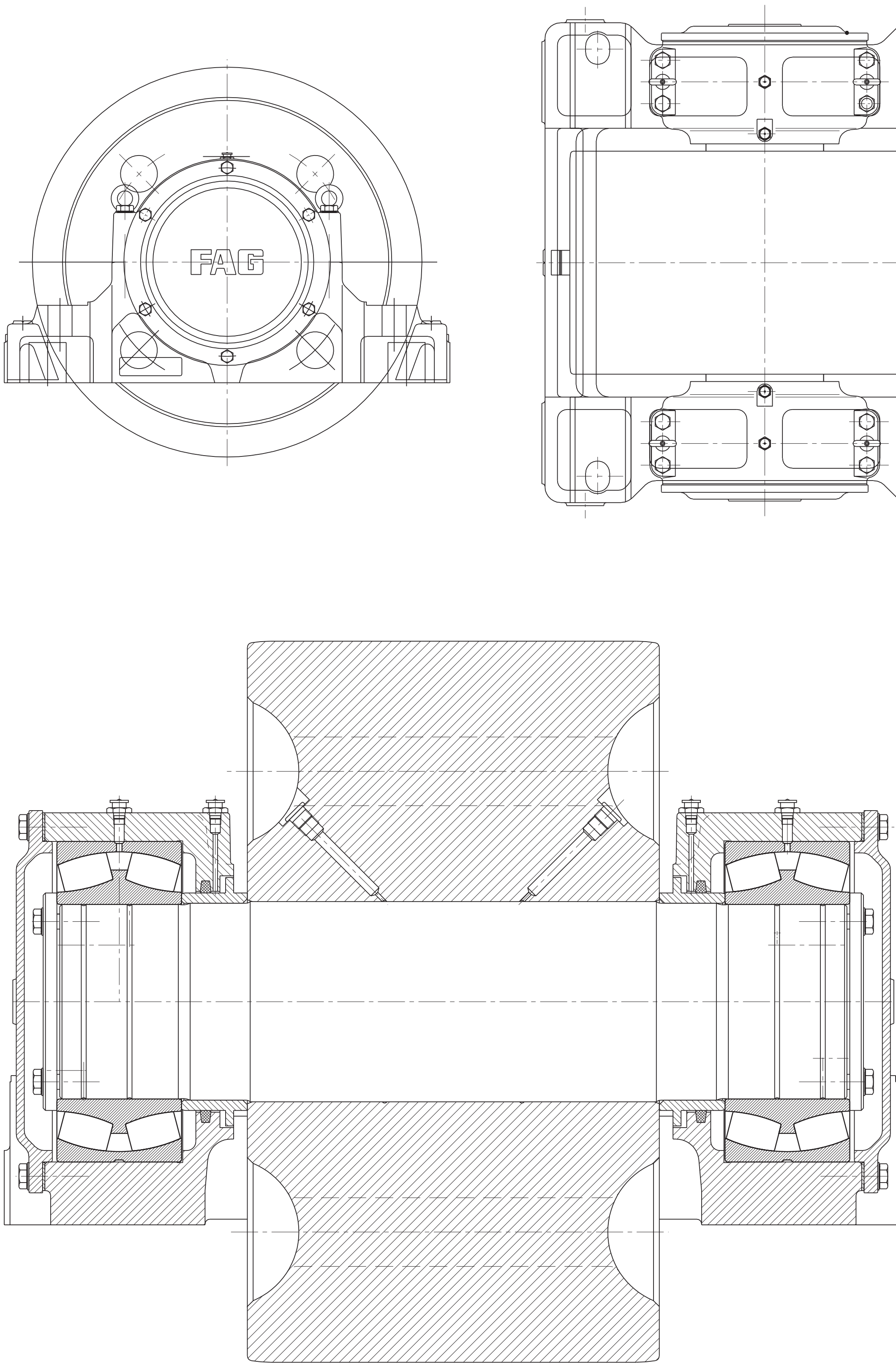
For such rotary kilns FAG offers complete assemblies consisting of a twin housing SRL, the support roller with axle LRW, and the bearings. In this example the two support-roller bearings are mounted into split plummer block housings with a common base (frame) made of grey-cast iron. Spherical roller bearings FAG 24184B (*dynamic load rating* C = 6,200 kN) are mounted in a *floating bearing arrangement,* i. e. the shaft can be displaced relative to the housing by a defined *axial clearance.*
In addition to the radial loads, the spherical roller bearings accommodate thrust loads resulting from displacements of the rotary kiln.
With an *index of dynamic stressing* f_L = 4.9, corresponding to a *nominal rating life* L_h = 100,000 h, the bearings are adequately designed.

Machining tolerances

Shaft to n6 (*circumferential load* on inner ring); housing bore to H7.

Lubrication, sealing

Grease lubrication with a lithium soap base grease with *EP additives* (e. g. rolling bearing grease *Arcanol* L186V).
At the roller side the bearings are *sealed* with felt strips and *grease*-packed labyrinths.



96: Support roller of a rotary kiln

Vibrating machines

Vibrating screens are used for conveying and grading bulk material. They operate in mines, quarries, stone crushing plants and foundries, in the foodstuff and chemical industries, and in many other preparation and processing plants.
The main vibrating screen types are: two-bearing screens with circle throw, two-bearing screens with straight-line motion, and four-bearing screens.
Vibrator motors and vibrating road rollers also come under the category of vibrating machines.

Selection of bearing type and bearing design

Rolling bearings in vibrating screens are stressed by high, mostly shock-type loads. To compound matters, the bearings, while rotating about their own axis, perform a circular, elliptical or linear vibrating motion. This results in high radial accelerations (up to 7 g) which additionally stress the bearings, and especially the *cages.* High operating speeds, usually with inaccurately aligned bearing locations, and pronounced shaft deflections are additional requirements which are best met by spherical roller bearings.

For these adverse operating conditions FAG spherical roller bearings with reduced bore and outside diameter tolerances and an increased *radial clearance* are used:
The FAG standard design E.T41A is used for shaft diameters of 40...150 mm. The centrifugal forces of the unloaded rollers are accommodated by two pressed-steel, window-type *cages* and radially supported by a *cage* guiding ring in the outer ring.
Shafts with diameters of 160 mm and more are supported on vibrating screen bearings A.MA.T41A. These bearings have a fixed centre lip on the inner ring and retaining lips on both sides. The split *machined* brass *cage* is of the outer-ring riding type.

Bearing dimensioning

Vibrating screen bearings which are comparable with field-proven bearings can be dimensioned on the basis of the *index of dynamic stressing* f_L, provided that the boundary conditions are comparable as well. f_L values between 2.5 and 3 are ideal.

97 Two-bearing screen with circle throw

Operating data

Screen box weight G = 35 kN; vibration radius r = 0.003 m; speed n = 1,200 min^{-1}; number of bearings z = 2 ; acceleration due to gravity g = 9.81 m/s^2.

Bearing dimensioning

Two-bearing screens work beyond the critical speed; thus the common centroidal axis of the screen box and the unbalanced load does not change during rotation. The bearing load due to the screen box centrifugal force is:

$$F_r = 1/z \cdot G / g \cdot r \cdot (\pi \cdot n/30)^2 =$$
$$= 1/2 \cdot 35 / 9.81 \cdot 0.003 \cdot (3.14 \cdot 1{,}200/30)^2 = 84.5 \text{ kN}$$

To allow for the unfavourable *dynamic stressing,* the bearing load should be multiplied by the supplementary factor f_z = 1.2. Thus, the *equivalent dynamic load*

$$P = f_z \cdot F_r = 1.2 \cdot 84.5 = 101.4 \text{ kN}$$

With the *index of dynamic stressing* f_L = 2.72 (L_h = 14,000 h) and the *speed factor* f_n = 0.34 (n = 1,200 min^{-1}) the required *dynamic load rating*

$$C = f_L/f_n \cdot P = 2.72/0.34 \cdot 101.4 = 811.2 \text{ kN}$$

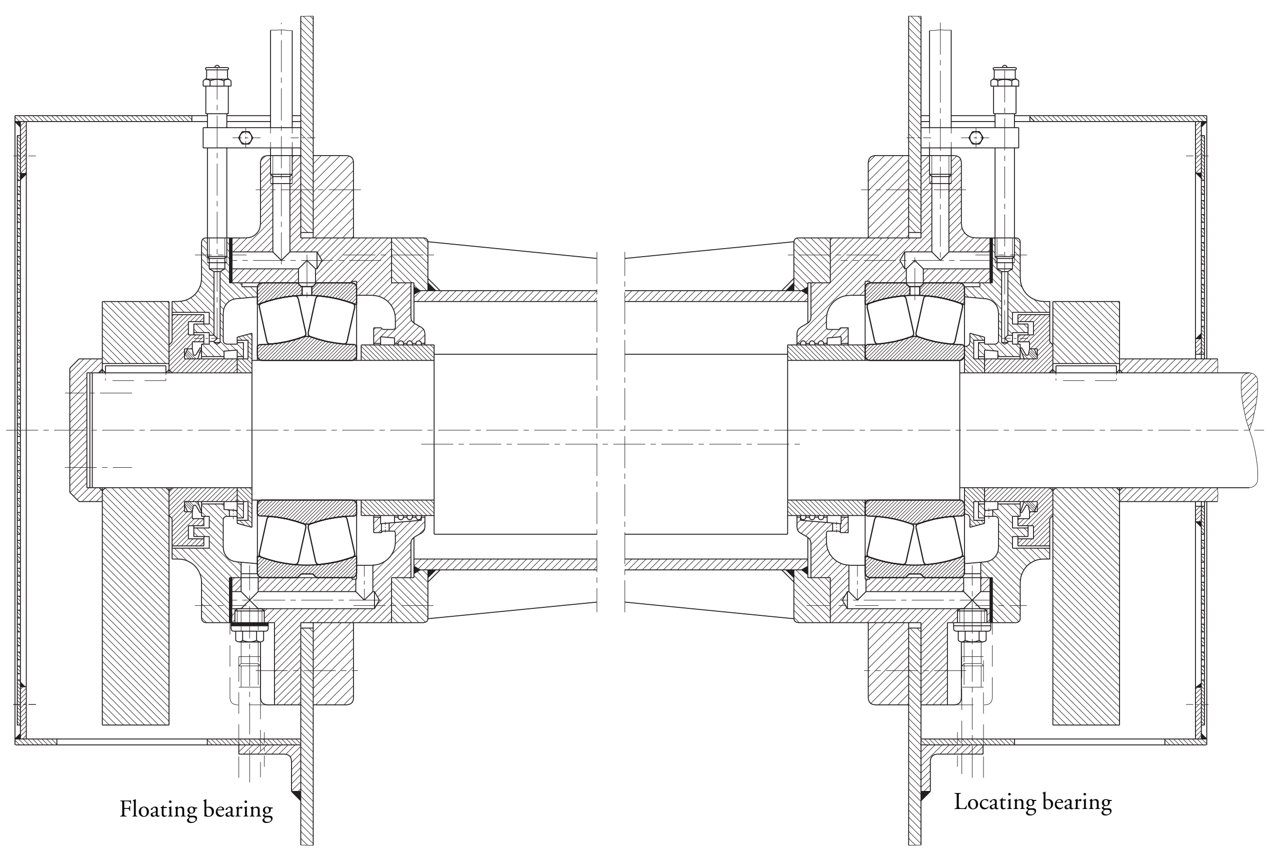
The recommended *index of dynamic stressing* f_L for vibrating screens is 2.5...3, corresponding to a *nominal fatigue life* L_h of 11,000 to 20,000 hours. Spherical roller bearings FAG 22324E.T41A with a *dynamic load rating* of 900 kN are chosen.

Machining tolerances

The eccentric shaft features two spherical roller bearings, one as the l*ocating bearing,* the other as *floating bearing.* The inner rings are *point loaded* and mounted with a shaft tolerance of g6 or f6. The outer rings are *circumferentially loaded* and *fitted* tightly in the housing bore to P6.

Lubrication, sealing

Circulating *oil* lubrication. *Mineral oils* with a minimum *viscosity* of 20 mm^2/s at operating temperature are recommended. The oil should contain *EP additives* and anti-corrosion *additives.*
Outer *sealing* is provided by a *grease*-filled, replenishable labyrinth. A flinger ring with an *oil* collecting groove prevents oil leakage. A V-ring is provided between flinger ring and labyrinth to separate *oil* and *grease.*



97: Two-bearing screen with circle throw

98 Two-bearing screen with straight-line motion

Basically, a two-bearing screen with straight-line motion consists of two contra-rotating, synchronous circular throw systems.

Operating data

Screen box weight G = 33 kN; imbalance weight G_1 = 7.5 kN; amplitude r = 0.008 m; speed n = 900 min^{-1}; number of bearings z = 4 ; acceleration due to gravity g = 9.81 m/s^2.

Bearing dimensioning

The bearing loads of a linear motion screen vary twice between the maximum value F_{rmax} and the minimum value F_{rmin} during one revolution of the eccentric shafts.

For calculation of these loads, the distance R between the centres of gravity of imbalance weight and the pertinent bearing axes is required. Weights G and G_1, amplitude of linear vibration r and distance R have the following relationship:

$$G \cdot r = G_1 \cdot (R - r)$$

In this example R = 0.043 m

When the centrifugal forces act perpendicular to the direction of vibration, the maximum radial load F_{rmax} is calculated as follows:

$$F_{rmax} = 1/z \cdot G_1 / g \cdot R \cdot (\pi \cdot n/30)^2 =$$
$$= 1/4 \cdot 7.5 / 9.81 \cdot 0.043 \cdot (3.14 \cdot 900/30)^2 = 73 \text{ kN}$$

The radial load is at its minimum (F_{rmin}) when the directions of centrifugal forces and vibration coincide. The radial load is then

$$F_{rmin} = 1/4 \cdot G_1/g \cdot (R - r) \cdot (\pi \cdot n/30)^2 =$$
$$= 1/4 \cdot 7.5/9.81 \cdot 0.035 \cdot (3.14 \cdot 900/30)^2 = 59.4 \text{ kN}$$

Since the radial load varies between the maximum and minimum according to a sinusoidal pattern, the *equivalent dynamic load* P with the supplementary factor f_z = 1.2 is thus:

$$P = 1.2 \cdot (0.68 \cdot F_{rmax} + 0.32 \cdot F_{rmin}) =$$
$$= 1.2 \cdot (0.68 \cdot 73 + 0.32 \cdot 59.4) = 82.4 \text{ kN}$$

With the *index of dynamic stressing* f_L = 2.53 (L_h = 11,000 h) selected for vibrating screens and the *speed factor* f_n = 0.372 (n = 900 min^{-1}) the required *dynamic load rating*

$$C = f_L/f_n \cdot P = 2.53/0.372 \cdot 82.4 = 560.4 \text{ kN}$$

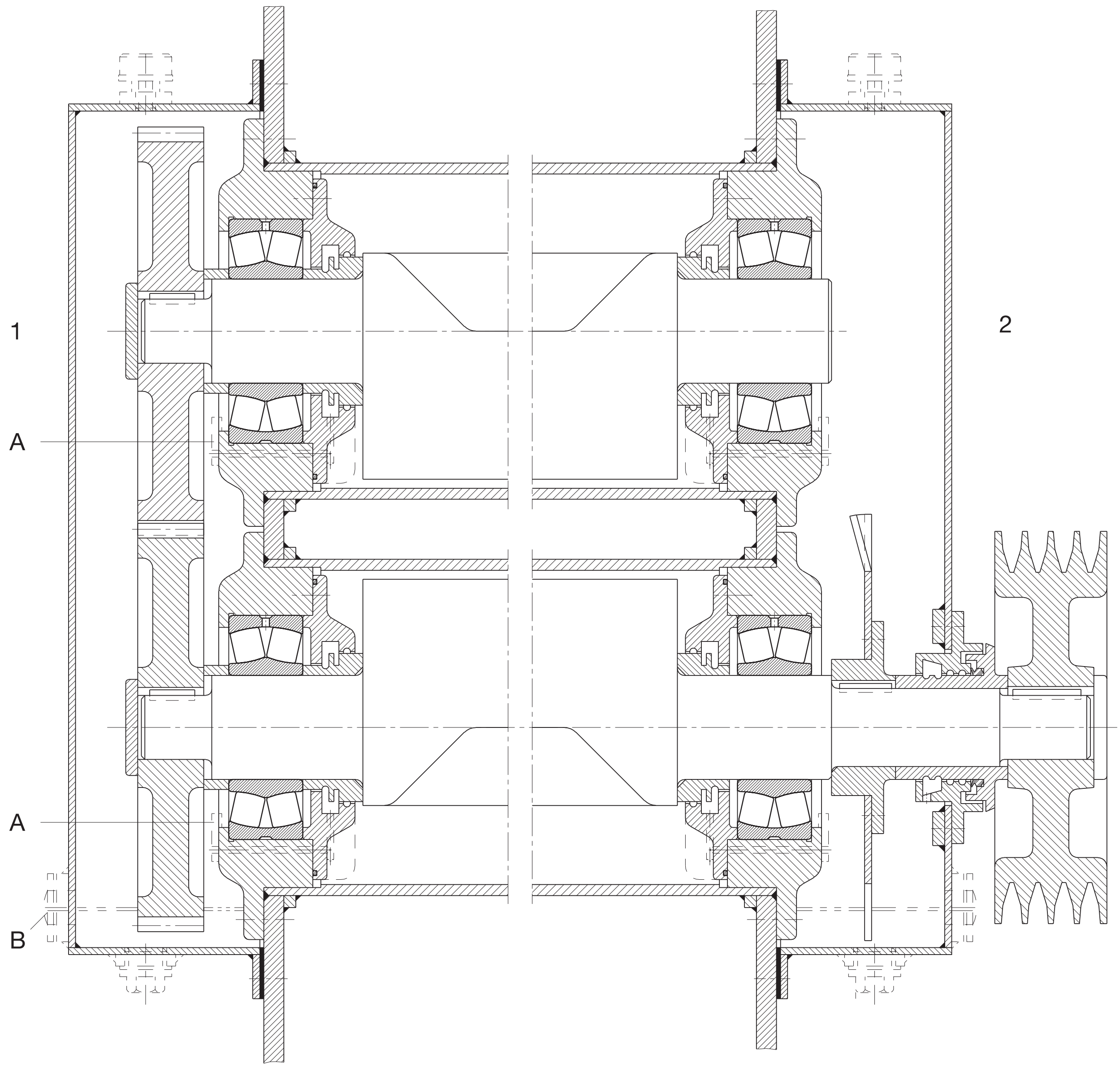
The spherical roller bearing FAG 22320E.T41A with a *dynamic load rating* of 655 kN is chosen.

Machining tolerances

The *locating bearings* of the two eccentric shafts are at the gear end, the *floating bearings* at the drive end. The inner rings (*point load*) are have loose *fits,* i. e. the shaft is machined to g6 or f6. The outer rings are *circumferentially loaded* and tightly fitted in the housing bore (P6).

Lubrication, sealing

Oil lubrication. For lubricating the spherical roller bearings at the locating end, the *oil* thrown off by the gear suffices. A flinger ring is provided for this purpose at the opposite end. Baffle plates (A) at the housing faces maintain an oil level reaching about the centre point of the lowest rollers. The oil level is such that the lower gear and the flinger ring are partly submerged. The oil level can be checked with a sight glass.
A flinger ring and a V-ring in the labyrinth provide *sealing* at the drive shaft passage.



1 Locating bearing
2 Floating bearing
A Baffle plates
B Sight glass

98: Bearing mounting of a two-bearing screen with straight-line motion

99 Four-bearing screen

The vibration radius of a four-bearing screen is a function of the shaft eccentricity. It is not variable; therefore these screens are also called rigid screens.

Operating data

Screen box weight G = 60 kN; eccentric radius r = 0.005 m; speed n = 850 min-1; number of inner bearings z = 2; acceleration due to gravity g = 9.81 m/s^2.

Bearing dimensioning

Inner bearings
For the two inner bearings of a four-bearing screen, which are subjected to vibration, the *equivalent dynamic load* P is the same as for the two-bearing screen with circular throw

$P = 1.2 \cdot F_r = 1.2/z \cdot G/g \cdot r \cdot (\pi \cdot n/30)^2 =$
$= 1.2/2 \cdot 60/9.81 \cdot 0.005 \cdot (3.14 \cdot 850/30)^2 = 145.4$ kN

The required *dynamic load rating*

$C = f_L/f_n \cdot P = 2.93/0.378 \cdot 145.4 = 1{,}127$ kN

Spherical roller bearings FAG 22328E.T41A (*dynamic load rating* C = 1,220 kN) are chosen.

Outer bearings
The stationary outer bearings are only lightly loaded since the centrifugal forces of the screen box are balanced by counterweights. Generally spherical roller bearings of series 223 are also used. The bearing size is dictated by the shaft diameter so that the load carrying capacity is high and *fatigue life* calculation unnecessary. Since these bearings are not subjected to vibration, the standard design with normal clearance is satisfactory. In the example shown spherical roller bearings FAG 22320EK (*dynamic load rating* C = 655 kN) are chosen.

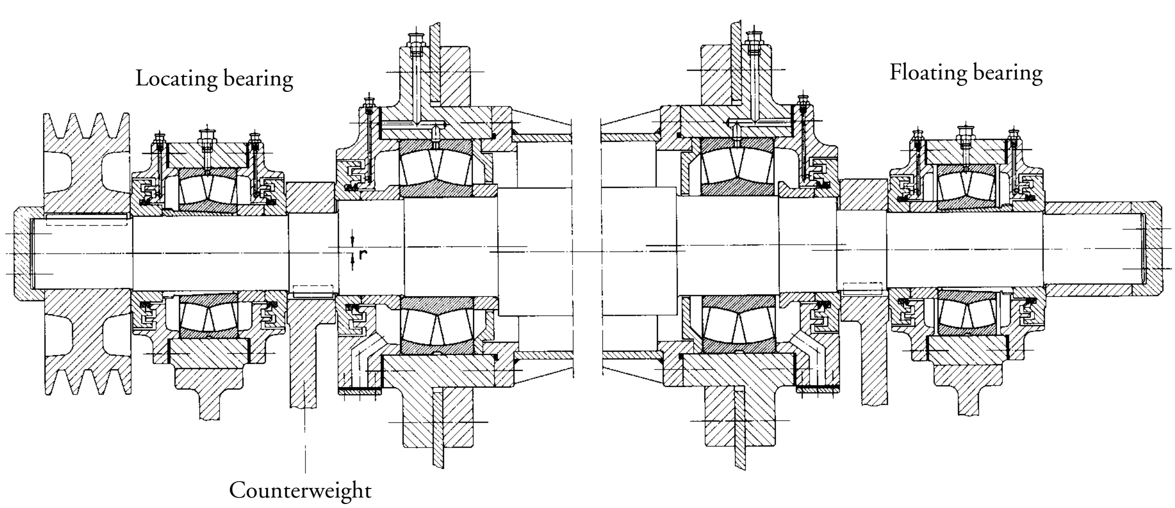
Machining tolerances

Inner bearings
The inner bearings (a *locating-floating bearing arrangement*) feature *point load* on the inner rings: The shaft is machined to g6 or f6. The bearings are fitted tightly into the housing (P6).

Outer bearings
The outer bearings – also a *locating-floating bearing arrangement* – are mounted on the shaft with withdrawal sleeves. The shaft is machined to h8, the housing bore to H7.

Lubrication, sealing

Grease lubrication with a lithium soap base *grease* of *penetration* class 2 with anti-corrosion and extreme pressure *additives.* Grease supply between the roller rows through lubricating holes in the outer rings. *Sealing* is provided by grease-packed, relubricatable labyrinths.



99: Four-bearing screen

100 Vibrator motor

The vibrations of vibrating equipment are generated by one or several activators. An electric motor with an imbalance rotor is an example of such an activator. It is referred to as a "vibrator motor". Vibrator motors are primarily mounted in machinery for making prefabricated concrete parts, in vibrating screens and vibrating chutes.

Operating data

Input power N = 0.7 kW, speed n = 3,000 min^{-1}.
The bearings are loaded by the rotor weight and the centrifugal forces resulting from the imbalances: maximum radial load on one bearing F_r = 6.5 kN.

Bearing selection, dimensioning

Due to the high centrifugal forces, the load carrying capacity of the deep groove ball bearings usually used for medium-sized electric motors is not sufficient for this application. Vibrator motors are, therefore, supported on cylindrical roller bearings. The arrangement shown incorporates two cylindrical roller bearings FAG NJ2306E.TVP2.C4; the *dynamic load rating* of the bearings is 73.5 kN.
The adverse dynamic bearing stressing by the centrifugal forces is taken into account by a supplementary factor f_z = 1.2. Considering this supplementary factor, the *equivalent dynamic load*

$P = 1.2 \cdot F_r = 7.8$ kN.

With the *speed factor* f_n = 0.26 (n = 3,000 min^{-1}), the *index of dynamic stressing*

$f_L = C/P \cdot f_n = 73.5/7.8 \cdot 0.26 = 2.45$

This f_L value corresponds to a *nominal rating life* of 10,000 h. Thus the bearings are correctly dimensioned.

Machining tolerances

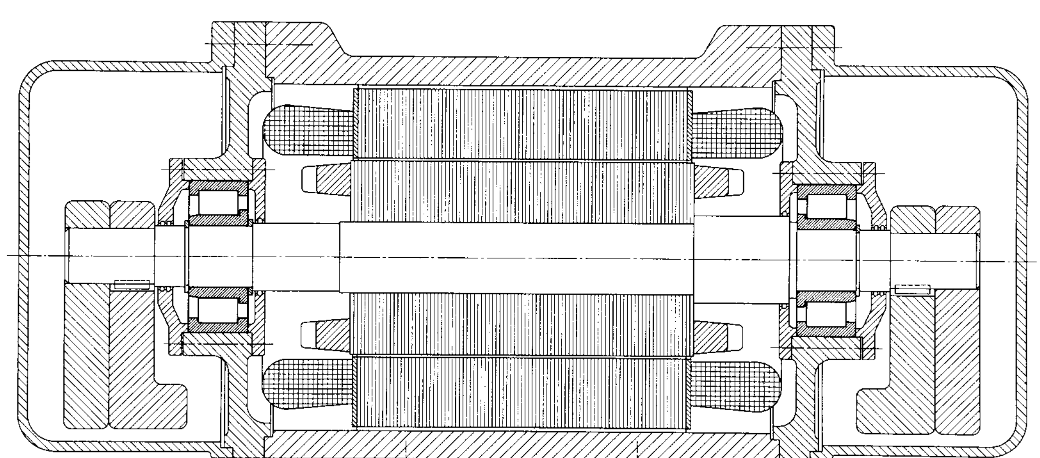
Shaft to k5; housing to N6.
The bearing outer rings carry *circumferential load* and are, therefore, tight *fits.* Since the inner rings are subjected to *oscillating loads,* it is advisable to fit them tightly onto the shaft as well. With non-*separable bearings* this requirement would make bearing mounting and dismounting extremely complicated. Therefore, *separable* cylindrical roller bearings of design NJ are used.

Bearing clearance

The initial *radial clearance* of the bearings is reduced by tight *fits.* Further *radial clearance* reduction results from the different thermal expansion of inner and outer rings in operation. Therefore, bearings of *radial clearance* group C4 (i. e. *radial clearance* larger than C3) are mounted.
To prevent detrimental axial preloading, the inner rings are assembled so that an *axial clearance* of 0.2...0.3 mm exists between the roller sets of the two bearings and the lips (*floating bearing arrangement*).

Lubrication, sealing

Both bearings are lubricated with *grease.* Lithium soap base greases of *penetration* class 2 with *EP additives* have proved successful. Relubrication after approximately 500 hours.
Since the vibrator motor is closed at both ends, gap-type *seals* with grooves are satisfactory.



100: Imbalance rotor bearings of a vibrator motor

101–103 Large capacity converters

Converters perform swinging motions and are occcasionally rotated up to 360°. Bearing selection is, therefore, based on static load carrying capacity. Important criteria in bearing selection are, besides a high *static load rating,* the compensation of major misalignments and length variations. Misalignment invariably results from the large distance between the bearings and from trunnion ring distortion and deflection. The considerable length variations are due to the large differences in converter temperature as the converter is heated up and cools down.

Bearing selection

Example 101 – showing the conventional design – features one spherical roller bearing each as *locating bearing* and as *floating bearing.* The housing of the *floating bearing* is fitted with a sleeve. This simplifies axial displacement of the spherical roller bearing. To minimize the frictional resistance, the bore of the sleeve is ground and coated with dry lubricant (molybdenum disulphide).
For thrust load calculation a coefficient of friction of $\mu = 0.1...0.15$ is used.

Example 102 shows two spherical roller bearings mounted in the housings as *locating bearings.* Axial displacement is permitted by two collaterally arranged linear bearings (rollers) which provide support for one of the two housings. With this design the amount of friction to be overcome during axial displacement is limited to the rolling contact friction occurring in the linear bearings (coefficient of friction $\mu \approx 0.05$).

Bearing dimensioning

For converters, the *index of static stressing* $f_s = C_0/P_0$ should be more than 2; see calculation example.
C_0 = *static load rating* of the bearing
P_0 = *equivalent static load*

Operating data

Calculation example: two spherical roller bearings and two linear bearings (example 102).
Locating bearing: Radial load $F_{rF} = 5{,}800$ kN;
Floating bearing: Radial load $F_{rL} = 5{,}300$ kN;
Thrust load from drive $F_a = 800$ kN and from axial displacement $0.05 \cdot F_{rL} = 265$ kN;
trunnion diameter at bearing seat 900 mm.

Two spherical roller bearings FAG 230/900K.MB (*static load rating* $C_0 = 26{,}000$ kN, thrust factor $Y_0 = 3.1$) are mounted.

Locating bearing

$$P_0 = F_{rF} + Y_0 \cdot (F_a + 0.05 \cdot F_{rL})$$
$$= 5{,}800 + 3.1 \cdot (800 + 265) = 9{,}100 \text{ kN}$$

Index of static stressing $f_s = 26{,}000 / 9{,}100 = 2.85$

Floating bearing

$$P_0 = F_{rL} + Y_0 \cdot 0.05 \cdot F_{rL}$$
$$= 5{,}300 + 3.1 \cdot 265 = 6{,}120 \text{ kN}$$

Index of static stressing $f_s = 26{,}000 / 6{,}120 = 4.24$

Both bearings are thus safely dimensioned. Five cylindrical rollers (80 x 120 mm) each are required for the two linear bearings. The hardness of the guide rails (raceways) is 59...65 HRC.

Machining tolerances

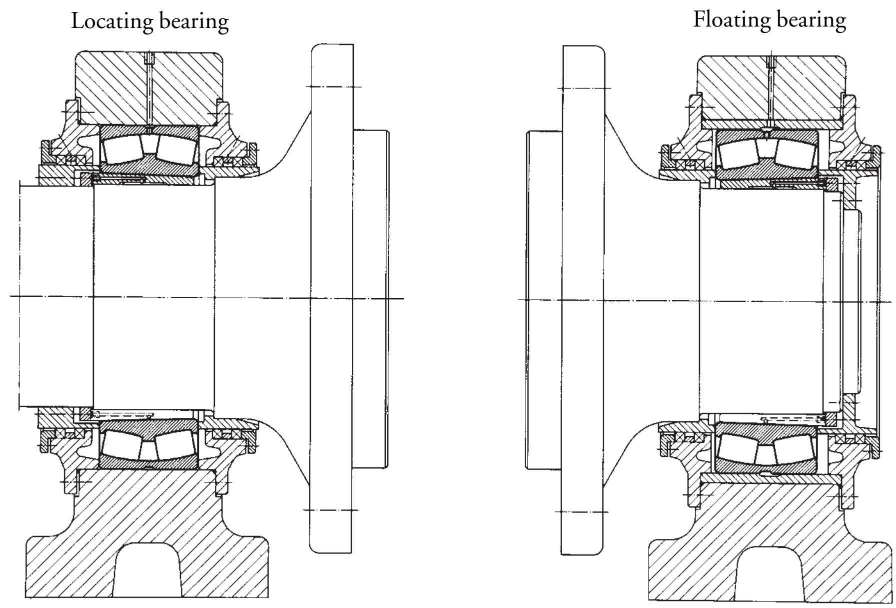
Bearings with a cylindrical bore: trunnion to m6.
Bearings with a tapered bore and hydraulic sleeve: trunnion to h7. The trunnions are machined with a cylindricity tolerance IT5/2 (DIN ISO 1101).
The support bores in the housing have H7 tolerance. Tighter *fits* should not be used in order to prevent bearing ovality which might otherwise result from the split housing.

Lubrication, sealing

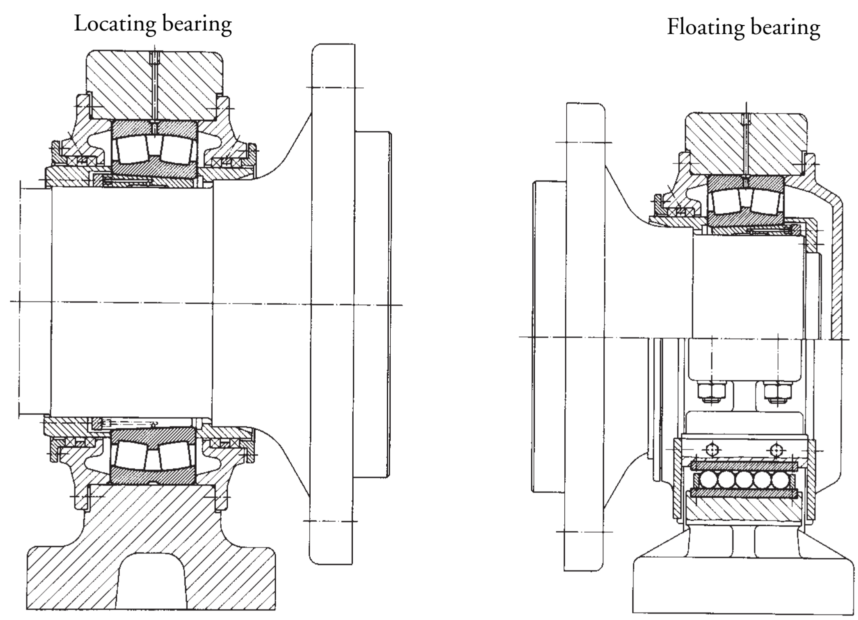
Converter bearings are lubricated with *grease.* Lithium soap base greases of *penetration* class 2 with *EP* and anti-corrosion *additives* (e. g. FAG rolling bearing grease *Arcanol* L186V) are a good choice. Efficient *sealing* is achieved by graphited packing rings.

Split rolling bearings

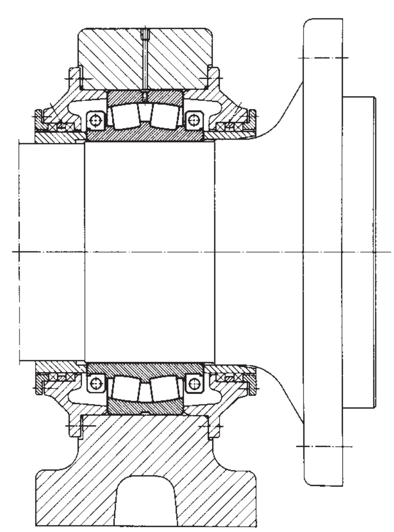
Steel mills often demand that the bearing at the converter drive end are replaceable without dismounting the drive unit. This requirement is satisfied by split spherical roller bearings (example 103).
For cost reasons, split bearings are usually used as replacement bearings.



101: Converter bearings
(two spherical roller bearings)



102: Converter bearings
(two spherical roller bearings,
two linear bearings)



103: Locating bearing end with split
spherical roller bearing

104 Roll bearings of a four-high cold rolling stand for aluminium

Operating data

Back-up rolls: roll diameter 1,525 mm
roll body length 2,500 mm

Work rolls: roll diameter 600 mm
roll body length 2,500 mm

Maximum rolling load 26,000 kN
Maximum rolling speed 1,260 m/min

Selection of the back-up roll bearings (fig. 104a)

Radial bearings
The high radial loads are best accommodated, in a limited mounting space and at high speeds, by cylindrical roller bearings. One four-row cylindrical roller bearing FAG 527048 (dimensions 900 x 1,220 x 840 mm) is mounted at each roll end. The bearings feature pin-type *cages* and reach a *dynamic load rating* of C = 31,500 kN.

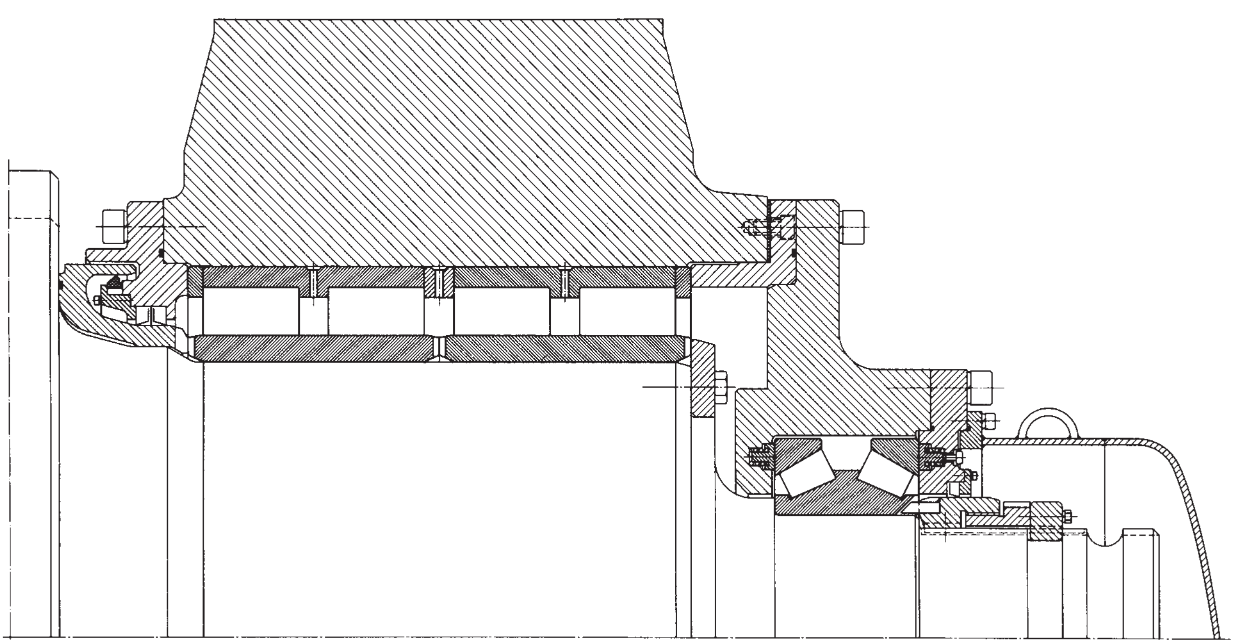
The increased *radial clearance* C4 is required as the inner rings are fitted tightly and heat up more in operation than the outer rings.

Machining tolerances:
Roll neck +0.350 / +0.440 mm, chock to H7.

Thrust bearings
Since thrust loads in strip rolling stands are low, *thrust bearings* are used that are small compared to the *radial bearings.* The back-up roll is supported at both ends by a double-row tapered roller bearing FAG 531295A (dimensions 400 x 650 x 240 mm) with a *dynamic load rating* C of 3,450 kN.

Machining tolerances: Shaft to f6.

The cups are not supported radially; axially, they are *adjusted* by means of helical springs.



104a: Back-up roll mounting of a four-high cold rolling stand for aluminium (identical bearing arrangements at drive end and operating end)

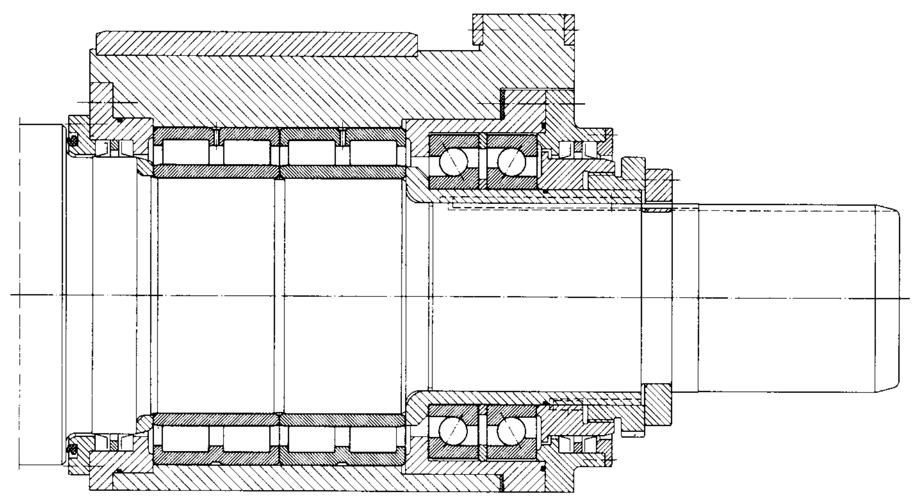
Selection of the work roll bearings (figs. 104b, c)

Radial bearings
Each roll end is supported on two double-row cylindrical roller bearings FAG 532381.K22 (dimensions 350 x 500 x 190 mm). The bearings feature reduced *tolerances* so that all roller rows are evenly loaded, *machined* brass *cages* and an increased *radial clearance* C3.
Machining tolerances
Roll neck to p6; chock bore to H6.

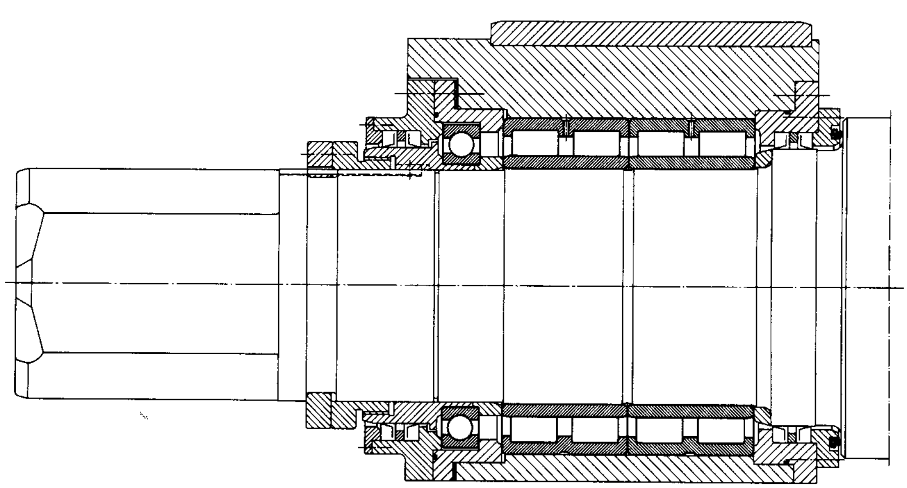
Thrust bearings
Locating bearing end (operating end): two angular contact ball bearings FAG 7064MP.UA in *X arrangement.* Any two bearings of *universal design* UA can be matched in *X or O arrangement,* yielding a bearing pair with a narrow *axial clearance.* The angular contact ball bearings accommodate the thrust loads from the rolls.
Floating bearing end (drive end): a deep groove ball bearing FAG 61972M.C3 merely provides axial guidance for the chock.
Machining tolerances: Sleeve to k6; outer rings not radially supported.

Lubrication

All bearings supporting the back-up rolls and work rolls are *oil*-mist lubricated. A high-*viscosity oil* with *EP additives* is used as the cylindrical roller bearings – especially at the back-up rolls – are heavily loaded and have to accommodate operating temperatures of up to 70 °C.



104b: Work roll bearings, operating end



104c: Work roll bearings, drive end

105 Work rolls for the finishing section of a four-high hot wide strip mill

Work roll bearings are often exposed to large amounts of water or roll coolant. In addition, considerable amounts of dirt have to be accommodated in hot rolling mills. Therefore, the bearings must be efficiently *sealed.* As a rule, they are lubricated with *grease,* which improves *sealing* efficiency. Operators of modern rolling mills endeavour to reduce *grease* consumption and damage to the environment caused by escaping grease-water emulsion.

Operating data

Roll body diameter 736 mm; roll body length 2,235 mm; rolling speed 3.5...15 m/s.

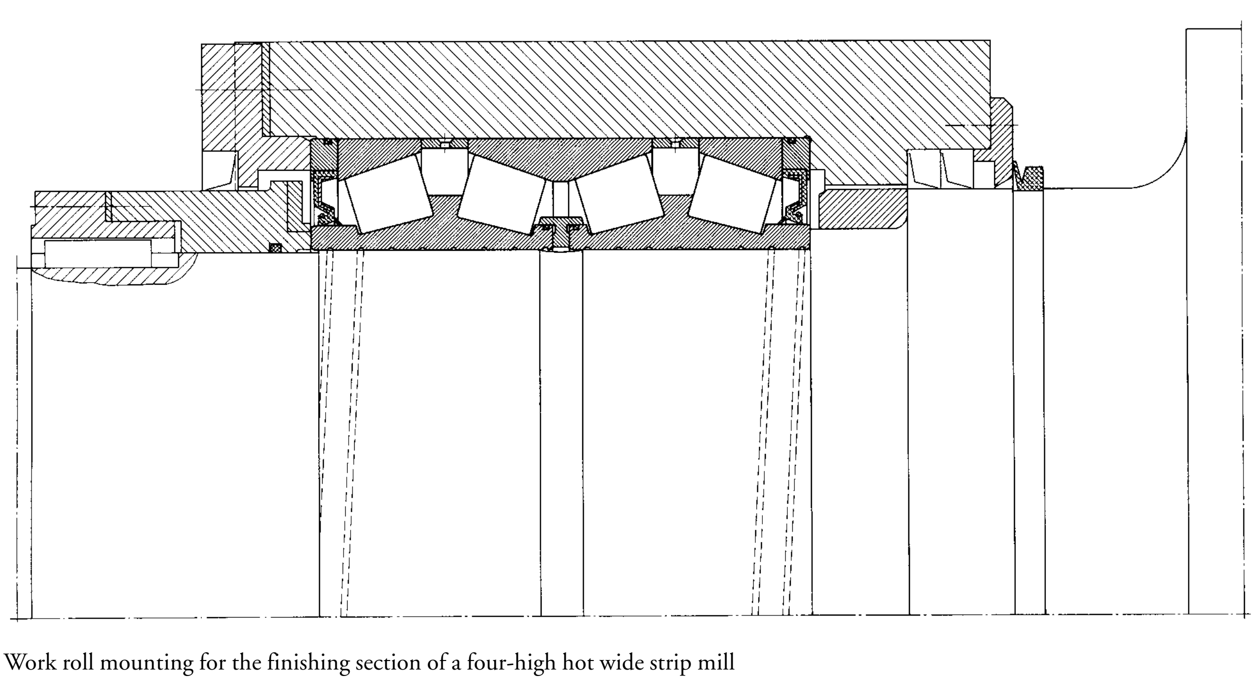
Bearing selection, dimensioning

Four-row tapered roller bearings have proved to be a good choice for work rolls. They accommodate not only high radial loads but also thrust loads, and they require only little mounting space. The bearings have a sliding fit on the roll neck, allowing rapid roll changes. In the example shown, sealed four-row tapered roller bearings FAG 563681A (dimensions 482.6 x 615.95 x 330.2 mm) are used.

The *service life* of work roll bearings is mainly dictated by the loads, rolling speed, lubrication and cleanliness. Open bearings, as a rule, do not reach their *nominal rating life* due to adverse lubricating and cleanliness conditions. On the other hand, the *modified life calculation* for sealed bearings usually yields a_{23} *factors* > 1, i. e. the *attainable life* exceeds the *nominal rating life.* In spite of the lower *load rating,* the value is generally higher than that reached by an open bearing of the same size.

Lubrication, sealing

The bearings are filled with relatively small amounts of high-quality rolling bearing *grease.* On each side they feature a double-lip rubbing *seal.* The inner lip prevents *grease* escape from the bearing; the outer lip protects the bearing from moisture that might have penetrated into the chock. No relubrication is required during rolling operation and roll change. The amount of *grease* provided during assembly usually suffices for the duration of one chock regrinding cycle, i. e. for 1,000...1,200 hours of operation. The chocks are fitted with the conventional external *seals* (collar seals). These are filled with a moderately priced, environmentally compatible sealing grease.



105: Work roll mounting for the finishing section of a four-high hot wide strip mill

106 Roll mountings of a two-high ingot slab stand or ingot billet stand

Operating data

Roll diameter 1,168 mm (46"); roll body length 3,100 mm (122"); rolling speed 2.5...5 m/s; yearly output of 1 million tons. The mill operates as a reversing stand, i.e. the rolled material moves back and forth, and the sense of rotation of the rolls alternates from pass to pass.

Roll bearings

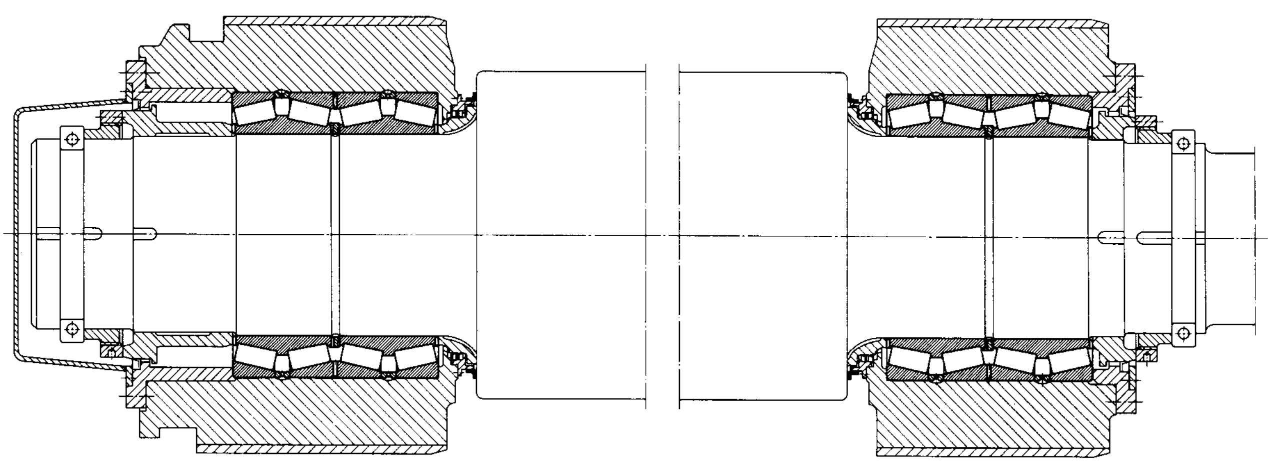
The work rolls in this example are also supported on multi-row tapered roller bearings. These bearings require relatively little mounting space and accommodate high radial and thrust loads. The rolls are supported at each end on a four-row tapered roller bearing FAG 514433A (dimensions 730.25 x 1,035.05 x 755.65 mm).

The bearing rings are loosely fitted on the roll neck and in the chocks for easy mounting and dismounting. The cones creep on the roll neck in circumferential direction. To reduce *wear* and heat generation, the fitting surfaces are usually supplied with *grease* through a helical groove in the bearing bore.

Lubrication

The tapered roller bearings are lubricated with *grease* which is continually supplied through grooves in the faces of cone and spacer ring.

Excess *grease* escapes through the bores in the central cup and in the spacers.



106: Roll mounting of a two-high ingot slab stand or ingot billet stand

107 Combined reduction and cogging wheel gear of a billet mill

Operating data

The billet mill is designed for a monthly output of 55,000 tons. The mill comprises a roughing and a finishing section, each with two vertical and two horizontal stands in alternate arrangement. The drive of the vertical stands is on top; with this arrangement the foundations are not as deep as for a bottom drive; on the other hand, the top drive involves a greater overall height.

Rated horsepower 1,100/2,200 kW;
motor speed 350/750 min^{-1}.

Bearing selection, dimensioning

Radial loads and thrust loads are accommodated separately: the radial loads by cylindrical roller bearings, the thrust loads by angular contact ball bearings and four point bearings. Cylindrical roller bearings offer the best radial load carrying capacity in a limited mounting space, thus keeping the distance between the gear shafts to a minimum. One decisive factor in the selection of the bearing size is the diameter of the individual gear shafts determined in the strength calculation. The two largest cylindrical roller bearings of the gear are situated on the cogging wheel side and have the following dimensions: 750 x 1,000 x 250 mm. Axial location of the four gear shafts is provided by one four point bearing each which are double direction angular contact ball bearings.

Compared to two angular contact ball bearings, a four point bearing offers the advantage of smaller width and, compared to a deep groove ball bearing, the advantage of smaller *axial clearance* and higher thrust carrying capacity. The use of four point bearings is, however, limited to applications where the thrust load is not constantly reversing. The bevel gear shafts feature the smallest possible *axial clearance* to ensure perfect meshing of the spiral-toothed gears. This is achieved by one duplex pair of angular contact ball bearings each on the pinion shaft and on the bevel shaft. They also accommodate the thrust load whereas the radial load is taken up by cylindrical roller bearings.

Machining tolerances

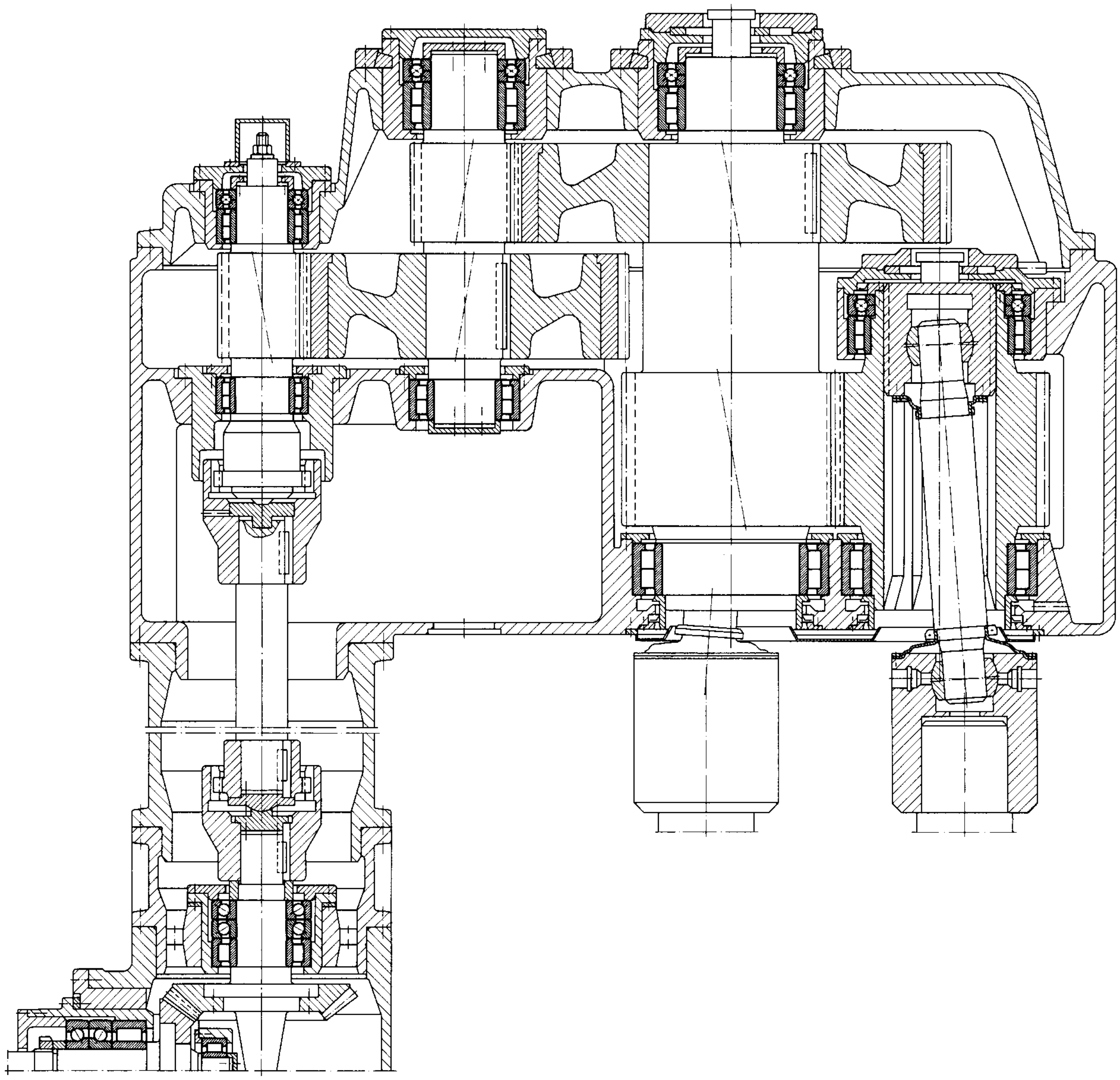
Cylindrical roller bearings: Shaft to p6; housing to H6/H7.

Four point bearings and angular contact ball bearings: Shaft to f6; housing to D10.

The outer rings of the four point bearings and angular contact ball bearings are *fitted* into the housing with clearance to relieve them of radial loads; thus, they accommodate only thrust loads.

Lubrication

Circulating *oil* lubrication. The bearings and gears share the same lubrication system. The *oil* is directly supplied to the bearings via an *oil* filter which prevents contamination of the bearings by particles abraded from the gears.

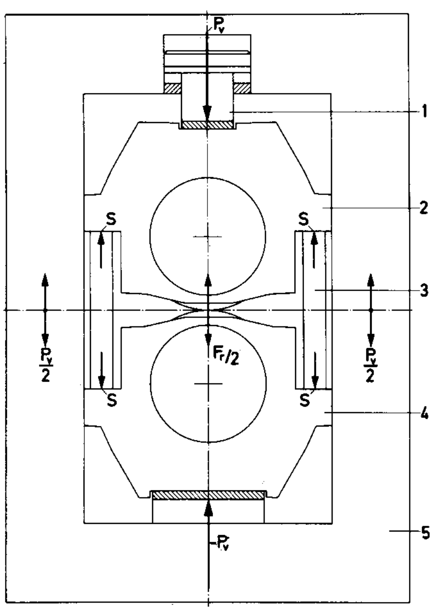


107: Combined reduction and cogging wheel gear of a billet mill

108 Work rolls of a section mill

The roll stand frames expand under the influence of high rolling loads, which can have a negative effect on the quality of the rolled material. This is usually prevented by means of elaborate roll adjustment mechanisms. Another way to compensate for the negative effect of the material's elasticity is to hydraulically preload the chocks which support the rolls and their bearing mountings against each other via the roll stands (see schematic drawing).

9 of the 13 in-line stands of a section mill are fitted with such hydraulically preloaded chocks. Five of the nine preloaded stands can also operate as universal stands. For this purpose they are equipped with two vertically arranged roll sets.



1 Hydraulic piston
2 Upper chock
3 Piston ram
4 Lower chock
5 Frame

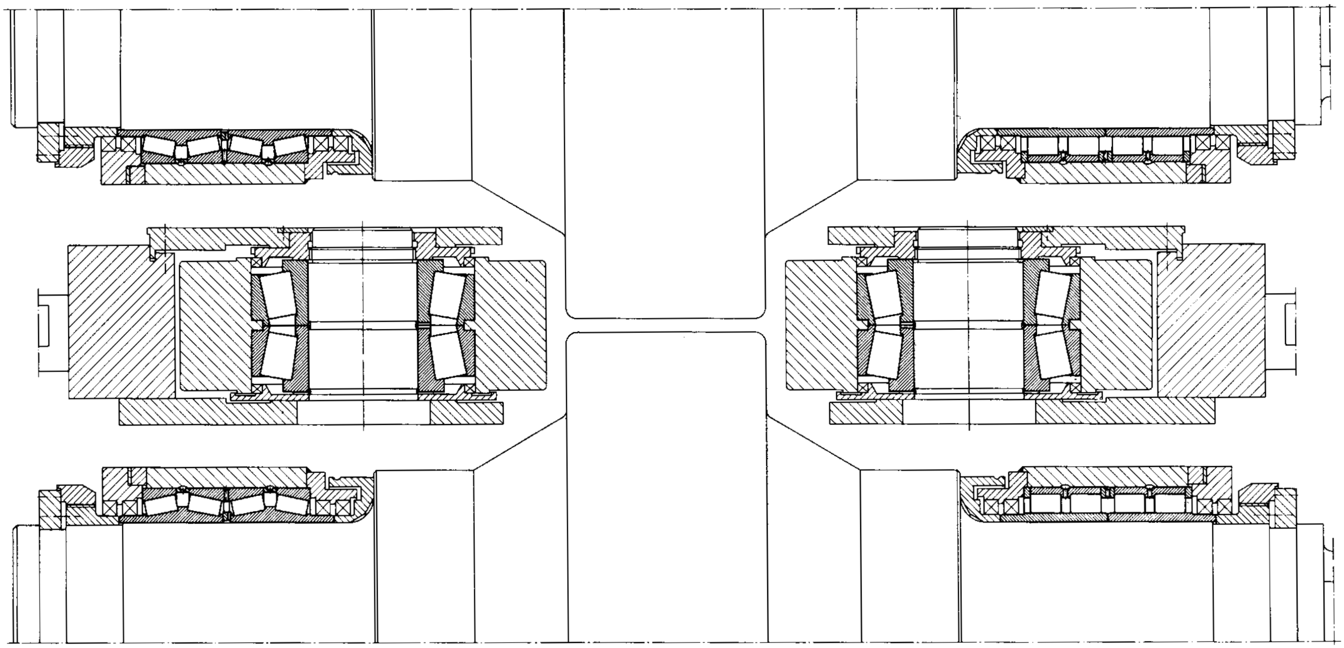
Roll neck mountings

The horizontal rolls are supported by multi-row cylindrical roller bearings and tapered roller bearings. The cylindrical roller bearings at the drive end compensate for the length variations caused by heat expansion. Compensation of length variations through the chock axially floating in the stand at the drive end is not possible with preloaded chocks.

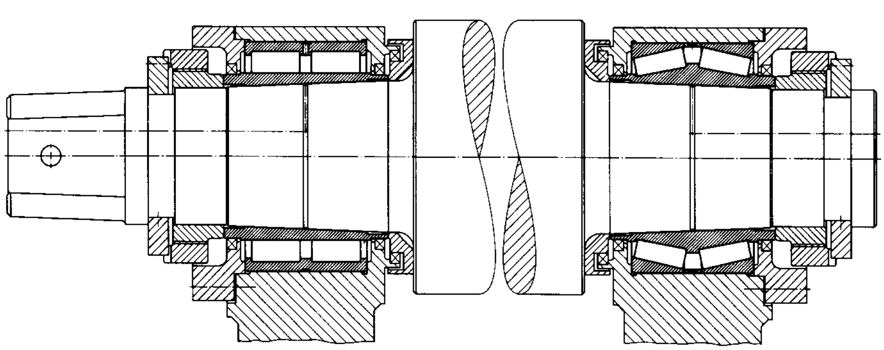
The horizontal rolls in the roughing stands, which are loaded with 3,150 kN, are supported in four-row cylindrical roller bearings and four-row tapered roller bearings of 355.6 x 257.2 x 323.8 mm (fig. a). The bearings have a loose *fit* on the roll neck (e7), which simplifies mounting.

No loose *fit* can be provided in those stands where section steels are finish-rolled as the required quality can only be achieved with accurately guided rolls. For this reason cylindrical roller bearings and tapered roller bearings with a tapered bore were selected and press-fitted onto the tapered roll neck. The hydraulic method used simplifies mounting and dismounting. Due to the lower rolling load (2,550 kN), the horizontal rolls in this case are supported by double-row cylindrical roller bearings and tapered roller bearings of 220.1 x 336.6 x 244.5 mm (fig. b).

The vertical rolls are each supported by a tapered roller bearing pair (dimensions 165.1 x 336.6 x 194.2 mm) in *O arrangement* (fig. a). The bearings sit directly on the rolls. As the rolling stock enters, the vertical rolls and their bearings are accelerated to operating speed very quickly. The tapered roller bearings are preloaded to ensure that the *rolling elements* always maintain contact with the raceways at these speeds. This is achieved by matching the tolerances of the bearings and bearing seats in such a way that the bearings after mounting have the right preload without any fitting work.



108a: Bearing mounting of horizontal rolls in the preloaded roughing stands
and bearing mounting of the vertical rolls



108b: Bearing mounting of horizontal rolls for stands in which section steel is finish-rolled

109 Two-high rolls of a dressing stand for copper and brass bands

On this dressing stand copper and brass bands with widths between 500 and 1,050 mm are rolled. The maximum initial thickness is 4 mm, and the minimum final thickness is 0.2 mm.

"Counterbending" is one special feature of this stand. The rolling forces cause an elastic deflection of the rolls. This deflection is hydraulically compensated for by counterbending forces. The counterbending forces are applied to the roll necks on both sides and outside the roll neck mounting via spherical roller bearings. This counterbending ensures a uniform band thickness over the entire band width.

Operating data

Two-high roll diameter 690/650 mm; roll body length 1,150 mm; maximum rolling speed 230 m/min; maximum rolling force 8,000 kN; maximum counterbending force 1,300 kN per roll neck.

Counterbending bearings

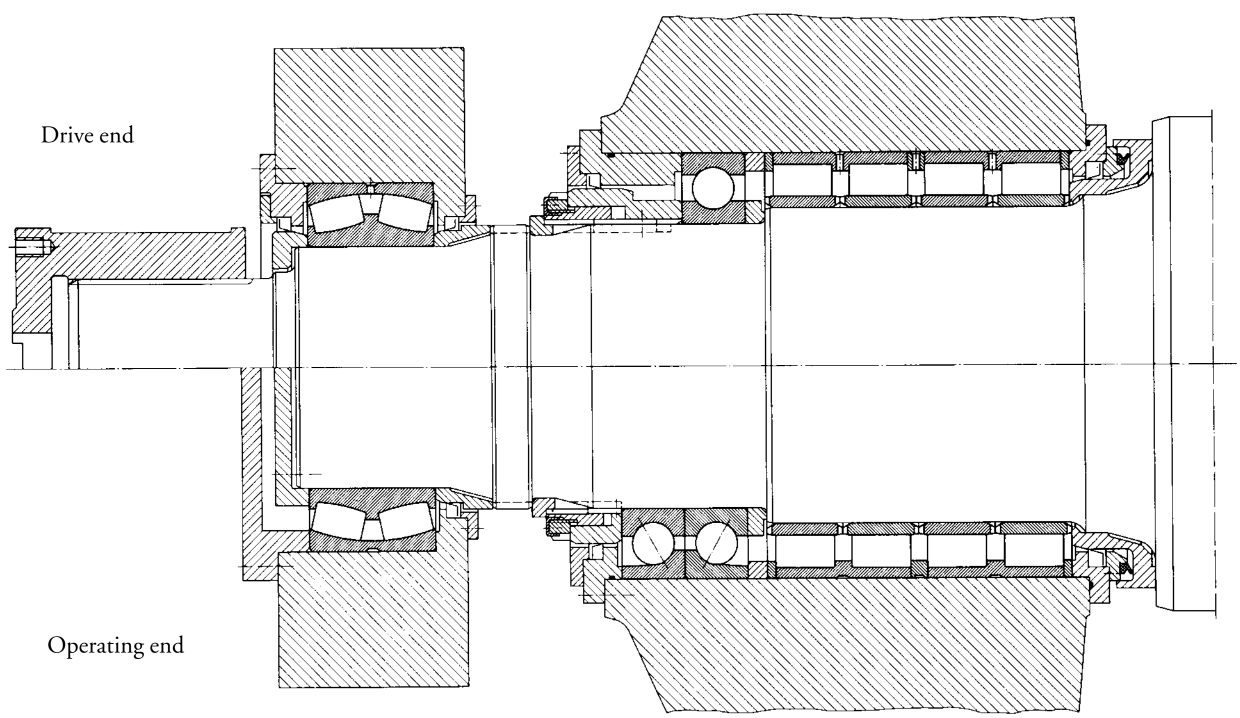
The counterbending forces are applied via spherical roller bearings FAG 24068B.MB.
Machining tolerances: roll neck to e7, housing to H6.

Accommodation of radial loads
One four-row cylindrical roller bearing FAG 547961 (dimensions 445 x 600 x 435 mm) is mounted at each end. The cylindrical roller bearings are fitted with pin-type *cages* consisting of two side washers to which the pins passing through the rollers are fastened. Grooves in the inner ring faces facilitate dismounting.
Machining tolerances:
roll neck +0.160 / +0.200 mm, chock H6.

Accommodation of thrust loads
At the operating end the axial forces are accommodated by two *O arranged* angular contact ball bearings FAG 507227.N10BA (dimensions 400 x 600 x 90 mm).
At the drive end the chock is located on the roll neck by a deep groove ball bearing FAG 6080M.C3.
Machining tolerances: roll neck to f6, outer ring radially relieved.

Lubrication

The cylindrical roller bearings, like the other bearings, are lubricated with a lithium soap base *grease* with *EP additives.* They can easily be lubricated through lubricating holes and lubricating grooves in the outer rings and spacers.

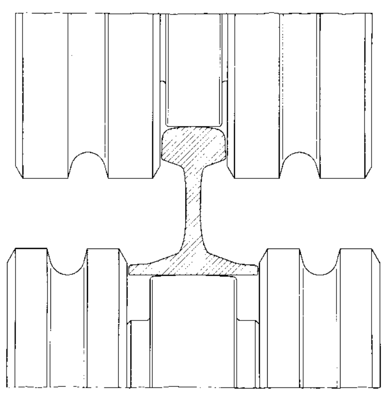


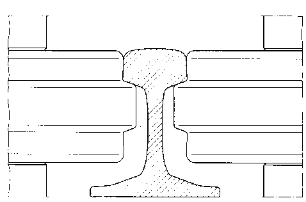
109: Two-high rolls of a dressing stand

110 Straightening rolls of a rail straightener

Rails for railway track systems or for craneways are hot rolled in rolling mills. After rolling the rails cool down on cooling beds but not uniformly, resulting in warping. Afterwards they have to be straightened in rail straighteners between horizontal and vertical rolls.

The straightening plant consists of two machines one installed behind the other. In the first machine the rails run through horizontally arranged rolls, in the second machine through vertically arranged rolls. Thus the rails are straightened in both planes after having passed through the two machines.





Each machine features nine straightening rolls, four of which are being driven. The straightening rolls with diameters of 600...1,200 mm form an overhung arrangement in order to allow easy replacement.

Demands on the bearing assembly

The mounting space for the bearings is dictated by the distance of the straightening rolls. In this mounting space bearings are accommodated which have such a high load carrying capacity as to allow for reasonable running times.
The bearing assembly for the straightening rolls must have maximum rigidity since this determines the accuracy of the rolled stock.
The roll position must be adjustable to the position of the rolled stock. For this reason the bearing assembly had to be designed such as to allow for a change of the position of the straightening rolls by ±50 mm in the axial direction.

Horizontal straightening rolls
The maximum rolling force at the horizontal rolls is 4,200 kN. Depending on the type of rolled stock, thrust loads of up to 2,000 kN have to be accommodated.
Speeds range from two to 60 min^{-1}.

Double-row cylindrical roller bearings have been provided to accommodate the radial forces and because of their high load carrying capacity. The higher loaded cylindrical roller bearing, which is situated directly beside the roll, was especially developed for supporting the straightening rolls (dimensions 530 x 780 x 285/475 mm). The less loaded cylindrical roller bearing has the dimensions 300 x 460 x 180 mm.

The cylindrical roller bearings are fitted with bored rollers which are evenly spaced by pins and *cage* side washers.

As this design allows the distance between the rollers to be indefinitely small, the largest possible number of rollers can be fitted and, adapted to the mounting space, the highest possible load carrying capacity can be obtained for the bearing.

The thrust loads are accommodated by two spherical roller thrust bearings FAG 29448E.MB (dimensions 240 x 440 x 122 mm). They are spring-*adjusted.*

When positioning the straightening rolls, the bearings must be able to compensate for axial displacements by up to ±50 mm. This is made possible by providing an extended inner ring for the cylindrical roller bearing located beside the straightening roll. The inner ring width is such that the lips of the two *seals* always slide safely on the inner ring even with maximum axial displacement.

The second cylindrical roller bearing is seated, together with the two spherical roller thrust bearings, in a sleeve which is axially displaceable within the hollow cylinder. The position of the straightening rolls relative to the rolled stock is adjusted by means of a ball screw.

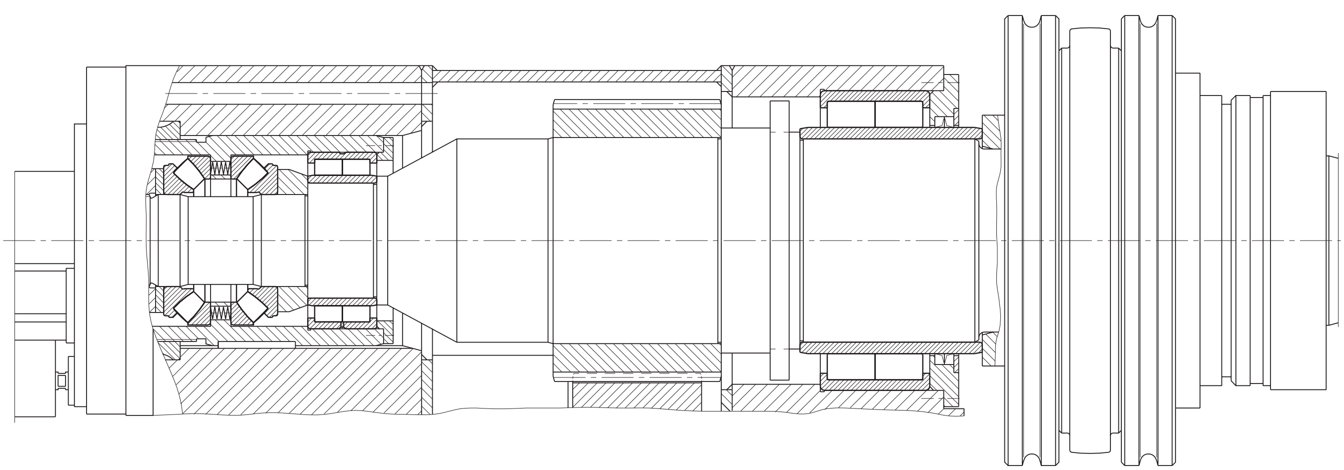
Vertical straightening rolls
The vertical straightening roll bearing arrangement is in principle identical to that of the horizontal straightening rolls. Due to the lower straightening loads, however, smaller bearings can be mounted.
Radial bearings: one axially displaceable double-row cylindrical roller bearing (dimensions 340 x 520 x 200/305 mm) and one single-row cylindrical roller bearing FAG NU2244M.C3 (dimensions 220 x 400 x 108 mm).

Thrust bearings: two spherical roller thrust bearings FAG 29432E (dimensions 160 x 320 x 95 mm).

Lubrication, sealing

In spite of the high loads and the low speeds it would be possible to lubricate the cylindrical roller bearings with *grease*. However, the spherical roller thrust bearings must be *oil*-lubricated. Therefore, all bearings are supplied with *oil* by means of a central lubricating system. The *oil* flow rate per straightening roll unit is about 10 l/min.

At the spherical roller thrust bearing end the unit is closed by a cover. At the shaft opening in the direction of the straightening roll two laterally reversed, *grease*-lubricated *seal* rings prevent oil escape and penetration of contaminants into the bearings.



110: Horizontal straightening rolls

111 Disk plough

In a disk plough the usual stationary blades are replaced by revolving disks fitted to the plough frame. The working width of the plough is determined by the number of disks.

Bearing selection

During ploughing both radial and axial loads are imposed on the bearings. Bearing loads depend on soil conditions and cannot, therefore, be exactly determined. For safety reasons roller bearings with the maximum possible load carrying capacity are used. One tapered roller bearing FAG 30210A (T3DB050 *) and one FAG 30306A (T2FB030 *) are installed in *O arrangement* and *adjusted,* via the cone of the smaller bearing, with zero clearance. This cone must, therefore, be able to slide on the journal.

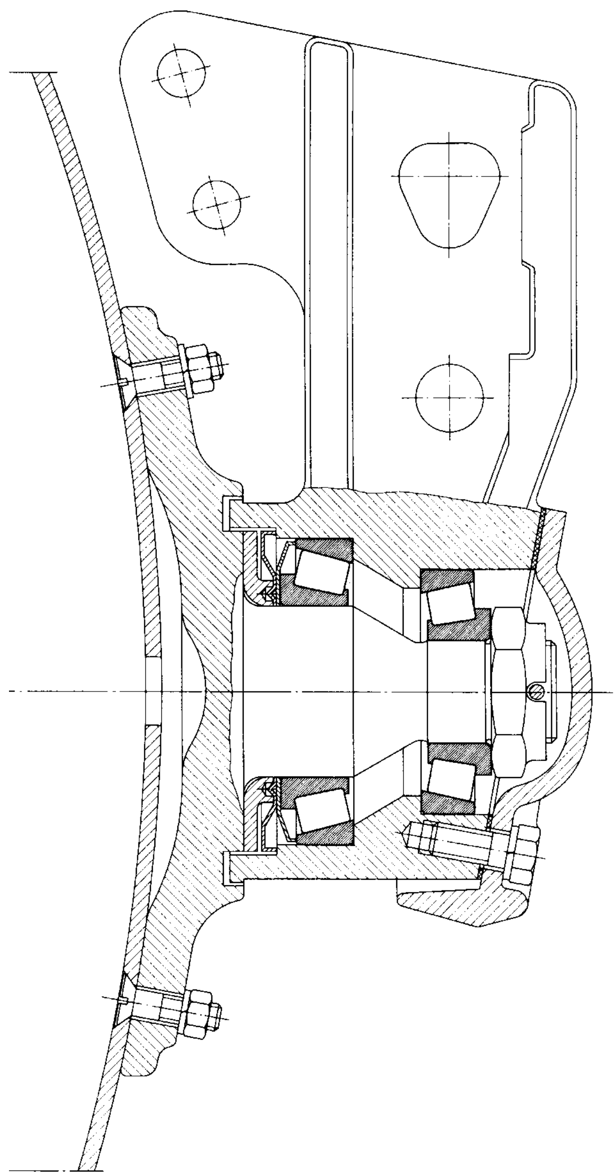
*) Designation to DIN ISO 355

Machining tolerances

on the journal:
– j6 for the smaller bearing,
– k6 for the larger bearing;
in the housing: N7.

Lubrication, sealing

Grease lubrication (FAG rolling bearing grease *Arcanol* L186V). The bearings are adequately protected from dirt and atmospheric influences by means spring steel *seals* and an additional labyrinth seal.



111: Disk plough

112 Plane sifter

Sifters are used in flour mills to segregate the different constituents (e.g. groats, grits, flour). The plane sifter described in this example consists of four sections, each comprising 12 sieves fastened to a frame. An eccentric shaft induces circular vibrations in the frame-sieve assembly.

Operating data

Starting power 1.1 kW, operating power 0.22 kW; speed 220...230 min^{-1}; total weight of balancing masses 5.5 kN; distance between centre of gravity of balancing masses and axis of rotation 250 mm; total weight of frame and sieves plus material to be sifted 20...25 kN.

Bearing selection

The drive shaft with the balancing masses is suspended from the top bearing. The supporting bearing must be *self-aligning* in order to avoid preloading. The bearings mounted are a self-aligning ball bearing FAG 1213 (65 x 120 x 23 mm) and a thrust ball bearing FAG 53214 (70 x 105 x 28,8 mm). The spherical housing washer FAG U214 compensates for misalignment during mounting.

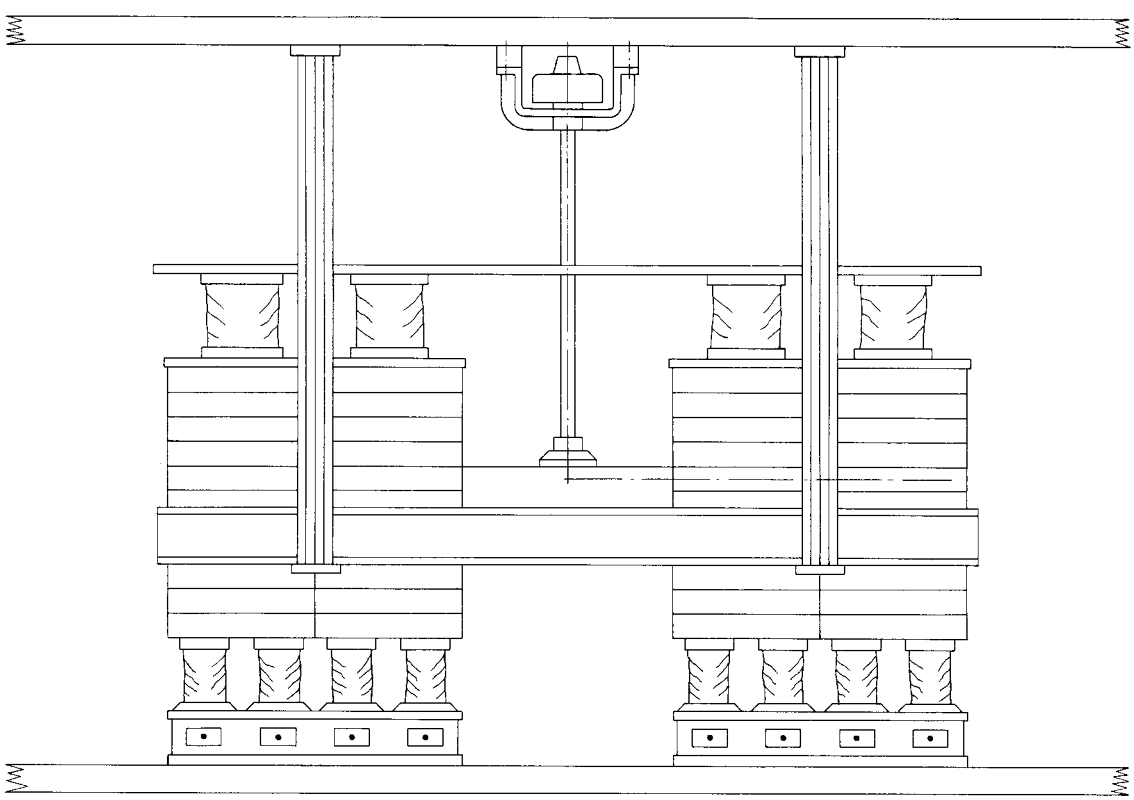
The *thrust bearing* has to accommodate the weight of the drive shaft and balancing masses. The eccentric shaft of the sifter frame is supported by a spherical roller bearing FAG 22320E.T41A. This bearing accommodates the high centrifugal forces resulting from the circular throw of the sifter frame and sieves. Sleeve B is a loose fit on the eccentric shaft; thus the spherical roller bearing is axially displaceable together with the sleeve and cannot be submitted to detrimental axial preloading.

Machining tolerances

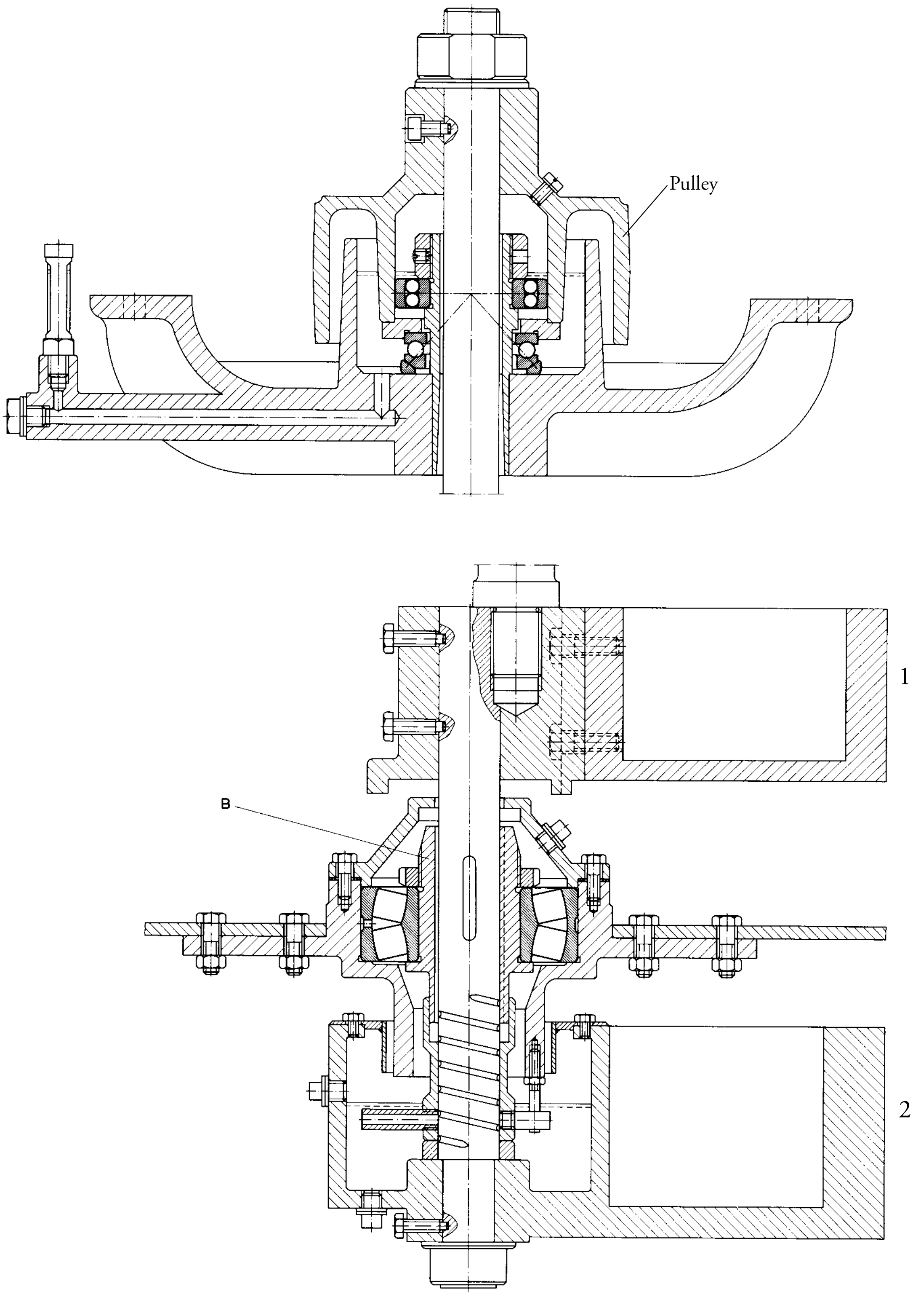
- Self-aligning ball bearing.
  Hollow shaft to k6, pulley bore to J6.
- Spherical roller bearing.
  Sleeve to k6, frame housing bore to K6.

Lubrication

The ball bearings at the top mounting run in an *oil* bath. The spherical roller bearing at the bottom mounting is lubricated by circulating *oil*. A thread cut in the eccentric shaft feeds the oil upward through sleeve B. From the top the oil passes through the spherical roller bearing and back into the oil bath.



Layout of a plane sifter



112: Plane sifter

Printing presses

Printing quality is created in the heart of a printing press, the printing group with its main cylinders. Plate cylinders, blanket cylinders and impression cylinders are, therefore, guided in rolling bearings which are particularly low in friction and which have a high degree of running accuracy and radial rigidity.

FAG has designed a number of highly efficient *locating/floating bearing arrangements* for the main cylinder bearings ranging from solutions with cylindrical roller bearings, tapered roller bearing pairs and spherical roller bearings to triple-ring eccentric bearing units.

113 Impression cylinders of a newspaper rotary printing press

Depending on the specific application, a variety of solutions can be adopted for supporting impression cylinders in a newspaper rotary printing press. Often the *floating bearing* at the operating end is a cylindrical roller bearing and the *locating bearing* arrangement at the drive end consists of a spherical roller bearing or a tapered roller bearing pair. The *floating bearing* accommodates only radial loads whereas the *locating bearing* takes up both radial and thrust loads. Differing spring rates (elastic deformation of *rolling elements* and raceways) and loads acting on the bearings can result in a differing vibration behaviour at each end of the cylinders (negative effect on printing quality).

Operating data

The forces acting on impression cylinders in rotary printing presses are safely accommodated by FAG rolling bearings. In newspaper rotary printing presses a paper web, which may be up to 1,400 mm wide, is fed into the machine via automatic wheel stands at a speed of 9.81 m/s. At a maximum speed of the impression cylinders of 35,000 revolutions per hour and double production, the rotary printing press produces 7,000 copies per hour with a volume of up to 80 pages.

The circumference and width of the impression cylinders are adapted to the required newspaper sizes (e.g. cylinder diameter 325 mm, speed 583.3 min^{-1}, mass 1,100 kg, operating temperature 50...60 °C, average time in operation 7,000 hours per year).

Bearing selection

To rule out differences in vibration behaviour FAG has separated the accommodation of the radial and axial loads from the impression cylinders.
At each end the radial loads are accommodated by a double-row cylindrical roller bearing FAG NN3024ASK.M.SP. A deep groove ball bearing pair 2 x FAG 16024.C3 provides axial guidance for the impression cylinder. The outer rings are radially relieved so that the ball bearings exclusively accommodate axial guiding forces in both directions. By providing identical bearing arrangements on both sides of the impression cylinder identical spring rates are obtained.

The separation of radial and thrust loads means that the radially supporting bearings are symmetrically loaded. This produces a uniform vibration behaviour on both sides of the impression cylinder.

Bearing clearance and adjustment

The low-friction *precision bearings* are accommodated on both sides by eccentric bushes which serve to control the "impression on" and "impression off" movements of the different impression cylinders independently of each other. This requires a high guiding accuracy and a minimal *radial clearance.* Heat development within the bearing is low, which helps achieve the required optimal guiding accuracy. The bearing clearance of 0...10 µm is adjusted via the tapered bearing seat. The temperature-related length compensation takes place in the cylindrical roller bearings between the rollers and the outer ring raceway so that the outer ring can be *fitted* tightly in spite of the *point load.*

The deep groove ball bearings are fitted in *X arrangement* with zero clearance (Technical Specification N13CA). The C3 *radial clearance* ensures a *contact angle* which is favourable for accommodating the axial guiding forces.

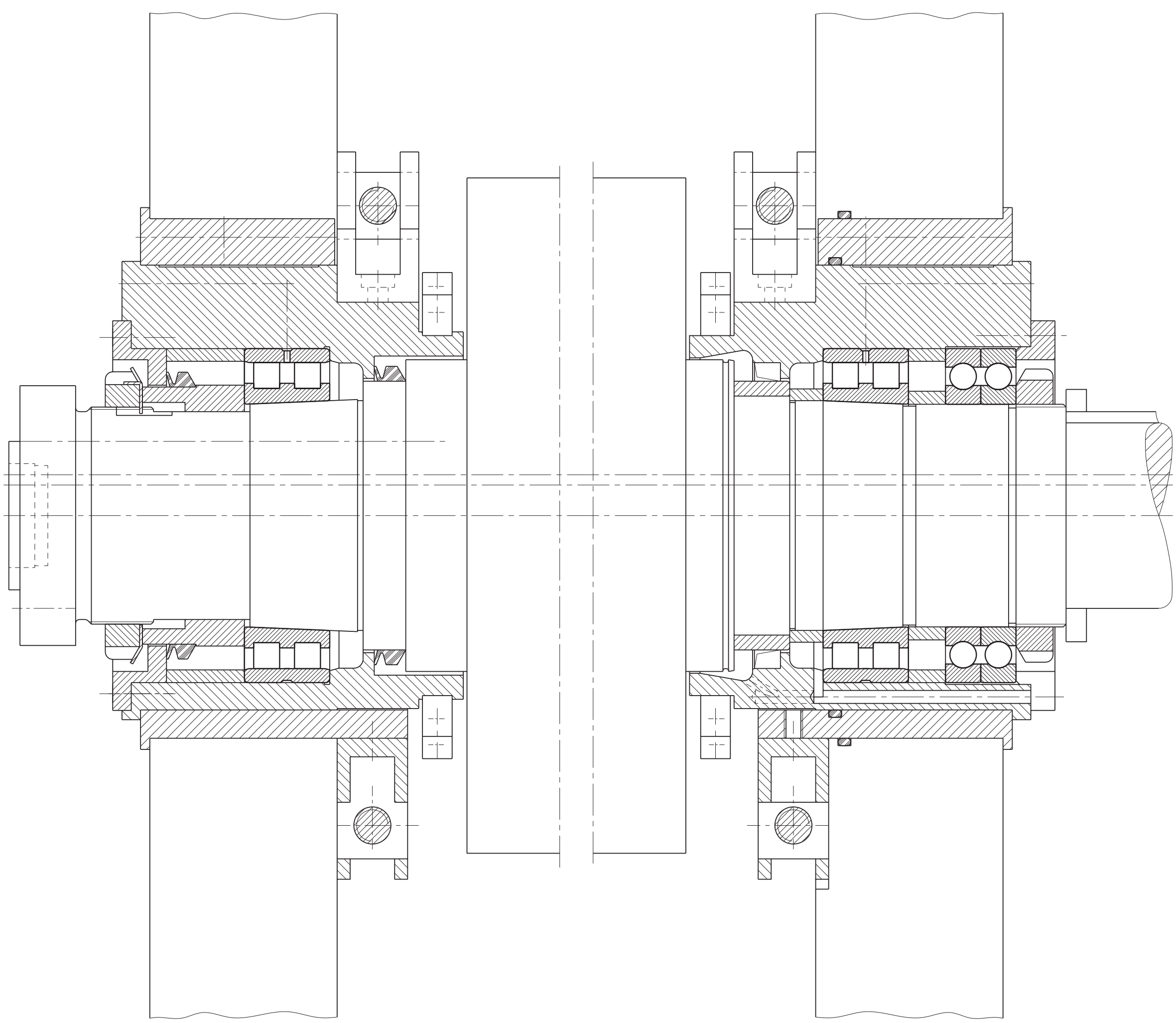
Machining tolerances

Cylindrical roller bearings
Inner ring: *Circumferential load;* interference *fit* on tapered shaft 1:12.
Outer ring: *Point load;* housing bore to K6.

Deep groove ball bearings
Shaft to j6 (k6),
outer ring radially relieved in the housing.

Lubrication, sealing

The bearings are automatically supplied with lubricant. Through a circumferential groove and lubricating holes in the outer ring the lubricant is fed directly into the bearings. At the operator end the supply lines are usually connected to a central *grease* lubrication system. V-ring *seals* prevent both *grease* escape and dirt ingresss. The bearings at the drive end are supplied with *oil* from the transmission oil lubrication system via feed ducts. The *oil* first flows through the cylindrical roller bearing and then through the deep groove ball bearing pair. At the cylinder end a pressure-relieved shaft *seal* retains the *oil* in the lubricating system.



113: Impression cylinder of a KBA Commander newspaper rotary printing press

114 Blanket cylinder of a sheet-fed offset press

To date it was common practice to integrate cylindrical roller bearings, needle roller bearings or other designs in a sliding bearing supported sleeve and to accurately fit this complete unit into an opening in the sidewall of the machine frame; this required an elaborate technology and was costly. Both the considerable cost and the risk of the sleeve getting jammed during the "impression on" and "impression off" movements of the blanket cylinder are eliminated by using a new triple-ring eccentric bearing unit. It offers the benefit of absolute zero clearance which is not possible with the conventional unit as the sleeve always requires some clearance. Another significant advantage is the adjustable preload which allows its radial rigidity to be considerably increased compared to bearings with clearance.

Bearing arrangement

The FAG triple-ring eccentric bearing units *(floating bearings)* are available both with a cylindrical and with a tapered bore. The ready-to-mount unit is based on an NN cylindrical roller bearing design which is used as a low-friction *precision bearing* in machine tools, and a double-row needle roller bearing which guides the eccentric ring. Axial guidance of the cylinder is provided by angular contact ball bearings (FAG 7207B) in *X arrangement,* or by a thrust ball bearing.

Operating data

Roll weight; press-on force; nominal speed

Bearing dimensioning

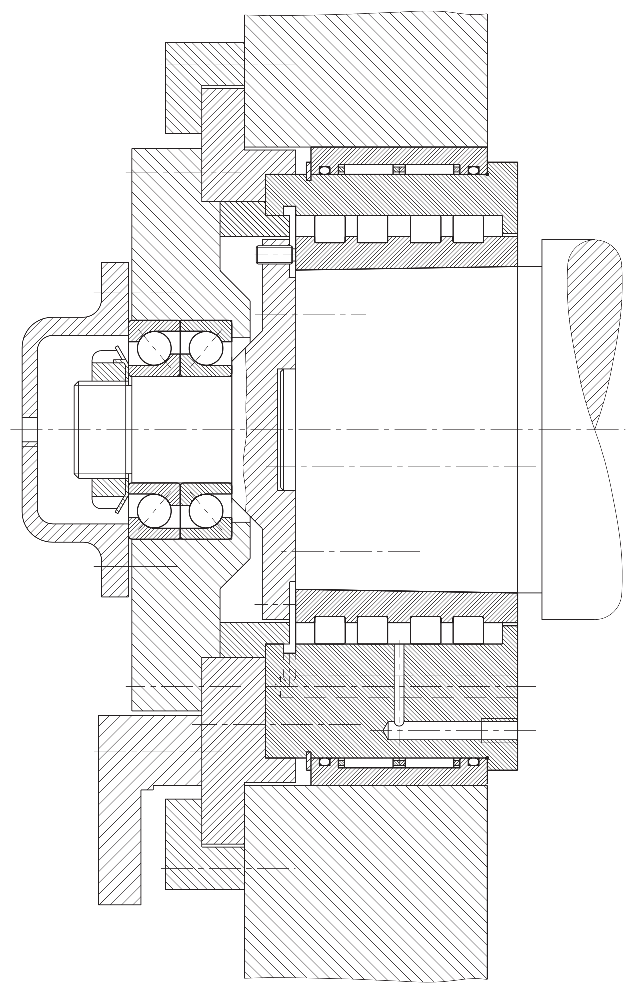
An *index of dynamic stressing* f_L of 4...4.5 would be ideal. This corresponds to a *nominal life* L_h of 50,000 – 80,000 hours. Under the given conditions the bearings are adequately dimensioned so that an *adjusted rating life calculation* is not required.

Machining tolerances

The inner rings are subjected to *circumferential load.* A tight *fit* is obtained by machining the cylinder journal to k4 (k5). With a tapered bearing seat, an interference fit is also obtained by axial displacement.
The outer ring is mounted with a K5 or K6 *fit* or reduced tolerances (with a slight interference).

Lubrication, sealing

The eccentric units can be lubricated both with *grease* and with *oil.* Thanks to the favourable ambient conditions, the lubricant is only very slightly stressed so that long grease *relubrication intervals* and thus a long *service life* are possible. A non-rubbing gap-type *seal* prevents grease escape.
With *oil lubrication,* the *oil* flows to the bearing rollers through feed ducts. Via collecting grooves and return holes the *oil* returns to the *oil* circuit.



114: Triple ring bearing for a blanket cylinder

115 Centrifugal pump

Operating data

Input power 44 kW; delivery rate 24,000 l/min; delivery head 9 m; speed $n = 1{,}450\ min^{-1}$; axial thrust 7.7 kN.

Bearing selection, dimensioning

The impeller is overhung. The coupling end of the impeller shaft is fitted with a duplex pair of contact ball bearings FAG 7314B.TVP.UA mounted in *X arrangement.* The suffix UA identifies bearings which can be universally mounted in *tandem, O* and *X arrangement.* When mounted in *O* or *X arrangement,* if the shaft is machined to j5 and the housing to J6, the bearings have a slight *axial clearance.* The bearing pair acts as the *locating bearing* and accommodates the thrust $F_a = 7.7$ kN. The radial load F_r is approx. 5.9 kN. Since $F_a/F_r = 1.3 > e = 1.14$, the *equivalent dynamic load* P of the bearing pair

$P = 0.57 \cdot F_r + 0.93 \cdot F_a = 10.5$ kN

Thus the *index of dynamic stressing*

$f_L = C/P \cdot f_n = 186/10.5 \cdot 0.284 = 5.03$

The *nominal life* amounts to approximately 60,000 hours. The *speed factor* for ball bearings $f_n = 0.284$ ($n = 1{,}450\ min^{-1}$) and the *dynamic load rating* of the bearing pair

$C = 1.625 \cdot C_{individual\ bearing} = 1.625 \cdot 114 = 186$ kN.

The impeller end of the shaft is fitted with a cylindrical roller bearing FAG NU314E.TVP2 acting as the *floating bearing.* This bearing supports a radial load of approximately 11 kN. Thus, the *index of dynamic stressing*

$f_L = C/P \cdot f_n = 204/11 \cdot 0.322 = 5.97$

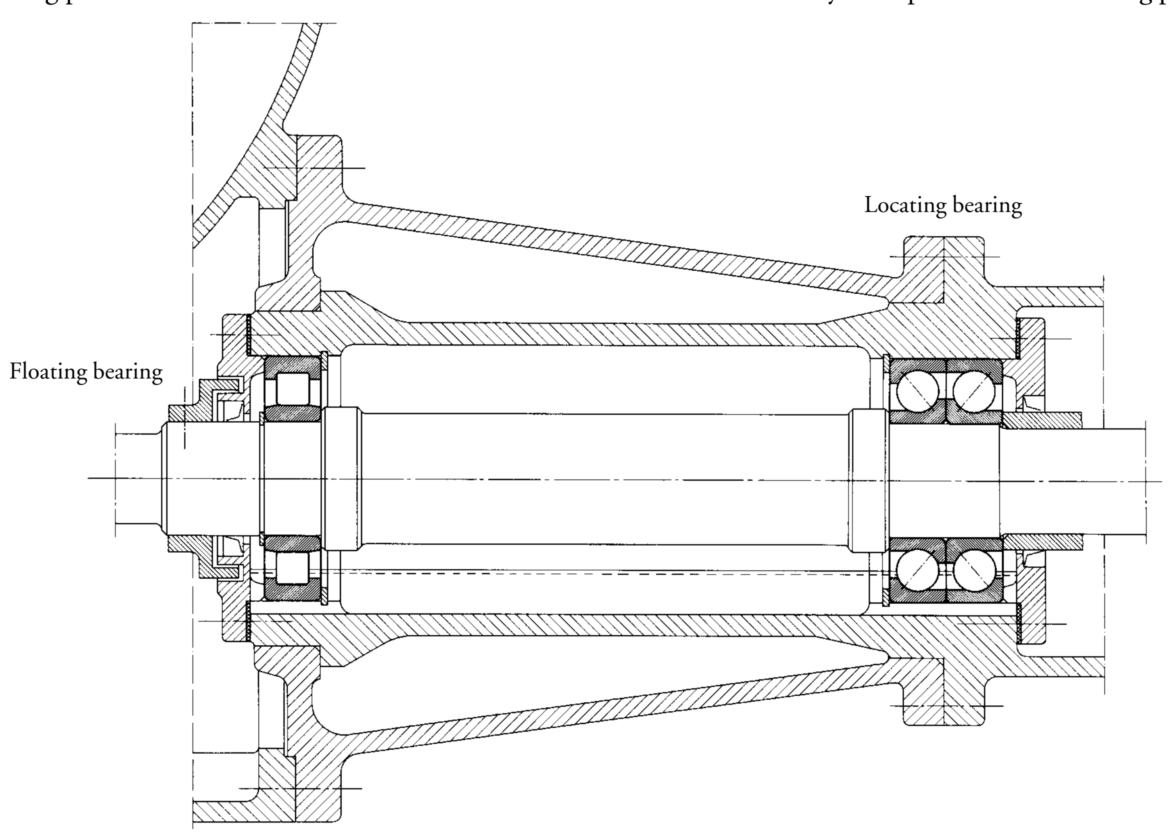
corresponding to a *nominal rating life* of more than 100,000 hours.

With the *speed factor* for roller bearings $f_n = 0.322$ ($n = 1{,}450\ min^{-1}$), the *dynamic load rating* of the bearing C = 204 kN.

The recommended f_L values for centrifugal pumps are 3 to 4.5. The bearings are, therefore, adequately dimensioned with regard to *fatigue life.* The *service life* is shorter if formation of condensation water in the bearings or penetration of contaminants is expected.

Lubrication, sealing

Oil bath lubrication. The *oil* level should be no higher than the centre point of the lowest *rolling element.* The bearings are *sealed* by shaft *seals.* At the impeller end of the shaft a labyrinth provides extra *sealing* protection.

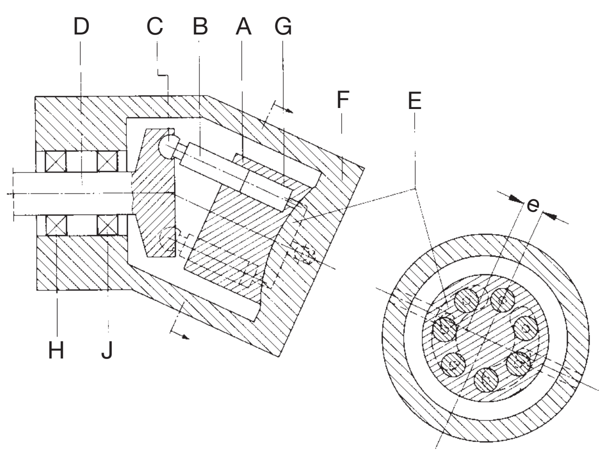


115: Centrifugal pump

116 Axial piston machine

Cylinder block A accommodates a number of pistons B symmetrically arranged about the rotational axis. Piston rods C transmit the rotation of drive shaft D to the cylinder block. They also produce the reciprocating motion of the pistons, provided that the rotational axis of cylinder block and drive shaft are at an angle to each other.

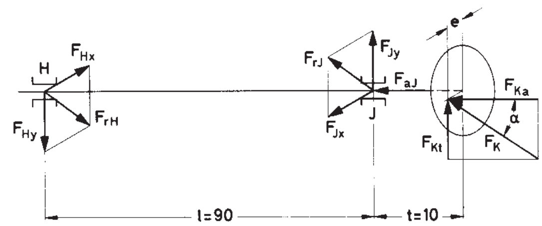
Fluid intake and discharge are controlled via two kidney-shaped openings E in pump housing F. Bore G establishes connection from each cylinder to openings E. During one rotation of the cylinder block, each bore sweeps once over the intake (suction) and discharge (pressure) openings. The discharge opening is subjected to high pressure. Consequently, the pistons are acted upon by a force. This force is carried by the piston rods to the drive shaft and from there to the drive shaft bearings.



In axial piston machines only some of the pistons are pressurized (normally half of all pistons). The individual forces of the loaded pistons are combined to give a resultant load which acts eccentrically on the swash plate and/or drive flange.

Operating data

Rated pressure $p = 100$ bar $= 10$ N/mm^2; max. speed $n_{max} = 3{,}000$ min^{-1}, operating speed $n_{nom} = 1{,}800$ min^{-1}; piston diameter $d_K = 20$ mm, piston pitch circle = 59 mm, angle of inclination $\alpha = 25°$, number of pistons $z = 7$; distance between load line and rotational axis $e = 19.3$ mm.



Bearing selection

At relatively high speeds, bearings H and J have to accommodate the reactions from the calculated resultant load. The bearing mounting should be simple and compact.

These requirements are met by deep groove ball bearings and angular contact ball bearings. Bearing location H features a deep groove ball bearing FAG 6208, bearing location J two *universal* angular contact ball bearings FAG 7209B.TVP.UA in *tandem arrangement.* Suffix UA indicates that the bearings can be universally mounted in *tandem, O* or *X arrangement.*

Bearing dimensioning

Assuming that half of the pistons are loaded, piston load

$F_K = z/2 \cdot p \cdot d_K^2 \cdot \pi/4 = 3.5 \cdot 10 \cdot 400 \cdot 3.14/4 =$
$= 11{,}000 \text{ N} = 11 \text{ kN}$

For determination of the bearing loads the piston load F_K is resolved into tangential component F_{Kt} and thrust load component F_{Ka}:

$F_{Kt} = F_K \cdot \sin \alpha = 11 \cdot 0.4226 = 4.65$ kN

$F_{Ka} = F_K \cdot \cos \alpha = 11 \cdot 0.906 = 9.97$ kN

The two components of the piston load produce radial loads normal to each other at the bearing locations. The following bearing loads can be calculated by means of the load diagram:

Bearing location J

$F_{Jx} = F_{Ka} \cdot e/l = 9.97 \cdot 19.3/90 = 2.14$ kN

$F_{Jy} = F_{Kt} \cdot (l + t)/l = 4.65 \cdot (90 + 10)/90 = 5.17$ kN

$F_{rJ} = \sqrt{F_{Jx}^2 + F_{Jy}^2} = \sqrt{4.58 + 26.73} = 5.59$ kN

In addition to this radial load F_{rJ}, bearing location J accommodates the thrust load component of the piston load:

$F_{aJ} = F_{Ka} = 9.97$ kN

Thus, the *equivalent dynamic load* with F_a/F_r = 9.97/5.59 > e = 1.14 and X = 0.35 and Y = 0.57.

$P = 0.35 \cdot F_{rJ} + 0.57 \cdot F_{aJ} =$
$= 0.35 \cdot 5.59 + 0.57 \cdot 9.97 = 7.64$ kN

With the *dynamic load rating* C = 72 kN and the *speed factor* $f_n = 0.265$ (n = 1,800 min^{-1}) the *index of dynamic stressing*

$f_L = C/P \cdot f_n = 72/7.64 \cdot 0.265 = 2.5$

Here the *load rating* C of the bearing pair is taken as double the *load rating* of a single bearing.

Bearing location H

$F_{Hx} = F_{Ka} \cdot e/l = 9.97 \cdot 19.3/90 = 2.14$ kN

$F_{Hy} = F_{Kt} \cdot t/l = 4.65 \cdot 10/90 = 0.52$ kN

$F_{rH} = \sqrt{F_{Hx}^2 + F_{Hy}^2} = \sqrt{4.58 + 0.27} = 2.2$ kN

The *equivalent dynamic load* for the deep groove ball bearing equals the radial load:

$P = F_{rH} = 2.2$ kN

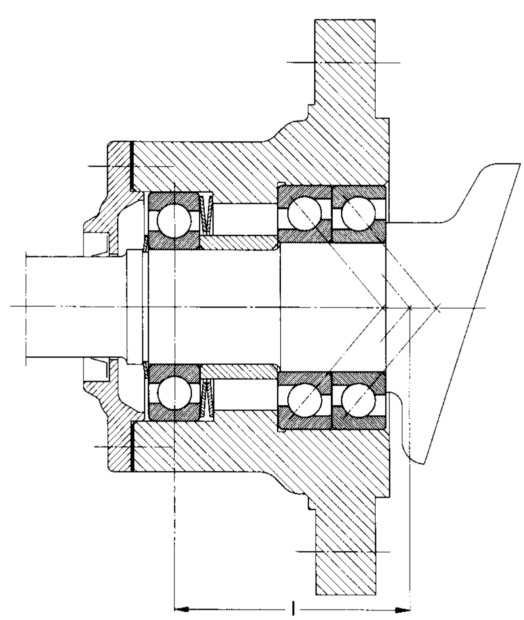
With the *dynamic load rating* C = 29 kN and the *speed factor* $f_n = 0.265$ (n = 1,800 min^{-1}) the *index of dynamic stressing*

$f_L = C/P \cdot f_n = 29/2.2 \cdot 0.265 = 3.49$

The index f_L for axial piston machines selected is between 1 and 2.5; thus the bearing mounting is adequately dimensioned. Loads occurring with gearwheel drive or V-belt drive are not taken into account in this example.

Machining tolerances

Seat	Deep groove ball bearing	Angular contact ball bearing
Shaft	j5	k5
Housing	H6	J6



116: Drive flange of an axial piston machine

117 Axial piston machine

Operating data

Rated pressure p = 150 bar; maximum speed n_{max} = 3,000 min^{-1}, operating speed n_{nom} = 1,500 min^{-1}; piston diameter d_K = 25 mm, piston pitch circle = 73.5 mm; angle of inclination α = 25°; number of pistons z = 7; distance between load line and rotational axis e = 24 mm.

Bearing selection, dimensioning

The bearing loads are determined as in example 116.

Bearing location H: Deep groove ball bearing FAG 6311
Index of dynamic stressing f_L = 2.98

Bearing location J: Angular contact ball bearing FAG 7311.TVP
Index of dynamic stressing f_L = 1.19

In examples 116 and 117 the axial load is accommodated by angular contact ball bearings mounted near the drive flange end. *Counter guidance* is provided by a deep groove ball bearing.

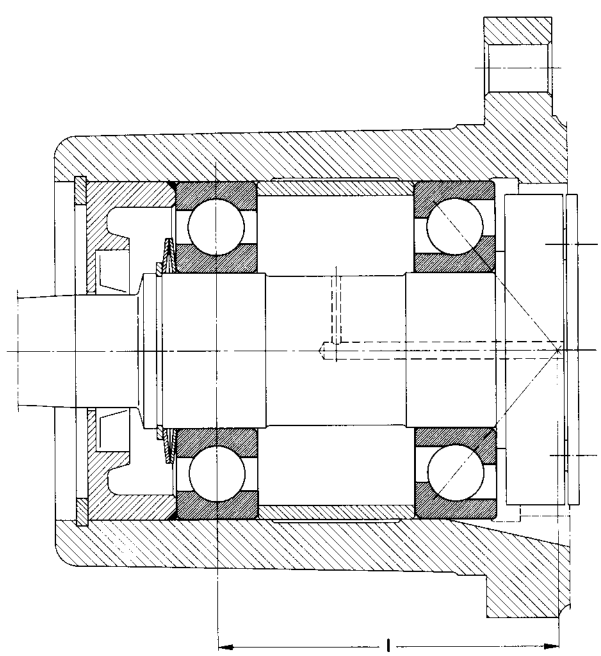
To minimize shaft tilting due to the *radial clearance* of the deep groove ball bearing, Belleville spring washers keep the bearing under light axial preload, thus ensuring zero clearance. A comparison of the f_L values determined for the two pumps shows that the pump described in example 117 is designed for only a short operating life (*rating fatigue life* 850 h). This life span is, however, sufficient for many applications (e.g. dump trucks).

Lubrication, sealing

The bearings are lubricated by leakage *oil* from the pump. A shaft *seal* is satisfactory.

Machining tolerances

Seat	Deep groove ball bearing	Angular contact ball bearing
Shaft	h6	j5
Housing	J6	J6



117: Drive flange of an axial piston machine

118 Exhauster

The exhauster is of the double-flow type; rotor weight 22 kN; speed 1,200 min^{-1}; exhaust gas temperature approx. 180 °C.

Bearing selection, dimensioning

The use of plummer blocks for mounting the rotor shaft is simple and economical. The shaft diameter is dictated by strength considerations, and determines plummer block and bearing size.

The shaft is mounted on spherical roller bearings FAG 22226E.C3 fitted in housings FAG LOE226BF and FAG LOE226AL. Due to the exhaust gas temperature of +180 °C and the relatively high exhauster speed, the bearings feature an increased *radial clearance* C3. This prevents the bearings from running under preload when there are major temperature differences between inner and outer ring. In addition, cooling discs are required to limit the bearing temperature. The plummer block at the drive end is designed as the *locating bearing* with a shaft opening (design BF), and that at the opposite end as the *floating bearing* with end cap (design AL).

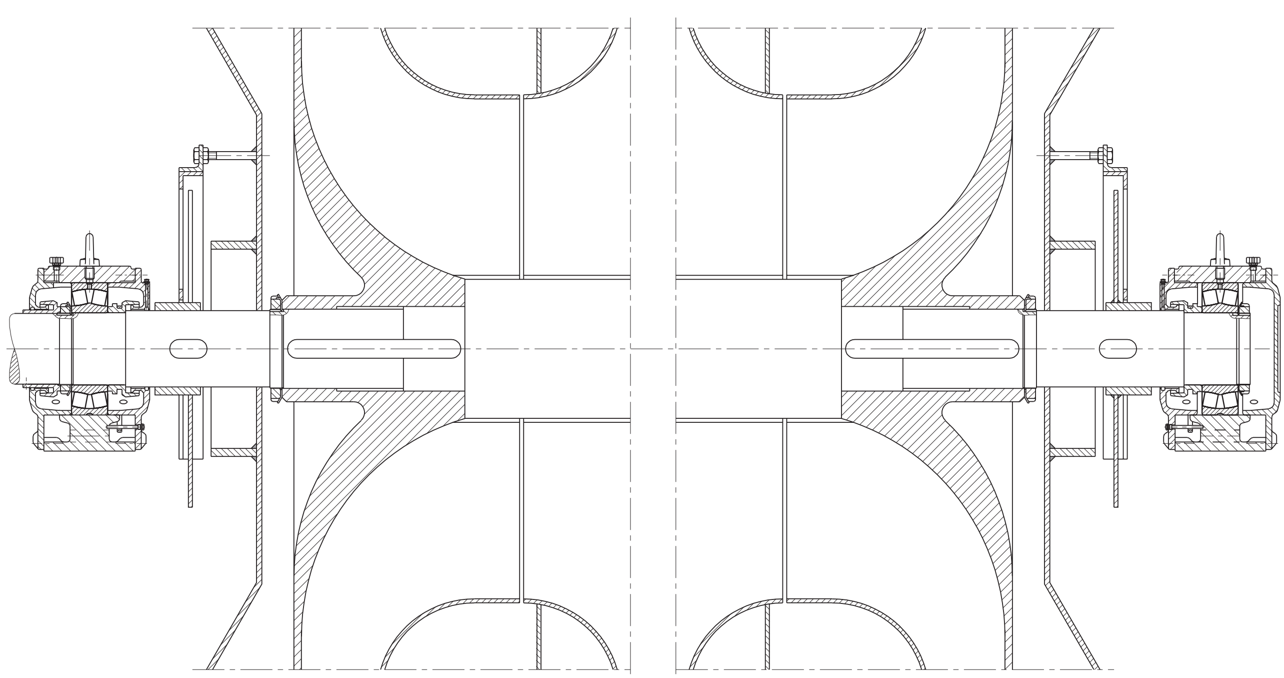
With the specified operating data the calculated *index of dynamic stressing* $f_L \approx 10$; an f_L value of 4...5 (corresponding to 55,000...100,000 h) would be adequate. Thus, the bearings are very safely dimensioned with regard to *fatigue life*. However, premature *wear* can be caused by slippage, ending the actual *service life* of the bearings before the *calculated fatigue life* has been reached.
The plummer blocks are made of grey cast iron. The housing bodies are split to simplify mounting.

Machining tolerances

Shaft to m6; housing to G6.

Lubrication, sealing

The LOE housings feature an *oil* bath. A ring oiler supplies the bearings with *oil*. The design of the lateral housing covers (oil collecting pockets and return ducts) allows excess *oil* to return to the sump.
A grease chamber is provided as an additional *sealing* between cover and labyrinth ring; the chamber is replenished with *grease* at regular intervals.



118: Rotor mounting of an exhauster

119 Hot gas fan

Gas temperature 150 °C; thrust 3 kN; operating speed 3,000 min^{-1}.

Bearing selection

The impeller of small and medium-sized fans is generally overhung. A particularly simple and economical arrangement is achieved by providing a one-piece housing incorporating two bearing mountings. The overhung impeller arrangement produces, however, a tilting moment from the impeller weight and unbalanced forces acting at the impeller. The radial loads resulting from this moment can be minimized by providing a large distance between the bearing locations in relation to the distance between the impeller and the first bearing location. This requirement is satisfied by plummer block housings of series FAG VR(E) (*grease lubrication*) or FAG VOS (*oil lubrication*) which were especially developed for fan applications. Since the operating speed is relatively high, bearings with a high *speed suitability* are used, e.g. cylindrical roller bearings for accommodating the radial loads and angular contact ball bearings for combined (i.e. radial and thrust) loads. The shaft diameter, dictated by strength considerations, is 85 mm.

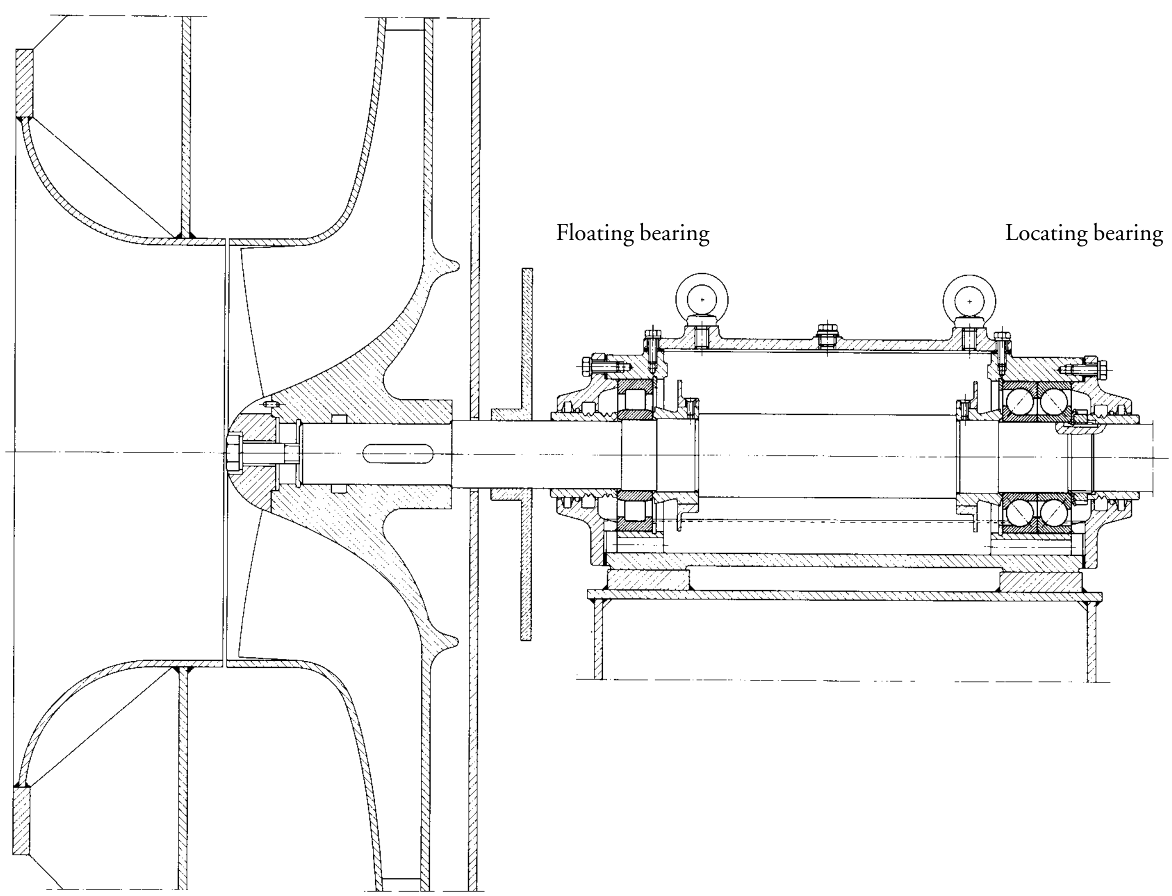
The mounting consists of a plummer block housing (series VOS) for *oil lubrication* FAG VOB317. At the impeller end a cylindrical roller bearing FAG NU317E.M1.C3 acts as the *floating bearing,* at the drive end two *universal* angular contact ball bearings FAG 7317B.MP.UA are mounted in *O arrangement.* Suffix UA identifies bearings which can be universally mounted in *tandem, O* or *X arrangement;* the *X* and *O arrangements* feature a small *axial clearance.* The *axial clearance* combined with *oil lubrication* prevents overheating of the bearings and thus preloading.

Machining tolerances

Cylindrical roller bearing:	Shaft to m5; housing to K6.
Angular contact ball bearings:	Shaft to k6; housing to J6.

Lubrication, sealing

Oil lubrication. The oil sump in the housing contains approximately 4 l of *oil.* Flinger rings feed the *oil* to the bearings. The sleeves mounted on the shaft feature flinger grooves. *Oil* collecting grooves and replenishable grease chambers are provided in the housing covers.



119: Rotor bearings of a hot gas ventilator

120 Fresh air blower

Weight of impeller 0.5 kN, weight of shaft 0.2 kN, thrust 0.3 kN; speed 3,000 min^{-1}.

Bearing selection

Since a simple and economical mounting is required, a plummer block FAG SNV120.G944AA with a self-aligning ball bearing FAG 2311K.TV.C3 is arranged at either side of the impeller. *Self-aligning bearings* are necessary because of the difficulty in aligning two separately mounted housings so accurately that the bores are exactly aligned.

The housing is suitable for *grease* replenishment (suffix G944AA). A grease nipple is provided at the housing cap and a grease escape bore at the opposite side of the housing base.

As long as the impeller is satisfactorily balanced the inner rings of the bearings are *circumferentially loaded.* They are mounted on the shaft with adapter sleeves FAG H2311. However, when the imbalance forces exceed the weight of impeller and shaft the *circumferential load* is transmitted to the outer ring.

Calculation of the *rating fatigue life* shows that the bearings are more than adequately dimensioned.

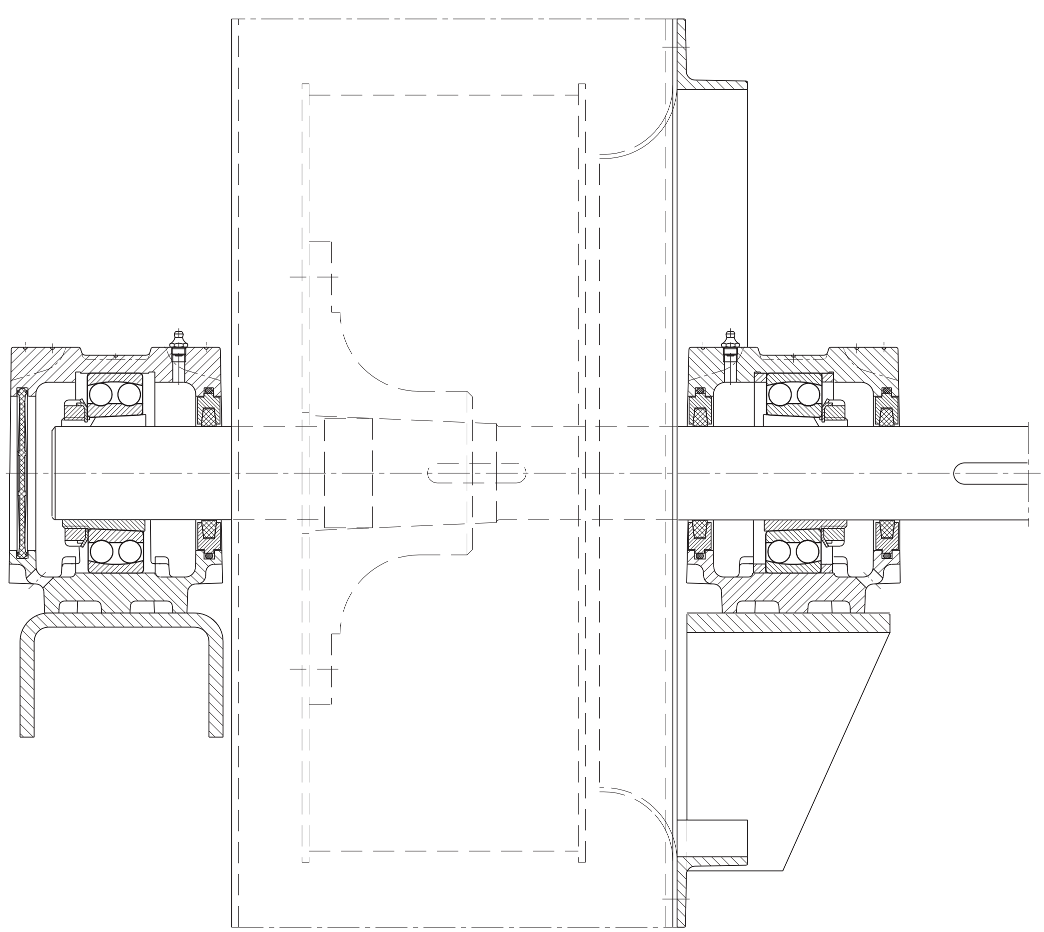
The SNV housings are made of grey-cast iron. The housing bodies are split to simplify mounting.

Machining tolerances

Shaft to h9, cylindricity tolerance IT6/2 (DIN ISO 1101); housing to H7.

Lubrication, sealing

The bearings are lubricated with FAG rolling bearing *grease Arcanol* L71V.
The housing is sealed on each side by an FSV felt *seal.*



120: Rotor mounting of a fresh air blower

121 Optical telescope

Operating data

The telescope is approximately 7 m high, 8 m long and weighs about 10 t, corresponding to 100 kN. The mirror diameter is 1 m. Due to the extremely low speed of rotation of the yoke axle (1 revolution in 24 hours), a very low and uniform bearing friction is required. Moreover, the yoke must be guided rigidly and with absolute zero clearance. Deflection of the yoke axle under the effect of the overhanging load must also be taken into account.

Bearing selection

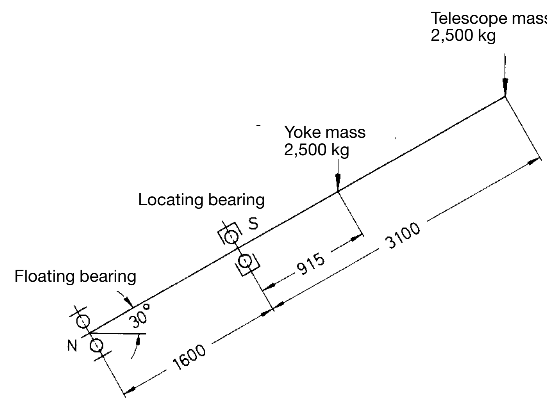
The *locating bearing* at the upper end of the yoke support is a high-precision double-row angular contact ball bearing with split outer ring. Its dimensions are 600 x 730 x 98 mm. The gap width between the two outer rings is such that, when *adjusting* the bearing axially, a preload of 35 kN is obtained. The lower end of the yoke axle is supported by a cylindrical roller bearing FAG NU1044K.M1.P51 acting as the *floating bearing.*

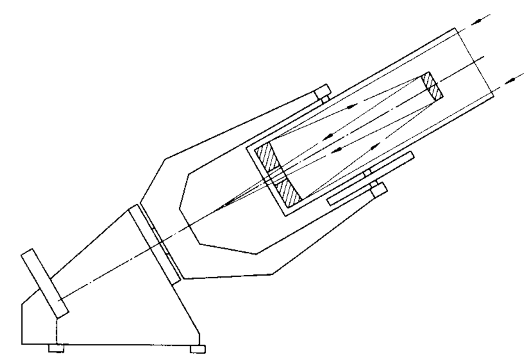
Bearing assembly

Despite the large diameter of the yoke axle, the deflection still existing would result in increased friction in the preloaded angular contact ball bearing unless suitable countermeasures were taken. The problem was solved by mounting the cylindrical roller bearing in two outer shroud rings whose inside diameters are eccentric to the outside diameter. These shroud rings are rotated in opposite directions during mounting (D) until the shaft deflection at the angular contact ball bearing location is equalized. The crowned inner ring raceway of the cylindrical roller bearing allows for slight misalignments and shaft deflections.

Lubrication, sealing

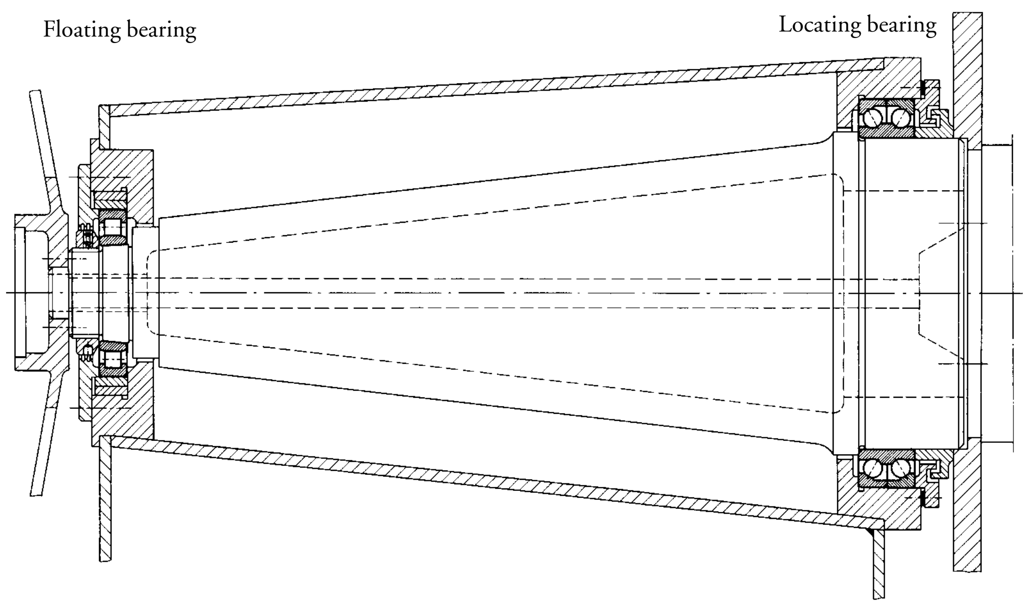
Grease lubrication (FAG rolling bearing grease *Arcanol* L186V). The cylindrical roller bearing is fitted with a gap-type *seal* with *grease* grooves, the angular contact ball bearing is sealed by a labyrinth.

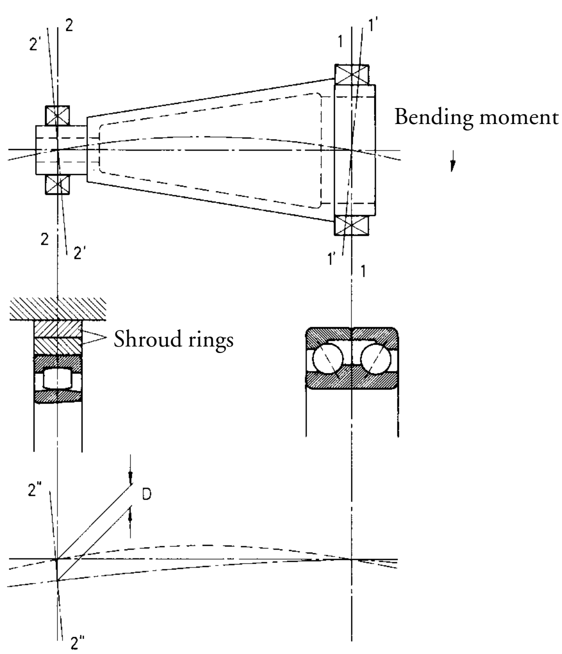




Machining tolerances

Bearing	Seat	Diameter tolerance	Form tolerance (DIN ISO 1101)	Axial run-out tolerance of abutment shoulder
Angular contact ball bearing	Shaft Housing	j5 J6	IT2/2 IT3/2	IT2 IT2
Cylindrical roller bearing	Shaft, tapered Housing	taper 1 : 12 K6	IT2/2 IT3/2	IT2 IT2





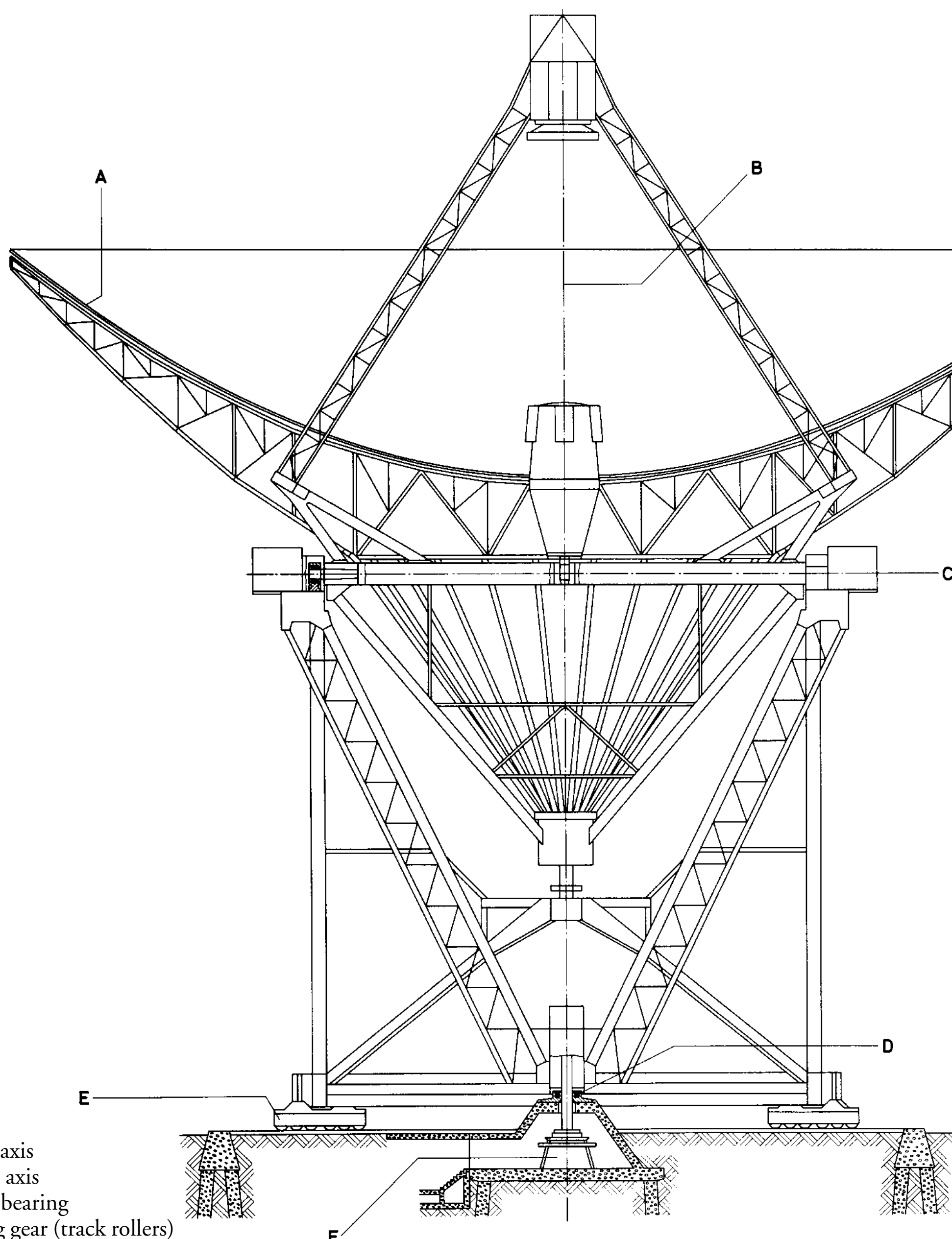
121: Optical telescope

122–124 Radiotelescope

For radioastronomy highly sensitive radiotelescopes are used for picking up radio waves from the universe. The radiotelescope antenna is a huge reflector in the form of a paraboloid. The reflector is slewable about an axis parallel to the earth surface, the elevation axis. The whole telescope slews about the vertical axis, the azimuth axis.

Operating data

Total mass of the radiotelescope 3,000 tons (load approximately 30,000 kN); reflector diameter 100 m, reflector mass 1,600 tons (load approximately 16,000 kN); speed of track rollers $n_{max} = 8\ min^{-1}$, $n_{min} = 0.01\ min^{-1}$; track diameter 64 m.



A Reflector
B Azimuth axis
C Elevation axis
D King pin bearing
E Travelling gear (track rollers)
F Data wheel

122 Elevation axis

The reflector is supported on two spherical roller bearings FAG 241/850BK30.P62 (*static load rating* C_0 = 49,000 kN). Each of the two bearings has to accommodate a radial load of 8,000 kN. Added to this are the loads resulting from the effects of wind and snow on the reflector. Maximum loads in the horizontal direction may be 5,500 kN, in the vertical direction 3,000 kN. Bearing centre distance is 50 m. The bearings feature *tolerance class* P6 and *radial clearance* C2 (smaller than normal clearance CN). The bearings are mounted onto the journals with tapered sleeves by means of the hydraulic method. During mounting the *radial clearance* is eliminated by driving in the sleeves.

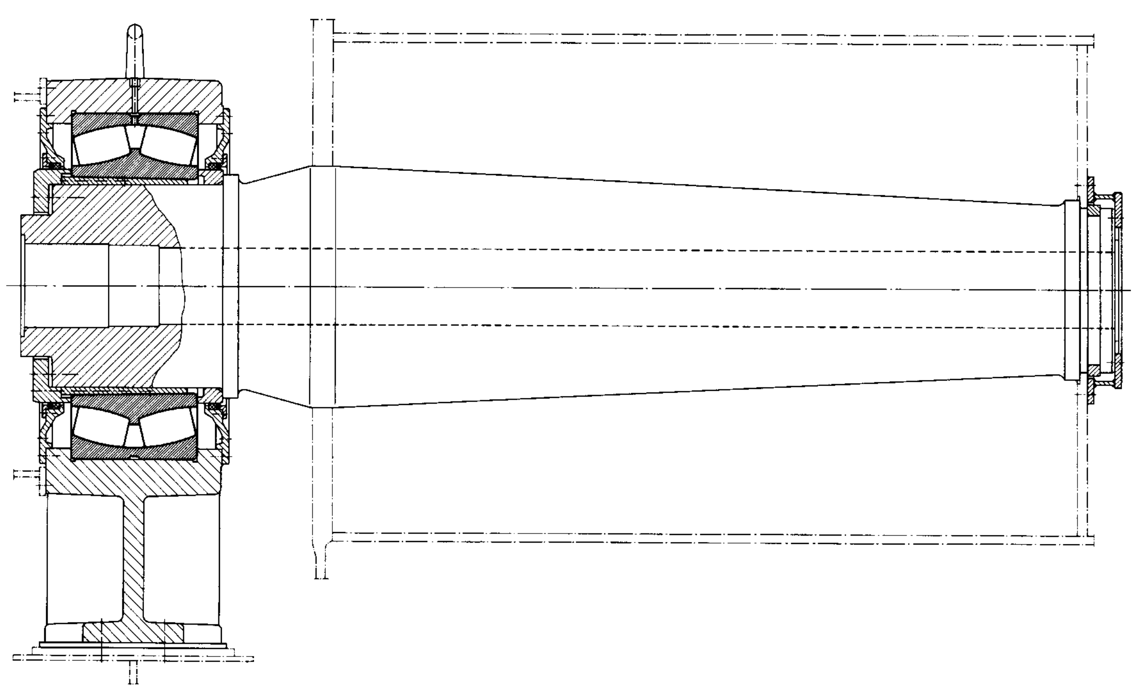
Machining tolerances

Journal to h7 / housing to H6

Lubrication, sealing

The spherical roller bearings are lubricated with FAG rolling bearing *grease Arcanol* L135V.

The bearings are sealed by a rubbing *seal.*



122: Elevation axis

123 Azimuth axis (track roller and king pin bearings)

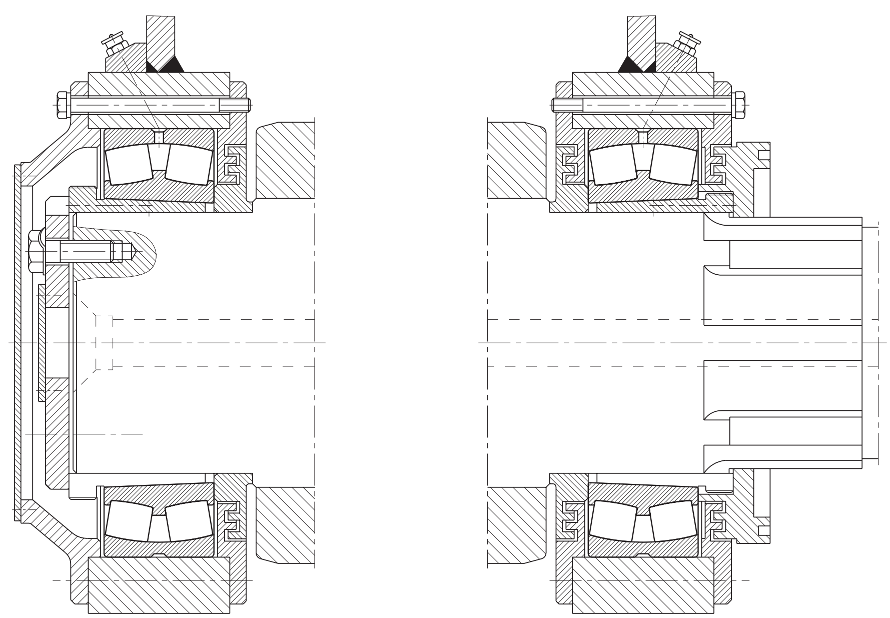
The radiotelescope with its complete superstructure is supported on a circular track of 64 m diameter. The roller track assembly, comprising four groups of eight rollers each, transmits the weight of approximately 30,000 kN.
Every second roller of a roller group is driven. Each roller is supported on two spherical roller bearings FAG 23060K.MB.C2. The bearings are mounted on the journal with withdrawal sleeves FAG AH3060H. In the most adverse case one bearing has to accommodate approximately 800 kN. With the *static load rating* C_0 = 3,550 kN the bearings are safely dimensioned. The outer rings of the bearings are mounted into the housings with *axial clearance* so that a *floating bearing arrangement* is obtained. Since low friction is required the rollers to not incorporate wheel flanges. Thus it is necessary to radially guide the superstructure on a king pin bearing. The FAG cylindrical roller bearing provided for this purpose has the dimensions 1,580 x 2,000 x 250 mm. The cylindrical roller outside diameters are slightly crowned in order to avoid edge stressing. By mounting the bearing with a tapered sleeve the *radial clearance* can be eliminated, thus providing accurate radial guidance.

Machining tolerances

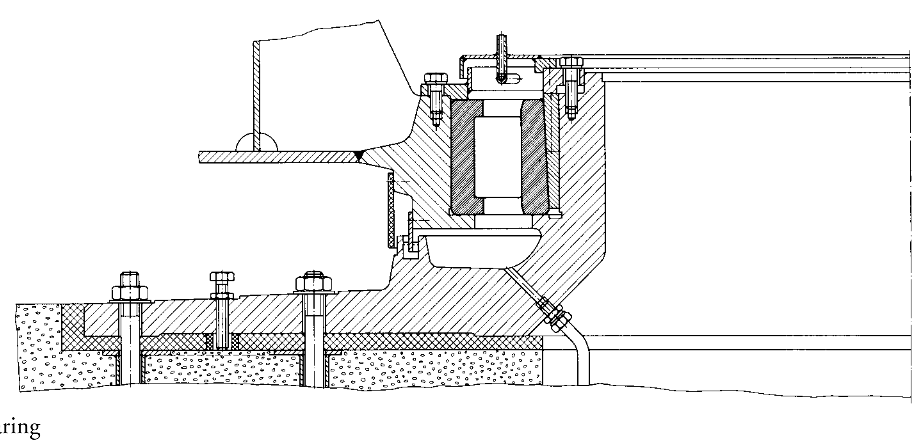
Track rollers: Housing to H7
King pin: Journal to h7/ housing to M7

Lubrication, sealing

The spherical roller bearings in the track rollers are lubricated with FAG rolling bearing *grease Arcanol* L135V. The cylindrical roller bearing for the king pin features circulating *oil* lubrication.
Sealing by multiple labyrinths.



123a: Roller track assembly



123b: King pin bearing

124 Data wheel

The data wheel is supported on a clearance-free FAG four-point bearing with the dimensions 1,300 x 1,500 x 80 mm.
Radial runout < 10 µm,
Axial runout < 25 µm.

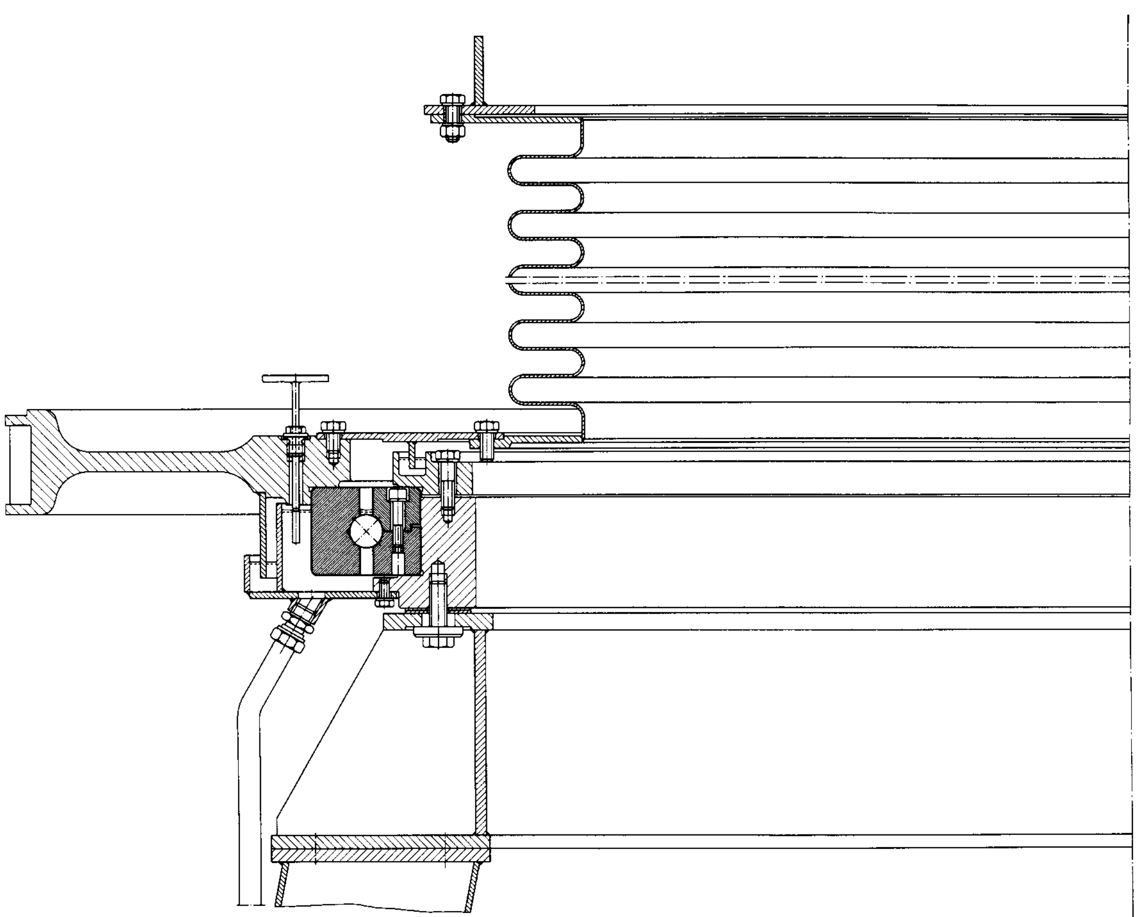
Machining tolerances

The four-point bearing is fitted according to the actual bearing dimensions.

Lubrication, sealing

The four-point bearing is fully immersed in *oil.*

Sealing by a multiple labyrinth.



124: Data wheel

Glossary

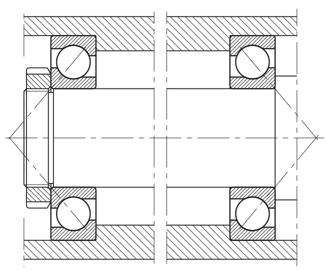
Additives

Additives are oil-soluble substances added to *mineral oils* or mineral oil products. By chemical or physical action, they change or improve lubricant properties (oxidation stability, EP properties, foaming, *viscosity-temperature behaviour,* setting point, flow properties, etc.). Additives are also an important factor in calculating the *attainable life* (cp. also *Factor* K).

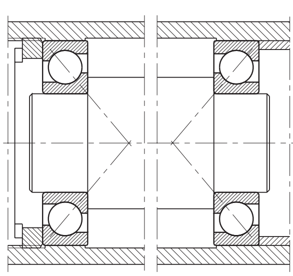
Adjusted bearing arrangement/ Adjustment

An adjusted bearing arrangement consists of two symmetrically arranged *angular contact bearings* or *thrust bearings.* During mounting, one bearing ring (for an *O arrangement,* the inner ring; for an *X arrangement,* the outer ring) is displaced on its seat until the bearing arrangement has the appropriate *axial clearance* or the required preload. This means that the adjusted bearing arrangement is particularly suitable for those cases where a close axial guidance is required, for example, for pinion bearing arrangements with spiral toothed bevel gears.

Adjusted bearing arrangement (O arrangement)



Adjusted bearing arrangement (X arrangement)



Adjusted rating life calculation

The *nominal life* L or L_h deviates more or less from the really *attainable life* of rolling bearings.
Therefore, the adjusted rating life calculation takes into account, in addition to the load, the failure probability (*factor a_1*) and other significant operating conditions (*factor a_{23}* in the FAG procedure for calculating the *attainable life*).
Cp. also *Modified life* in accordance with DIN ISO 281.

Alignment

Self-aligning bearings are used to compensate for misalignment and tilting.

Angular contact bearings

The term "angular contact bearing" is collectively used for single-row bearings whose *contact lines* are inclined to the radial plane. So, angular contact bearings are angular contact ball bearings, tapered roller bearings and spherical roller thrust bearings. Axially loaded deep groove ball bearings also act in the same way as angular contact bearings.

Arcanol (FAG rolling bearing greases)

FAG rolling bearing greases Arcanol are field-proven *lubricating greases.* Their scopes of application were determined by FAG by means of the latest test methods under a large variety of operating conditions and with rolling bearings of all types. The eight Arcanol greases listed in the table on page 179 cover almost all demands on the lubrication of rolling bearings.

Attainable life L_{na}, L_{hna}

The FAG calculation method for determining the attainable life (L_{na}, L_{hna}) is based on DIN ISO 281 (cp. *Modified life*). It takes into account the influences of the operating conditions on the rolling *bearing life* and indicates the preconditions for reaching *endurance strength.*

$L_{na} = a_1 \cdot a_{23} \cdot L$ [10^6 revolutions]

and

$L_{hna} = a_1 \cdot a_{23} \cdot L_h$ [h]

a_1 *factor a_1* for failure probability (DIN ISO 281); for a normal (10%) failure probability $a_1 = 1$.
a_{23} *factor* a_{23} (*life adjustment factor*)
L *nominal rating life* [10^6 revolutions]
L_h *nominal rating life* [h]

If the quantities influencing the *bearing life* (e. g. load, speed, temperature, cleanliness, type and condition of lubricant) are variable, the attainable life (L_{hna1}, L_{hna2}, ...) under constant conditions has to be determined for every operating time q [%]. The attainable life is calculated for the total operating time using the formula

$$L_{hna} = \frac{100}{\frac{q_1}{L_{hna1}} + \frac{q_2}{L_{hna2}} + \frac{q_3}{L_{hna3}}}$$

Glossary

Arcanol rolling bearing greases · Chemo-physical data · Directions for use

Arcanol	Thickener Base oil	Base oil viscosity at 40°C mm²/s	Consistency NLGI-Class DIN 51818	Temperature range °C	Colour RAL	Main characteristics Typical applications
L12V	Polyurea Mineral oil	ISO VG 100	2	–30...+160	2002 vermillion	Special grease for high temperatures Couplings, electric machines (motors, generators)
L71V	Lithium soap Mineral oil	ISO VG 100	3	–30...+140	4008 signal violet	Standard grease for bearings with O.D.s > 62 mm Large electric motors, wheel bearings for motor vehicles, ventilators
L74V	Special soap Synthetic oil	ISO VG 22	2	–40...+120	6018 yellow-green	Special grease for high speeds and low temperatures Machine tools, spindle bearings, instruments
L78V	Lithium soap Mineral oil	ISO VG 100	2	–30...+130	1018 zinc yellow	Standard grease for bearings with O.D.s ≤ 62 mm Small electric motors, agricultural and construction machinery, household appliances
L79V	Synthetic Synthetic oil	390	2	–30...+270	1024 yellow ochre	Special grease for extremely high temperatures and chemically aggressive environments Track rollers in bakery machines, piston pins in compressors, kiln trucks, chemical plants (please observe safety data sheet)
L135V	Lithium soap wit EP additives Mineral oil	85	2	–40...+150	2000 yellow orange	Special grease for high loads, high speeds, high temperatures Rolling mills, construction machinery, motor vehicles, rail vehicles, spinning and grinding spindles
L186V	Lithium soap with EP additives Mineral oil	ISO VG 460	2	–20...+140	7005 mouse-grey	Special grease for extremely high loads, medium speeds, medium temperatures Heavily stressed mining machinery, construction machinery, machines with oscillating movements
L223V	Lithium soap with EP additives Mineral oil	ISO VG 1000	2	–10...+140	5005 signal blue	Special grease for extremely high loads, low speeds Heavily stressed mining machinery, construction machinery, particularly for impact loads and large bearings

Glossary

Axial clearance

The axial clearance of a bearing is the total possible axial displacement of one bearing ring measured without load. There is a difference between the axial clearance of the unmounted bearing and the axial *operating clearance* existing when the bearing is mounted and running at operating temperature.

Base oil

is the oil contained in a *lubricating grease.* The amount of oil varies with the type of *thickener* and the grease application. The *penetration* number and the frictional behaviour of the grease vary with the amount of base oil and its *viscosity.*

Basic a_{23II} value

The basic a_{23II} value is the basis for determining *factor* a_{23}, used in *attainable life* calculation.

Bearing life

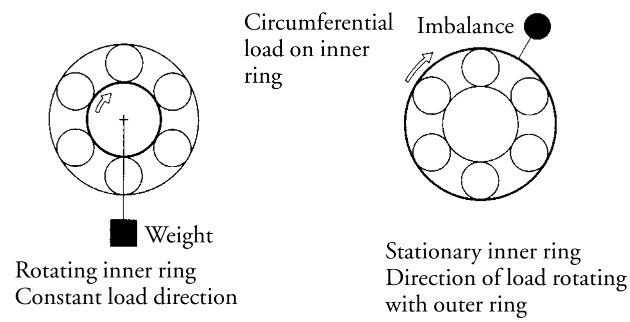
The life of *dynamically stressed* rolling bearings, as defined by DIN ISO 281, is the operating time until failure due to material fatigue (*fatigue life*).
By means of the classical calculation method, a comparison calculation, the *nominal rating life* L or L_h, is determined; by means of the refined FAG calculation process, the *attainable life* L_{na} or L_{hna} is determined (see also *factor* a_{23}).

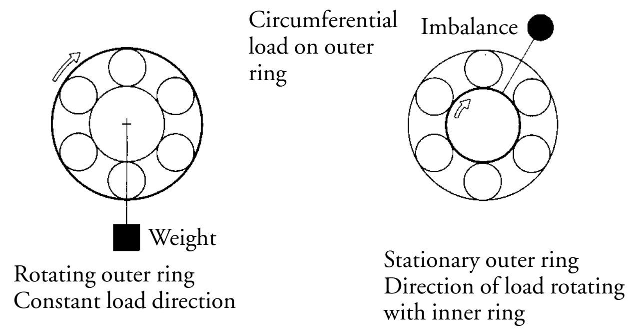
Cage

The cage of a rolling bearing prevents the *rolling elements* from rubbing against each other. It keeps them evenly spaced and guides them through unloaded sections of the bearing circumference.
The cage of a needle roller bearing also has to guide the needle rollers parallel to the axis. In the case of *separable bearings* the cage retains the *rolling element* set, thus facilitating bearing mounting. Rolling bearing cages are classified into the categories *pressed cages* and *machined/moulded cages.*

Circumferential load

If the ring under consideration rotates in relation to the radial load, the entire circumference of the ring is, during each revolution, subjected to the maximum load. This ring is circumferentially loaded. Bearings with circumferential load must be mounted with a tight *fit* to avoid sliding (cp. *Point load, Oscillating load*).





Cleanliness factor s

The cleanliness factor s quantifies the effect of contamination on the *attainable life.* The product of s and the *basic* a_{23II} factor is the *factor* a_{23}.
Contamination factor V is required to determine s.
s = 1 always applies to normal cleanliness (V = 1).
With improved cleanliness (V = 0.5) and utmost cleanliness (V = 0.3) a cleanliness factor s > 1 is obtained from the right diagram (a) on page 181, based on the *stress index* f_{s^*} and depending on the *viscosity ratio* κ.
s = 1 applies to $\kappa < 0.4$.
With V = 2 (moderately contaminated lubricant) to V = 3 (heavily contaminated lubricant), s < 1 is obtained from diagram (b).

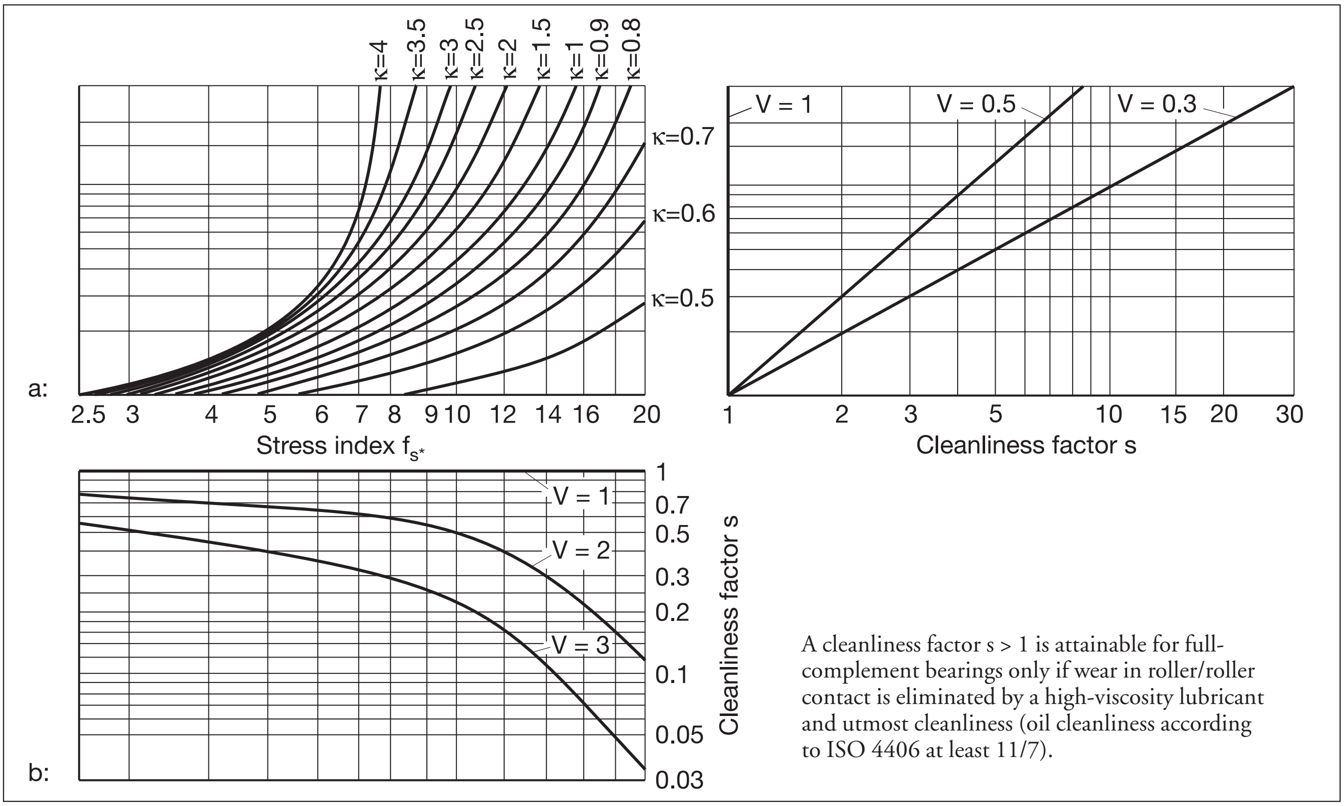
Combined load

This applies when a bearing is loaded both radially and axially, and the resulting load acts, therefore, at the *load angle* β.
Depending on the type of load, the *equivalent dynamic load* P or the *equivalent static load* P_0 is determined with the radial component F_r and the thrust component F_a of the combined load.

Glossary

Diagram for determining the cleanliness factor s

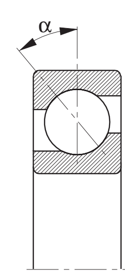
a Diagram for improved to utmost cleanliness
b Diagram for moderately contaminated lubricant and heavily contaminated lubricant



Consistency

Measure of the resistance of a *lubricating grease* to being deformed.
Consistency classification to NLGI, cp. *Penetration.*

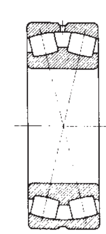
Contact angle α



The contact angle α is the angle formed by the *contact lines* of the *rolling elements* 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 inner ring and outer ring are not identical. The equilibrium of forces in these bearings is maintained by a force component which is directed towards the lip.

Contact line

The *rolling elements* transmit loads from one bearing ring to the other in the direction of the contact lines.



Glossary

Contamination factor V

The contamination factor V indicates the degree of cleanliness in the lubricating gap of rolling bearings based on the oil cleanliness classes defined in ISO 4406.
When determining the *factor* a_{23} and the *attainable life,* V is used, together with the *stress index* f_{s*} and the *viscosity ratio* κ, to determine the *cleanliness factor* s.
V depends on the bearing cross section (D – d)/2, the type of contact between the mating surfaces and especially the cleanliness level of the oil.

If hard particles from a defined size on are cycled in the most heavily stressed contact area of a rolling bearing, the resulting indentations in the contact surfaces lead to premature material fatigue. The smaller the contact area, the more damaging the effect of a particle above a certain size when being cycled. Small bearings with point contact are especially vulnerable.

According to today's knowledge the following cleanliness scale is useful (the most important values are in boldface):

V = 0.3 utmost cleanliness
V = 0.5 improved cleanliness
V = 1 normal cleanliness
V = 2 moderately contaminated lubricant
V = 3 heavily contaminated lubricant

Preconditions for utmost cleanliness (V = 0.3):
- bearings are greased and protected by seals or shields against dust by the manufacturer
- grease lubrication by the user who fits the bearings into clean housings under top cleanliness conditions, lubricates them with clean grease and takes care that dirt cannot enter the bearing during operation
- flushing the oil circulation system prior to the first operation of the cleanly fitted bearings and taking care that the oil cleanliness class is ensured during the entire operating time

Guide values for V

(D-d)/2 mm	V	**Point contact** required oil cleanliness class according to ISO 4406	guide values for filtration ratio according to ISO 4572	**Line contact** required oil cleanliness class according to ISO 4406	guide values for filtration ratio according to ISO 4572
	0.3	11/8	$\beta_3 \geq 200$	12/9	$\beta_3 \geq 200$
	0.5	12/9	$\beta_3 \geq 200$	13/10	$\beta_3 \geq 75$
≤ 12.5	1	14/11	$\beta_6 \geq 75$	15/12	$\beta_6 \geq 75$
	2	15/12	$\beta_6 \geq 75$	16/13	$\beta_{12} \geq 75$
	3	16/13	$\beta_{12} \geq 75$	17/14	$\beta_{25} \geq 75$
	0.3	12/9	$\beta_3 \geq 200$	13/10	$\beta_3 \geq 75$
	0.5	13/10	$\beta_3 \geq 75$	14/11	$\beta_6 \geq 75$
> 12.5...20	1	15/12	$\beta_6 \geq 75$	16/13	$\beta_{12} \geq 75$
	2	16/13	$\beta_{12} \geq 75$	17/14	$\beta_{25} \geq 75$
	3	18/14	$\beta_{25} \geq 75$	19/15	$\beta_{25} \geq 75$
	0.3	13/10	$\beta_3 \geq 75$	14/11	$\beta_6 \geq 75$
	0.5	14/11	$\beta_6 \geq 75$	15/12	$\beta_6 \geq 75$
> 20...35	1	16/13	$\beta_{12} \geq 75$	17/14	$\beta_{12} \geq 75$
	2	17/14	$\beta_{25} \geq 75$	18/15	$\beta_{25} \geq 75$
	3	19/15	$\beta_{25} \geq 75$	20/16	$\beta_{25} \geq 75$
	0.3	14/11	$\beta_6 \geq 75$	14/11	$\beta_6 \geq 75$
	0.5	15/12	$\beta_6 \geq 75$	15/12	$\beta_{12} \geq 75$
> 35	1	17/14	$\beta_{12} \geq 75$	18/14	$\beta_{25} \geq 75$
	2	18/15	$\beta_{25} \geq 75$	19/16	$\beta_{25} \geq 75$
	3	20/16	$\beta_{25} \geq 75$	21/17	$\beta_{25} \geq 75$

The oil cleanliness class can be determined by means of oil samples by filter manufacturers and institutes. It is a measure of the probability of life-reducing particles being cycled in a bearing. Suitable sampling should be observed (see e. g. DIN 51570). Today, online measuring instruments are available. The cleanliness classes are reached if the entire oil volume flows through the filter within a few minutes.
To ensure a high degree of cleanliness flushing is required **prior** to bearing operation.
For example, a filtration ratio $\beta_3 \geq 200$ (ISO 4572) means that in the so-called multi-pass test only one of 200 particles ≥ 3 µm passes the filter. Filters with coarser filtration ratios than $\beta_{25} \geq 75$ should not be used due to the ill effect on the other components within the circulation system.

Preconditions for normal cleanliness (V = 1):
– good *sealing* adapted to the environment
– cleanliness during mounting
– oil cleanliness according to V = 1
– observing the recommended oil change intervals

Possible causes of heavy lubricant contamination (V = 3):
– the cast housing was inadequately cleaned
– abraded particles from components which are subject to wear enter the circulating oil system of the machine
– foreign matter penetrates into the bearing due to unsatisfactory *sealing*
– water which entered the bearing, also condensation water, caused standstill corrosion or deterioration of the lubricant properties

The necessary oil cleanliness class according to ISO 4406 is an objectively measurable level of the contamination of a lubricant.

In accordance with the particle-counting mehod, the number of all particles > 5 µm and all particles > 15 µm are allocated to a certain ISO oil cleanliness classs. For example, an oil cleanliness class 15/12 according to ISO 4406 means that between 16,000 and 32,000 particles > 5 µm and between 2,000 and 4,000 particles > 15 µm are present per 100 ml of a fluid.

A defined filtration ratio β_x should exist in order to reach the oil cleanliness required.

The filtration ratio is the ratio of all particles > x µm before passing the filter to the particles > x µm which have passed the filter. For example, a filtration ratio $\beta_3 \geq 200$ means that in the so-called multi-pass test (ISO 4572) only one of 200 particles ≥ 3 µm passes the filter.

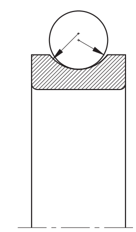
Counter guidance

Angular contact bearings and single-direction *thrust bearings* accommodate axial forces only in one direction. A second, symmetrically arranged bearing must be used for "counter guidance", i.e. to accommodate the axial forces in the other direction.

Curvature ratio

In all bearing types with a curved raceway profile the radius of the raceway is slightly larger than that of the *rolling elements.* This curvature difference in the axial plane is defined by the curvature ratio κ. The curvature ratio is the curvature difference between the rolling element radius and the slightly larger groove radius.

$$\text{curvature ratio } \kappa = \frac{\text{groove radius} - \text{rolling element radius}}{\text{rolling element radius}}$$



Dynamic load rating C

The dynamic load rating C (see FAG catalogues) is a factor for the load carrying capacity of a rolling bearing under *dynamic load.* It is defined, in accordance with DIN ISO 281, as the load a rolling bearing can theoretically accommodate for a *nominal life* L of 10^6 revolutions (*fatigue life*).

Dynamic stressing/dynamic load

Rolling bearings are dynamically stressed when one ring rotates relative to the other under load. The term "dynamic" does not refer, therefore, to the effect of the load but rather to the operating condition of the bearing. The magnitude and direction of the load can remain constant.

When calculating the bearings, a dynamic stress is assumed when the speed n amounts to at least 10 min^{-1} (see *Static stressing*).

Endurance strength

Tests by FAG and field experience have proved that, under the following conditions, rolling bearings can be fail-safe:

– utmost cleanliness in the lubricating gap (*contamination factor* V = 0.3)
– complete separation of the components in rolling contact by the lubricating film (*viscosity ratio* κ ≥ 4)
– load according to *stress index* $f_{s*} \geq 8$

Glossary

EP additives

Wear-reducing *additives* in *lubricating greases* and *lubricating oils,* also referred to as extreme pressure lubricants.

Equivalent dynamic load P

For *dynamically loaded* rolling bearings operating under a *combined load,* the calculation is based on the equivalent dynamic load. This is a radial load for radial bearings and an axial and centrical load for axial bearings, having the same effect on *fatigue* as the *combined load.* The equivalent dynamic load P is calculated by means of the following equation:

$P = X \cdot F_r + Y \cdot F_a$ [kN]

F_r radial load [kN]
F_a axial load [kN]
X radial factor (see FAG catalogues)
Y thrust factor (see FAG catalogues)

Equivalent static load P_0

Statically stressed rolling bearings which operate under a *combined load* are calculated with the equivalent static load. It is a radial load for *radial bearings* and an axial and centric load for *thrust bearings,* having the same effect with regard to permanent deformation as the *combined load.*
The equivalent static load P_0 is calculated with the formula:

$P = X_0 \cdot F_r + Y_0 \cdot F_a$ [kN]

F_r radial load [kN]
F_a axial load [kN]
X_0 radial factor (see FAG catalogues)
Y_0 thrust factor (see FAG catalogues)

Factor a_1

Generally (nominal rating life L_{10}), 10 % failure probability is taken. The factor a_1 is also used for failure probabilities between 10 % and 1 % for the calculation of the *attainable life,* see following table.

Failure probability %	10	5	4	3	2	1
Fatigue life	L_{10}	L_5	L_4	L_3	L_2	L_1
Factor a_1	1	0.62	0.53	0.44	0.33	0.21

Factor a_{23} (life adjustment factor)

The a_{23} factor is used to calculate the *attainable life.* FAG use a_{23} instead of the mutually dependent adjustment factors for material (a_2) and operating conditions (a_3) indicated in DIN ISO 281.

$a_{23} = a_2 \cdot a_3$

The a_{23} factor takes into account effects of:

– amount of load (*stress index* f_{s*}),
– lubricating film thickness (*viscosity ratio* κ),
– lubricant *additives* (value K),
– contaminants in the lubricating gap (*cleanliness factor* s),
– bearing type (*value* K).

The diagram on page 185 is the basis for the determination of the a_{23} factor using the *basic a_{23II} value.* The a_{23} factor is obtained from the equation $a_{23II} \cdot s$ (s being the *cleanliness factor*).

The *viscosity ratio* $\kappa = \nu/\nu_1$ and the *value* K are required for locating the *basic value.* The most important zone (II) in the diagram applies to normal cleanliness (s = 1).

The *viscosity ratio* κ is a measure of the lubricating film development in the bearing.

ν *operating viscosity* of the lubricant, depending on the nominal viscosity (at 40 °C) and the operating temperature t (fig. 1). In the case of *lubricating greases,* ν is the operating viscosity of the *base oil.*

ν_1 *rated viscosity,* depending on mean bearing diameter d_m and operating speed n (fig. 2).

The diagram (fig. 3) for determining the *basic a_{23II} factor* is subdivided into zones I, II and III.

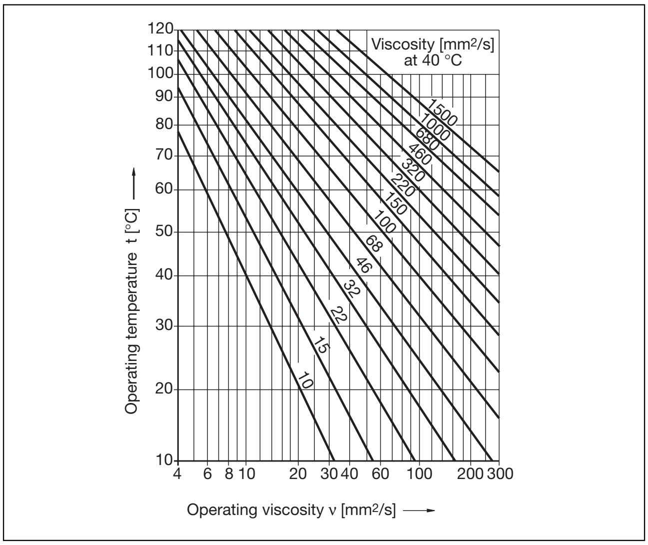
Most applications in rolling bearing engineering are covered by zone II. It applies to normal cleanliness (*contamination factor* V = 1). In zone II, a_{23} can be determined as a function of κ by means of *value* K.

With K = 0 to 6, a_{23II} is found on one of the curves in zone II of the diagram.

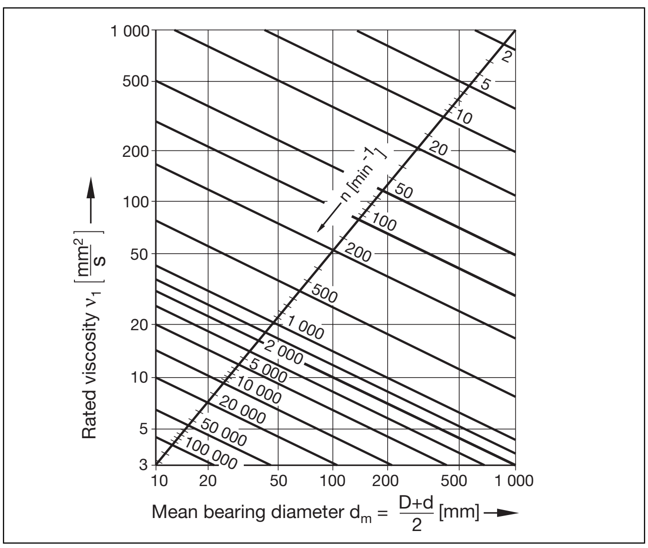
With K > 6, a_{23} must be expected to be in zone III. In such a case conditions should be improved so that zone II can be reached.

Glossary

1: Average v*iscosity-temperature behaviour* of *mineral oils;* diagram for determining the *operating viscosity*



2: *Rated viscosity* ν_1



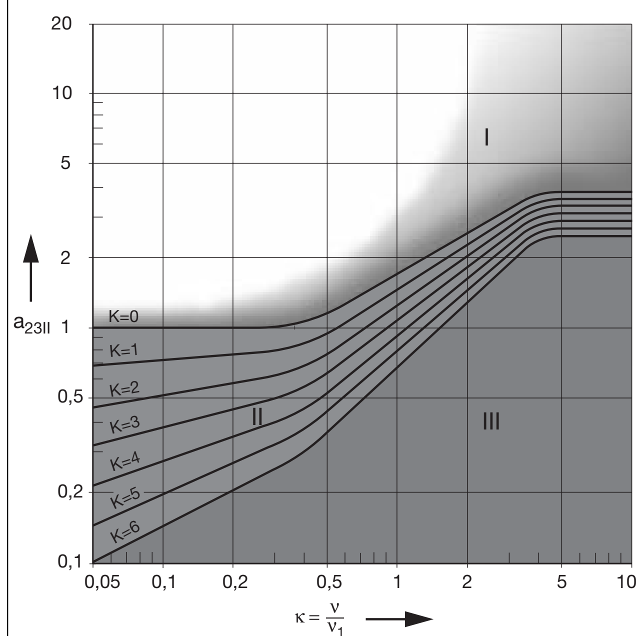
3: *Basic* a_{23II} *factor* for determining the *factor* a_{23}

Zones

I Transition to endurance strength
Precondition: Utmost cleanliness in the lubricating gap and loads which are not too high, suitable lubricant

II Normal degree of cleanliness in the lubricating gap (with effective *additives* tested in rolling bearings, a_{23} factors > 1 are possible even with $\kappa < 0.4$)

III Unfavourable lubricating conditions
Contaminated lubricant
Unsuitable lubricants



Limits of adjusted rating life calculation
As in the case of the former life calculation, only material fatigue is taken into consideration as a cause of failure for the *adjusted life calculation.* The calculated *attainable life* can only correspond to the actual *service life* of the bearing when the lubricant service life or the life limited by *wear* is not shorter than the *fatigue life.*

Fatigue life

The fatigue life of a rolling bearing is the operating time from the beginning of its service until failure due to material fatigue. The fatigue life is the upper limit of *service life.*
The classical calculation method, a comparison calculation, is used to determine the *nominal life* L or L_h; by means of the refined FAG calculation process the *attainable life* L_{na} or L_{hna} is determined (see also a_{23} factor).

Fits

The tolerances for the bore and for the outside diameter of rolling bearings are standardized in DIN 620 (cp. *Tolerance class*). The seating characteristics required for reliable bearing operation, which are dependent on the operating conditions of the application, are obtained by the correct selection of shaft and housing machining tolerances.
For this reason, the seating characteristics of the rings are indicated by the shaft and housing tolerance symbols.
Three factors should be borne in mind in the selection of fits:

Glossary

1. Safe retention and uniform support of the bearing rings
2. Simplicity of mounting and dismounting
3. Axial freedom of the *floating bearing*

The simplest and safest means of ring retention in the circumferential direction is achieved by a tight fit.
A tight fit will support the rings evenly, a factor which is indispensable for the full utilization of the load carrying capacity. Bearing rings accommodating a *circumferential load* or an *oscillating load* are always fitted tightly. Bearing rings accommodating a *point load* may be fitted loosely.
The higher the load the tighter should be the interference fit provided, particularly for shock loading. The temperature gradient between bearing ring and mating component should also be taken into account. Bearing type and size also play a role in the selection of the correct fit.

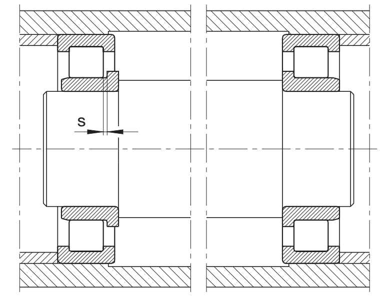
Floating bearing

In a *locating/floating bearing arrangement* the floating bearing compensates for axial thermal expansion. Cylindrical roller bearings of NU and N designs, as well as needle roller bearings, are ideal floating bearings. Differences in length are compensated for in the floating bearing itself. The bearing rings can be given tight *fits.*
Non-*separable bearings,* such as deep groove ball bearings and spherical roller bearings, can also be used as floating bearings. In such a case one of the two bearing rings is given a loose *fit,* with no axial mating surface so that it can shift freely on its seat.

Floating bearing arrangement

A floating bearing arrangement is an economical solution where no close axial shaft guidance is required. The design is similar to that of an *adjusted bearing arrangement.* In a floating bearing arrangement, however, the shaft can shift relative to the housing by the *axial clearance* s. The value s is determined depending on the required guiding accuracy in such a way that detrimental axial preloading of the bearings is prevented even under unfavourable thermal conditions.

In floating bearing arrangements with NJ cylindrical roller bearings, length variations are compensated for in the bearings. Inner and outer rings can be *fitted* tightly.
Non-*separable radial bearings* such as deep groove ball bearings, self-aligning ball bearings and spherical roller bearings can also be used. One ring of each bearing – generally the outer ring – is given a loose *fit.*



Grease, grease lubrication

cp. Lubricating grease

Grease service life

The grease service life is the period from start-up until the failure of a bearing as a result of lubrication breakdown.
The grease service life is determined by the
- amount of grease
- grease type (*thickener, base oil, additives*)
- bearing type and size
- type and amount of loading
- *speed index*
- bearing temperature

Index of dynamic stressing f_L

The value recommended for dimensioning can be expressed, instead of in hours, as the index of dynamic stressing f_L. It is calculated from the *dynamic load rating* C, the *equivalent dynamic load* P and the *speed factor* f_n.

$$f_L = \frac{C}{P} \cdot f_n$$

The f_L value to be obtained for a correctly dimensioned bearing arrangement is an empirical value obtained from field-proven identical or similar bearing mountings.
The values indicated in various FAG publications take into account not only an adequate *fatigue life* but also other requirements such as low weight for light-weight constructions, adaptation to given mating parts, higher-than-usual peak loads, etc. The f_L values conform with the latest standards resulting from technical progress. For comparison with a field-proven bearing mounting the calculation of stressing must, of course, be based on the same former method.
Based on the calculated f_L value, the *nominal rating life* L_h in hours can be determined.

$L_h = 500 \cdot f_L{}^p$ [h]

p = 3 for ball bearings

$p = \frac{10}{3}$ for roller bearings and needle roller bearings

Index of static stressing f_s

The index of static stressing f_s for *statically loaded bearings* is calculated to ensure that a bearing with an adequate load carrying capacity has been selected. It is calculated from the *static load rating* C_0 and the *equivalent static load* P_0.

$$f_s = \frac{C_0}{P_0}$$

The index f_s is a safety factor against permanent deformations of the contact areas between raceway and the most heavily loaded *rolling element.* A high f_s value is required for bearings which must run smoothly and particularly quietly. Smaller values suffice where a moderate degree of running quietness is required. The following values are generally recommended:

f_s = 1.5...2.5 for a high degree
f_s = 1...1.5 for a normal degree
f_s = 0.7...1 for a moderate degree

K value

The K value is an auxiliary quantity needed to determine the *basic a_{23II} factor* when calculating the *attainable life* of a bearing.

$K = K_1 + K_2$

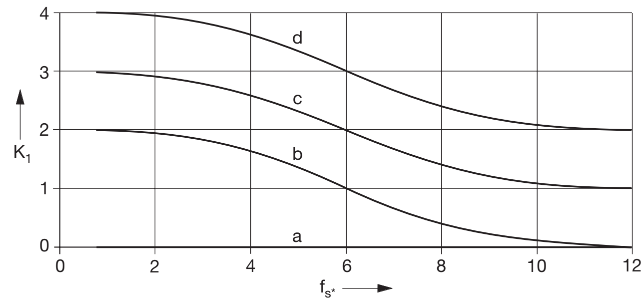
K_1 depends on the bearing type and the *stress index* f_{s*}, see diagram.

K_2 depends on the *stress index* f_{s*} and the *viscosity ratio* κ. The values in the diagram (below) apply to lubricants without *additives* and lubricants with *additives* whose effects in rolling bearings was not tested.

With K = 0 to 6, the *basic a_{23II} value* is found on one of the curves in zone II of diagram 3 on page 185 (cp. *factor* a_{23}).

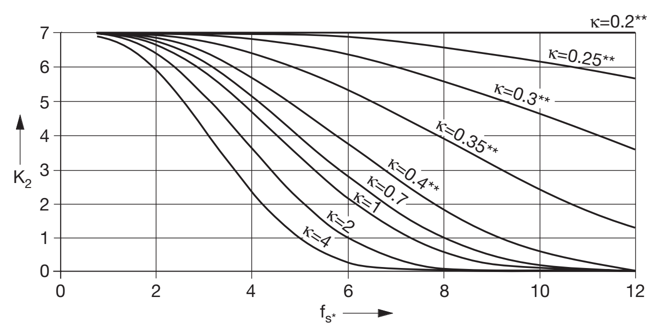
Value K_1

a ball bearings
b tapered roller bearings, cylindrical roller bearings
c spherical roller bearings, spherical roller thrust bearings[3], cylindrical roller thrust bearings[1), 3)]
d full complement cylindrical roller bearings[1), 2)]



[1)] Attainable only with lubricant filtering corresponding to V < 1, otherwise $K_1 \geq 6$ must be assumed.
[2)] To be observed for the determination of ν: the friction is at least twice the value in caged bearings. This results in higher bearing temperature.
[3)] Minimum load must be observed.

Value K_2



K_2 equals for 0 for lubricants with additives with a corresponding suitability proof.

** With κ ≦ 0.4 wear dominates unless eliminated by suitable additives.

Kinematically permissible speed

The kinematically permissible speed is indicated in the FAG catalogues also for bearings for which – according to DIN 732 – no *thermal reference speed* is defined. Decisive criteria for the kinematically permissible speed are e.g. the strength limit of the bearing components or the permissible sliding velocity of rubbing *seals.* The kinematically permissible speed can be reached, for example, with
– specially designed lubrication
– bearing clearance adapted to the operating conditions
– accurate machining of the bearing seats
– special regard to heat dissipation

Life

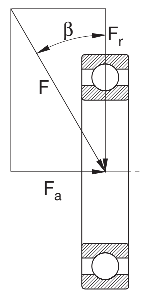
Cp. also *Bearing life.*

Glossary

Load angle

The load angle β is the angle between the resultant applied load F and the radial plane of the bearing. It is the resultant of the radial component F_r and the axial component F_a:

$\tan \beta = F_a/F_r$



Load rating

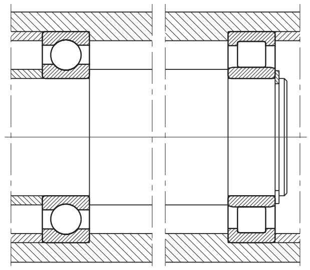
The load rating of a bearing reflects its load carrying capacity. Every rolling bearing has a *dynamic load rating* (DIN ISO 281) and a *static load rating* (DIN ISO 76). The values are indicated in the FAG rolling bearing catalogues.

Locating bearing

In a *locating/floating bearing arrangement,* the bearing which guides the shaft axially in both directions is referred to as locating bearing. All bearing types which accommodate thrust in either direction in addition to radial loads are suitable. Angular contact ball bearing pairs (*universal design*) and tapered roller bearing pairs in *X* or *O arrangement* may also be used as locating bearings.

Locating/floating bearing arrangement

With this bearing arrangement the *locating bearing* guides the shaft axially in both directions; the *floating bearing* compensates for the heat expansion differential between shaft and housing. Shafts supported with more than two bearings are provided with only one *locating bearing;* all the other bearings must be *floating bearings.*



Lubricating grease

Lubricating greases are consistent mixtures of *thickeners* and *base oils.* The following grease types are distinguished:
– metal soap base greases consisting of metal soaps as *thickeners* and *lubricating oils,*
– non-soap greases comprising inorganic gelling agents or organic *thickeners* and *lubricating oils*
– synthetic greases consisting of organic or inorganic *thickeners* and *synthetic oils.*

Lubricating oil

Rolling bearings can be lubricated either with *mineral oils* or *synthetic oils.* Today, mineral oils are most frequently used.

Lubrication interval

The lubrication interval corresponds to the minimum *grease service life* of standard *greases* (see FAG publication WL 81 115). This value is assumed if the grease service life for the grease used is not known.

Machined/moulded cages

Machined *cages* of metal and textile laminated phenolic resin are produced in a cutting process. They are made from tubes of steel, light metal or textile laminated phenolic resin, or cast brass rings. Cages of polyamide 66 (*polyamide cages*) are manufactured by injection moulding. Like *pressed cages,* they are suitable for large-series bearings.

Machined cages of metal and textile laminated phenolic resin are mainly eligible for bearings of which only small series are produced. Large, heavily loaded bearings feature machined cages for strength reasons. Machined cages are also used where lip guidance of the cage is required. Lip-guided cages for high-speed bearings are often made of light materials, such as light metal or textile laminated phenolic resin to minimize the inertia forces.

Mineral oils

Crude oils and/or their liquid derivates.
Cp. also *Synthetic lubricants.*

Modified life

The standard Norm DIN ISO 281 introduced, in addition to the *nominal rating life* L_{10}, the *modified life* L_{na} to take into account, apart from the load, the influence of the failure probability (*factor a_1*), of the material (*factor a_2*) and of the operating conditions (*factor a_3*).
DIN ISO 281 indicates no figures for the factor a_{23} ($a_{23} = a_2 \cdot a_3$). With the FAG calculation process for the *attainable life* (L_{na}, L_{hna}), however, operating conditions can be expressed in terms of figures by the *factor a_{23}*.

NLGI class

Cp. *Penetration.*

Nominal rating life

The standardized calculation method for *dynamically stressed rolling bearings* is based on material fatigue (formation of pitting) as the cause of failure. The life formula is:

$$L_{10} = L = \left(\frac{C}{P}\right)^p \quad [10^6 \text{ revolutions}]$$

L_{10} is the nominal rating life in millions of revolutions which is reached or exceeded by at least 90 % of a large group of identical bearings.
In the formula,
C *dynamic load rating* [kN]
P *equivalent dynamic load* [kN]
p *life exponent*
p = 3 for ball bearings
p = 10/3 for roller bearings and needle roller bearings.

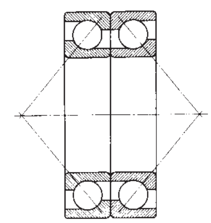
Where the bearing speed is constant, the life can be expressed in hours.

$$L_{h10} = L_h = \frac{L \cdot 10^6}{n \cdot 60} \quad [h]$$

n speed [min^{-1}]
L_h can also be determined by means of the *index of dynamic stressing* f_L.
The nominal rating life L or L_h applies to bearings made of conventional rolling bearing steel and the usual operating conditions (good lubrication, no extreme temperatures, normal cleanliness).
The nominal rating life deviates more or less from the really *attainable life* of rolling bearings. Influences such as lubricating film thickness, cleanliness in the lubricating gap, lubricant *additives* and bearing type are taken into account in the *adjusted rating life calculation* by the *factor* a_{23}.

O arrangement

In an O arrangement (*adjusted bearing* mounting) two *angular contact bearings* are mounted symmetrically in such a way that the *pressure cone apex* of the left-hand bearing points to the left and the *pressure cone apex* of the right-hand bearing points to the right.
With the O arrangement one of the bearing inner rings is adjusted. A bearing arrangement with a large *spread* is obtained which can accommodate a considerable tilting moment even with a short bearing distance. A suitable *fit* must be selected to ensure displaceability of the inner ring.



Oil/oil lubrication

see *Lubricating oil.*

Operating clearance

There is a distinction made between the *radial* or *axial clearance* of the bearing prior to mounting and the radial or axial clearance of the mounted bearing at operating temperature (operating clearance). Due to tight *fits* and temperature differences between inner and outer ring the operating clearance is usually smaller than the clearance of the unmounted bearing.

Operating viscosity ν

Kinematic *viscosity* of an oil at operating temperature. The operating viscosity ν can be determined by means of a viscosity-temperature diagram if the viscosities at two temperatures are known. The operating viscosity of *mineral oils* with average *viscosity-temperature behaviour* can be determined by means of diagram 1 (page 185).
For evaluating the lubricating condition the *viscosity ratio* κ (*operating viscosity* ν/*rated viscosity* ν_1) is formed when calculating the *attainable life.*

Oscillating load

In selecting the *fits* for *radial bearings* and *angular contact bearings* the load conditions have to be considered. With relative oscillatory motion between the radial load and the ring to be fitted, conditions of "oscillating load" occur. Both bearing rings must be given a tight *fit* to avoid sliding (cp. *circumferential load*).

Penetration

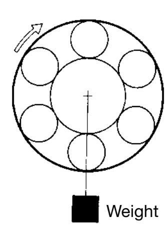
Penetration is a measure of the *consistency* of a *lubricating grease.* Worked penetration is the penetration of a grease sample that has been worked, under exactly defined conditions, at 25 °C. Then the depth of penetration – in tenths of a millimetre – of a standard cone into a grease-filled vessel is measured.

Penetration of common rolling bearing greases

NLGI class (Penetration classes)	Worked penetration 0.1 mm
1	310...340
2	265...295
3	220...250
4	175...205

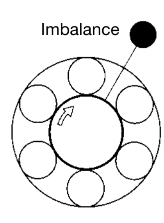
Point load

In selecting the *fits* for the bearing rings of *radial bearings* and *angular contact bearings* the load conditions have to be considered. If the ring to be fitted and the radial load are stationary relative to each other, one point on the circumference of the ring is always subjected to the maximum load. This ring is point-loaded. Since, with point load, the risk of the ring sliding on its seat is minor, a tight fit is not absolutely necessary. With *circumferential load* or *oscillating load,* a tight *fit* is imperative.

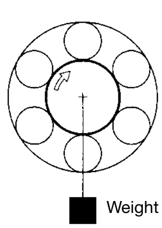


Stationary inner ring
Constant load direction

Point load on inner ring

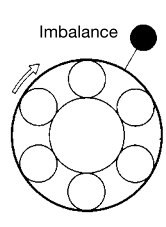


Rotating inner ring
Direction of load rotating with inner ring



Stationary outer ring
Constant load direction

Point load on outer ring



Rotating outer ring
Direction of load rotating with outer ring

Polyamide cage

Moulded cages of glass fibre reinforced polyamide PA66-GF25 are made by injection moulding and are used in numerous 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.
Cages of glass fibre reinforced polyamide 66 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.

Precision bearings/precision design

In addition to bearings of normal precision (*tolerance class* PN), bearings of precision design (precision bearings) are produced for increased demands on working precision, speeds or quietness of running.
For these applications the tolerance classes P6, P6X, P5, P4 and P2 were standardized. In addition, some bearing types are also produced in the *tolerance classes* P4S, SP and UP in accordance with an FAG company standard.

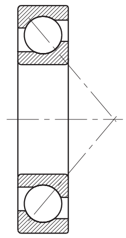
Pressed cage

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, *lubricating grease* can easily penetrate into the bearing. It is stored at the *cage.*

Pressure cone apex

The pressure cone apex is that point on the bearing axis where the contact lines of an *angular contact bearing* intersect. The contact lines are the generatrices of the pressure cone.
In *angular contact bearings* the external forces 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.

Glossary



Radial bearings

Radial bearings are those primarily designed to accommodate radial loads; they have a nominal *contact angle* $\alpha_0 \leq 45°$. The *dynamic load rating* and the *static load rating* of radial bearings refer to pure radial loads (see *Thrust bearings*).

Radial clearance

The radial clearance of a bearing is the total distance by which one bearing ring can be displaced in the radial plane, under zero measuring load. There is a difference between the radial clearance of the unmounted bearing and the radial *operating clearance* of the mounted bearing running at operating temperature.

Radial clearance group

The *radial clearance* of a rolling bearing must be adapted to the conditions at the bearing location (*fits,* temperature gradient, speed). Therefore, rolling bearings are assembled into several radial clearance groups, each covering a certain range of radial clearance.
The radial clearance group CN (normal) is such that the bearing, under normal *fitting* and operating conditions, maintains an adequate *operating clearance.* The other clearance groups are:
C2 radial clearance less than normal
C3 radial clearance larger than normal
C4 radial clearance larger than C3.

Rated viscosity ν_1

The rated *viscosity* is the kinematic *viscosity* attributed to a defined lubricating condition. It depends on the speed and can be determined with diagram 2 (page 185) by means of the mean bearing diameter and the bearing speed. The *viscosity ratio* κ (*operating viscosity* ν/*rated viscosity* ν_1) allows the lubricating condition to be assessed (see also *factor* a_{23}).

Relubrication interval

Period after which the bearings are relubricated. The relubrication interval should be shorter than the *lubrication interval.*

Rolling elements

This term is used collectively for balls, cylindrical rollers, barrel rollers, tapered rollers or needle rollers in rolling contact with the raceways.

Seals/Sealing

On the one hand the sealing should prevent the lubricant (usually *lubricating grease* or *lubricating oil*) from escaping from the bearing and, on the other hand, prevent contaminants from entering into the bearing. It has a considerable influence on the *service life* of a bearing arrangement (cp. *Wear, Contamination factor V*).
A distinction is made between non-rubbing seals (e.g. gap-type seals, labyrinth seals, shields) and rubbing seals (e.g. radial shaft seals, V-rings, felt rings, sealing washers).

Self-aligning bearings

Self-aligning bearings are all bearing types capable of self-*alignment* during operation to compensate for mis*alignment* as well as shaft and housing deflection.
These bearings have a spherical outer ring raceway.
They are self-aligning ball bearings, barrel roller bearings, spherical roller bearings and spherical roller thrust bearings.
Thrust ball bearings with seating rings and S-type bearings are not self-aligning bearings because they can compensate for mis*alignment* and deflections only during mounting and not in operation.

Separable bearings

These are rolling bearings whose rings can be mounted separately. This is of advantage where both bearing rings require a tight *fit.*
Separable bearings include four-point bearings, cylindrical roller bearings, tapered roller bearings, thrust ball bearings, cylindrical roller thrust bearings and spherical roller thrust bearings.
Non-separable bearings include deep groove ball bearings, single-row angular contact ball bearings, self-

aligning ball bearings, barrel roller bearings and spherical roller bearings.

Service life

This is the life during which the bearing operates reliably.
The *fatigue life* of a bearing is the upper limit of its service life. Often this limit is not reached due to *wear* or lubrication breakdown (cpl. *Grease service life*).

Speed factor f_n

The auxiliary quantity f_n is used, instead of the speed n [min^{-1}], to determine the *index of dynamic stressing*, f_L.

$$f_n = \sqrt[p]{\frac{33\,^1/_3}{n}}$$

p = 3 for ball bearings

$p = \frac{10}{3}$ for roller bearings and needle roller bearings

Speed index $n \cdot d_m$

The product from the operating speed n [min^{-1}] and the mean bearing diameter d_m [mm] is mainly used for selecting suitable lubricants and lubricating methods.

$$d_m = \frac{D + d}{2} \quad \text{[mm]}$$

D	bearing outside diameter	[mm]
d	bearing bore	[mm]

Speed suitability

Generally, the maximum attainable speed of rolling bearings is dictated by the permissible operating temperatures. This limiting criterion takes into account the *thermal reference speed.* It is determined on the basis of exactly defined, uniform criteria (reference conditions) in accordance with DIN 732, part 1 (draft).
In catalogue WL 41 520 "FAG Rolling Bearings" a reference is made to a method based on DIN 732, part 2, for determining the *thermally permissible operating speed* on the basis of the *thermal reference speed* for cases where the operating conditions (load, oil *viscosity* or permissible temperature) deviate from the reference conditions.
The *kinematically permissible speed* is indicated also for bearings for which – according to DIN 732 – no thermal reference speed is defined, e. g. for bearings with rubbing *seals.*

Spread

Generally, the spread of a machine component supported by two rolling bearings is the distance between the two bearing locations. While the distance between deep groove ball bearings etc. is measured between the bearing centres, the spread with single-row angular contact ball bearings and tapered roller bearings is the distance between the *pressure cone apexes.*

Static load/static stressing

Static stress refers to bearings carrying a load when stationary (no relative movement between the bearing rings).
The term "static", therefore, relates to the operation of the bearings but not to the effects of the load. The magnitude and direction of the load may change.
Bearings which perform slow slewing motions or rotate at a low speed ($n < 10\ min^{-1}$) are calculated like statically stressed bearings (cp. *Dynamic stressing*).

Static load rating C_0

The static load rating C_0 is that load acting on a stationary rolling bearing which causes, at the centre of the contact area between the most heavily loaded *rolling element* and the raceway, a total plastic deformation of about 1/10,000 of the *rolling element* diameter. For the normal curvature ratios this value corresponds to a Hertzian contact pressure of about
4,000 N/mm^2 for roller bearings,
4,600 N/mm^2 for self-aligning ball bearings and
4,200 N/mm^2 for all other ball bearings.
C_0 values, see FAG rolling bearing catalogues.

Stress index f_{s*}

In the *attainable life* calculation the stress index f_{s*} represents the maximum compressive stress occurring in the rolling contact areas.

$$f_{s*} = C_0/P_{0*}$$

C_0	*static load rating*	[kN]
P_{0*}	equivalent bearing load	[kN]
P_{0*}	$= X_0 \cdot F_r + Y_0 \cdot F_a$	[kN]
F_r	dynamic radial force	[kN]
F_a	dynamic axial force	[kN]
X_0	radial factor (see catalogue)	
Y_0	thrust factor (see catalogue)	

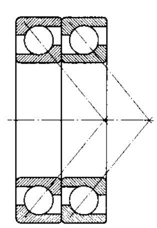
Glossary

Synthetic lubricants/synthetic oils

Lubricating oils produced by chemical synthesis; their properties can be adapted to meet special requirements: very low setting point, good *V-T behaviour,* small evaporation losses, long life, high oxidation stability.

Tandem arrangement

A tandem arrangement consists of two or more *angular contact bearings* which are mounted adjacent to each other facing in the same direction, i.e. asymmetrically. In this way, the axial force is distributed over all bearings. An even distribution is achieved with universal-design *angular contact bearings.*



Thermal reference speed

The thermal reference speed is a new index of the speed suitability of rolling bearings. In the draft of DIN 732, part 1, it is defined as the speed at which the reference temperature of 70 °C is established. In FAG catalogue WL 41 520 the standardized reference conditions are indicated which are similar to the normal operating conditions of the current rolling bearings (exceptions are, for example, spindle bearings, four-point bearings, barrel roller bearings, thrust ball bearings). Contrary to the past (limiting speeds), the thermal reference speed values indicated in the FAG catalogue WL 41 520 now apply equally to *oil* lubrication and *grease* lubrication.
For applications where the operating conditions deviate from the reference conditions, the *thermally permissible operating speed* is determined.
In cases where the limiting criterion for the attainable speed is not the permissible bearing temperature but, for example, the strength of the bearing components or the sliding velocity of rubbing *seals* the *kinematically permissible speed* has to be used instead of the thermal reference speed.

Thermally permissible operating speed

For applications where the loads, the *oil viscosity* or the permissible temperature deviate from the reference conditions for the *thermal reference speed* the thermally permissible operating speed can be determined by means of diagrams.
The method is described in FAG catalogue WL 41 520.

Thickener

Thickener and *base oil* are the constituents of *lubricating greases.* The most commonly used thickeners are metal soaps (e. g. lithium, calcium) as well as polyurea, PTFE and magnesium aluminium silicate compounds.

Thrust bearings

Bearings designed to transmit pure or predominantly thrust loading, with a nominal *contact angle* $\alpha_0 > 45°$, are referred to as thrust bearings.
The *dynamic load rating* and the *static load rating* of thrust bearings refer to pure thrust loads (cp. *Radial bearings*).

Tolerance class

In addition to the standard tolerance (tolerance class PN) for rolling bearings there are also the tolerance classes P6, P6X, P5, P4 and P2 for *precision bearings.* The standard of precision increases with decreasing tolerance number (DIN 620).
In addition to the standardized tolerance classes FAG also produces rolling bearings in tolerance classes P4S, SP (super precision) and UP (ultra precision).

Universal design

Special design of FAG angular contact ball bearings. The position of the ring faces relative to the raceway bottom is so closely toleranced that the bearings can be universally mounted without shims in *O, X* or *tandem arrangement.*
Bearings suffixed UA are matched together in such a way that unmounted bearing pairs in *O* or *X arrangement* have a small *axial clearance.* Under the same conditions, bearings suffixed UO feature zero *axial clearance,* and bearings suffixed UL a light preload. If the bearings are given tight *fits* the *axial clearance* of the bearing pair is reduced or the preload increased.

Viscosity

Viscosity is the most important physical property of a *lubricating oil.* It determines the load carrying capacity of the oil film under elastohydrodynamic lubricating conditions. Viscosity decreases with rising temperature and vice-versa (see *V-T behaviour*). Therefore it is necessary to specify the temperature to which any given viscosity value applies. The nominal viscosity ν_{40} of an oil is its kinematic viscosity at 40 °C.
SI units for the kinematic viscosity are m^2/s and mm^2/s. The formerly used unit Centistoke (cSt) corresponds to the SI unit mm^2/s. The dynamic viscosity is the product of the kinematic viscosity and the density of a fluid (density of *mineral oils:* 0.9 g/cm^3 at 15 °C).

Viscosity ratio κ

The viscosity ratio, being the quotient of the *operating viscosity* ν and the *rated viscosity* ν_1, is a measure of the lubricating film development in a bearing, cp. *factor* a_{23}.

Viscosity-temperature behaviour (V-T behaviour)

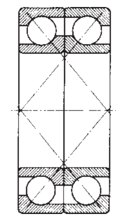
The term V-T behaviour refers to the *viscosity* variations in *lubricating oils* with temperature. The V-T behaviour is good if the viscosity varies little with changing temperatures.

Wear

The life of rolling bearings can be terminated, apart from fatigue, as a result of wear. The clearance of a worn bearing gets too large.
One frequent cause of wear are foreign particles which penetrate into a bearing due to insufficient *sealing* and have an abrasive effect. Wear is also caused by starved lubrication and when the lubricant is used up.
Therefore, wear can be considerably reduced by providing good lubrication conditions (*viscosity ratio* $\kappa > 2$ if possible) and a good degree of cleanliness in the rolling bearing. Where $\kappa \le 0.4$ wear will dominate in the bearing if it is not prevented by suitable *additives* (*EP additives*).

X arrangement

In an X arrangement, two *angular contact bearings* are mounted symmetrically in such a way that the *pressure cone apex* of the left-hand bearing points to the right and that of the right-hand bearing points to the left.



With an X arrangement, the bearing clearance is obtained by *adjusting* one outer ring. This ring should be subjected to *point load* because, being displaceable, it cannot be fitted tightly (*Fits*). Therefore, an X arrangement is provided where the outer ring is subjected to *point load* or where it is easier to adjust the outer ring than the inner ring. The effective bearing *spread* in an X arrangement is less than in an *O arrangement.*

Notes

Notes

The Design of Rolling Bearing Mountings

Every care has been taken to ensure the correctness of the information contained
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Technical Information

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FAG
Rolling Bearings

Stromisolierte FAG Wälzlager verhindern Stromdurchgangsschäden

Current-Insulated FAG Rolling Bearings Prevent Damage due to Passage of Electric Current

An den Lagern von Elektromotoren können unter ungünstigen Bedingungen Stromdurchgangsschäden auftreten. Magnetische Unsymmetrien, die auch bei sorgfältiger Fertigung der Motoren nicht ganz vermieden werden können, rufen ein Spannungsgefälle zwischen Rotor und Stator hervor. Der Stromkreis schließt sich über die Lager. Besonders gefährdet sind Wälzlager in Elektromotoren, die mit einer Umrichtereinspeisung betrieben werden.
Der Stromdurchgang erzeugt an den Laufflächen Schäden in Form von:
- Schmelzkratern
- Schmelzperlen
- Riffeln
- Verfärbungen
- Mikroverschleiß

Stromdurchgangsschäden machen sich in der Praxis zumeist in Form von erhöhten Lagergeräuschen bemerkbar.
Eine Isolierung zwischen Lagerschild und Gehäuse oder zwischen Welle und Lagerinnenring verhindert mit Sicherheit solche Stromdurchgänge.
Eine andere, sehr einfache Lösung, den induzierten Stromkreis zu unterbrechen, besteht darin, ein stromisoliertes Wälzlager an **einer** Lagerstelle einzubauen.

Eigenschaften beschichteter stromisolierter Lager

Bild 1 zeigt Lagerquerschnitte in stromisolierter Ausführung. Wie zu erkennen, sind das Rillenkugellager (a) und das Zylinderrollenlager (b) an der Außenringmantelfläche und an den Außenringstirnflächen beschichtet. Die Beschichtung besteht aus Oxydkeramik, die im Plasmaspritzverfahren aufgebracht wird.
Der elektrische Widerstand der Schicht beträgt temperaturabhängig bei Gleichspannung zwischen $2 \cdot 10^5$ und $2 \cdot 10^{10}$ Ohm und bei 50 Hz Wechselspannung zwischen $5 \cdot 10^4$ und $6 \cdot 10^5$ Ohm.
Die Durchschlagsspannung kann für die normale Beschichtung mit > 500 V angesetzt werden. Die Härte der Oxydkeramikschicht ist > 2.000 HV. Das Material ist verschleißfest und ein guter Wärmeleiter.

Abmessungen stromisolierter Lager

Die Außenabmessungen der stromisolierten FAG Wälzlager entsprechen den Abmessungen nach DIN 616 (ISO 15). Stromisolierte Lager sind also mit genormten Lagern austauschbar. Die beschichteten Lager werden mit dem Nachsetzzeichen **J20A** gekennzeichnet.

Hybridlager als Alternative

Als interessante Alternative zu den beschichteten Wälzlagern bieten sich Hybridlager (c, d) an, deren Ringe aus Stahl und Wälzkörper aus Keramik (Siliziumnitrid) hergestellt werden. Hierbei übernehmen die Wälzkörper die Funktion der Stromisolierung. Hybridlager werden mit dem Vorsetzzeichen **HC** gekennzeichnet.
Hybridlager bringen natürlich, außer daß sie stromisolierend wirken, eine Reihe weitere Vorteile für den Konstrukteur.
Er kann die Drehzahl steigern sowie die Reibung und Temperatur senken.
Besonders mit abgedichteten Hybridlagern läßt sich eine höhere Fettstandzeit und damit eine deutlich längere Lagergebrauchsdauer erzielen.

When conditions are unfavourable in electromotors bearing damage due to current passage can occur. Magnetic asymmetries which cannot be completely avoided even when production is carried out very carefully causes a voltage difference between rotor and stator. The circuit is closed through the bearings. Rolling bearings in electric motors that are operated with a frequency-converter are particularly jeopardized.

Current passage generates damage in the running areas in the form of:
- craters
- beads
- fluting
- discolourations
- microwear

Usually, damage due to the passage of electric current attracts attention through increased running noise.
If insulation is provided between the bearing shield and the housing or between the shaft and the bearing inner ring such passages of current can definitely be avoided.
Another, very simple method is to interrupt the induced current circuit by using a current-insulated rolling bearing in **one** bearing position.

Properties of Coated, Current-Insulated Bearings

Figure 1 shows bearing cross sections in current-insulated design. The deep groove ball bearing (a) and the cylindrical roller bearing (b) are coated on the outside diameter and on the faces of the outer ring. The layer consists of oxide-ceramic, that is deposited by means of plasma spraying.
Depending on the temperature, the electric resistance of the layer is between $2 \cdot 10^5$ and $2 \cdot 10^{10}$ ohm with direct voltage and between $5 \cdot 10^4$ and $6 \cdot 10^5$ ohm with 50 hertz alternating voltage.
The disruptive voltage for standard coating can be assumed to be > 500 V. The oxide-ceramic layer has a hardness of > 2000 HV. The material is resistant to wear and a good heat conductor.

Boundary Dimensions of Current-Insulated Bearings

The boundary dimensions of FAG current-insulated rolling bearings are in accordance with DIN 616 (ISO 15). They are therefore interchangeable with standard bearings.
The coated, current-insulated bearings are suffixed **J20A.**

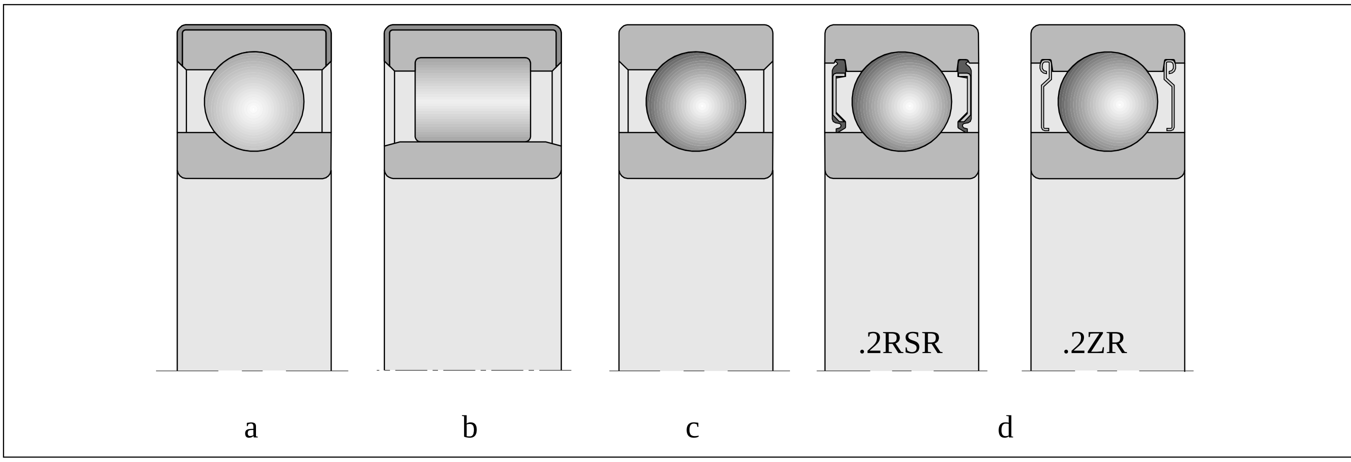
Hybrid Bearings an Alternative

An interesting alternative to the coated rolling bearings are hybrid bearings (c, d) with steel rings and ceramic (silicon nitride) balls or rollers. The rolling elements provide the required current insulation.
Hybrid bearings are prefixed **HC.**

Of course, hybrid bearings, apart from providing current insulation, offer a number of additional benefits. Designers can increase speed and reduce friction and temperature.

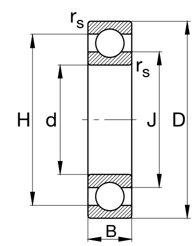
Especially with sealed hybrid bearings a longer grease life and thus a clearly longer service life can be achieved.

1: Stromisolierte Ausführung a, b beschichtete Lager; c, d Hybridlager
Current-insulated Design a, b Coated Rolling Bearings; c, d Hybrid Bearings



Stromisolierte FAG Rillenkugellager in bevorzugt lieferbaren Ausführungen

Current-insulated FAG deep groove ball bearings in most readily available designs



Welle / Shaft	Abmessung / Dimensions d	D	B	r_s min	H ≈	J ≈	Tragzahl / Load rating dyn. C	stat. C_0	Bezugs-drehzahl / Reference speed	Kurzzeichen / Code Lager / Bearing FAG	Gewicht / Mass ≈
	mm						kN		min^{-1}		kg
75	75	160	37	2.1	133.2	101.8	114	76.5	7000	6315M.C3.J20A	3.23
80	80	170	39	2.1	141.8	108.6	122	86.5	6700	6316M.C4.J20A	3.82
85	85	180	41	3	151.6	114.4	132	96.5	6300	6317M.C3.J20A	4.33
90	90	190	43	3	157.1	123.8	134	102	6000	6318M.C3.J20A	5.53
95	95	200	45	3	165	129.1	143	112	5600	6319M.C4.J20A	6.34
100	100	215	47	3	179	138.6	163	134	5000	6320M.C3.J20A	7.78
110	110	240	50	3	197.4	153.4	190	166	4500	6322M.C3.J20A	10.5
120	120	260	55	3	214.8	165.1	212	190	4000	6324M.C3.J20A	13
130	130	280	58	4	231.2	178.9	228	216	3800	6326M.C3.J20A	18.3

Liefermöglichkeit von stromisolierten Ausführungen anderer Lagerbauarten und -größen, z. B. von Zylinderrollenlagern und Hybridlagern, auf Anfrage!

Availability of current-insulated designs of other bearing types and sizes; e. g. cylindrical roller bearings and hybrid bearings, will be indicated on request!

Bei größeren Wälzlagern ist die beschichtete stromisolierte Ausführung (J20A) wirtschaftlicher. Bei kleineren Kugellagern ist die Wirtschaftlichkeit der Hybridausführung günstiger.

With larger rolling bearings, the coated, current-insulated design (J20A) is the more economical choice. With smaller ball bearings, the hybrid design is more economical.

Einbaubeispiel

Technische Daten:
Umrichtergespeister Drehstrommotor
Leistung 375 kW
Vierpolige Ausführung

Eingebaut ist auf der Belüftungsseite ein stromisoliertes Rillenkugellager FAG 6316.C3.J20A und auf der Antriebsseite ein Rillenkugellager FAG 6320.C3.
Beide Lager werden mit Fett geschmiert. Es ist eine Nachschmiereinrichtung vorgesehen.

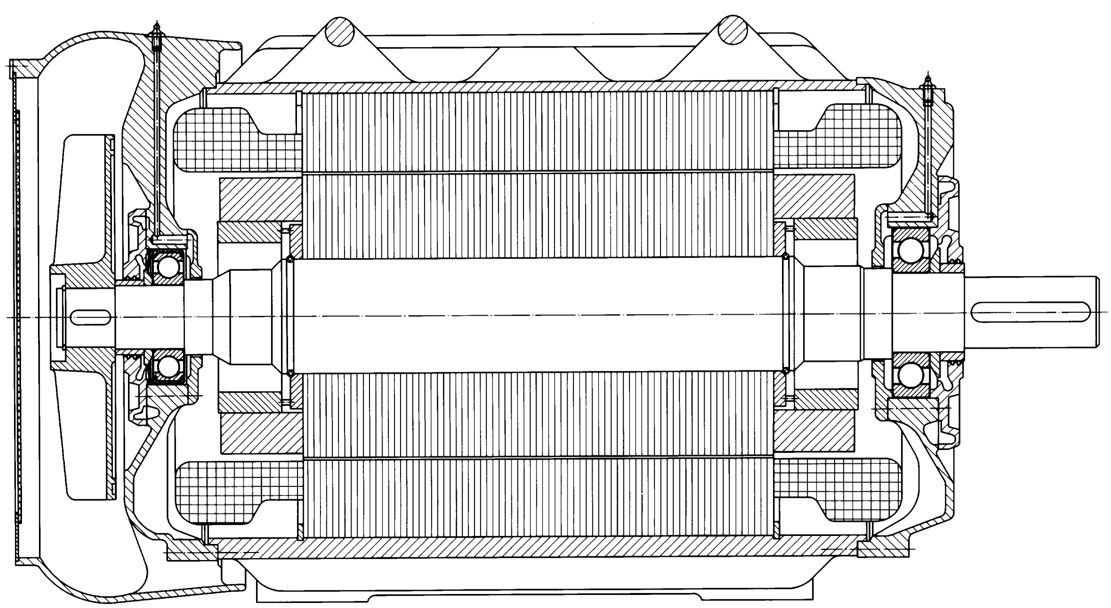
2: Drehstrommotor mit stromisoliertem Lager

Mounting example

Technical data:
Three-phase current motor fed by a frequency converter
Power 375 kW
Quadripolar design

At the ventilated end a current-insulated deep groove ball bearing FAG 6316.C3.J20A and at the drive end a deep groove ball bearing FAG 6320.C3 are mounted.
Both bearings are grease-lubricated. A relubrication device is provided.

2: Three-phase current motor with current-insulated bearing



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Technical Information

FAG Rolling Bearings

TI No. WL 43-1190 EA

FAG Rolling Bearings
Fundamentals · Types · Designs

Contents · Introduction

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Introduction

This Technical Information contains a summary of fundamental knowledge of FAG rolling bearings and should serve as an introduction to rolling bearing engineering. It is intended for those who have little or no knowledge of rolling bearings.

If you should like to enlarge your fundamental knowledge at your PC, we recommend you to use our **rolling bearing learning system W.L.S.** (cp. also Publ. No. WL 00106).

The FAG catalogue WL 41520 "FAG Rolling Bearings" is frequently referred to in this publication. It provides all the essential data designers need to safely and economically design all standard rolling bearings.

The **FAG rolling bearing catalogue on CD-ROM** outshines the usual software catalogues, being a comfortable, electronic consulting system. In a dialogue with WINDOWS you can quickly select the right FAG rolling bearing for your application and accurately calculate its life, speed, friction, temperature and cycling frequencies. This will save you a lot of money and time.

A large number of technical publications is available for specific applications which you can order from us indicating the publication number.

Rolling bearing codes are explained in detail in our Technical Information WL 43-1191.

Key rolling bearing engineering terms appear in boldface and will be explained in more detail (see also index at the end of this TI).

The FAG rolling bearing programme

The FAG rolling bearing programme

The FAG rolling bearing programme comprises the standard rolling bearing programme and target industry programmes. In the catalogue WL 41520 "FAG Rolling Bearings", priority is given to rolling bearings in DIN/ISO dimensions (see diagram below). This allows designers to solve almost any application problem quickly and cost-effectively. In addition, FAG have compiled special programmes for certain branches of industry which also contain numerous special designs.

The FAG product programme is divided into three service classes:

– standard programme
– preference programme
– scheduled product programme

Standard programme

Bearings of the FAG standard programme are produced according to current demand and are usually available from stock. The FAG standard programme contains rolling bearings, housings and rolling bearing accessories.

Preference programme

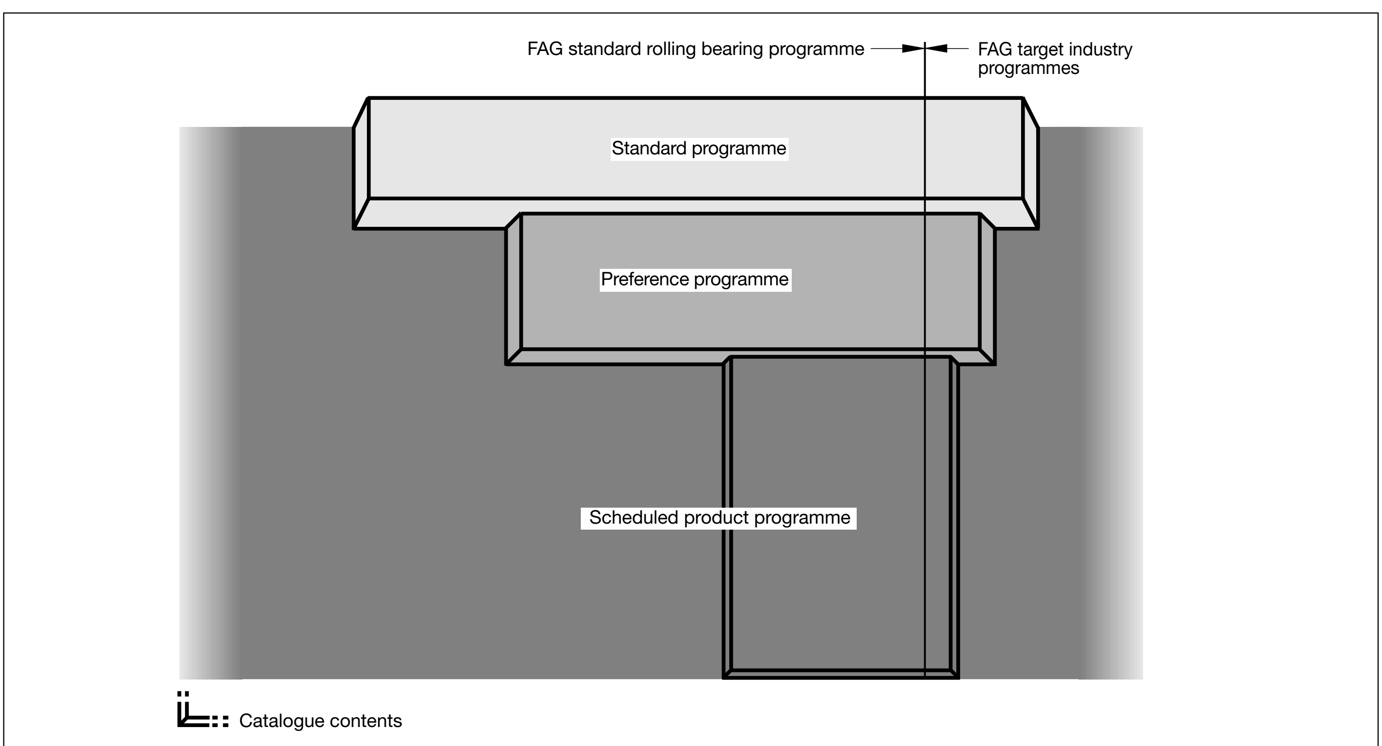
FAG preference programme bearings are produced in regular series and are therefore generally available at fairly short notice. The FAG contact partners indicated in the catalogue know the delivery periods.

Scheduled product programme

The delivery periods of products from the scheduled product programme depend on the production time. These periods may be reduced if FAG receive information for preplanning prior to placing of an order.

Current FAG product programme

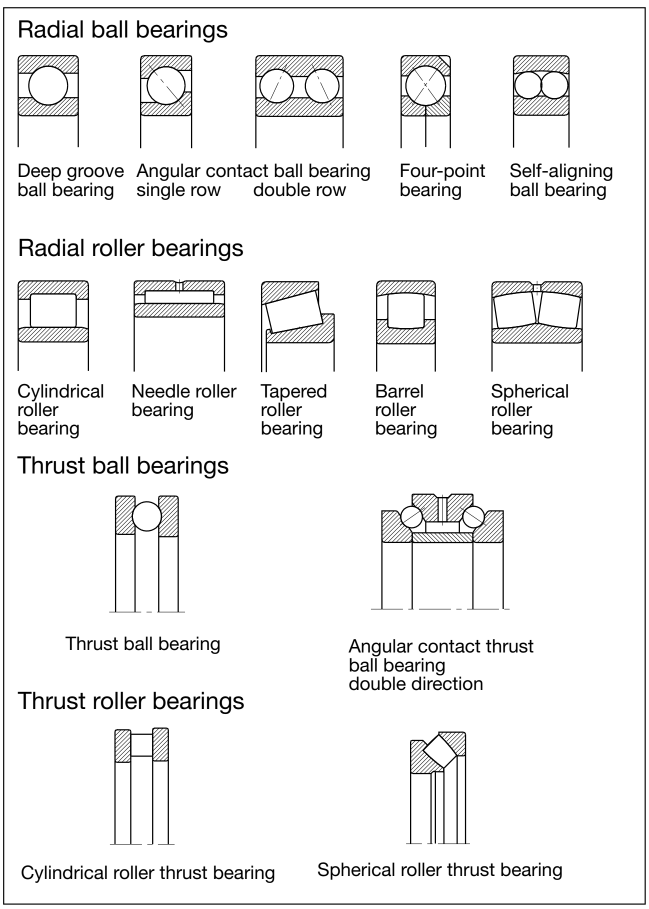
You will find the current FAG product programme in our latest price list. The advantages of this current programme are that our customers can plan well in advance, both commercially and technically. Ordering systems and stock-keeping are simplified in that an extensive, but nevertheless clear view of supplies, is always available.



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.**

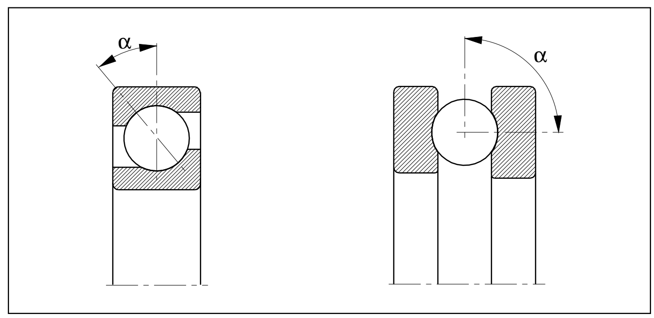


The essential differences between ball bearings and roller bearings are:
– Ball bearings: lower load carrying capacity, higher *speeds*
– Roller bearings: higher load carrying capacity, lower *speeds*

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

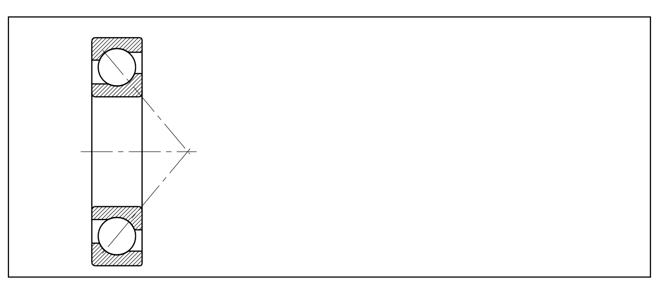
The *rolling elements* transmit loads from one *bearing ring* to the other in the direction of the **contact lines.** The contact angle α is the angle formed by the contact lines and the radial plane of the bearing. α_0 refers to the nominal contact angle, i.e. the contact angle of the load-free bearing. 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

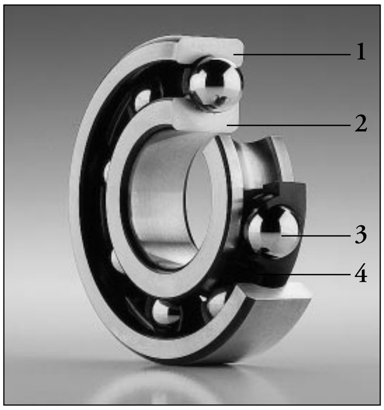
The pressure cone apex is that point on the bearing axis where the *contact lines* of an **angular contact bearing,** i.e. an angular contact ball bearing, a tapered roller bearing or a spherical roller thrust bearing, intersect. The *contact lines* are the generatrices of the pressure cone apex.



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 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.



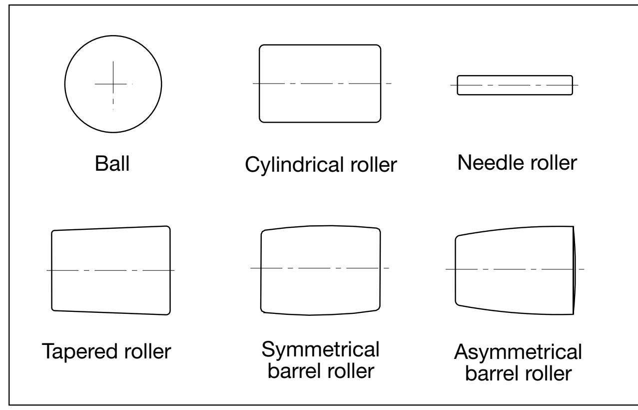
1 Outer ring, 2 Inner ring, 3 Rolling element, 4 Cage

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.



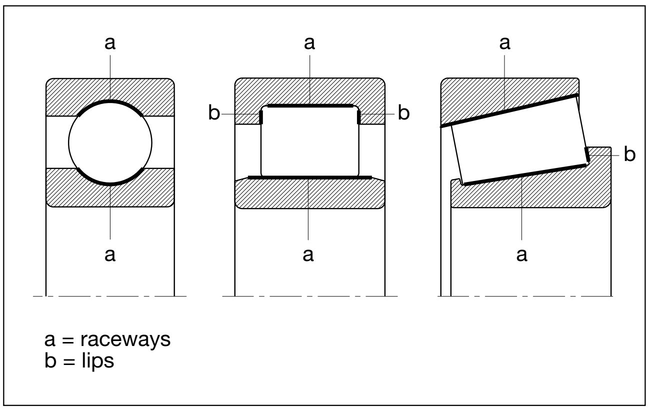
The rolling elements' function is to transmit the force acting on the bearing from one ring to the other. For a high load carrying capacity it is important that as many rolling elements as possible, which are as large as possible, are accommodated between the bearing rings. Their number and size depend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

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 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

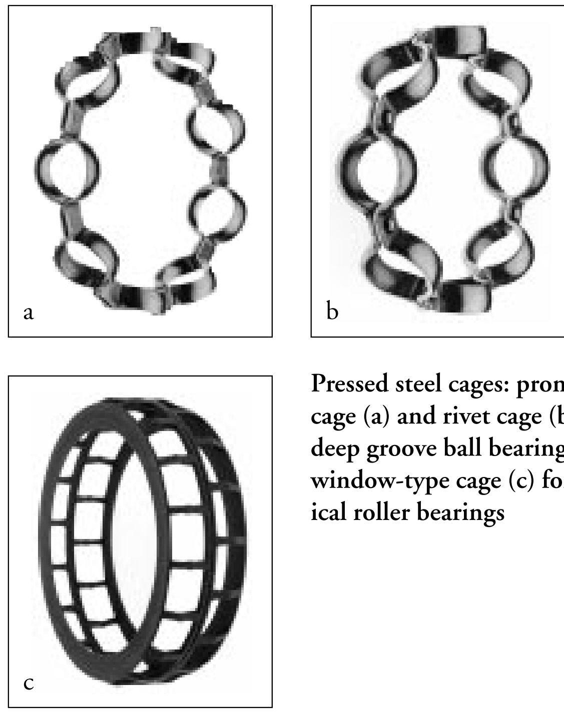
– to prevent rolling elements from falling out of *separable bearings* and bearings which are swiveled out

– 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


d


e


f

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.


g


h

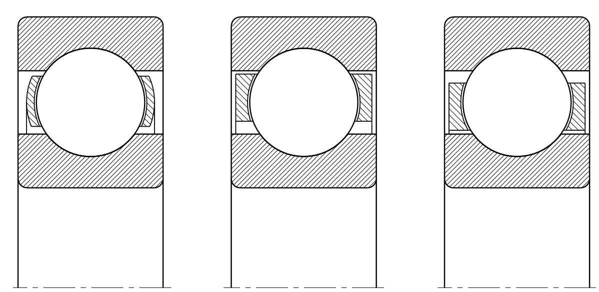

i

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.

Load ratings · Combined load

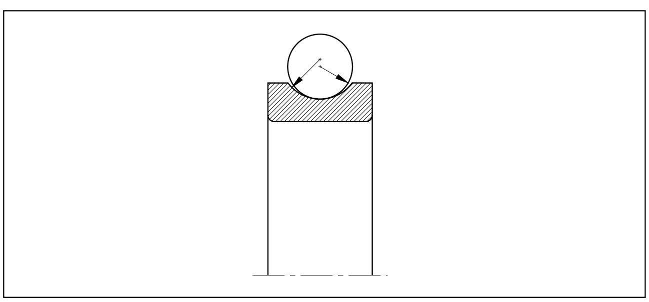
Load ratings

The load rating of a bearing reflects its load carrying capacity and is an important factor in the *dimensioning* of rolling bearings. It is determined by the number and size of the *rolling elements,* the *curvature ratio,* the *contact angle* and the pitch circle diameter of the bearing. Due to the larger contact area between rollers and raceways the load ratings of *roller bearings* are higher than those of *ball bearings.*

The load rating of a *radial bearing* is defined for radial loads whereas that of a *thrust bearing* is defined for axial loads. Every rolling bearing has a dynamic load rating and a static load rating. The terms "dynamic" and "static" refer to the movement of the bearing but not to the type of load.

In all rolling bearings with a curved raceway profile the radius of the raceway is slightly larger than that of the rolling *elements.* This curvature difference in the axial plane is defined by the **curvature ratio** $\varkappa$. The curvature ratio is the curvature difference between the rolling element radius and the slightly larger groove radius.

$$\text{curvature ratio } \varkappa = \frac{\text{groove radius} - \textit{rolling element} \text{ radius}}{\textit{rolling element} \text{ radius}}$$



Dynamic load rating

Load rating comparison of a few rolling bearing types with a bore diameter of d = 25 mm

Rolling bearing	Dyn. load rating C kN
Deep groove ball bearing 6205	14
Cylindrical roller bearing NU205E	29
Tapered roller bearing 30205A	32.5
Spherical roller bearing 22205ES	42.5

The dynamic load rating C is a factor for the load carrying capacity of a rolling bearing under dynamic load at which the bearing rings rotate relative to each other. It is defined as the load, constant in magnitude and direction, a rolling bearing can theoretically accommodate for a *nominal rating life* of 1 million revolutions (DIN ISO 281).

Static load rating

In statically stressed bearings there is no relative motion between the *bearing rings* or only a very slow one. A load equalling the static load rating C_0 in magnitude generates in the middle of the *rolling element* /raceway contact area, which is the most heavily loaded, a Hertzian contact pressure of approximately

4600 N/mm^2 in self-aligning ball bearings,
4200 N/mm^2 in all other ball bearings,
4000 N/mm^2 in all roller bearings

Under the C_0 load a total plastic deformation of rolling element and raceway of about 0.01% of the rolling element diameter at the most heavily loaded contact area arises (DIN ISO 76).

Combined load

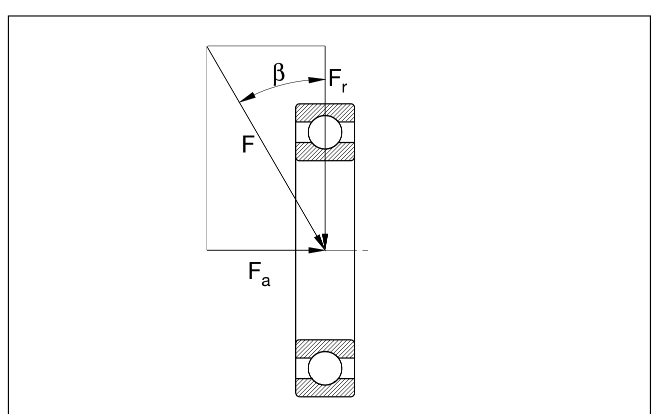
This applies when a bearing is loaded both radially and axially, and the resulting load acts, therefore, at the *load angle* β.

Depending on the type of load, the *equivalent static load* P_0, (page 9) or the *equivalent dynamic load* P (page 10) is determined in the bearing calculation with the radial component F_r and the axial component F_a of the combined load.

Load angle

The load angle β is the angle between the resultant applied load F and the radial plane of the bearing. It is the resultant of the radial component F_r and the axial component F_a:

$\tan \beta = F_a/F_r$



Dimensioning

A dimension calculation is carried out to check whether requirements on *life,* static safety and cost efficiency of a bearing have been fulfilled. This calculation involves the comparison of a bearing's load with its load carrying capacity. In rolling bearing engineering a differentiation is made between *dynamic* and *static* stress.

Statically stressed bearings

For static stress conditions the safety against excessive plastic deformations of the raceways and *rolling elements* is checked.

Static stress refers to bearings carrying a load when stationary (no relative movement between the *bearing rings*). The term "static", therefore, relates to the operation of the bearing but not to the effects of the load. The magnitude and direction of load may change.

Bearings which perform slow slewing motions or rotate at a low speed ($n < 10\ min^{-1}$) are calculated like statically stressed bearings (cp. *dynamically stressed rolling bearings,* page 10).

Equivalent static load P_0

Statically stressed rolling bearings which operate under a *combined* load are calculated with the equivalent static load. It is a radial load for *radial bearings* and an axial load for *thrust bearings,* having the same effect with regard to permanent deformation as the *combined load.* The equivalent static load P_0 is calculated with the formula:

$$P_0 = X_0 \cdot F_r + Y_0 \cdot F_a$$

F_r radial load
F_a axial load
X_0 radial factor (see FAG catalogues)
Y_0 axial factor (see FAG catalogues)

Index of static stressing f_s

The index of static stressing f_s for *statically loaded bearings* is calculated to ensure that an adequately dimensioned bearing has been selected. It is calculated from the *static load rating* C_0 (see page 8) and the *equivalent static load* P_0.

$$f_s = \frac{C_0}{P_0}$$

The index f_s is a safety factor against excessively great total plastic deformation in the contact area of the raceway and the most highly loaded *rolling element.*

A high f_s value is necessary for bearings which must run smoothly and particularly quietly. Smaller values satisfy modest demands on the quietness of running. Commonly applicable values are:

$f_s = 1.5...2.5$ for high demands
$f_s = 1...1.2$ for normal demands
$f_s = 0.7...1$ for modest demands

Service life

This is the life during which the bearing operates reliably.

The *fatigue life* of a bearing (cp. section on "Bearing life", page 10) is the upper limit of the service life. Often this limit is not reached due to *wear* or lubrication breakdown.

Wear

The *life* of rolling bearings can be terminated, apart from *fatigue,* as a result of wear. The clearance of a worn bearing gets too large.

One frequent cause of wear are foreign particles which penetrate into a bearing due to insufficient *sealing* and have an abrasive effect. Wear is also caused by starved lubrication and when the lubricant is used up.

Therefore, wear can be considerably reduced by providing good lubrication conditions (*viscosity ratio* $\varkappa > 2$ if possible) and a good degree of cleanliness in the rolling bearing. Where $\varkappa \leq 0.4$ wear will dominate in the bearing if it is not prevented by suitable *additives* (EP additives).

Dynamically stressed rolling bearings

Rolling bearings are dynamically stressed when one ring rotates relative to the other under load. The term "dynamic" does not refer, therefore, to the effect of the load but rather to the operating condition of the bearing. The magnitude and direction of the load can remain constant.

When calculating the bearings, a dynamic stress is assumed when the speed n amounts to at least 10 min^{-1} (see *static stressing*).

Equialent dynamic load P

For dynamically loaded rolling bearings operating under *combined load,* the calculation is based on the equivalent dynamic load. This is a radial load for *radial bearings* and an axial and centrical load for *axial bearings,* having the same effect on *fatigue* as the *combined load.* The equivalent dynamic load P is calculated by means of the following equation:

$$P = X \cdot F_r + Y \cdot F_a$$

F_r radial load
F_a axial load
X radial factor
Y axial factor

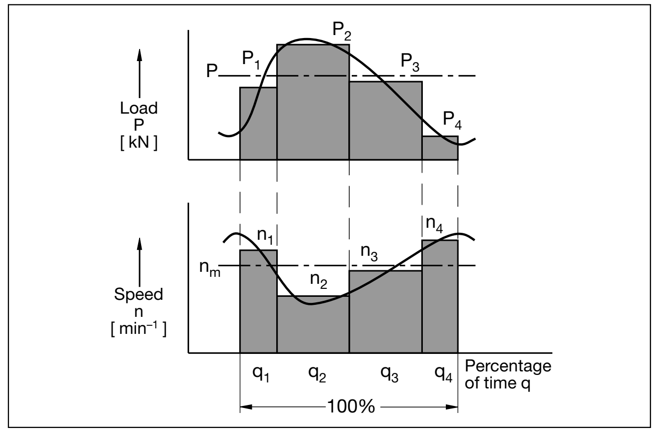
Variable load and speed

If loads and speeds vary over time this has to be taken into account when calculating the equivalent dynamic load. The curve is approximated by a series of individual loads and speeds of a certain duration q [%]. In this case, the equivalent dynamic load P is obtained from

$$P = \sqrt[3]{P_1^3 \cdot \frac{n_1}{n_m} \cdot \frac{q_1}{100} + P_2^3 \cdot \frac{n_2}{n_m} \cdot \frac{q_2}{100} + \ldots} \, [kN]$$

and the mean rotational speed n_m from:

$$n_m = n_1 \cdot \frac{q_1}{100} + n_2 \cdot \frac{q_2}{100} + \ldots \, [min^{-1}]$$

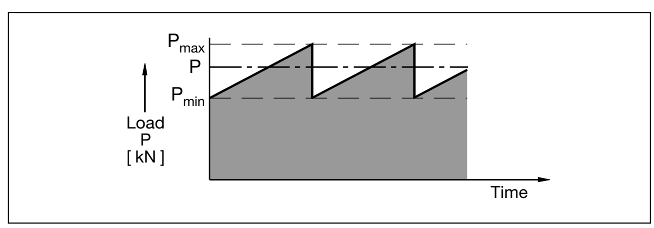


If the load is variable but the speed constant:

$$P = \sqrt[3]{P_1^3 \cdot \frac{q_1}{100} + P_2^3 \cdot \frac{q_2}{100} + \ldots} \, [kN]$$

If the load increases linearly from a minimum value P_{min} to a maximum value P_{max} at a constant speed:

$$P = \frac{P_{min} + 2P_{max}}{3} \, [kN]$$



The mean value of the equivalent dynamic load may **not** be used for the *adjusted rating life calculation* (page 12ff). Rather, the *attainable life* under constant conditions has to be determined for every operating time.

Bearing life

The life of *dynamically stressed rolling bearings,* as defined by DIN ISO 281, is the operating time until failure due to material fatigue (**fatigue life**).

By means of the classical calculation method, a comparison calculation, the *nominal rating life* L or L_h of a bearing is determined; by means of the refined FAG calculation process, the *attainable life* L_{na} or L_{hna} is determined (see also a_{23} factor).

Nominal rating life

The standardized calculation method (DIN ISO 281) for dynamically stressed rolling bearings is based on material fatigue (formation of pitting) as the cause of failure. The life formula is:

$$L_{10} = L = \left(\frac{C}{P}\right)^p 10^6 \text{ revolutions}$$

L_{10} is the nominal rating life in millions of revolutions which is reached or exceeded by at least 90% of a large group of identical bearings.

In the formula,

C *dynamic load rating* (see page 8)
P *equivalent dynamic load* (see page 10)
p **life exponent**
p = 3 for ball bearings
$p = \frac{10}{3}$ for roller bearings and needle roller bearings

Where the bearing speed is constant, the life can be expressed in hours.

$$L_{h10} = L_h = \frac{L \cdot 10^6}{n \cdot 60} [h]$$

L nominal rating life [10^6 revolutions]
n speed [min^{-1}]

L_h can also be determined by means of the *index of dynamic stressing*, f_L.

The nominal rating life L or L_h applies to bearings made of conventional rolling bearing steel and the usual operating conditions (good lubrication, no extreme temperatures, normal cleanliness).

The nominal rating life deviates more or less from the really *attainable life* of rolling bearings. Influences like the lubricating film thickness, the cleanliness in the lubricating gap, lubricant *additives* and bearing type are taken into account in the *adjusted rating life calculation* by the *factor* a_{23}.

Index of dynamic stressing f_L

It is convenient to express the **value recommended** for dimensioning not in hours but as the index of dynamic stressing, f_L. It is calculated from the *dynamic load rating* C, the *equivalent dynamic load* P and the *speed factor* f_n.

$$f_L = \frac{C}{P} \cdot f_n$$

The f_L value is an empirical value obtained from field-proven identical or similar bearing mountings. The f_L values help to select the right bearing size. The values indicated in various FAG publications take into account not only an adequate *fatigue life* but also other requirements such as low weight for light-weight constructions, adaptation to given mating parts, higher-than-usual peak loads, etc. The f_L values conform with the latest standards resulting from technical progress. For comparison with a field-proven bearing mounting the calculation of stressing must, of course, be based on the same former method.

The **speed factor** f_n is an auxiliary quantity which is used, instead of the speed n, to determine the *index of dynamic stressing*, f_L.

$$f_n = \sqrt[p]{\frac{33\frac{1}{3}}{n}}$$

p = 3 for ball bearings
$p = \frac{10}{3}$ for roller bearings and needle roller bearings

Based on the calculated value of f_L, the nominal rating life in hours can be determined.

$$L_h = 500 \cdot f_L^{\,p}$$

Rolling bearing selection system

Rolling bearings can be very comfortably selected and calculated by means of the FAG W.A.S. rolling bearing selection system, a computer programme for the P.C., see FAG publication No. WL 40 135 EA.

Adjusted rating life calculation

The *nominal rating life* L or L_h deviates more or less from the really *attainable life* of rolling bearings.

Therefore, additional important operating conditions besides the load have to be taken into account in the adjusted rating life calculation.

Modified life

The standard DIN ISO 281 introduced, in addition to the *nominal rating life* L_{10}, the modified life L_{na} to take into account, apart from the load, the influence of the failure probability (*factor a_1*), of the material (factor a_2) and of the operating conditions (factor a_3).

DIN ISO 281 indicates no figures for the *factor a_{23}* ($a_{23} = a_2 . a_3$). With the FAG calculation process for the *attainable life* (L_{na}, L_{hna}), however, operating conditions can be expressed in terms of figures by the *factor a_{23}*.

Factor a_1

Generally (*nominal rating life* L_{10}), 10% failure probability is taken. The factor a_1 is also used for failure probabilities between 10% and 1% for the calculation of the *attainable life,* see following table.

Failure probability %	10	5	4	3	2	1
Fatigue life	L_{10}	L_5	L_4	L_3	L_2	L_1
Factor a_1	1	0.62	0.53	0.44	0.33	0.21

Attainable life L_{na}, L_{hna} according to the FAG method

The FAG calculation method for determining the attainable life (L_{na}, L_{hna}) is based on DIN ISO 281 (cp. *Modified Life*). It takes into account the influences of the operating conditions on the rolling bearing life.

$$L_{na} = a_1 \cdot a_{23} \cdot L \quad [10^6 \text{ revolutions}]$$

and

$$L_{hna} = a_1 \cdot a_{23} \cdot L_h \quad [\text{h}]$$

a_1 *factor a_1* for failure probability;
usually, a = 1 is assumed for a 10% failure probability
a_{23} *factor a_{23}* (*life adjustment factor*)
L *nominal rating life* [10^6 revolutions]
L_h *nominal rating life* [h]

Changing operating conditions

If the quantities influencing the bearing life (e.g. load, speed, temperature, cleanliness, type and condition of the lubricant) are variable, the attainable life (L_{hna1}, L_{hna2}, ...) under constant conditions has to be determined for every operating time q [%]. The attainable life is calculated for the total operating time using the formula

$$L_{hna} = \frac{100}{\frac{q_1}{L_{hna1}} + \frac{q_2}{L_{hna2}} + \frac{q_3}{L_{hna3}} + \ldots}$$

Factor a_{23} (life adjustment factor)

The a_{23} factor (= $a_2 \cdot a_3$, cp. "Modified Life") takes into account not only the influence of material and lubrication but also the amount of load acting on the bearing and the bearing type as well as the influence of the cleanliness in the lubricating gap.

The a_{23} factor is determined by the lubricant film formation within the bearing, i.e. by the **viscosity ratio** $\kappa = \nu/\nu_1$.

ν *operating viscosity* of the lubricant, depending on the nominal *viscosity* (at 40 °C) and the operating temperature (fig. 1). In the case of lubricating greases, ν is the *operating viscosity* of the *base oil.*

ν_1 *rated viscosity,* depending on the mean bearing diameter and the operating speed (fig. 2).

Fig. 3 for determining the a_{23} factor is subdivided into zones I, II and III.

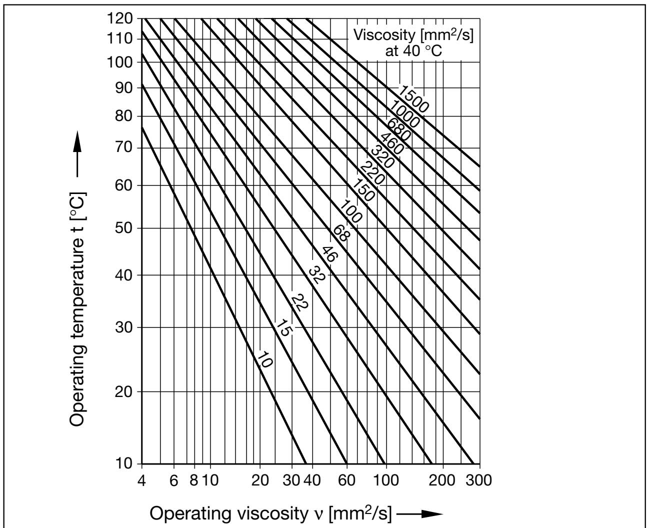
Most applications in rolling bearing engineering are covered by zone II. It applies to normal cleanliness (*contamination factor* V = 1).

The **basic** a_{23II} **factor** can be determined as a function of K on one of the curves in zone II by means of the **value** K (K = 0 to 6).

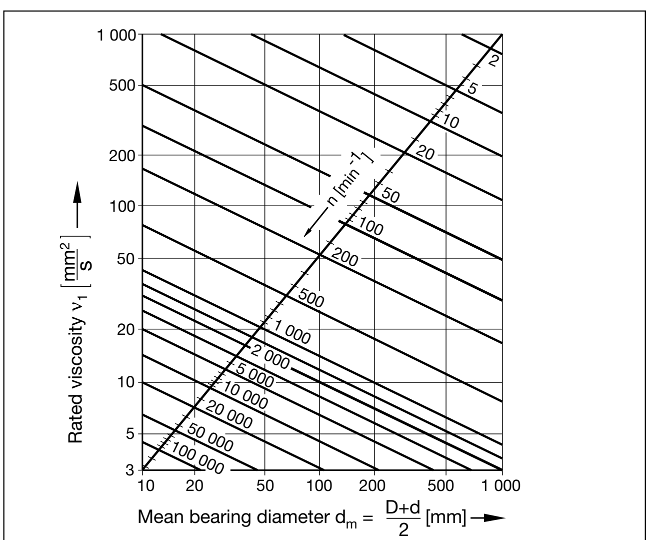
If K > 6, a_{23} must be expected to be in zone III. In such a case, conditions should be improved so that zone II can be reached.

The a_{23} factor is obtained as the product of the **basic** a_{23II} **factor** and the **cleanliness factor** s (see page 16).

1: Average *viscosity-temperature behaviour* of *mineral oils*



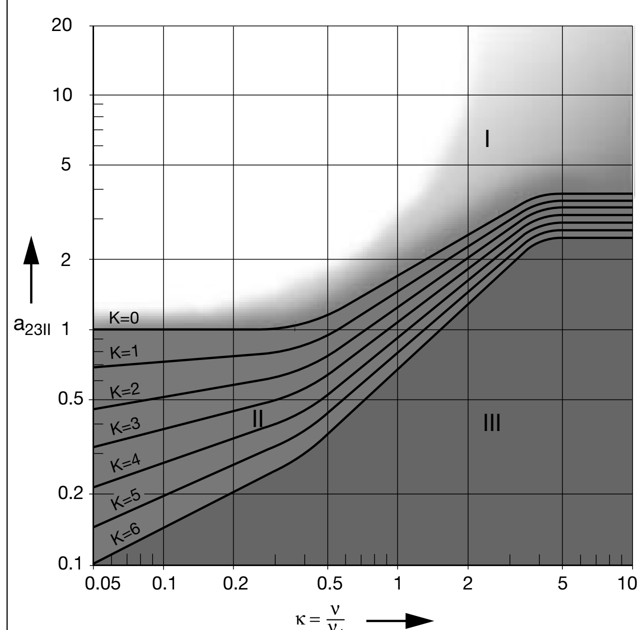
2: *Rated viscosity* ν_1



3: Basic a_{23II} factor for determining the a_{23} factor

Zone

I	Transition to endurance strength Precondition: Utmost cleanliness in the lubricating gap and loads which are not too high, suitable lubricant
II	Normal degree of cleanliness in the lubricating gap (with effective *additives* tested in rolling bearings, a_{23} factors > 1 are possible even with κ < 0.4)
III	Unfavourable operating conditions Contaminated lubricant Unsuitable lubricants



Limits of life calculation
As is the case with the former life calculation method, only material fatigue is taken into consideration as a cause of failure for the *adjusted life calculation* as well. The calculated life can only correspond to the actual service life of the bearing when the lubricant service life or the life limited by *wear* is not shorter than the *fatigue life.*

Dimensioning

Dynamically stressed bearings · Adjusted rating life calculation

Value K

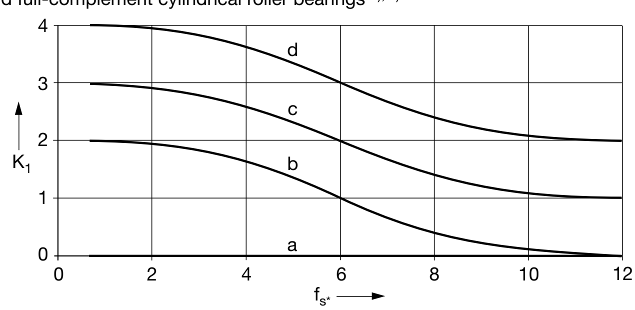
The value K is an auxiliary quantity needed to determine the *basic a_{23II} factor* when calculating the *attainable life* of a bearing.

$K = K_1 + K_2$

K_1 depends on the bearing type and the *stress index f_{s^*}*, see diagram.

Value K_1

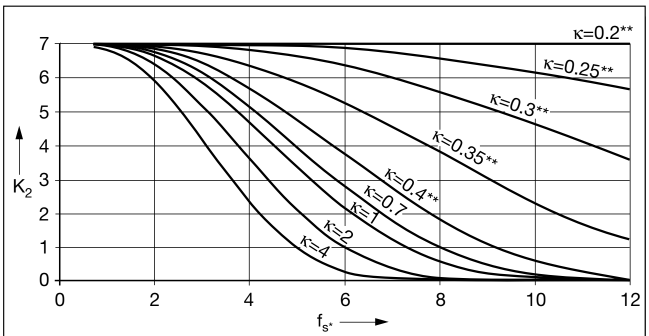
a ball bearings
b tapered roller bearings, cylindrical roller bearings
c spherical roller bearings, spherical roller thrust bearings 3), cylindrical roller thrust bearings 1), 3)
d full-complement cylindrical roller bearings 1), 2)



1) Attainable only with lubricant filtering corresponding to V < 1, otherwise $K_1 \geq 6$ must be assumed.
2) To be observed for the determination of V: the friction is at least twice the value in caged bearings. This results in higher bearing temperature.
3) Minimum load must be observed.

K_2 depends on the *stress index* f_{s^*} and the *viscosity ratio ϰ*. The values in the diagram (below) apply to lubricants without additives and lubricants with *additives* whose effect in rolling bearings was not tested.

Value K_2



K_2 equals 0 for lubricants with additives with a corresponding suitable proof.
** With κ ≤ 0.4 wear dominates unless eliminated by suitable additives.

Stress index f_{s^*}

When calculating the *attainable life* of a bearing, the stress index f_{s^*} is taken into account as a measure of the maximum compressive stresses generated in the rolling contact areas.

$f_{s^*} = C_0/P_{0^*}$

C_0 *static load rating* (see page 8)
P_{0^*} equivalent bearing load

$P_{0^*} = X_0 \cdot F_r + Y_0 \cdot F_a$

F_r dynamic radial force
F_a dynamic axial force
X_0 radial factor (see catalogue)
Y_0 thrust factor (see catalogue)

Contamination factor V

The contamination factor V indicates the degree of cleanliness in the lubricating gap of rolling bearings based on the *oil cleanliness classes* defined in ISO 4406.

When determining the attainable *life,* V is used, together with the *stress index f_{s^*}* and the *viscosity ratio ϰ,* to determine the *cleanliness factor* s (see page 16).

V depends on the bearing cross section, the type of contact between the mating surfaces and especially the *cleanliness level of the oil.* If hard particles from a defined size on are cycled in the most heavily stressed contact area of a rolling bearing, the resulting indentations in the contact surfaces lead to premature material *fatigue.* The smaller the contact area, the more damaging the effect of a particle above a certain size when being cycled. Small bearings with point contact are especially vulnerable.

According to today's knowledge the following cleanliness scale is useful (the most important values are in boldface):

V = 0.3 utmost cleanliness
V = 0.5 improved cleanliness
V = 1 normal cleanliness
V = 2 moderately contaminated lubricant
V = 3 heavily contaminated lubricant

Preconditions for utmost cleanliness (V = 0.3):

– bearings are greased and protected by seals or shields against dust by the manufacturer
– grease lubrication by the user who fits the bearings into clean housings under top cleanliness conditions, lubricates them with clean grease and takes care that dirt cannot enter the bearings during operation

- flushing the oil circulation system prior to the first operation of the cleanly fitted bearings and taking care that the oil cleanliness class is ensured during the entire operating time

Preconditions for normal cleanliness (V = 1):
- good *sealing* adapted to the environment
- cleanliness during mounting
- oil cleanliness according to V = 1
- observing the recommended oil change intervals

Possible causes of heavy lubricant contamination (V = 3):
- the cast housing was inadequately cleaned
- abraded particles from components which are subject to wear enter the circulating oil system of the machine
- foreign matter penetrates into the bearing due to an unsatisfactory *sealing*
- water which entered the bearing, also condensation water, caused standstill corrosion or deterioration of the lubricant properties

The necessary **oil cleanliness class** according to ISO 4406 is an objectively measurable level of the contamination of a lubricant.

In accordance with the particle-counting method, the numbers of all particles > 5 µm and all particles > 15 µm are allocated to a certain ISO oil cleanliness class. An oil cleanliness 15/12 according to ISO 4406 means, for example, that between 16000 and 32000 particles > 5 µm and between 2000 and 4000 particles > 15 µm are present per 100 ml of a fluid. The step from one class to the next is by doubling or halving the particle number.

Guide values for the contamination factor V

(D – d)/2 mm	V	Point contact: required oil cleanliness class according to ISO 4406	Point contact: guide values for filtration ratio according to ISO 4572	Line contact: required oil cleanliness class according to ISO 4406	Line contact: guide values for filtration ratio according to ISO 4572
≤ 12.5	0.3	11/8	$\beta_3 \geq 200$	12/9	$\beta_3 \geq 200$
	0.5	12/9	$\beta_3 \geq 200$	13/10	$\beta_3 \geq 75$
	1	14/11	$\beta_6 \geq 75$	15/12	$\beta_6 \geq 75$
	2	15/12	$\beta_6 \geq 75$	16/13	$\beta_{12} \geq 75$
	3	16/13	$\beta_{12} \geq 75$	17/14	$\beta_{25} \geq 75$
> 12.5...20	0.3	12/9	$\beta_3 \geq 200$	13/10	$\beta_3 \geq 75$
	0.5	13/10	$\beta_3 \geq 75$	14/11	$\beta_6 \geq 75$
	1	15/12	$\beta_6 \geq 75$	16/13	$\beta_{12} \geq 75$
	2	16/13	$\beta_{12} \geq 75$	17/14	$\beta_{25} \geq 75$
	3	18/14	$\beta_{25} \geq 75$	19/15	$\beta_{25} \geq 75$
> 20...35	0.3	13/10	$\beta_3 \geq 75$	14/11	$\beta_6 \geq 75$
	0.5	14/11	$\beta_6 \geq 75$	15/12	$\beta_6 \geq 75$
	1	16/13	$\beta_{12} \geq 75$	17/14	$\beta_{12} \geq 75$
	2	17/14	$\beta_{25} \geq 75$	18/15	$\beta_{25} \geq 75$
	3	19/15	$\beta_{25} \geq 75$	20/16	$\beta_{25} \geq 75$
>35	0.3	14/11	$\beta_6 \geq 75$	14/11	$\beta_6 \geq 75$
	0.5	15/12	$\beta_6 \geq 75$	15/12	$\beta_{12} \geq 75$
	1	17/14	$\beta_{12} \geq 75$	18/14	$\beta_{25} \geq 75$
	2	18/15	$\beta_{25} \geq 75$	19/16	$\beta_{25} \geq 75$
	3	20/16	$\beta_{25} \geq 75$	21/17	$\beta_{25} \geq 75$

The oil cleanliness class can be determined by means of oil samples by filter manufacturers and institutes. It is a measure of the probability of life-reducing particles being cycled in a bearing. Suitable sampling should be observed (see e.g. DIN 51570). Today, on-line measuring instruments are available. The cleanliness classes are reached if the entire oil volume flows through the filter within a few minutes. To ensure a high degree of cleanliness flushing is required **prior** to bearing operation.

For example, a filtration ratio $\beta_3 \geq 200$ (ISO 4572) means that in the so-called multi-pass test only one of 200 particles ≥ 3 µm passes the filter. Filters with coarser filtration ratios than $\beta_{25} \geq 75$ should not be used due to the ill effect on the other components within the circulation system.

A defined **filtration ratio** β_x should exist in order to reach the oil cleanliness required. The filtration ratio is a measure of the separation ability of a filter at defined particle sizes. The filtration ratio is the ratio of all particles > x µm before passing the filter to the particles > x µm which have passed the filter.

A filter of a certain filtration ratio is not automatically indicative of an *oil cleanliness class.*

Cleanliness factor s

The cleanliness factor s quantifies the effect of contamination on the *attainable life.* The product of s and the *basic a_{23II} factor* is the *a_{23} factor.*

Contamination factor V is required to determine s. s = 1 always applies to normal cleanliness (V = 1).

With improved cleanliness (V = 0.5) and utmost cleanliness (V = 0.3) a cleanliness factor s ≥ 1 is obtained from the right diagram (a) below, based on the *stress index f_{s*}* and depending on the *viscosity ratio* $\varkappa$.

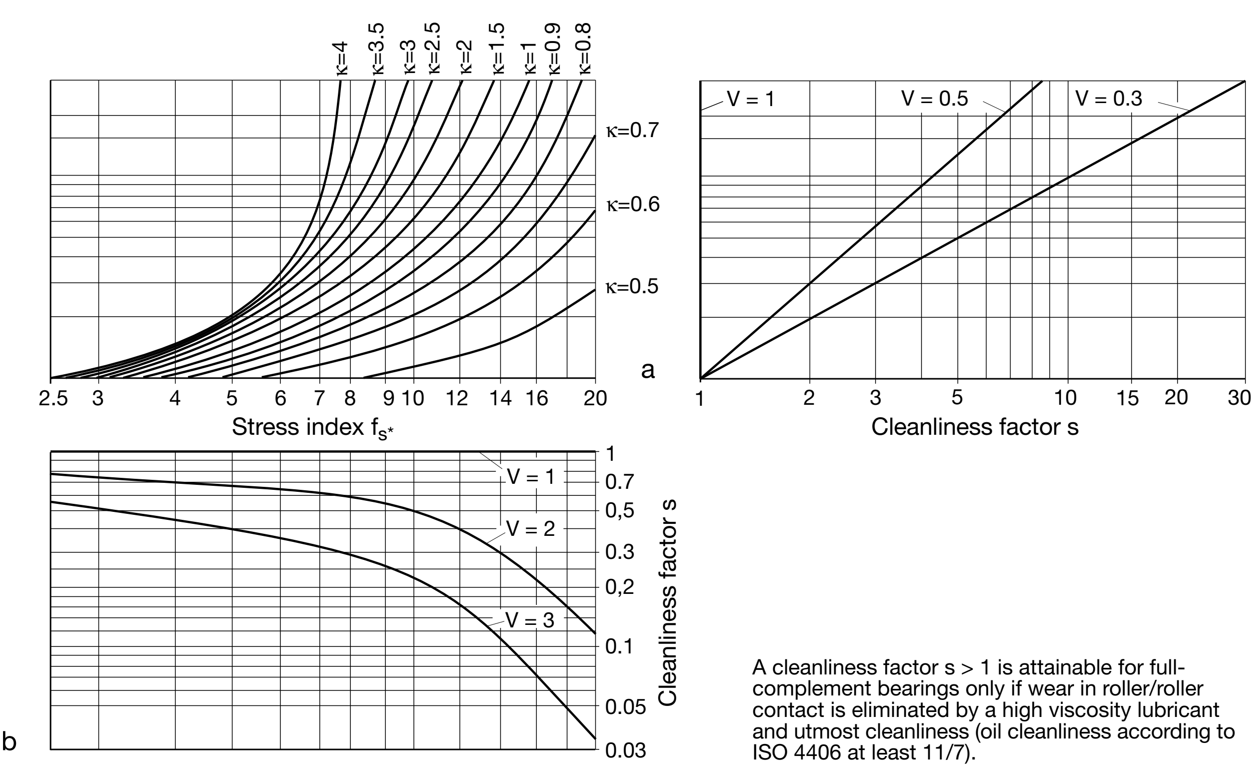
s = 1 applies to $\varkappa \leq 0.4$.

With V = 2 (moderately contaminated lubricant) to V = 3 (heavily contaminated lubricant), s < 1 is obtained from diagram (b) below.

Diagram for determining the cleanliness factor s

a Diagram for improved (V = 0.5) to utmost (V = 0.3) cleanliness

b Diagram for moderately contaminated lubricant (V = 2) and heavily contaminated lubricant (V = 3)



A cleanliness factor s > 1 is attainable for full-complement bearings only if wear in roller/roller contact is eliminated by a high viscosity lubricant and utmost cleanliness (oil cleanliness according to ISO 4406 at least 11/7).

Lubrication

The main objective of lubrication is to prevent metal-to-metal contact between the *bearing rings* and the *rolling elements* by means of a lubricant film. In this way, *wear* and premature rolling bearing *fatigue* are avoided. In addition, lubrication reduces the development of noise and friction, thus improving the operating characteristics of a bearing. Additional functions may include protection against corrosion and heat dissipation from the bearing.

Usually, bearings are lubricated with grease or oil; in rare cases, e.g. where very high temperatures are involved, dry lubricants are also used.

Rolling bearing lubrication is discussed in detail in the FAG publication No. WL 81115/4EA.

Grease lubrication

Grease lubrication is used for about 90% of all rolling bearings. The main advantages of grease lubrication are:
– a very simple design
– it enhances the *sealing effect*
– long *service life* but little maintenance is required

With normal operating and environmental conditions, for-life grease lubrication is often possible.

If a bearing is heavily stressed (load, speed, temperature), suitable *relubrication intervals* must be scheduled.

Oil lubrication

Oil lubrication is the obvious solution for applications where adjacent machine elements are already supplied with oil or where heat has to be removed by means of the lubricant.

Heat can be removed by circulating substantial oil volumes. It may be required where high loads and/or high speeds have to be accommodated or where the bearings are exposed to external heating.

With oil throwaway lubrication, e.g. oil mist lubrication or oil-air lubrication, the bearing friction is kept low.

Important rolling bearing lubrication terms (in alphabetical order)

Additives

Additives are oil soluble substances wich are added to *mineral oils* or mineral oil products. By chemical and/or physical action, they change or improve the lubricant properties (oxidation stability, EP properties, *viscosity-temperature behaviour,* setting point, flow property, etc.). Additives are also an important factor in calculating the *attainable bearing life.*

Ageing

is the undesirable chemical alteration of mineral and synthetic products (e.g. lubricants, fuels) during their application and storage; triggered by reactions with oxygen (development of peroxides, hydrocarbon radicals); heat, light as well as catalytic influences of metals and other contaminants accelerate oxidation. Formation of acids and sludge. Agents inhibiting deterioration (anti-oxidants) retard the deterioration process.

Arcanol (FAG rolling bearing greases)

FAG rolling bearing greases Arcanol are field-proven *lubricating greases* whose application ranges were determined with bearings of all types under diverse operating conditions. A selection of the main Arcanol rolling bearing greases is shown in the table on page 18. It also contains directions for use.

Base oil

is the oil contained in a *lubricating grease.* The amount of oil varies with the type of *thickener* and the grease application. The penetration number (see *Consistency*) and the frictional behaviour of the grease vary with the amount of base oil and its *viscosity.*

Consistency

A measure of the resistance of a *lubricating grease* to being deformed. The so-called worked penetration at 25 °C is indicated for the greases available on the market. There are several penetration classes (NLGI classes).

Dry lubricants

Substances, such as graphite and molybdenum disulphide, suspended in *lubricating oils* and *greases* or applied directly.

EP additives

Additives which reduce *wear* in *lubricating oils* and *lubricating greases,* also referred to as extreme pressure additives.

Arcanol rolling bearing greases · Chemo-physical data and directions for use

Arcanol	Thickener Base oil	Base oil viscosity at 40 °C mm^2/s	Consistency NLGI-class DIN 51818	Temperature range °C	Colour RAL	Main characteristics Typical applications
L12V	Polyurea Mineral oil	115	2	–30...+160	2002 vermillion	Special greease for high temperatures Couplings, electric machines (motors, generators)
L71V	Lithium soap Mineral oil	ISO VG 100	3	–30...+140	4008 signal violet	Standard grease for bearings with O.D.s > 62 mm Large electric motors, wheel bearings for motor vehicles, ventilators
L74V	Special soap Synthetic oil	ISO VG 22	2	–40...+120	6018 yellow green	Special grease for high speeds and low temperatures Machine tools, spindle bearings, instruments
L78V	Lithium soap Mineral oil	ISO VG 100	2	–30...+130	1018 zinc yellow	Standard grease for bearings with O.D.s ≤ 62 mm Small electric motors, agricultural and construction machinery, household appliances
L79V	Synthetic Synthetic oil	390	2	–30...+270	1024 yellow ochre	Special grease for extremely high temperatures and chemically aggressive environment Track rollers in bakery machines, piston pins in compressors, kiln trucks, chemical plants
L135V	Lithium soap with EP additives Mineral oil	85	2	–40...+150	2000 yellow-orange	Special grease for high loads, high speeds, high temperatures Rolling mills, construction machinery, motor vehicles, rail vehicles, spinning and grinding spindles
L186V	Lithium soap with EP additives Mineral oil	ISO VG 460	2	–20...+140	7005 mouse-grey	Special grease for extremely high loads, medium speeds, medium temperatures Heavily stressed mining machinery, construction machinery, machines with oscillating movements
L223V	Lithium soap with EP additives Mineral oil	ISO VG 1000	2	–10...+140	5005 signal blue	Special grease for extremely high loads, low speeds Heavily stressed mining machinery, construction machinery, particularly for impact loads and large bearings

Lubrication

Important rolling bearing lubrication terms

Grease life

The grease life F_{10} is the period from start-up of a bearing until its failure due to lubrication breakdown. The grease life depends on the

– amount of grease,
– grease type (*thickener, base oil, additives*),
– bearing type and size,
– type and amount of loading,
– *speed index,*
– bearing temperature.

Lithium soap base greases

have definite performance merits in terms of water resistance and width of temperature range. Frequently, they incorporate oxidation inhibitors, corrosion inhibitors and *EP* additives. Due to their favourable properties, lithium soap base greases are widely used as rolling bearing greases. Standard lithium soap base greases can be used at temperatures ranging from –35 °C to +130 °C.

Lubricating conditions

The following lubricating conditions exist in a rolling bearing (see illustration on page 20):

– **Full fluid film lubrication:** The surfaces of the components in relative motion are separated by a lubricant film. For continuous operation this type of lubrication, which is also referred to as fluid lubrication, should always be aimed at.

– **Mixed lubrication:** Where the lubricant film gets too thin, local metal-to-metal contact occurs, resulting in mixed friction.

– **Boundary lubrication:** If the lubricant contains suitable additives, reactions between the additives and the metal surfaces are triggered at the high pressures and temperatures in the contact areas. The resulting reaction products have a lubricating effect and form a thin boundary layer.

Lubricating greases

Greases are consistent mixtures of *thickeners* and *base oils.* The following grease types are distinguished:

– Metal soap base greases consisting of metal soaps as *thickeners* and *lubricating oils,*
– Non-soap greases comprising inorganic gelling agents or organic *thickeners* and *lubricating oils,*
– Synthetic greases consisting of organic or inorganic *thickeners* and *synthetic oils.*

Lubricating oils

Rolling bearings can be lubricated either with *mineral oils* or *synthetic oils.* Today, mineral oils are most frequently used.

Lubrication interval

The lubrication interval corresponds to the minimum *grease life* F_{10} of standard greases in accordance with DIN 51 825, see lubrication interval curve in the FAG publication No. WL 81 115. This value is assumed if the *grease life* F_{10} of the grease used is not known.
Influences which reduce the lubrication interval are taken into account by reduction factors.

Mineral oils

Crude oils and/or their liquid derivates. Mineral oils used to lubricate rolling bearings must at least meet the requirements defined in DIN 51501.
Cp. also *Synthetic lubricants.*

Operating viscosity ν

Kinematic *viscosity* of an oil at operating temperature. Cp. also *Viscosity ratio* κ and *Attainable life.*

Rated viscosity ν_1

The rated viscosity is the kinematic *viscosity* attributed to a defined lubrication condition. Cp. also *Viscosity ratio* κ and *Attainable life.*

Relubrication interval

Period after which lubricant is replenished. The relubrication interval should be shorter than the lubricant *renewal* interval.

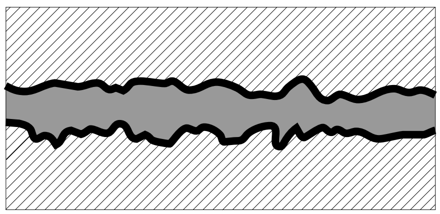
Speed index $n \cdot d_m$

Product from the operating speed n [min^{-1}] and the mean bearing diameter d_m [mm]
$d_m = (D + d)/2$
D = bearing outside diameter [mm], d = bearing bore [mm]
The speed index is predominantly used when selecting suitable lubrication modes and lubricants.

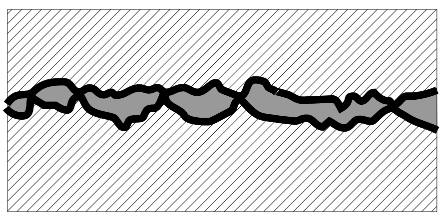
Synthetic lubricants/synthetic oils

Lubricating oils produced by chemical synthesis; their properties can be adapted to meet special requirements: very low setting point, good *V-T behaviour,* small evaporation losses, long life, high oxidation stability.

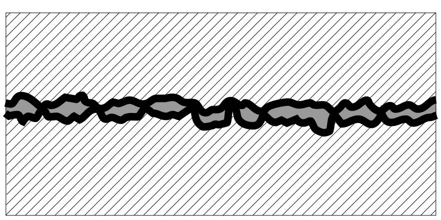
1: The different lubricating conditions



a) Full fluid film lubrication
The surfaces are completely separated by a load carrying oil film



b) Mixed lubrication
Both the load carrying oil film and the boundary layer play a major role



c) Boundary lubrication
The lubrication effect mainly depends on the lubricating properties of the boundary layer

■ Boundary layer ■ Lubricant layer

Thickener

Thickener and *base oil* are the constituents of *lubricating greases*. The most commonly used thickeners are metal soaps and compounds, e.g. of the polyurea type.

Viscosity

Physically, viscosity is the resistance which contiguous fluid strata oppose to mutual displacement. Distinction is made between the **dynamic viscosity** η and the **kinematic viscosity** ν. The dynamic viscosity is the product of the kinematic viscosity and the density of a fluid (density *of mineral oils:* 0.9 g/cm^3 at 15 °C).

SI Units (internationally agreed coherent system of units)
– for the dynamic viscosity: Pa s or mPa s.
– for the kinematic viscosity m^2/s and mm^2/s.

The viscosity of *lubricating oils* determines the load carrying capacity of the oil film in the bearing under elastohydrodynamic lubricating conditions. It decreases with climbing temperatures and increases with falling temperatures (see *V-T behaviour*).

For this reason the temperature to which any viscosity value applies must always be indicated. The **nominal viscosity** is the kinematic viscosity at 40 °C.

Viscosity classification

The standards ISO 3448 and DIN 51 519 specify 18 viscosity classes ranging from 2 to 1500 mm^2/s at 40 °C for industrial liquid lubricants (see table).

Viscosity ratio $\varkappa$

The viscosity ratio, being the quotient of the *operating viscosity* ν and the *rated viscosity* ν_1, is a measure of the lubricating film development in the bearing, cp. *factor* a_{23}.

Viscosity-temperature behaviour (V-T behaviour)

The term V-T behaviour refers to the viscosity variations in *lubricating oils* with temperatures. The V-T behaviour is good if the *viscosity* varies little with changing temperatures.

Seals

The seal should, on the one hand, prevent the *lubricating grease* or *oil* from escaping from the bearing and, on the other hand, prevent contaminants from entering the bearing. The effectiveness of a seal has a considerable influence on the *service life* of a bearing arrangement.

Non-rubbing seals

The only friction arising with non-rubbing seals is the lubricant friction in the lubricating gap. These seals can function for a long time and are suitable even for very high speeds.

Outside the bearing, gap-type seals or labyrinth seals may, for instance, be used.

Space-saving sealing elements are dust shields mounted in the bearing. Bearings with dust shields are supplied with a grease filling.

Rubbing seals

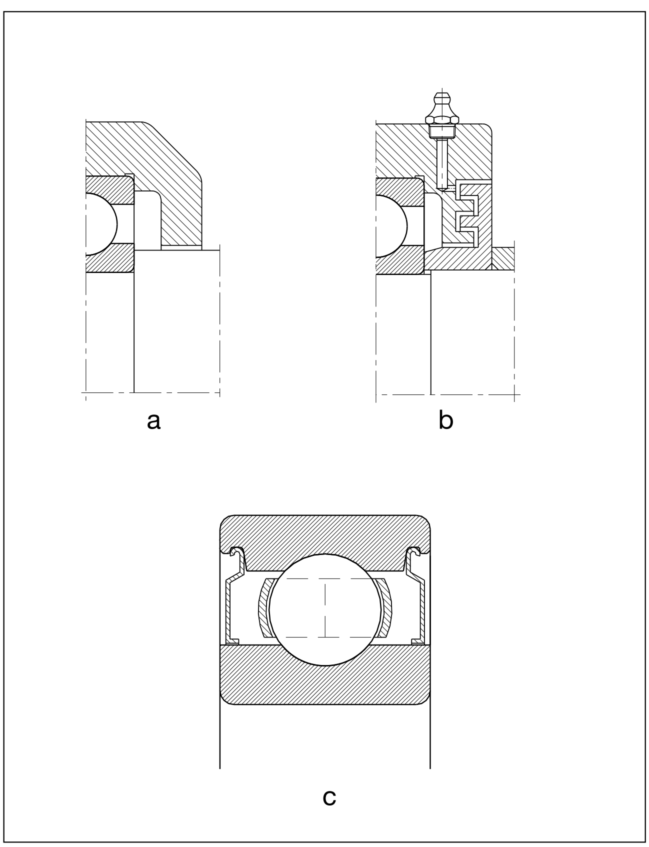
Rubbing seals contact their metallic running surfaces under a certain force. The intensity of the resulting friction depends on the magnitude of this force, the lubricating condition and the roughness of the running surface, as well as on the sliding velocity.

Felt rings prove particularly successful with grease lubrication. Radial shaft seals are above all used at oil lubrication.

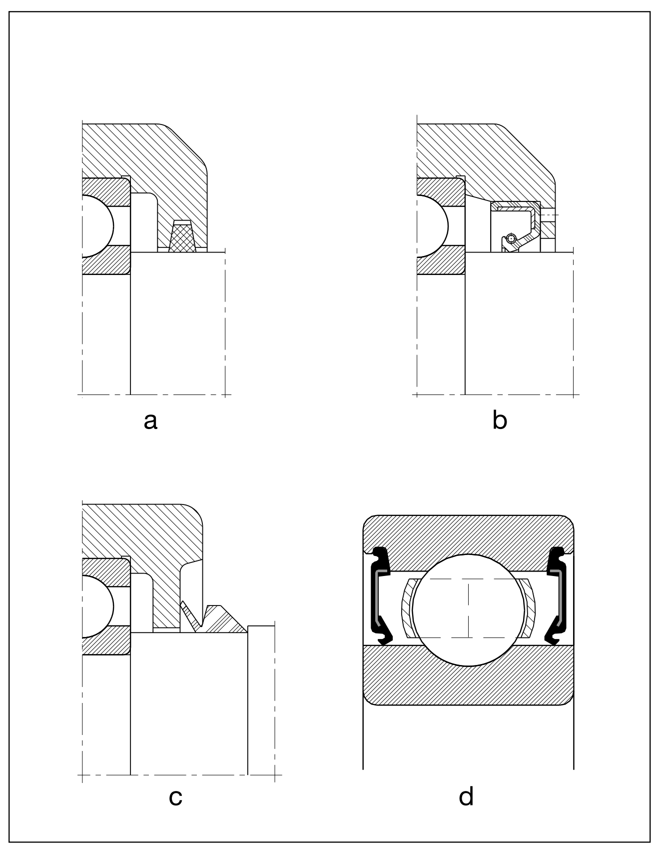
V-rings are lip seals with axial effect which are frequently used as preseals in order to keep dirt away from a radial shaft seal.

Bearings with integrated sealing washers allow the construction of plain designs. FAG offer maintenance-free bearings with two sealing washers and a grease filling.

Non-rubbing seals (examples)
a = gap-type seal, b = labyrinth seal, c = bearing with dust shields



Rubbing seals (examples)
a = felt seal , b = radial shaft seal, c = V-ring, d = bearing with sealing washers



Speed suitability

Generally, the maximum attainable speed of rolling bearings is dictated by the permissible operating temperatures. This limiting criterion takes into account the *thermal reference speed.*

The *kinematically permissible speed* may be higher or lower than the *thermal reference speed.* It is indicated in the FAG catalogues also for bearings for which – according to DIN 732 – no *thermal reference speed* is defined. The *kinematically permissible speed* may only be exceeded on consultation with FAG.
In the catalogue WL 41 520 EA "FAG Rolling Bearings" a reference is made to a method based on DIN 732, Part 2, for determining the *thermally permissible operating speed* on the basis of the *thermal reference speed* for cases where the operating conditions (load, oil viscosity or permissible temperature) deviate from the reference conditions.

Kinematically permissible speed

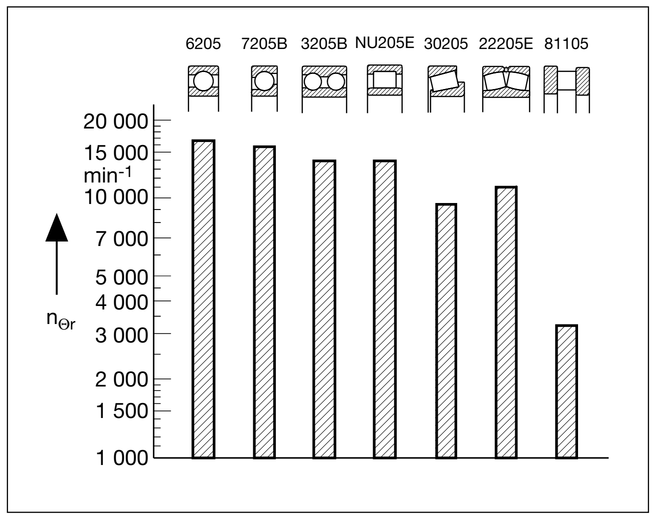
Decisive criteria for the kinematically permissible speed are e.g. the strength limit of the bearing parts or the permissible sliding velocity of rubbing *seals.* Kinematically permissible speeds which are higher than the thermal reference speeds can be reached, for example, with

– specially designed lubrication
– bearing clearance adapted to the operating conditions
– accurate machining of the bearing seats
– special regard to heat dissipation

Thermal reference speed

The thermal reference speed is a new index of the *speed suitability* of rolling bearings. It is defined in the draft of DIN 732, Part 1, as the speed at which the reference temperature of 70 °C is established. In the FAG catalogue WL 41 520 the standardized reference conditions are indicated which are similar to the normal operating conditions of the current rolling bearings (exceptions are, for example, spindle bearings, four point bearings, barrel roller bearings, thrust ball bearings). Contrary to the past (limiting speeds), the thermal reference speed values indicated in the catalogue now apply equally to oil lubrication and grease lubrication.

Thermal reference speeds $n_{\theta r}$ of various bearing types with a bore of d = 25 mm



Thermally permissible operating speed

For applications where the loads, the oil *viscosity* or the permissible temperature deviate from the reference conditions for the *thermal reference speed* the thermally permissible operating speed can be determined by means of diagrams. The method is described in the FAG catalogue WL 41 520.

High temperature suitability
(over +150 °C)

The rolling bearing steel used for *bearing rings* and *rolling elements* is generally heat-treated so that it can be used at operating temperatures of up to +150 °C. At higher temperatures, dimensional changes and hardness reductions result. Therefore, operating temperatures over +150 °C require special heat treatment. Such bearings are identified by the suffixes S1...S4 (DIN 623).

Suffix	without	S1	S2	S3	S4
Maximum operating temperature	150 °C	200 °C	250 °C	300 °C	350 °C

Bearings with an outside diameter of more than 240 mm are generally dimensionally stable up to 200 °C. Bearings of normal design which are heat-treated in accordance with S1 have no heat-treatment suffix. Details of the heat treatment process are provided in the catalogue.

For all applications involving operating temperatures over +100 °C, the limiting temperatures of the other bearing components have to be observed, e.g.:

- *cages* of glass fibre reinforced polyamide PA66 +120 °C (+100 °C)
- *cages* of textile laminated phenolic resin +100 °C
- common sealing washers of synthetic caoutchouc NBR +110 °C
- common *lithium soap base greases* approx. +130 °C
  When using these greases, one should remember that, at constant temperatures of +70°C and higher, any increase in temperature reduces the *grease life.* This has also to be taken into account with those double seal bearings which were filled with such greases by the manufacturer.

Where higher temperatures have to be accommodated metal *cages,* heat-resistant *sealings* and special greases are used.

The temperature limit of application for rolling bearings made of standard steels is approx. +300 °C. Where even higher temperatures have to be accommodated, the hardness of these steels would be so heavily reduced that high-temperature materials must be used.

If high-temperature synthetic materials are used it has to be taken into account that the very efficient fluorinated materials, when heated above +300 °C, can release gases and vapours which are detrimental to health. This has to be remembered especially if bearing parts are dismounted with a welding torch. FAG uses fluorinated materials for *seals* made of fluorocaoutchouc (FKM, FPM, e.g. Viton®) or for fluorinated greases, e.g. *Arcanol* L79V, an FAG rolling bearing grease. Where high temperatures cannot be avoided, the safety data sheet for the fluorinated material in question should be observed. The data sheet is available on request.

Examples of operating temperatures:

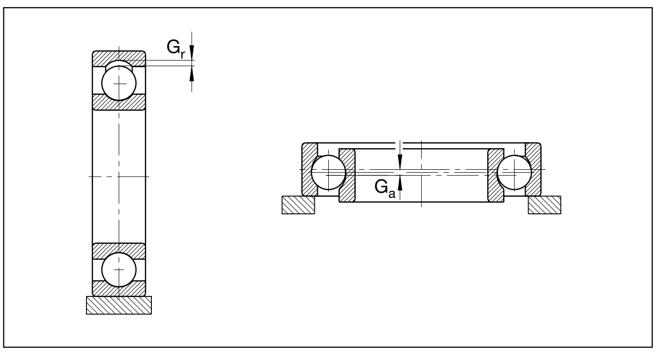
Bench drill	+40 °C	Vibration motor	+70 °C
Mandrel	+50 °C	Vibrating screen	+80 °C
Jaw crusher	+60 °C	Vibratory roller	+90 °C

Examples of bearings which are used at higher temperatures:

Bearings for sand-lime brick autoclave trucks, Publ. No. WL 07 137 EA

Bearing clearance

The bearing clearance is the distance by which one *bearing ring* can be freely displaced in relation to the other one. With axial clearance the bearing is displaced along its axis, with radial clearance vertically to the bearing axis.



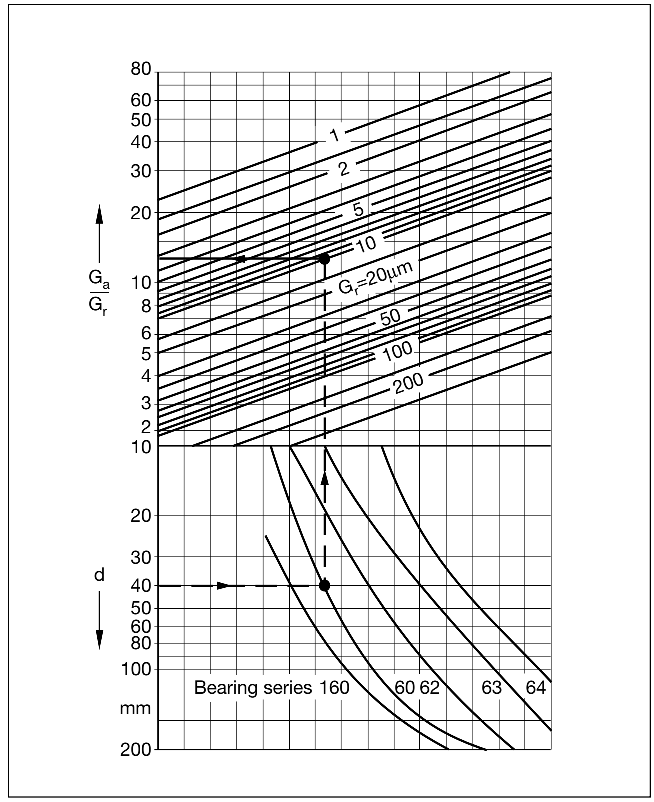
G_r radial bearing clearance
G_a axial bearing clearance

Depending on the bearing type, either the radial or the axial bearing clearance is decisive. It is standardized in DIN 620 for most bearing types and sizes and classified in bearing clearance groups designated C1...C4.

Clearance group Suffix	Bearing clearance
C1	smaller than C2
C2	smaller than normal
–	normal
C3	larger than normal
C4	larger than C3

The suffix identifying the clearance group is added to the bearing code; no suffix is used for the clearance group "normal" (CN).

Relation between radial and axial clearances with deep groove ball bearings



d = bearing bore [mm]
G_r = radial bearing clearnace [µm]
G_a = axial bearing clearance [µm]

Example:
Deep groove ball bearing 6008.C3 with d = 40 mm
Radial clearance before mounting: 15...33 µm
Actual radial clearance: G_r = 24 µm

Mounting tolerances: Shaft k5
Housing J6

Radial clearance reduction during mounting: 14 µm
Radial clearance after mounting: 24 µm – 14 µm = 10 µm

According to this diagram, $\frac{G_a}{G_r} = 13$

Axial clearance: $G_a = 13 \cdot 10$ µm = 130 µm

Bearing clearance

Relation between radial and axial clearance with other bearing types

Bearing type	G_a/G_r
Self-aligning ball bearings	$2.3 \cdot Y_0$ *)
Spherical roller bearings	$2.3 \cdot Y_0$ *)
Tapered roller bearings, single row Tapered roller bearings, arranged in pairs (N11CA)	$4.6 \cdot Y_0$ *) $2.3 \cdot Y_0$ *)
Angular contact ball bearings, double row series 32 and 33 series 32B and 33B	 1.4 2
Angular contact ball bearings, single row series 72B and 73B and arranged in pairs	 1.2
Four-point bearings	1.4

*) Y_0 value from catalogue

The clearance of the installed bearing at operating temperature (**operating clearance**) should be as small as possible for accurate guidance of the shaft but the bearing should nevertheless be able to rotate easily. It should be remembered that during mounting the original bearing clearance usually decreases:

– when the inner ring is expanded or the outer ring is compressed due to a tight *fit* of the bearing;
– when the inner ring expands even more due to the operating temperature, which is often the case.

Both of these have to be taken into consideration by selecting the right bearing clearance. The classification into clearance groups (C) allows the determination of the required bearing clearance for the wide range of fits and operating conditions.

The normal bearing clearance (CN) is calculated to ensure that, in the medium diameter range, with normal fits and normal operating conditions (max. temperature difference between inner and outer ring 10 K), the mounted bearings have the right clearance. The following fits are considered normal:

	Shaft	Housing
Ball bearings	j5 to k5	H7 to J7
Roller bearings and needle roller bearings	k5 to m5	H7 to M7

However, the respective operating conditions are ultimately decisive for the selection of the fit (see section on fits).

A larger-than-normal bearing clearance is selected for tighter fits and/or a great temperature difference between inner ring and outer ring.

Bearing clearance C2 or C1 is used where a very rigid shaft guidance is required, e.g. in machine tools, where bearings often run under preload.

Any bearing clearance not covered by the C-classification is written uncoded, e.g.:

6210.R10.30	= radial clearance 10 to 30 µm
QJ210MPA.A100.150	= axial clearance 100 to 150 µm

Please note: bearing clearance tables differentiate between bearings with a cylindrical bore and those with a tapered bore.

Tolerances

The tolerances of rolling bearings are standardized according to DIN 620 Part 2 (radial bearings) and DIN 620 Part 3 (thrust bearings). The tolerances are laid down for the dimensional and running accuracy of the bearings or bearing rings.

Beginning with PN (normal tolerance), there are **tolerance classes** P6, P6X, P5, P4 and P2 for **precision bearings,** the precision of which is the greater the lower the number. In addition, there are the (non-standardized) FAG tolerance classes SP (Super Precision) and UP (Ultra Precision) for double-row cylindrical roller bearings and P4S for spindle bearings. These bearings are mainly used in machine tools.

The suffix for the tolerance class is always added to the bearing code, with the exception of PN for the normal clearance, which is omitted.

Please remember that bearings in inch dimensions have different tolerance systems (AFBMA tolerances).

Bore diameter

Δ_{dmp} = $d_{mp} - d$
Mean bore diameter deviation from nominal dimension

Δ_{d1mp} = $d_{1mp} - d_1$
Deviation of mean large diameter from nominal dimension (tapered bore)

V_{dp} Bore diameter variation; difference between maximum and minimum bore diameter in a single radial plane

V_{dmp} = $d_{mpmax} - d_{mpmin}$
Mean bore diameter variation; difference between maximum and minimum mean bore diameter

Outside diameter

Δ_{Dmp} = $D_{mp} - D$
Mean O.D. deviation from nominal dimension

V_{Dp} O.D. variation; difference between maximum and minimum O.D. in a single radial plane

V_{Dmp} = $D_{mpmax} - D_{mpmin}$
Mean O.D. variation; difference between maximum and minimum mean O.D.

Width and height

Δ_{Bs} = $B_s - B$, $\Delta_{Cs} = C_s - C$
Deviation of a single ring width (inner or outer ring) from nominal dimension

V_{Bs} = $B_{smax} - B_{smin}$, $V_{Cs} = C_{smax} - C_{smin}$
Variation of inner ring width or outer ring width; difference between maximum and minimum measured ring width

Δ_{Ts} = $T_s - T$, $\Delta_{T1s} = T_{1s} - T_1$, $\Delta_{T2s} = T_{2s} - T_2$
Deviation of a single overall tapered roller bearing height from nominal dimension

*) Δ_{Hs} = $H_s - H$, $\Delta_{H1s} = H_{1s} - H_1$, $\Delta_{H2s} = H_{2s} - H_2$, ...
Deviation of a single overall thrust bearing height from nominal dimension

Running accuracy

K_{ia} Radial runout of inner ring of assembled bearing

K_{ea} Radial runout of outer ring of assembled bearing

S_i Washer raceway to back face thickness variation (thrust bearing shaft washer)

S_e Washer raceway to back face thickness variation (thrust bearing housing washer)

*) In the standard, the overall height of thrust bearings is designated T.

Alignment

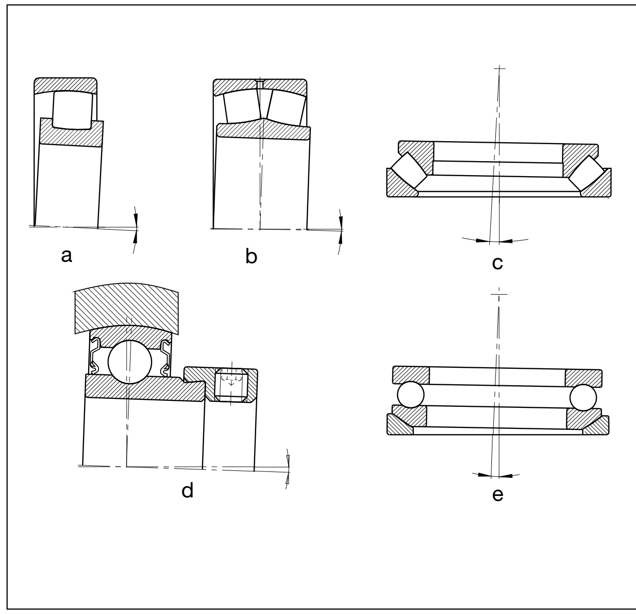
The machining of the bearing seats on a shaft or in a housing can lead to misalignment, particularly when the seats are not machined in one setting. Misalignment can also be expected to occur where single housings such as flanged housings or plummer block housings are used. Tilting of bearing rings relative to each other as a result of shaft inflections brought about by operating loads has similar effects.

Self-aligning bearings – self-aligning ball bearings, barrel roller bearings, radial spherical roller bearings and spherical roller thrust bearings – compensate for misalignment and tilting during operation. These bearings have a spherical outer ring raceway, which enables the inner ring and the rolling element set to make angular motions. The angle of alignment of these bearings depends on the bearing type and size as well as on the load.

S-type bearings and thrust ball bearings with a seating ring have a spherical support surface; during mounting they can align themselves on the spherical mating surface.

The bearing types not listed above have only a very limited self-aligning capability, some in fact have none at all.

Self-aligning rolling bearings:
Barrel roller bearings (a), spherical roller bearings (b), spherical roller thrust bearings (c); S-type bearings (d) and thrust ball bearings with a seating ring (e) have a spherical support surface.



Fits

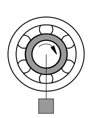
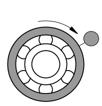
The fit of a rolling bearing determines how tightly or loosely the bearing sits on the shaft and in the housing.

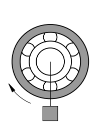
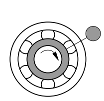
As a rule, both *bearing rings* should be tightly fitted for the following reasons:
– easiest and safest means of ring retention in circumferential direction
– complete support of the rings over their entire circumference; in this way full utilization of the bearing's load carrying capacity is possible.

On the other hand, a loose fit is often necessary in practice:
– it facilitates mounting of non-*separable* bearings
– it permits displacement of non-*separable* bearings in longitudinal direction as *floating bearings.*

Based on a compromise of the above requirements, the following rule applies:
– a tight fit is necessary for the ring with **circumferential load,**
– a loose fit is permitted for the ring with **point load.**

The different load and motion conditions are shown in the following diagram.

Bearing kinematics	Example	Illustration	Loading conditions	Fits
Rotating inner ring Stationary outer ring Constant load direction	Weight suspended by shaft	 Weight	Circumfer-ential load on inner ring	Inner ring: tight fit mandotory
			and	
Stationary inner ring Rotating outer ring Direction of load rotating with outer ring	Hub bearing mounting with large imbalance	 Imbalance	Point load on outer ring	Outer ring: loose fit permissible

Bearing kinematics	Example	Illustration	Loading conditions	Fits
Stationary inner ring Rotating outer ring Constant load direction	Automotive front wheel Track roller (hub bearing mounting)	 Weight	Point load on inner ring	Inner ring: loose fit permissible
			and	
Rotating inner ring Stationary outer ring Direction of load rotating with inner ring	Centrifuge Vibrating screen	 Imbalance	Circumfer-ential load on outer ring	Outer ring: tight fit mandotory

When selecting the fit, the following should also be taken into account:
– The greater the load, the tighter the fit should be, particularly where shock-type loads are expected.
– Possible varying heat expansion of bearing rings and mating parts.
– The radial clearance is reduced by tight fits, and a correspondingly higher clearance group must therefore be selected.

Principle fits for rolling bearings

The type of fit is described by the terms interference fit (tight fit), transition fit and sliding fit (loose fit). These seats or fits are the result of the combined effects of the bearing tolerances for the bore (Δ_{dmp}), for the outside diameter (Δ_{dmp}), and the ISO tolerances for shaft and housing.

The ISO tolerances are classified in the form of tolerance zones. They are determined by their position relative to the zero line (= tolerance position) and by their size (= tolerance quality). The tolerance position is indicated by letters (capital letters for housings, small letters for shafts) and the tolerance quality by numbers.

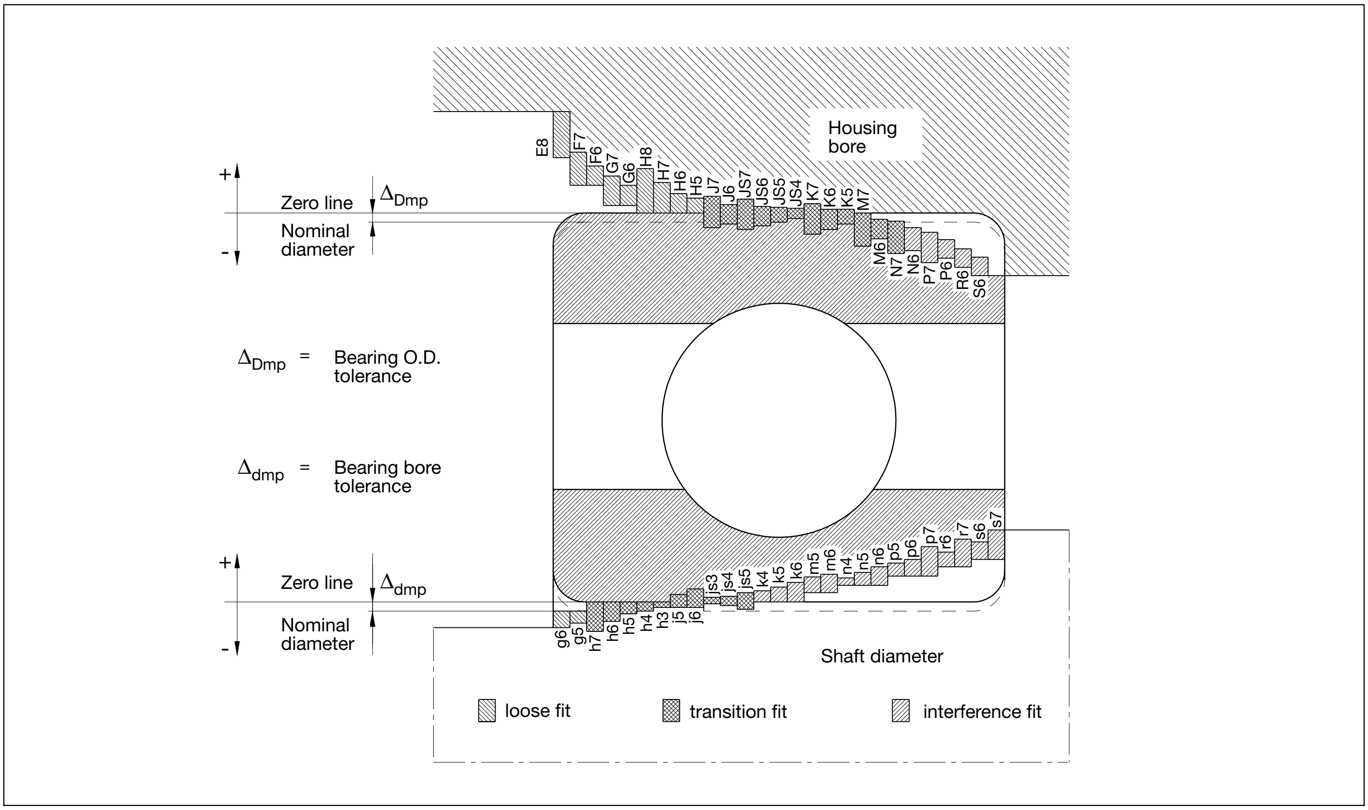
The bearing tolerance tables and the tables for shaft and housing tolerances as well as recommendations for fits under certain mounting conditions are contained in the catalogue WL 41 520EA "FAG Rolling Bearings".

Mounting and dismounting of rolling bearings

The fits of the *bearing rings,* the bearing type and the bearing size have considerable influence on how (mechanical, thermal or hydraulic method), and in which order, the rings are mounted and dismounted. Detailed information on the mounting of rolling bearings is given in FAG Publ. No. WL 80 100EA.

Fits · Bearing arrangement
Locating bearing/floating bearing arrangement

Principle fits for rolling bearings



Bearing arrangement

In order to guide and support a rotating shaft, at least two bearings are required which are arranged at a certain distance from each other. Depending on the application, a bearing arrangement with locating and floating bearings, with adjusted bearings or with floating bearings can be selected.

Locating-floating bearing arrangement

Due to machining tolerances the centre distances between the shaft seats and the housing seats are often not exactly the same with a shaft which is supported by two *radial bearings.* Warming-up during operation also causes the distances to change. These differences in distance are compensated for in the **floating bearing.** Cylindrical roller bearings of N and NU designs are ideal floating bearings. These bearings allow the roller and cage assembly to shift on the raceway of the lipless *bearing ring.* Both rings can be fitted tightly.

All other bearing types, e.g. deep groove ball bearings and spherical roller bearings, only function as floating bearings when one bearing ring is provided with a loose fit. The ring under *point load* is therefore given a loose fit; this is generally the outer ring.

The **locating bearing,** on the other hand, guides the shaft axially and transmits external axial forces. For shafts with more than two radial bearings, only one bearing is designed as a locating bearing in order to avoid detrimental axial preload.

The bearing to be designed as a locating bearing depends on how high the axial load is and how accurately the shaft must be axially guided.

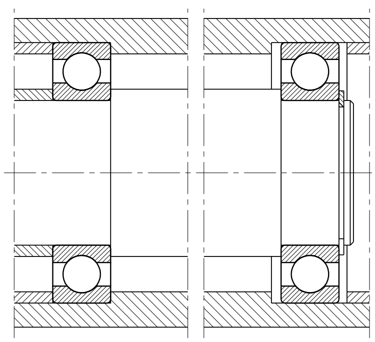
Closer axial guidance is achieved for example with a double row angular contact ball bearing than with a deep groove ball bearing or a spherical roller bearing. A pair of symmetrically arranged angular contact ball bearings or tapered roller bearings provide extremely close axial guidance when designed as locating bearings.

With angular contact ball bearings of universal design, mounted in *X* or *O arrangement,* or matched tapered roller bearings (design N11) neither setting nor adjusting jobs are required.

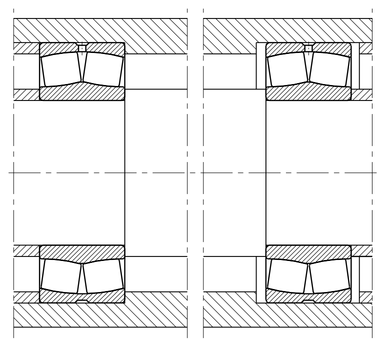
In the case of transmissions, a four-point bearing is sometimes mounted directly next to a cylindrical roller bearing in such a way that a locating bearing results. A four-point bearing whose outer ring is not supported radially can only transfer axial forces. The cylindrical roller bearing takes on the radial load.

Examples of locating-floating bearing arrangements are shown on page 30.

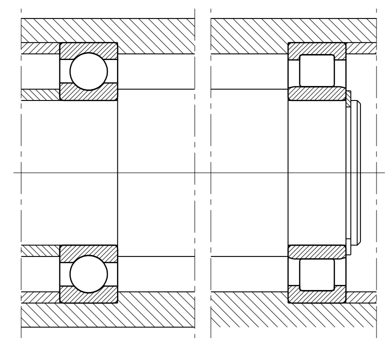
Examples of a locating-floating bearing arrangement



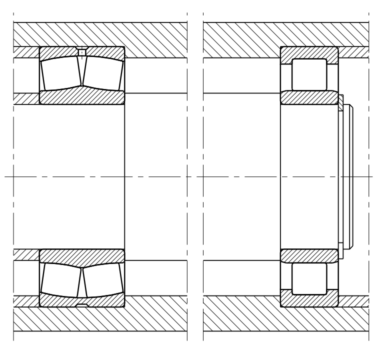
a. Locating bearing: deep groove ball bearing
Floating bearing: deep groove ball bearing



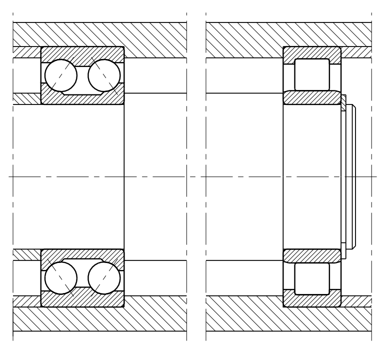
b. Locating bearing: spherical roller bearing
Floating bearing: spherical roller bearing



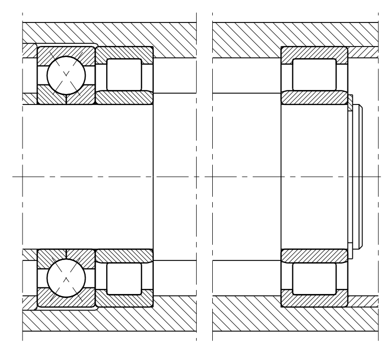
c. Locating bearing: deep groove ball bearing
Floating bearing: cylindrical roller bearing NU



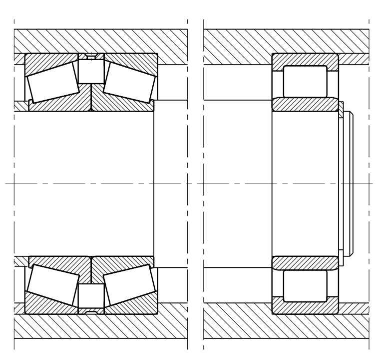
d. Locating bearing: spherical roller bearing
Floating bearing: cylindrical roller bearing NU



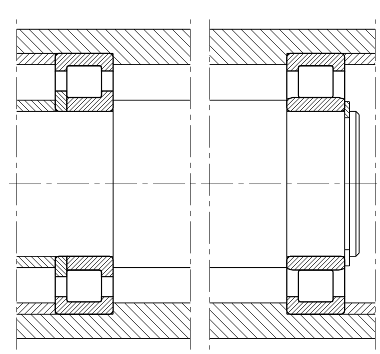
e. Locating bearing: double row angular contact ball bearing
Floating bearing: cylindrical roller bearing NU



f. Locating bearing: four-point bearing and cylindrical roller bearing NU
Floating bearing: cylindrical roller bearing NU



g. Locating bearing: two tapered roller bearings
Floating bearing: cylindrical roller bearing NU



h. Locating bearing: cylindrical roller bearing NUP
Floating bearing: cylindrical roller bearing NU

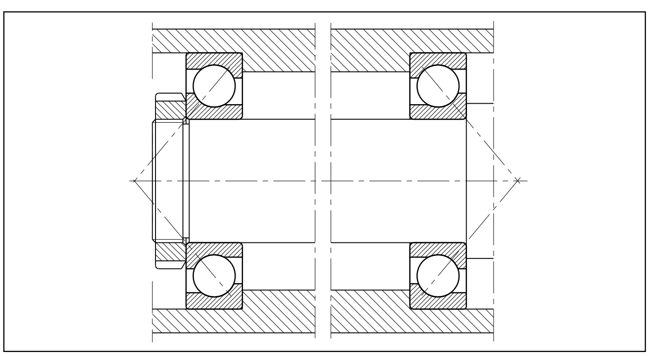
Adjusted bearing arrangement

As a rule, an adjusted bearing arrangement consists of two symmetrically arranged angular contact ball bearings or tapered roller bearings. During mounting, the required *bearing clearance* (see also page 24) or the preload is set.

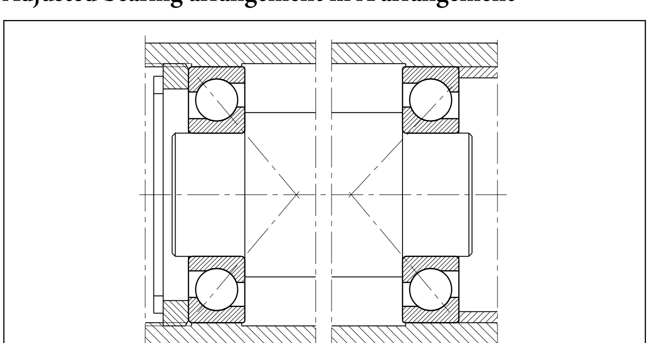
For this purpose, one ring is axially displaced on its seat until the required clearance or preload is achieved (in the case of an *O arrangement,* the inner ring; in the case of an *X arrangement,* the outer ring). This procedure is referred to in rolling bearing engineering as "adjusting" (adjusted bearing arrangement). This means that the adjusted bearing arrangement is particularly suitable for those cases in which close axial guidance is required, for example, for pinion bearing arrangements with spiral toothed bevel gears and spindle bearing arrangements in machine tools.

In the O arrangement, the apexes of the cone formed by the *contact lines* point outward while those of the X arrangement point inward. The **spread,** i.e. the distance between the *pressure cone apexes,* is larger in the O arrangement than in the X arrangement. The O arrangement therefore provides a smaller tilting clearance.

Adjusted bearing arrangement in O arrangement



Adjusted bearing arrangement in X arrangement



Floating bearing arrangement

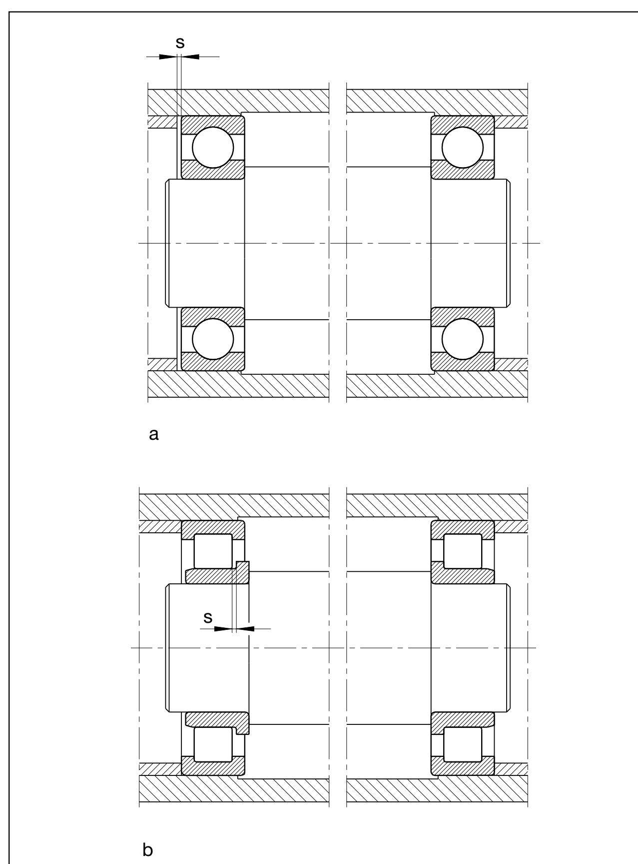
The floating bearing arrangement is an economical solution where close axial guidance of the shaft is not required. Its design is similar to that of the *adjusted bearing arrangement.* In a floating bearing arrangement, the shaft, however, can shift by the axial clearance s relative to the housing. The value s is determined depending on the guiding accuracy in such a way that detrimental axial preloading of the bearings is prevented even under unfavourable thermal conditions.

In floating bearing arrangements with NJ cylindrical roller bearings, length is compensated for in the bearings. Inner and outer rings can be fitted tightly.

Non-*separable radial bearings* such as deep groove ball bearings, self-aligning ball bearings and spherical roller bearings are also suitable for the floating bearing arrangement. One ring of both bearings – generally the outer ring – is *fitted* loosely to allow displacement.

Tapered roller bearings and angular contact ball bearings are not suitable for a floating bearing arrangement because they must be *adjusted* for flawless running.

Examples of a floating bearing arrangement
(s = axial clearance)
a = two deep groove ball bearings
b = two cylindrical roller bearings NJ



Bearing arrangement · Symbols
More bearing arrangement terms

Counter guidance

Angular contact bearings and single direction *thrust bearings* accommodate axial forces only in one direction. A second, symmetrically arranged bearing must be used for "counter guidance", i.e. to accommodate the axial forces in the other direction (cp. also "Adjusted bearing arrangement", page 31).

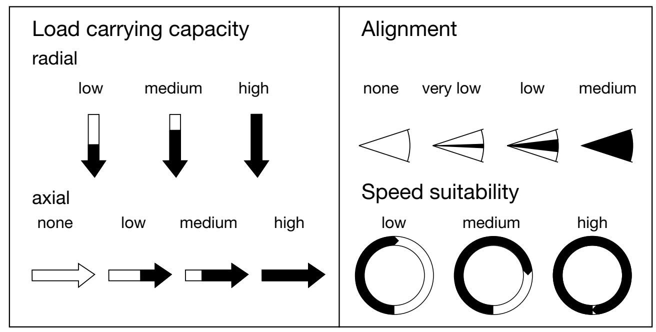
Tandem arrangement

A tandem arrangement consists of two or more *angular contact bearings* which are mounted adjacent to each other facing in the same direction, i.e. asymmetrically. In this way, the axial forces are distributed over all bearings. An even distribution is achieved with *universal-design angular contact bearings* (cp. "Matched Rolling Bearings", page 50).

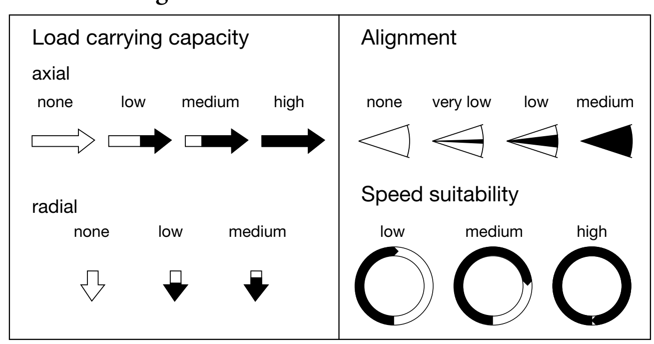
Symbols for load carrying capacity, alignment and speed suitability

The symbols allow a comparison between the different bearing types, but only within the categories "radial bearings" and "thrust bearings". The relative categories apply to bearings with identical bore diameters.

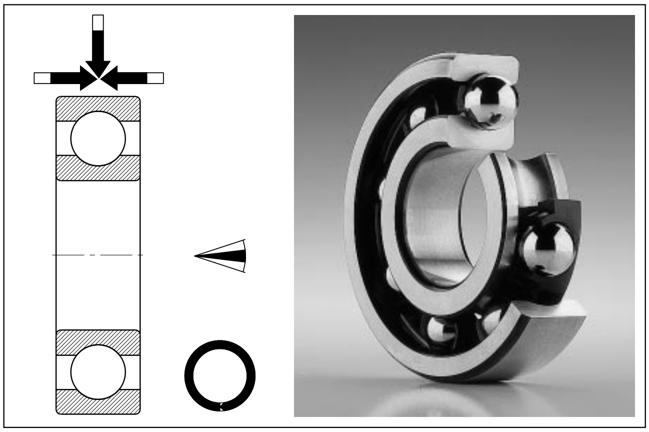
Radial bearings

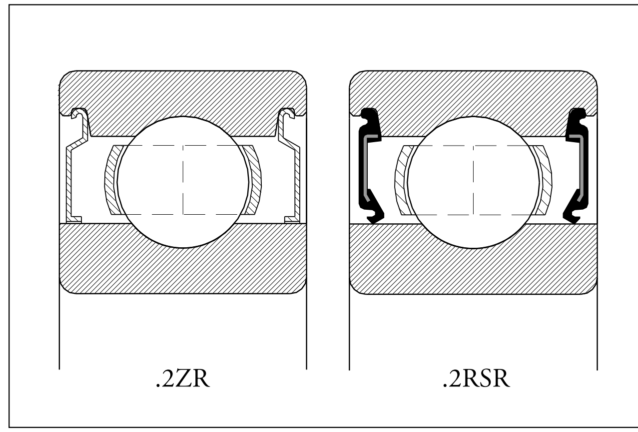


Thrust bearings



Deep groove ball bearings





Single row: series 618, 160, 161, 60, 62, 622, 63, 623, 64
Double row: series 42B, 43B

Single row deep groove ball bearings can accommodate both radial and axial forces and can be used at high speeds. Deep groove ball bearings are not separable. Thanks to their versatility and their competitive price, deep groove ball bearing are the most commonly used bearing type.

Standards

Single row deep groove ball bearings	DIN 625, Part 1
Double row deep groove ball bearings	DIN 625, Part 3
Dimension plan	DIN 616

Tolerances, bearing clearance

Single row deep groove ball bearings of basic design have normal clearance and tolerances. Designs with an increased bearing clearance (suffix C3) or reduced tolerances are also available.

Alignment

Bearing series	Low loads	High loads
	in angular minutes	in angular minutes
62, 622, 63, 623, 64	5...10'	8...16'
618, 160, 60	2...6'	5...10'

Contact angle

Nominal contact angle α_0 = 0°. Under axial load and with enlarged bearing clearance, the contact angle can increase to 20°.

Cages

Deep groove ball bearings without cage suffix are fitted with a pressed steel cage. The cage designs used in all other deep groove ball bearings are indicated in the bearing code.

Load carrying capacity

Radial and axial: good.

Speed suitability

High to very high.

High temperatures

FAG deep groove ball bearings are heat-treated in such a way that they are dimensionally stable up to 150 °C. For application in sand-lime brick autoclave trucks, FAG offers deep groove ball bearings which were specially heat-treated, with an increased radial clearance (see Publ. No. WL 07 137). These bearings are lubricated with dry lubricants.

Sealed deep groove ball bearings

Deep groove ball bearings with ZR shields (non-rubbing sealings, Z shields for miniature bearings) or RSR seals (rubbing seals, RS seals for miniature bearings) make simple designs possible. The bearings can be sealed either on one side or on both sides. In the latter case the bearings are provided with a grease filling during production which, under normal operating conditions, is sufficient for life (for-life lubrication). Quality greases tested in accordance with FAG specification are used. The non-rubbing RSD seal combines the advantages of shields (no friction) with those of seals (efficient sealing). It makes high speeds possible, even with a rotating outer ring.

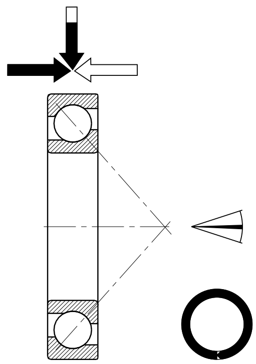
Stainless steel deep groove ball bearings

These bearings are used for applications where the effects of water or aggressive substances have to be accommodated; they are available both with and without seals.
Code:
Prefix S + suffix W203B.
Examples:
S6205.W203B
S6205.2RSR.W203B.

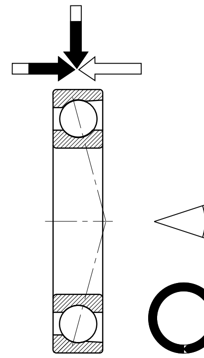
Double row deep groove ball bearings

Where higher loads have to be accommodated, double row deep groove ball bearings are used. The bearings of standard design without a filling slot (series 42B and 43B) have synthetic material cages and are already greased at the manufacturer's plant. Double row deep groove ball bearings have no self-aligning capacity. The basic-design bearings have normal bearing clearance and normal tolerances.

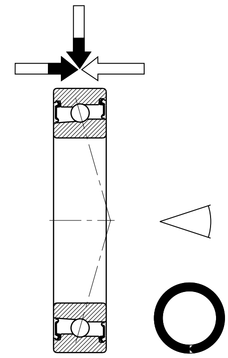
Angular contact ball bearings, single row



72B, 73B



B719, B70, B72



HSS719, HSS70

Angular contact ball bearings:

Series 72B, 73B

Spindle bearings:

Series B719, B70, B72,
HSS719, HSS70,
HCS719, HCS70

Single row angular contact ball bearings can accommodate axial loads in only one direction; usually, they are adjusted against another, symmetrically arranged bearing. Single row angular contact ball bearings are non-separable.

FAG spindle bearings are specially designed single row angular contact ball bearings; they were developed primarily for high-speed work spindles in machine tools. They differ from the normal angular contact ball bearings by their contact angle, accuracy and cage design.

In addition to open B-design spindle bearings, sealed high-speed spindle bearings (HSS) with small steel balls and sealed hybrid spindle bearings (HCS) with ceramic balls are available (cp. Publ. No. AC 41 130).

Standards

Single row angular contact ball bearings DIN 628, Part 1

Universal design

Where angular contact ball bearings with a specific axial clearance are required, bearings of universal design (suffix U) are used. Their bearing faces are machined, in relation to the raceways, in such a way that bearing pairs in X or O arrangement, or in a combination of X or O and tandem arrangement, have a specific axial clearance or preload prior to mounting (see also section on "Matched Rolling Bearings").

The most commonly used universal-design bearings have the following suffixes:

UA small axial clearance (angular contact ball bearings)
UO zero clearance (angular contact ball bearings)
UL light preload (spindle bearings)

With tight fits, the axial clearance is reduced or the preload of the bearing pair increased (fit recommendations for angular contact ball bearings, see catalogue WL 41 520EA, for spindle bearings, see FAG Publ. No. AC 41 130).
When ordering, please state the number of individual bearings, not the number of bearing groups.

Tolerances

Angular contact ball bearings of series 72B and 73B are machined to normal tolerances.
Spindle bearings are only available with narrow tolerances (tolerance class P4S with dimensional and form accuracies of tolerance class P4 and running precision of tolerance class P2).

Contact angle

Angular contact ball bearings of series 72B and 73B have a contact angle of 40°.
Spindle bearings are produced with contact angles of 15° (suffix C) and 25° (suffix E).

Cage

The smaller angular contact ball bearings are fitted with synthetic material cages (TVP), the larger ones with machined brass cages (MP).
The standard cage used in spindle bearings is an outer-ring riding machined cage of textile laminated phenolic (T).

Alignment

Very limited.

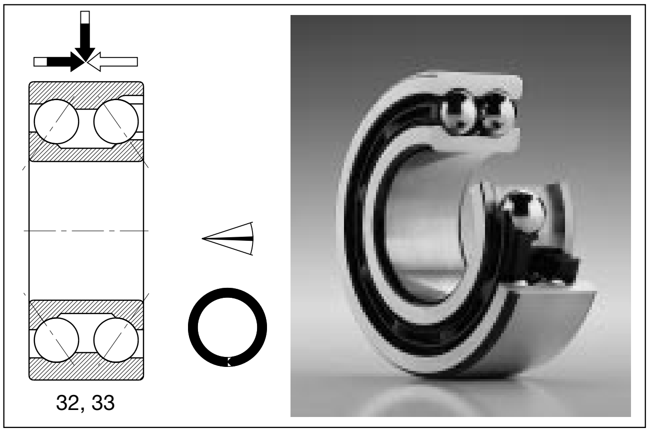
Load carrying capacity

Axial: high; radial: good.

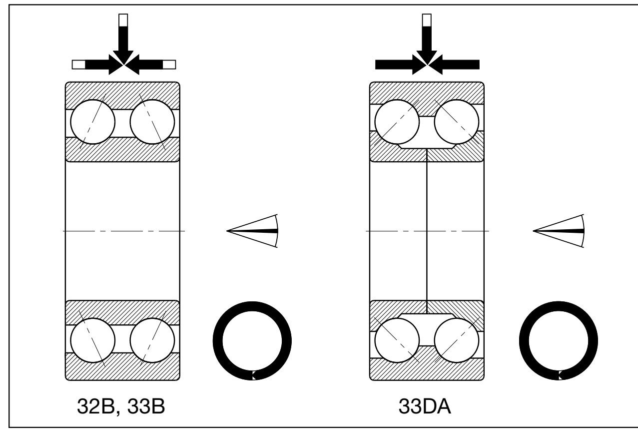
Speed suitability

Angular contact ball bearings: high; spindle bearings: very high.

Angular contact ball bearings, double row



Series 32, 33
Contact angle 35°



Series 32B, 33B
Contact angle 25°

Series 33DA
Contact angle 45°

The structure of a double row angular contact ball bearing corresponds to a pair of single row angular contact ball bearings in O arrangement. The bearing can accommodate high radial loads, and thrust loads in both directions. It is particularly suitable for bearing arrangements requiring a rigid axial guidance.

Double row angular contact ball berings are available in 3 designs:

– with an unsplit inner ring and filling slots on one side (no suffix): series 32, 33
– with a split inner ring, no filling slots (suffix DA): series 33DA
– with an unsplit inner ring, no filling slots, greased (suffix B.TVH): series 32B, 33B

Standards

Double row angular contact ball bearings DIN 628, Part 3

Tolerances, bearing clearance

Basic double row angular contact ball bearings have normal tolerances and normal clearance. Bearings with larger than normal (C3) or smaller than normal (C2) axial clearance are also available.

Double row angular contact ball bearings with a split inner ring, which are designed for higher loads, are usually mounted with a tighter fit than unsplit bearings. Their normal clearance corresponds to the clearance group C3 of unsplit bearings.

The radial clearance for unsplit bearings with filling slots amounts to about 70% of their axial clearance, and for bearings without filling slots to about 50% of their axial clearance. For bearings with a split inner ring, the axial and radial clearances are the same.

Cages

Double row angular contact ball bearings with pressed cages do not have a cage suffix. Bearings with machined brass cages are identified by the suffixes M or MA. Double row angular contact ball bearings with a moulded cage of glass-fibre reinforced polyamide cage are identified by the suffixes TVH or TVP.

Contact angle

The double row angular contact ball bearings without filling slots and an unsplit inner ring have a contact angle of 25°, bearings with filling slots have a contact angle of 35°. The high axial load carrying capacity of bearings with a split inner ring is due to the contact angle of 45°.

Sealed double row angular contact ball bearings

Bearings of series 32B and 33B are also available with ZR shields (non-rubbing seals) and RSR seals (rubbing seals) on both sides. These bearings are filled, at the manufacturer's plant, with a tested high-quality grease.

Alignment

Very limited.

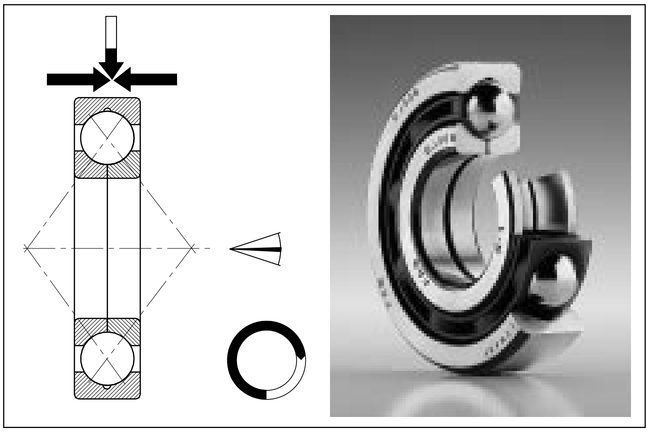
Load carrying capacity

The axial load carrying capacity of bearings with a filling slot is lower on the filling slot side than on the opposite side. Bearings without filling slots can accommodate axial loads of the same magnitude in both directions. Designs with a split inner ring can accommodate particularly high axial loads.

Speed suitability

Not as high as that of single row deep groove ball bearings or single row angular contact ball bearings.

Four-point bearings



Series QJ2, QJ3

Four-point bearings are single row angular contact ball bearings which can accommodate axial loads in both directions and low radial loads.
Four-point bearings feature a split inner ring; this allows a large complement of balls to be filled in. The outer ring with the ball and cage assembly and the inner ring halves can be mounted separately.

Standards

Angular contact ball bearings (four-point bearings) DIN 628, Part 4

Tolerances, bearing clearance, contact angle

Four-point bearings are usually manufactured to normal tolerances and normal clearance. The high load carrying capacity in axial direction is achieved with the large number of balls, the high raceway shoulders and the 35° contact angle.

Cages

Depending on the bearing series and size, four-point bearings have either moulded cages of glass-fibre reinforced polyamide (suffix TVP) or machined brass cages (MPA).

Retaining grooves

Four-point bearings which are mounted as thrust bearings have a loose fit in the housing to avoid radial loading. Large four-point bearings have two grooves (suffix N2) to retain the outer rings.

Alignment

Very limited.

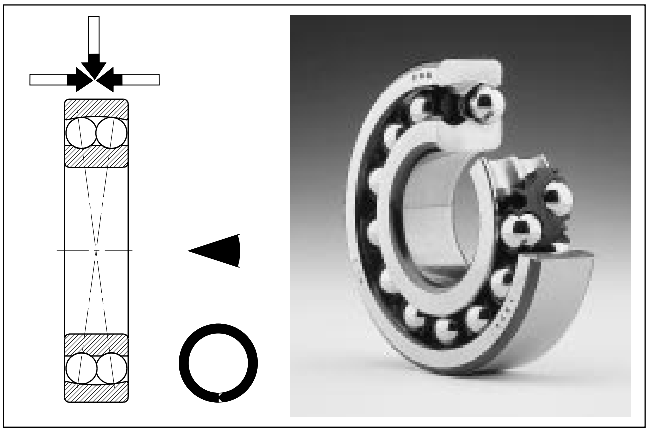
Load carrying capacity

High axial loads in both directions; low radial loads.

Speed suitability

Medium to high (if subjected to purely axial loads, cp. catalogue WL 41 520EA).

Self-aligning ball bearings



Series 12, 13, 22, 23
Series 112, 113 with extended inner ring

Self-aligning ball bearings are of the double row type, with a spherical outer ring raceway. Their self-aligning capability allows them to compensate for misalignments, shaft deflections and housing deformations. Self-aligning ball bearings are not separable.

Standards

Self-aligning ball bearings	DIN 630
Adapter sleeves	DIN 5415

Tolerances, bearing clearance

The self-aligning ball bearings of basic design with a cylindrical bore are machined to normal tolerances and to "normal" clearance. Basic designs with a tapered bore have the larger-than-normal radial clearance C3.

Contact angle

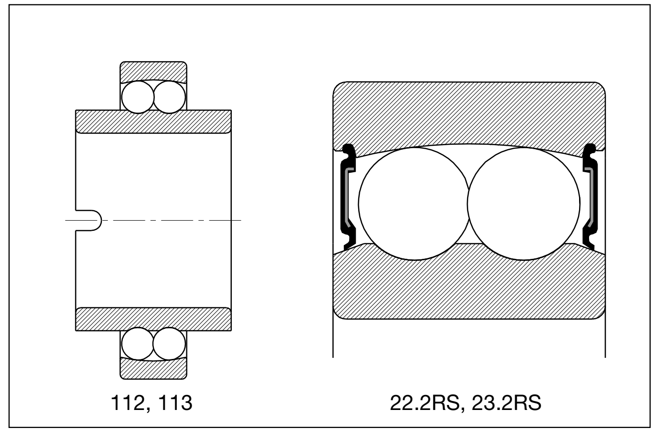
α_0 = 6 ... 20°, depending on the bearing series.

Cages

Small self-aligning ball bearings have a ball riding moulded cage of glass-fibre reinforced polyamide (suffix TV); larger self-aligning ball bearings are fitted with a ball riding machined brass cage (suffix M).

Tapered bore

Self-aligning ball bearings with a bore taper 1:12 (suffix K) can be mounted either directly on a tapered shaft or on a cylindrical shaft using adapter sleeves.



Bearings with an extended inner ring

Self-aligning ball bearings of series 112 and 113 have an extended inner ring. They are located on the shaft by means of dowel pins which engage in a slot on one side of the inner ring. If a shaft is supported by a pair of self-aligning ball bearings the slots must be symmetrically arranged, either on the bearing sides facing each other or on the outboard sides. The bores of series 112 and 113 are machined to J7.

Sealed self-aligning ball bearings

Sealed self-aligning ball bearings have seals (rubbing seals) on both sides (series 22.2RS, 22K.2RS and 23.2RS). These bearings are filled with grease at the manufacturer's plant.

Alignment

Non-sealed self-aligning ball bearings can compensate for a misalignment of approx. 4° out of the centre position; sealed self-aligning ball bearings up to 1.5°.

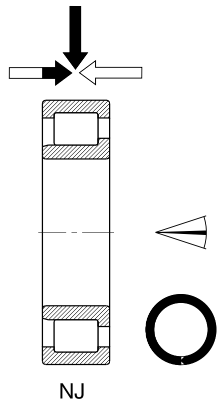
Load carrying capacity

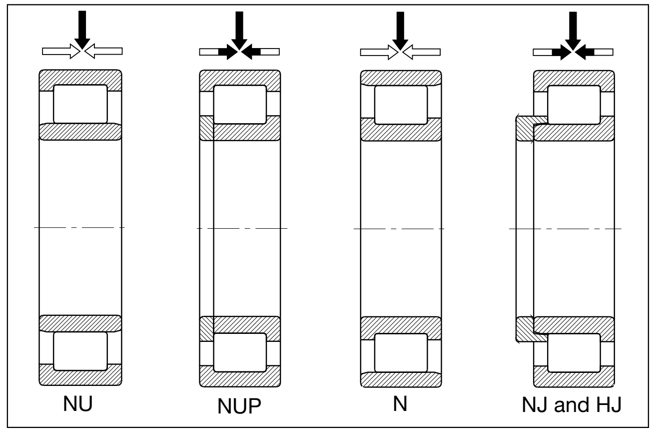
Low radial and axial loads.

Speed suitability

High.

Cylindrical roller bearings, single row and double row





Series
single row: NU19, NU10, NU2, NU22, NU3, NU23, NU4, also with a different lip design
double row: NNU49S(K), NN30ASK

Cylindrical roller bearings are separable. This facilitates mounting and dismounting. Both rings can be given a tight fit.

The various designs of single row cylindrical roller bearings are distinguished by the arrangement of their lips. Design NU has two lips on the outer ring, the inner ring being lipless. The inner ring of design N has two lips, the outer ring has none.
Cylindrical roller bearings of design NU and N are used as floating bearings; they make length compensation within the bearing possible.
Cylindrical roller bearings NJ have two lips on the outer ring and one on the inner ring. They can transmit axial forces in one direction.
Cylindrical roller bearings NUP are installed as locating bearings to accommodate reversing axial forces. They have two lips on the outer ring and one fixed lip and one loose lip on the inner ring. A cylindrical roller bearing NJ with an angle ring HJ also forms a locating bearing.
Maximum capacity single row cylindrical roller bearings (suffix E, for larger bearings also EX) are available as basic designs in series 2E, 22E, 3E and 23E. Their roller set is designed for maximum load carrying capacity.

Double row FAG cylindrical roller bearings of series NN30ASK have a lipless outer ring and three lips on the inner ring. The suffix S identifies a lubricating groove and lubricating holes in the outer ring, K the tapered bearing bore (taper 1:12).
Double row bearings of series NNU49S have three lips on the outer ring, and the inner ring is lipless.
Double row cylindrical roller bearings are floating bearings. With them, arrangements are obtained which are radially rigid, have a high load carrying capacity and are of high precision.

Standards

Single row cylindrical roller bearings	DIN 5412, Part 1
Double row cylindrical roller bearings	DIN 5412, Part 4
Cylindrical roller bearings for electric machines in electric vehicles	DIN 43283
Angle rings	ISO 246 and DIN 5412, Part 1

Tolerances, bearing clearance

Single row FAG cylindrical roller bearings of basic design are available in the tolerance class "normal" and with normal radial clearance. Upon request, designs suffixed C3 (radial clearance larger than normal) and C4 (radial clearance larger than C3) are also available.

Double row cylindrical roller bearings are precision bearings with narrow tolerances according to tolerance class SP (FAG specification). These bearings have the reduced radial clearance C1NA (clearance group C1 according to FAG specification, bearing rings not interchangeable). C1NA is not indicated in the bearing code.

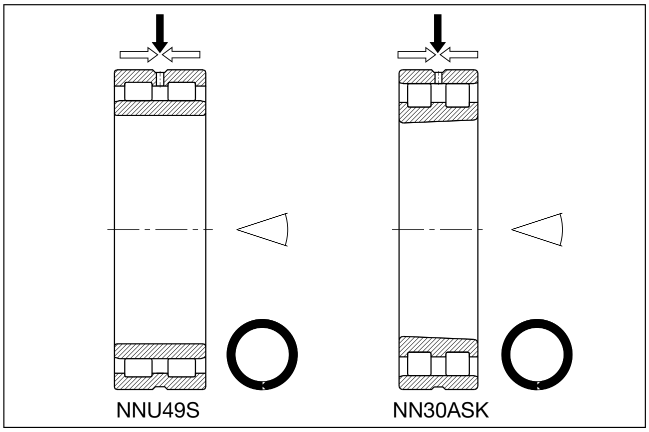
Boundary circle dimensions

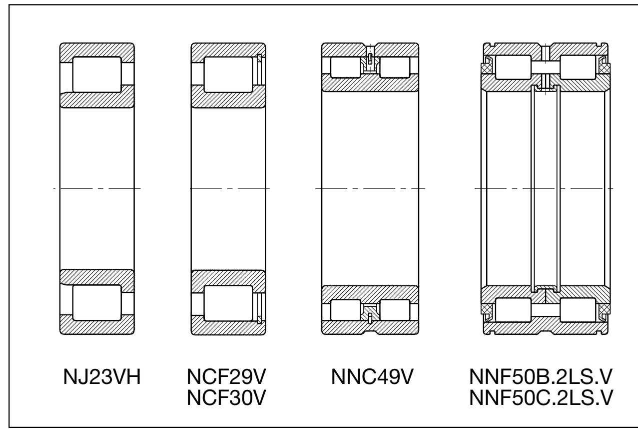
The dimensions F and E are especially important where one adjacent component serves as a raceway instead of the separable ring.

– An NU bearing without inner ring becomes design RNU, whose rollers (dimension F) run directly on the shaft.
– An N bearing without outer ring becomes design RN, whose rollers (dimension E) run directly in the housing bore.

Due to the usually differing boundary circles, components of E design bearings are not interchangeable with those of non-reinforced bearings with the same basic code. This also applies for components of new EX designs and old E designs.

Cylindrical roller bearings, single row and double row · Full complement cylindrical roller bearings





Alignment

The modified line contact between rollers and raceways prevents edge stressing and allows a certain self-aligning capability of the single-row cylindrical roller bearings. With a load ratio of $P/C \leq 0.2$, the angle of alignment must not exceed 4 angular minutes.

P = equivalent dynamic load [kN]
C = dynamic load rating [kN]

For applications where higher loads or greater misalignment have to be accommodated, please consult FAG.

Bearing locations designed for double row cylindrical roller bearings must be free from misalignment.

Cages

Single row cylindrical roller bearings without cage suffix have a pressed steel cage.
The suffixes M and M1 indicate bearings with roller-riding machined brass cages.
Small bearings of series 2E, 22E, 3E and 23E have cages of glass-fibre reinforced polyamide 66 (suffix TVP2).

Load carrying capacity

Very high radial loads. Axial loads can only be accommodated by designs NJ and NUP or if HJ angle rings are used (NJ + HJ).

Speed suitability

High to very high.

Full complement cylindrical roller bearings – series
single row: NCF29V, NCF30V, NJ23VH
double row: NNC49V, NNF50B.2LS.V, NNF50C.2LS.V

Full complement cylindrical roller bearings are suitable for bearing locations where particularly high loads and low speeds have to be accommodated.

Single row full complement bearings can accommodate, in addition to very high radial loads, axial loads in one direction. Bearings of series NCF29V and NCF30V have two lips on the inner ring and are not separable. In the separable bearings of series NJ23VH the roller set is self-retained in the outer ring so that the rollers do not drop out even if the inner ring is removed.

Double row full complement cylindrical roller bearings can accommodate very high radial loads, axial loads in both directions and tilting moments. Bearings of series NNC49V have a lubricating groove and lubricating holes in the outer ring. The grease filling on both sides of sealed bearings NNF50B.2LS.V and NNF50C.2LS.V is sufficient for the entire bearing life.

Alignment

The self-aligning capability of full complement cylindrical roller bearings corresponds to that of caged bearings.

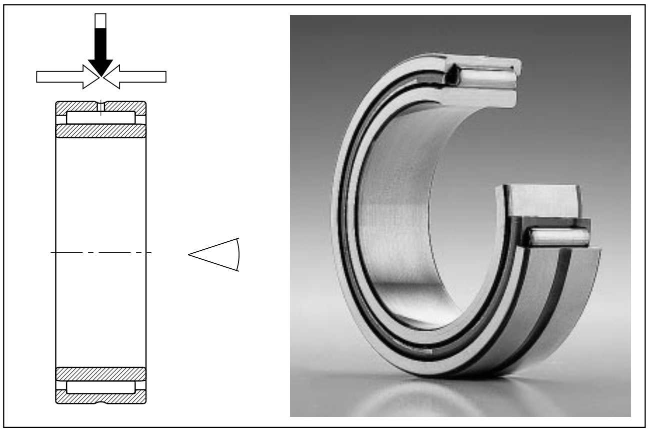
Tolerances, bearing clearance

Full complement cylindrical roller bearings of basic design have the normal clearance of radial bearings. Sealed double row bearings are available with normal radial clearance. Unsealed single row and double row cylindrical roller bearings have the increased bearing clearance C3.

Speed suitability

As the rollers rotate in opposite directions where they are in mutual contact, full complement cylindrical roller bearings have a considerably higher friction than caged bearings. Therefore, they are suitable only for low speeds.

Needle roller bearings



Series NA48, NA48A, NA49

Needle roller bearings are used as floating bearings; they are separable and consist of two bearing rings and a large number of needle rollers which are retained and guided by a cage. The prime feature of needle roller bearings is their high load carrying capacity in spite of a low section height, thus meeting the requirements of lightweight constructions as regards high capacity in a restricted mounting space.

FAG needle roller bearings of series NA48, NA48A and NA49 have two fixed lips on the outer ring. The inner ring is lipless. The lubricating groove and the lubricating hole in the outer ring make the lubrication of FAG needle roller bearings easier.

Standards

Needle roller bearings NA48, NA49   ISO 1206 and DIN 617

Tolerances, bearing clearance

Needle roller bearings of basic design have normal tolerances and normal radial clearance. Needle roller bearings of tolerance class P5, bearings with an increased radial clearance C3 or C4 and with a reduced clearance C2 are available upon request.

The needle roller bearings have the same radial clearance as cylindrical roller bearings.

Contact angle

$\alpha_0 = 0$

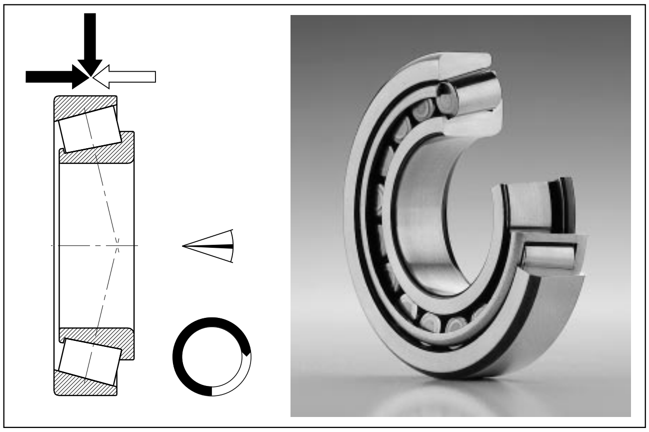
Alignment

None.
Needle roller bearings are very sensitive to misalignment and shaft deflections.

Load carrying capacity

Radial: good; axial: none.

Tapered roller bearings



Series 329, 320, 330, 331, 302, 322, 332, 303, 313, 323

Tapered roller bearings are separable; the cone and the cup can be mounted separately. As tapered roller bearings can accommodate axial loads only in one direction, a second, symmetrically arranged tapered roller bearing is usually needed for counter guidance. In this respect, they can be compared with angular contact ball bearings, but they have a higher load carrying capacity and are less suitable for high speeds.

Standards

Tapered roller bearings in metric dimensions DIN 720 and DIN ISO 355.

Tolerances, bearing clearance

Tapered roller bearings of basic design have a normal tolerance PN. Bearings of series 320X, 329, 330, 331 and 332 with bore diameters of up to 200 mm have the narrow width tolerances of tolerance class P6X (without suffix). Larger bearings of these series and bearings of the other series have width tolerances of tolerance class PN.
On request, tapered roller bearings are also available with an increased precision.
When mounting two symmetrically arranged tapered roller bearings, one bearing ring is displaced along its seat until the bearing arrangement has the required axial clearance or axial preload.

Contact angle

Due to their contact angle (α_0 = 5...28°), tapered roller bearings can accommodate both radial and axial loads. Larger contact angles, and consequently a greater axial load carrying capacity, are featured by bearings of series 323B (as compared to the normal design 323 and 323A) and especially bearings of series 313.

Cages

FAG tapered roller bearings, with the exception of integral tapered roller bearings (page 42), are fitted with pressed steel cages for which no suffix is used. The cages slightly project laterally; this must be taken into account for mounting.

Alignment

The modified line contact between the tapered rollers and the raceways (logarithmic profile) eliminates edge stressing and allows the tapered roller bearings to align. For single row tapered roller bearings with a load ratio of $P/C < 0.2$ a maximum angular alignment of 4 angular minutes is admissible. If higher loads or greater misalignments have to be accommodated, please consult FAG.

P = equivalent dynamic load [kN]
C = dynamic load rating [kN]

Load carrying capacity

Radial: very high loads; axial: high loads in one direction.

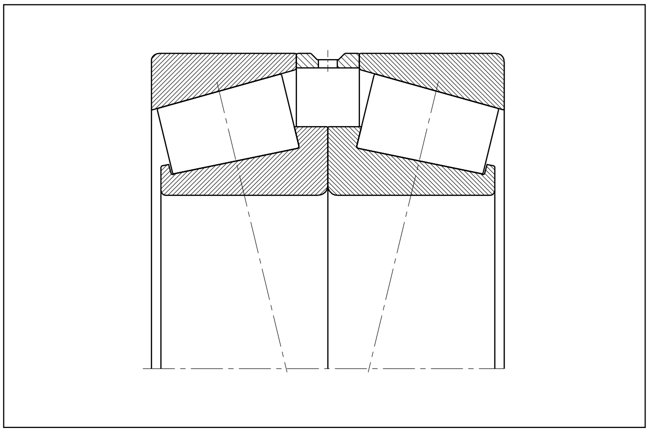
Speed suitability

Medium to high. The speeds reached by matched bearings are approx. 20% lower than those of single bearings.

Inch dimensions

Tapered roller bearings in metric dimensions should be preferred for new designs. In addition to the metric bearings, FAG also offers tapered roller bearings in inch dimensions.

Tapered roller bearings



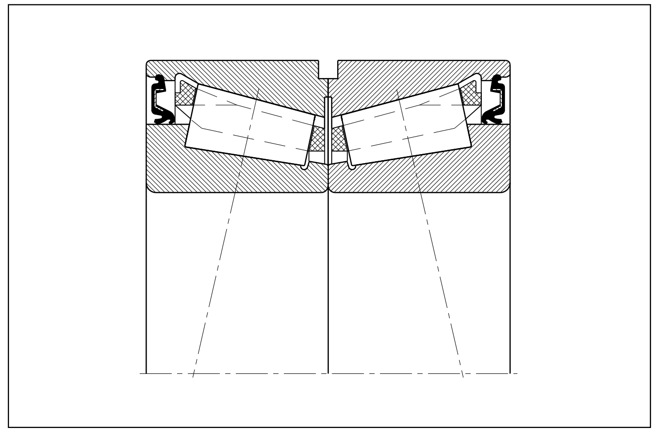
Design N11CA

Matched bearings

The suffix N11CA (formerly K11) identifies matched tapered roller bearing pairs with a defined axial clearance. The axial clearance is obtained by means of a matched spacer ring between the outer rings.

Example for ordering: 2 bearings 31306A.A50.90.N11CA

The spacer ring is part of the delivery scope. A50.90 means that the axial clearance of the bearing pair before mounting is between 50 and 90 µm.

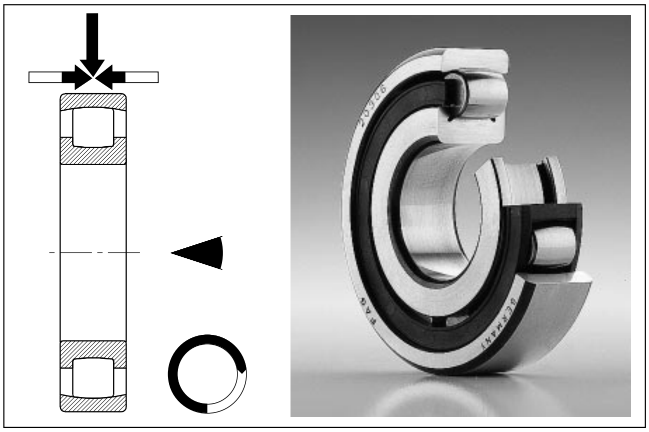


Series JK0S

Integral tapered roller bearings

Tapered roller bearings of series JK0S are self-retaining, sealed and greased. They are primarily intended for the mounting of pairs in O arrangement. The axial clearance need not be set. The bearings have cages of glass-fibre reinforced polyamide (no suffix).

Barrel roller bearings



Series 202, 203

FAG barrel roller bearings are single row, self-aligning roller bearings. They are particularly suitable for applications where a high radial load carrying capacity and the compensation of misalignments are required. Their sturdy design has proven its worth especially in cases where shock-type radial loads have to be accommodated. The axial load carrying capacity of the barrel roller bearings is limited. The bearings are not separable.

Standards

Barrel roller bearings DIN 635, Part 1

Tolerances, bearing clearance

The FAG barrel roller bearings of basic design have a normal tolerance. Bearings with a cylindrical bore have the clearance group "normal" (no suffix), bearings with a tapered bore have an increased radial clearance (suffix C3).

Contact angle

$\alpha_0 = 0°$.

Cages

Barrel roller bearings are fitted with moulded window-type cages of glass-fibre reinforced polyamide 66 (suffix T) or with inner ring riding machined brass cages (suffix MB).

Tapered bore

Barrel roller bearings with a tapered bore (taper 1:12) are fastened either directly on a tapered shaft seat or, using an adapter sleeve, on a cylindrical shaft seat.

Alignment

Under normal loads and with rotating inner ring barrel roller bearings can compensate for misalignments of up to 4°.

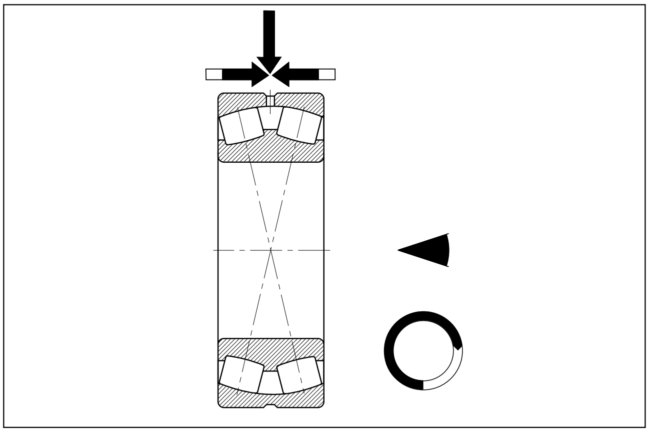
Load carrying capacity

Very high radial loads, low axial loads.

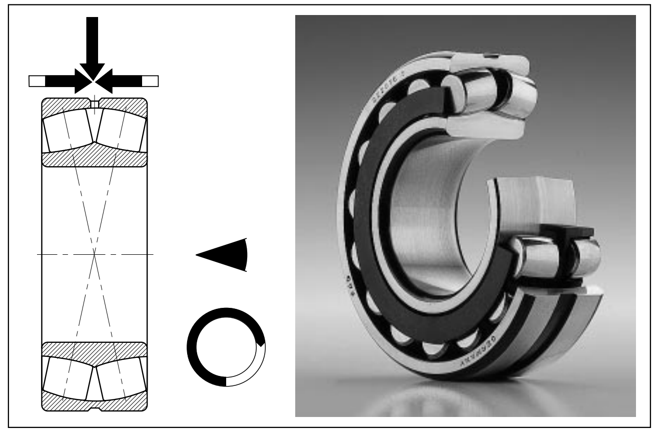
Speed suitability

Low to medium.

Spherical roller bearings



Series 222, 223, 230, 231, 232, 233, 239, 240, 241



E-design (213E, 222E, 223E, 230E, 231E, 240E, 241E)

FAG spherical roller bearings are made for heavy-duty applications. They feature two rows of symmetrical barrel rollers which can align freely in the spherical outer ring raceway, thus compensating for misalignments of the bearing seats and shaft deflections.
FAG spherical roller bearings have a maximum number of long rollers with a large diameter. The close contact between the rollers and raceways yields a uniform stress distribution and a high load carrying capacity.
Most FAG spherical roller bearings with an outside diameter of up to 320 mm are of the E design. Unlike the other spherical roller bearings, these bearings have no centre lip on the inner ring, and therefore their rollers are longer. This yields higher load ratings.
For particularly punishing applications, e.g. where vibratory stresses have to be accommodated, FAG offer special spherical roller bearings (suffix T41A) with narrow dimensional tolerances and an increased radial clearance (see also Publ. No. WL 21 100).

Examples: 22322E.T41A
22332A.MA.T41A

Another special design which is increasingly being used are the split spherical roller bearings. Their inner ring, outer ring and roller-and-cage assembly are divided into 2 halves which facilitates mounting, especially in the case of bearing replacement (cp. TI No. WL 43-1205).

Standards

Spherical roller bearings DIN 635, Part 2

Tolerances, bearing clearance

Spherical roller bearings of basic design are made with normal tolerances and the clearance group "normal". To account for varying operating and mounting conditions, bearings with an increased radial clearance (C3 and C4) are also available.

Contact angle

$\alpha_0 = 6...15°$.

Tapered bore

In addition to spherical roller bearings with a cylindrical bore, there are two designs with a tapered bore:
Taper 1:12 (suffix K) for standard width series
Taper 1:30 (suffix K30) for the wide series 240 and 241
Taper 1:12 means that the bore expands by 1 mm every 12 mm and in the case of taper 1:30 only every 30 mm.
Spherical roller bearings with a tapered bore are usually fastened on the shaft by means of adapter sleeves or withdrawal sleeves (see catalogue WL 41 520EA). As these bearings are mounted, their radial clearance is reduced.

Heat treatment

Spherical roller bearings are normally heat-treated in such a way that they can be used at operating temperatures of up to 200 °C (S1). If bearings with a polyamide cage are used, the temperature limits of application of the cage have to be observed.

Alignment

Under normal operating conditions and with rotating inner ring, spherical roller bearings can compensate for misalignments of up to 0.5° out of the centre position. If the loads are low, angular misalignments of up to 2° are admissible if there is a suitable surrounding structure.

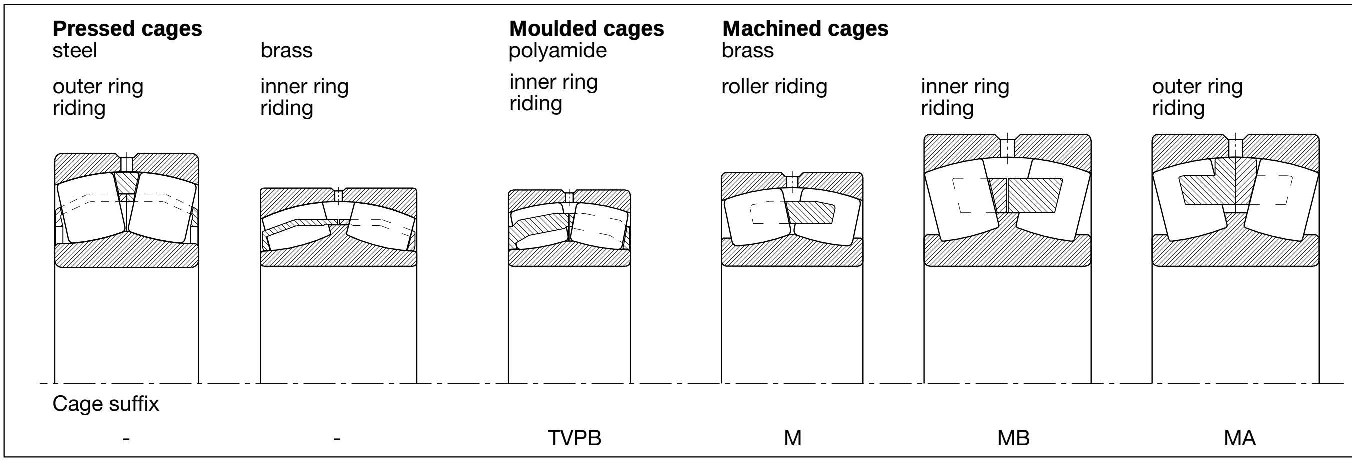
Load carrying capacity

Radial: very high, axial: good.

Speed suitability

Low to medium.

Spherical roller bearings



Cages

Spherical roller bearings of series 222E and 223E have pressed steel cages (no suffix) which are outer ring guided. Other E-design bearings have cages of glass-fibre reinforced PA66 (suffix TVPB) or machined brass cages (suffix M).

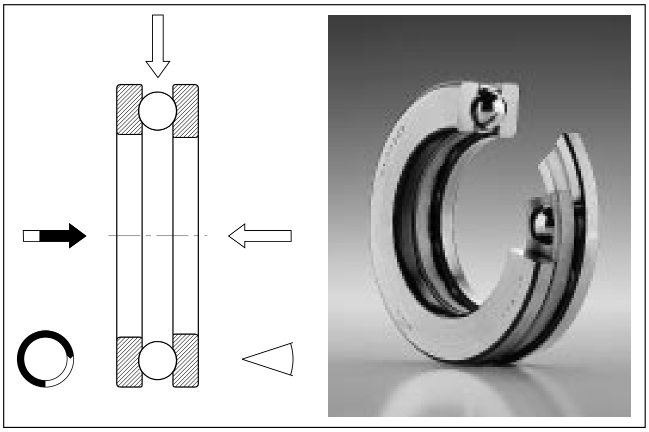
Spherical roller bearings with an integral centre lip on the inner ring have either machined brass cages or pressed brass cages. Bearings with a pressed cage have no cage suffix. The machined brass cages are inner ring riding (MB), bearings of design T41A are outer ring riding (MA).

The table below shows the allocation of the standard cages to the series (designs) and sizes of the FAG spherical roller bearings.

Standard cages of FAG spherical roller bearings

Series (Design)	Pressed steel cage (–)	Pressed brass cage (–)	Moulded polyamide cage (TVPB)	Machined brass cage (M)	Machined brass cage (MB)	Machined brass cage (MA)
	Bore reference number					
213E			up to 22			
222					from 38 on	
222E	up to 36					
223					from 32 on	
223A (T41A)						from 32 on
223E	up to 30					
223E (T41A)	up to 30					
230					from 44 on	
230E			up to 40			
230EA				up to 40		
231					from 40 on	
231E			up to 38			
231EA				up to 38		
232					from 38 on	
232E			up to 36			
232EA				up to 36		
233A (T41A)						from 20 on
239					from 36 on	
240					from 24 on	
240E			up to 32			
241		up to 88			from 92 on	
241E			up to 28			

Thrust ball bearings



single direction
series 511, 512, 513, 514, 532, 533

Thrust ball bearings are used where purely axial loads have to be accommodated. The single direction (= single row) design is designed for loads from one direction, the double direction one (= double row) for reversing loads. Besides the design with flat washers, designs with spherical housing washers and seating washers are also available which can compensate for misalignment.

Standards

Single direction thrust ball bearings	DIN 711
Double direction thrust ball bearings	DIN 715
Seating washers for thrust ball bearings	DIN 711

Tolerances

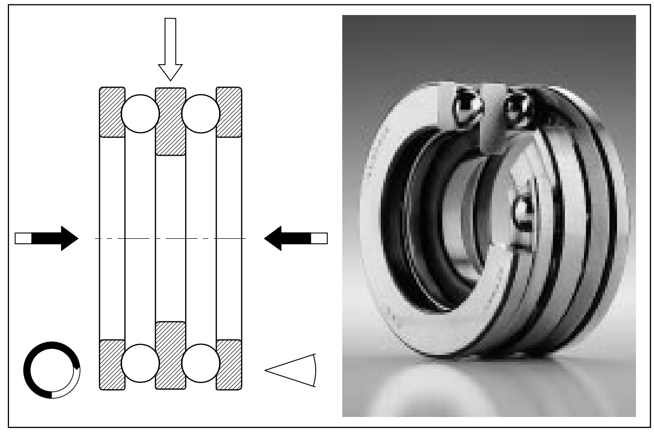
Thrust ball bearings of basic design are machined to normal tolerances. FAG bearings of series 511 are also available with narrow tolerances (suffixes P6 and P5).

Cages

Small bearings have pressed steel cages (no cage suffix), the larger ones have ball-riding machined window-type steel or brass cages (suffix FP or MP) or ball-riding machined brass cages (suffix M).

Minimum axial load

At high speeds bearing kinematics is affected by the inertia forces of the balls if the axial load does not reach a certain minimum value. For details on the minimum axial load F_{amin}, see catalogue WL 41 520EA. If the external load is too low, the bearings must be preloaded, e.g. by means of springs.



double direction
series 522, 523, 542, 543

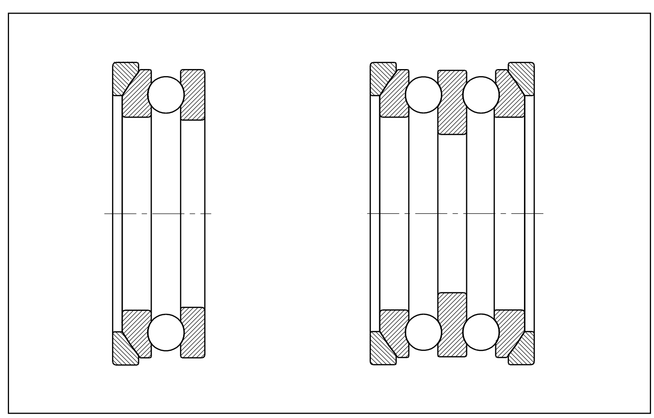
Contact angle

$\alpha_0 = 90°$.

Alignment

None. The mating surfaces of the bearing washers must be parallel to each other. Misalignments can be compensated for by means of spherical housing washers and seating washers.

single direction with one seating washer	double direction with two seating washers
532.. + U2..	542.. + U2..
533.. + U3..	543.. + U3..



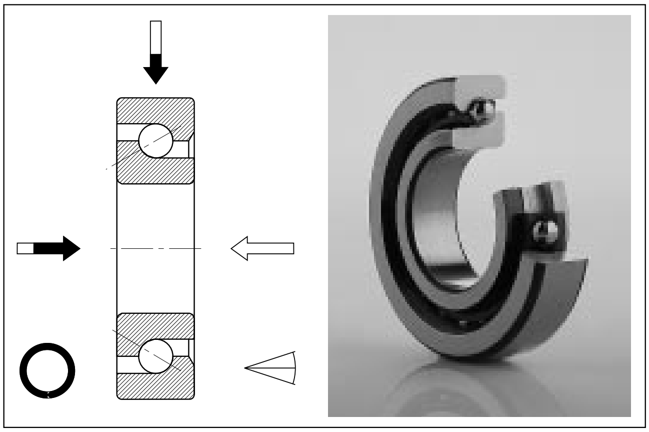
Load carrying capacity

No radial loads; high axial loads.

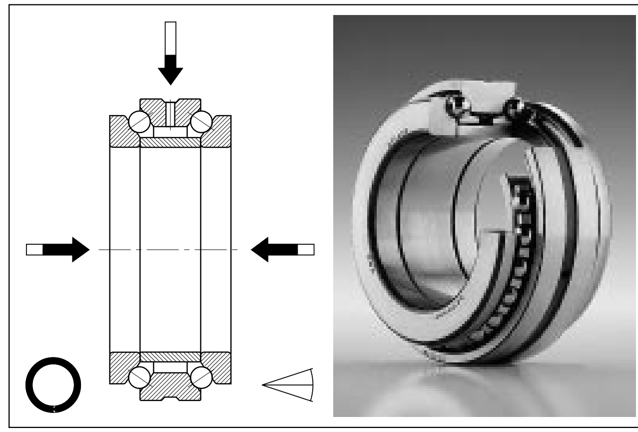
Speed suitability

Medium.

Angular contact thrust ball bearings



single direction
series 7602, 7603



double direction
series 2344, 2347

Single direction angular contact thrust ball bearings are precision bearings for machine tools. These bearings are characterized by great rigidity, low friction and suitability for high speeds at fast changes of position. Like all angular contact ball bearings, they can accommodate axial loads in only one direction.

Tolerances

Dimensional tolerances (diameter):	tolerance class P4 for radial bearings
Running tolerance (axial runout):	tolerance class P4 for thrust bearings

Preload, rigidity

Single direction angular contact thrust ball bearings are preferably mounted in pairs or groups. The width tolerances of the bearing rings permit the matching of identically sized bearings directly side by side in pairs or groups. O and X arranged bearings have a defined preload. The preload and rigidity of the bearing arrangement are increased by lining up several bearings at one bearing location.

Cage

The ball-riding, moulded window-type cage of glass fibre reinforced polyamide (suffix TVP) allows a large number of balls to be fitted.

Lubrication, speed suitability

Single direction angular contact thrust ball bearings are usually lubricated with grease. If the bearings are mounted in groups of three or four the speeds reached by bearing pairs must be reduced accordingly.

Contact angle, load carring capacity

Contact angle α_0 = 60°, and consequently a high load carrying capacity. Radial loads can also be accommodated.

Double direction angular contact thrust ball bearings are mainly used, together with double row cylindrical roller bearings of series NN30ASK, in precision spindles of machine tools. Bearings of series 2347 are mounted at the wider end of the cylindrical roller bearing bore, whereas bearings of series 2344 are mounted at the narrower end. Double direction angular contact thrust ball bearings are separable; their components must not be interchanged with parts of other bearings of the same size.

Tolerances, preload

Double row angular contact thrust ball bearings have the same nominal outside diameter as cylindrical roller bearings NN30ASK. The tolerance of the outside diameter, however, is defined so that there is a loose fit if the seats of the angular contact thrust ball bearing and of the cylindrical roller bearing were machined together.
Angular contact thrust ball bearings are produced in the tolerance class SP. Tolerance class UP on request.
The preload is determined by means of the spacer ring between the two shaft washers.

Contact angle, cage

Due to the contact angle of 60°, the bearings have a great axial rigidity and load carrying capacity.
The machined brass cage is designed for high speeds. Every ball row has its own, ball-riding cage (suffix M).

Alignment

None, i.e. the mating surfaces of the bearing washers must be parallel.

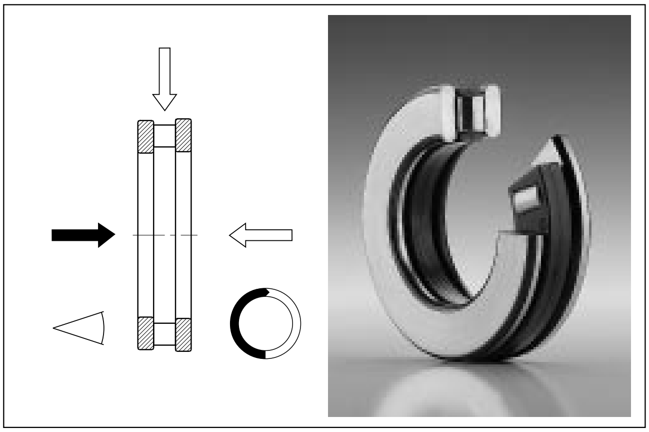
Load carrying capacity

Axial: good; radial: low.

Speed suitability

Very high.

Cylindrical roller thrust bearings



single direction
series 811, 812

FAG cylindrical roller thrust bearings provide rigid bearing arrangements which can accommodate high axial loads and shock loads without problems but no radial loads. They have no self-aligning capability.

Cylindrical roller thrust bearings can be separated into thrust cylindrical roller and cage assembly, shaft washer and housing washer.

Standards

Cylindrical roller thrust bearings DIN 722

Contact angle

$\alpha_0 = 90°$.

Cages

FAG cylindrical roller thrust bearings have moulded cages of glass fibre reinforced polyamide (TVPB), machined cages of light metal (LPB) or brass (MPB, MB). The cage is guided on the shaft.

Alignment

None, i.e. the mating surfaces of the bearing washers must be parallel.

Minimum axial load

To prevent slippage between rollers and bearing washers, cylindrical roller thrust bearings must always be loaded axially (see catalogue WL 41 520EA). If the external load is too low the bearing must be preloaded, e.g. with springs.

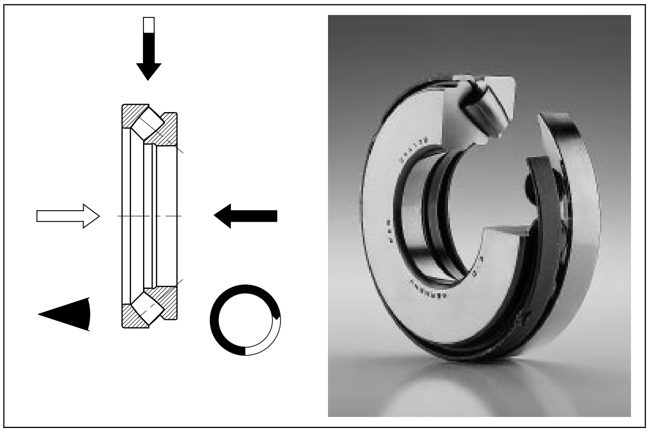
Load carrying capacity

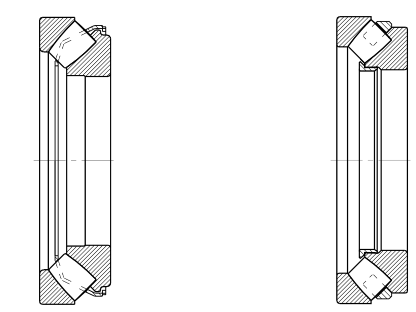
Very high axial loads, no radial loads.

Speed suitability

Low.

Spherical roller thrust bearings





series 292E, 293E, 294E

Spherical roller thrust bearings can accommodate high axial loads. They are suitable for relatively high speeds. The raceways which are inclined towards the bearing axis allow the bearings to accommodate radial loads as well. The radial load must not exceed 55% of the axial load.

The bearings have asymmetrical barrel rollers and compensate for misalignment. As a rule, spherical roller thrust bearings have to be lubricated with oil.

FAG supply spherical roller thrust bearings of reinforced design (suffix E). The bearings are designed for maximum load carrying capacity.

Standards

Spherical roller thrust bearings ISO 104 and DIN 728

Tolerances

Spherical roller thrust bearings are made with normal tolerances.

Contact angle

$\alpha_0 = 50°$.

Cages

Spherical roller thrust bearings have either pressed steel cages (no cage suffix) or machined brass cages (suffix MB). The cages hold together the roller set and the shaft washer.

Alignment

Owing to their spherical housing washer, spherical roller thrust bearings are self-aligning and can compensate for misalignments and shaft deflections.

If P or $P_0 \leq 0.05 \cdot C_0$ [kN], the misalignment values indicated in the table are admissible provided the shaft washer rotates and the misalignment is constant.

Angular misalignment in degrees

Bearing series	Angular alignment
292E	1 ... 1.5°
293E	1.5 ... 2.5°
294E	2 ... 3°

The lower values apply to large bearings.

For details on the aligning capability at rotating housing washer or wobbling shaft motion (dynamic misalignment) please consult our Technical Service.

Minimum axial load

At high speeds bearing kinematics is impaired by the inertia forces of the rollers if the axial load does not reach a certain minimum. For details on this minimum axial load F_{amin} see catalogue WL 41 520.

If the external load and the weight of the supported machine elements are lower than the minimum load the bearings have to be preloaded, e.g. by means of springs.

If a radial load has to be accommodated in addition to the axial load, the requirement $F_r \leq 0.55 \cdot F_a$ must be fulfilled.

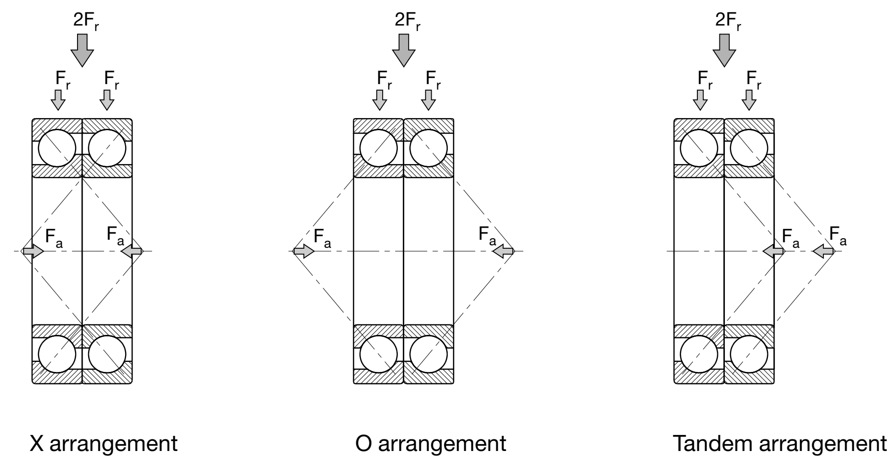
Load carrying capacity

Very high axial loads, medium radial loads.

Speed suitability

Medium to high.

Matched rolling bearings



If the load carrying capacity of one single bearing is not sufficient several bearings can be mounted adjacent to one another. In this case the bearings have to be matched in such a way that as uniform a load distribution as possible and a specific clearance in the bearing set can be achieved.

Rolling bearings are matched together within narrow tolerances in accordance with technical specifications. One example are matched tapered roller bearings of design N11CA (see also page 42).

Spindle bearings are also available as ready-to-mount sets, cp. Catalogue WL 41 520 and Publ. No. AC 41 130.

Furthermore, angular contact ball bearings, especially spindle bearings, that are intended for mounting in pairs or sets in X, O or tandem arrangement (see drawing above) are also available in **universal design.** In bearings of universal design the bearing faces match the raceways in such a way that the bearing pairs, prior to mounting in X or O arrangement, or in a combination of X or O and tandem arrangement, have a certain axial clearance, zero clearance or preload. If they are fitted tightly, the axial clearance is reduced or the preload increased by mounting.

Suffixes:

UA Universal design, small axial clearance
UO Universal design, zero clearance
UL Universal design, light preload
UM Universal design, medium preload

Bearing units

Bearing units

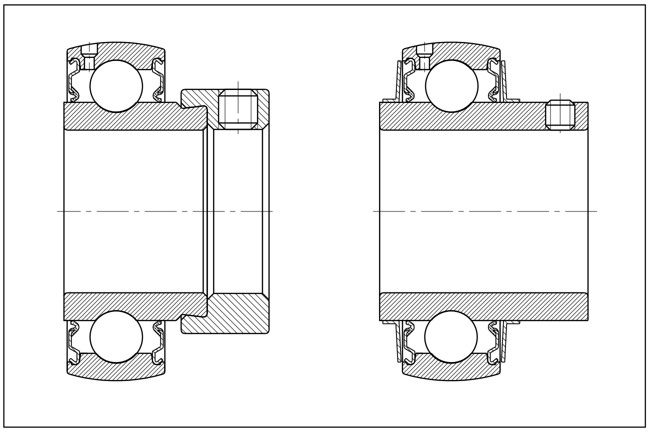
A complete bearing mounting comprises not only the bearing itself but *sealing* and *lubrication* as well. Rolling bearings into which these elements are integrated are referred to as bearing units. These are cost-efficient bearing designs because, as a rule, they do not require any maintenance throughout their entire service life. The most commonly used bearing units incorporate deep groove ball bearings with seals or dust shields. Sealed designs offered by FAG also include self-alining ball bearings, double-row full complement cylindrical roller bearings, JK0S tapered roller bearings and high-speed spindle bearings.

Apart from the sealing, other components adjacent to the rolling bearing can be integrated in the unit as well. For instance, clamping elements which are used to fasten the inner rings of S-type bearings on the shaft. The thick-walled cylindrical or spherical outer rings of track rollers can run directly on tracks. The function of the housing is completely or partly integrated in the unit with wheel bearing units for automobiles, journal roller bearing units for rail vehicles, VRE plummer block units for fans, flanged bearing units for electric machines and bottom bracket bearing units for bicycles (see also "FAG Target Industry Programmes" in catalogue WL 41 520).

S-type bearings

S-type bearings are used for highly contaminated environments, shaft deflections and misalignment, e.g. in agricultural machines, conveyor systems and construction machines. These sealed deep groove ball bearings require no maintenance. They have a spherical outside diameter and are mounted into spherical housings so that they can compensate for misalignment. The inner ring is fastened on the shaft either by means of an eccentric self-locking collar (series 162 and 362B) or by means of two threaded pins (series 562). For more details, see catalogue WL 41 520.

S-type bearing units (only bearings)



FAG deep groove ball bearings with an integrated sensor

In an extremely limited space, speed and sense of rotation are recorded and the data transmitted via a cable, for instance to a frequency converter. You will no longer need expensive rotary encoder systems in electric machines, mobile and stationary transmissions, conveying machines, as well as textile and packing machinery.

Mast guide rollers

Mast guide rollers transmit longitudinal and transverse forces from the fork carriage to the fork lift truck's lift mast. They have thick-walled outer rings with which the rollers run directly on the tracks. Mast guide rollers are sealed on both sides and lubricated for life.

Mast guide rollers

Bearing units

Bottom bracket bearing units for bicycles

FAG supply ready-to-mount bottom bracket bearing units of various designs for series bicycles which can be fitted into all commonly used frames. The unit incorporates two sealed deep groove ball bearings which are lubricated for life. The bearing clearance does not have to be adjusted. The fitter only has to screw or press two components into the frame: a long flanged sleeve accommodating the spindle, and a short flanged sleeve.

The bottom bracket bearing units are largely made of synthetic material, which considerably contributes to their cost-effective design. For more detailed information, see Publ. No. WL 05 114.

Plummer block units VRE3

These units, which were originally developed for fans, are especially suitable for applications where precise and easy-to-mount bearing units are required, e.g. in conveyor systems, test rigs, textile machines and feeding mechanisms.

A one-piece housing accommodates two bearings. Depending on the operating conditions, users can choose from six bearing variations. The completely assembled units are equipped with deep groove ball bearings, cylindrical roller bearings or matched angular contact ball bearings.

For more detailed information, see Publ. No. WL 90 121 "FAG Bearing Units for Fans, Series VRE3".

Bottom bracket bearing unit for screwing into frame

Plummer block unit VRE3

Checklist for rolling bearing determination

Dimensions [mm]

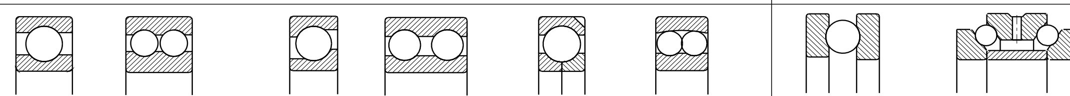
Bore d =	Outside diameter D =	Width B =
Other dimensions		

Rolling bearing type

☐ single row	☐ double row	☐ multi row (number of rows)
☐ with cage	☐ without cage	

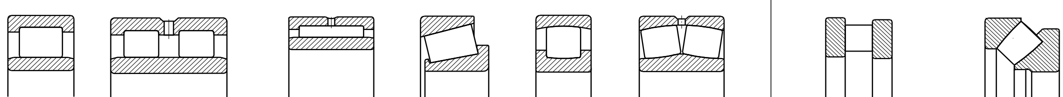
Radial bearing / Thrust bearing

Ball bearing



Deep groove ball bearing – single row	Deep groove ball bearing – double row	Angular contact ball bearing – single row	Angular contact ball bearing – double row	Four point bearing	Self-aligning ball bearing	Thrust ball bearing	Angular contact thrust ball bearing
☐	☐	☐	☐	☐	☐	☐	☐

Roller bearing



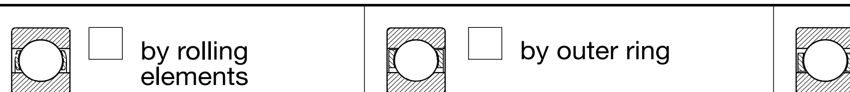
Cylindrical roller bearing – single row	Cylindrical roller bearing – double row	Needle roller bearing	Tapered roller bearing	Barrel roller bearing	Spherical roller bearing	Cylindrical roller thrust bearing	Spherical roller thrust bearing
☐	☐	☐	☐	☐	☐	☐	☐

☐ Other types

Cage material

Pressed cage	Machined/moulded cage	
☐ Steel	☐ Steel	☐ Polyamide
☐ Brass	☐ Brass	☐ Textile laminated phenolic resin
☐	☐ Light metal	☐

Cage guidance



☐ by rolling elements	☐ by outer ring	☐ by inner ring

Special features

☐ Seal ☐ Dust shield	☐ on one side	☐ on both sides
☐ Cylindrical bore	☐ Tapered bore	
☐ Circular groove for snap ring ☐ Lubricating groove and lubricating holes	☐ in the outer ring	☐ in the inner ring
☐ Other features (e.g. spherical outer ring)		

Markings

Manufacturer	Country of origin	Number

Operating conditions

Bearing location ____________

Speed min $^{-1}$ ____________

Temperature °C ____________

Lubrication

☐ Grease ☐ Oil sump ☐ Oil circulation ☐ Oil throwaway

☐ Other lubrication modes ____________

☐ Lubricant designation ____________

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FAG Rolling Bearings

Fundamentals · Types · Designs

Every care has been taken to ensure the correctness of the information contained in this publication but no liability can be accepted for any errors or omissions. We reserve the right to make changes in the interest of technical progress.

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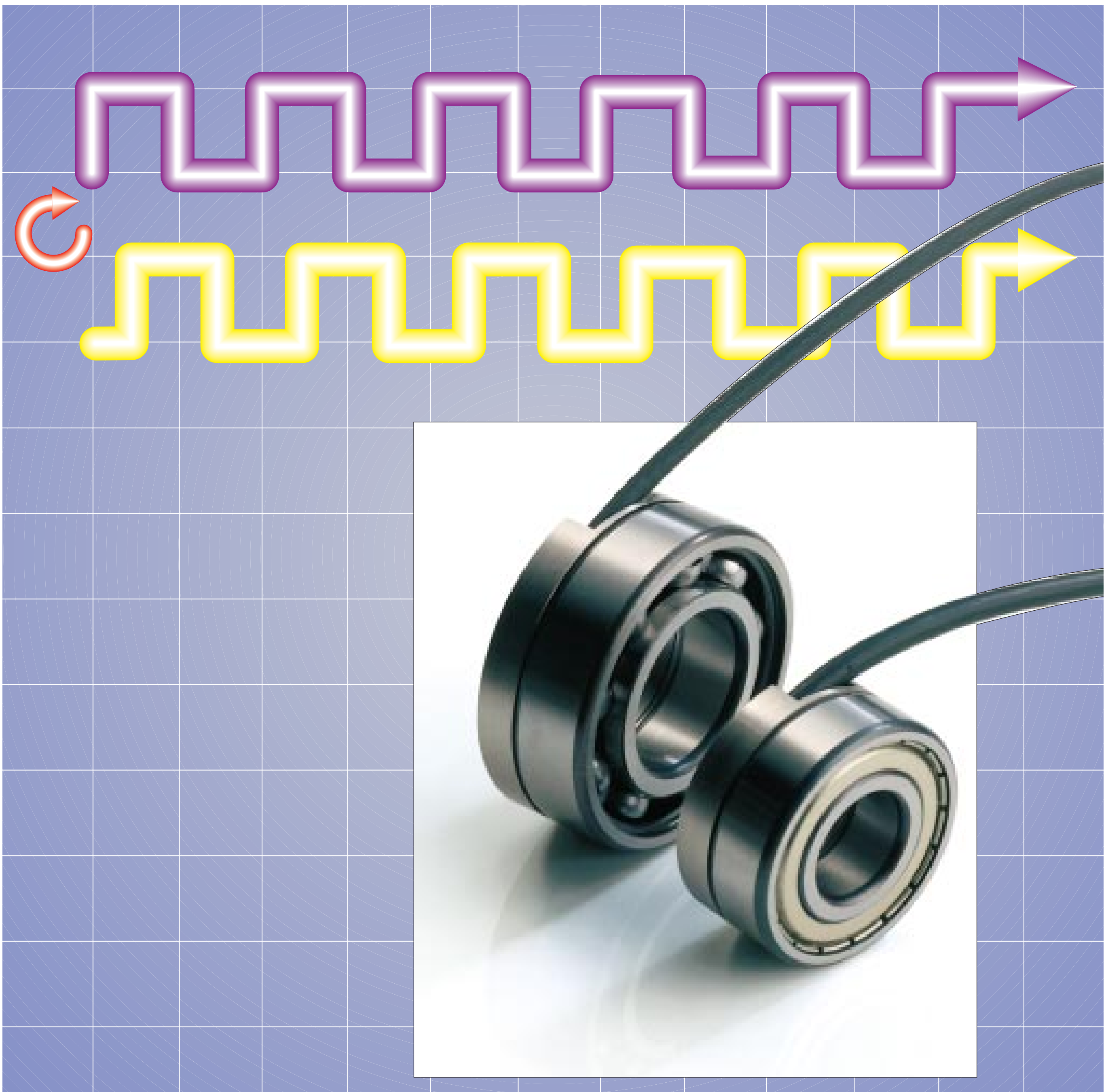
Technical Information

TI No. WL 43-1206 E December 1998

FAG
Rolling Bearings

Precise and cost-effective speed measurement in an extremely limited space:

FAG Deep Groove Ball Bearings with an Integrated Sensor



Applications · Advantages · Standard deep groove ball bearings with an integrated sensor

Application of sensor bearings

FAG deep groove ball bearings with an integrated sensor support rotating shafts, and in addition measure relative motions between the two bearing rings. The sensors record speed and sense of rotation. From these data the angular acceleration and number of revolutions can be derived. This information is increasingly needed in control engineering in order to monitor plants electronically and run them automatically.

Typical applications for rolling bearings with an integrated sensor include

– electric machines, especially frequency-controlled three-phase asynchronous motors
– transmissions, e.g. in machine tools, transmission motors
– materials handling equipment, e.g. elevators, escalators, belt conveyors, fork lift truck drives
– textile and packing machinery

Advantages of FAG sensor bearings

FAG deep groove ball bearings with an integrated sensor offer several advantages over solutions involving separate incremental encoders and other solutions:

- **Low cost**
  Sensor bearings cost up to 50% less than solutions with incremental encoders
- **Little space required**
  Bores and O.D.s are the same as those of standard deep groove ball bearings, only the overall width is greater by 8 mm; space-saving cable outlet in circumferential direction and strain relief
- **Simple mounting**
  Sensor bearings are ready-to-mount units, no adjustment required; integrated anti-rotation system
- **Maintenance-free bearings**
  Standard deep groove ball bearings with a shield or seal on one side, gap-type seal on the other side, for-life lubrication
- **Can be used as locating bearings**
  Sturdy sensor housing allows axial loads
- **High measuring accuracy**
  High pulse frequency and low dividing error
- **Good electromagnetic compatibility (EMC)**
  Screened cable
- **Short circuit and polarity protection**

Sensor bearings - standard deep groove ball bearings with an integrated speed sensor

FAG sensor bearings have - except for the overall width - the main dimensions and the internal design of standard deep groove ball bearings of dimensional series 62. The abutment dimensions defined in DIN 5418 apply for the sensor bearings as well.

The cage is made of pressed steel.

Bearings with a normal radial clearance (clearance group CN) have no suffix identifying the clearance. On request, bearings with a smaller radial clearance (suffix C2) and with a larger radial clearance (suffixes C3, C4) than normal are also available.

The bearing is fitted on one side either with a shield (suffix ZR) or a seal (suffix RSR). Bearings with shields or seals are lubricated for life with standard grease, i.e. they require no maintenance.

Sensor bearings without sealing are also available.

The performance data - load ratings and high-speed suitability - for the designs 2ZR or 2RSR or open deep groove ball bearings of the same dimensions are as indicated in our catalogue WL 41 520 „FAG Rolling Bearings“.

The speed sensor unit is attached to the side opposite the seal, fig. 1. The sensor housing is attached in the sealing recess of the outer ring. The sturdy housing design allows axial loads. The labyrinth seal between sensor housing and pulse generator ring protects the bearing from contamination and retains the grease within the bearing.

Standard deep groove ball bearings with an integrated sensor · Sensor housing

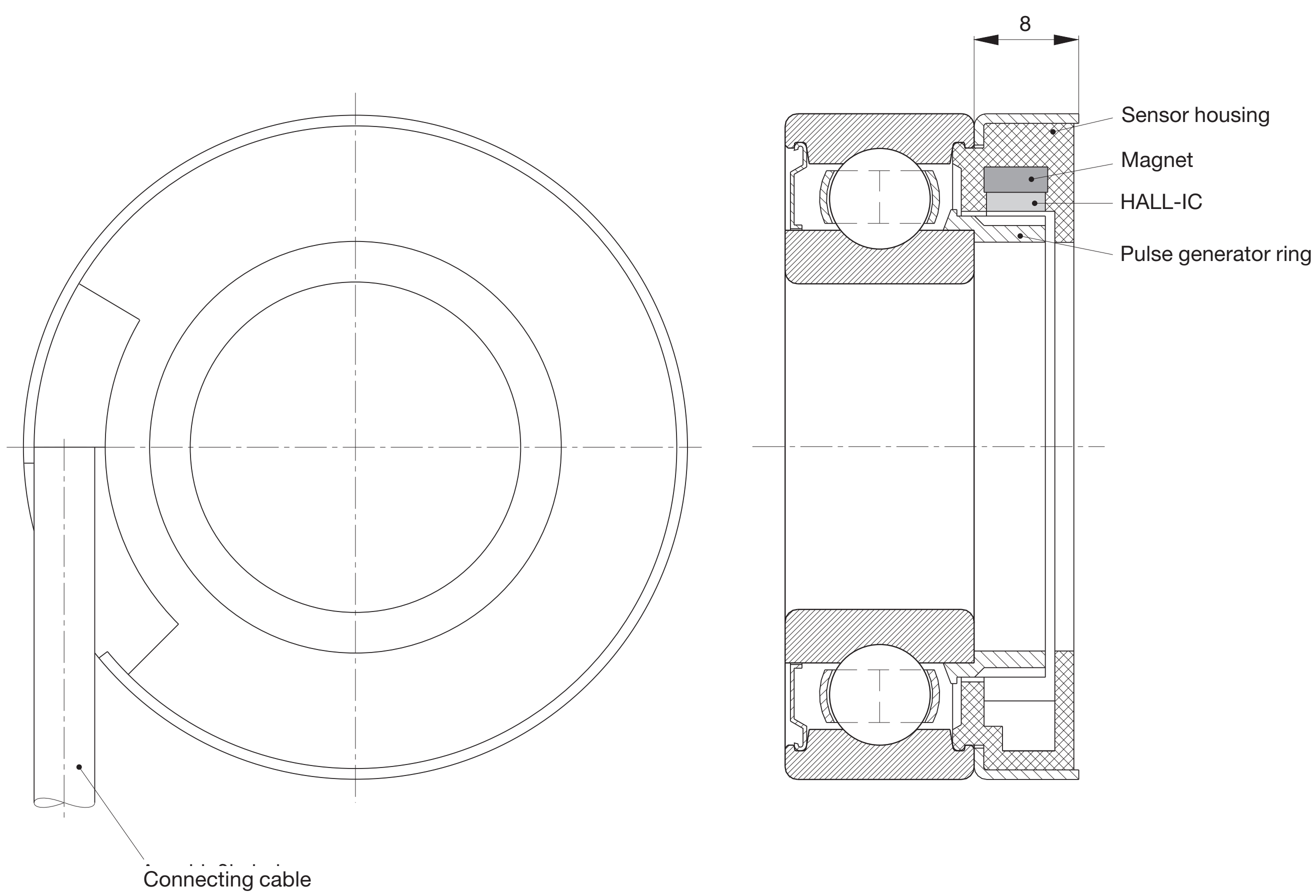
The shielded connecting cable is attached in circumferential direction to the sensor housing and relieved of strain. The cable is very robust and requires little space, and no direct through-hole leading to the sensor bearing is needed.

Sensor housing with magnet and Hall-IC

Only one Hall sensor is required to measure just the speed. By using two Hall sensors, the FAG sensor bearings can record the sense of rotation as well. Depending on the sense of rotation, one of the 90 el° phase-shifted signals leads. In addition, the second sensor can be used to increase the number of pulses per revolution. The external evaluation of the pulse flanks makes 4 x 64 = 256 pulses possible.

A magnetic field is generated by means of a permanent magnet positioned on top of the Hall-IC. The Hall-IC incorporates, apart from the Hall generator, also the signal amplifier and the signal converter. The analogue sinusoidal signal generated by the Hall generator is amplified, and converted into a square wave signal by a Schmitt-trigger, fig. 2. The signal is emitted through an output stage with actively driving transistors. A voltage of 5 to 24 V is required to operate the sensor. Speeds as low as nearly 0 revolutions per minute can be recorded.

1: The FAG speed sensor bearing is a standard deep groove ball bearing with an integrated speed sensor.



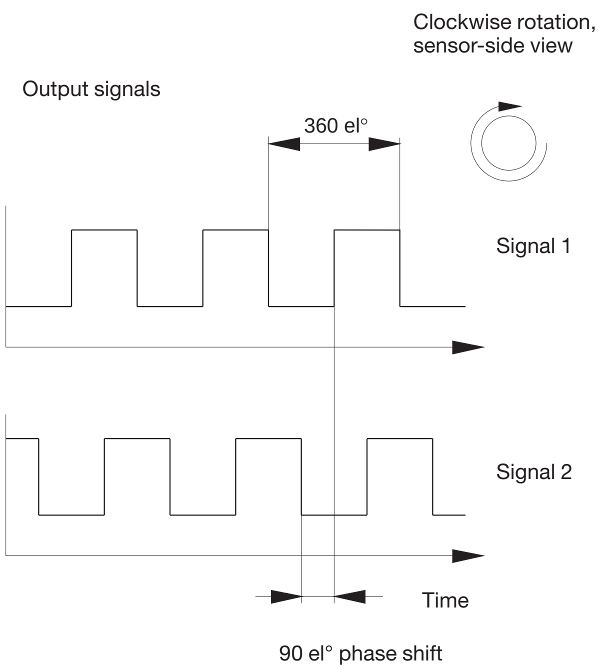
Pulse generator ring · Action · Mounting

Pulse generator ring

The pulse generator ring is made of a ferromagnetic sintered material and is mounted on the inner ring. In order to achieve a better separation of bearing inner space and sensor, the ring is provided with a flinger edge. The number of teeth on the pulse generator ring, and consequently the number of pulses per revolution, depend on the bearing size:

- 48 for bore diameters of up to 20 mm,
- 64 for bore diameters of 25, 30 and 35 mm,
- 80 for bore diameters from 40 mm on.

2: Output signals of the speed sensor bearing



Action of the FAG speed sensor bearing:

The magnetic flux generated by the permanent magnet goes through the Hall sensor, then through a tooth on the pulse generator ring and then, outside the Hall sensor, back into the permanent magnet. As the pulse generator ring rotates, every time a tooth goes under the sensor, the magnetic flow density increases; every time a tooth gap is below the sensor, the flow generated by the permanent magnet is almost interrupted. Every time the magnetic field changes, the Hall-IC is triggered into action. The speed of the bearing is the quotient of the pulse frequency and the number of teeth on the pulse generator ring. The maximum switching frequency is limited to 20 kHz by the Hall sensor itself. The output signal is transmitted, via the connecting cable, to an electronic evaluation module - in the case of a three-phase asynchronous motor, usually to a frequency converter.

Mounting

Sensor bearings can be used where

- rotating shaft and circumferential load acting on the inner ring
- stationary outer ring

are involved.

Usually, the outer ring is stationary.
It may, however, be caused to rotate, too, under the influence of additional, dynamic forces (vibrations).
The sensor housing is mobile relative to the bearing outer ring and can be form-locked by means of adjacent parts (e.g. the motor's bearing shield). In this way, damage to the outgoing cable is prevented.

Technical data · Programme · Order designation

Technical data of the sensor unit

Output signals

- 2 square wave signals
- phase shift 90±40 el°
- open-collector circuit with short-circuit fuse (up to 24V), fig. 3
- max. output current per signal: 40 mA
- pulses per revolution: 48 (design 6204), 64 (designs 6205, 6206) or 80 (designs 6208, 6209, 6210)
- dividing error ±1%
- duty factor 1:1 ±25%

Supply

- voltage: 5 V ... 24 V
- current consumption: max. 15 mA at I_{out} = 40 mA
- polarity protection up to max. 40 V and max. 60 s

Electromagnetic compatibility

- burst on control circuits: IEC 801-4, degree of sharpness 4
- ESD on housing components: IEC 801-2, degree of sharpness 2

Accelerations

- shock: max. 50 g over 6 ms (DIN IEC 68-2-27)
- vibration: max. 10 g between 55 and 2000 cps (DIN IEC 68-2-6)

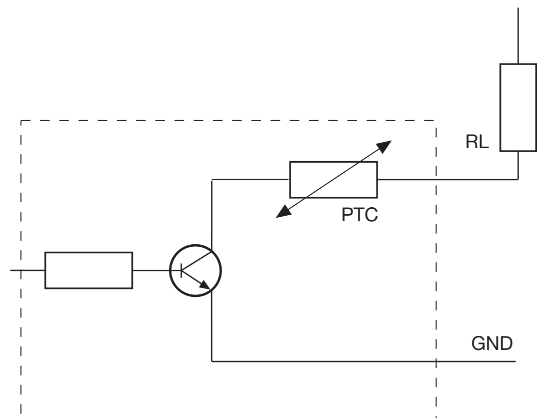
Temperature range

– constantly: -30 °C ... +120 °C
– briefly: +150 °C

Power supply

- 0.46 m cable, outlet in circumferential direction
- 4 conductors + shield
- strain–relieved cable
- plug according to customers' requirements

3: Output circuit



Programme

The FAG speed sensor bearings are based on deep groove ball bearings of series 62, beginning with bore reference number 04. Please contact us about the availability of specific bearing sizes.

Structure of order designation:

Example: 6206 ZR.C3.H124

- standard design (6206)
- dust shield (ZR) or seal (RSR), no suffix for open bearing (ZR)
- radial clearance (if other than CN) (C3)
- sensor (H124)

Information on other bearing sizes and special designs will be provided upon inquiry.

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FAG Deep Groove Ball Bearings with an Integrated Sensor

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TI No. WL 43-1206 E/96/12/98

Technical Information

TI No. WL 43-1207 D-E March 1997

Rolling Bearings

FAG Pendelrollenlager E
- weiterentwickelte Stahlblechkäfige für Lager der Reihen 222E und 223E

FAG E-Design Spherical Roller Bearings
- improved pressed steel cages for bearings of series 222E and 223E

E-Konstruktion • Weiterentwickelter Blechkäfig

FAG Pendelrollenlager der E-Konstruktion

FAG Pendelrollenlager der E-Konstruktion haben sich seit fast zwei Jahrzehnten bestens bewährt. Man findet sie überall dort, wo schwere Beanspruchungen auftreten und Wellenbiegungen oder Fluchtfehler der Lagersitze auszugleichen sind.

Das Prinzip der FAG-Pendelrollenlager der E-Konstruktion: Lager ohne Mittelbord am Innenring.
Es erlaubt die beste Ausnutzung des Lagerquerschnitts und ergibt die höchstmögliche Tragzahl. Durch Austausch von Pendelrollenlagern älterer Konstruktionen gegen FAG E-Lager erhält man meist erheblich höhere Lebensdauerwerte. In anderen Fällen ist es möglich, ein kleineres Lager als bisher einzubauen.

Wegen der hohen Leistungsfähigkeit und Wirtschaftlichkeit wird das Konzept der FAG Pendelrollenlager E auch bei der weiterentwickelten Ausführung mit Stahlblechkäfig beibehalten.

Das weiterentwickelte Pendelrollenlager E mit Blechkäfig

Bei den FAG Pendelrollenlagern der Reihen 222E und 223E wurde der Blechkäfig weiterentwickelt. Jede Rollenreihe hat einen Fensterkäfig aus Stahlblech, der nun am Außenring statt am Innenring geführt wird, Bild 1.

1: Das weiterentwickelte FAG Pendelrollenlager E mit am Außenring geführtem Stahlblechkäfig

E-design • Improved pressed cage

FAG E-design spherical roller bearings

FAG E-design spherical roller bearings have proven their worth for almost two decades. They are found everywhere where heavy stresses have to be accommodated and where shaft deflections or misalignments of the bearing seats have to be compensated for.

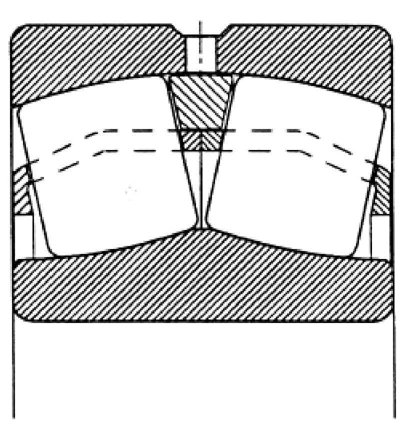
The principle of the FAG E-design spherical roller bearings: bearings without a centre lip on the inner ring.
It allows maximum utilization of the bearing cross section and yields the maximum possible load rating. By replacing spherical roller bearings of older designs with E-design bearings, considerably higher life values are achieved as a rule. In other cases it becomes possible to install a smaller bearing than before.

Owing to its high efficiency and economy, the concept of the FAG E-design spherical roller bearings will be maintained in the improved design with pressed steel cages.

The improved E-design spherical roller bearing with a pressed cage

The pressed cages for the FAG spherical roller bearings of series 222E and 223E were further improved. Every row of rollers is guided by a pressed-steel window-type cage which is now of the outer-ring riding type instead of inner-ring riding, fig. 1.

1: The improved FAG E-design spherical roller bearing with an outer-ring riding pressed steel cage



Weiterentwickelter Blechkäfig • Vorteile

Die beiden Käfighälften stützen sich über einen metallischen Führungsring im Außenring ab. Der Führungsring ist bei kleinen Lagern geteilt und bei größeren Lagern geschlossen ausgeführt.
Die Käfigoberflächen der Pendelrollenlager 222E erhalten durch Gleitbondern gute Gleiteigenschaften.
Bei den Lagern der Reihe 223E sind der Käfig und der Führungsring oberflächengehärtet. Dies gilt auch für die Spezial-Pendelrollenlager der Ausführung 223E.T41A für schwingende Beanspruchung).

Vorteile

Durch die neue Käfigausführung ergeben sich gegenüber der bisherigen, die am Innenring geführt wurde, zusätzliche Vorteile, nämlich eine noch höhere Führungsstabilität und Verschleißfestigkeit.
Die Führung der Käfige im Außenring ermöglicht den Einsatz von Pendelrollenlagern der Reihe 222E nun auch bei Anwendungen mit radialer Schwingbeanspruchung und Stößen.

Geblieben sind die bekannten Vorteile der FAG Pendelrollenlager E mit Blechkäfig:

• Höchste Tragfähigkeit

Größtmögliche Rollendurchmesser und -längen und eine optimierte Schmiegung zwischen Rollen und Laufbahnen für eine gleichmäßige Spannungsverteilung ergeben höchste dynamische und statische Tragzahlen.

• Eignung für hohe Temperaturen

Der Stahlblechkäfig eignet sich auch für hohe Temperaturen. Er verträgt sich mit allen üblichen, auch mit hoch additivierten Schmierstoffen.

• Sichere Führung der Rollen

Die Rollen werden von den Laufbahnen und vom Käfig geführt. Die engen Fertigungstoleranzen und die Geometrie des Käfigs tragen wesentlich dazu bei, daß die Rollen in der Lastzone und auch in der lastfreien Zone exakt geführt werden.
Der Käfig hält die Rollen sicher beim Ausschwenken während der Montage und bei späteren Inspektionen.

• Niedrige Betriebstemperatur

Definierte Rauheitswerte für die Oberflächen von Laufbahnen, Rollen und Käfig sorgen für niedrige Reibung. Deshalb wird der Schmierstoff nur gering beansprucht. Daraus resultieren niedrige Betriebstemperaturen, eine hohe Drehzahleignung und eine lange Gebrauchsdauer des Schmierstoffs.

Improved pressed cage • Advantages

The two cage halves are supported by a metallic guiding ring in the outer ring. Small bearings have split guiding rings whereas larger bearings have one-piece guiding rings.
The cage surfaces of the spherical roller bearings of series 222E are subjected to an anti-friction bonderizing process, which endows them with good sliding properties.
The cage and the guiding ring of series 223E bearings have hardened surface layers. This also applies for the special spherical roller bearings of design 223E.T41A for vibratory stressing.

Advantages

The new cage design yields additional advantages as compared with the previous, inner-ring riding one, i.e. an even improved guiding stability and wear resistance.

The outer-ring riding cages now allow spherical roller bearings of series 222E to be used in applications involving radial vibratory stressing and impacts.

Of course, the FAG E-design spherical roller bearings with a pressed cage still offer the following, well-known advantages:

• Utmost load carrying capacity

Largest possible roller diameters and lengths and an optimized curvature ratio between rollers and raceways yield the highest dynamic and static load ratings.

• High-temperature suitability

Pressed steel cages are suitable even for high temperatures. They are compatible with all commonly used lubricants, including highly doped ones.

• Safe roller guidance

The rollers are guided by the raceways and by the cage. The narrow machining tolerances and the geometry of the cage contribute considerably to guiding the rollers accurately in the loaded zone and in the unloaded zone.
The cage retains the rollers securely when the outer ring is swivelled out during mounting and subsequent inspections.

• Low operating temperature

Defined roughness values for the surfaces of raceways, rollers and cage ensure a reduced friction. Consequently, the lubricant is subject to little stress only. This results in low operating temperatures, high speed suitability and a long service life of the lubricant.

Vorteile • Kurzzeichen

• Notlaufeigenschaften

Hohe Oberflächenqualität und optimierte Kinematik sowie die hohe Festigkeit des Käfigs sorgen für gute Notlaufeigenschaften auch bei ungenügender Trennung durch den Schmierfilm.

• Hohe Wirtschaftlichkeit

Die hohe Tragfähigkeit und die geringe Schmierstoffbeanspruchung bei den Pendelrollenlagern E mit Blechkäfig sind günstige Voraussetzungen für eine lange Gebrauchsdauer.

Der Wartungsaufwand ist gering, weil die Nachschmierfristen lang sind und die Lager nur wenig Schmierstoff benötigen.

Zahlreiche Versuche haben bestätigt, daß die Käfigführungsringe die Nachschmierbarkeit durch die Schmierbohrungen im Außenring nicht beeinträchtigen. Die Fettgebrauchsdauer der bisherigen FAG Pendelrollenlager E bleibt erhalten.

Anwendungstechnische Kriterien

Die anwendungstechnischen Kriterien (Winkeleinstellbarkeit, Toleranzen, Lagerluft, Drehzahleignung, Wärmebehandlung) sind ausführlich behandelt im Katalog WL 41 520 "FAG Wälzlager".
Gegenüber den bisherigen Pendelrollenlagern 222E und 223E mit Blechkäfig ändern sich lediglich die Kurzzeichen, siehe folgenden Abschnitt. Die Leistungsdaten bleiben wie im Katalog angegeben.

Kurzzeichen

Das Kurzzeichen der FAG Pendelrollenlager E mit Blechkäfig besteht aus der Bezeichnung der Maßreihe, der Bohrungskennzahl und dem Nachsetzzeichen E für die verstärkte Ausführung.
Der Blechkäfig wird **nicht** angeschrieben. Dies gilt auch für Spezial-Pendelrollenlager der Reihe 223E.T41A, bei denen bisher für den Käfig das Nachsetzzeichen JPA verwendet wurde.

Advantages • Code

• Dry running properties

High surface quality, optimized kinematics and the great strength of the cage guarantee good dry running properties even if separation by the lubricant film is insufficient.

• High ecomonic efficiency

The high load carrying capacity and the reduced lubricant stressing achieved with E-design spherical roller bearings with a pressed cage are favourable preconditions for a long service life.

Only little maintenance is required as the relubrication intervals are long and the bearings require only small quantities of lubricant.

Numerous tests have confirmed that the cage guiding rings do not impair relubrication through the lubricating holes in the outer ring. The grease service life achieved is the same as that reached with the previous FAG E-design spherical roller bearings.

Application Engineering Criteria

The application engineering criteria (alignment, tolerances, bearing clearance, speed suitability, heat treatment) are discussed in detail in the catalogue WL 41 520EA "FAG Rolling Bearings". Only the codes of the spherical roller bearings of series 222E and 223E with a pressed cage differ from those of the previous design, see following section. The performance data indicated in the catalogue remain valid.

Code

The code designating FAG E-design spherical roller bearings with a pressed cage consists of the designations of the dimensional series, the bore reference number and the suffix E for the reinforced design. The pressed cage is **not** specified in the code. The same holds for special spherical roller bearings of series 223E.T41A where previously the suffix JPA was used for the cage.

Kurzzeichen • Programm

Alle Lager mit Blechkäfig der Reihen 222E und 223E haben standardmäßig eine Schmiernut und Schmierbohrungen im Außenring. Im Unterschied zur bisherigen Regelung wird bei diesen Lagern auch bei einem Außendurchmesser < 320 mm das Nachsetzzeichen S **nicht** mehr verwendet.

Beispiele:

FAG 22212E
FAG 22317EK
FAG 22320E.T41A.

Anmerkung: Bei den anderen Pendelrollenlagern, die FAG mit Schmiernut und Schmierbohrungen liefert, bleibt es im genannten Größenbereich beim Nachsetzzeichen S.

Beispiele:

FAG 23024ES.TVPB
FAG 23220EASK.M

Programm, Verfügbarkeit

Pendelrollenlager der E-Ausführung mit dem weiterentwickelten, außenringgeführten Blechkäfig ergänzen das FAG-Standardprogramm.

Pendelrollenlager mit außenringgeführtem Stahlblechkäfig stehen zur Verfügung

mit Bohrungskennzahl 05 bis 36 bei der Reihe 222E,
mit Bohrungskennzahl 08 bis 30 bei der Reihe 223E.

Die verfügbaren Lager in der Grundausführung und in der Ausführung für schwingende Beanspruchung mit zylindrischer und mit kegeliger Bohrung sind in der folgenden Tabelle aufgeführt.

Code • Programme

All bearings of series 222E and 223E with a pressed cage have a lubricating groove and lubricating holes in the outer ring. In contrast to the previous regulation, these bearings, even those with an outside diameter of less than 320 mm, are **no longer** suffixed S.

Examples:

FAG 22212E
FAG 22317EK
FAG 22320E.T41A.

Please note: The other spherical roller bearings in the indicated size range with a lubricating groove and lubricating holes offered by FAG will continue to be suffixed S.

Examples:

FAG 23024ES.TVPB
FAG 23220EASK.M

Programme, Availability

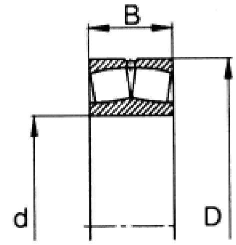
E-design spherical roller bearings with an improved, outer-ring riding pressed cage supplement the FAG standard programme.

Spherical roller bearings with an outer-ring riding pressed steel cage are available

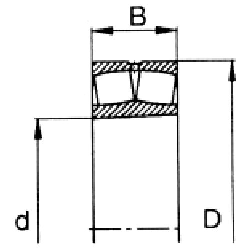
with bore reference numbers 05 to 36 in series 222E,
with bore reference numbers 08 to 30 in series 223E.

The available bearings of the basic design and of the design for vibratory stressing with a cylindrical or with a tapered bore are listed in the following table.

FAG Pendelrollenlager E mit Stahlblechkäfig
FAG E-design spherical roller bearings with pressed steel cages



zylindrische Bohrung
cylindrical bore



kegelige Bohrung
tapered bore
(Kegel / taper 1:12)

Abmessungen Dimensions			Tragzahl Load rating dyn.	Lager-Kurzzeichen Bearing code		Schwingsieblager Bearing for vibrating screens	
d	D	B	C	zylindrische Bohrung cylindrical bore	kegelige Bohrung tapered bore	zylindrische Bohrung cylindrical bore	kegelige Bohrung tapered bore
mm			kN	FAG	FAG	FAG	FAG
25	52	18	42,5	**22205E**	**22205EK**		
30	62	20	58,5	**22206E**	**22206EK**		
35	72	23	78	**22207E**	**22207EK**		
40	80	23	90	**22208E**	**22208EK**		
	90	33	129	**22308E**	**22308EK**	**22308E.T41A**	
45	85	23	95	**22209E**	**22209EK**		
	100	36	156	**22309E**	**22309EK**	**22309E.T41A**	
50	90	23	100	**22210E**	**22210EK**		
	110	40	190	**22310E**	**22310EK**	**22310E.T41A**	
55	100	25	116	**22211E**	**22211EK**		
	120	43	224	**22311E**	**22311EK**	**22311E.T41A**	**22311EK.T41A**
60	110	28	146	**22212E**	**22212EK**		
	130	46	260	**22312E**	**22312EK**	**22312E.T41A**	**22312EK.T41A**
65	120	31	173	**22213E**	**22213EK**		
	140	48	290	**22313E**	**22313EK**	**22313E.T41A**	**22313EK.T41A**
70	125	31	173	**22214E**	**22214EK**		
	150	51	325	**22314E**	**22314EK**	**22314E.T41A**	**22314EK.T41A**
75	130	31	176	**22215E**	**22215EK**		
	160	55	375	**22315E**	**22315EK**	**22315E.T41A**	**22315EK.T41A**
80	140	33	216	**22216E**	**22216EK**		
	170	58	415	**22316E**	**22316EK**	**22316E.T41A**	**22316EK.T41A**

FAG Pendelrollenlager E mit Stahlblechkäfig
FAG E-design spherical roller bearings with pressed steel cages

Abmessungen Dimensions			Tragzahl Load rating dyn.	Lager-Kurzzeichen Bearing code		Schwingsieblager Bearing for vibrating screens	
d	D	B	C	zylindrische Bohrung cylindrical bore	kegelige Bohrung tapered bore	zylindrische Bohrung cylindrical bore	kegelige Bohrung tapered bore
mm			kN	FAG	FAG	FAG	FAG
85	150	36	260	**22217E**	**22217EK**		
	180	60	455	**22317E**	**22317EK**	**22317E.T41A**	**22317EK.T41A**
90	160	40	285	**22218E**	**22218EK**		
	190	64	510	**22318E**	**22318EK**	**22318E.T41A**	**22318EK.T41A**
95	170	43	315	**22219E**	**22219EK**		
	200	67	560	**22319E**	**22319EK**	**22319E.T41A**	**22319EK.T41A**
100	180	46	360	**22220E**	**22220EK**		
	215	73	655	**22320E**	**22320EK**	**22320E.T41A**	**22320EK.T41A**
110	200	53	455	**22222E**	**22222EK**		
	240	80	800	**22322E**	**22322EK**	**22322E.T41A**	**22322EK.T41A**
120	215	58	540	**22224E**	**22224EK**		
	260	86	900	**22324E**	**22324EK**	**22324E.T41A**	**22324EK.T41A**
130	230	64	630	**22226E**	**22226EK**		
	280	93	1040	**22326E**	**22326EK**	**22326E.T41A**	**22326EK.T41A**
140	250	68	735	**22228E**	**22228EK**		
	300	102	1220	**22328E**	**22328EK**	**22328E.T41A**	**22328EK.T41A**
150	270	73	850	**22230E**	**22230EK**		
	320	108	1370	**22330E**	**22330EK**	**22330E.T41A**	**22330EK.T41A**
160	290	80	965	**22232E**	**22232EK**		
170	310	86	1100	**22234E**	**22234EK**		
180	320	86	1140	**22236E**	**22236EK**		

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FAG Pendelrollenlager E
- weiterentwickelte Stahlblechkäfige für Lager der Reihen 222E und 223E

FAG E-design spherical roller bearings
- improved pressed steel cages for bearings of series 222E and 223E

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Technical Information

TI No. WL 80-46 E   January 2000

FAG

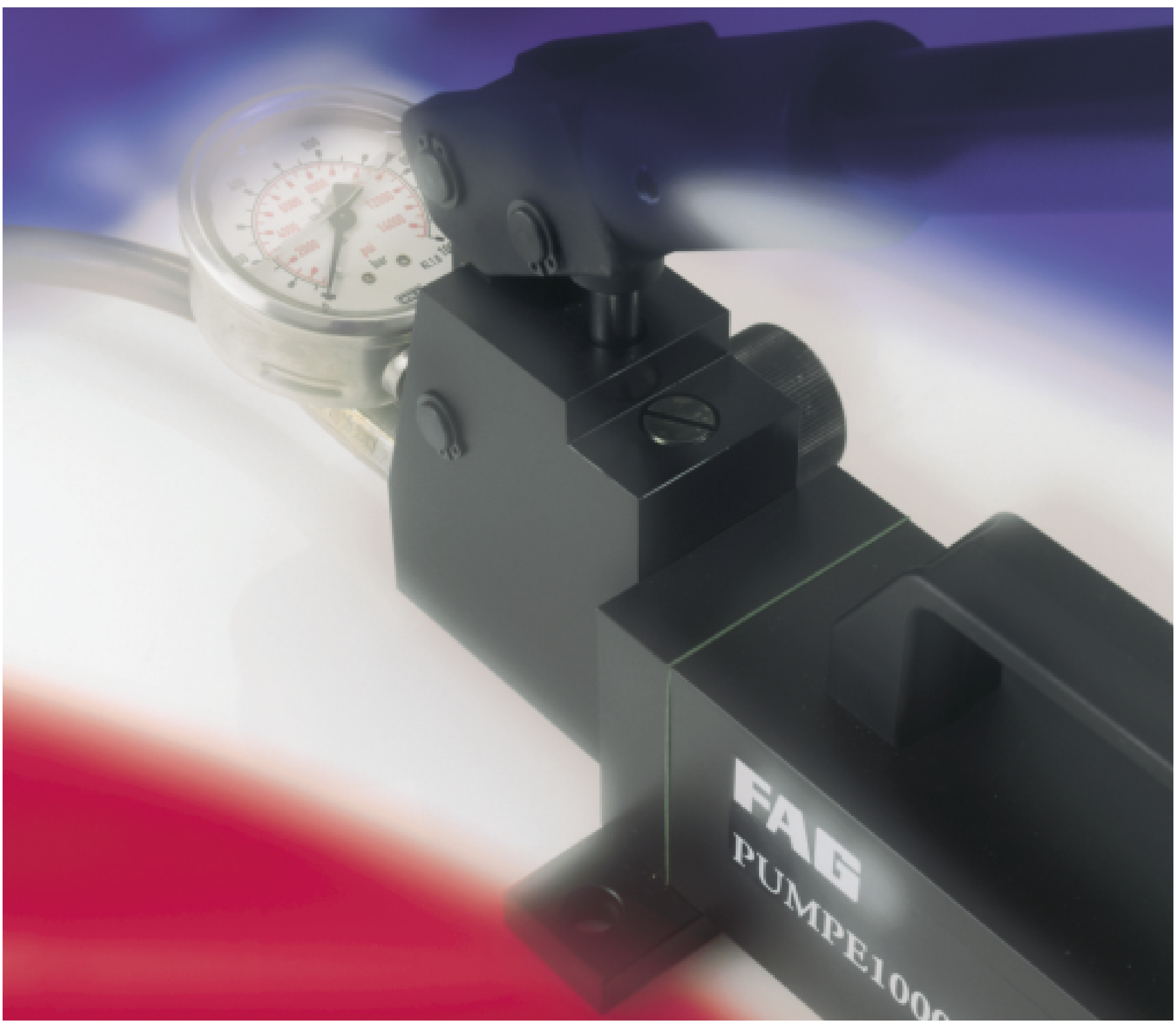
Rolling Bearings

FAG Hand Pump Sets

The programme of FAG hand pump sets comprises the following basic designs:
- PUMPE1000.0,7L (one-step pump)
- PUMPE1000.4L (two-step pump)
- PUMPE1600.4L (two-step pump)
- PUMPE2500.4L (two-step pump)

The two-step pumps have a large delivery volume in the low-pressure range and then automatically switch to the high-pressure stage. In this way a high working speed is achieved. For applications where larger amounts of oil are required the two-step pumps are also available with an 8-litre oil container (suffix .8L).

For applications where a separate oil supply is required by the way the adapter sleeves or withdrawal sleeves are mounted we will supply on request a two-way valve (suffix .V).



FAG Hand Pump Set 1000 bar (one-step pump)

Pressure generator for the hydraulic method and for hydraulic nuts

FAG hand pump set 1000 bar (0.7-liter oil container)

This hand pump set is suitable for hydraulically mounting and dismounting rolling bearings, for mounting press-fitted assemblies with contact pressures of up to 50 N/mm² and for driving hydraulic nuts up to RKP395 and RKP300.526205A, respectively.

The oil container has a volume of 0.7 l.

The pump is connected by means of a high-pressure tube (1000 bar, 1.5 m long) and a plug-in joint (1000 bar) for connecting thread hole G 1/4 (see drawing).

Sleeve connecting pieces have to be used for mounting and dismounting rolling bearings with adapter and withdrawal sleeves. If other connections are provided, adapters and reduction adapters can be used.

The pump set is delivered ready for use in a metal box.

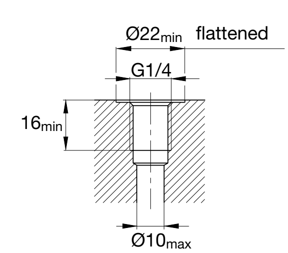
Scope of delivery:

1 hand pump set (1000 bar) with an 0.7-litre oil container with an oil filling of Shell Voltol sliding oil 46 (viscosity 46 mm²/s at 40 °C), pressure-gauge connection in the pump head
1 pressure gauge (0-1000 bar, dia 63 mm)
1 HP tube (1000 bar, 1.5 m long)
1 plug-in joint (1000 bar, connecting thread G 1/4)
1 metal box (650 x 260 x 200 mm)
Weight (incl. oil filling and metal box) 10 kg

Order designation:
PUMPE1000.0,7L

Order designation for repair kit for the one-step, 1000-bar pump:
KIT.PUMPE1000.0,7L

Oil volume per stroke cm³
2.2



Connecting thread bore G1/4

FAG Hand Pump Sets 1000 bar (two-step pump)

Pressure generators for the hydraulic method and for hydraulic nuts

FAG hand pump sets 1000 bar (4-l oil container)

These hand pump sets are suitable for hydraulically mounting and dismounting rolling bearings, for hydraulic nuts and for mounting press-fitted assemblies with up to 50 N/mm², e.g. ship's propellers.

The oil containers have a volume of 4 l (8-litre containers also available on request).

The pumps are connected by means of a high-pressure tube (1000 bar, 2 m long) and a plug-in joint (1000 bar) for connecting thread bore G 1/4 (see drawing on page 2).

If two connections have to be supplied with oil simultaneously the pump set is additionally fitted with a two-way valve. Oil supply is then effected through two high-pressure tubes and two plug-in joints.

The pump sets are delivered ready for use in a metal box.

Hand pump set PUMPE1000.4L
(for 1 connection)

Scope of delivery:

1 hand pump (1000 bar) with a 4-litre oil container with an oil filling of Shell Voltol 46 sliding oil (viscosity 46 mm²/s at 40 °C)
1 attached pressure-gauge connecting piece
1 pressure gauge (0-1000 bar, dia 63 mm)
1 HP tube (1000 bar, 2 m long)
1 plug-in joint (1000 bar)
1 metal box 900 x 250 x 250 mm
Weight (incl. oil filling and metal box) 24 kg

Order designation:
PUMPE1000.4L

Hand pump set PUMPE1000.4L.V
(for 2 connections)

Scope of delivery:

1 hand pump (1000 bar) with a 4-litre oil container with an oil filling of Shell Voltol 46 sliding oil (viscosity 46 mm²/s at 40 °C)
1 attached two-way valve (with pressure-gauge connection)
1 pressure gauge (0-1000 bar, dia 63 mm)
2 HP tubes (1000 bar, 2 m long)
2 plug-in joints (1000 bar)
1 metal box 900 x 250 x 250 mm
Weight (incl. oil filling and metal box) 27 kg

Order designation:
PUMPE1000.4L.V

Order designation for repair kit for the two-step, 1000-bar pumps:
KIT.PUMPE1000.4L

Oil volume per stroke

up to 30 bar cm³	**30 to 1000 bar**
32	1.6

FAG Hand Pump Sets 1600 bar

Pressure generators for the hydraulic method

FAG hand pump sets 1600 bar

These hand pump sets are suitable for hydraulically mounting and dismounting rolling bearings and for mounting press-fitted assemblies with contact pressures of up to 80 N/mm^2, e.g. ship's rudder shafts and rudder blades.

The oil containers have a volume of 4 l (8-litre containers also available on request).

The pump is connected by means of an HP tube (1600 bar, 2 m long) and a plug-in joint (1600 bar, for connecting thread holes G 1/4, see drawing on page 2).

If two connections have to be supplied with oil simultaneously, the pump set is additionally fitted with a two-way valve. Oil supply is then effected through two high-pressure tubes and two plug-in joints.

The pump sets are delivered ready for use in a metal box.

Hand pump set PUMPE1600.4L
(for 1 connection)

Scope of delivery:

1 hand pump (1600 bar) with a 4-litre oil container with an oil filling of Shell Voltol sliding oil 46 (viscosity 46 mm^2/s at 40 °C)
1 attached pressure-gauge connecting piece
1 pressure gauge (0-1600 bar, dia 100 mm)
1 HP tube (1600 bar, 2 m long)
1 plug-in joint (1600 bar)
1 metal box 900 x 250 x 250 mm
Weight (incl. oil filling and metal box) 25 kg

Order designation:
PUMPE1600.4L

Hand pump set PUMPE1600.4L.V
(for 2 connections)

Scope of delivery:

1 hand pump (1600 bar) with a 4-litre oil container with an oil filling of Shell Voltol sliding oil (viscosity 46 mm^2/s at 40 °C)
1 attached two-way valve (with pressure-gauge connection)
1 pressure gauge (0-1600 bar, dia 100 mm)
2 HP tubes (1600 bar, 2 m long)
2 plug-in joints (1600 bar)
1 metal box 900 x 250 x 250 mm
Weight (incl. oil filling and metal box) 28 kg

Order designation:
PUMPE1600.4L.V

Order designation for repair kit for the two-step, 1600-bar pumps:
KIT.PUMPE1600.4L

Oil volume per stroke

up to 30 bar	30 to 1600 bar
cm^3	
32	1.6

FAG Hand Pump Sets 2500 bar

Pressure generators for the hydraulic method

FAG hand pump sets 2500 bar

These hand pump sets are suitable for hydraulically mounting and dismounting rolling bearings and for mounting press-fitted assemblies with high contact pressures of up to 125 N/mm², e.g. gearwheels and couplings.

The oil containers have a volume of 4 l (8-litre containers also available on request).

The pump is connected by means of an HP tube (2500 bar, 2 m long) and an adapter or reduction adapter (dimensions and connecting hole, see drawing and table).

If two connections have to be supplied with oil simultaneously, the pump set is additionally fitted with a two-way valve. Oil supply is then effected through two high-pressure tubes.

The pump sets are delivered ready for use in a metal box.

Hand pump set PUMPE2500.4L
(for 1 connection)

Scope of delivery:

1 hand pump (2500 bar) with a 4-litre oil container with an oil filling of Shell Voltol sliding oil 46 (viscosity 46 mm²/s at 40 °C)
1 attached pressure-gauge connecting piece
1 pressure gauge (0-2500 bar, dia 100 mm)
1 HP tube (2500 bar, 2 m long)
1 closing nipple G 1/4
1 adapter G 1/4, and 3 reduction adapters (G 3/8, G 1/2, G 3/4)
1 metal box 940 x 280 x 280 mm
Weight (incl. oil filling and metal box) 27 kg

Order designation:
PUMPE2500.4L

Hand pump set PUMPE2500.4L.V
(for 2 connections)

Scope of delivery:

1 hand pump (2500 bar) with a 4-litre oil container with an oil filling of Shell Voltol sliding oil 46 (viscosity 46 mm²/s at 40 °C)
1 attached two-way valve (with pressure-gauge connection)
1 pressure gauge (0-2500 bar, dia 100 mm)
2 HP tubes (2500 bar, 2 m long)
2 closing nipples G 1/4
each 2 adapters G 1/4 and reduction adapters G 3/8, G 1/2, G 3/4
1 metal box 940 x 280 x 280 mm
Weight (incl. oil filling and metal box) 30 kg

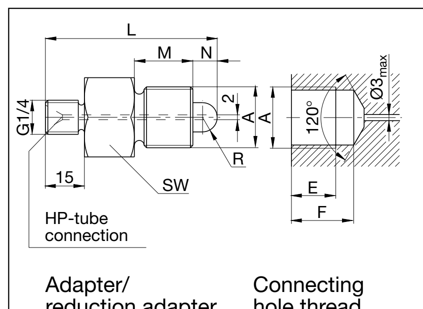
Order designation:
PUMPE2500.4L.V

Order designation for repair kit for the two-step, 2500-bar pumps:
KIT.PUMPE2500.4L

Oil volume per stroke

up to 20 bar	**20 to 2500 bar**
cm³	
32	0.9

Reduction adapters and adapters and connecting hole



Connecting thread A	Dimensions R	L	SW	M	N	E	F
	mm						
G 1/4	5.5	56	17	14	8	14	15
G 3/8	6.0	58	17	16	10	16	20
G 1/2	6.75	58	17	20	12	18	25
G 3/4	8.0	67	32	20	12	18	25

FAG Hand Pump Sets
Order designations

FAG hand pump sets (order designations)

Pump	Hand pump sets Basic design	with 8-litre container	with distributor	with 8-litre container and distributor
one-step 1000 bar	**PUMPE1000.0,7L**			
two-step				
1000 bar	**PUMPE1000.4L**	**PUMPE1000.8L**	**PUMPE1000.4L.V**	**PUMPE1000.8L.V**
1600 bar	**PUMPE1600.4L**	**PUMPE1600.8L**	**PUMPE1600.4L.V**	**PUMPE1600.8L.V**
2500 bar	**PUMPE2500.4L**	**PUMPE2500.8L**	**PUMPE2500.4L.V**	**PUMPE2500.8L.V**

Repair kits

KIT.PUMPE1000.0,7L	0.2 kg
KIT.PUMPE1000.4L	0.4 kg
KIT.PUMPE1600.4L	0.4 kg
KIT.PUMPE2500.4L	0.6 kg

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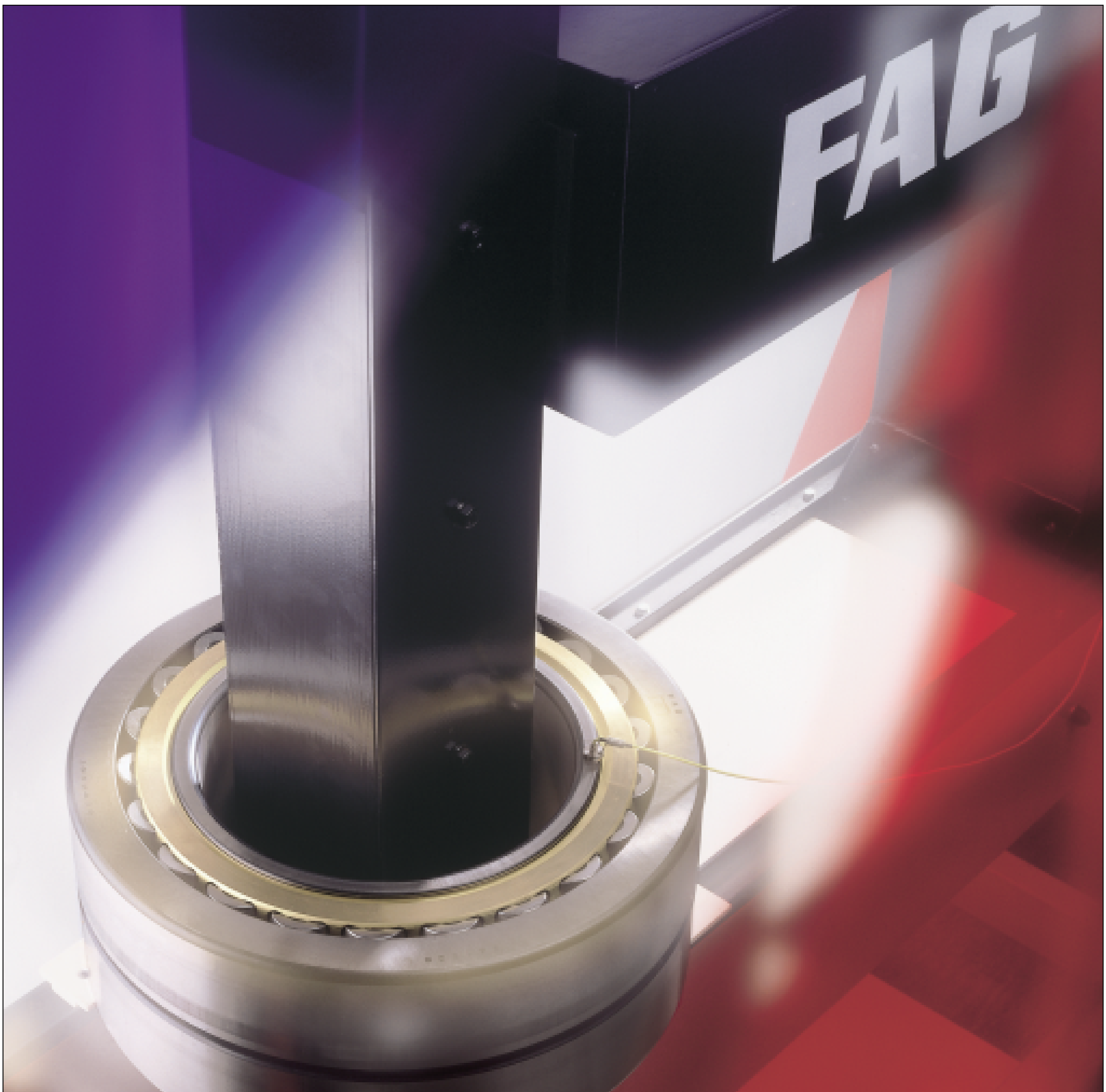
Technical Information

FAG

Rolling Bearings

TI No. WL 80-47 E March 2000

FAG Induction Heating Devices
AWG.MINI · AWG3,5 · AWG8
AWG13 · AWG25 · AWG40



Induction heating devices

Application · Advantages · Basic principle · Safety

Application

Many rolling bearings and other rotationally symmetric steel parts are fitted tightly on the shaft. Especially larger parts can be considerably easier fitted if they are heated prior to mounting (rolling bearings up to a maximum of 120 °C). Induction heating is superior to traditional methods such as heating furnaces, heating plates or oil baths.

The induction heating methods are fast and clean. They are, therefore, particularly suitable for batch mounting. The devices can be used for heating complete bearings, rings of cylindrical roller bearings or needle roller bearings, as well as other rotationally symmetric steel parts such as labyrinth rings, roll couplings, tyres, etc.

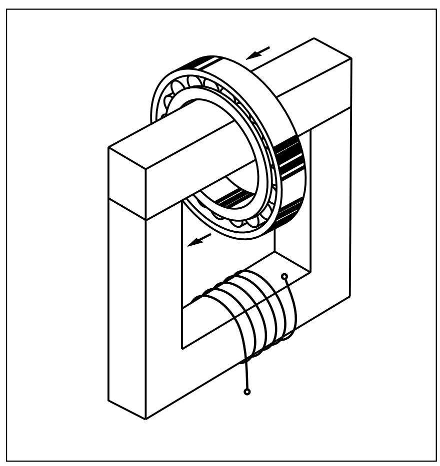
FAG offers six sizes of induction heating devices which cover a wide range of applications.

Advantages

- fast, energy-saving working
- suitable for rolling bearings and other ring-shaped steel parts
- extremely safe operation
- environmentally compatible, no oil required (no disposal)
- uniform, controlled heating
- simple operation
- automatic demagnetization
- very efficient as the most suitable size can be selected for every application

Basic principle

Basically, the heating device consists of a live coil with an iron core (primary coil) which induces in a short-circuited secondary circuit (rolling bearing or other steel part) a high current at low voltage. The part to be mounted is heated quickly. Non-metallic components and the device itself are not heated.



Safety

The FAG induction heating devices bear the CE symbol.

Operating errors or malfunctions are indicated by an acoustic or optical signal. This may happen if the temperature sensor is not correctly attached, if the sensor or the sensor wire is damaged, or if the part to be heated is too heavy for the device.

Every induction heating device generates a strong magnetic field. Such a magnetic field can have a negative effect on pacemakers and watches, disks, credit cards and other data carriers as well as electronic circuits in instruments. The safety distance is two meters.

The devices must not be used in a damp environment or in hazardous locations.

Every device comes with detailed operating instructions and safety gloves.

Induction heating devices
Programme

Programme of FAG induction heating devices (basic designs*)

Heating device	**AWG.MINI**	**AWG3,5**	**AWG8**
			
max. power consumption	3.5 kVA	3.5 kVA	8 kVA
Voltage/Frequency	230 V / 50 Hz	230 V / 50 Hz	400 V / 50 Hz
Current	16 A	16 A	20 A
Weight	19 kg	45 kg	56 kg
Length	420 mm	320 mm	470 mm
Width	230 mm	330 mm	310 mm
Height	265 mm	335 mm	455 mm
Ledges (incl.)	14x14x200 mm 20x20x200 mm 30x30x200 mm 40x40x200 mm	20x20x270 mm 30x30x270 mm 40x40x270 mm 60x60x270 mm	70x70x350 mm
Clear width between supports	120 mm	145 mm	210 mm
Clear height	140 mm	155 mm	195 mm
Ledges (accessories)	-	14x14x270 mm 17.5x17.5x270 mm 24.5x24.5x270 mm	20x20x350 mm 30x30x350 mm 40x40x350 mm 50x50x350 mm 60x60x350 mm
Workpiece			
max. width	120 mm	145 mm	210 mm
max. weight	20 kg	40 kg	100 kg

* On request FAG will also supply heating devices with other rated voltages and frequencies.

AWG13	AWG25	AWG40	Heating devices with higher power on request.
			
13 kVA	25 kVA	40 kVA	
400 V / 50 Hz	400 V / 50 Hz	400 V / 50 Hz	
32 A	63 A	100 A	
108 kg	350 kg	600 kg	
1000 mm	1045 mm	1800 mm	
500 mm	500 mm	685 mm	
1000 mm	1370 mm	1400 mm	
80x80x490 mm	100x100x700 mm	150x150x850 mm	
330 mm	385 mm	600 mm	
300 mm	420 mm	450 mm	
20x20x490 mm 30x30x490 mm 40x40x490 mm 60x60x490 mm	30x30x700 mm 40x40x700 mm 60x60x700 mm 80x80x700 mm	60x60x850 mm 80x80x850 mm 100x100x850 mm	
330 mm	385 mm	600 mm	
200 kg	400 kg	800 kg	

Induction heating devices
AWG.MINI

Induction heating device AWG.MINI

The FAG induction heating device AWG.MINI is suitable for bearings with bore diameters of 20 mm and more, and weighing up to 40 kg. Sealed, greased bearings and other rotationally symmetric steel parts can also be heated.

The heating device comes with support ledges and magnetic temperature sensor in a sturdy, scratch-resisistant case which is easy to handle. It is particularly suitable for mobile fitting missions.

The two lateral supports carry the support ledge with the part to be heated. The case contains four different support ledges for various workpiece sizes.

The contact areas of the support ledges and supports are ground so that energy losses are kept low.

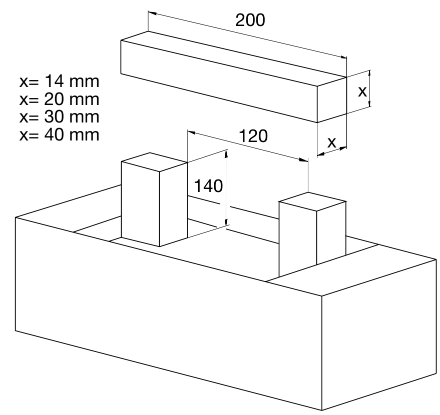
The heating device can be connected to any normal, 16-A two-pin safety socket. The clearly structured control panel with clear-cut symbols for the different operating modes can even be operated wearing work gloves. The foil keyboard is oil-resistant, dust-proof and water-proof. All operating modes and functions can be controlled by means of four keys.

The device offers temperature hold and time control modes.

In the temperature hold mode the heat-up temperature is adjusted between 50 and 240°C. The device holds the workpiece at the preselected temperature, which is monitored by the attached magnetic temperature sensor. When the selected temperature is reached the device emits a buzzing sound and the display flashes. When the Stop key is pressed the part is automatically demagnetized.

In the time control mode the desired heat-up time (up to 100 minutes) is set. After the selected period the bearing is automatically demagnetized. A prolonged buzzing sound indicates the end of the process. During the heating process the magnetic temperature sensor can be attached, and the temperature measured. The time control mode is especially convenient if several bearings of the same size have to be heated. During the first heating cycle the time needed to reach the required temperature is stored. Then each bearing of the batch is heated for the same period of time.

Order designation:
AWG.MINI



General data

Time control	adjustable between 0 and 100 min
Temperature hold	adjustable between 50 and 240 °C, with safety mechanism for rolling bearings
Bearing bore d	min. 20 mm
Bearing weight G	max. 20 kg

Electrical data

Operating voltage	230 V
Frequency	50 cps
Power consumption	3.5 kVA
Rated current	16 A
Retained magnetism	< 2 A/cm
Operating cycle	100 %

Scope of delivery: Device, ready for service, with 4 support ledges (14, 20, 30, 40) and magnetic temperature sensor in a carrying case

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Heating device	**AWG.MINI**	420x230x265	20	19

Spare parts

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Support ledge	**AWG.MINI.L14**	14x14x200	20	0.3
Support ledge	**AWG.MINI.L20**	20x20x200	30	0.6
Support ledge	**AWG.MINI.L30**	30x30x200	45	1
Support ledge	**AWG.MINI.L40**	40x40x200	60	2.5
Magnetic temperature sensor	**AWG.M**			0.05
Electronic spare parts kit	**AWG.MINI.E**			0.45

Induction heating devices
AWG3,5

Induction heating devices

The FAG induction heating device AWG3,5 is suitable for bearings with bore diameters of 30 mm (with accessories 20 mm) and more, and weighing up to 40 kg. Sealed, greased bearings and other rotationally symmetric steel parts can also be heated.

The heating device has a sturdy, scratch-resistant polyurethane housing. It can be easily handled thanks to its lateral handholds.

The two lateral supports carry the support ledge with the part to be heated. FAG provides four different support ledges for various workpiece sizes in a metal box (three more support ledges are available as special accessories).

The contact areas of the support ledges and supports are ground so that energy losses are kept low.

The heating device can be connected to any normal, 16-A two-pin safety socket.

The clearly structured control panel with clear-cut symbols for the different operating modes can even be operated wearing work gloves. The foil keyboard is oil-resistant, dust-proof and water-proof. All operating modes and functions can be controlled by means of six keys.

The device offers temperature hold, temperature control and time control modes.

In the temperature hold mode a heat-up temperature of up to 240°C is set. The device holds the workpiece at the preselected temperature. After about every 30 seconds a buzzing sound indicates that the selected temperature has been reached. When the Stop key is pressed the part is automatically demagnetized.

In the temperature control mode the desired heat-up temperature is set in steps of 1°C. After the preselected temperature is reached the bearing (workpiece) is automatically demagnetized. A prolonged buzzing sound indicates the end of the process.

In the time control mode the desired heat-up time (up to 999 s) is set in 1-second steps. After the selected period the bearing is automatically demagnetized. A prolonged buzzing sound indicates the end of the process. The time control mode is especially convenient if batches of identical bearings have to be heated. During the first heating cycle the time needed to reach the specified temperature is stored. Then each bearing of the batch is heated for the same period of time. The magnetic temperature sensor does not have to be attached.

Additional functions

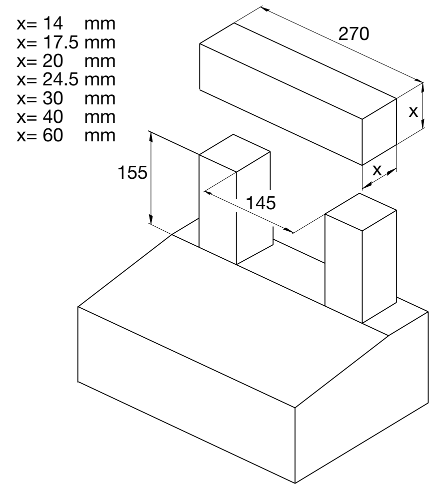
- Power reduction
- Selected and actual temperatures and times are displayed
- Menu guidance in 9 languages
- Temperature display either in °C or °F

Accessories

For parts with a smaller bore diameter the following accessories are available:
- 20 mm and more
  Support ledge 14x14x270 mm
  Order designation: **AWG3,5.L14**
- 25 mm and more
  Support ledge 17.5x17.5x270 mm
  Order designation: **AWG3,5.L17**
- 35 mm and more
  Support ledge 24.5x24.5x270 mm
  Order designation: **AWG3,5.L24**

Order designation: **AWG3,5**

Induction heating devices
AWG3,5 · Technical Data



General Data

Time control	adjustable up to 999 s
Temperature hold/ Temperature control	adjustable up tp 240 °C, with safety mechanism for rolling bearings
Bearing bore d	min. 30 mm (with accessories, min. 20 mm)
Bearing weight G	max. 40 kg

Electrical Data

Operating voltage	220 V to 240 V	Rated current	16 A
Frequency	50 cps	Retained magnetsim	< 2 A/cm
power consumption	3.5 kVA	Operating cycle	100 %

Scope of delivery: Device, ready for service, in a metal box, with 4 support ledges (20, 30, 40, 60) and magnetic temperature sensor

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Heating device, complete	**AWG3,5**	320x330x335	30	45

Spare parts

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Metal box	**AWG3,5.BOX**			
Support ledge	**AWG3,5.L20**	20x20x270	30	0.8
Support ledge	**AWG3,5.L30**	30x30x270	45	1.4
Support ledge	**AWG3,5.L40**	40x40x270	60	3.4
Support ledge	**AWG3,5.L60**	60x60x270	85	7.6
Magnetic temperature sensor	**AWG3,5.M**			
Elektronic spare parts kit	**AWG3,5.E**			

Accessories

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Support ledge	**AWG3,5.L14**	14x14x270	20	0.4
Support ledge	**AWG3,5.L17**	17.5x17.5x270	25	0.6
Support ledge	**AWG3,5.L24**	24.5x24.5x270	35	1.3

Special design

This device is also available for a rated voltage of 110 V/60 Hz.
Order designation: **AWG3,5.V110**

Induction heating devices
AWG8

Induction heating device AWG8

The FAG induction heating device AWG8 is suitable for heating ring-shaped metal workpieces with bore diameters of 100 mm (with accessories 30 mm) and more to a maximum temperature of 240°C. The workpieces may weigh up to 100 kg.

The heating device has a sturdy, scratch-resistant polyurethane housing.

The slewing mechanism facilitates the loading of heavy parts. The clearly structured control panel with clear-cut symbols for the different operating modes can even be operated wearing work gloves. The foil keyboard is oil-resistant, dust-proof and water-proof.

The basic design of the device comes with a magnetic temperature sensor which can be used up to 240 °C. The rated voltage is 400 V, the frequency 50 cps.

The device offers temperature hold, temperature control and time control modes.

In the temperature hold mode the heat-up temperature is freely adjusted between 50 and 240 °C. The device holds the workpiece at the previously selected temperature. When the Stop key is pressed the part is automatically demagnetized.

In the temperature control mode the desired heat-up temperature is freely adjusted between 50 and 240 °C. After the preselected temperature is reached the workpiece is automatically demagnetized; the device switches off. A prolonged buzzing sound indicates the end of the process.

In the time control mode the desired heat-up time (up to 100 minutes) is freely adjusted. After the selected period the workpiece is automatically demagnetized; the device switches off. An acoustic signal indicates the end of the process.

The time control mode is especially convenient if batches of identical bearings or workpieces have to be heated. During the first heating cycle the time needed to reach the required temperature is stored. Then each bearing of the batch is heated for the same period of time. The temperature sensor does not have to be attached.

Additional functions

- Demagnetization without heating
- Power reduction
- Programme interruption
- Actual temperatures can be called up

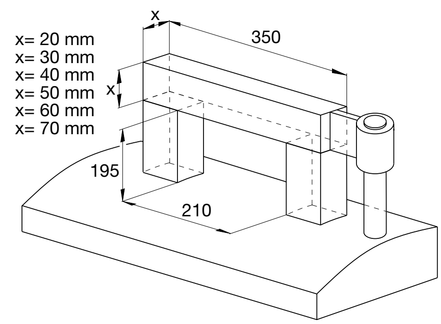
Accessories

For parts with a smaller bore diameter the following accessories are available:
- 30 mm and more
  Slewing ledge 20x20x350 mm
  Order designation: **AWG8.L20**
- 45 mm and more
  Slewing ledge 30x30x350 mm
  Order designation: **AWG8.L30**
- 60 mm and more
  Slewing ledge 40x40x350 mm
  Order designation: **AWG8.L40**
- 75 mm and more
  Slewing ledge 50x50x350 mm
  Order designation: **AWG8.L50**
- 85 mm and more
  Slewing ledge 60x60x350 mm
  Order designation: **AWG8.L60**

Order designation: **AWG8**

Induction heating devices

AWG8 · Technical data



General Data

Time control	adjustable from 0 to 100 min
Temperature hold/ Temperature control	adjustable from 50 to 240 °C, with safety mechanism for rolling bearings
Bearing bore d	min. 100 mm (with accessories, min. 30 mm)
Bearing weight G	max. 100 kg

Electrical Data

Operating voltage	400 V	Rated current	20 A
Frequency	50/60 cps	Retained magnetism	< 2 A/cm
Power consumption	8 kVA		

Scope of delivery: Device, ready for service, with slewing ledge 70x70x350 mm, and magnetic temperature sensor

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Heating device, complete	**AWG8**	470x310x455	100	56

Spare parts

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Slewing ledge	**AWG8.L70**	70x70x350	100	12.8
Magnetic temperature sensor	**AWG.M**			0.05
Electronic spare parts kit	**AWG8.E**			0.45

Accessories

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Slewing ledge	**AWG8.L20**	20x20x350	30	1.04
Slewing ledge	**AWG8.L30**	30x30x350	45	2.4
Slewing ledge	**AWG8.L40**	40x40x350	60	4.2
Slewing ledge	**AWG8.L50**	50x50x350	75	6.55
Slewing ledge	**AWG8.L60**	60x60x350	85	9.4

Special designs

This device is also available for rated voltages of 200 V, 270 V, 440 V, 480 V, and 600 V.
Order designation, e.g. for 480 V: **AWG8.V480**

Induction heating devices
AWG13

Induction heating device AWG13

The FAG induction heating device AWG13 is suitable for heating ring-shaped metal workpieces with bore diameters of 115 mm (with accessories 30 mm) and more to a maximum temperature of 240°C. The workpieces may weigh up to 200 kg.

The solid-steel device is mounted on a sturdy trolley. A slewing mechanism facilitates the loading of heavy parts. The clearly structured control panel with clear-cut symbols for the different operating modes can even be operated wearing work gloves. The foil keyboard is oil-resistant, dust-proof and water-proof.

The basic design of the device comes with a magnetic temperature sensor which can be used up to 240°C. The rated voltage is 400 V, the frequency 50 cps.

The device offers temperature hold, temperature control and time control modes.

In the temperature hold mode a heat-up temperature between 50 and 240°C is freely adjusted. The device holds the workpiece at the preselected temperature. When the Stop key is pressed the part is automatically demagnetized.

In the temperature control mode the desired heat-up temperature is freely adjusted between 50 and 240°C. After the preselected temperature is reached the workpiece is automatically demagnetized; the device switches off. An acoustic signal indicates the end of the process.

In the time control mode the desired heat-up time (up to 100 minutes) is freely adjusted. After the selected period the workpiece is automatically demagnetized; the device switches off. An acoustic signal indicates the end of the process.

The time control mode is especially convenient if batches of identical bearings or workpieces have to be heated. During the first heating cycle the time needed to reach the required temperature is stored. Then each bearing of the batch is heated for the same period of time. The temperature sensor does not have to be attached.

Additional functions

- Demagnetization without heating
- Power reduction
- Programme interruption
- Selected and actual temperatures and times are displayed

Accessories

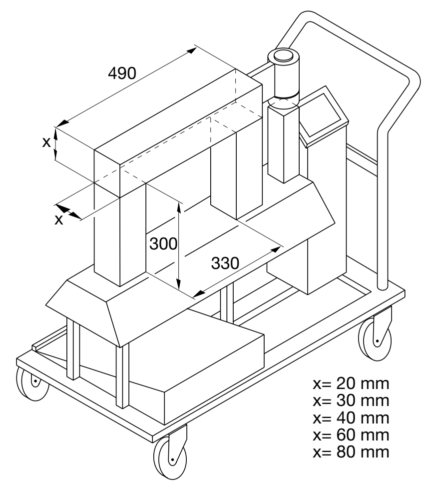
For parts with a smaller bore diameter the following accessories are available:
- 30 mm and more
  Slewing ledge 20x20x490 mm
  Order designation: **AWG13.L20**
- 45 mm and more
  Slewing ledge 30x30x490 mm
  Order designation: **AWG13.L30**
- 60 mm and more
  Slewing ledge 40x40x490 mm
  Order designation: **AWG13.L40**
- 85 mm and more
  Slewing ledge 60x60x490 mm
  Order designation: **AWG13.L60**

Order designation: **AWG13**

Induction heating devices
AWG13 · Technical data

General data

Time control	adjustable from 0 to 100 min
Temperature hold/ Temperature control	adjustable from 50 to 240°C, with safety mechanism for rolling bearings
Bearing bore d	min. 115 mm (with accessories, min. 30 mm)
Bearing weight G	max. 200 kg



Electrical data

Operating voltage	400 V	Rated current	32 A
Frequency	50/60 cps	Retained magnetism	< 2 A/cm
Power consumption	13 kVA		

Scope of delivery: Device, ready for service, with slewing ledge 80x80x490 mm, and magnetic temperature sensor

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Heating device, complete	**AWG13**	1000x500x1000	115	108

Spare parts

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Slewing ledge	**AWG13.L80**	80x80x490	115	24
Magnetic temperature sensor	**AWG.M**			0.05
Electronic spare parts kit	**AWG13.E**			0.45

Accessories

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Slewing ledge	**AWG13.L20**	20x20x490	30	2
Slewing ledge	**AWG13.L30**	30x30x490	45	4
Slewing ledge	**AWG13.L40**	40x40x490	60	9
Slewing ledge	**AWG13.L60**	60x60x490	85	14

Special designs:

This device is also available for rated voltages of 200 V, 270 V, 440 V, 480 V, and 600 V.

Order designation, e. g. for 480 V: **AWG13.V480**

Induction heating devices
AWG25

Induction heating device AWG25

The FAG induction heating device AWG25 is suitable for heating ring-shaped metal workpieces with bore diameters of 145 mm (with accessories 45 mm) and more to a maximum temperature of 240 °C. The workpieces may weigh up to 400 kg.

The solid-steel device is coated with synthetic resin which is resistant to impacts and corrosion.

The clearly structured control panel with clear-cut symbols for the different operating modes can even be operated wearing work gloves. The foil keyboard is oil-resistant, dust-proof and water-proof.

The basic design of the device comes with a magnetic temperature sensor which can be used up to 240 °C. The rated voltage is 400 V, the frequency 50 cps.

The device offers temperature hold, temperature control and time control modes.

In the temperature hold mode a heat-up temperature between 50 and 240 °C is freely adjusted. The device holds the workpiece at the preselected temperature. When the Stop key is pressed the part is automatically demagnetized.

In the temperature control mode the desired heat-up temperature is freely adjusted between 50 and 240 °C. After the preselected temperature is reached the workpiece is automatically demagnetized; the device switches off. An acoustic signal indicates the end of the process.

In the time control mode the desired heat-up time (up to 100 minutes) is freely adjusted. After the selected period the workpiece is automatically demagnetized; the device switches off. An acoustic signal indicates the end of the process.

The time control mode is especially convenient if batches of identical bearings or workpieces have to be heated. During the first heating cycle the time needed to reach the required temperature is stored. Then each bearing of the batch is heated for the same period of time. The temperature sensor does not have to be attached.

Additional functions

- Demagnetization without heating
- Programme interruption

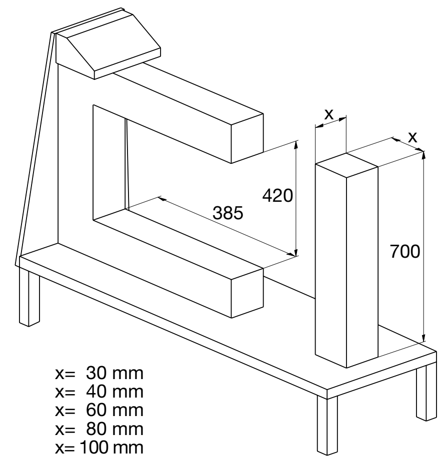
Accessories

For parts with a smaller bore diameter the following accessories are available:

- 45 mm and more
  Ledge 30x30x700 mm
  Order designation: **AWG25.L30**
- 60 mm and more
  Ledge 40x40x700 mm
  Order designation: **AWG25.L40**
- 85 mm and more
  Ledge 60x60x700 mm
  Order designation: **AWG25.L60**
- 115 mm and more
  Ledge 80x80x700 mm
  Order designation: **AWG25.L80**

Order designation: **AWG25**

Induction heating devices
AWG25 · Technical data



General data

Time control	adjustable from 0 to 100 min
Temperature hold/ Temperature control	adjustable from 50 to 240°C, with safety mechanism for rolling bearings
Bearing bore d	min. 145 mm (with accessories, min. 45 mm)
Bearing weight G	max. 400 kg

Electrical data

Operating voltage	400 V	Rated current	63 A
Frequency	50/60 cps	Retained magnetism	< 2 A/cm
Power consumption	25 kVA		

Scope of delivery: Device, ready for service, with ledge 100x100x700 mm and magnetic temperature sensor

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Heating device, complete	**AWG25**	1045x500x1370	145	350

Spare parts

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Ledge	**AWG25.L100**	100x100x700	145	52.4
Magnetic temperature sensor	**AWG.M**			0.05
Electronic spare parts kit	**AWG25.E**			0.45

Accessories

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Ledge	**AWG25.L30**	30x30x700	45	4.7
Ledge	**AWG25.L40**	40x40x700	60	8.4
Ledge	**AWG25.L60**	60x60x700	85	18.8
Ledge	**AWG25.L80**	80x80x700	115	33.5

Special designs:

This device is also available for rated voltages of 200 V, 270 V, 440 V, 480 V, and 600 V.

Order designation, e. g. for 480 V: **AWG25.V480**

Induction heating device AWG40

The FAG induction heating device AWG40 is suitable for heating ring-shaped metal workpieces with bore diameters of 220 mm (with accessories 85 mm) and more to a maximum temperature of 240 °C. The workpieces may weigh up to 800 kg.

The all-steel construction is coated with synthetic resin which is resistant to impacts and corrosion.

The clearly structured control panel with clear-cut symbols for the different operating modes can even be operated wearing work gloves. The foil keyboard is oil-resistant, dust-proof and water-proof.

The basic design of the device comes with a magnetic temperature sensor which can be used up to 240°C. The rated voltage is 400 V, the frequency 50 cps.

The device offers temperature hold, temperature control and time control modes.

In the temperature hold mode a heat-up temperature between 50 and 240°C is freely adjusted. The device holds the workpiece at the preselected temperature. When the Stop key is pressed the part is automatically demagnetized.

In the temperature control mode the desired heat-up temperature is freely adjusted between 50 and 240°C. After the preselected temperature is reached the workpiece is automatically demagnetized; the device switches off. An acoustic signal indicates the end of the process.

In the time control mode the desired heat-up time (up to 100 minutes) is freely adjusted. After the selected period the workpiece is automatically demagnetized; the device switches off. An acoustic signal indicates the end of the process.

The time control mode is especially convenient if batches of identical bearings or workpieces have to be heated. During the first heating cycle the time needed to reach the required temperature is stored. Then each bearing of the batch is heated for the same period of time. The temperature sensor does not have to be attached.

Additional functions

- Demagnetization without heating
- Power reduction
- Programme interruption

Accessories

For parts with a smaller bore diameter the following accessories are available:
- 85 mm and more
  Ledge 60x60x850 mm
  Order designation: **AWG40.L60**
- 115 mm and more
  Ledge 80x80x850 mm
  Order designation: **AWG40.L80**
- 145 mm and more
  Ledge 100x100x850 mm
  Order designation: **AWG40.L100**

The device AWG40 is delivered without plug and cable.

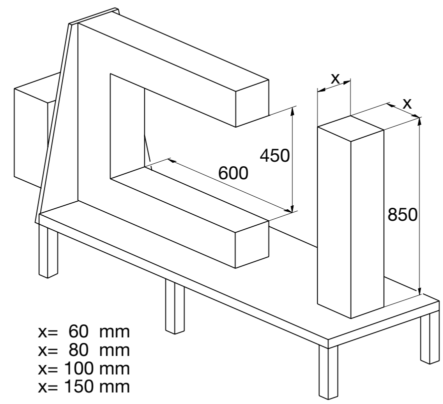
Order designation: **AWG40**

Induction heating devices

AWG40 · Technical data

General data

Time control	adjustable from 0 to 100 min
Temperature hold / Temperature control	adjustable from 50 to 240 °C with safety mechanism for rolling bearings
Bearing bore d	min. 220 mm (with accessories, min. 85 mm)
Bearing weight G	max. 800 kg



Electrical data

Operating voltage	400 V	Rated current	100 A
Frequency	50/60 cps	Retained magnetism	< 2 A/cm
Power consumption	40 kVA		

Scope of delivery: Device, ready for service, with ledge 150x150x850 mm, and magnetic temperature sensor.

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Heating device, complete	**AWG40**	1800x685x1400	220	600

Spare parts

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Ledge	**AWG40.L150**	150x150x850	220	143
Magnetic temperature sensor	**AWG.M**			0.05
Electronic spare parts kit	**AWG40.E**			0.45

Accessories

Designation	Order designation	Dimensions mm	for bore diameters from mm	Weight kg
Ledge	**AWG40.L60**	60x60x850	85	22.9
Ledge	**AWG40.L80**	80x80x850	115	40.7
Ledge	**AWG40.L100**	100x100x850	145	63.6

Special designs:

This device is also available for rated voltages of 200 V, 270 V, 440 V, 480 V, and 600 V.
Order designation, e. g. for 480 V: **AWG40.V480**

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FAG Induction Heating Devices

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Technical Information

TI No. WL 80-48 E April 1999

Rolling Bearings

FAG Mechanical Extractors

Small rolling bearings with bore diameters of up to about 100 mm which have an interference fit on the shaft or in the housing are usually dismounted by means of mechanical extractors. The bearings can be dismounted without getting damaged if the device is applied at the tightly fitted bearing ring.

With FAG mechanical extractors, the extraction force is usually applied by means of threaded spindles. Hydraulic pressure tools make the job easier in some cases.
Larger bearings are usually dismounted using the hydraulic method or induction heating devices.

In this TI the fields of application and the operation of the FAG mechanical extractors are described. Apart from two-, three- and four-arm extractors and a hydraulic pressure tool, special extractors are described.

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Two-Arm Extractor 54

Application

- For extracting complete rolling bearings of all types or tightly fitted inner rings as well as other parts, e.g. gearwheels, that are gripped from inside or outside.
- Good radial and axial accessibility of the bearing location, possibly slots, required

Operation

Depending on bearing size and mounting conditions, the extractor with the suitable dimensions is selected. The extraction arms are adjusted on the cross arm until they have the right span. When the spindle is screwed in, a self-locking mechanism prevents the arms from slipping off.

Rolling bearing rings that are extracted correctly remain undamaged. Complete bearings where the extraction force is transmitted through the rolling elements usually become unserviceable.

Programme

Order designation Two-arm extractor	**Span** mm	**Depth** mm	**Weight** ≈ kg
ABZIEHER54.100	80	100	0.75
ABZIEHER54.200	120	125	0.9
ABZIEHER54.300	160	150	2.3
ABZIEHER54.400	200	175	2.5
ABZIEHER54.500	250	200	3.45
ABZIEHER54.600	350	250	4.4
ABZIEHER54.SET *)			15.5

*) consists of a holder (W x D x H) 215 x 235 x 475 mm, complete with the 6 extractors listed above

Two-Arm Bearing Extractor 47

Application

- For extracting complete rolling bearings or tightly fitted inner rings
- Bearing rings may be fitted against a surface, i.e. slots are not required

Operation

Depending on bearing size and mounting conditions, the extractor with the suitable dimensions is selected. By means of the tightening shackle the ring to be extracted can be wedged loose by means of the specially shaped arms. The wedging and centering on the shaft are important for dismounting bearings without damage.

Rolling bearing rings that are extracted correctly do not get damaged. Complete bearings where the extraction force is transmitted through the rolling elements usually become unserviceable.

Programme

Order designation	Span	Depth	Weight ≈
Two-arm extractor	mm	mm	kg
ABZIEHER47.100	45	65	0.55
ABZIEHER47.200	90	100	1.45

Three-Arm Extractor 52

Application

- For extracting complete rolling bearings or tightly fitted inner rings
- Good radial and axial accessibility of the bearing location, possibly slots, required
- Big extractors (spans 390 and 640 mm) can be equipped with a hydraulic spindle

Operation

Depending on bearing size and mounting conditions, the extractor with the suitable dimensions is selected. The span can be adjusted by shifting the lever system on the cylinder. During the extraction process the lever system causes self-locking of the arms and ensures a good grip.

Rolling bearing rings that are extracted correctly remain undamaged. Complete bearings where the extraction force is transmitted through the rolling elements usually become unserviceable.

Programme

Order designation Three-arm extractor	**Span** mm	**Depth** mm	**Weight** ≈ kg
ABZIEHER52.085	85	65	0.36
ABZIEHER52.130	130	105	2.4
ABZIEHER52.230	230	150	5.4
ABZIEHER52.295	295	235	6.2
ABZIEHER52.390	390	270	12.3
ABZIEHER52.640	640	300	15.8

Three-Arm Extractor 53

Application

- For extracting complete rolling bearings or tightly fitted inner rings as well as similar parts
- Good radial and axial accessibility of the bearing location, possibly slots, required

Operation

Depending on bearing size and mounting conditions, the extractor with the suitable dimensions is selected. The span can be adjusted by turning the knurled disk above the upper star. The two stars move on the cylinder symmetrically to each other so that the entire spread range can be covered with just a few rotations. The arms are locked during the extraction process so that they cannot be opened accidentally.

Rolling bearing rings that are extracted correctly do not get damaged. Complete bearings where the extraction force is transmitted through the rolling elements usually become unserviceable.

The availability of hydraulically assisted larger extractors will be indicated on inquiry.

Programme

Order designation Three-arm extractor	**Span**	**Depth**	**Weight** ≈
	mm	mm	kg
ABZIEHER53.130	130	105	1.9
ABZIEHER53.230	230	150	4
ABZIEHER53.295	295	235	5.1
ABZIEHER53.390	390	270	10
ABZIEHER53.640	640	300	13.8

Hydraulic Pressure Tool 44

Application

The pressure tool is usually used to loosen tightly fitted parts in conjunction with mechanical extractors.

Operation

The hydraulic pressure tool generates an axial force of 80 or 150 kN, respectively, thus making the job considerably easier. The spindle thread of the mechanical extractor is not unduly stressed as the main extraction force acts on static thread flanks.

The pressure tool 44.150 features a hydraulic resetting mechanism, i.e. when the thrust bolt is reversed the hydraulic system automatically returns to its normal position.

The hydraulic pressure tool is applied between shaft end and extractor spindle. Then the spindle is applied. The hydraulic system is actuated by screwing in the thrust bolt. The axial force generated will loosen the part. The part can then be extracted in the usual manner with the mechanical spindle.

For safety reasons, the minimum spindle diameter and the maximum torque (see table) must be observed.

Programme

Order designation Hydraulic pressure tool	**Axial force** kN	**Stroke** mm	**Section height** mm	**Spindle diameter** min. mm	**Torque** max. N m	**Weight** ≈ kg
ABZIEHER44.080	80	7	35	M22	25	0.6
ABZIEHER44.150	150	10	85	M30	50	1.74

Ball Bearing Extractor 56

Application

– For extracting complete radial ball bearings

– For ball bearings with a tightly fitted outer ring

– For bearings that are radially not accessible

– As the extraction hooks are applied at the outer ring and the threaded spindle is applied at the shaft, the extraction force is transmitted via the rolling elements, rendering the bearing unserviceable.

Operation

The extractor claws grasp the raceway edge of the outer ring between the balls and are supported by the inner ring. The bearing is extracted by means of a threaded spindle.

Depending on the bearing size, one of three extractor sizes and one of 13 sets of claws (see table on page 9) is selected. The number of arms required, and their arrangement, depends on the number of balls in the bearing.

Complete extractor sets consist of one extractor, three or five sets of claws and a wrench with T-shaped handle in a box, see table below.

Programme

Order designation Ball bearing extractor set	**Depth** mm	**with claws nos.**	**Wrench with T-shaped handle**	**Weight** ≈ kg
ABZIEHER56.020.SET	65	01, 02, 03	SW14	2.1
ABZIEHER56.120.SET	90	1, 2, 3, 4, 5	SW22	3.45
ABZIEHER56.220.SET	150	7, 11, 16, 17, 23	SW22	4.15

Mechanical Extractors

Ball Bearing Extractor 56

Allocation of extractor sets, extractors and claws to standard rolling bearings

Extractor set	Extractor	Bearing	Claw no.	Bearing	Claw no.	Bearing	Claw no	Bearing	Claw no.
ABZIEHER56.020.SET	**ABZIEHER56.000**	6004	01	6200	02	6300	01		
		6005	02	6201	02	6301	03		
		6006	01	6202	01	6302	03		
				6203	03				
				6204	03				
				6205	03				
ABZIEHER56.120.SET	**ABZIEHER56.100**	6007	1	6206	2	6303	2	6403	4
		6008	1	6207	3	6304	2	6404	5
		6009	1	6208	3	6305	3	6405	5
		6010	1	6209	4	6306	4		
		6011	2	6210	4	6307	4		
		6012	2	6211	4	6308	5		
		6013	2	6212	5				
		6014	3						
		6015	3						
		6016	4						
		6017	4						
		6018	5						
		6019	5						
		6020	5						
ABZIEHER56.220.SET	**ABZIEHER56.200**	6021	16	6213	16	6309	16	6406	16
				6214	16	6310	16	6408	7
				6215	16	6311	11	6409	17
				6216	16	6312	17	6410	17
				6217	7	6313	17	6412	23
				6218	17	6314	17		
				6219	17	6315	23		
						6316	23		
						6317	23		
						6318	23		
						6319	23		

Special Bearing Extractor 64

Application

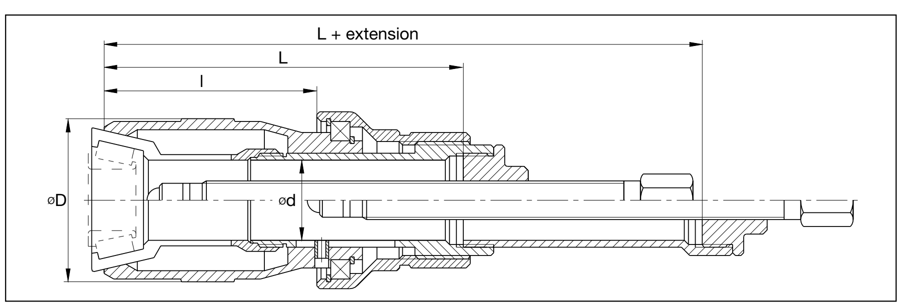
- For radial bearings (deep groove ball bearings, angular contact ball bearings, cylindrical roller bearings, tapered roller bearings and spherical roller bearings).
  Since the number of rolling elements is not standardized, the same bearing size from different manufacturers may require different collets. So when ordering an extractor the bearing manufacturer should always be indicated.
- Bearings with a tightly fitted inner or outer ring
- For applications where the inner ring is adjacent to a shaft shoulder without extraction slots; also applications where the bearing to be extracted from the shaft is still inside a housing.
- If handled correctly, the bearings can be extracted without getting damaged.

Operation

The special extractor consists of a basic unit and a collet which is screwed onto the upper part of the basic unit. The collet is closed via the left-hand thread of the coupling nut and clamped against the inner ring by means of a tapered clamping ring. A threaded spindle generates the extraction force.

The finger-shaped extensions of the collet engage between the rolling elements at the inner ring raceway edge, behind the rollers or behind the chamfer of the bearing ring, wedging it loose. The extraction principle must be observed when selecting the suitable collet for a specific bearing, see page 11.

The availability of hydraulically assisted larger extractors will be indicated on inquiry.



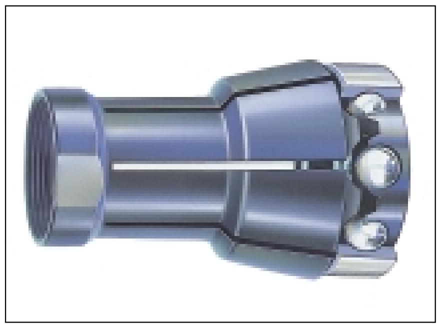
Programme

Order designation Basic unit to special extractor	Dimensions d mm	D mm	l mm	L mm	Weight ≈ kg
ABZIEHER64.400	30.5	60	78	135	1.25
ABZIEHER64.500	46	75	80	150	2.5
ABZIEHER64.600	66	100	92	170	3.8
ABZIEHER64.700	77	126	120	205	7.8

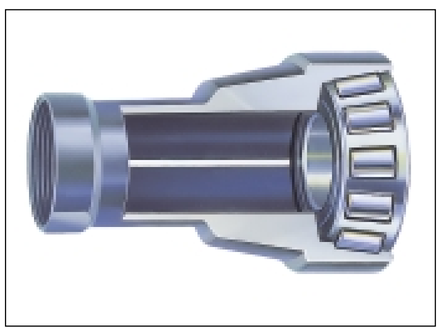
Collets for Special Bearing Extractor 64

The gripping profile of the collets must be adapted to the geometry of the bearing to be extracted. The extraction principle depends on bearing design and mounting situation.

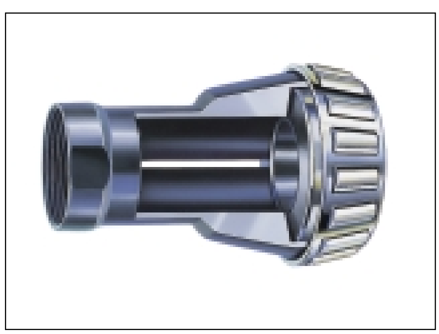
Extraction principle A:
for deep groove ball bearings, angular contact ball bearings, four point bearings, self-aligning ball bearings
The bearing is grasped at the inner ring. Bearings that are located deep in a housing can also be grasped if the bearing's O.D. is larger than that of the basic unit.
Code of the collets:
ABZIEHER64A. + bearing code



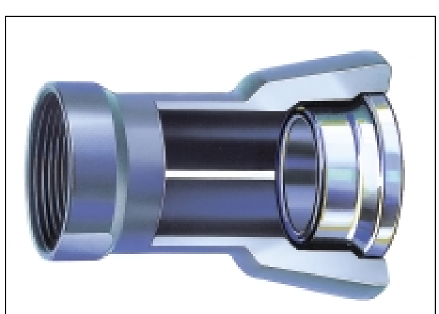
Extraction principle B:
for tapered roller bearings (mounted in X-arrangement)
The collet reaches over the rollers, irrespective of their number. Bearings of certain dimensions that are located deep on the shaft can also be extracted.
Code of the collets:
ABZIEHER64B. + bearing code



Extraction principle C:
for tapered roller bearings (mounted in O-arrangement)
The collet engages behind the inner ring's large lip.
Code of the collets:
ABZIEHER64C. + bearing code



Extraction principle D:
for the inner rings of cylindrical roller bearings and four point bearings, and for the outer rings of deep groove ball bearings and spherical roller bearings
Engaging behind the chamfer of the bearing ring and wedging the bearing loose.
Code of the collets:
ABZIEHER64D. + bearing code



Selection of basic unit and collet

The basic unit is always selected such that the bearing bore is smaller than the diameter d of the unit.

Examples of order designations for special bearing extractors, complete:

a) for deep groove ball bearings 6000 (Principle A):
ABZIEHER64.400A.6000
(Basic unit ABZIEHER64.400 + collet ABZIEHER64A.6000)

b) for tapered roller bearings 30203A (Principle B):
ABZIEHER64.400B.30203A
(Basic unit ABZIEHER64.400 + collet ABZIEHER64B.30203A)

c) for deep groove ball bearings 6007 (Principle A):
ABZIEHER64.500A.6007
(Basic unit ABZIEHER64.500 + collet ABZIEHER64A.6007)

d) for self-aligning ball bearings 2312 (Principle A):
ABZIEHER64.600A.2312
(Basic unit ABZIEHER64.600 + collet ABZIEHER64A.2312)

e) for cylindrical roller bearings NU315 (Principle D):
ABZIEHER64.700D.NU315
(Basic unit ABZIEHER64.700 + collet ABZIEHER64.700D.NU315)

Mechanical Extractors

Internal Extractor 62 and Countersupport

Internal Extractor 62

Application

- For deep groove ball bearings and angular contact ball bearings.
  Internal extractors are available in various sizes for bearing bores of up to ca. 70 mm.
- For bearings with a tightly fitted outer ring.
- The inner ring bore must be easily accessible
- As the extraction force is transmitted via the rolling elements, the bearing may get damaged.

Operation

The gripping segments spread when the threaded spindle is tightened, and the lip of the jaws is pressed behind the bore of the bearing's inner ring. The bearing is extracted by means of the threaded spindle.

Internal extractors are suitable for small diameter ranges only.

Order designations for sets:
ABZIEHER62.SET (two countersupports and nine internal extractors)
ABZIEHER62.SET.100 (countersupport ABZIEHER62.100 + 6 internal extractors)
ABZIEHER62.SET.200 (countersupport ABZIEHER62.200 + 3 internal extractors)

Order designation Internal extractor with countersupport	Countersupport	Internal extractor	for bore diameters from mm	to	Depth mm	Weight ≈ kg
ABZIEHER62.100.005	ABZIEHER62.100	ABZIEHER62.005	5	6.5	35	0.09
ABZIEHER62.100.007	ABZIEHER62.100	ABZIEHER62.007	7	9.5	35	0.09
ABZIEHER62.100.010	ABZIEHER62.100	ABZIEHER62.010	10	13.5	35	0.1
ABZIEHER62.100.014	ABZIEHER62.100	ABZIEHER62.014	14	19.5	45	0.13
ABZIEHER62.100.020	ABZIEHER62.100	ABZIEHER62.020	20	29.5	50	0.18
ABZIEHER62.100.030	ABZIEHER62.100	ABZIEHER62.030	30	39.5	90	0.25
ABZIEHER62.200.040	ABZIEHER62.200	ABZIEHER62.040	40	49.5	95	0.48
ABZIEHER62.200.050	ABZIEHER62.200	ABZIEHER62.050	50	59.5	95	0.56
ABZIEHER62.200.060	ABZIEHER62.200	ABZIEHER62.060	60	69.5	95	0.62

Extractor 49

Application

– For all rolling bearing types.
For extracting complete rolling bearings or tightly fitted inner rings.
The extractor and the separating device are available in various sizes with openings of up to 210 mm

– Especially for applications where the inner ring is adjacent to a shaft shoulder without extraction slots. The bearing location must be radially accessible without problems.

– If handled correctly, inner rings and complete rolling bearings are extracted without getting damaged

Operation

The two wedge-shaped halves of the separating device are inserted between shaft shoulder and inner ring by alternately tightening the nuts. The separating device is bolted to the extractor by means of two tie rods that are fastened on the extractor's cross arm. The bearing or inner ring is extracted by screwing in the spindle. For parts that are located very deep on a shaft tie rod extensions can be supplied.

Order designation Extractor with separating device	**Order designation** Extractor	**Span** mm	**Depth** mm	**Weight** ≈ kg	**Order desigantion** Separating device	**Span** mm	**Weight** ≈ kg
ABZIEHER49.100.060	ABZIEHER49.100	45 - 130	150	0.97	ABZIEHER49.060	60	0.57
ABZIEHER49.100.075	ABZIEHER49.100	45 - 130	150	0.97	ABZIEHER49.075	75	0.7
ABZIEHER49.200.115	ABZIEHER49.200	85 - 210	200	3.35	ABZIEHER49.115	115	1.75
ABZIEHER49.300.150	ABZIEHER49.300	100 - 300	300	6.2	ABZIEHER49.150	150	4
ABZIEHER49.400.210	ABZIEHER49.400	150 - 360	300	8.81	ABZIEHER49.210	210	10

Impact-Type Extractor 59

– For extracting sleeves or rings with a connection thread M10 or M14x1,5: The impact-type extractor is screwed to internal extractor 62 if no counter-support can be used.

Depending on the size of the internal extractor, one of two impact-type extractor sizes is recommended:
59.062 up to bore diameters of 39 mm,
59.362 up to bore diameters of 69 mm.

Operation of impact-type extractor and pin extractor

Extraction is effected by moving the impact weight on the slide bar. The size of the extractor used is determined by the application in hand.

Order designation Impact-type extractor	**Impact distance** mm	**Impact mass** kg	**Weight** ≈ kg
ABZIEHER59.062	90	0.9	1.2
ABZIEHER59.362	300	0.9	1.4

Pin extractor 59

– For extracting parts with an internal thread, such as tapered or straight pins from M4 to M12. The delivery scope includes M4, M5, M6, M8, M10 and M12 bolts (30 mm thread length) as well as 5 seating rings.
Available pin extractor designs: 59.090 and 59.300.

Order designation Pin extractor	**Impact distance** mm	**Impact mass** kg	**Weight** ≈ kg
ABZIEHER59.090	90	0.9	1.18
ABZIEHER59.300	300	0.9	1.38

Notes

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FAG Mechanical Extractors

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Technical Information

TI No. WL 80-48 E April 1999

FAG
Rolling Bearings

FAG Mechanical Extractors

Small rolling bearings with bore diameters of up to about 100 mm which have an interference fit on the shaft or in the housing are usually dismounted by means of mechanical extractors. The bearings can be dismounted without getting damaged if the device is applied at the tightly fitted bearing ring.

With FAG mechanical extractors, the extraction force is usually applied by means of threaded spindles. Hydraulic pressure tools make the job easier in some cases.
Larger bearings are usually dismounted using the hydraulic method or induction heating devices.

In this TI the fields of application and the operation of the FAG mechanical extractors are described. Apart from two-, three- and four-arm extractors and a hydraulic pressure tool, special extractors are described.

Contents

Two-Arm Extractor 54 3

Two-Arm Bearing Extractor 47 4

Three-Arm Extractor 52 5

Three-Arm Extractor 53 6

Hydraulic Pressure Tool 44 7

Ball Bearing Extractor 56 8

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Extractor 49 13

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Notes

FAG

Rolling Bearings

A Classic with a Future

FAG Bottom Bracket Bearings · In over 10 million bicycles

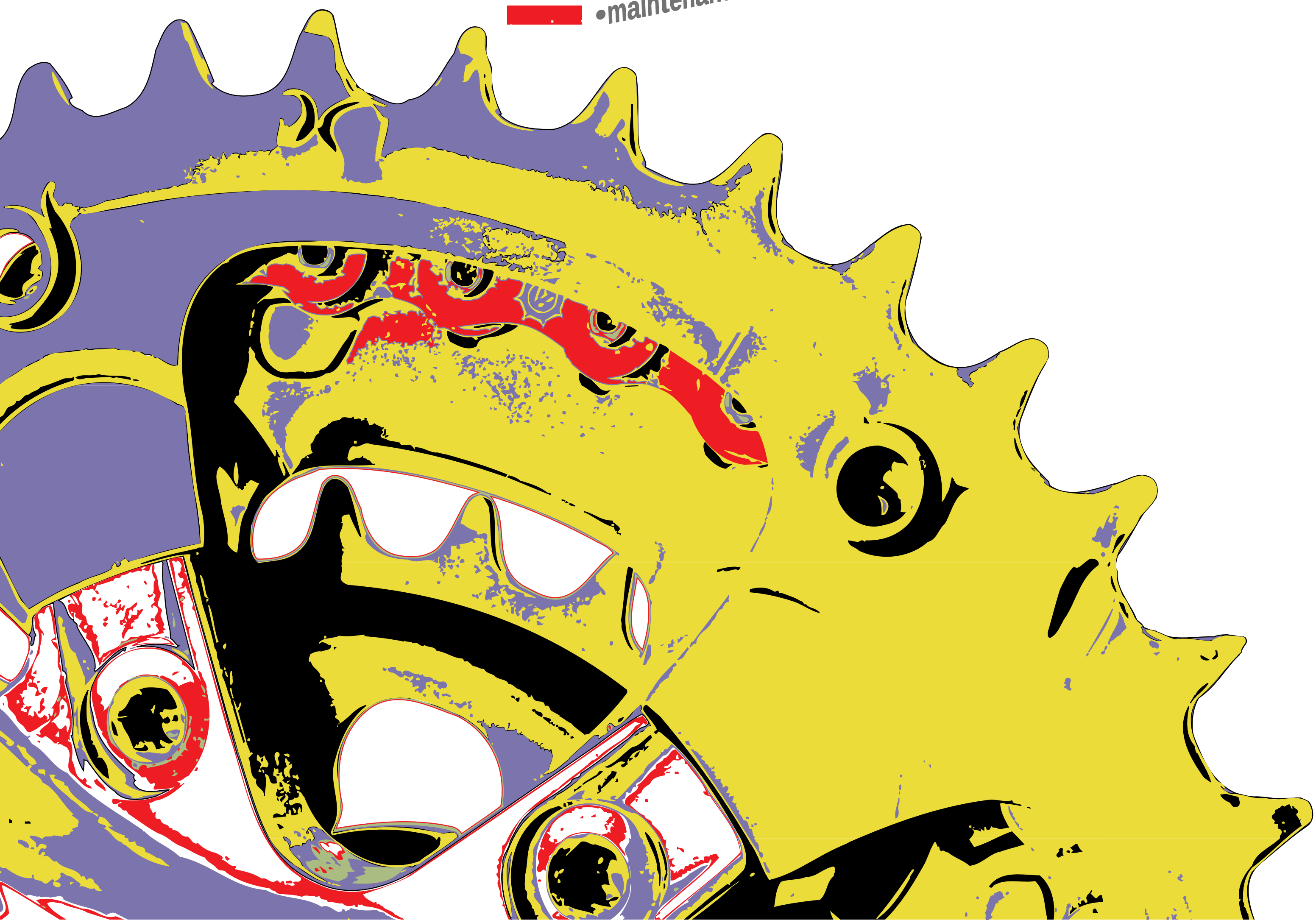
The Power Package for Bicycle Drive

Round-the-globe cyclists, like Wolfgang Reiche, should know what they are talking about when reporting on their experience and writing in their diaries: „As I travelled through the continents on my bike I was accompanied by a great sense of ease and freedom particularly because I knew the reliability of the fully-encapsulated and low-friction FAG bottom bracket bearing.“

Only when you think about the fact that a bottom bracket bearing rotates about its own axis about 17 million times on a world trip of approximately 70,000 kilometres and the fact that it also accommodates enormous loads going uphill as well as coping with dirt, rain, sand, and dust, only then is it possible to really appreciate the tremendous performance of this rather inconspicuous component. All cyclists, whether on standard bicycles or mountain bikes, who make a point of having an FAG bottom bracket bearing at this most crucial position of the bicycle, gain that special little extra in safety and reliability.

Benefits at a glance

- nicely priced ready-to-mount unit
- easy mounting
- no clearance adjustment
- sealed and greased for life
- maintenance-free



Easy mounting
Compact construction

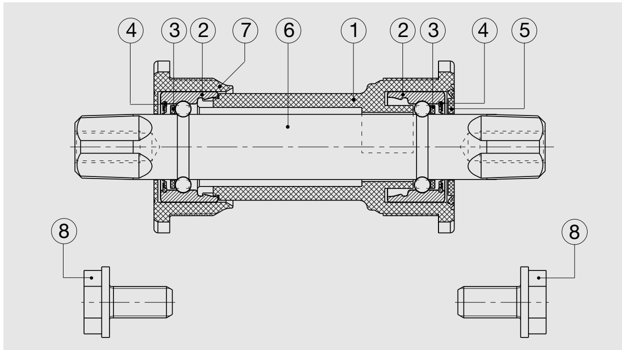
FAG bottom bracket bearings are ready to mount. The fitter has just two parts to either screw or press into the frame – a long flanged sleeve accommodating the spindle and the bearings and a short flanged sleeve. Dumping up to ten parts of a conventional bearing out of a package onto the work bench is a thing of the past.

The flanged sleeves of glass-fibre reinforced polyamide are designed for a safe connection with the bearing outer rings.

The inner ball raceways which are ground into the spindle are hardened. The spindle, which is protected against corrosion, is guided by the precision ball bearings with a specified minimum clearance set during production. The clearance need no longer be adjusted during assembly nor readjusted after a certain running time. This is one advantage which is particularly obvious to those of us whose patience has been taxed when adjusting or readjusting the bearing clearance.

The ball bearings are greased for life. They need never be replenished and are maintenance-free. The special rolling bearing grease ensures positive running properties and a long service life.

Special low-friction rubber-lip seals in the outer rings prevent grease from escaping and, at the same time, dirt and water from penetrating into the bottom bracket bearings. The extended face of the short flanged sleeve and a shield in the long flanged sleeve add to the sealing effect.



1 = long flanged sleeve
2 = deep groove ball bearings
3 = snap-type cages
4 = rubber-lip seals
5 = shield
6 = spindle
7 = short flanged sleeve
8 = bolts

The two bolts for axially securing the cranks on the square seat are also supplied.

The source of success lies not alone in a well thought out construction but also in modern production facilities, quality assurance and logistics.

FAG bottom bracket bearings are supplied individually wrapped or in boxes with 34 (L66 BSA-...) or 30 (L66 THO-...) pieces.

FAG bottom bracket bearings screwed in with BSA thread
Delivery programme · Codes · Tools · Components

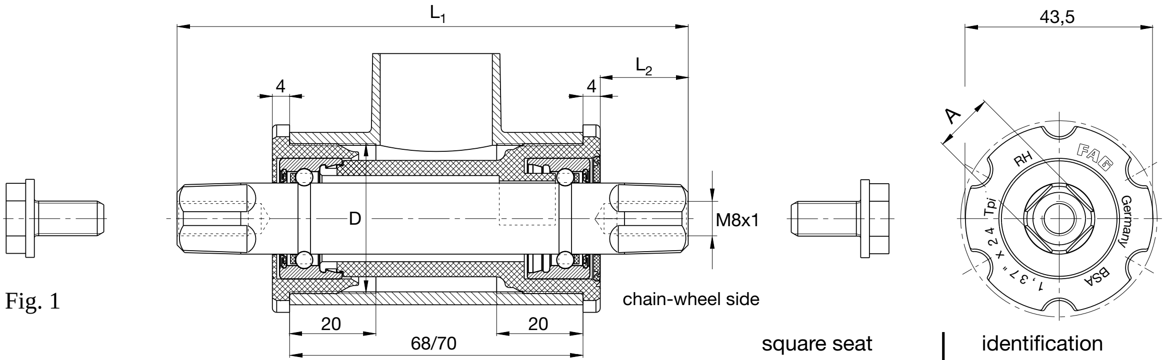


Fig. 1

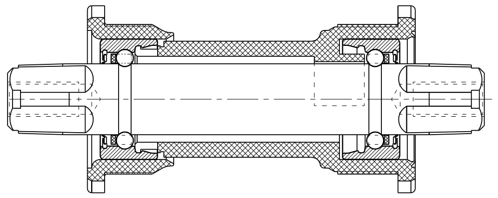
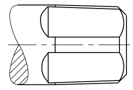
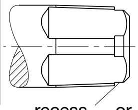
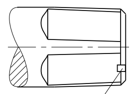


Fig. 2

square seat design	identification feature
L66...EV.. dimension A 12.5 mm ISO 6695	
L66...V.. dimension A 12.63 mm JIS D9403	  recess or 2 notches opposite one another

Frame Treaded bore D (mm)	Spindle length L_1 (mm)	 L_2 (mm)	tapered square seat A (mm) L66...V..	 L66...EV..	FAG code	Fig.
BSA	110.5	16	12.63		**L66BSA-V110.5/16BB**	2
1.37“xTpi left/right	113	18	12.63		**L66BSA-V113/18AA**	1
chain-wheel side left-hand	114.5	20		12.5	**L66BSA-EV114.5/20AA**	1
thread	119	23	12.63		**L66BSA-V119/23AA**	1
opposite side right-hand	119	23		12.5	**L66BSA-EV119/23AA**	1
thread	122.5	24	12.63		**L66BSA-V122.5/24AA**	1
	122.5	24		12.5	**L66BSA-EV122.5/24AA**	1
	127	25.5	12.63		**L66BSA-V127/25AA**	1
	127	25.5		12.5	**L66BSA-EV127/25AA**	1
	132	28	12.63		**L66BSA-V132/28AA**	1
	132	28		12.5	**L66BSA-EV132/28AA**	1

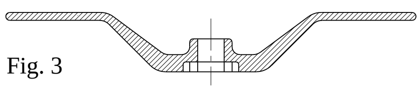


Fig. 3

Handle wrench		**WKZG.564414**	3

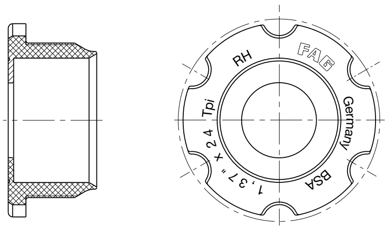


Fig. 4

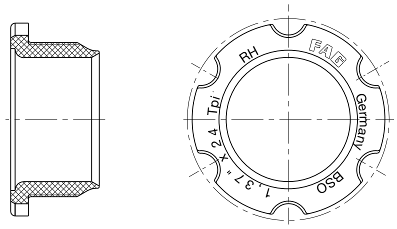


Fig. 5

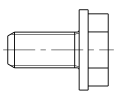


Fig. 6

Short flanged sleeve	(10 pieces per package unit)	**RG.L66BSA.AA**	4
Short flanged sleeve (open)	(10 pieces per package unit)	**RG.L66BSO.BB**	5
Bolts (M8x1; class 10.9)	(68 pieces per package unit)	**SRB.563956B**	6

FAG bottom bracket bearings for pressing in
Delivery programme · Codes · Tools · Components

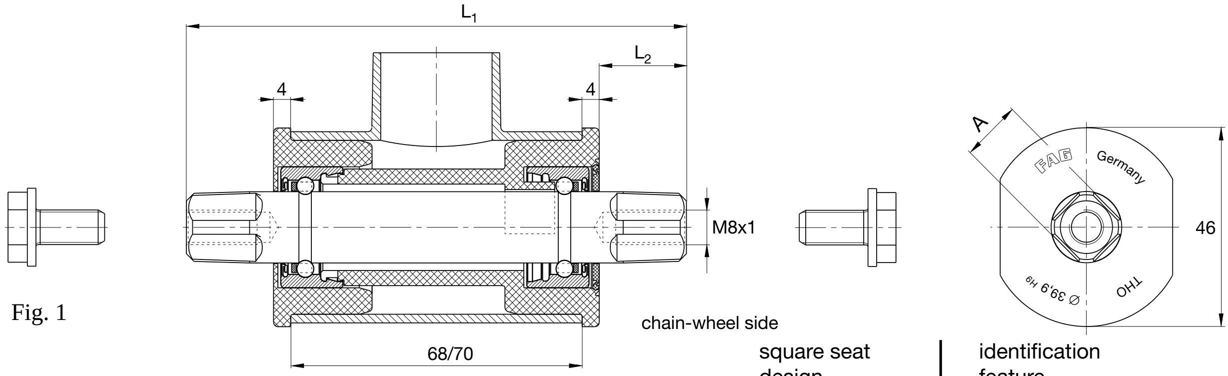
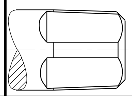
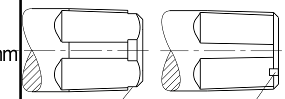


Fig. 1

square seat design	identification feature
L66...EV.. dimension A 12.5 mm ISO 6695	
L66...V.. dimension A 12.63 mm JIS D9403	

recess or 2 notches opposite one another

Frame Straight bore D (mm)	Spindle length L1 (mm)	L2 (mm)	tapered square seat A (mm) L66...V..	L66...EV..	FAG code	Fig.
THO	119	23	12.63		**L66THO-V119/23AA**	1
Ø 39.9	119	23		12.5	**L66THO-EV119/23AA**	1
	127	25.5	12.63		**L66THO-V127/25AA**	1
	127	25.5		12.5	**L66THO-EV127/25AA**	1

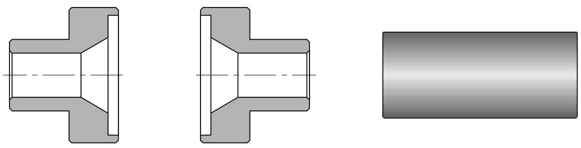


Fig. 2

Tool set: 2 thrust collars, 1 pin	**562291**	2

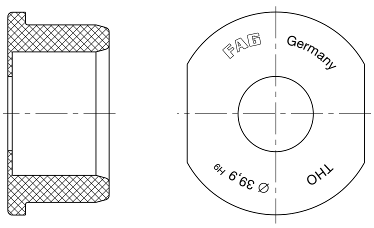


Fig. 3

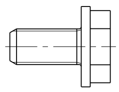
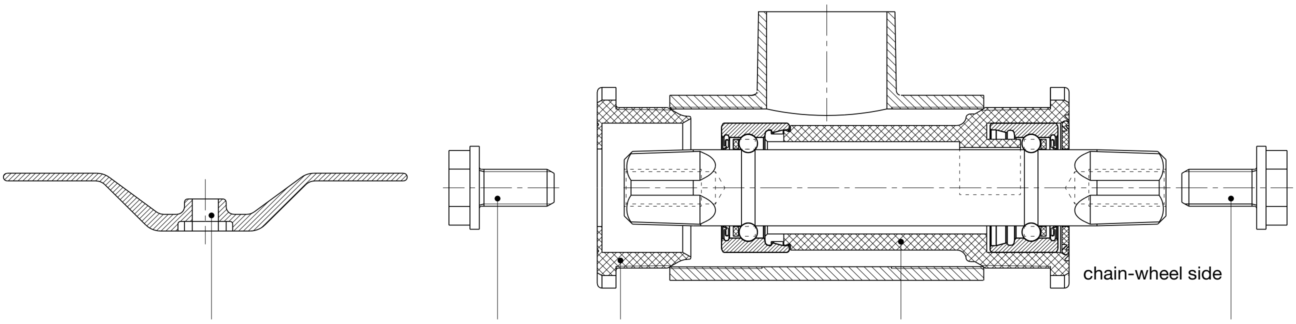


Fig. 4

Short flanged sleeve (open)	(10 pieces per package unit)	**RG.L66THO.AA**	3
Bolts (M8x1; class 10.9)	(68 pieces per package unit)	**SRB.563956B**	4

FAG bottom bracket bearings for screwing in Mounting · Dismounting



Tool
The FAG WKZG.564414 ③ handle wrench is used for mounting and dismounting.

Mounting preparation
Determine thread type of frame. The exact thread code is indicated on the flange of the sleeve. The left-hand thread is marked by LH, the right-hand thread by RH.

The thread of the frame must be neatly cut and free of paint. The thread length is about 20 mm.

Mounting with handle wrench
A Screw short flanged sleeve ① about 1/3 by hand at the non-chain-wheel side.

B Then tighten with the handle wrench ③ until the flange abuts the frame (tightening torque about 30 Nm).

C Press long flanged sleeve ② (left-hand thread) gently into the frame at the chain-wheel side and screw by hand.

D Then tighten with handle wrench until the flange abuts the frame (tightening torque about 30 Nm)

E Mount cranks. Tighten bolts ④ with standard torque wrench (tightening torque about 35 Nm).


A


B


C

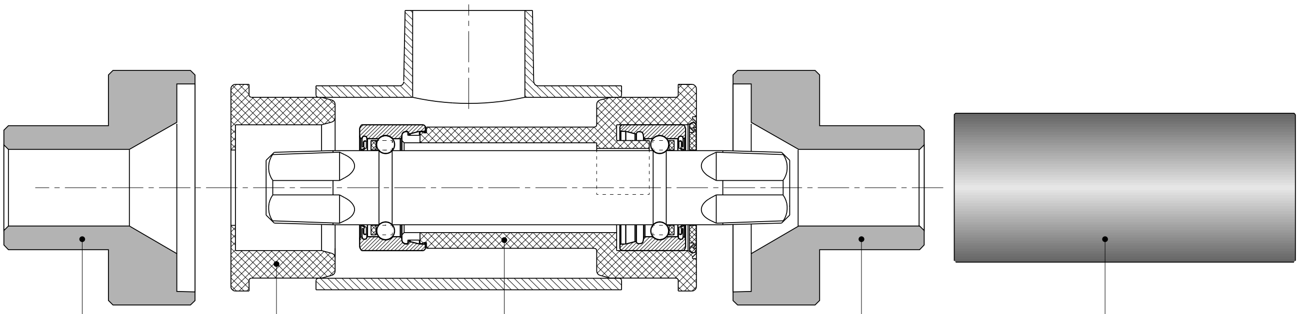

D

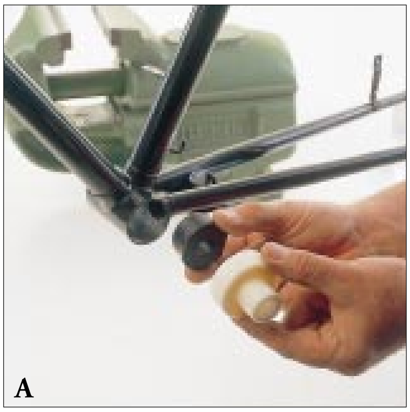

E

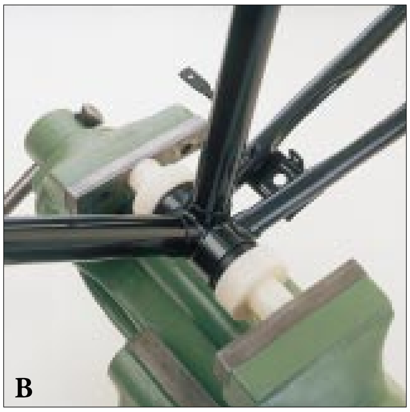
Dismounting

To dismount bottom bracket bearing units simply proceed in the reverse order to mounting

FAG bottom bracket bearings for pressing in Mounting · Dismounting




A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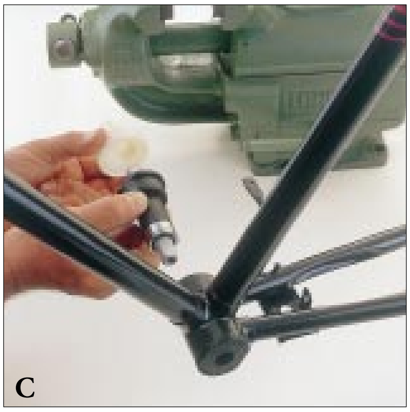
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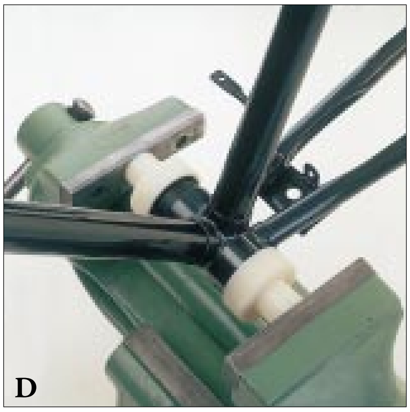
D


E


F

Tools
FAG 562291 tool set (2 thrust collars, 1 pin, suitable for all designs) is used for mounting and dismounting.

It is best to use a vice for pressing in.

Mounting
Check frame bore for accurate dimensions. A deburred or slightly chamfered bore edge facilitates mounting.

A Position short flanged sleeve ① with thrust collar ③ at the non-chain-wheel side and
B thrust collar ④ at the chain-wheel side to protect frame, tighten in the vice and press in short flanged sleeve until flange abuts the frame.
C Put long flanged sleeve on the chain-wheel side, push on thrust collar ④ and
D tighten together with thrust collar ③ on the non-chain-wheel side. Press in long flanged sleeve until flange abuts the frame.

Dismounting
E Support the frame on the chain-wheel side at the two parallel flat areas of the bottom bracket bearing.

By means of the small end of the thrust collar ③ and a suitable mandrel push through the bottom of the shorter flanged sleeve and knock the long flanged sleeve out of the frame.
F Support frame at the non-chain-wheel side. Knock out the short flanged sleeve ① with mandrel and pin.

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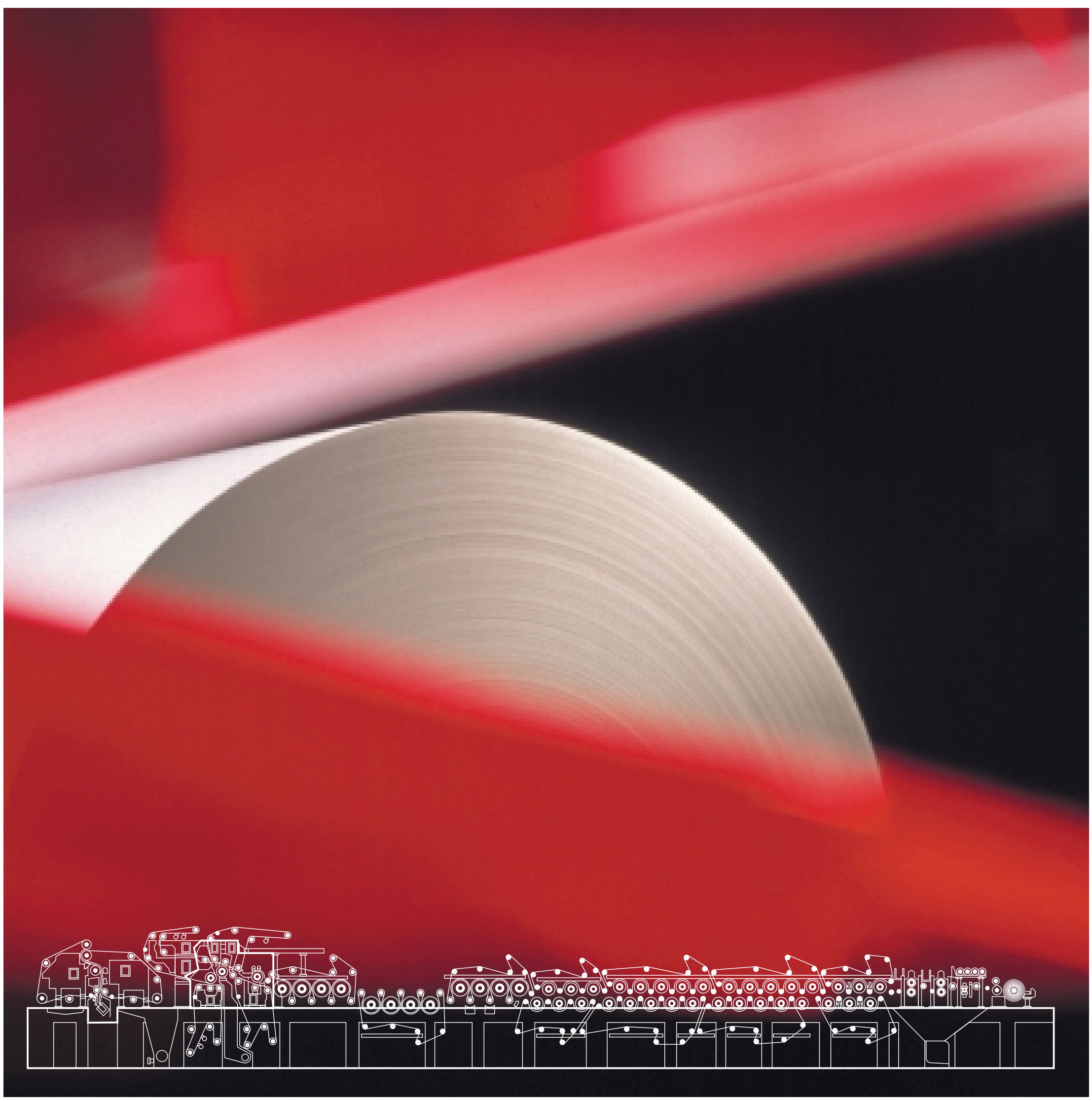
FAG
Rolling Bearings

A Partnership in Paper



FAG OEM und Handel AG
A company of the FAG Kugelfischer Group

1. Innovation and Quality Assured

The quality of FAG products goes beyond agreed and expected manufacturing standards.

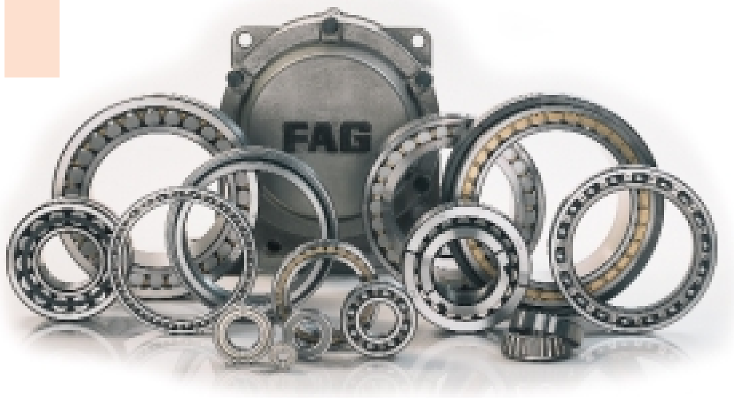
- Quality procedures and activities are directly based on results of Application Engineering and Research / Development
- Continuous improvement of performance parameters of our products
- Going beyond agreed and expected manufacturing standards (ISO 9000 et seq. / QS 9000)
- FAG quality policy is uniformly executed at the same standards world-wide
- Enviromental certificate ISO 14001

2. Global Resources and Support

FAG factories, warehouses, offices and trained staff are located world-wide to satisfy your every Requirement.

- World-wide Manufacturing Facilities
- World-wide References
- World-wide Sales Organization and Service Network
- World-wide Warehouses
- World-wide Data Transfer of Information, enabling us to solve problems globally

3. Products



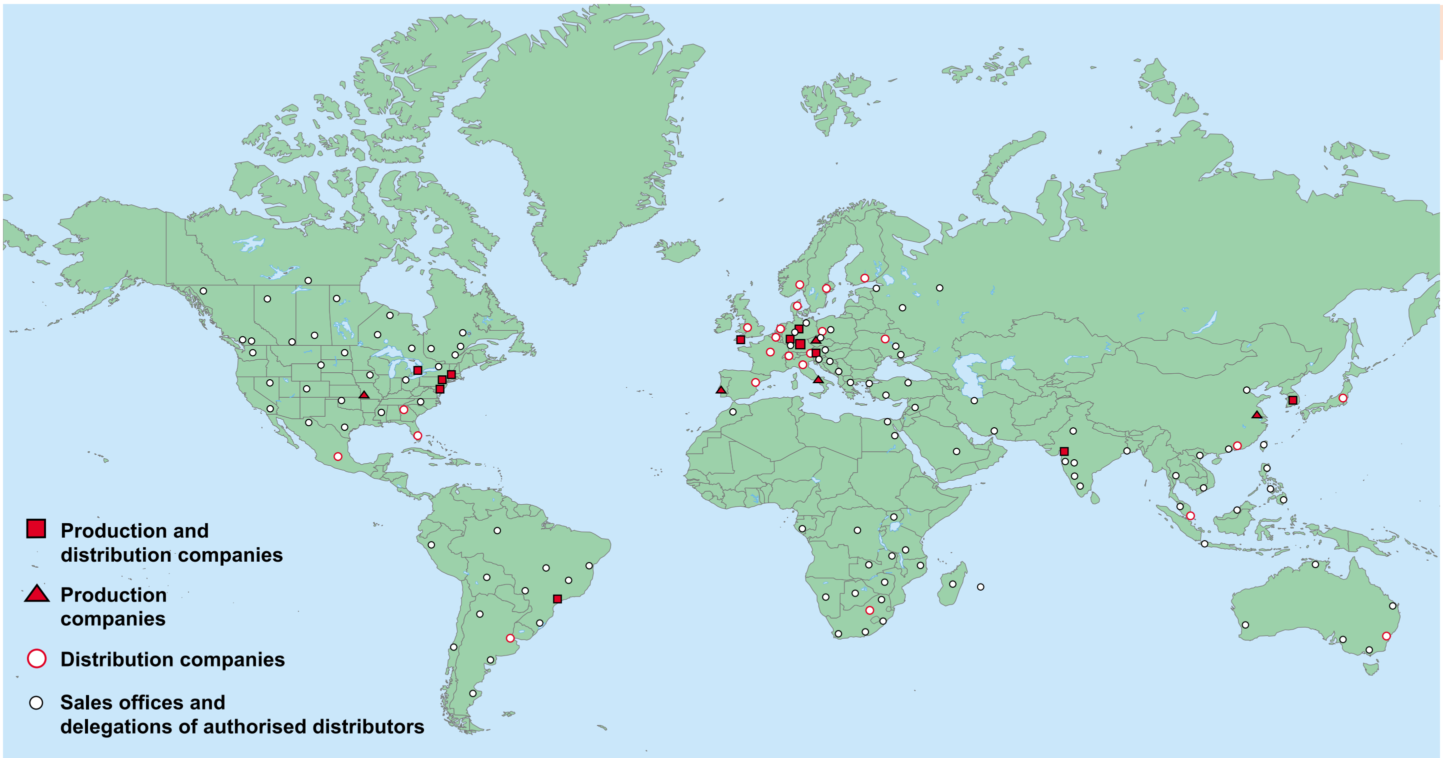
FAG supplies bearings of all types and sizes for all segments of the Pulp & Paper Industry.

- Spherical and Cylindrical Roller Bearings designed for pulp preparation, paper production, finishing and converting
- Deep Groove - Angular Contact Ball Bearings and Tapered Roller Bearings for gears, motors, fans and pumps
- Self-Aligning Cylindrical Roller Bearings
- Split Spherical Roller Bearings
- Triple Ring Bearings
- Specially Designed Housings for the Paper Industry

FAG offers a complete Paper Mill Program that compliments our Distributor Network

FAG is committed to the Pulp & Paper Industry to assure a total Quality Process from start to finish. Our total 10-point concept from Order Entry to Proactive Maintenance brings cost savings on a continual basis.

Let us customize a program for you !



4. Inventory Review

FAG has programs that will eliminate excess and obsolete products. This combined with the standardization of bearing and housing designs leads to overall cost reductions.

6. Training Program

5. Stock Management

Custom-made stock programs made in close cooperation with your distributor will establish stock levels that offer outstanding cost savings.

- By identifying your critical spares and working closely with your FAG distributor, we would establish stock levels which would optimise cost savings
- Establishing a custom-made stock management program to assure availability each and every time

FAG offers a variety of training programs to cover all facets from the very basics to tailor-made programs that fit the most demanding of training requirements.

- Basic Bearing Seminars
- Lubrication Guidelines
- Mounting and Dismounting Training
- Damage Analysis Seminars
- Computer-based Bearing Learning System
- Tailor-made In-house Seminars

7. Technical Service

FAG has an outstanding program supplying total technical services that will assure the smooth running of your paper mill with a minimum of down time.

- Application Engineering and Customer Support
- Trouble Shooting
- Bearing Refurbishing
- Installation Services
- Maintenance Planning and Tool Rentals
- Bearing Interchange, Selection and EngineeringSoftware
- Technical Brochures and Selection Guidelines

8. Proactive Maintenance

FAG offers a proactive maintenance program to assure early detection of problems. We can then schedule corrective actions before a catastrophic failure occurs.

- Condition Analysis
- Vibration Analysis by using the " FAG Bearing Analyzer"
- Online Condition Monitoring by " FAG VibroCheck"
- Failure Analysis
- Root / Cause Analysis

9. Communication

FAG has a world-wide communication system in place that allows us to communicate, follow up and plan for the future. It has proven itself time and time again with cost savings for all concerned.

10. Documented Savings

FAG will provide a documented savings report that will track the savings this program has achieved at your various mill locations.

- Through Application Engineering
- Through Stock Management
- Through Downtime Cost Reduction with Proactive Maintenance
- Through Trouble Shooting

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WL 13112 E/95/6/99

Sealed FAG Spherical Roller Bearings for Continuous Casting Plants

The cost-effective and environmentally friendly solution

Rolling Bearings

FAG OEM und Handel AG

Publ. No. WL 17 114 EA

Application · Characteristics · Programme

Application

Continuous casting plants feature a large number of spherical roller bearings. Most of the bearings are grease-lubricated. Ensuring continuous supply of many bearings means that an enormous amount of grease is used. Therefore, in order to reduce costs and meet increasingly stringent obligations to protect the environment, the operators of continuous casting plants are eager to reduce the grease consumption.

Field experience shows that sealed spherical roller bearings are an excellent solution to this problem. They require up to 80% less grease than open bearings.

The new, improved, design of sealed spherical roller bearings is also suitable for other fields of application, e.g. pumps, transmissions, materials handling engineering. If necessary, the bearing design has to be adapted accordingly.

Characteristics of the new design of sealed spherical roller bearings:

- Main dimensions identical with those of open bearings, facilitating in many cases simple substitution
- Load ratings of most sizes comparable with those of open bearings with metal cage
- E-design, i.e. inner ring without centre lip
- Machined brass cage or pressed steel cage
- Greasing with a lubricant tested by FAG (DIN 51502 KP2R-30), for temperature range –35...+180 °C
- Dimensionally stable up to 200 °C
- Radial clearance C4
- Rubbing seals made of fluorocaoutchouc, suitable for temperatures of –30...+180 °C – for a short period +200 °C

Safety note: FAG use fluorinated materials for seals made of fluorocaoutchouc (FKM, FPM, e.g. Viton®). It has to be taken into account that the very efficient fluorinated materials, when heated above +300 °C, can give off gasses vapours which are detrimental to health. This has to be remembered especielly if bearing parts are dismounted with a welding torch. Where high temperatures cannot be avoided the safety data sheet for the luorinated material in question should be observed. The data sheet is available on request.

- Self-aligning capability 0.5° from centre position
- Special design with circumferential groove and three lubricating holes in the outer ring available (suffix H40F)

Programme

The FAG product programm covers sealed spherical roller bearings with bore diameters ranging from 40 to 200 mm. The delivery periods for sealed spherical roller bearings will be indicated upon inquiry.

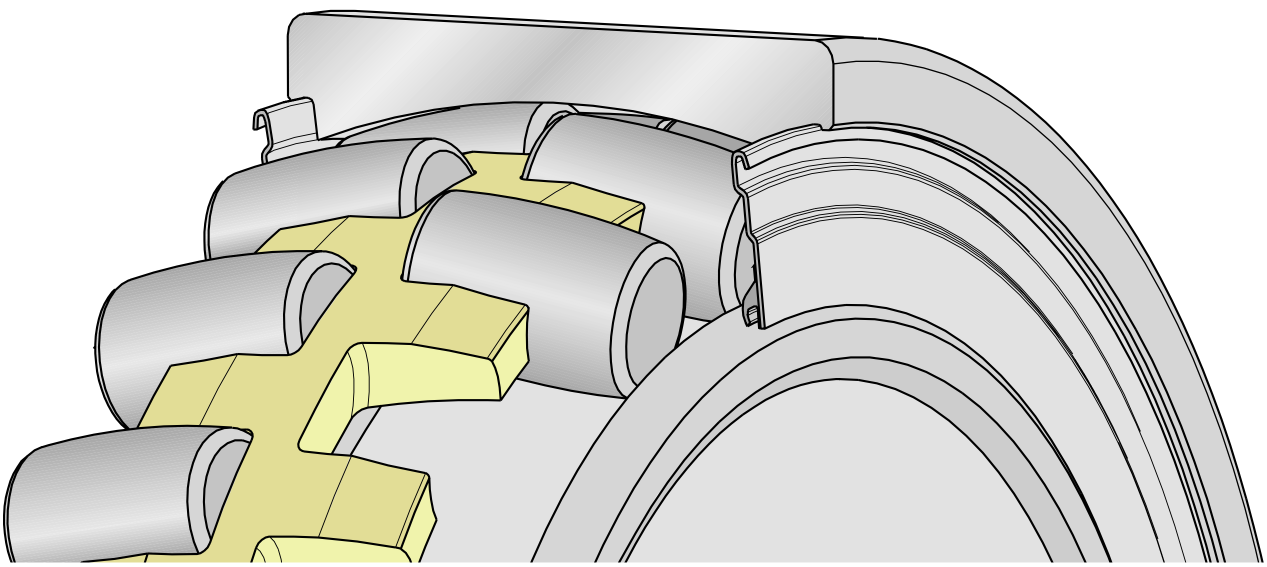
Equivalent dynamic load

$P = F_r + Y_1 \cdot F_a$	[kN]	for $F_a/F_r \le e$
$P = 0.67\ F_r + Y_2 \cdot F_a$	[kN	for $F_a/F_r > e$

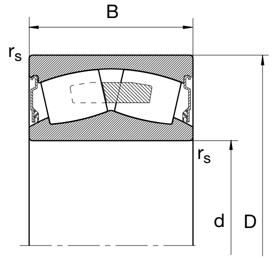
Equivalent static load

$P_0 = F_r + Y_0\ \ F_a$ [kN]

Sealed FAG spherical roller bearing for continuous casting mills

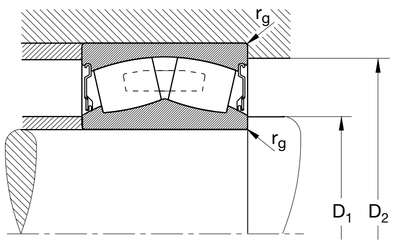


Sealed spherical roller bearings for continuous casting plants



Dimension				Load rating · Factor						Weight
				dyn.				stat.		≈
d	D	B	r_s min	C	e	Y_1	Y_2	C_0	Y_0	
mm				kN				kN		kg
40	80	28	1.1	88	0.28	2.41	3.59	95	2.35	0.62
45	85	28	1.1	93	0.26	2.62	3.9	106	2.56	0.69
50	90	28	1.1	98	0.24	2.81	4.19	114	2.75	0.72
55	100	31	1.5	120	0.23	2.92	4.35	146	2.86	1.03
60	110	34	1.5	143	0.24	2.84	4.23	166	2.78	1.32
65	120	38	1.5	173	0.24	2.81	4.19	208	2.75	1.8
70	125	38	1.5	173	0.23	2.95	4.4	228	2.89	1.85
70	150	51	2.1	305	0.29	2.32	3.45	345	2.26	4.2
75	130	38	1.5	183	0.22	3.1	4.62	236	3.03	2
80	140	40	2	212	0.22	3.14	4.67	270	3.07	2.43
85	150	44	2	260	0.22	3.04	4.53	325	2.97	3.05
90	150	72	2.5[1])	390	0.43	1.59	2.36	600	1.55	5.5
90	160	48	2	285	0.23	2.9	4.31	360	2.83	3.9
90	160	52.4	2	325	0.26	2.55	3.8	425	2.5	4.4
100	150	50	2	255	0.26	2.6	3.87	430	2.54	3.1
100	165	52	2	335	0.26	2.62	3.9	480	2.56	4.2
100	170	65		415	0.32	2.09	3.11	655	2.04	6.1
100	180	60.3	2.1	405	0.24	2.84	4.23	550	2.78	7.2
100	180	55	2.1	360	0.28	2.43	3.61	465	2.37	5.74
110	170	45	2	275	0.20	3.31	4.92	440	3.23	3.7
110	170	60	2	355	0.28	2.39	3.56	600	2.34	5
110	180	69	2	450	0.33	2.06	3.06	680	2.01	7
110	200	62	2.1	455	0.25	2.71	4.04	585	2.65	8
120	180	46	2	300	0.28	2.43	3.61	450	2.37	4
120	180	60	2	400	0.28	2.39	3.56	695	2.34	5.4
130	200	52	2	390	0.20	3.46	5.15	600	3.38	5.75
130	200	69	2	480	0.29	2.3	3.42	850	2.25	7.9
130	210	80	2	600	0.32	2.09	3.11	1000	2.04	10.8
140	210	69	2	520	0.27	2.49	3.71	915	2.43	8.2
140	225	85	2.1	655	0.32	2.09	3.11	1140	2.04	12.7
150	225	75	2.1	600	0.27	2.49	3.71	1060	2.43	10.3
150	250	100	2.1	880	0.35	1.95	2.9	1530	1.91	20
160	240	80	2.1	655	0.28	2.45	3.64	1200	2.39	12.7
160	270	86	2.1	865	0.25	2.67	3.97	1290	2.61	19.4
170	260	90	2.1	830	0.18	3.66	5.46	1460	3.58	15.5
170	280	109	2.1	1040	0.34	1.99	2.96	1800	1.94	26.3
180	280	100	2.1	965	0.29	2.33	3.47	1730	2.28	22.8
190	290	75	2.1	800	0.2	3.46	5.15	1270	3.38	17.2
200	310	109	3	1180	0.29	2.33	3.47	2240	2.28	30.5
200	340	140	3	1660	0.37	1.83	2.72	2900	1.79	52.5

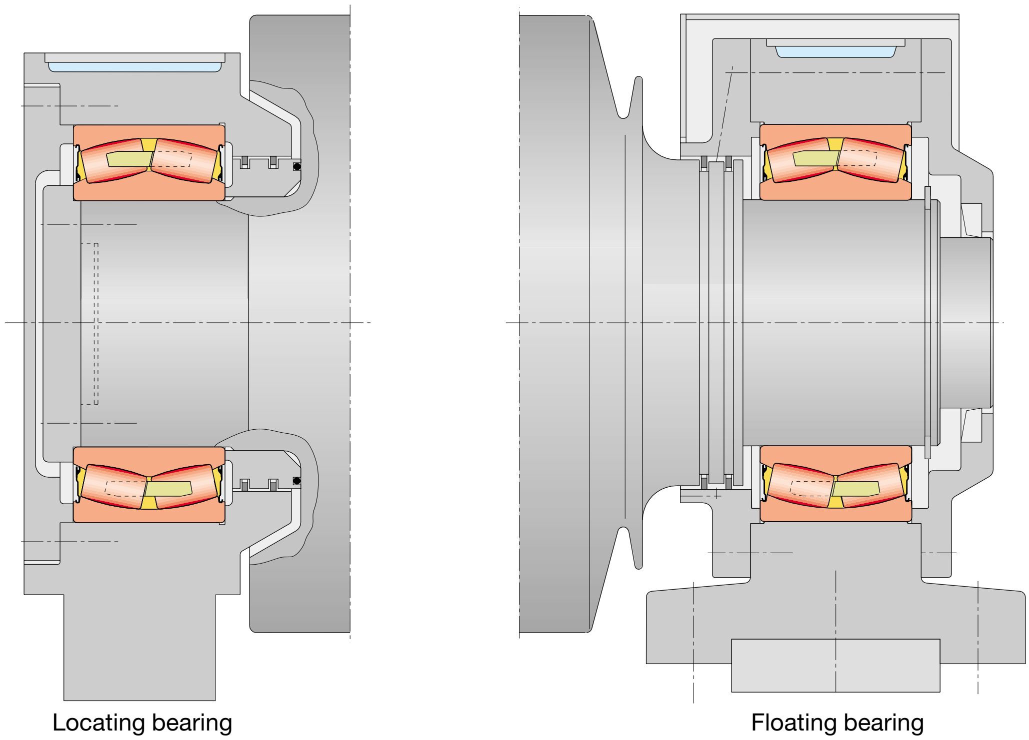
[1]) inner ring chamfer r_{smin} = 0.6 mm



Code sealed bearing FAG	permissible speed[3]) min^{-1}	Abutment D_1 min mm	D_2 max	r_g max	Code open bearing FAG	Dimension d mm	D	B
803019	2400	47	73	1	**22208E**	40	80	23
803020	2400	52	78	1	**22209E**	45	85	23
803021	2200	57	83	1	**22210E**	50	90	23
803022	1900	64	91	1.5	**22211E**	55	100	25
803023	1700	69	101	1.5	**22212E**	60	110	28
803024	1500	74	111	1.5	**22213E**	65	120	31
803014	1400	79	116	1.5	**22214E**	70	125	31
803030	1000	82	138	2.1	**22314E.M**	70	150	51
803025	1400	84	121	1.5	**22215E**	75	130	31
803026	1300	91	129	2	**22216E**	80	140	33
803015	1200	96	139	2	**22217E**	85	150	36
803007	750	96	138	2[2])	**541019**	90	150	72
803027	1000	101	149	2	**22218E**	90	160	40
803031	950	101	149	2	**23218EAS.M**	90	160	52.4
803041	1200	107	143	1.5	**24020S.M**	100	150	50
803000	900	111	154	2	**23120EAS.M**	100	165	47
803008	700	111	156	2	**533653M**	100	170	65
803032	750	112	168	2.1	**23220EAS.M**	100	180	60.3
803028	900	112	168	2	**22220E**	100	180	46
803013	950	119	161	2	**23022EAS.M**	110	170	45
803033	800	119	161	2	**24022S.M**	110	170	60
803004	750	121	169	2	**24122S.M**	110	180	69
803029	800	122	188	2.1	**22222E.M**	110	200	53
803034	950	129	171	2	**23024EAS.M**	120	180	46
803001	750	129	171	2	**24024S.M**	120	180	60
803045	900	139	191	2	**23026E.M**	130	200	52
803002	630	139	191	2.1	**24026S.M**	130	200	69
803005	530	141	199	2	**24126B.M**	130	210	80
803003	670	149	201	2	**24028S.M**	140	210	69
803006	530	152	213	2.1	**24128S.M**	140	225	85
803035	630	160	215	2.1	**24030S.M**	150	225	75
803036	400	162	238	2.1	**24130B.M**	150	250	100
803012	560	170	230	2.1	**24032S.M**	160	240	80
803010	560	172	258	2.1	**23132EAS.M**	160	270	86
803037	530	180	250	2.1	**24034BS.M**	170	260	90
803038	380	182	268	2.1	**24134BS.M**	170	280	109
803011	450	190	270	2.1	**24036BS.M**	180	280	100
803039	600	200	280	2.1	**23038EAS.M**	190	290	75
803044	400	210	300	2.1	**24040BS.M**	200	310	109
803040	280	215	325	2.5	**24140B.M**	200	340	140

[2]) radius on shaft shoulder $r_{gmax} = 0.6$ mm
[3]) At the indicated speeds, taking into account the prevailing operating conditions, sealed spherical roller bearings have to be relubricated if necessary. In such cases the special design of these bearings should be ordered (suffix .H40F).

Examples for continuous slab casting plant



Customer benefit

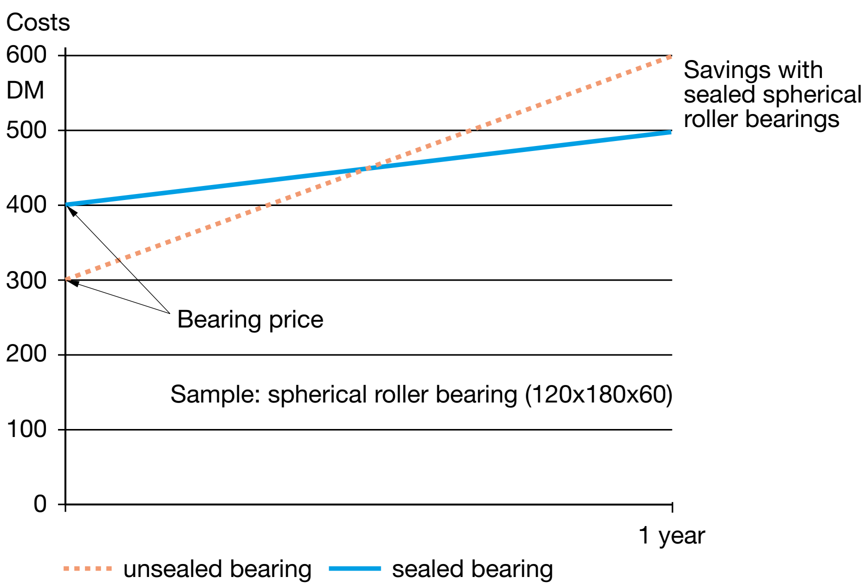
The following comparison for a continuous casting plant shows the extent of savings made possible by using sealed spherical roller bearings instead of open bearings.

The following costs were taken into account in the calculation: grease for relubricating the open bearing and for presealing the sealed bearing (DM 3.00/kg); disposal and removal of the grease from the coolant circuit (same amount).

The production costs of new plants are reduced due to the fact that no pumping units and lubricating lines are needed. In addition, less maintenance is required.

As a rule, sealed spherical roller bearings reach significantly longer lives than open bearings. Thus the higher bearing price pays off quickly.

Cost comparison unsealed/sealed spherical roller bearings



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Sealed FAG Spherical Roller Bearings for Continuous Casting Plants

The cost-effective and environmentally friendly solution

Every care has been taken to ensure the correctness of the information contained in this publication but no liability can be accepted for any errors or omissions. We reserve the right to make changes in the interest of technical progress.

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FAG Wälzlager für Walzgerüste
FAG Rolling Bearings for Rolling Mills

FAG Wälzlager
Rolling Bearings

FAG OEM und Handel AG

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Vorwort

Diese Druckschrift enthält Tabellen über Wälzlager, die vorwiegend in Walzgerüsten verwendet werden. Dabei handelt es sich zum einen um Lager mit genormten Abmessungen (DIN 616), zum anderen um Lager, die speziell für Walzgerüste entwickelt wurden. Die Lagertabellen werden ergänzt durch Tabellen über Stützrollen für Vielwalzen-Kaltwalzgerüste.

Viele Fragen zur Lagerauswahl beantworten unser Katalog WL 41 520 »FAG Wälzlager« und die Druckschrift Publ.-Nr. WL 17 200. Darüber hinaus gibt es eine Reihe von Fachpublikationen, die Interessenten zur Verfügung stehen. Bei Anforderung solcher Publikationen bitten wir um Hinweise auf das entsprechende Fachgebiet. Für weitergehende Fragen steht unser Beratungsdienst zur Verfügung, der rechtzeitig in Anspruch genommen werden sollte.

Änderungen, die durch die technische Entwicklung notwendig werden, behalten wir uns vor. Bei Bestellungen sind deshalb immer die neuesten FAG-Zeichnungen anzufordern.

Preface

This publication contains tables of rolling bearings which are mainly used in rolling mills. On the one hand it covers bearings with standardized dimensions (DIN 616), and on the other hand bearings which were developed especially for rolling mills. The bearing tables are complemented by tables of support rollers for multi-roll cold rolling mills.

Many questions as to bearing selection are answered by our catalogue WL 41 520 »FAG Rolling Bearings« and our publication no. WL 17 200. Special publications are available also for many other fields of application; it is sufficient to indicate the field of interest. For the solution of bearing problems, please do not hesitate to contact our Technical Service.

We reserve the right to make changes in the interest of technical progress. When ordering please ask for the latest FAG drawing.

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FAG Tapered Roller Bearings, four row
with integrated seals 54
FAG Tapered Roller Bearings, four row
with extended cones 62
FAG Tapered Roller Bearings, double row
for loose fit on the roll neck 66
FAG Tapered Roller Bearings, double row
with extended cone 74
FAG Tapered Roller Bearings, double row, O-arrangement
in inch dimensions 78
FAG Tapered Roller Bearings, double row, O-arrangement
in metric dimensions 92
FAG Tapered Roller Bearings, double row
thrust bearings for work rolls 94
FAG Tapered Roller Bearings, double row
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FAG Tapered Roller Bearings, double row
thrust bearings, e. g. for oil film bearings 98
FAG Angular Contact Ball Bearings, single and double row
thrust bearings, e. g. for oil film bearings 99
FAG Spherical Roller Bearings for Cold Pilger Rolling Mills
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FAG Tapered Roller Thrust Bearings, full complement
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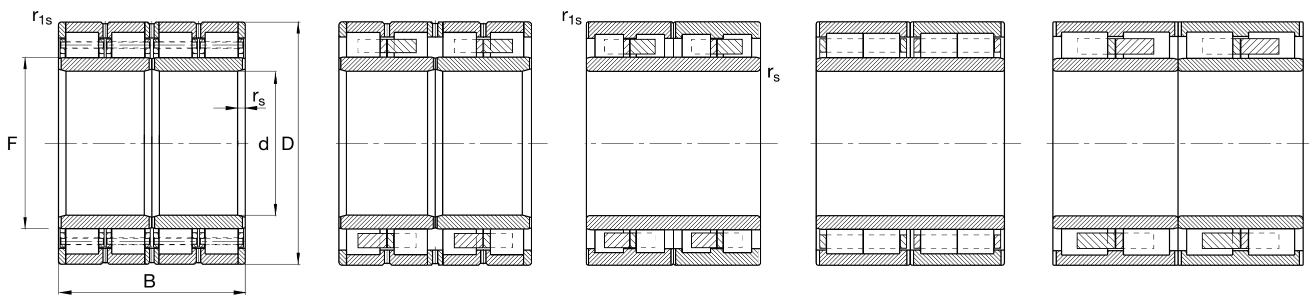
FAG Zylinderrollenlager, vierreihig für festen Sitz auf dem Walzenzapfen
FAG Cylindrical Roller Bearings, four row for interference fit on the roll neck



Ausführung 1 / Design 1 · Ausführung 2 / Design 2 · Ausführung 3 / Design 3 · Ausführung 4 / Design 4 · Ausführung 5 / Design 5

Kurzzeichen Code	Aus-führung Design	Abmessung Dimension						Tragzahl Load rating		Gewicht Weight
		d	D	B	F	r_s min	r_{1s} min	dyn. C	stat. C_0	≈
FAG		mm						kN		kg
537675	3	120	165	90	132	1.5	1.5	510	780	5.55
529469.N12BA	5	127	174.65	150.812	139.5	1.1	1.5	800	1430	10.7
511605	3	145	210	155	166	2	2	1080	1930	18
512764	4	145	225	156	169	2	2	1250	1960	23.5
538522	3	145	225	156	169	2	2	1100	1660	22.7
508955	4	150	230	156	174	2.1	2.1	1250	2080	25.1
506962	3	150	230	156	174	2.1	2.1	1140	1860	24
502894A	3	160	230	130	180	1.5	1.5	830	1340	17.6
510150	3 US	160	230	168	179	2.1	2.1	1160	2080	22.8
529468.N12BA	5	165.1	225.45	168.3	181	1.5	1.5	1100	2000	19.8
508370	3 ZW	170	230	130	188.5	2	2	780	1400	15.1
567622	5 US	170	230	160	185.5	2.1	2.1	1200	2200	18.9
505470	3 US	170	260	225	196	2.1	2.1	1930	3350	43.3
507536	3	180	260	168	202	2	2	1200	2000	29.7
507735	3	190	260	168	212	2	2	1340	2600	26.7
508657	3	190	270	200	212	2	2	1660	3000	35.9
510199	3	190	280	200	214	2.1	2.1	1830	3150	42.4
522742	3	200	270	170	222	2.1	2.1	1290	2600	28.2
549864	3	200	280	170	223	2	2	1500	2600	33.7
507344	4	200	280	170	222	2	2	1630	2900	33.4
508726	3	200	280	200	222	2.1	2.1	1630	3200	38.8
512580	3	200	290	192	226	2	2	1730	3000	41.9
503901.N12BA	5	200	310	230	229	2.1	2.1	2360	4000	65.4
514958	2	200	310	265	227	2	2	2700	4250	70.2

US umlaufende Schmiernuten und Schmierbohrungen in den Außenringen
with circumferential lubricating grooves and lubricating holes in outer rings

ZW mit äußerem Zwischenring / spacer between the outer rings

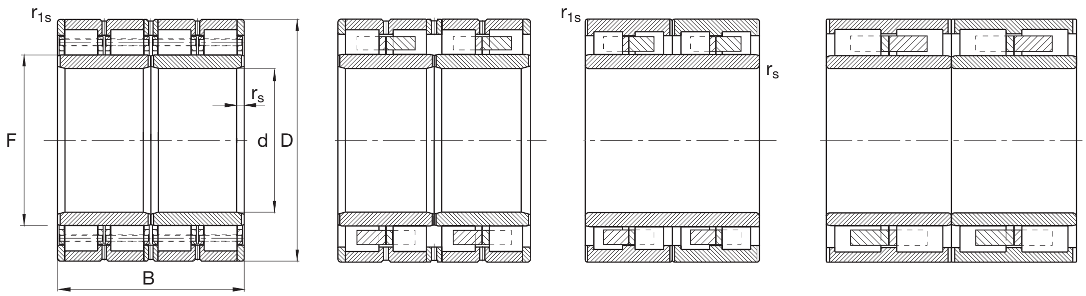
Ausführung 1 mit Bolzenkäfigen / Design 1 with pin type cages

Ausführungen 2 bis 5 mit Messing-Massivkäfigen / Designs 2 to 5 with machined brass cages

FAG Zylinderrollenlager, vierreihig für festen Sitz auf dem Walzenzapfen
FAG Cylindrical Roller Bearings, four row for interference fit on the roll neck

Kurzzeichen Code FAG	Aus- führung Design	Abmessung Dimension d mm	 D	 B	 F	 r_s min	 r_{1s} min	Tragzahl Load rating dyn. C kN	 stat. C_0	Gewicht Weight ≈ kg
507628	3	210	290	192	236	2.1	2.1	1700	3400	38.7
567623	5 US	220	300	200	240	2.1	2.1	1830	3350	40.9
507333	3	220	310	192	246	2.1	2.1	1830	3200	44.8
514461	3	220	310	225	244	1	2.1	2200	4150	54.2
506869	3	220	310	225	245	1	2.1	2200	4150	53.6
541452	3	220	330	230	249	3	3	2360	3900	66.8
525147	2	220	340	290	250	3	3	3250	5400	94.5
508727	3	230	330	206	260	2	2	2080	3750	58.2
504547	4	240	330	180	265	2.1	2.1	2040	3900	46.9
508368	3	240	330	220	270	2	2	2080	4250	56.9
512972	4	240	340	200	266	3	3	2500	4500	60.5
513703	3	240	340	220	268	3	3	2400	4250	61.8
514959	2	240	360	290	270	12.5x30	4	3350	5700	99.3
522310	3 US	250	340	230	276	2.1	2.1	2120	4050	59.7
533880	3	260	360	230	292.2	4	4	2500	5000	71.5
507336	3	260	370	220	292	3	3	2200	4050	76
518214	2	260	400	290	296	4	4	3900	6300	131
521065	2	260	400	335	294	4	1.5	4300	7200	151
517423	3	265	370	234	300	2.1	2.1	2500	5100	80
507339	3	280	390	220	312	3	3	2280	4300	81.5
527104	2	280	390	275	308	3	2	3600	6800	99.3
513729A	3 US	280	390	275	312	2.1	2.1	3150	6400	101
513342.N12BA	5	280	400	285	316	4	4	3400	6400	113.6
510350.C4.N12BA	5	280	410	300	313	4	4	3900	6950	132.6
517796	3	290	440	310	328	4	4	4300	7200	164
524289B	2	300	420	300	332	7x20°	1.5	4150	8000	128
517795	1	300	460	350	341	4	2.5	5500	9650	233

FAG Zylinderrollenlager, vierreihig für festen Sitz auf dem Walzenzapfen
FAG Cylindrical Roller Bearings, four row for interference fit on the roll neck



Ausführung 1 / Design 1 — Ausführung 2 / Design 2 — Ausführung 3 / Design 3 — Ausführung 5 / Design 5

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm	D	B	F	r_s min	r_{1s} min	Tragzahl Load rating dyn. C kN	stat. C_0	Gewicht Weight ≈ kg
574469	3	310	440	240	345	3	3	3250	5700	115
513654A	1	320	480	350	364	12x20°	1.5	5850	10800	225
541851	2	320	480	350	364	4	1.5	5600	9800	219
543447	2	330	460	340	365	10.5x20°	1.5	4650	9500	174
521593A	1	330	460	340	365	4	2	5100	10800	176
525837A	1	340	480	350	378	10x20°	1.5	5700	12000	207
527634	2	340	480	350	378	10x20°	1.5	5300	11000	205
517794	1	340	500	370	385	6	3	6550	13200	253
545171	1	340	560	380	396	4	1.5	7650	12200	379
532381.N12BA	5 US	350	500	380	389	5	5	5700	11200	238
532001	1	350	500	410	388	5	2	7100	14300	268
568450	2	350	520	300	401	5	5	5100	8800	220
562913	2	360	520	380	405	13.5x20°	2	6200	12200	264
517793A	1	360	520	380	405	13.5x20°	2	6550	13200	272
543975	2	370	520	380	409	10x20°	1.5	6100	11800	248
524678A	1	370	520	380	409	10x20°	1.5	6400	12900	252
576360	3 US	380	520	290	418	4	4	4500	9000	182
545768	1	380	540	300	421	8.5x20°	2	5850	10800	226
541982	2	380	540	300	421	3	1.1	5100	9150	217
544794	2	380	540	400	422	5	2	6700	13400	297
517792	1	380	540	400	422	5	2	7350	15300	301
578278	1	390	540	320	431	10x20°	3	5500	11000	225
513769A	1	400	560	410	445	12x20°	2	7800	16600	321
542395	2	400	590	440	450	4	4	8300	16000	408
513770	1	400	590	440	450	4	4	9150	17600	420

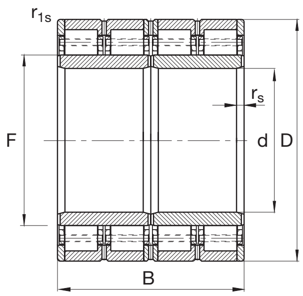
US umlaufende Schmiernuten und Schmierbohrungen in den Außenringen
with circumferential lubricating grooves and lubricating holes in outer rings

Ausführung 1 mit Bolzenkäfigen / Design 1 with pin type cages
Ausführungen 2, 3 und 5 mit Messing-Massivkäfigen / Designs 2, 3 and 5 with machined brass cages

FAG Zylinderrollenlager, vierreihig für festen Sitz auf dem Walzenzapfen
FAG Cylindrical Roller Bearings, four row for interference fit on the roll neck

Kurzzeichen Code	Aus- führung Design	Abmessung Dimension						Tragzahl Load rating		Gewicht Weight
		d	D	B	F	r_s min	r_{1s} min	dyn. C	stat. C_0	≈
FAG		mm						kN		kg
543736	2	410	560	400	450	4	2	6550	13400	285
561005	1	410	560	400	450	4	2	7500	16000	290
517436	1	410	600	440	460	13x20°	5	9300	18600	435
533053.N12BA	5 US	420	580	320	463	4	4	2280	5200	252
517464	1	420	600	440	470	14x20°	2	8800	19000	414
545467	2	420	600	440	470	14x20°	2	8150	17000	409
517454A	1	440	620	450	487	12x20°	3	9500	20000	448
545628	2	440	620	450	487	12x20°	3	8800	18000	424
543174	1	445	600	435	478	14x30°	2	9150	19600	353
560371	1	447.295	635.176	463.55	495	5	3	10000	20400	482
542648	1	450	590	435	486	5	2	8150	19000	311
513584A	1	460	650	424	510	6	3	9000	18300	447
518846	1	460	650	470	509	14x20°	2.5	10400	22000	498
547659	1	480	650	450	525	15x20°	3	9800	22000	443
547660	2	480	650	450	525	15x20°	3	9000	19600	429
533522	1	480	680	420	528	15x20°	3	9800	19300	500
514445B	1	480	680	500	532	15x20°	2.5	11600	24000	582
546152	1	480	700	500	534	6	4	12200	23600	656
523399	2	480	700	530	536	6	6	11200	22800	687
533023	1	500	670	450	556	15x20°	4	9000	22800	458
546335	1	500	680	450	550	5	2	10200	22800	509
517692	1	500	700	500	554	6	3	11600	25000	608
530488	1	500	710	480	558	18x20°	5	11200	23200	615
513378A	1	500	720	530	568	17x20°	3	12700	27500	749

FAG Zylinderrollenlager, vierreihig für festen Sitz auf dem Walzenzapfen
FAG Cylindrical Roller Bearings, four row for interference fit on the roll neck

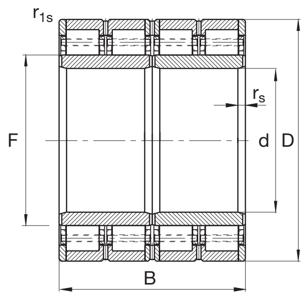


Ausführung 1
Design 1

Kurzzeichen Code	Ausführung Design	Abmessung Dimension						Tragzahl Load rating		Gewicht Weight
								dyn.	stat.	≈
		d	D	B	F	r_s min	r_{1s} min	C	C_0	
FAG		mm						kN		kg
567725A	1 JR	510	680	500	560	7.5	3	10400	25500	513
541646	1	510	730	520	565	6	3	13400	28000	728
517690	1	510	760	550	570	16x20°	3	14600	28000	892
541647	1	520	750	530	576	6	3	13700	28000	785
531597	1	530	760	520	587	6	3	13700	29000	798
517689A	1	530	780	570	601	15x20°	2.5	14600	30500	947
543481	1	530	870	670	615	7.5	5	21200	38000	1651
524544A	1	536.176	762.03	558.8	598	18x20°	3	13400	30000	872
532843	1	550	740	510	600	15x20°	2	12200	28500	639
517688	1	550	800	560	610	6	3	15300	30500	964
517687A	1	560	820	600	625	20x20°	4	16300	33500	1105
514444	1	571.1	812.97	594	636	14x20°	4	16000	35500	1019
517685	1	580	850	640	648	20x20°	4	18000	38000	1263
518780	1	600	820	550	660	6	3	14000	33500	884
528518	1	600	820	575	660	15x20°	3	15000	35500	936
533259	1	600	870	540	672	22x20°	4	15300	31000	1106
517684A	1	600	870	640	672	6	3	18300	40000	1317
561221	1	628	922	600	702	18x20°	6	19000	38000	1386
515141	1	634.5	901.87	674	705	20x15°	3	20400	45000	1430
515194A	1	650	920	670	723	18x20°	4	20800	46500	1457
533258	1	670	870	530	725	6	3	13700	34500	827
517682	1	670	950	690	740	18x20°	4	22400	50000	1606
533683	1	680	940	600	743	7.5	4	19000	42500	1295
524229	1	680	980	640	760	20x20°	4	21200	45000	1219

JR vier Innenringe / four inner rings
Ausführung 1 mit Bolzenkäfigen / Design 1 with pin type cages

FAG Zylinderrollenlager, vierreihig für festen Sitz auf dem Walzenzapfen
FAG Cylindrical Roller Bearings, four row for interference fit on the roll neck

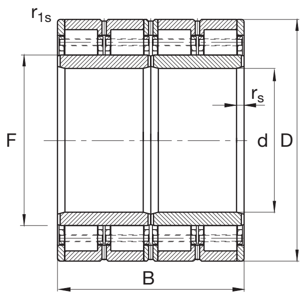


Ausführung 1
Design 1

Kurzzeichen Code	Ausführung Design	Abmessung Dimension						Tragzahl Load rating		Gewicht Weight
		d	D	B	F	r_s min	r_{1s} min	dyn. C	stat. C_0	≈
FAG		mm						kN		kg
517681	1	690	980	715	767.5	20x20°	4	22800	52000	1775
530487	1	700	930	620	763	18x20°	3	17000	44000	1197
517680A	1	710	1000	715	787.5	22x20°	4	23200	53000	1818
525438	1	730	960	620	790	20x20°	3	17600	45000	1218
517679	1	730	1030	750	809	20x20°	6	25500	58500	2020
524881A	1	750	1000	670	813	20x20°	3	20400	50000	1492
800494	1	750	1090	615	836	7.5	7.5	21600	43000	1966
524238A	1	761.425	1079.6	787.4	846	22x20°	5	28000	63000	2373
540088	1	780	1070	780	853	7.5	5	26500	64000	2151
517678	1	790	1120	810	875	7.5	4	30000	69500	2605
526169	1	800	1080	700	878	25x20°	3	22800	58500	1933
803317	1	820	1130	800	903	7.5	7.5	27000	67000	2502
567729	1	830	1080	710	896	20x20°	2.5	22800	61000	1724
545636	1	850	1150	840	928	23x20°	4	30500	76500	2563
529054	1	860	1131.57	669.952	940	7.5	4	23200	60000	1895
524239A	1	863	1219.302	889 *)	956	13x30°	5	34500	85000	3540
566883	1	865	1180	750	945.3	20x20°	8.5	27500	64000	2462
527048	1	900	1220	840	989	24x20°	4	31500	80000	2954
541812	1	900	1280	930	1000	6	3	39000	91500	3975
527977	1	937.5	1270.25	825.5	1027	25x20°	4	32000	80000	3139

*) Innenringbreite 876.3 mm / inner ring width 876.3 mm
Ausführung 1 mit Bolzenkäfigen / Design 1 with pin type cages

FAG Zylinderrollenlager, vierreihig für festen Sitz auf dem Walzenzapfen
FAG Cylindrical Roller Bearings, four row for interference fit on the roll neck

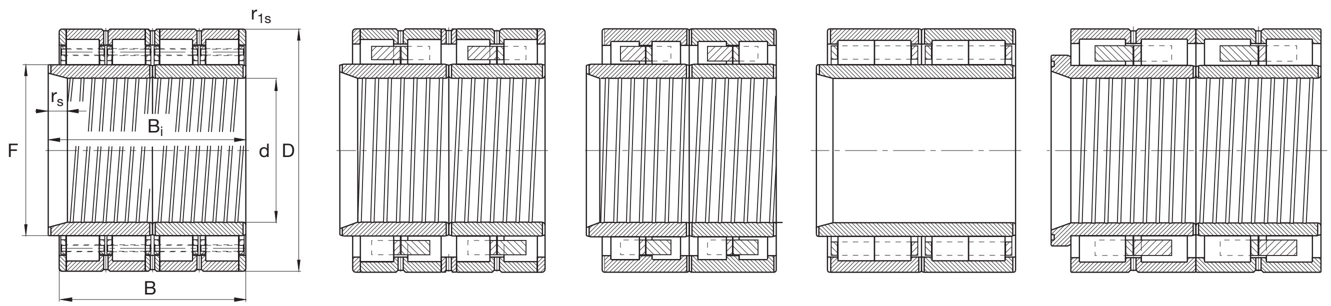


Ausführung 1
Design 1

Kurzzeichen Code	Ausführung Design	Abmessung Dimension						Tragzahl Load rating		Gewicht Weight
								dyn.	stat.	≈
		d	D	B	F	r_s min	r_{1s} min	C	C_0	
FAG		mm						kN		kg
517676	1	940	1320	1000	1029	7.5	4	41500	98000	4375
517369A	1	950	1360	1000	1075	9.5	5	44000	108000	5006
580309	1	980	1310	880	1061.7	20x20°	6	35500	93000	3455
517740	1	980	1360	1000	1080	25x20°	5	41500	106000	4671
522071	1	990	1360	760	1080	12	6	30500	68000	3269
527021	1	1000	1360	800	1101	25x20°	3	34000	83000	3481
517675	1	1040	1440	1000	1145	20x20°	5	44000	112000	5172
521910	1	1060	1360	800	1137	18x20°	5	32500	91500	3005
517737	1	1100	1500	1000	1194	7.5	4	47500	116000	5358
518206	1	1150	1500	760	1240	20x20°	5	33500	86500	3622
518649	1	1200	1590	1050	1305	30x20°	6	47500	129000	5793
528717	1	1400	1900	1150	1520	40x20°	10	64000	156000	9470
534900	1	1500	1950	1230	1610	9.5	6	71000	200000	9880

Ausführung 1 mit Bolzenkäfigen / Design 1 with pin type cages

FAG Zylinderrollenlager, vierreihig für losen Sitz auf dem Walzenzapfen
FAG Cylindrical Roller Bearings, four row for loose fit on the roll neck

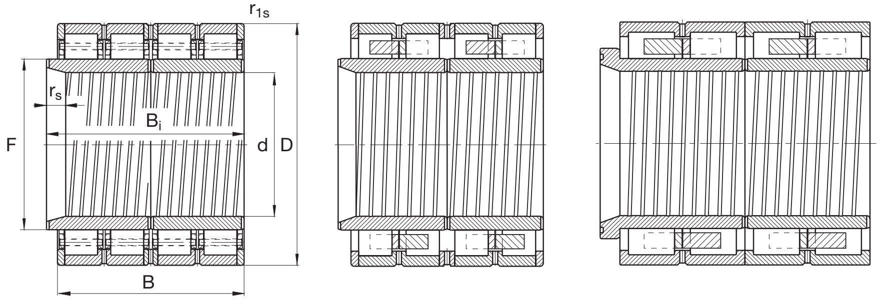


Ausführung 1 / Design 1 — Ausführung 2 / Design 2 — Ausführung 3 / Design 3 — Ausführung 4 / Design 4 — Ausführung 5 / Design 5

Kurzzeichen Code	Aus-führung Design	Abmessung Dimension							Tragzahl Load rating		Gewicht Weight
		d	D	B	B_i	F	r_s min	r_{1s} min	dyn. C	stat. C_0	≈
FAG		mm							kN		kg
801083	5	170	260	225	250	196	27.5x20°	2.1	1930	3350	41.8
530908	4	200	280	170	180	222	15x15°	2	1630	2900	33.8
800426	5	200	310	230	260	229	30x20°	3	2360	3750	64.9
580510	5 BS,KA	220	340	290	320	250	3	2	3550	5850	100
801076	5	250	350	290	320	277	28x20°	3	3100	6000	86.5
536897	2 EJ	260	370	220	240	292	15x20°	2.5	2200	4050	79.4
522009	3 US	270	380	275	295	300	15.5x15°	2.1	3550	6800	100
533575	3	280	390	220	240	312	17x20°	3	2280	4300	83.9
532504	2	300	420	300	320	332	15x20°	2	4150	8000	134
580511	5 KA	320	440	340	370	350	4	1.5	4650	9500	160
531839	2	340	480	350	370	378	15x20°	1.5	5300	11000	210
580512	5 US,KA	340	500	370	410	385	6	3	5850	11200	289
538977	1 KA	350	500	380	400	388	6	3	6550	13200	246
801476	2	350	520	300	320	401	28x20°	5	5100	8800	224
533808	2	360	510	380	400	399	28x15°	2	6100	11800	244
801082	5	370	520	380	410	409	30x20°	1.5	6100	11800	258
522007	1	380	540	380	400	424	35x15°	1.5	6700	13700	291
565463	2	380	540	380	400	422	20x20°	1.5	6700	13200	284
561269	1	410	560	400	420	450	30x15°	2	7500	16000	293
561270	2	410	560	400	420	450	32x15°	2	6700	13700	280
533022	1	430	570	340	360	465	35x15°	5	6200	13200	245
579578	1	440	620	410	430	487	12x20°	2	8650	17600	398
572891	1	440	620	450	450	487	12x20°	3	9500	20000	449

Innenringe aus Einsatzstahl; Radialluft C2 / inner rings made of case hardening steel; radial clearance C2
BS mit Bordscheiben / with loose lips
EJ einteiliger Innenring / inner ring one-piece
KA Kantenabstand statt Innenring-Abschrägung / chamfer instead of inner ring slope
US umlaufende Schmiernut und Schmierbohrungen in den Außenringen / with circumferential lubricating groove and lubricating holes in outer rings

FAG Zylinderrollenlager, vierreihig für losen Sitz auf dem Walzenzapfen
FAG Cylindrical Roller Bearings, four row for loose fit on the roll neck



Ausführung 1
Design 1

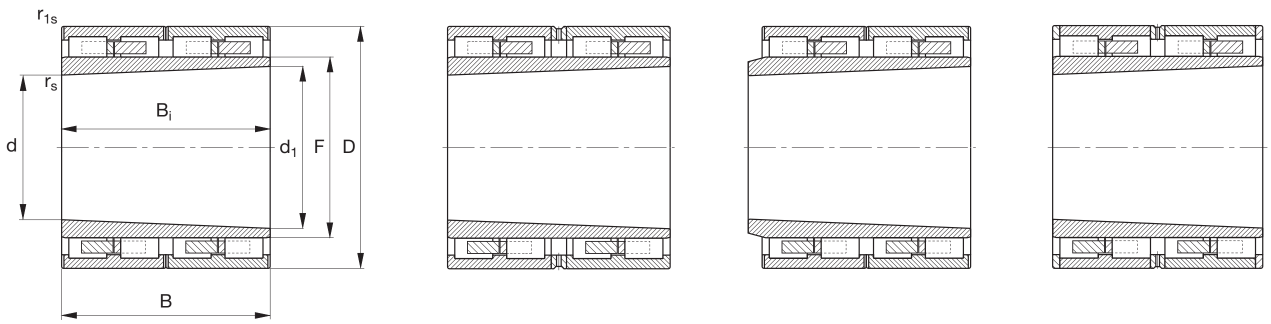
Ausführung 2
Design 2

Ausführung 5
Design 5

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm	D	B	B_i	F	r_s min	r_{1s} min	Tragzahl Load rating dyn. C kN	stat. C_0	Gewicht Weight ≈ kg
533578	1	440	620	450	470	487	30x20°	3	9500	20000	455
561271	2	440	620	450	470	487	32x20°	3	9300	19300	428
532465	1 KA	460	650	470	470	509	6	2.5	10400	22000	500
536712	1 ON	460	650	470	490	509	34x15°	2.5	10400	22000	513
567014	1	460	680	410	410	516	14x20°	2.5	9800	18300	527
533487	1	480	650	450	450	525	12.5x20°	3	9800	22000	443
540386	1	500	670	450	450	540	13x20°	5	9500	21200	459
564182	1	500	670	450	470	540	34x15°	4	9500	21600	454
579713	5 BK,BS	530	760	520	555	587	45x12.5°	2.5	13700	29000	809
566466	1	536.176	762.03	558.8	558.8	598	18x20°	4	13400	30000	845
579741	1	550	740	510	527	600	15x20°	2	12200	28500	645
532470	1 ON	570	830	600	630	635	35x15°	4	16600	34500	1155
572176	1	571.1	812.97	594	594	636	15x20°	5	16000	35500	1020
565652	1	600	820	575	575	660	15x20°	3	15000	35500	937
572137	5 BK,BS	600	870	540	578	672	53x12°	4	15300	31000	1260

BK Bolzenkäfige / pin type cages
BS mit Bordscheiben / with loose lips
KA Kantenabstand statt Innenring-Abschrägung / chamfer instead of inner ring slope
ON ohne schraubenförmige Nut in der Lagerbohrung / without spiral groove in inner ring bore

FAG Zylinderrollenlager, vierreihig mit kegeliger Bohrung (Kegel 1:12)
FAG Cylindrical Roller Bearings, four row with tapered bore (taper 1:12)



Ausführung 1 / Design 1 — Ausführung 2 / Design 2 — Ausführung 3 / Design 3 — Ausführung 4 / Design 4

Kurzzeichen Code FAG	Aus-führung Design	Abmessung Dimension d mm	d_1	D	B	B_i	F	r_s min	r_{1s} min	Tragzahl Load rating dyn. C kN	stat. C_0	Gewicht Weight ≈ kg
803431	1 US	151.5	165.5	230	168		178.81	1	2.1	1160	2080	23.4
505467	1 US	151.5	165.5	230	168		179	1	2.1	1160	2080	23.3
507509	1	160	174.583	240	175		189	1	2	1250	2280	35.2
500861	2	162	172.833	230	130		188.5	1	2	780	1400	15.3
509665	1 US	181	196	260	180		209	2	2	1250	2400	28.8
505466	1	181.5	195.5	260	168		209	2	2	1220	2320	27.9
500860	3	182	196.01	260	168	183	212	2	2	1340	2600	27.8
503745	1	190	206.667	280	200		222	1.1	2.1	1630	3200	39.6
507508	1	190	205	290	180		223	1	2.1	1560	2650	40.3
502284	1	192	206.167	270	170		222	1	2.1	1290	2600	28.3
502279	1	202	218	290	192		236	2	2.1	1700	3400	38.7
503742	1	205	223.75	310	225		244	1	2.1	2200	4150	57.6
506743A	1	230	248.333	330	220		266	2	2	2280	4500	57.2
500857A	3	231	249.333	330	220	235	270	1.5	2	2080	4250	58.2
522518A	1	260	280.833	400	250		310	1.5	3	3000	5400	109
507518	1	260	283.75	400	285		316	1.5	3	3400	6550	124
505356	4	320	349.167	480	350		378	1.5	1.5	5400	11200	211
510302A	4	356.667	390	550	400		423.4	2.5	4	6700	13400	328
527181	1 US,OS	412.335	453.002	650	488		494.5	1.5	4	9800	19000	576
527388	4 BK	485	530	740	540		572	3	2	13200	27500	815
577938	4 BK	485	530	740	540		572.3	3	2	13200	27500	798

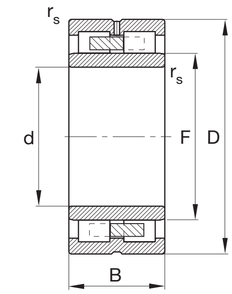
BK Bolzenkäfige / pin type cages
OS ohne Schmiernuten in den Außenring-Stirnflächen / without lubricating grooves in outer ring faces
US umlaufende Schmiernut und Schmierbohrungen in den Außenringen / with circumferential lubricating groove and lubricating holes in outer rings

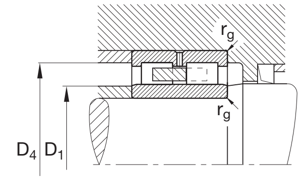
FAG Zylinderrollenlager, zweireihig

Reihe NNU49S.M, für Arbeitswalzen

FAG Cylindrical Roller Bearings, double row

Series NNU49S.M, for work rolls





Kurzzeichen Code FAG	Abmessung Dimension d mm	 D	 B	 F	 r_s min	Tragzahl Load rating dyn. C kN	 stat. C_0	Einbaumaß Abutment D_1 max mm	 D_4 max	 r_g max	Gewicht Weight ≈ kg
NNU4920S.M.P53	100	140	40	113	1.1	129	255	112	134	1	1.84
NNU4921S.M.P53	105	145	40	118	1.1	129	260	117	139	1	1.96
NNU4922S.M.P53	110	150	40	123	1.1	132	270	122	144	1	1.96
NNU4924S.M.P53	120	165	45	134.5	1.1	176	340	133	159	1	2.86
NNU4926S.M.P53	130	180	50	146	1.5	190	390	145	172	1.5	3.83
NNU4928S.M.P53	140	190	50	156	1.5	190	400	155	182	1.5	4.08
NNU4930S.M.P53	150	210	60	168.5	2	325	655	167	201	2	6.12
NNU4932S.M.P53	160	220	60	178.5	2	335	680	177	211	2	6.46
NNU4934S.M.P53	170	230	60	188.5	2	340	695	187	221	2	7.6
NNU4936S.M.P53	180	250	69	202	2	405	850	200	241	2	11.1
NNU4938S.M.P53	190	260	69	212	2	405	880	210	251	2	11.7
NNU4940S.M.P53	200	280	80	225	2.1	490	1040	223	270	2	15.2
NNU4944S.M.P53	220	300	80	245	2.1	510	1140	243	290	2	16.6
NNU4948S.M.P53	240	320	80	265	2.1	530	1200	263	310	2	19
NNU4952S.M.P53	260	360	100	292	2.1	750	1700	289	350	2	31.7
NNU4956S.M.P53	280	380	100	312	2.1	765	1800	309	370	2	33.6
NNU4960S.M.P53	300	420	118	339	3	1040	2400	335	408	2.5	52.3
NNU4964S.M.P53	320	440	118	359	3	1060	2550	355	428	2.5	55
NNU4968S.M.P53	340	460	118	379	3	1100	2650	375	448	2.5	57.9
NNU4972S.M.C3	360	480	118	399	3	1140	2800	395	468	2.5	60.8
NNU4976S.M.C3	380	520	140	426	4	1430	3600	422	505	3	91.1
NNU4980S.M.C3	400	540	140	446	4	1500	3800	442	525	3	94.8
NNU4984S.M.C3	420	560	140	466	4	1530	4000	462	545	3	98.8
NNU4988S.M.C3	440	600	160	490	4	2040	5200	486	585	3	137
NNU4992S.M.C3	460	620	160	510	4	2120	5500	506	605	3	142
NNU4996S.M.C3	480	650	170	534	5	2360	6100	530	633	4	168
NNU49/500S.M.C3	500	670	170	554	5	2320	6100	550	653	4	172
NNU49/530S.M.C3	530	710	180	588	5	2900	7650	583	693	4	205
NNU49/560S.M.C3	560	750	190	617	5	3150	8800	612	733	4	246
NNU49/600S.M.C3	600	800	200	666	5	3750	10400	661	783	4	284
NNU49/630S.M.C3	630	850	218	704	6	4150	11400	699	827	5	362
NNU49/670S.M.C3	670	900	230	738	6	5000	13400	733	877	5	421
NNU49/710S.M.C3	710	950	243	782	6	5500	15000	777	927	5	493
NNU49/750S.M.C3	750	1000	250	825	6	5850	16600	820	977	5	555
NNU49/800S.M.C3	800	1060	258	880	6	6100	17300	875	1037	5	626
NNU49/850S.M.C3	850	1120	272	931	6	6300	18000	926	1097	5	737

Anstelle von "P53" sind auch Ausführungen in "SP.C3" lieferbar; bitte fragen Sie bei uns an.
Instead of design "P53" design with suffix SP.C3 will be supplied on request.
6 Schmierbohrungen ab NNU49/500S.M.C3 / 6 lubricating holes from NNU49/500S.M.C3 on

FAG Rillenkugellager Reihe 619
FAG Deep Groove Ball Bearings Series 619

Dynamisch äquivalente Belastung
Equivalent dynamic load

$P = F_r$ [kN] für/for $\frac{F_a}{F_r} \le e$

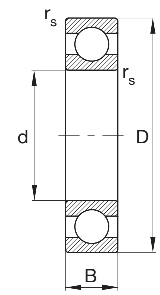
$P = 0.46 \cdot F_r + Y \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} > e$

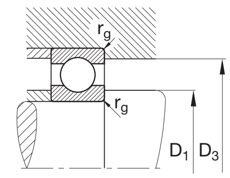
Statisch äquivalente Belastung
Equivalent static load

$P_0 = F_r$ [kN] für/for $\frac{F_a}{F_r} \le 0.8$

$P_0 = 0.6 \cdot F_r + 0.5 \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} > 0.8$

$\frac{f_0 \cdot F_a}{C_0}$	e	Y
0.3	0.32	1.7
0.5	0.35	1.56
0.9	0.39	1.41
1.6	0.43	1.27
3	0.48	1.14
6	0.54	1



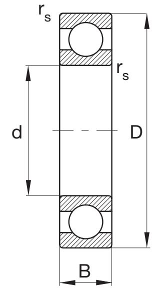


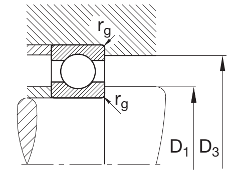
Kurzzeichen Code FAG	Abmessung Dimension d mm	D	B	r_s min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	f_0	Einbaumaß Abutment D_1 min mm	D_3 max	r_g max	Gewicht Weight ≈ kg
61932M.C3	160	220	28	2.0	100	108	16.4	169	211	2	3.21
61934.C3	170	230	28	2.0	102	114	16.5	179	221	2	2.83
61936.C3	180	250	33	2.0	122	137	16.4	189	241	2	4.22
61938.C3	190	260	33	2.0	132	146	16.4	199	251	2	4.39
61940.C3	200	280	38	2.1	150	166	16.4	210	270	2.1	6.27
61944M.C3	220	300	38	2.1	176	204	16.4	230	290	2.1	7.84
61948M.C3	240	320	38	2.1	200	240	16.3	250	310	2.1	8.55
61952M.C3	260	360	46	2.1	220	280	16.3	270	350	2.1	14.4
61956M.C3	280	380	46	2.1	236	310	16.4	290	370	2.1	15.4
61960M.C3	300	420	56	3.0	285	400	16.2	312	408	2.5	24.5
61964M.C3	320	440	56	3.0	300	430	16.4	332	428	2.5	25.9
61968MB.C3	340	460	56	3.0	305	455	16.5	352	448	2.5	26.9
61972MB.C3	360	480	56	3.0	310	480	16.5	372	468	2.5	28.2
61976MB.C3	380	520	65	4.0	365	585	16.4	395	505	3	41.4
61980MB.C3	400	540	65	4.0	375	620	16.5	415	525	3	42.6
61984MB.C3	420	560	65	4.0	390	655	16.5	435	545	3	44.9
61988MB.C3	440	600	74	4.0	390	670	16.4	455	585	3	62.9
61992MB.C3	460	620	74	4.0	400	710	16.4	475	605	3	70.0
61996MB.C3	480	650	78	5.0	440	815	16.4	498	632	4	74.6
619/500MB.C3	500	670	78	5.0	440	800	16.4	518	652	4	77.9
619/530MB.C3	530	710	82	5.0	455	850	16.3	548	692	4	98.8
619/560MB.C3	560	750	85	5.0	510	1000	16.4	578	732	4	109
619/600MB.C3	600	800	90	5.0	550	1120	16.3	618	782	4	128
619/630MB.C3	630	850	100	6.0	630	1320	16.4	653	827	5	168
619/670MB.C3	670	900	103	6.0	640	1370	16.3	693	877	5	189
619/710MB.C3	710	950	106	6.0	680	1530	16.3	733	927	5	222
619/750MB.C3	750	1000	112	6.0	720	1660	16.3	773	977	5	245
619/800MB.C3	800	1060	115	6.0	800	1900	16.3	823	1037	5	282
619/850MB.C3	850	1120	118	6.0	815	2000	16.2	873	1097	5	333

Die Lager sind auf Anfrage auch mit einer Haltenut im Außenring (Nachsetzzeichen N1) lieferbar.
Bestellbeispiel: FAG 619/500N1MB.C3

Bearings with retaining groove in the outer ring will be supplied on request (suffix N1).
Order example: FAG 619/500N1MB.C3

FAG Rillenkugellager Reihe 60
FAG Deep Groove Ball Bearings Series 60





Dynamisch äquivalente Belastung
Equivalent dynamic load

$P = F_r$ [kN] für/for $\frac{F_a}{F_r} \leq e$

$P = 0.46 \cdot F_r + Y \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} > e$

$\frac{f_0 \cdot F_a}{C_0}$	e	Y
0.3	0.32	1.7
0.5	0.35	1.56
0.9	0.39	1.41
1.6	0.43	1.27
3	0.48	1.14
6	0.54	1

Statisch äquivalente Belastung
Equivalent static load

$P_0 = F_r$ [kN] für/for $\frac{F_a}{F_r} \leq 0.8$

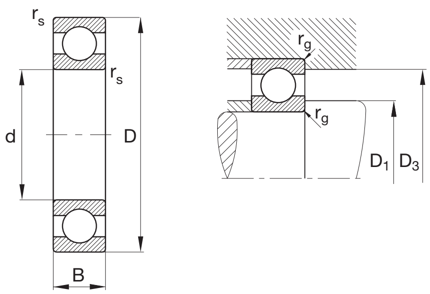
$P_0 = 0.6 \cdot F_r + 0.5 \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} > 0.8$

Kurzzeichen Code	**Abmessung Dimension**				**Tragzahl · Faktor Load rating · Factor**			**Einbaumaß Abutment**			**Gewicht Weight**
	d	D	B	r_s min	dyn. C	stat. C_0	f_0	D_1 min	D_3 max	r_g max	≈
FAG	mm				kN			mm			kg
6020.C3	100	150	24	1.5	60	54	15.9	107	143	1.5	1.32
6021.C3	105	160	26	2	71	64	15.8	114	151	2	1.68
6022.C3	110	170	28	2	80	71	15.6	119	161	2	2.06
6024.C3	120	180	28	2	83	78	15.9	129	171	2	2.18
6026.C3	130	200	33	2	104	100	15.8	139	191	2	3.33
6028.C3	140	210	33	2	108	108	16	149	201	2	3.56
6030.C3	150	225	35	2.1	122	125	16	160	215	2.1	4.38
6032M.C3	160	240	38	2.1	137	134	15.9	170	230	2.1	6.12
6034M.C3	170	260	42	2.1	170	173	15.7	180	250	2.1	8.27
6036M.C3	180	280	46	2.1	186	196	15.6	190	270	2.1	10.7
6038M.C3	190	290	46	2.1	196	212	15.8	200	280	2.1	11.3
6040M.C3	200	310	51	2.1	212	240	15.6	210	300	2.1	14.4
6044M.C3	220	340	56	3	245	290	15.6	232	328	2.5	18.8
6048M.C3	240	360	56	3	255	315	15.8	252	348	2.5	20.5
6052M.C3	260	400	65	4	300	390	15.7	275	385	3	31.6
6056M.C3	280	420	65	4	310	425	15.9	295	405	3	33.5
6060MB.C3	300	460	74	4	365	510	15.7	315	445	3	47.4
6064MB.C3	320	480	74	4	380	560	15.9	335	465	3	50
6068MB.C3	340	520	82	5	440	695	15.8	358	502	4	67.1
6072MB.C3	360	540	82	5	455	735	15.9	378	522	4	68.0
6076MB.C3	380	560	82	5	455	750	16	398	542	4	72.9
6080MB.C3	400	600	90	5	520	865	15.9	418	582	4	92.6
6084MB.C3	420	620	90	5	530	930	16	438	602	4	100
6088MB.C3	440	650	94	6	550	965	16	463	627	5	110
6092MB.C3	460	680	100	6	585	1060	16	483	657	5	127
6096MB.C3	480	700	100	6	600	1120	16.1	503	677	5	139
60/500MB.C3	500	720	100	6	610	1140	16.1	523	697	5	137

Die Lager sind auf Anfrage auch mit einer Haltenut im Außenring (Nachsetzzeichen N1) lieferbar.
Bestellbeispiel: FAG 60/500N1MB.C3

Bearings with retaining groove in the outer ring will be supplied on request (suffix N1).
Order example: FAG 60/500N1MB.C3

FAG Rillenkugellager Reihe 60
FAG Deep Groove Ball Bearings Series 60



Kurzzeichen Code FAG	Abmessung Dimension d mm	 D	 B	 r_s min	Tragzahl · Faktor Load rating · Factor dyn. C kN	 stat. C_0	 f_0	Einbaumaß Abutment D_1 min mm	 D_3 max	 r_g max	Gewicht Weight ≈ kg
60/530MB.C3	530	780	112	6	710	1400	16	553	757	5	190
60/560MB.C3	560	820	115	6	765	1530	16	583	797	5	209
60/600MB.C3	600	870	118	6	780	1660	16.1	623	847	5	245
60/630MB.C3	630	920	128	7.5	880	1900	16	658	892	6	289
60/670MB.C3	670	980	136	7.5	965	2160	16	698	952	6	352
60/710MB.C3	710	1030	140	7.5	1020	2320	16	738	1002	6	389
60/750MB.C3	750	1090	150	7.5	1100	2650	16	778	1062	6	463
60/800MB.C3	800	1150	155	7.5	1140	2800	16.1	828	1122	6	538
60/850MB.C3	850	1220	165	7.5	1220	3150	16.2	878	1192	6	624

FAG Rillenkugellager
FAG Deep Groove Ball Bearings

Dynamisch äquivalente Belastung
Equivalent dynamic load

$P = F_r$ [kN] für/for $\frac{F_a}{F_r} \leq e$

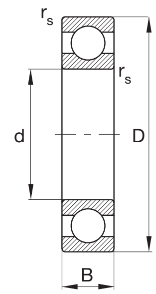
$P = 0.46 \cdot F_r + Y \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} > e$

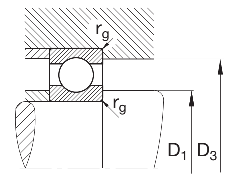
Statisch äquivalente Belastung
Equivalent static load

$P_0 = F_r$ [kN] für/for $\frac{F_a}{F_r} \leq 0.8$

$P_0 = 0.6 \cdot F_r + 0.5 \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} > 0.8$

$\frac{f_0 \cdot F_a}{C_0}$	Lagerluft C3 Clearance C3 e	 Y	Lagerluft C4 Clearance C4 e	 Y
0.3	0.32	1.7	0.4	1.4
0.5	0.35	1.56	0.43	1.31
0.9	0.39	1.41	0.45	1.23
1.6	0.43	1.27	0.48	1.16
3	0.48	1.14	0.52	1.08

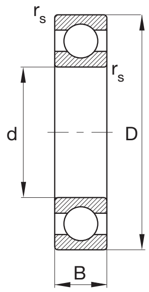


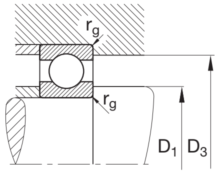


Kurzzeichen **Code** **FAG**	**Abmessung** **Dimension** d mm	 D	 B	 r_s min	**Tragzahl · Faktor** **Load rating · Factor** dyn. C kN	 stat. C_0	 f_0	**Einbaumaß** **Abutment** D_1 min mm	 D_3 max	 r_g max	**Gewicht** **Weight** ≈ kg
538271	150	229.5	35	2.1	122	125	16.0	160	220	2.1	5.45
506964	150	230	35	2.1	122	125	16.0	160	220	2.1	5.5
567422	160	229.5	33	2	102	114	16.5	169	221	2	4.34
574960	160	230	33	2	102	114	16.4	169	221	2	4.38
507540	180	259.5	33	2	122	137	16.4	189	251	2	5.88
502288	190	269.5	33	2	132	146	16.4	199	261	2	6.31
510452	190	280	33	2	132	146	16.4	199	271	2	7.45
508728	200	279.5	38	2.1	150	166	16.4	210	269	2.1	7.17
502283	200	289.5	38	2.1	150	166	16.4	210	270	2.1	8.46
800679 HA	220	309.5	38	2.1	176	204	16.4	230	290	2.1	9.19
507335	220	309.5	38	2.1	176	204	16.4	230	290	2.1	9.19
508729	230	329.5	40	2.1	200	240	16.3	240	319	2.1	11.5
801656 HA	230	329.5	40	2.1	200	240	16.3	240	319	2.1	11.5
578545	240	329.5	40	2.1	196	240	16.4	250	319	2.1	10.4
507338A	260	369.5	46	2.1	220	280	16.3	270	360	2.1	16.4
507341	280	389.5	46	2.1	236	310	16.4	290	380	2.1	17.5
578599	290	409.5	60	3	310	425	15.9	302	397	2.5	26.2
538205	300	419.5	56	3	285	400	16.2	312	407	2.5	24.4
509173	330	460	56	3	305	455	16.4	352	448	2.5	29.6
538204	340	479.5	60	3	280	415	16.5	352	467	2.5	35.7
576368	340	489.5	65	5	345	510	16.2	358	472	4	40.9
532002	350	500	70	4	355	550	16.3	365	485	3	44.3
533303	360	550	85	5	455	735	15.9	378	532	4	75.4
576367	380	519.5	65	4	365	585	16.4	397	505	3	40.3

HA Haltenut im Außenring / retaining groove in the outer ring

FAG Rillenkugellager
FAG Deep Groove Ball Bearings





Kurzzeichen Code FAG	Abmessung Dimension d mm	D	B	r_s min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	f_0	Einbaumaß Abutment D_1 min mm	D_3 max	r_g max	Gewicht Weight ≈ kg
576366	420	559.5	65	4	390	655	16.5	435	545	3	45.6
544178	420	580	70	4	380	640	16.5	435	565	3	57
530352	500	700	100	6	585	1120	16.2	523	677	5	116
508780 HA	530	760	100	6	600	1160	16.3	553	737	5	158
529220 HA	530	780	112	6	710	1400	16.0	553	757	5	190
508308	640	940	128	7.5	815	1760	16.2	668	912	6	327
514645	650	920	118	6	750	1630	16.4	673	897	5	262
509029	670	850	85	6	550	1180	16.1	693	827	5	118
502954	710	1000	140	7.5	880	2000	16.4	738	972	6	361
534196 HA[1])	710	1030	140	7.5	1020	2320	16.0	738	1002	6	394
528283 HA[1])	710	1080	160	7.5	1140	2700	15.8	785	1005	7.5	534
565323 HA	750	1016	125	6	830	2000	16.4	773	993	5	312
500909 HA	760	1080	150	7.5	1100	2650.	16.0	788	1052	6	381
526190	800	1080	115	6	865	2080.	16.4	823	1057	5	313
801911 HA	800	1150	155	7.5	1140	2800.	16.1	828	1122	6	538
501657 HA[2])	850	1220	165	7.5	1220	3150.	16.2	878	1192	6	643
529055 HA	860	1130	120	7.5	930	2360.	16.4	888	1102	6	337

HA Haltenut im Außenring / retaining groove in the outer ring

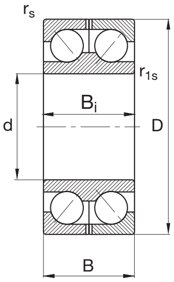
[1]) Radialluft C4; alle anderen Lager haben C3-Lagerluft / radial clearance C4; C3-clearance for the other bearings
[2]) R200.300 (Radialluft von 200...300 µm) / radial clearance to 200 to 300 µm

FAG Schrägkugellager, zweireihig nicht zerlegbar

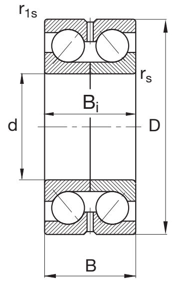
Axiallager für Drahtwalzgerüste

FAG Angular Contact Ball Bearings, double row non-separable

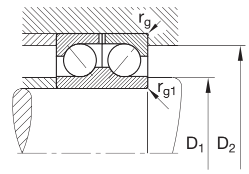
Thrust bearings for wire mills

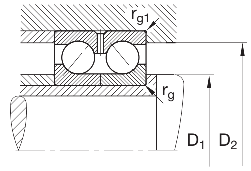


Ausführung 1
Design 1



Ausführung 2
Design 2





Kurzzeichen Code	Ausführung Design	Abmessung Dimension						Tragzahl Load rating		Einbaumaß Abutment				Gewicht Weight ≈
		d	D	B	B_i	r_s min	r_{1s} min	dyn. C	stat. C_0	D_1 min	D_2 max	r_g max	r_{g1} max	
FAG		mm						kN		mm				kg
511044A	2	100	170	60.3	60.3	2	2	140	170	111	159	2	2	5.57
541983	2	120	180	56	56	2	1	146	193	129	175	2	1	4.75
540889*)	2 Z	120	190	66	66	2	2	186	236	131	179	2	2	6.74
517458A*)	2	120	190	66	66	2	2	186	236	131	179	2	2	6.74
538854	2	140	209.5	66	66	2	2	173	236	149	201	2	2	7.52
577243	2 HA	150	225	70	70	2.1	2.1	180	255	160	215	2	2	9.47
568819	2 HA	150	225	73	73	2.1	2.1	180	255	160	215	2.1	2.1	9.89
510776A	2	150	225	73	73	2.1	2.1	180	255	160	215	2.1	2.1	9.89
506963	2	150	230	70	70	2.1	2.1	212	290	160	220	2.1	2.1	9.63
567620	2 HA	150	230	70	70	2.1	2.1	236	325	160	220	2.1	2.1	10.7
504083	1	150	240	84	84	1.5	1	240	335	155	233	1.5	1	15.8
514478	2	160	215	50	56	1.8	1.8	132	204	167	208	1.8	1.8	5.27
537406	2	160	239.5	76	76	2.1	2	232	325	170	231	2.1	2	11.4
507511	1	160	240	76	76	2	2	232	325	169	231	2	2	12.3
503288	1	170	260	84	84	2.1	2.1	280	405	180	250	2.1	2.1	16.5
506872	1	175	280	92	92	2.1	2.1	315	475	185	270	2.1	2.1	23.4
528711A	1	180	250	66	66	2	2	190	285	189	241	2	2	9.93
508893A	1	180	250	70	70	2	2	190	285	189	241	2	2	10.4
509059A	2	180	259.5	66	66	2	2	196	305	189	251	2	2	11.9
566013	2 HA	180	280	92	92	2	2	290	430	189	271	2	2	20.1
503739	1	180	280	92	92	2.1	1.1	290	440	186	270	2.1	1.1	21.6

HA Haltenut im Außenring / retaining groove in the outer ring
Z Lager zerlegbar / bearing separable

Dynamisch äquivalente Belastung
Equivalent dynamic load

$P = 0.93 \cdot F_a$ [kN]
*) $P = 1.24 \cdot F_a$ [kN]

Statisch äquivalente Belastung
Equivalent static load

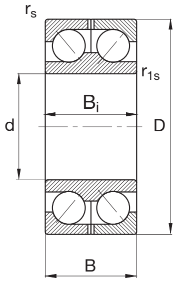
$P_0 = 0.52 \cdot F_a$ [kN]
*) $P_0 = 0.66 \cdot F_a$ [kN]

FAG Schrägkugellager, zweireihig nicht zerlegbar

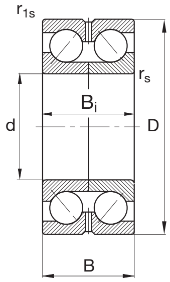
Axiallager für Drahtwalzgerüste

FAG Angular Contact Ball Bearings, double row non-separable

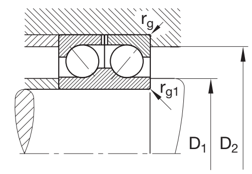
Thrust bearings for wire mills

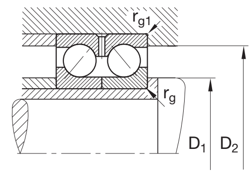


Ausführung 1
Design 1



Ausführung 2
Design 2

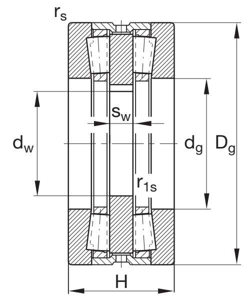


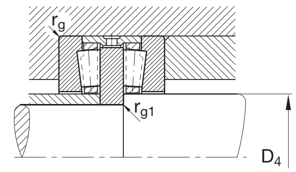


Kurzzeichen Code	Ausführung Design	Abmessung Dimension						Tragzahl Load rating		Einbaumaß Abutment				Gewicht Weight ≈
		d	D	B	B_i	r_s min	r_{1s} min	dyn. C	stat. C_0	D_1 min	D_2 max	r_g max	r_{g1} max	
FAG		mm						kN		mm				kg
514479	2	190	255	58	66	1.1	1.1	180	285	196	249	1.1	1.1	8.73
508658A	2	190	269.5	66	66	2	2	224	345	199	261	2	2	10.4
507510A	1	190	290	92	92	2.1	1.1	325	500	196	280	2.1	1.1	23.4
508733A	2	200	279.5	76	76	2.1	2.1	245	380	210	270	2.1	2.1	14.3
507629	1	200	280	80	80	2.1	1.1	255	390	206	270	2.1	1.1	15.8
509590A	2	200	289.5	76	76	2.1	2.1	245	380	210	280	2.1	2.1	16.9
581040	2 HA	200	289.5	76	76	2.1	2.1	245	380	210	280	2.1	2.1	16.9
507448	1	200	289.5	76	76	2.1	1.1	245	380	206	280	2.1	2.1	17.9
538852	2	200	309.5	96	96	2.1	2.1	365	585	210	300	2.1	2.1	26.3
506871	1	200	310	96	96	2.1	2.1	365	585	210	300	2.1	2.1	28.3
514480	2	220	300	70	76	1.1	1.1	265	430	226	294	1.1	1.1	14.6
511045A	2	220	309.5	76	76	2	2	255	405	229	301	2	2	17.5
567621	2 HA	220	309.5	76	76	2	2	285	465	229	301	2	2	17.6
508732A	2	230	329.5	80	80	2.1	2.1	320	530	240	320	2.1	2.1	22.0
573446	1	230	329.5	80	80	2.1	1.1	320	530	236	320	2.1	1.1	23.9
514481	2	250	340	70	76	2.1	1.5	300	510	260	333	2.1	1.5	18.9
508731A	2	260	369.5	92	92	2.1	2.1	390	695	270	360	2.1	2.1	30.5
505057	1	260	400	130	130	4	4	540	1020	277	383	4	4	61.5
508730A	2	280	389.5	92	92	2.1	2.1	405	750	290	380	2.1	2.1	32.5

FAG Axial-Kegelrollenlager
zweiseitig wirkend, mit Zwischenring

FAG Tapered Roller Thrust Bearings
double acting, with spacer

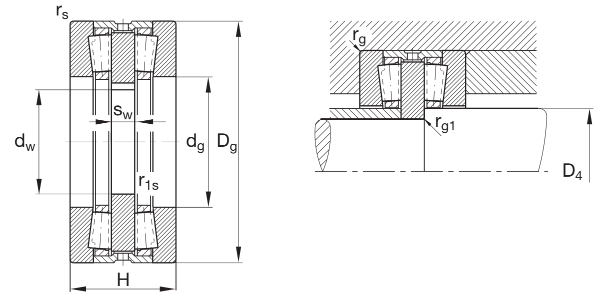




Kurzzeichen Code		Abmessung Dimension							Tragzahl Load rating		Einbaumaß Abutment			Gewicht Weight
									dyn.	stat.				≈
		d_w	d_g	D_g	H	s_w	r_s min	r_{1s} min	C	C_0	D_4 max	r_g max	r_{g1} max	
FAG		mm							kN		mm			kg
528974		170	184	240	84	20	2	0.6	380	1430	180.5	2	0.6	11.5
528294		180	196	280	90	20	2	1	720	3250	190	2	1	20
563400		200	236	300	96	22	2	0.6	570	2240	229.5	2	0.6	23
528876		220	236	300	96	22	2	0.6	570	2240	229.5	2	0.6	20
529086		240	256	320	96	22	2	0.6	610	2600	249	2	0.6	20
545678		240	275	380	105	27	2	2	980	5200	267	2	2	44
547482		250	285	360	96	24	2.1	1.1	680	3100	274	2.1	1	26
522010	HW	250	275	380	100	22	2	1.1	980	5200	267	2	1	41
509352		260	285	360	92	20	2.1	1.1	680	3100	274	2	1	26
527907	HW	270	316	450	180	44	6	3	2000	8500	302	5	2.5	110
524740		300	330	420	100	23	1.1	1.1	865	4400	322	1	1	45
528562		320	355	440	108	26	3	1.5	980	4900	345	2.5	1.5	47
509654		320	350	470	130	30	3	1.1	1340	6550	335	2.5	1	74
522837		320	380	600	240	50	4	2	3900	17600	360	3	2	324
530739	HW	350	390	490	130	30	3	1.1	1320	6700	375	2.5	1	73
579703		350	390	490	145	45	3	1.5	1320	6700	375	3	1.5	81
522008		350	400	540	135	30	3	1	1800	10400	385	2.5	1	106
573320		360	410	530	145	45	4	2	1500	7800	398	3	2	104
524194		360	396	560	200	48	5	2	2900	12900	383	4	2	175
513828		380	410	530	130	30	5	3	1660	8500	398	4	2.5	90
513125		380	430	560	130	32	2.5	1.5	1800	10800	411	2.5	1.5	102
567356		380	430	560	145	47	2.5	1.5	1800	10800	411	2.5	1.5	129
545936	HW	380	450	650	215	65	6	3	3750	19300	430	5	2.5	275
509392		420	470	620	170	35	3	1.5	2280	12000	450	2.5	1.5	185
545991		420	470	620	185	50	3	1	2280	12000	450	2.5	1	202
579704		420	470	620	200	65	3	3	2280	12000	450	2.5	2.5	217

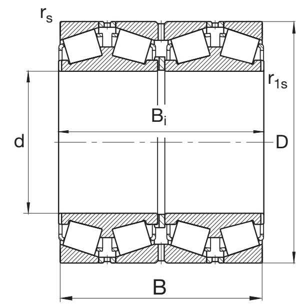
HW Haltenut in der Wellenscheibe / retaining groove in shaft washer

FAG Axial-Kegelrollenlager
zweiseitig wirkend, mit Zwischenring
FAG Tapered Roller Thrust Bearings
double acting, with spacer

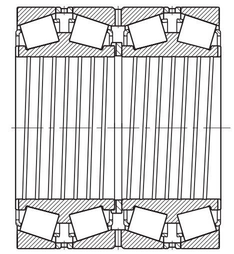


Kurzzeichen Code		Abmessung Dimension							Tragzahl Load rating		Einbaumaß Abutment			Gewicht Weight
									dyn.	stat.				≈
		d_w	d_g	D_g	H	s_w	r_s min	r_{1s} min	C	C_0	D_4 max	r_g max	r_{g1} max	
FAG		mm							kN		mm			kg
534038	HW	440	500	645	167	50	5	2	2240	12700	480	4	2	160
513401	HW	450	500	645	155	38	5	3	2240	12700	480	4	2.5	150
509391	HW	470	535	720	200	50	3	2	3400	19300	517	2.5	2	283
549701		470	535	720	210	60	3	2	3400	19300	517	2.5	2	296
547584	HW	480	575	710	218	57	5	3	2700	14000	555	4	2.5	280
511746	HW	530	575	710	218	57	5	2	2700	14000	555	4	2	235
515196	HW	550	610	760	230	50	5	2	3200	16300	581	4	2	296
521823	HW	670	725	900	230	50	5	2	3800	21200	700	4	2	395

FAG Kegelrollenlager, vierreihig
in Zollabmessungen
FAG Tapered Roller Bearings, four row
in inch dimensions



Ausführung 1
Design 1


Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
538585	1	120.65 4.7500	174.625 6.8750	139.703 5.5001	141.288 5.5625	1.5	0.8
509680	1	127 5.0000	182.562 7.1875	158.875 6.2549	158.875 6.2549	3.3	1.5
514353	1	130.175 5.1250	196.85 7.7500	200.025 7.8750	200.025 7.8750	3.3	1.5
509693A	1	139.7 5.5000	200.025 7.8750	160.34 6.3126	157.165 6.1876	3.3	0.8
802114	1	152.4 6.0000	222.25 8.7500	174.625 6.8750	174.625 6.8750	1.5	1.5
802114.H122AA	2	152.4 6.0000	222.25 8.7500	174.625 6.8750	174.625 6.8750	1.5	1.5
802159	1	165.1 6.5000	225.425 8.8750	168.275 6.6250	165.1 6.5000	3.3	0.8
802117	1	177.8 7.0000	247.65 9.7500	192.088 7.5625	192.088 7.5625	3.3	1.5
508776A	1	187.325 7.3750	269.875 10.6250	211.138 8.3125	211.138 8.3125	3.3	1.5
802123	1	190.5 7.5000	266.7 10.5000	188.912 7.4375	187.325 7.3750	3.3	1.5
521799A	1	198.438 7.8125	284.162 11.1875	225.425 8.8750	225.425 8.8750	3.3	1.5
574331	1	203.2 8.0000	317.5 12.5000	266.7 10.5000	266.7 10.5000	3.3	1.5
802016	1	206.375 8.1250	282.575 11.1250	190.5 7.5000	190.5 7.5000	3.3	0.8
802016.H122AA	2	206.375 8.1250	282.575 11.1250	190.5 7.5000	190.5 7.5000	3.3	0.8

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.

Tragzahl · Faktor Load rating · Factor			Vergleichstragzahl[1]) Equivalent load rating[1])		Axialfaktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C	stat. C_0	e	C_{r90}	C_{a90}	K		
kN			kN			kg	TQO-Type
815	1400	0.33	204	32.5	1.75	11	M224749DW.710.710D
950	1900	0.31	240	36	1.91	14	48290DW.220.220D
1250	2280	0.34	315	53	1.70	22	67391DW.322.323D
1020	2040	0.34	255	42.5	1.74	17	48680DW.620.620D
1180	2120	0.35	300	50	1.68	22	M231649DW.610.610D
1180	2120	0.35	300	50	1.68	22	M231649DGW.610.610D
965	2080	0.38	240	45	1.52	19.8	46791DW.720.721D
1400	2900	0.44	355	76.5	1.33	28.4	67791DW.720.721D
2080	3800	0.33	520	85	1.75	40	M238849DW.810.810D
1400	3000	0.48	355	83	1.22	33	67885DW.67820.67820D
2160	4150	0.34	550	91.5	1.72	48	M240648DW.611.611D
2550	4800	0.53	640	66	1.11	81	93800DW.125.127D
1500	3250	0.51	375	93	1.15	36	67986DW.920.921D
1500	3250	0.51	375	93	1.15	36	67986DGW.920.921D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

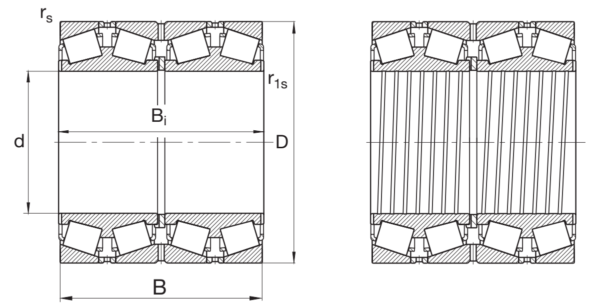
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, vierreihig

in Zollabmessungen

FAG Tapered Roller Bearings, four row

in inch dimensions



Ausführung 1
Design 1

Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
523935	1	215.9 8.5000	288.925 11.3750	177.8 7.0000	177.8 7.0000	3.3	0.8
802100	1	216.103 8.5080	330.2 13.0000	269.875 10.6250	263.525 10.3750	3.3	1.5
802018	1	220.662 8.6875	314.325 12.3750	239.712 9.4375	239.712 9.4375	3.3	1.5
802018.H122AA	2	220.662 8.6875	314.325 12.3750	239.712 9.4375	239.712 9.4375	3.3	1.5
511115	1	228.6 9.0000	355.6 14.0000	260.35 10.2500	266.7 10.5000	1.5	1.5
524152	1	228.6 9.0000	400.05 15.7500	296.875 11.6880	296.875 11.6880	3.3	3.3
513166A	1	234.95 9.2500	327.025 12.8750	196.85 7.7500	196.85 7.7500	3.3	1.5
564027	1	241.224 9.4970	355.498 13.9960	228.6 9.0000	228.6 9.0000	3.3	1.5
802115	1	241.478 9.5070	349.148 13.7460	228.6 9.0000	228.6 9.0000	3.3	1.5
509411	1	244.475 9.6250	327.025 12.8750	193.675 7.6250	193.675 7.6250	3.3	1.5
521798	2	244.475 9.6250	327.025 12.8750	193.675 7.6250	193.675 7.6250	3.3	1.5
522847	1	244.475 9.6250	381 15.0000	304.8 12.0000	304.8 12.0000	4.8	3.3
513833	1	254 10.0000	358.775 14.1250	269.875 10.6250	269.875 10.6250	3.3	1.5
510375	1	260.35 10.2500	400.05 15.7500	253.995 9.9998	255.585 10.0624	6.4	1.5

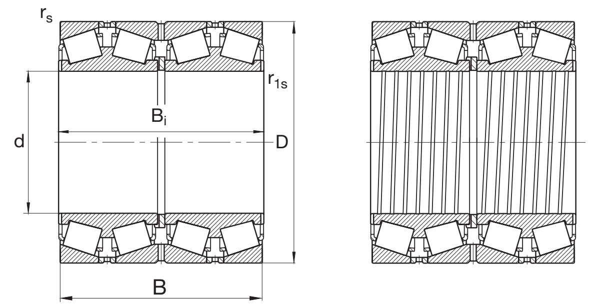
Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.

Tragzahl · Faktor Load rating · Factor			Vergleichstragzahl[1]) Equivalent load rating[1])		Axialfaktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C	stat. C_0	e	C_{r90}	C_{a90}	K		
kN			kN			kg	TQO-Type
1460	3200	0.48	365	86.5	1.21	33.3	LM742749DW.714.714D
2750	5200	0.56	695	190	1.05	84	9974DW.9920.9920D
2360	4550	0.35	600	102	1.67	59	M244249DW.210.210D
2360	4550	0.35	600	102	1.67	59	M244249DGW.210.210D
2900	5000	0.34	735	125	1.69	101	EE130904DW.400.402D
4150	6400	0.31	1040	160	1.89	164	EE529091DW.157.158D
1960	4000	0.41	490	98	1.44	52	8576DW.8520.8520D
2400	4550	0.35	600	104	1.66	80	EE127094DW.138.139D
2400	4550	0.35	600	104	1.66	72	EE127097DW.135.136D
1630	3450	0.48	405	95	1.22	47	LM247748DW.710.710D
1630	3450	0.48	405	95	1.22	47	LM247748DGW.710.710D
3750	7100	0.46	950	216	1.26	133	EE126096DW.150.151D
3200	6300	0.34	800	134	1.71	86	M249748DW.710.710D
2900	5100	0.44	735	156	1.32	115	EE221027DW.575.576D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, vierreihig
in Zollabmessungen
FAG Tapered Roller Bearings, four row
in inch dimensions



Ausführung 1
Design 1

Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
517254	1	260.35 10.2500	422.275 16.6250	317.5 12.5000	314.325 12.3750	3.3	6.4
802010	1	266.7 10.5000	355.6 14.0000	228.6 9.0000	230.188 9.0625	3.3	1.5
802010.H122AA	2	266.7 10.5000	355.6 14.0000	228.6 9.0000	230.188 9.0625	3.3	1.5
802099	1	269.875 10.6250	381 15.0000	282.575 11.1250	282.575 11.1250	3.3	3.3
504512	1	276.225 10.8750	393.7 15.5000	269.878 10.6251	269.878 10.6251	6.4	1.5
802009	1	279.4 11.0000	393.7 15.5000	269.875 10.6250	269.875 10.6250	6.4	1.5
802009.H122AA	2	279.4 11.0000	393.7 15.5000	269.875 10.6250	269.875 10.6250	6.4	1.5
802051	1	279.578 11.0070	380.898 14.9960	244.475 9.6250	244.475 9.6250	3.3	1.5
802051.H122AA	2	279.578 11.0070	380.898 14.9960	244.475 9.6250	244.475 9.6250	3.3	1.5
802056	1	285.75 11.2500	380.898 14.9960	244.475 9.6250	244.475 9.6250	3.3	1.5
802056.H122AA	2	285.75 11.2500	380.898 14.9960	244.475 9.6250	244.475 9.6250	3.3	1.5
514225	1	288.925 11.3750	406.4 16.0000	298.45 11.7500	298.45 11.7500	3.3	3.3
512630	1	292.1 11.5000	422.275 16.6250	269.875 10.6250	269.875 10.6250	3.3	6.4
802067	1	300 11.8110	440 17.3228	279.4 11.0000	280.988 11.0625	4.8	3.3

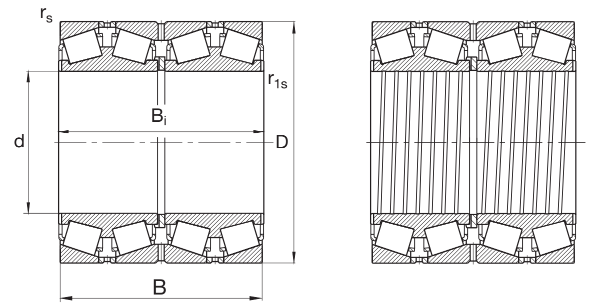
Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.

Tragzahl · Faktor Load rating · Factor			Vergleichstragzahl[1]) Equivalent load rating[1])		Axialfaktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C	stat. C_0	e	C_{r90}	C_{a90}	K		
kN			kN			kg	TQO-Type
4400	7100	0.33	1100	180	1.74	180	HM252349DW.310.310D
2550	5400	0.36	640	112	1.64	62	LM451349DW.310.310D
2550	5400	0.36	640	112	1.64	62	LM451349DGW.310.310D
3650	7350	0.33	915	150	1.76	103	M252349DW.310.310D
3200	6100	0.45	815	180	1.29	109	EE275109DW.155.156D
3550	6800	0.38	900	166	1.54	100	EE135111DW.155.156D
3550	6800	0.38	900	166	1.54	100	EE135111DGW.155.156D
2600	6200	0.42	655	134	1.39	84	LM654644DW.610.610D
2600	6200	0.42	655	134	1.39	84	LM654644DGW.610.610D
2600	6200	0.42	655	134	1.39	79	LM654648DW.610.610D
2600	6200	0.42	655	134	1.39	79	LM654648DGW.610.610D
4050	8300	0.35	1020	176	1.68	125	M255449DW.410.410D
3650	6950	0.33	915	150	1.74	123	EE330116DW.166.167D
3150	6400	0.40	800	156	1.46	145	EE129119DW.174.175D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, vierreihig
in Zollabmessungen
FAG Tapered Roller Bearings, four row
in inch dimensions



Ausführung 1
Design 1

Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
802067.H122AA	2	300 11.8110	440 17.3228	279.4 11.0000	280.988 11.0625	3.3	3.3
802136	1	300.038 11.8125	422.275 16.6250	311.15 12.2500	311.15 12.2500	3.3	3.3
504415A	1	304.648 11.9940	438.048 17.2460	279.4 11.0000	280.990 11.0626	4.8	3.3
511861	1	304.8 12.0000	419.1 16.5000	269.875 10.6250	269.875 10.6250	6.4	1.5
575220	1	304.8 12.0000	495.3 19.5000	349.25 13.7500	342.9 13.5000	6.4	3.3
802024	1	304.902 12.0040	412.648 16.2460	266.7 10.5000	266.7 10.5000	3.3	3.3
802024.H122AA	2	304.902 12.0040	412.648 16.2460	266.7 10.5000	266.7 10.5000	3.3	3.3
518078	1	305.003 12.0080	438.048 17.2460	279.4 11.0000	280.99 11.0626	4.8	3.3
802045	1	317.5 12.5000	422.275 16.6250	269.875 10.6250	269.875 10.6250	3.3	1.5
802045.H122AA	2	317.5 12.5000	422.275 16.6250	269.875 10.6250	269.875 10.6250	3.3	1.5
524469	2	317.5 12.5000	447.675 17.6250	327.025 12.8750	327.025 12.8750	3.3	3.3
531883	1	330.2 13.0000	444.5 17.5000	301.625 11.8750	301.625 11.8750	3.3	3.3
525465	2	330.302 13.0040	438.023 17.2450	254 10.0000	247.65 9.7500	3.3	1.5
802062	1	333.375 13.1250	469.9 18.5000	342.9 13.5000	342.9 13.5000	3.3	3.3

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.

Tragzahl · Faktor Load rating · Factor			Vergleichstragzahl[1]) Equivalent load rating[1])		Axialfaktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C	stat. C_0	e	C_{r90}	C_{a90}	K		
kN			kN			kg	TQO-Type
3150	6400	0.40	800	156	1.46	145	EE129119DGW.174.175D
4150	8800	0.36	1060	190	1.61	137	HM256849DW.810.810D
3900	7350	0.47	1000	232	1.23	131	M757448DW.410.410D
3650	7650	0.32	915	143	1.83	115	M257149DW.110.110D
5400	9150	0.40	1370	270	1.46	271	EE724121DW.195.196D
3650	7650	0.32	915	143	1.83	103	M257248DW.210.210D
3650	7650	0.32	915	143	1.83	103	M257248DGW.210.210D
3900	7350	0.47	1000	232	1.23	131	M757449DW.410.410D
3450	7800	0.32	880	137	1.83	103	LM258648DW.610.610D
3450	7800	0.32	880	137	1.83	103	LM258648DGW.610.610D
4800	10400	0.33	1220	200	1.75	167	HM259049DGW.010.010D
3800	8500	0.40	950	186	1.46	136	M260149DW.110.110D
3250	6800	0.44	830	176	1.33	108	EE138131DGW.172.173D
4900	10800	0.38	1250	232	1.55	187	HM261049DW.010.010D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

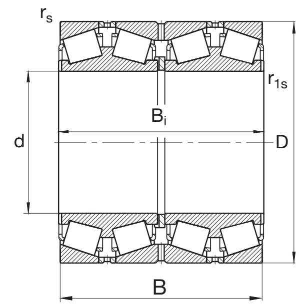
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, vierreihig

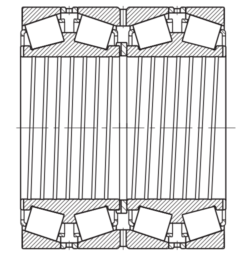
in Zollabmessungen

FAG Tapered Roller Bearings, four row

in inch dimensions



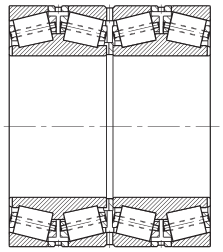
Ausführung 1
Design 1



Ausführung 2
Design 2

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min
802062M	3	333.375 13.1250	469.9 18.5000	342.9 13.5000	342.9 13.5000	3.3	3.3
572452	3	342.9 13.5000	571.5 22.5000	342.9 13.5000	342.9 13.5000	6.4	3.3
802002.A270.300	1	343.052 13.5060	457.098 17.9960	254 10.0000	254 10.0000	3.3	1.5
802002.A270.300.H122AA	2	343.052 13.5060	457.098 17.9960	254 10.0000	254 10.0000	3.3	1.5
802028	1	346.075 13.6250	488.95 19.2500	358.775 14.1250	358.775 14.1250	3.3	3.3
802052	1	347.662 13.6875	469.9 18.5000	292.1 11.5000	292.1 11.5000	3.3	3.3
802119	1	355.6 14.0000	457.2 18.0000	252.412 9.9375	252.412 9.9375	3.3	1.5
802022	1	355.6 14.0000	482.6 19.0000	269.875 10.6250	265.112 10.4375	3.3	1.5
802022.H122AA	2	355.6 14.0000	482.6 19.0000	269.875 10.6250	265.112 10.4375	3.3	1.5
802137.H122AA	2	355.6 14.0000	488.95 19.2500	317.5 12.5000	317.5 12.5000	3.3	1.5
548757	1	368.3 14.5000	523.875 20.6250	382.588 15.0625	382.588 15.0625	6.4	3.3
509737A	2	368.3 14.5000	523.875 20.6250	382.588 15.0625	382.588 15.0625	6.4	3.3
527934	1	374.65 14.7500	501.65 19.7500	260.35 10.2500	250.825 9.8750	3.3	1.5
506725A	1	384.175 15.1250	546.1 21.5000	400.05 15.7500	400.05 15.7500	6.4	3.3

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.

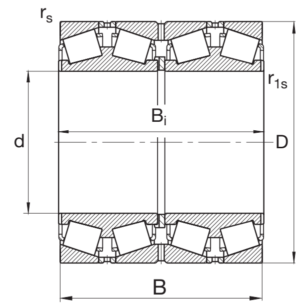


Ausführung 3
Design 3

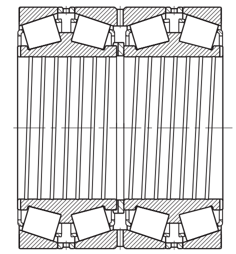
Tragzahl · Faktor Load rating · Factor dyn. C	 stat. C_0	 e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90}	 C_{a90}	Axialfaktor Thrust factor K	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
kN			kN			kg	TQO-Type
5000	11000	0.38	1270	236	1.55	193	HM261049DW.010.010D
6550	10600	0.33	1660	270	1.75	369	EE536136DW.225.226D
3350	6800	0.47	830	193	1.23	110	LM761649DW.610.610D
3350	6800	0.47	830	193	1.23	110	LM761649DGW.610.610D
5850	12500	0.33	1460	240	1.75	215	HM262749DW.710.710D
4250	8650	0.31	1060	163	1.87	140	M262449DW.410.410D
3450	8150	0.32	865	137	1.83	104	LM263149DW.110.110D
3600	8000	0.45	900	196	1.31	142	LM763449DW.410.410D
3600	8000	0.45	900	196	1.31	142	LM763449DGW.410.410D
4900	10800	0.39	1250	240	1.48	179	M263349DGW.310.310D
6400	13700	0.35	1630	280	1.66	272	HM265049DW.010.010D
6400	13700	0.35	1630	280	1.66	272	HM265049DGW.010.010D
3800	7800	0.47	950	220	1.23	145	LM765149DW.110.110D
7100	15600	0.33	1800	290	1.75	309	HM266449DW.410.410D

1) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, vierreihig
in Zollabmessungen
FAG Tapered Roller Bearings, four row
in inch dimensions

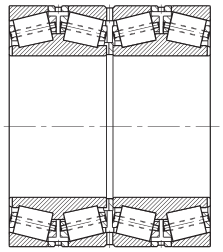


Ausführung 1
Design 1


Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
802014	1	385.762 15.1875	514.35 20.2500	317.5 12.5000	317.5 12.5000	3.3	3.3
802014.H122AA	2	385.762 15.1875	514.35 20.2500	317.5 12.5000	317.5 12.5000	3.3	3.3
508328B	1	406.4 16.0000	546.1 21.5000	288.925 11.3750	268.288 10.5625	6.4	1.5
524533B	2	406.4 16.0000	546.1 21.5000	288.925 11.3750	268.288 10.5625	6.4	1.5
802104	1	406.4 16.0000	546.1 21.5000	288.925 11.3750	288.925 11.3750	6.4	1.5
802104.H122BA	2	406.4 16.0000	546.1 21.5000	288.925 11.3750	288.925 11.3750	6.4	1.5
802086	1	406.4 16.0000	565.15 22.2500	381 15.0000	381 15.0000	6.4	3.3
802086.H122AA	2	406.4 16.0000	565.15 22.2500	381 15.0000	381 15.0000	6.4	3.3
511569	1	406.4 16.0000	590.55 23.2500	400.05 15.7500	400.05 15.7500	6.4	3.3
517944	3	406.4 16.0000	590.55 23.2500	400.05 15.7500	400.05 15.7500	6.4	3.3
802047	1	409.575 16.1250	546.1 21.5000	334.962 13.1875	334.962 13.1875	6.4	1.5
802047.H122AA	2	409.575 16.1250	546.1 21.5000	334.962 13.1875	334.962 13.1875	6.4	1.5
802047M	3	409.575 16.1250	546.1 21.5000	334.962 13.1875	334.962 13.1875	6.4	1.5
802048.H122AA	2	415.925 16.3750	590.55 23.2500	434.975 17.1250	434.975 17.1250	6.4	3.3

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.

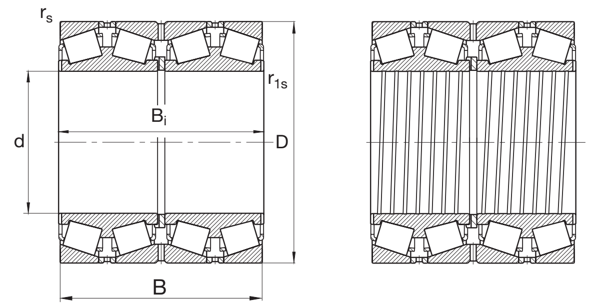


Ausführung 3
Design 3

Tragzahl · Faktor Load rating · Factor			Vergleichstragzahl[1]) Equivalent load rating[1])		Axialfaktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C	stat. C_0	e	C_{r90}	C_{a90}	K		
kN			kN			kg	TQO-Type
4650	10800	0.45	1160	260	1.30	183	LM665949DW.910.910D
4650	10800	0.45	1160	260	1.30	183	LM665949DGW.910.910D
4250	8650	0.47	1060	245	1.23	192	EE234161DW.215.216D
4250	8650	0.47	1060	245	1.23	192	EE234161DGW.215.216D
4500	9500	0.43	1140	240	1.35	183	LM767749DW.710.710D
4500	9500	0.43	1140	240	1.35	183	LM767749DGW.710.710D
6950	15000	0.43	1760	365	1.36	290	M267949DW.910.910D
6950	15000	0.43	1760	365	1.36	290	M267949DGW.910.910D
7350	15000	0.34	1860	310	1.72	367	EE833161DW.232.233D
7650	16000	0.34	1930	320	1.72	378	EE833161DW.232.233D
5300	12500	0.45	1340	300	1.30	218	M667947DW.910.910D
5300	12500	0.45	1340	300	1.30	218	M667947DGW.910.910D
5500	13200	0.45	1370	305	1.30	225	M667947DW.910.910D
7800	16600	0.34	2000	335	1.71	376	M268749DGW.710.710D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, vierreihig
in Zollabmessungen
FAG Tapered Roller Bearings, four row
in inch dimensions



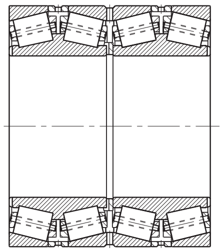
Ausführung 1
Design 1

Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
802048M	3	415.925 16.3750	590.55 23.2500	434.975 17.1250	434.975 17.1250	6.4	3.3
802155	1	431.8 17.0000	571.5 22.5000	279.4 11.0000	279.4 11.0000	3.3	1.5
802012	1	431.8 17.0000	571.5 22.5000	336.55 13.2500	336.55 13.2500	6.4	1.5
802012.H122BP	2	431.8 17.0000	571.5 22.5000	336.55 13.2500	336.55 13.2500	6.4	1.5
802012M	3	431.8 17.0000	571.5 22.5000	336.55 13.2500	336.55 13.2500	6.4	1.5
530985	1	431.8 17.0000	635 25.0000	355.6 14.0000	355.6 14.0000	6.4	6.4
530731	3	431.8 17.0000	635 25.0000	355.6 14.0000	355.6 14.0000	6.4	6.4
529077	1	432.003 17.0080	609.524 23.9970	317.5 12.5000	317.5 12.5000	6.4	3.6
513357	2	447.675 17.6250	635 25.0000	463.55 18.2500	463.55 18.2500	6.4	3.3
513894	3	447.675 17.6250	635 25.0000	463.55 18.2500	463.55 18.2500	6.4	3.3
802063.H122AD	1 SB	450 17.7165	595 23.4252	368 14.4882	368 14.4882	6	3
802098	1	457.2 18.0000	596.9 23.5000	279.4 11.0000	276.225 10.875	3.3	1.5
802098M	3	457.2 18.0000	596.9 23.5000	279.4 11.0000	276.225 10.8750	3.3	1.5
522388	1	460 18.1102	625 24.6063	421 16.5748	421 16.5748	9	3

SB Lager mit Schmierbohrungen durch die Mittelborde der Innenringe
Bearing with lubrication holes through center lips of the inner rings

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.



Ausführung 3
Design 3

Tragzahl · Faktor **Load rating · Factor** dyn. C	 stat. C_0	 e	**Vergleichstragzahl[1])** **Equivalent load rating[1])** C_{r90}	 C_{a90}	**Axialfaktor** **Thrust factor** K	**Gewicht** **Weight** ≈	**Vergleichsbezeichnung** **Equivalent number**
kN			kN			kg	TQO-Type
8150	17600	0.34	2080	345	1.71	402	M268749DW.710.710D
4650	9650	0.55	1180	315	1.07	185	LM869449DW.410.410D
5850	13700	0.44	1460	315	1.33	236	LM769349DW.310.310D
5850	13700	0.44	1460	315	1.33	236	LM769349DGW.310.310D
5850	14000	0.44	1500	320	1.33	246	LM769349DW.310.310D
7200	12900	0.32	1830	285	1.83	385	EE931170DW.250.251D
7350	13400	0.32	1860	290	1.83	396	EE931170DW.250.251D
5850	11000	0.47	1460	335	1.25	320	EE736173DW.238.239D
9800	20800	0.33	2500	400	1.79	470	M270749DGW.710.710D
10000	21200	0.33	2550	405	1.79	484	M270749DW.710.710D
6800	16000	0.33	1700	280	1.75	277	M270449DA.410.410D
4750	10200	0.47	1200	275	1.23	197	L770847DW.810.810D
4800	10400	0.47	1200	280	1.23	205	L770847DW.810.810D
8150	18300	0.33	2040	335	1.75	370	M271149DW.110.110D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
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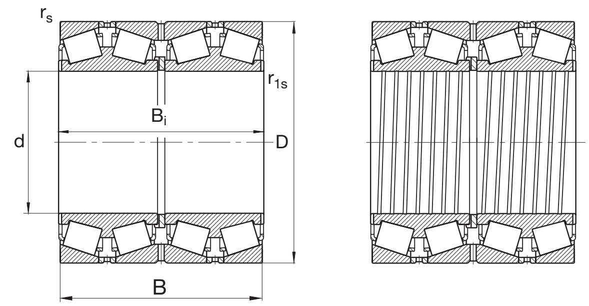
FAG Kegelrollenlager, vierreihig
in Zollabmessungen
FAG Tapered Roller Bearings, four row
in inch dimensions

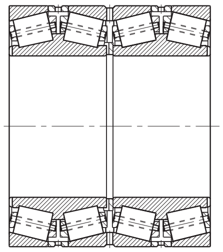


Ausführung 1
Design 1

Ausführung 2
Design 2

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min
506201	1	479.425 18.8750	679.45 26.7500	495.3 19.5000	495.3 19.5000	6.4	3.3
561038	3	479.425 18.8750	679.45 26.7500	495.3 19.5000	495.3 19.5000	6.4	3.3
802006.H122AB	1	482.6 19.0000	615.95 24.2500	330.2 13.0000	330.2 13.0000	6.4	6.4
802006.H122BA	2	482.6 19.0000	615.95 24.2500	330.2 13.0000	330.2 13.0000	6.4	6.4
561772	1	482.6 19.0000	635 25.0000	421 16.5748	421 16.5748	6.4	3
522121	1	482.6 19.0000	647.7 25.5000	417.513 16.4375	417.513 16.4375	6.4	3.3
802122	1	488.95 19.2500	660.4 26.0000	361.95 14.2500	365.125 14.3750	6.4	8
802037	1	489.026 19.2530	634.873 24.9950	320.675 12.6250	320.675 12.6250	3.3	3.3
802037.H122BB	2	489.026 19.2530	634.873 24.9950	320.675 12.6250	320.675 12.6250	3.3	3.3
802085.H122AC	1	501.65 19.7500	673.1 26.5000	387.35 15.2500	400.05 15.7500	6.4	3.3
802085M	3	501.65 19.7500	673.1 26.5000	387.35 15.2500	400.05 15.7500	6.4	3.3
515180	1	501.65 19.7500	711.2 28.0000	520.7 20.5000	520.7 20.5000	6.4	3.3
529275	2	501.65 19.7500	711.2 28.0000	520.7 20.5000	520.7 20.5000	6.4	4.6
530843	3	501.65 19.7500	711.2 28.0000	520.7 20.5000	520.7 20.5000	6.4	3.3

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.



Ausführung 3
Design 3

Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90} kN	C_{a90}	Axialfaktor Thrust factor K	Gewicht Weight ≈ kg	Vergleichsbezeichnung Equivalent number TQO-Type
10200	22400	0.35	2600	450	1.66	574	M272749DW.710.710D
10600	23600	0.35	2700	465	1.66	576	M272749DW.710.710D
5400	14000	0.37	1370	245	1.58	244	LM272248DW.210.210D
5400	14000	0.37	1370	245	1.58	244	LM272248DGW.210.210D
7650	19000	0.33	1960	320	1.75	358	M272449DW.410.410D
7800	18300	0.31	2000	300	1.88	400	M272647DW.610.610D
6000	13700	0.45	1530	335	1.29	348	EE640193DW.260.261D
5850	13700	0.47	1460	345	1.23	253	LM772749DW.710.710D
5850	13700	0.47	1460	345	1.23	253	LM772749DGW.710.710D
8000	18000	0.32	2000	315	1.83	385	EE641198DW.265.266D
8150	18600	0.32	2040	320	1.83	400	EE641198DW.265.266D
11400	25500	0.35	2900	500	1.66	662	M274149DW.110.110D
11400	25500	0.35	2900	500	1.66	662	M274149DGW.110.110D
11600	26000	0.35	3000	510	1.66	680	M274149DW.110.110D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
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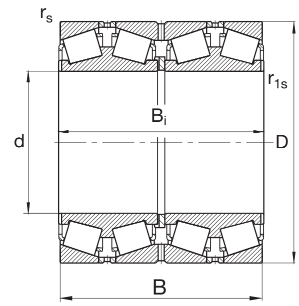
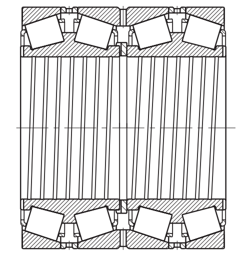
FAG Kegelrollenlager, vierreihig
in Zollabmessungen
FAG Tapered Roller Bearings, four row
in inch dimensions

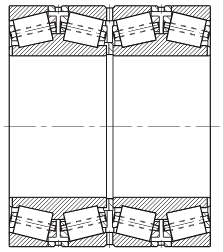


Ausführung 1
Design 1


Ausführung 2
Design 2

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min
802053	1	508 20.0000	762 30.0000	463.55 18.2500	463.55 18.2500	6.4	6.4
802053M	3	508 20.0000	762 30.0000	463.55 18.2500	463.55 18.2500	6.4	6.4
802030	1	514.35 20.2500	673.1 26.5000	422.275 16.6250	422.275 16.6250	6.4	3.3
802030.H122AA	2	514.35 20.2500	673.1 26.5000	422.275 16.6250	422.275 16.6250	6.4	3.3
802030M	3	514.35 20.2500	673.1 26.5000	422.275 16.6250	422.275 16.6250	6.4	3.3
802148.H122BD	1	519.112 20.4375	736.6 29.0000	536.575 21.1250	536.575 21.1250	6.4	3.3
501359A	1	520.7 20.5000	711.2 28.0000	400.05 15.7500	400.05 15.7500	6.4	3.3
802038	1	536.575 21.1250	761.873 29.9950	558.8 22.0000	558.8 22.0000	6.4	3.3
802038M	3	536.575 21.1250	761.873 29.9950	558.8 22.0000	558.8 22.0000	6.4	3.3
802102	1	558.8 22.0000	736.6 29.0000	322.268 12.6877	322.265 12.6876	6.4	3.3
802102M	3	558.8 22.0000	736.6 29.0000	322.268 12.6877	322.265 12.6876	6.4	3.3
802093	1	558.8 22.0000	736.6 29.0000	409.575 16.1250	409.575 16.1250	6.4	3.3
802093M	3	558.8 22.0000	736.6 29.0000	409.575 16.1250	409.575 16.1250	6.4	3.3
521179	1SB	558.8 22.0000	736.6 29.0000	457.2 18.0000	455.612 17.9375	6.4	3.3

SB Schmierbohrungen durch die Mittelborde der Innenringe
Lubricating holes through center lips of the inner rings
Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.



Ausführung 3
Design 3

Tragzahl · Faktor Load rating · Factor dyn. C	 stat. C_0	e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90}	C_{a90}	Axialfaktor Thrust factor K	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
kN			kN			kg	TQO-Type
10200	20000	0.39	2600	500	1.50	710	EE531201DW.300.301D
10800	21200	0.39	2750	530	1.50	762	EE531201DW.300.301D
8150	20000	0.33	2080	335	1.79	391	LM274449DW.410.410D
8150	20000	0.33	2080	335	1.79	391	LM274449DGW.410.410D
8300	20400	0.33	2120	335	1.79	400	LM274449DW.410.410D
11800	27000	0.33	3050	490	1.77	734	M275349DW.310.310D
8650	18600	0.43	2160	455	1.36	470	LM275349DW.310.310D
13700	29000	0.30	3450	510	1.97	800	M276449DW.410.410D
14000	30500	0.30	3550	520	1.97	836	M276449DW.410.410D
6800	15000	0.34	1700	290	1.71	363	EE843221DW.290.291D
6950	15600	0.34	1730	290	1.71	376	EE843221DW.290.291D
9000	21600	0.35	2280	390	1.68	466	LM377449DW.410.410D
9150	22400	0.35	2320	390	1.68	486	LM377449DW.410.410D
10000	24500	0.32	2550	400	1.85	530	LM277149DA.110.110D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
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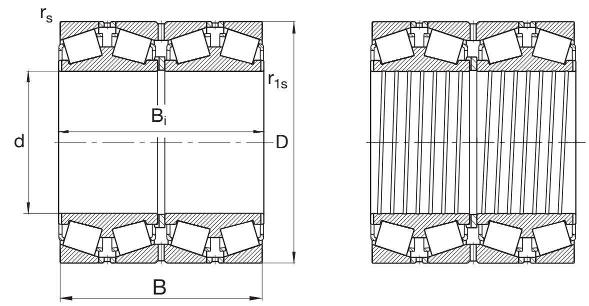
FAG Kegelrollenlager, vierreihig

in Zollabmessungen

FAG Tapered Roller Bearings, four row

in inch dimensions

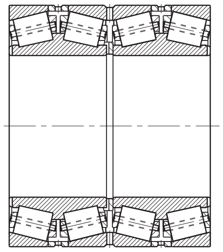


Ausführung 1
Design 1

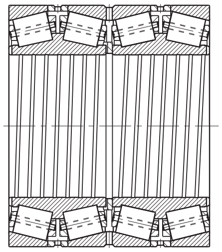
Ausführung 2
Design 2

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min
802049	1	571.5 22.5000	812.8 32.0000	593.725 23.3750	593.725 23.3750	6.4	3.3
802049M	3	571.5 22.5000	812.8 32.0000	593.725 23.3750	593.725 23.3750	6.4	3.3
802090	1	584.2 23.0000	762 30.0000	401.638 15.8125	396.875 15.6250	6.4	3.3
802090M	3	584.2 23.0000	762 30.0000	401.638 15.8125	396.875 15.6250	6.4	3.3
567392	3	585.788 23.0625	771.525 30.3750	479.425 18.8750	479.425 18.8750	6.4	3.3
518674	2	585.788 23.0625	771.525 30.3750	479.425 18.8750	479.425 18.8750	6.4	3.3
518067	1	595.313 23.4375	844.55 33.2500	615.95 24.2500	615.95 24.2500	6.4	3.3
544840	3	595.313 23.4375	844.55 33.2500	615.95 24.2500	615.95 24.2500	6.4	3.3
802075	1	603.25 23.7500	857.25 33.7500	622.3 24.5000	622.3 24.5000	6.4	3.3
802075M.H122AA	4	603.25 23.7500	857.25 33.7500	622.3 24.5000	622.3 24.5000	6.4	3.3
802054M.H122AB	3	609.6 24.0000	787.4 31.0000	361.95 14.2500	361.95 14.2500	6.4	3.3
802054M.H122AP	3	609.6 24.0000	787.4 31.0000	361.95 14.2500	361.95 14.2500	6.4	6.4
525937	2	609.6 24.0000	813.562 32.0300	479.425 18.8750	479.425 18.8750	3.3	6.4
530986	3	609.6 24.0000	863.6 34.0000	660.4 26.0000	660.4 26.0000	6.4	3.3

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.



Ausführung 3
Design 3



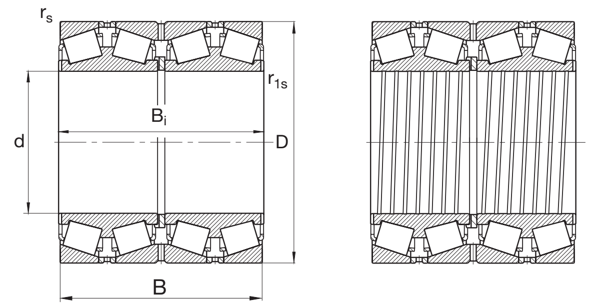
Ausführung 4
Design 4

Tragzahl · Faktor Load rating · Factor dyn. C	 stat. C_0	 e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90}	 C_{a90}	Axialfaktor Thrust factor K	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
kN			kN			kg	TQO-Type
15300	33500	0.33	3900	630	1.75	972	M278749DW.710.710D
16000	35500	0.33	4050	655	1.75	1030	M278749DW.710.710D
8300	20400	0.35	2120	365	1.65	470	LM778549DW.510.510D
8650	21600	0.35	2160	375	1.65	483	LM778549DW.510.510D
10600	27000	0.33	2700	440	1.75	620	LM278849DW.810.810D
10200	25000	0.33	2550	415	1.75	605	LM278849DGW.810.810D
16600	37500	0.34	4250	710	1.72	1105	M280049DW.010.010D
17000	39000	0.34	4300	720	1.72	1140	M280049DW.010.010D
16600	38000	0.35	4250	720	1.68	1130	M280249DW.M210.210D
17300	40000	0.35	4400	750	1.68	1200	M280249DGW.210.210D
7500	18600	0.50	1860	455	1.17	465	EE649241DW.310.311D
7500	18600	0.50	1860	455	1.17	465	EE649242DW.310.311D
12000	28500	0.26	3050	400	2.21	710	LM280249DGW.210.210D
18000	41500	0.35	4550	780	1.68	1270	M280349DW.310.310D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, vierreihig
in Zollabmessungen
FAG Tapered Roller Bearings, four row
in inch dimensions

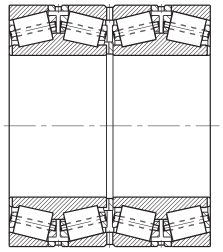


Ausführung 1
Design 1

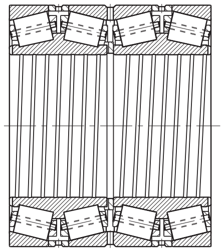
Ausführung 2
Design 2

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min
513141	3	635 25.0000	901.7 35.5000	654.05 25.7500	654.05 25.7500	6.4	3.3
802147M	3	646.112 25.4375	857.25 33.7500	542.925 21.3750	542.925 21.3750	6.4	3.3
514434	3	647.7 25.5000	1028.7 40.5000	565.15 22.2500	558.8 22.0000	6.4	11.2
802057M.H122AA	4	650 25.5906	915 36.0236	674 26.5354	674 26.5354	6.1	3.6
503326A	3	657.225 25.8750	933.45 36.7500	676.275 26.6250	676.275 26.6250	6.4	3.3
529001	1	660 25.9843	855 33.6614	319.192 12.5666	318.480 12.5386	9.7	4.8
511347	2	660.4 26.0000	812.8 32.0000	365.125 14.3750	365.125 14.3750	6.4	3.3
527018	4	660.4 26.0000	812.8 32.0000	365.125 14.3750	365.125 14.3750	6.4	3.3
568422	3	679.45 26.7500	901.7 35.5000	552.45 21.7500	552.45 21.7500	6.4	3.3
523543	3	682.625 26.8750	965.2 38.0000	701.675 27.6250	701.675 27.6250	6.4	3.3
802040	1	685.8 27.0000	876.3 34.5000	355.6 14.0000	352.425 13.8750	6.4	3.3
802040M	3	685.8 27.0000	876.3 34.5000	355.6 14.0000	352.425 13.8750	6.4	3.3
530297	3	708.025 27.8750	930.275 36.6250	565.15 22.2500	565.15 22.2500	6.4	3.3
802121M.H122AA	4	710 27.9528	900 35.4331	410 16.1417	410 16.1417	6.4	3.3

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.



Ausführung 3
Design 3



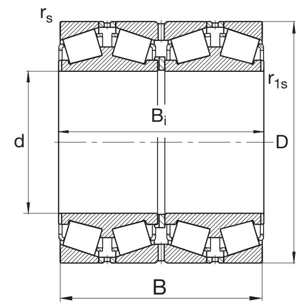
Ausführung 4
Design 4

Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90} kN	C_{a90}	Axialfaktor Thrust factor K	Gewicht Weight ≈ kg	Vergleichsbezeichnung Equivalent number TQO-Type
18600	44000	0.33	4800	780	1.75	1355	M281049DW.010.010D
14300	35500	0.33	3650	600	1.75	901	LM281049DW.010.010D
18300	33500	0.31	4650	710	1.87	1860	EE424257DW.405.407D
18600	44000	0.33	4650	765	1.75	1450	M281349DGW.310.310D
20400	46500	0.32	5200	850	1.75	1530	M281649DW.610.610D
7650	17600	0.35	1900	335	1.65	470	EE749259DW.334.335D
8150	21200	0.33	2040	335	1.75	400	L281149DGW.110.110D
8500	22400	0.33	2120	345	1.75	422	L281149DGW.110.110D
13700	34500	0.33	3450	560	1.79	995	LM281849DW.810.810D
20800	50000	0.33	5300	865	1.75	1680	M282249DW.210.210D
7800	20000	0.41	1960	390	1.44	523	EE655271DW.345.346D
8150	21200	0.41	2040	405	1.44	542	EE655271DW.345.346D
15600	40500	0.33	4000	640	1.78	1060	LM282549DW.510.510D
10600	27000	0.35	2650	450	1.68	638	

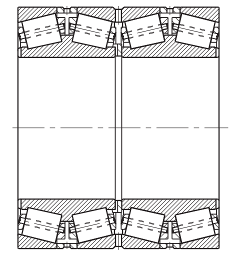
[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, vierreihig
in Zollabmessungen

FAG Tapered Roller Bearings, four row
in inch dimensions



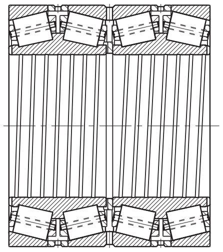
Ausführung 1
Design 1



Ausführung 3
Design 3

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min
802055	1	711.2 28.0000	914.4 36.0000	317.5 12.5000	317.5 12.5000	6.4	3.3
802055M	3	711.2 28.0000	914.4 36.0000	317.5 12.5000	317.5 12.5000	6.4	3.3
527030	3	714.375 28.1250	1016 40.0000	704.85 27.7500	704.85 27.7500	6.4	3.3
802103M	3	717.55 28.2500	946.15 37.2500	565.15 22.2500	565.15 22.2500	6.4	3.3
802103M.H122AA	4	717.55 28.2500	946.15 37.2500	565.15 22.2500	565.15 22.2500	6.4	3.3
514433A	4	730.25 28.7500	1035.05 40.7500	755.65 29.7500	755.65 29.7500	6.4	3.3
526837	1	749.3 29.5000	990.6 39.0000	605 23.8189	605 23.8189	6.4	3.3
527082	3	749.3 29.5000	990.6 39.0000	605 23.8189	605 23.8189	6.4	3.3
513140	3	749.3 29.5000	1066.8 42.0000	736.6 29.0000	723.9 28.5000	12.7	25.4x20°
802032M	3	762 30.0000	1066.8 42.0000	736.6 29.0000	723.9 28.5000	12.7	7.9
514752	3	762 30.0000	1079.5 42.5000	787.4 31.0000	787.4 31.0000	12.7	4.8
802110M.H122AA	4	812.8 32.0000	1143 45.0000	768.35 30.2500	768.35 30.2500	12.7	6.4
517623	3	825.5 32.5000	1168.4 46.0000	844.55 33.2500	844.55 33.2500	12.7	4.8
514432	3	825.5 32.5000	1193.8 47.0000	812.8 32.0000	812.8 32.0000	12.7	6.4

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.



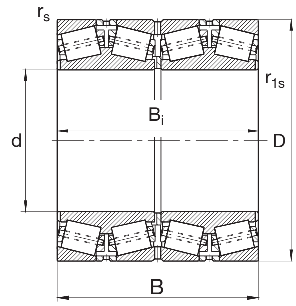
Ausführung 4
Design 4

Tragzahl · Faktor Load rating · Factor dyn. C	 stat. C_0	 e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90}	 C_{a90}	Axialfaktor Thrust factor K	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
kN			kN			kg	TQO-Type
7800	19000	0.38	1960	365	1.53	518	EE755281DW.360.361D
8000	19300	0.38	2000	375	1.53	542	EE755281DW.360.361D
23200	53000	0.32	6000	950	1.80	1895	M383240DW.210.210D
15600	40500	0.33	4000	640	1.75	1117	LM282847DW.810.810D
15600	40500	0.33	4000	640	1.75	1117	LM282847DGW.810.810D
24000	57000	0.35	6100	1060	1.65	2095	M283449DGW.410.410D
16300	43000	0.34	4150	680	1.74	1270	LM283649DW.610.610D
17300	45500	0.34	4400	720	1.74	1300	LM283649DW.610.610D
24000	56000	0.34	6200	1020	1.71	2185	EE325296DW.420.421D
23600	57000	0.33	6100	980	1.75	2125	M284148DW.111.110D
25500	60000	0.35	6550	1100	1.68	2370	M284249DW.210.210D
26000	64000	0.37	6700	1200	1.58	2590	
29000	71000	0.34	7500	1250	1.73	2975	M285849DW.810.810D
30000	67000	0.39	7800	1500	1.49	3110	EE631325DW.470.470D

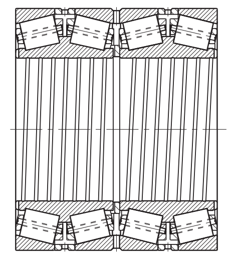
[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, vierreihig
in Zollabmessungen
FAG Tapered Roller Bearings, four row
in inch dimensions



Ausführung 3
Design 3


Ausführung 4
Design 4

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min
525789	3	863.6 34.0000	1130.3 44.5000	669.925 26.3750	669.925 26.3750	12.7	4.8
561585	3	863.6 34.0000	1181.1 46.5000	666.75 26.2500	666.75 26.2500	12.7	4.8
511775	3	863.6 34.0000	1219.2 48.0000	889 35.0000	876.3 34.5000	12.7	4.8
521592	3	901.7 35.5000	1295.4 51.0000	914.4 36.0000	901.7 35.5000	12.7	4.8
802139M	3	938.212 36.9375	1270 50.0000	825.5 32.5000	825.5 32.5000	12.7	4.8
511781	3	939.8 37.0000	1333.5 52.5000	952.5 37.5000	952.5 37.5000	12.7	4.8
539519	3	1006.475 39.6250	1295.4 51.0000	764 30.0787	764 30.0787	12.7	4.8
802027M	3	1139.825 44.8750	1509.712 59.4375	923.925 36.3750	923.925 36.3750	12.7	4.8
523207	3	1200.15 47.2500	1593.85 62.7500	990.6 39.0000	990.6 39.0000	12.7	4.8
801326	4	1346.2 53.0000	1729.74 68.1000	1143 45.0000	1143 45.0000	12.7	4.8

Bohrung und Außendurchmesser haben Plustoleranzen.
Bore and outside diameter have plus tolerances.

Tragzahl · Faktor **Load rating · Factor**			**Vergleichstragzahl[1])** **Equivalent load rating[1])**		**Axialfaktor** **Thrust factor**	**Gewicht** **Weight** ≈	**Vergleichsbezeichnung** **Equivalent number**
dyn. C	stat. C_0	e	C_{r90}	C_{a90}	K		
kN			kN			kg	TQO-Type
22400	60000	0.33	5700	930	1.75	1835	LM286249DW.210.210D
22800	58500	0.38	5850	1100	1.52	2170	LM286449DW.410.410D
33500	80000	0.33	8650	1400	1.77	3290	EE547341DW.480.481D
35500	81500	0.32	9150	1430	1.83	4075	EE634356D.510.510D
31500	81500	0.32	8000	1270	1.83	3170	LM287649DW.610.610D
37500	91500	0.33	9500	1560	1.75	4390	LM287849DW.810.810D
27500	78000	0.33	7100	1140	1.75	2600	LM288249DW.210.210D
37500	104000	0.32	9650	1530	1.81	4690	
46500	129000	0.33	12000	1930	1.78	5610	LM288949D.910.910D
50000	153000	0.33	12900	2120	1.75	6830	

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
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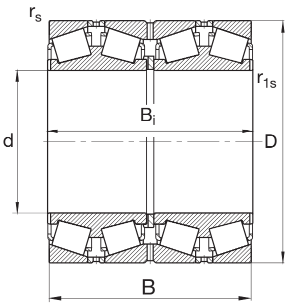
FAG Kegelrollenlager, vierreihig in metrischen Abmessungen
FAG Tapered Roller Bearings, four row in metric dimensions

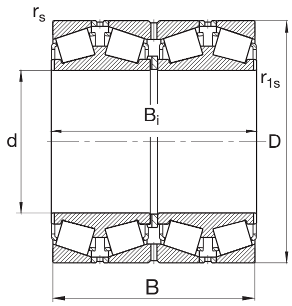


Ausführung 1
Design 1

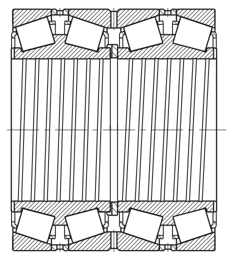
Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm	D	B	B_i	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
534283	1	170	260	160	160	3	1	1430	2320	0.38	32
538147	1	170	280	181	181	3	3	1730	2500	0.4	46
565472	1	180	260	200	200	2	2	1700	3050	0.32	36
531517	1	180	280	158	158	3	3	1560	2450	0.29	38
531518	1	180	280	180	180	3	3	1730	2500	0.4	43
538787	1	190	268	196	196	2.5	2.5	1500	2850	0.38	36
561419	1	200	282	206	206	1.5	1.5	2000	3750	0.39	41
526731	1	200	310	200	200	3	1.5	2240	3450	0.37	60
512055	1	205	320	205	205	4	4	2040	3250	0.43	54
567972	1	220	320	200	200	4	1.5	2040	3400	0.34	55
802105	1	220	340	305	305	3	4	3600	6400	0.35	100
535193	1	240	338	248	248	3	2	2600	5300	0.38	72
532028	1	240	360	218	218	3	1	2650	4400	0.43	81
540650	1	240	360	310	310	3	3	3600	6800	0.3	114
534751	1	240	410	270	270	4	4	3900	5850	0.29	150
508990A	1	245	380	254	255.5	3	1	2850	4900	0.42	104
535192	1	260	368	268	268	5	5	3100	6100	0.35	93
522614	1	260	380	200	200	5	2	2450	4150	0.32	79
512056	1	260	400	255	255	7.5	5	2900	5100	0.44	121
534480	1	260	400	345	345	5	5	4650	8650	0.43	163
549348	1	260	440	300	300	5	2	4300	6700	0.49	194
574281	1	280	395	288	288	5	5	3650	7350	0.35	115
548651	1	280	420	224	224	4	4	3100	5300	0.37	113
532029	1	280	420	250	250	5	2	3250	6300	0.47	105
802132	1	280	420	345	345	5	5	4800	9300	0.46	167
510039	1	280	460	324	324	6	6	4800	7800	0.34	197
535191	1	300	424	310	310	5	4	4150	8800	0.36	140
574613	1	300	460	248	248	4	5	3550	6000	0.46	156

Bohrung und Außendurchmesser haben Minustoleranzen.
Bore and outside diameter have minus tolerances.

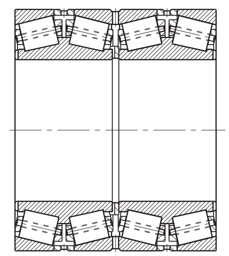
FAG Kegelrollenlager, vierreihig in metrischen Abmessungen
FAG Tapered Roller Bearings, four row in metric dimensions



Ausführung 1
Design 1



Ausführung 2
Design 2

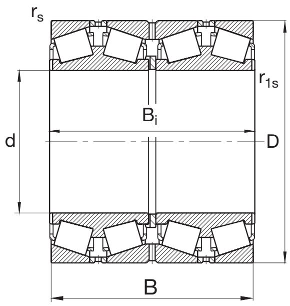


Ausführung 3
Design 3

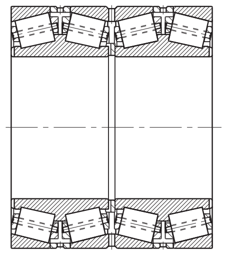
Kurzzeichen **Code** **FAG**	**Aus-führung** **Design**	**Abmessung** **Dimension** d mm	D	B	B_i	r_s min	r_{1s} min	**Tragzahl · Faktor** **Load rating · Factor** dyn. C kN	stat. C_0	e	**Gewicht** **Weight** ≈ kg
522130	1	300	460	390	390	5	5	6300	12000	0.32	243
534753	1	300	500	350	350	5	6	5400	9500	0.58	280
576008	1	310	430	310	310	4	4	4300	9150	0.32	141
566230	1	320	440	335	335	2	2	4800	10400	0.33	153
547880	1	340	520	325	325	5	6	5700	10400	0.29	258
534754	1	350	590	420	420	6	3	7200	11800	0.7	485
523453	2	355	490	316	316	2.5	1.5	4900	10800	0.39	183
530758	1	360	510	380	380	5	1.5	5850	12200	0.34	260
572344	1	360	520	370	370	4	3	6200	13200	0.35	267
514166	1	360	540	325	325	6	6	5400	9650	0.41	270
546304	1	360	540	340	340	5	4	6000	11000	0.4	282
565625	1	380	560	325	325	6	2.5	5850	11000	0.35	282
802109	1	380	560	360	360	5	1.5	6550	12500	0.35	296
802109M	3	380	560	360	360	5	1.5	6700	12900	0.35	312
523695	1	380	620	388	388	5	5	7800	12900	0.43	427
510038	1	380	620	420	420	5	5	8300	14000	0.46	510
802116	1	395	545	288.7	268.7	7.5	5	4250	8650	0.47	193
802116.H122AA	2	395	545	288.7	268.7	7.5	5	4250	8650	0.47	193
802074	1	400	540	280	280	5	5	4250	8650	0.47	177
561420	1	400	564	412	412	4	4	7500	15600	0.37	334
534284	1	400	600	355	355	6	3	6700	13400	0.34	365
575106	1	420	592	432	432	6	6	8000	17000	0.4	327
539120	1	420	620	355	355	6	4	6700	12700	0.43	370
510036	1	420	760	500	500	9.5	9.5	11800	19300	0.35	1003
531841	2	430	570	336	336	6	1.5	5850	13700	0.44	235
546420	1	440	620	454	454	6	6	9000	19300	0.4	440
510035	1	440	650	355	355	6	5	7200	13700	0.48	406

Bohrung und Außendurchmesser haben Minustoleranzen.
Bore and outside diameter have minus tolerances.

FAG Kegelrollenlager, vierreihig in metrischen Abmessungen
FAG Tapered Roller Bearings, four row in metric dimensions



Ausführung 1
Design 1



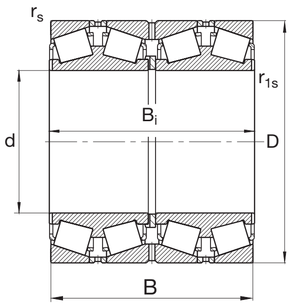
Ausführung 3
Design 3

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm	D	B	B_i	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
802063.H122AD	1 SB	450	595	368	368	6	3	6800	16000	0.33	277
527351	1	460	610	360	360	5	2.5	6550	14600	0.38	278
522388	1	460	625	421	421	9	3	8150	18300	0.33	370
537420	1	460	700	420	420	5	6	8800	16600	0.43	585
549349	1	460	760	520	520	6	3	12700	22400	0.45	950
802021	1	475	600	368	368	6	2	6300	16000	0.26	242
802034	1	475	620	380	380	6	2	7100	17000	0.29	220
533018	1	475	660	450	450	6	4	9300	20400	0.37	470
549928	1	480	700	420	420	6	6	9150	18000	0.32	545
802004	1	500	670	515	515	5	5	9800	23600	0.33	498
542738	3	500	705	515	515	6	6	11400	25500	0.35	655
532030	1	500	720	400	400	6	3	8650	16600	0.46	540
537903	1	500	720	420	420	7.5	7.5	9300	18600	0.33	564
537904	1	500	830	570	570	9.5	9.5	14300	25000	0.37	1250
546305	1	530	780	450	450	6	3	11200	21600	0.36	735
579827	1	530	880	544	544	9.5	9.5	14000	27000	0.46	1382
802005	1	533	810	450	450	7.5	7.5	10400	20000	0.37	810
565904	3	535	750	560	560	7.5	7.5	12900	28500	0.35	786
527308	1	540	690	400	400	5	2.5	7800	21200	0.37	375
539193	3	560	920	620	620	9.5	9.5	18300	33500	0.4	1690
577804	3	570	780	515	515	6	6	12700	29000	0.36	753
533792	1	570	810	590	590	6	3	14000	31500	0.31	975
534755	1	600	800	365	365	5	6	8500	18000	0.32	510
568986	1	600	870	488	488	7.5	3	12700	25000	0.43	968
539110	1	620	800	365	365	6	3	7800	20000	0.32	466
534756	1	630	920	515	515	9.5	9.5	14300	29000	0.43	1130

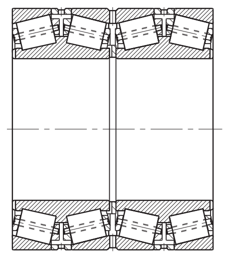
SB Schmierbohrungen durch die Mittelborde der Innenringe.
Bearings with lubricating holes through the center lips in the inner rings.

Bohrung und Außendurchmesser haben Minustoleranzen.
Bore and outside diameter have minus tolerances.

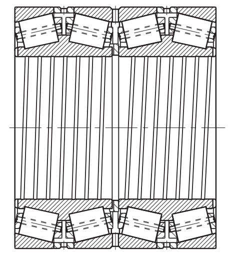
FAG Kegelrollenlager, vierreihig in metrischen Abmessungen
FAG Tapered Roller Bearings, four row in metric dimensions



Ausführung 1
Design 1



Ausführung 3
Design 3



Ausführung 4
Design 4

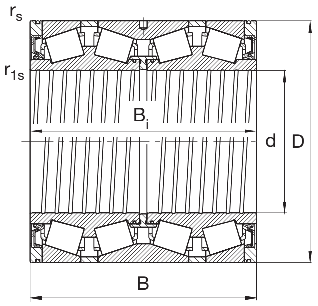
Kurzzeichen Code FAG	Aus- führung Design	Abmessung Dimension d mm	D	B	B_i	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
800695	4	635	900	660	660	9.5	9.5	18600	44000	0.33	1404
802061M	3	647	1030	560	560	15	9.5	18300	33500	0.31	1839
802057M	3	650	915	674	674	6.1	3.6	18600	44000	0.33	1450
802060M	3	650	1030	560	560	15	9.5	18300	33500	0.31	1825
510033	1	660	855	320	320	7.5	5	7650	17600	0.35	472
534757	3	660	1070	650	650	9.5	9.5	22400	40500	0.31	2305
537905	3	670	1090	710	710	9.5	9.5	25000	48000	0.29	2702
566305	4	676	910	620	620	7.5	4	17300	41500	0.37	1150
802121M	3	710	900	410	410	6.4	3.3	10600	27000	0.35	638
528249	4	730	940	500	500	6	3	14300	36500	0.35	900
802033M	3	750	950	410	410	6	6	11400	29000	0.35	712
572275	3	750	1130	690	690	9.5	9.5	23600	47500	0.49	2538
581213	3	750	1220	840	840	12	12	32500	64000	0.32	4105
533277	1	785	1040	560	560	12	6	16000	41500	0.41	1303
549321	3	840	1170	840	840	6	6	30000	72000	0.29	2870
522129	3	850	1360	910	910	9.5	5	39000	78000	0.32	5285
533780	3	950	1360	880	880	12	12	35500	83000	0.37	4250
802070AM	3 AR	1070	1400	889.6	890	13.2	5.1	32500	91500	0.36	3690
577801	3	1320	1760	800	800	12	7.5	37500	95000	0.35	5151
521936	4	1370	1765	1050	1035	12	5	50000	146000	0.33	6700
543378	3	1400	1820	1020	1160	12.7	6.4	50000	146000	0.38	7295
533447	3	1500	1950	1230	1230	12	12	63000	186000	0.32	9835
534898	3	1600	1950	1230	1230	6	12	57000	212000	0.26	7870

AR Lager mit vier Außenringen / Bearing with four outer rings

Bohrung und Außendurchmesser haben Minustoleranzen.
Bore and outside diameter have minus tolerances.

FAG Kegelrollenlager, vierreihig
mit eingebauten Dichtungen

FAG Tapered Roller Bearings, four row
with integrated seals



Ausführung 1
Design 1

Kurzzeichen Code FAG	Aus-führung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
573415	1	139.7 5.5000	200.025 7.8750	160.34 6.3126	157.165 6.1876	3.3	0.8	880	1460	0.35	17
802107	1	152.4 6.0000	244.475 9.6250	187.325 7.3750	192.088 7.5625	3.3	1.5	1370	2160	0.35	33
577692	1	165.1 6.5000	225.425 8.8750	168.275 6.6250	165.1 6.5000	3.3	0.8	950	1660	0.40	20
802050	1	177.8 7.0000	247.65 9.7500	192.088 7.5625	192.088 7.5625	3.3	1.5	1320	2320	0.44	26.6
575937	1	190.5 7.5000	266.7 10.5000	188.912 7.4375	187.325 7.3750	3.3	1.5	1340	2360	0.44	34
577254	1	203.2 8.0000	317.5 12.5000	266.7 10.5000	266.7 10.5000	3.3	1.5	2450	4150	0.51	75.8
802017	1	206.375 8.1250	282.575 11.1250	190.5 7.5000	190.5 7.5000	3.3	0.8	1320	2450	0.49	33
573416	1	215.9 8.5000	288.925 11.3750	177.8 7.0000	177.8 7.0000	3.3	0.8	1250	2240	0.49	33.5
580180	1	216.103 8.5080	330.2 13.0000	269.875 10.6250	263.525 10.3750	3.3	1.5	2400	4150	0.53	78
802019.H122AG	1	220.662 8.6875	314.325 12.3750	239.712 9.4375	239.712 9.4375	3.3	1.5	2040	3750	0.35	57
802130	1	228.6 9.0000	311.15 12.2500	200.025 7.8750	200.025 7.8750	3.3	1.5	1630	3000	0.33	41.5
576479	1	228.6 9.0000	400.050 15.7500	296.875 11.6880	296.875 11.6880	3.3	3.3	3750	5500	0.33	164

Die Tabelle zeigt nur die Grundausführung. Die Liefermöglichkeit für andere Ausführungen nennen wir auf Anfrage.
The list only shows the basic designs. Availability of other designs on request.

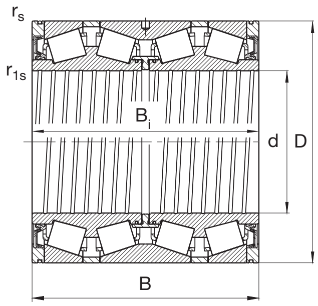
Dichtungen aus Fluorkautschuk, z. B. aus Viton, können bei über 300 °C gesundheitsschädliche Gase und Dämpfe abgeben. Dieser Fall kann dann eintreten, wenn z. B. beim Ausbau eines Lagers ein Schweißbrenner verwendet wird. In solchen Fällen bitte das entsprechende Sicherheits-Datenblatt beachten.
Seals made of fluorocaoutchouc, e. g. Viton can give off vapours and gasses at temperatures over 300 °C, which are detrimental to health. This has to be remembered if bearings are dismounted with a welding torch. The relevant safety data sheet should be observed.

FAG Kegelrollenlager, vierreihig

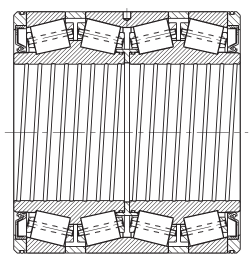
mit eingebauten Dichtungen

FAG Tapered Roller Bearings, four row

with integrated seals



Ausführung 1
Design 1



Ausführung 2
Design 2

Kurzzeichen Code FAG	Aus- führung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
573745	1	234.95 9.2500	327.025 12.8750	196.85 7.7500	196.85 7.7500	3.3	1.5	1660	3000	0.46	52
573331	1	241.478 9.5070	349.148 13.7460	228.6 9.0000	228.6 9.0000	3.3	1.5	2120	3750	0.37	75
802082	1	244.475 9.6250	327.025 12.8750	193.675 7.6250	193.675 7.6250	3.3	1.5	1500	2750	0.47	42.5
577255	1	244.475 9.6250	381 15.0000	304.8 12.0000	304.8 12.0000	4.8	3.3	3550	5850	0.45	133
802066	1	254 10.0000	358.775 14.1250	269.875 10.6250	269.875 10.6250	3.3	1.5	2700	5200	0.35	83
578395	2	260.35 10.2500	422.275 16.6250	317.5 12.5000	314.325 12.3750	3.3	6.4	3900	6200	0.33	180
802011.H122AE	1 ON	266.7 10.5000	355.6 14.0000	228.6 9.0000	230.188 9.0625	2	1.5	2200	4400	0.36	61
802011	1	266.7 10.5000	355.6 14.0000	228.6 9.0000	230.188 9.0625	2	1.5	2200	4400	0.36	61
573688	1	266.7 10.5000	393.7 15.5000	269.878 10.6251	269.878 10.6251	3.3	1.5	3000	5500	0.45	115
580961	1	273.05 10.7500	381 15.0000	244.475 9.6250	244.475 9.6250	3.3	1.5	2500	4900	0.43	84
567712	1	276.225 10.8750	393.7 15.5000	269.878 10.6251	269.878 10.6251	3.3	1.5	3000	5500	0.45	109
575940	1	279.4 11.0000	393.7 15.5000	269.878 10.6251	269.878 10.6251	3.3	1.5	3000	5500	0.45	106

ON ohne schraubenförmige Nut in der Innenringbohrung / Without spiral groove in inner ring bore

Die Tabelle zeigt nur die Grundausführung. Die Liefermöglichkeit für andere Ausführungen nennen wir auf Anfrage.
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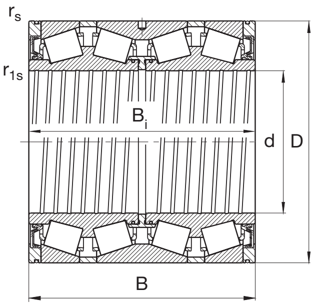
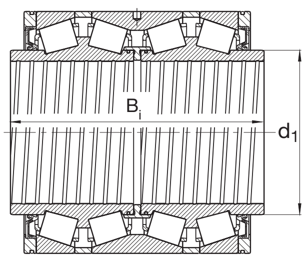
FAG Kegelrollenlager, vierreihig
mit eingebauten Dichtungen

FAG Tapered Roller Bearings, four row
with integrated seals



Ausführung 1
Design 1



Ausführung 3
Design 3

Kurzzeichen Code FAG	Aus- führung Design	Abmessung Dimension d mm/inch	D	B	B_i	d_1	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
802101.A250.300	1	285.75 11.2500	380.898 14.9960	244.475 11.0000	244.475 11.0626		3.3	1.5	2650	5400	0.43	74
802071.H122AG	1	304.648 11.9940	438.048 17.2460	279.4 11.0000	280.99 11.0626		3.3	3.3	3600	6400	0.47	128
802079	1	304.8 12.0000	419.1 16.5000	269.875 10.6250	269.875 10.6250		6.4	3.3	3200	6000	0.49	104
577249	1	304.902 12.0040	412.648 16.2460	266.7 10.5000	266.7 10.5000		2	3.3	2850	5600	0.52	106
802025	1	304.902 12.0040	412.648 16.2460	266.7 10.5000	266.7 10.5000		3.3	3.3	3050	6100	0.32	98
567640	3	304.902 12.0040	412.648 16.2460	266.7 10.5000	336.55 13.2500	330.2 13.0000	3.3	3.3	3050	6100	0.32	113
802072.H122AG	1	305.003 12.0080	438.048 17.2460	279.4 11.0000	280.99 11.0626		3.3	3.3	3600	6400	0.47	128
802081.H122AE	1 ON	317.5 12.5000	422.275 16.6250	269.875 10.6250	269.875 10.6250		3.3	1.5	3050	6550	0.32	100
581035	1	317.5 12.5000	447.675 17.6250	327.025 12.8750	327.025 12.8750		3.3	3.3	4300	8500	0.33	168
802068	1	330.302 13.0040	438.023 17.2450	254 10.0000	247.65 9.7500		3.3	1.5	2700	5400	0.43	97
576210	1	333.375 13.1250	469.9 18.5000	342.9 13.5000	342.9 13.5000		3.3	3.3	4750	9500	0.34	193
802108.H122AG	1	341.312 13.4375	457.098 17.9960	254 10.0000	254 10.0000		3.3	1.5	3050	6100	0.47	110

ON ohne schraubenförmige Nut in der Innenringbohrung / Without spiral groove in inner ring bore

Die Tabelle zeigt nur die Grundausführung. Die Liefermöglichkeit für andere Ausführungen nennen wir auf Anfrage.
The list only shows the basic designs. Availability of other designs on request.

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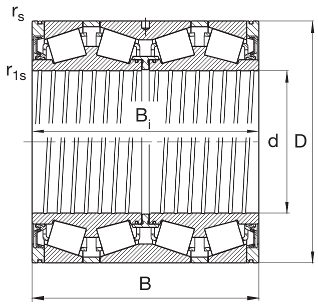
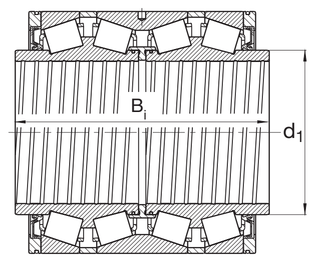
FAG Kegelrollenlager, vierreihig
mit eingebauten Dichtungen

FAG Tapered Roller Bearings, four row
with integrated seals



Ausführung 1
Design 1



Ausführung 3
Design 3

Kurzzeichen Code FAG	Aus-führung Design	Abmessung Dimension mm/inch d	D	B	B_i	d_1	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
802003.H122AG	1	343.052 13.5060	457.098 17.9960	254 10.0000	254 10.0000		3.3	1.5	3050	6100	0.47	108
802003.H122AF	1	343.052 13.5060	457.098 17.9960	254 10.0000	254 10.0000		3.3	1.5	3050	6100	0.47	108
578862	1	343.052 13.5060	457.098 17.9960	254 10.0000	254 10.0000		3.3	1.5	2600	5200	0.7	119
802003.H122BJ	1 ON	343.052 13.5060	457.098 17.9960	254 10.0000	254 10.0000		3.3	1.5	3050	6100	0.47	108
802029	1	346.075 13.6250	488.95 19.2500	358.775 14.1250	358.775 14.1250		3.3	3.3	5000	10200	0.32	208
802023	1	355.6 14.0000	482.6 19.0000	269.875 10.6250	265.112 10.4375		3.3	1.5	3200	6550	0.49	137
575032	3	355.6 14.0000	482.6 19.0000	269.875 10.6250	330.2 13.0000	381 15.0000	3.3	1.5	3200	6550	0.49	152
802111	1	355.6 14.0000	488.95 19.2500	317.5 12.5000	317.5 12.5000		3.3	1.5	4500	9500	0.32	177
579769	1	368.3 14.5000	523.875 20.6250	382.588 15.0625	382.588 15.0625		6.4	3.3	6000	11800	0.32	255
802015	1	385.762 15.1875	514.35 20.2500	317.5 12.5000	317.5 12.5000		3.3	3.3	4500	9500	0.44	175
802039	1	406.4 16.0000	546.1 21.5000	288.925 11.3750	288.925 11.3750		6.4	0.9	4000	8000	0.48	180
573326	1	406.4 16.0000	546.1 21.5000	288.925 11.3750	268.288 10.5625		6.4	1.5	3550	6950	0.49	192

ON ohne schraubenförmige Nut in der Innenringbohrung / Without spiral groove in inner ring bore

Die Tabelle zeigt nur die Grundausführung. Die Liefermöglichkeit für andere Ausführungen nennen wir auf Anfrage.
The list only shows the basic designs. Availability of other designs on request.

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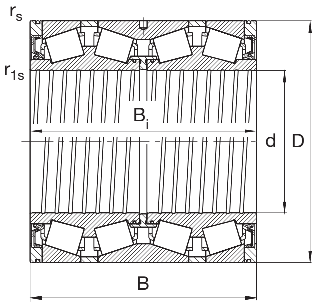
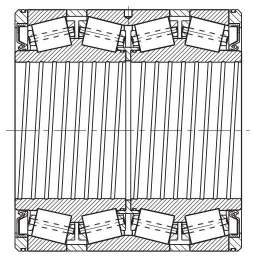
FAG Kegelrollenlager, vierreihig
mit eingebauten Dichtungen

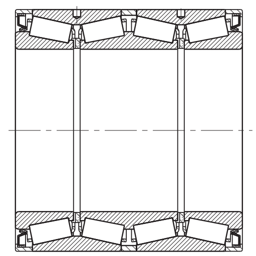
FAG Tapered Roller Bearings, four row
with integrated seals



Ausführung 1
Design 1



Ausführung 2
Design 2



Ausführung 4
Design 4

Kurzzeichen Code FAG	Aus-führung Design	Abmessung Dimension d mm/inch	D	B	B_i	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
802078	1	409.575 16.1250	546.1 21.5000	334.962 13.1875	334.962 13.1875	6.4	1.5	5000	10800	0.40	209
802046M	2	415.925 16.3750	590.55 23.2500	434.975 17.1250	434.975 17.1250	6.4	3.3	7500	15600	0.34	387
576306	1	415.925 16.3750	590.55 23.2500	434.975 17.1250	434.975 17.1250	6.4	3.3	6950	15000	0.52	382
564363	1	431.8 17.0000	571.5 22.5000	279.4 11.0000	279.4 11.0000	3.3	1.5	3900	7650	0.62	180
580091	2	431.8 17.0000	571.5 22.5000	336.55 13.2500	336.55 13.2500	3.3	1.5	5200	11200	0.44	242
802013	1	431.8 17.0000	571.5 22.5000	336.55 13.2500	336.55 13.2500	3.3	1.5	4800	10400	0.46	225
802044	1	440 17.3228	590 23.2283	480 18.8976	480 18.8976	5	3	7800	18300	0.35	359
800917	1	440 17.3228	650 25.5906	353.05 13.8996	353.05 13.8996	6	5	6300	11400	0.37	378
574347	1	444.5 17.5000	571.5 22.5000	355.6 14.0000	355.6 14.0000	18.7x25°	3.3	5400	12900	0.35	229
575857	2	447.675 17.6250	635 25.0000	463.55 18.2500	463.55 18.2500	6.4	3.3	8500	18000	0.35	470
574663	1	450 17.7165	595 23.4252	368 14.4882	368 14.4882	3	3	5850	13400	0,32	280
576497	1	450 17.7165	595 23.4252	398 15.6693	398 15.6693	3	3	6800	16000	0.33	302
580269	4	450 17.7165	595 23.4252	414 16.2992	414 16.2992	2	6	6800	16000	0.33	308

Die Tabelle zeigt nur die Grundausführung. Die Liefermöglichkeit für andere Ausführungen nennen wir auf Anfrage.
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Dichtungen aus Fluorkautschuk, z. B. aus Viton, können bei über 300 °C gesundheitsschädliche Gase und Dämpfe abgeben. Dieser Fall kann dann eintreten, wenn z. B. beim Ausbau eines Lagers ein Schweißbrenner verwendet wird. In solchen Fällen bitte das entsprechende Sicherheits-Datenblatt beachten.
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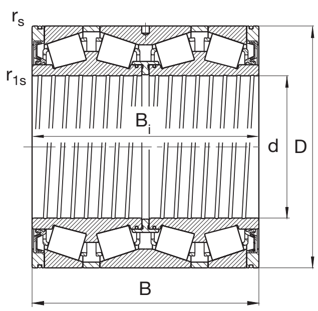
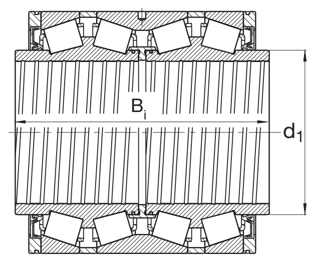
FAG Kegelrollenlager, vierreihig
mit eingebauten Dichtungen

FAG Tapered Roller Bearings, four row
with integrated seals



Ausführung 1
Design 1



Ausführung 3
Design 3

Kurzzeichen Code FAG	Aus-führung Design	Abmessung Dimension d mm/inch	D	B	B_i	d_1	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
802042	1	457.2 18.0000	596.9 23.5000	279.4 11.0000	276.225 10.8750		3.3	1.5	3750	8000	0.61	194
575213	1	460 18.1102	610 24.0157	360 14.1732	360 14.1732		5	2.5	5850	13200	0.35	290
572067	1	479.425 18.8750	679.45 26.7500	495.3 19.5000	495.3 19.5000		3.3	3.3	9800	20800	0.35	574
802007.H122BH	1 ON	482.6 19.0000	615.95 24.2500	330.2 13.0000	330.2 13.0000		3.3	6.4	5200	12500	0.36	230
802007.H122AG	1	482.6 19.0000	615.95 24.2500	330.2 13.0000	330.2 13.0000		3.3	6.4	5200	12500	0.36	230
579990	1	482.6 19.0000	615.95 24.2500	330.2 13.0000	330.2 13.0000		3.3	6.4	5200	12500	0.36	246
802112	1	482.6 19.0000	615.95 24.2500	400 15.7480	400 15.7480		6.4	6.4	6300	16000	0.31	283
802143.H122AG	3	482.6 19.0000	615.95 24.2500	330.2 13.0000	406.4 16.0000	514.35 20.2500	3.3	4	5200	12500	0.36	245
564537	3	482.6 19.0000	615.95 24.2500	330.2 13.0000	419.1 16.5000	514.35 20.2500	6.4	3.3	5200	12500	0.36	247
579576	1	482.6 19.0000	615.95 24.2500	402.05 15.8287	419.1 16.5000		3.3	3.3	5400	14000	0.37	288
572123	1	489.026 19.2530	634.873 24.9950	320.675 12.6250	320.675 12.6250		3.3	3.3	5200	11600	0.43	250
577346	1	501.65 19.7500	711.2 28.0000	520.7 20.5000	520.7 20.5000		6.4	3.3	10600	22400	0.37	632
567899	1	509.948 20.0767	654.924 25.7844	379 14.9213	377 14.8425		5	2	6400	15300	0.37	320

ON ohne schraubenförmige Nut in der Innenringbohrung / Without spiral groove in inner ring bore

Die Tabelle zeigt nur die Grundausführung. Die Liefermöglichkeit für andere Ausführungen nennen wir auf Anfrage.
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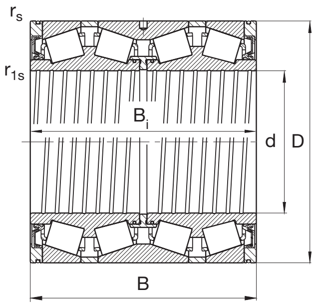
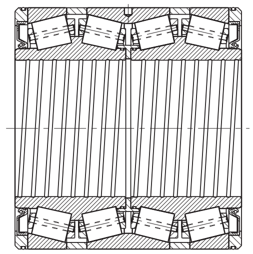
FAG Kegelrollenlager, vierreihig
mit eingebauten Dichtungen

FAG Tapered Roller Bearings, four row
with integrated seals



Ausführung 1
Design 1



Ausführung 2
Design 2

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension mm/inch d	D	B	B_i	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
575859	1	514.35 20.2500	673.1 26.5000	422.275 16.6250	422.275 16.6250	6.4	3.3	7500	18600	0.35	398
574472	1	519.113 20.4375	736.6 29.0000	536.575 21.1250	536.575 21.1250	6.4	3.3	11400	25000	0.33	732
802152	1	540 21.2598	690 27.1654	400 15.7480	400 15.7480	5	2.5	6950	17000	0.37	356
575848	1	558.8 22.0000	736.6 29.0000	322.263 12.6875	322.263 12.6875	6.4	3.3	5850	12200	0.35	371
565249	1	558.8 22.0000	736.6 29.0000	409.575 16.1250	409.575 16.1250	6.4	3.3	8000	18600	0.35	460
802080	1	558.8 22.0000	736.6 29.0000	457.2 18.0000	455.612 17.9375	6.4	3.3	9000	21600	0.35	512
574859	1	584.2 23.0000	762 30.0000	401.638 15.8125	396.875 15.6250	6.4	3.3	7800	18000	0.47	480
575824	1	585.788 23.0625	771.525 30.3750	479.425 18.8750	479.425 18.8750	6.4	3.3	9650	23600	0.35	605
575863	2	585.788 23.0625	771.525 30.3750	479.425 18.8750	479.425 18.8750	6.4	3.3	9800	24000	0.35	622
572242	1	595.313 23.4375	844.55 33.2500	615.95 24.2500	615.95 24.2500	6.4	3.3	14600	33500	0.33	1105
578717	2	600 23.6220	850 33.4646	450 17.7165	450 17.7165	7.5	5.0	9500	19600	0.32	820
802043.H122AG	1	609.6 24.0000	787.4 31.0000	361.95 14.2500	361.95 14.2500	6.4	3.3	7100	16000	0.40	425
573689	1	609.6 24.0000	813.562 32.0300	479.425 18.8750	479.425 18.8750	3.3	6.4	10400	24500	0.35	695

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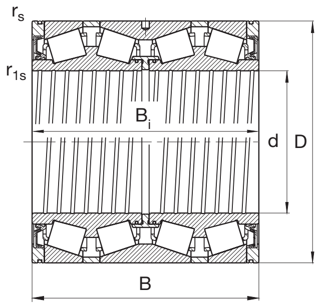
FAG Kegelrollenlager, vierreihig

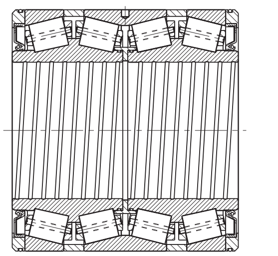
mit eingebauten Dichtungen

FAG Tapered Roller Bearings, four row

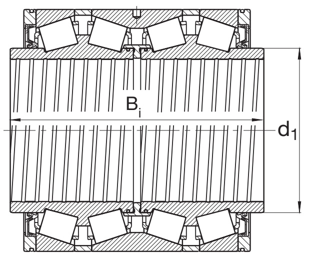
with integrated seals



Ausführung 1
Design 1



Ausführung 2
Design 2



Ausführung 3
Design 3

Kurzzeichen Code FAG	Aus-führung Design	Abmessung Dimension mm/inch d	D	B	B_i	d_1	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
580638	2	635 25.0000	901.7 35.5000	654.05 25.7500	654.05 25.7500		6.4	3.3	16600	37500	0.33	1355
572660	2	657.225 25.8750	933.45 36.7500	676.275 26.6250	676.275 26.6250		6.4	3.3	17600	39000	0.35	1530
575037	1	679.45 26.7500	901.7 35.5000	552.45 21.7500	552.45 21.7500		6.4	3.3	13400	32500	0.33	970
802087M	2	685.8 27.0000	876.3 34.5000	355.6 14.0000	352.425 13.8750		6.4	3.3	7350	17000	0.40	516
574473	2	708.025 27.8750	930.275 36.6250	565.15 22.2500	565.15 22.2500		6.4	3.3	14000	35500	0.33	1060
802095	1	710 27.9528	900 35.4331	410 16.1417	410 16.1417		6.4	3.3	9000	20400	0.37	570
802095M	2	710 27.9528	900 35.4331	410 16.1417	410 16.1417		6.4	3.3	9300	21600	0.37	600
802031	1	711.2 28.0000	914.4 36.0000	317.5 12.5000	317.5 12.5000		6.4	3.3	5850	14000	0.37	507
802031M	2	711.2 28.0000	914.4 36.0000	317.5 12.5000	317.5 12.5000		6.4	3.3	6000	14300	0.37	523
567922	3	711.2 28.0000	914.4 36.0000	317.5 12.5000	425.45 16.7500	767 30.1969	6.4	3.3	7800	19000	0.38	575
565250	2	749.3 29.5000	1066.8 42.0000	736.6 29.0000	723.9 28.5000		9.7	25.4x20°	21600	48000	0.35	2185
802069M.H122BU	2	863.6 34.0000	1169.987 46.0625	844.55 33.2500	844.55 33.2500		12.7	4.8	24500	62000	0.37	2640
576211	2	863.6 34.0000	1219.2 48.0000	889 35.0000	876.3 34.5000		12.7	4.8	28500	67000	0.35	3364

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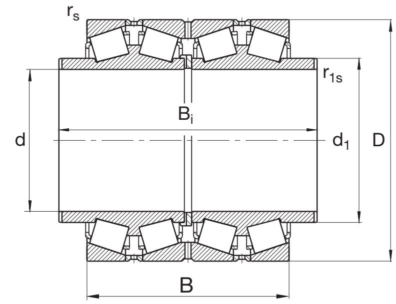
FAG Kegelrollenlager, vierreihig
mit verlängerten Innenringen
FAG Tapered Roller Bearings, four row
with extended cones



Kurzzeichen Code	Abmessung Dimension						
	d	D	B	B_i	d_1	r_s min	r_{1s} min
FAG	mm/inch						
541134	273.05 10.7500	381 15.0000	244.475 9.6250	304.8 12.0000	304.8 12.0000	3.3	1.5
547044	279.578 11.0070	380.898 14.9960	244.475 9.6250	304.8 12.0000	304.8 12.0000	3.3	1.5
522458	285.75 11.2500	380.898 14.9960	244.475 9.6250	314.475 12.3809	300 11.8110	3.3	1.5
549895	304.902 12.0040	412.648 16.2460	266.7 10.5000	336.55 13.2500	330.2 13.0000	3.3	6.4
572368	343.052 13.5060	457.098 17.9960	254 10.0000	323.85 12.7500	365.125 14.3750	3.3	1.5
802120	355.6 14.0000	457.2 18.0000	252.412 9.9375	323.85 12.7500	374.65 14.7500	3.3	1.5
547043	355.6 14.0000	482.6 19.0000	269.875 10.6250	330.2 13.0000	381 15.0000	3.3	1.5
544260	355.6 14.0000	488.95 19.2500	317.5 12.5000	381 15.0000	381 15.0000	3.3	1.5
564155	374.65 14.7500	501.65 19.7500	260.35 10.2500	323.85 12.7500	400.05 15.7500	3.3	1.5
541941	431.8 17.0000	571.5 22.5000	279.4 11.0000	368.3 14.5000	457.2 18.0000	3.3	1.5
548232	431.8 17.0000	571.5 22.5000	336.55 13.2500	412.75 16.2500	454.025 17.8750	6.4	1.5
574289	444.5 17.5000	571.5 22.5000	317.5 12.5000	355.6 14.0000	469.9 18.5000	3.3	1.5
548641	482.6 19.0000	615.95 24.2500	330.2 13.0000	406.4 16.0000	514.35 20.2500	6.4	4.1

Tragzahl · Faktor Load rating · Factor dyn. C kN	 stat. C_0	 e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90} kN	 C_{a90}	Axial-faktor Thrust factor K	Gewicht Weight ≈ kg
2600	6200	0.42	655	134	1.39	94
2600	6200	0.42	655	134	1.39	89.5
2600	6200	0.42	655	134	1.39	82
3650	7650	0.32	915	143	1.83	111
3450	7200	0.47	880	204	1.23	126
3450	8150	0.32	865	137	1.83	110
3600	8000	0.45	900	196	1.31	150
4900	10800	0.39	1250	240	1.48	190
3800	7800	0.47	950	220	1.23	154
4650	9650	0.55	1180	315	1.07	210
5850	13700	0.44	1460	315	1.33	245
5400	12900	0.35	1340	232	1.68	220
5400	14000	0.37	1370	245	1.58	257

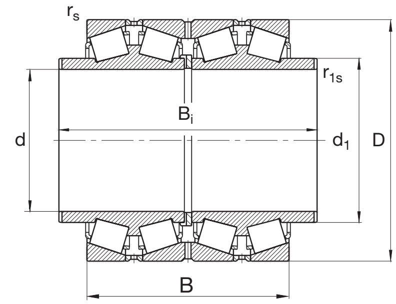
[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

FAG Kegelrollenlager, vierreihig

mit verlängerten Innenringen

FAG Tapered Roller Bearings, four row

with extended cones



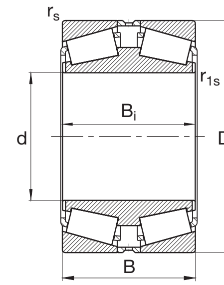
Kurzzeichen Code		Abmessung Dimension						
		d	D	B	B_i	d_1	r_s min	r_{1s} min
FAG		mm/inch						
802059.H122AB		482.6 19.0000	615.95 24.2500	330.2 13.0000	419.1 16.5000	514.35 20.2500	6.4	3.6
548234		501.65 19.7500	711.2 28.0000	520.7 20.5000	603.25 23.7500	539.75 21.2500	6.4	3.3
548233		536.575 21.1250	761.873 29.995	558.8 22.0000	638.175 25.1250	577.85 22.7500	6.4	3.3
561017		585.788 23.0625	771.525 30.3750	479.425 18.875	555.625 21.8750	622.3 24.5000	6.4	3.3
523039		685.8 27.0000	876.3 34.5000	355.6 14.0000	457.2 18.0000	736.6 29.0000	6.4	3.3
802041M	BK	685.8 27.0000	876.3 34.5000	355.6 14.0000	457.2 18.0000	736.6 29.0000	6.4	3.3
532479	SN	711.2 28.0000	914.4 36.0000	317.5 12.5000	425.45 16.7500	774.7 30.5000	6.4	8.1

BK Bolzenkäfig / pin-type cage
SN Innenringbohrungen mit schraubenförmiger Nut / inner ring bores with spiral groove

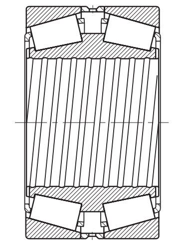
Tragzahl · Faktor Load rating · Factor			**Vergleichstragzahl[1]) Equivalent load rating[1])**		**Axial-faktor Thrust factor**	**Gewicht Weight ≈**
dyn. C	stat. C_0	e	C_{r90}	C_{a90}	K	
kN			kN			kg
5400	14000	0.37	1370	245	1.58	257
5400	14000	0.37	1370	245	1.58	259
11800	27000	0.35	3000	520	1.66	680
13700	29000	0.3	3450	510	1.97	838
10200	25000	0.33	2550	415	1.75	625
7800	20000	0.41	1960	390	1.44	551
8150	21200	0.41	2040	405	1.44	588
7500	19000	0.38	1860	345	1.53	588

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

FAG Kegelrollenlager, zweireihig
für losen Sitz auf dem Walzenzapfen
FAG Tapered Roller Bearings, double row
for loose fit on the roll neck



Ausführung 1
Design 1


Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
512127	1	136.525 5.3750	225.425 8.8750	120.65 4.7500	120.65 4.7500	3.3	1.5
540696	2	177.8 7.0000	247.65 9.7500	90.488 3.5625	90.488 3.5625	3.3	1.5
541398	1	177.8 7.0000	288.925 11.3750	123.825 4.8750	123.825 4.8750	3.3	3.3
530979	1	203.2 8.0000	317.5 12.5000	123.825 4.8750	123.825 4.8750	3	1.5
521522	1	203.2 8.0000	317.5 12.5000	133.35 5.2500	133.35 5.2500	3.3	6.4
535518	1	203.2 8.0000	317.5 12.5000	142.875 5.6250	133.35 5.2500	3.3	6.4
541397	1	203.2 8.0000	368.3 14.5000	158.75 6.2500	152.4 6.0000	3.3	3.3
565920	1	220.663 8.6875	314.325 12.3750	115.888 4.5625	115.888 4.5625	3.3	1.5
800579	1	234.95 9.2500	327.025 12.8750	93.662 3.6875	93.662 3.6875	3.3	1.5
564290	1	244.475 9.6250	381 15.0000	146.05 5.7500	146.05 5.7500	4.8	3.3
511577	1	254 10.0000	358.775 14.1250	130.175 5.1250	130.175 5.1250	3.3	1.5
547757	1	254 10.0000	438.15 17.2500	165.1 6.5000	165.1 6.5000	6.4	3.3
505684	1	254 10.0000	444.5 17.5000	133.35 5.2500	133.35 5.2500	6.4	3.3

Tragzahl · Faktor Load rating · Factor				Vergleichstragzahl[1]) Equivalent load rating[1])		Axial- faktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C ISO 281 kN	dyn. C[2])	stat. C_0	e	C_{r90} kN	C_{a90}	K	 kg	 TDI-Type
880	1040	1630	0.37	265	95	1.58	19.3	H228649DW.610
610	710	1460	0.44	176	76.5	1.33	13.6	67790DW.720
1160	1340	2120	0.32	340	108	1.83	31.7	HM237546DW.510
1080	1270	2400	0.53	320	166	1.11	37.4	93800D.125
1080	1270	2400	0.53	320	166	1.11	41.0	93801DW.125
1080	1270	2400	0.53	320	166	1.11	42.3	93801D.126
1700	1960	3450	0.39	500	196	1.48	77.1	EE420800DW.450
1000	1180	2280	0.35	300	102	1.67	29.2	M244249DW.210
850	980	2000	0.41	245	98	1.44	24.7	8576DW.8520
1600	1900	3550	0.46	475	216	1.26	67.8	EE126096DW.150
1370	1600	3150	0.34	400	134	1.71	41.6	M249749DW.710
2160	2500	4050	0.36	640	228	1.62	104	EE738101DW.712
1700	2000	3050	0.36	500	180	1.6	89.7	EE822101DW.175

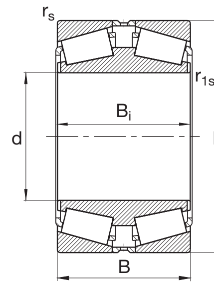
[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
[2]) Tragzahlen gelten für winkeleinstellbare Gehäuse / load ratings be of value for housings with angular freedom
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, zweireihig

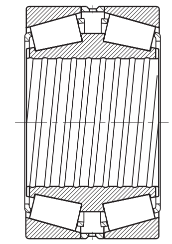
für losen Sitz auf dem Walzenzapfen

FAG Tapered Roller Bearings, double row

for loose fit on the roll neck

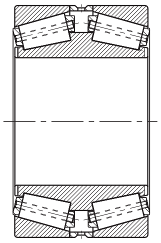


Ausführung 1
Design 1



Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
517563A	1	269.875 10.6250	381 15.0000	136.525 5.3750	136.525 5.3750	3.3	3.3
564144	1	279.4 11.0000	469.9 18.5000	169.863 6.6875	166.688 6.5625	3.3	6.4
546348	1	288.925 11.3750	406.4 16.0000	144.462 5.6875	144.462 5.6875	3.3	3.3
542664	1	300.038 11.8125	422.275 16.6250	150.813 5.9375	150.813 5.9375	3.3	3.3
572151	1	304.8 12.0000	419.1 16.5000	130.175 5.1250	130.175 5.1250	6.4	1.5
575744	1	305 12.0079	438.048 17.2460	133.35 5.2500	134.938 5.3125	4.8	3.3
510687A	1	333.375 13.1250	469.9 18.5000	166.688 6.5625	166.688 6.5625	3.3	3.3
515956	1	342.9 13.5000	533.4 21.0000	139.69 5.4996	146.05 5.7500	3.3	3.3
575296	2	346.075 13.6250	488.95 19.2500	174.625 6.8750	174.625 6.8750	3.3	3.3
518240A	2	384.175 15.1250	546.1 21.5000	193.675 7.6250	193.675 7.6250	6.4	3.3
533805	3	384.175 15.1250	546.1 21.5000	193.675 7.6250	193.675 7.6250	6.4	3.3
531821	1	406.4 16.0000	565.15 22.2500	184.15 7.2500	184.15 7.2500	6.4	3.3



Ausführung 3
Design 3

Tragzahl · Faktor Load rating · Factor				Vergleichstragzahl[1]) Equivalent load rating[1])		Axial-faktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C ISO 281 kN	dyn. C[2])	stat. C_0	e	C_{r90} kN	C_{a90}	K	kg	TDI-Type
1560	1800	3750	0.33	455	150	1.76	50.2	M252349DW.310
2400	2800	5100	0.37	710	260	1.56	129	EE722111DW.185
1730	2040	4150	0.35	510	176	1.68	59.5	M255449DW.410
1800	2080	4400	0.36	530	190	1.61	67.8	HM256849DW.810
1560	1830	3800	0.32	455	143	1.83	55.2	M257149DW.110
1340	1560	3250	0.40	400	156	1.46	68	EE129123DW.172
2120	2450	5400	0.38	630	232	1.55	92	HM261049DW.010
2120	2450	3900	0.33	620	204	1.75	112	EE971355DW.100
2500	2900	6300	0.33	735	240	1.75	106	HM262749DW.710
3050	3550	7800	0.33	900	290	1.75	149	HM266449DW.410
3050	3550	7800	0.33	900	290	1.75	150	HM266449D.410
3000	3450	7500	0.43	880	365	1.36	145	M267949DW.910

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
[2]) Tragzahlen gelten für winkeleinstellbare Gehäuse / load ratings be of value for housings with angular freedom
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
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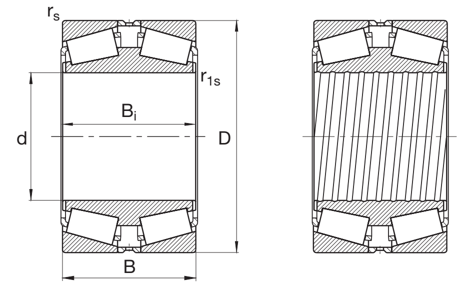
FAG Kegelrollenlager, zweireihig

für losen Sitz auf dem Walzenzapfen

FAG Tapered Roller Bearings, double row

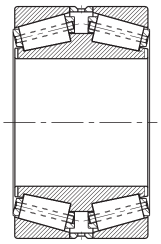
for loose fit on the roll neck



Ausführung 1
Design 1

Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
525090	1	409.575 16.1250	546.1 21.5000	161.925 6.3750	161.925 6.3750	6.4	1.5
524903	1	415.925 16.3750	590.55 23.2500	209.55 8.2500	209.55 8.2500	6.4	3.3
528949	1	431.902 17.0040	685.698 26.9960	330.2 13.0000	330.2 13.0000	6.4	6.4
518667	1	447.675 17.6250	635 25.0000	223.838 8.8125	223.838 8.8125	6.4	3.3
515087	1	479.425 18.8750	679.45 26.7500	238.125 9.3750	238.125 9.3750	6.4	3.3
503772	2	501.65 19.7500	711.2 28.0000	250.825 9.8750	250.825 9.8750	6.4	3.3
536245	1	508 20.0000	762 30.0000	219.075 8.6250	219.075 8.6250	6.4	6.4
532273	3	520 20.4724	820 32.2835	300 11.8110	300 11.8110	6	4.0
526165	2	536.575 21.1250	761.873 29.9950	269.875 10.6250	269.875 10.6250	6.4	3.3
544145	1	558.8 22.0000	736.6 29.0000	196.85 7.7500	196.85 7.7500	6.4	3.3
543718	3	571.5 22.5000	812.8 32.0000	285.75 11.2500	285.75 11.2500	6.4	3.3
528269	3	600 23.6220	1000 39.3701	350 13.7795	350 13.7795	9.5	5.0



Ausführung 3
Design 3

Tragzahl · Faktor Load rating · Factor				Vergleichstragzahl[1]) Equivalent load rating[1])		Axial-faktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C ISO 281 kN	dyn. C[2])	stat. C_0	e	C_{r90} kN	C_{a90}	K	kg	TDI-Type
2280	2650	6300	0.45	670	300	1.30	115	M667947DW.911
3350	3900	8300	0.34	1000	335	1.71	184	M268749DW.710
6700	7800	15300	0.32	2000	630	1.83	474	EE650171D.270
4150	4900	10400	0.33	1250	400	1.79	230	M270749DW.710
4400	5100	11200	0.35	1290	450	1.66	281	M272749DW.710
4900	5700	12700	0.35	1460	500	1.66	320	M274149DW.110
4400	5100	10000	0.39	1320	500	1.5	351	EE531201DW.300
7350	8650	17000	0.40	2200	865	1.45	610	
5850	6800	14600	0.30	1760	510	1.97	405	M276449DW.410
3900	4500	10800	0.35	1140	390	1.68	228	LM377449DW.410
6800	8000	18000	0.33	2040	655	1.75	505	M278749DW.710
10400	12000	22400	0.35	3100	1040	1.68	1150	

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
[2]) Tragzahlen gelten für winkeleinstellbare Gehäuse / load ratings be of value for housings with angular freedom
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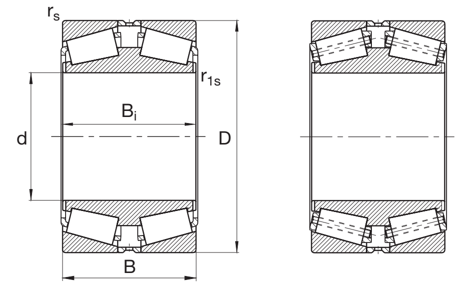
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, zweireihig
für losen Sitz auf dem Walzenzapfen
FAG Tapered Roller Bearings, double row
for loose fit on the roll neck



Ausführung 1
Design 1

Ausführung 3
Design 3

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	B	B_i	r_s min	r_{1s} min
FAG		mm/inch					
538086	1	609.6 24.0000	820 32.2835	171.45 6.7500	171.45 6.7500	6.4	3.3
515897A	3	657.225 25.8750	933.45 36.7500	328.613 12.9375	328.613 12.9375	6.4	3.3
568023	3	682.625 26.8750	965.2 38.0000	338.138 13.3125	338.138 13.3125	6.4	3.3
532828	3 SN	710 27.9528	900 35.4331	197 7.7559	197 7.7559	6.4	3.3
518933	1	711.2 28.0000	914.4 36.0000	149.225 5.8750	149.225 5.8750	6.4	3.3
524770	3	825.5 32.5000	1168.4 46.0000	409.575 16.1250	409.575 16.1250	12.7	4.8
539945	3 SB	901.7 35.5000	1295.4 51.0000	450.85 17.7500	438.15 17.2500	12.7	4.8
521872	3	939.8 37.0000	1333.5 52.5000	463.55 18.2500	463.55 18.2500	12.7	4.8

SB Lager mit Schmierbohrungen durch den Mittelbord des Innenrings / bearing with lubricating hole through the center lip in inner ring
SN Lager mit schraubenförmiger Nut in der Innenringbohrung / bearing with spiral groove in inner ring bore

Tragzahl · Faktor Load rating · Factor				Vergleichstragzahl[1]) Equivalent load rating[1])		Axial-faktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C ISO 281 kN	dyn. C[2])	stat. C_0	e	C_{r90} kN	C_{a90}	K	kg	TDI-Type
3350	3900	9300	0.48	980	465	1.2	267	
8800	10200	23200	0.33	2600	850	1.75	735	M281649D.610
8800	10400	25000	0.33	2650	865	1.75	800	M282249DW.210
4500	5300	13400	0.35	1320	450	1.68	320	
3350	3900	9500	0.38	980	365	1.53	253	EE755281D.360
12500	14600	35500	0.34	3750	1250	1.73	1436	M285848D.810
15600	18300	42500	0.32	4650	1460	1.83	2000	EE634356D.510
16300	19000	46500	0.33	4900	1600	1.75	2170	LM287849DW.810

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
[2]) Tragzahlen gelten für winkeleinstellbare Gehäuse / load ratings be of value for housings with angular freedom
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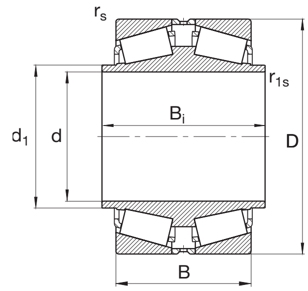
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, zweireihig

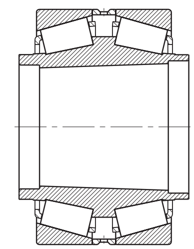
mit verlängertem Innenring

FAG Tapered Roller Bearings, double row

with extended cone



Ausführung 1 / Design 1
zylindrische Bohrung
cylindrical bore



Ausführung 2 / Design 2
kegelige Bohrung, Kegel 1:12
tapered bore, taper 1:12

Kurzzeichen Code	Aus- führung Design	Abmessung Dimension d	D	B	B_i	d_1	r_s min	r_{1s} min
FAG		mm / inch						
543067	2	152.4 6.0000	254 10.0000	120.65 4.7500	179.37 7.0618	177.8 7.0000	3	3
548433	1	160 6.2992	240 9.4488	94 3.7008	145 5.7087	175 6.8898	3	1
544752	2	177.8 7.0000	269.875 10.6250	139.7 5.5000	184.15 7.2500	193.675 7.6250	3.3	0.8
575387	2 KB	187.325 7.3750	269.875 10.6250	101.6 4.0000	139.7 5.5000	202.184 7.9600	3.3	1.5
548245	1	187.325 7.3750	269.875 10.6250	101.6 4.0000	160.338 6.3125	202.184 7.9600	3.3	1.5
535083	2	187.325 7.3750	269.875 10.6250	101.6 4.0000	160.338 6.3125	206.375 8.1250	3.3	1.5
564286	1	187.325 7.3750	290 11.4173	142 5.5906	192 7.5591	206.375 8.1250	2.5	1.5
542048	2	190 7.4803	290 11.4173	142 5.5906	192 7.5591	206.375 8.1250	2.5	1.5
535082	2	208.89 8.2240	336.55 13.2500	180.975 7.1250	244.475 9.6250	228.6 9.0000	3.3	1.5
563390	1	215.9 8.5000	317.5 12.5000	125 4.9213	175 6.8898	238.125 9.3750	3.3	1.5
539084	2	219.605 8.6459	336.55 13.25	160.34 6.3126	223.83 8.8122	241.3 9.5000	3	1.5
548244	1	220 8.6614	340 13.3858	140 5.5118	200 7.8740	241.3 9.5000	4	1.5
564232	2 KB	220 8.6614	340 13.3858	140 5.5118	200 7.8740	241.3 9.5000	4	1.5

KB Lager mit kegeliger Bohrung, Kegel 1:30 / Bearing with tapered bore, taper 1:30

Tragzahl · Faktor **Load rating · Factor**				**Vergleichstragzahl[1])** **Equivalent load rating[1])**		**Axial-faktor** **Thrust factor**	**Gewicht** **Weight** ≈
dyn. C ISO 281 kN	dyn. C[2])	stat. C_0	e	C_{r90} kN	C_{a90}	K	 kg
1000	1180	2000	0.35	300	102	1.68	28
735.0	850	1500	0.46	216	96.5	1.27	17
1180	1370	2550	0.26	355	91.5	2.21	36
880	1040	1900	0.33	260	85	1.75	20
880	1040	1900	0.33	260	85	1.75	22
850	1000	1830	0.33	250	81.5	1.75	22
1270	1500	2750	0.32	380	118	1.83	38
1270	1500	2750	0.32	380	118	1.83	38
1930	2240	4000	0.34	570	190	1.73	70
1270	1500	2800	0.35	375	129	1.68	40
1660	1960	3600	0.35	500	170	1.68	58
1530	1800	3250	0.43	455	190	1.36	51.3
1530	1800	3250	0.43	455	190	1.36	55

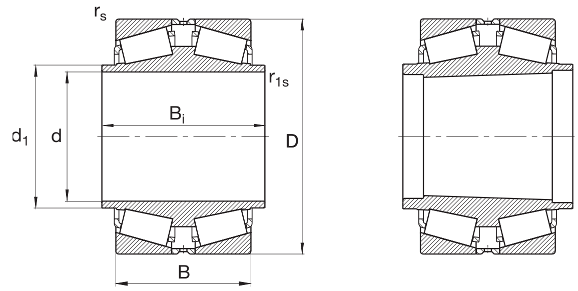
[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
[2]) Tragzahlen gelten für winkeleinstellbare Gehäuse / load ratings be of value for housings with angular freedom

FAG Kegelrollenlager, zweireihig

mit verlängertem Innenring

FAG Tapered Roller Bearings, double row

with extended cone



Ausführung 1 / Design 1
zylindrische Bohrung
cylindrical bore

Ausführung 2 / Design 2
kegelige Bohrung, Kegel 1:12
tapered bore, taper 1:12

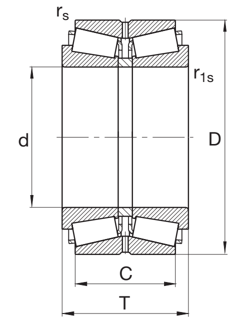
Kurzzeichen Code	Aus- führung Design	Abmessung Dimension						
		d	D	B	B_i	d_1	r_s min	r_{1s} min
FAG		mm / inch						
542129	2	220.13 8.6665	336.55 13.2500	180.975 7.1250	244.475 9.6250	241.3 9.5000	3.3	1.5
539574	2	230 9.0551	370 14.5669	160 6.2992	223.5 8.7992	260.35 10.2500	3	3
535081	1	269.875 10.6250	381 15.0000	136.525 5.3750	196.85 7.7500	292.1 11.5000	3.3	3.3
542146	2	272.39 10.7240	381 15.0000	136.525 5.3750	196.85 7.7500	292.1 11.5000	3.3	1.5
544753	2	280 11.0236	460 18.1102	220 8.6614	280 11.0236	311.15 12.2500	6	1
548243	1	288.925 11.3750	406.4 16.0000	165.1 6.5000	234.95 9.2500	307.975 12.1250	3.3	1.5
564231	2 KB	288.925 11.3750	406.4 16.0000	165.1 6.5000	234.95 9.2500	307.975 12.1250	3.3	1.5
539576	2	317.5 12.5000	447.675 17.6250	159.512 6.2800	222.25 8.7500	342.9 13.5000	3.3	3.3
803981	1 SN	325 12.7953	469.9 18.5000	182.563 7.1875	247.65 9.7500	355.6 14.0000	3.3	1.5
548242	1	333.375 13.1250	469.9 18.5000	166.688 6.5625	231.775 9.1250	355.6 14.0000	3.3	1.5
564230	2 KB	333.375 13.1250	469.9 18.5000	166.688 6.5625	231.775 9.1250	355.6 14.0000	3.3	1.5
541965	2	333.375 13.1250	469.9 18.5000	182.563 7.1875	247.65 9.7500	355.6 14.0000	3.3	1.5
544754	2	340 13.3858	520 20.4724	220 8.6614	280 11.0236	371.475 14.6250	6	1

KB Lager mit kegeliger Bohrung, Kegel 1:30 / Bearing with tapered bore, taper 1:30
SN Lager mit schraubenförmiger Nut in der Innenringbohrung / bearing with spiral groove in inner ring bore

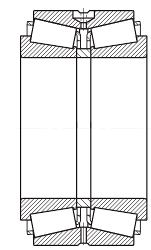
Tragzahl · Faktor **Load rating · Factor**				**Vergleichstragzahl[1])** **Equivalent load rating[1])**		**Axial-faktor** **Thrust factor**	**Gewicht** **Weight** ≈
dyn. C ISO 281 kN	dyn. C[2])	stat. C_0	e	C_{r90} kN	C_{a90}	K	kg
1860	2160	4250	0.35	560	190	1.68	62
1800	2120	3650	0.39	540	208	1.48	77
1560	1800	3750	0.33	455	150	1.76	52.5
1560	1800	3750	0.33	455	150	1.76	56
3150	3650	6300	0.35	930	320	1.67	170
2000	2320	4750	0.33	600	190	1.78	74
2000	2320	4750	0.33	600	190	1.78	76
2080	2400	5200	0.33	610	200	1.75	92
2550	3000	6400	0.32	750	236	1.83	117
2120	2450	5400	0.38	630	232	1.55	100
2120	2450	5400	0.38	630	232	1.55	102
2550	3000	6400	0.32	750	236	1.83	115
3350	3900	7200	0.4	1000	400	1.44	228

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).
[2]) Tragzahlen gelten für winkeleinstellbare Gehäuse / load ratings be of value for housings with angular freedom

FAG Kegelrollenlager, zweireihig, in O-Anordnung
in Zollabmessungen
FAG Tapered Roller Bearings, double row, O-arrangement
in inch dimensions



Ausführung 1
Design 1



Ausführung 2
Design 2

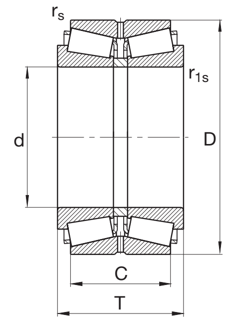
Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	T	C	r_s min	r_{1s} min
FAG		mm/inch					
515090	1	114.3 4.5000	228.6 9.0000	115.888 4.5625	84.138 3.3125	2.3	3.6
540157	1	133.35 5.2500	200.025 7.8750	101.6 4.0000	85.725 3.3750	0.8	3.6
543176	2	139.7 5.5000	254 10.0000	149.225 5.8750	111.125 4.3750	1.5	7.1
562080	2	146.05 5.7500	254 10.0000	149.225 5.8750	111.125 4.3750	1.5	7.1
510855	1	152.4 6.0000	222.25 8.7500	100.01 3.9374	76.2 3.0000	0.8	3.6
503316	1	152.4 6.0000	254 10.0000	149.225 5.8750	111.125 4.3750	1.5	7.1
522040	1	165.1 6.5000	288.925 11.3750	142.875 5.6250	111.125 4.3750	1.5	7.1
532949	1	177.8 7.0000	269.875 10.6250	119.062 4.6875	93.662 3.6875	1.5	3.6
503594	1	177.8 7.0000	288.925 11.3750	142.875 5.6250	111.125 4.3750	1.5	7.1
525012	1	187.325 7.3750	269.875 10.6250	119.062 4.6875	93.662 3.6875	1.5	3.6
512704A	1	190.5 7.5000	266.7 10.5000	103.188 4.0625	84.138 3.3125	0.8	3.6
525882	1	200.025 7.8750	317.5 12.5000	146.05 5.7500	111.125 4.3750	1.5	4.3

Tragzahl · Faktor **Load rating · Factor**			**Vergleichstragzahl[1])** **Equivalent load rating[1])**		**Axialfaktor** **Thrust** **factor**	**Gewicht** **Weight** ≈	**Vergleichsbezeichnung** **Equivalent number**
dyn. C ISO 281 kN	stat. C_0	e	C_{r90} kN	C_{a90}	K	kg	TDO-Type
695	1180	0.7	208	143	0.83	22	HM926740.710D
540	1140	0.34	160	53	1.7	11.1	67390.325D
1000	1930	0.41	290	116	1.43	31.3	99550.102CD
1000	1930	0.41	290	116	1.43	29.7	99575.102CD
510	1060	0.35	150	50	1.68	12.7	M231649.610D
1000	1930	0.41	290	116	1.43	29.1	99600.102D
1160	2120	0.32	340	108	1.83	36.8	HM237535.510D
880	1900	0.33	260	85	1.75	23.9	M238840.810D
1160	2120	0.32	340	108	1.83	33.6	HM237545.510D
880	1900	0.33	260	85	1.75	20.8	M238849.810D
600	1500	0.48	176	83	1.22	17.2	67885.820D
1080	2400	0.53	320	166	1.11	41.9	93787.127D

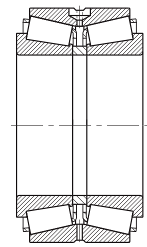
[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, zweireihig, in O-Anordnung
in Zollabmessungen
FAG Tapered Roller Bearings, double row, O-arrangement
in inch dimensions



Ausführung 1
Design 1



Ausführung 2
Design 2

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm/inch	D	T	C	r_s min	r_{1s} min
518879A	2	203.2 8.0000	317.5 12.5000	146.05 5.7500	111.125 4.3750	1.5	4.3
523062	2	206.375 8.1250	336.55 13.2500	211.138 8.3125	169.862 6.6875	1.5	3.3
518468	1	228.6 9.0000	355.6 14.0000	152.4 6.0000	111.125 4.3750	1.5	6.9
514401	1	228.6 9.0000	355.6 14.0000	152.4 6.0000	114.3 4.5000	1.5	6.4
515125	2	228.6 9.0000	488.95 19.2500	254 10.0000	152.4 6.0000	1.5	6.4
505612	2	254 10.0000	358.775 14.1250	152.4 6.0000	117.475 4.6250	1.5	3.6
515129	1	254 10.0000	533.4 21.0000	276.225 10.8750	165.1 6.5000	1.5	6.4
514599	1	260.35 10.2500	422.275 16.6250	178.592 7.0312	139.7 5.5000	1.5	6.9
524440A	2	285.75 11.2500	380.898 14.9960	139.7 5.5000	107.95 4.2500	1.5	3.6
525830	1	285.75 11.2500	501.65 19.7500	203.2 8.0000	120.65 4.7500	3.3	6.4
505614A	2	288.925 11.3750	406.4 16.0000	165.1 6.5000	130.175 5.1250	1.5	6.4
526864	1	300.038 11.8125	422.275 16.6250	174.625 6.8750	136.525 5.3750	1.5	6.4

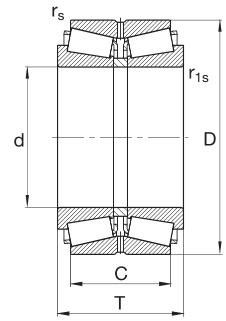
Tragzahl · Faktor Load rating · Factor			Vergleichstragzahl[1]) Equivalent load rating[1])		Axialfaktor Thrust factor	Gewicht Weight ≈	Vergleichsbezeichnung Equivalent number
dyn. C ISO 281 kN	stat. C_0	e	C_{r90} kN	C_{a90}	K	kg	TDO-Type
1080	2400	0.53	320	166	1.11	40.6	93800.127CD
1930	4000	0.34	570	190	1.73	69.3	H242649.610CD
1120	2650	0.59	335	193	0.99	53.6	130902.131401D
1120	2650	0.59	335	193	0.99	52.8	HM746646.610D
2550	4400	0.94	765	695	0.62	205	HH949549.510CD
1370	3150	0.34	400	134	1.71	44.2	M249749.710CD
3350	5400	0.87	1000	850	0.67	259	HH953749.710D
1860	3550	0.33	550	180	1.74	86.8	HM252349.310D
1180	3250	0.43	345	146	1.35	42	LM654649.610CD
2160	3750	0.78	640	490	0.75	143	EE147112.198D
1730	4150	0.35	510	176	1.68	62.6	M255449.410CD
1800	4400	0.36	530	190	1.61	72.1	HM256849.810D

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

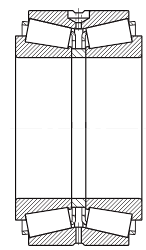
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.

The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

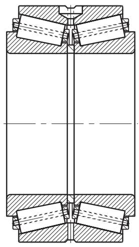
FAG Kegelrollenlager, zweireihig, in O-Anordnung
in Zollabmessungen
FAG Tapered Roller Bearings, double row, O-arrangement
in inch dimensions



Ausführung 1
Design 1


Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	T	C	r_s min	r_{1s} min
FAG		mm/inch					
527128	2	304.8 12.0000	438.048 17.2460	165.1 6.5000	120.65 4.7500	1.5	6.4
512601	1	311.15 12.2500	558.8 22.0000	190.5 7.5000	111.125 4.3750	3.3	9.7
521746	2	317.5 12.5000	444.5 17.5000	146.05 5.7500	98.425 3.8750	1.5	7.9
510607A	2	317.5 12.5000	447.675 17.6250	180.975 7.1250	146.05 5.7500	1.5	3.6
515495	2	330.2 13.0000	482.6 19.0000	177.8 7.0000	127 5.0000	1.5	6.4
526831	2	333.375 13.1250	469.9 18.5000	190.5 7.5000	152.4 6.0000	1.5	6.4
505613A	2	346.075 13.6250	488.95 19.2500	200.025 6.2500	158.75 7.8750	1.5	6.4
523319	2	355.6 14.0000	444.5 17.5000	136.525 5.3750	111.125 4.3750	1.5	3.6
510608A	2	355.6 14.0000	501.65 19.7500	155.575 6.1250	107.95 4.2500	1.5	6.4
581099	4	368.249 14.4980	523.875 20.6250	214.312 8.4375	169.862 6.6875	1.5	6.4
573335	2	368.3 14.5000	596.9 23.5000	203.2 8.0000	133.35 5.2500	2.3	9.7
527366	2	371.475 14.6250	501.65 19.7500	155.575 6.1250	107.95 4.2500	1.5	6.4



Ausführung 4
Design 4

Tragzahl · Faktor Load rating · Factor dyn. C ISO 281 kN	stat. C_0	e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90} kN	C_{a90}	Axialfaktor Thrust factor K	Gewicht Weight ≈ kg	Vergleichsbezeichnung Equivalent number TDO-Type
1340	3250	0.4	400	156	1.46	73.8	EE129120X.173CD
2160	3900	0.88	640	550	0.66	172	EE148122.220D
1250	2800	0.38	365	134	1.55	59.8	EE291250.751CD
2080	5200	0.33	610	200	1.75	85	HM259049.010CD
2080	4550	0.47	620	285	1.23	97.7	EE526130.191CD
2120	5400	0.38	630	232	1.55	97.8	HM261049.010CD
2500	6300	0.33	735	240	1.75	112	HM262749.710CD
1250	3750	0.31	360	110	1.9	45	L163149.110CD
1630	3750	0.44	480	208	1.32	85.1	EE231400.976CD
2750	6800	0.35	815	280	1.66	141	HM265049.010CD
2800	5300	0.42	815	335	1.40	184	EE181453.351CD
1630	3750	0.44	480	208	1.32	73.7	EE231462.976CD

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.

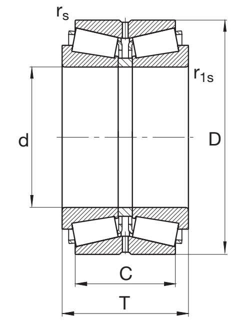
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, zweireihig, in O-Anordnung

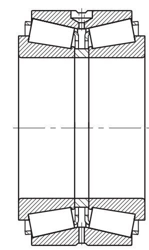
in Zollabmessungen

FAG Tapered Roller Bearings, double row, O-arrangement

in inch dimensions

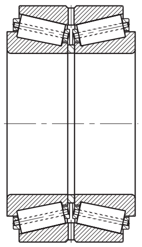


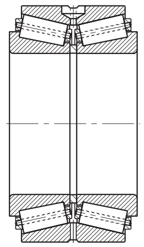
Ausführung 1
Design 1



Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	T	C	r_s min	r_{1s} min
FAG		mm/inch					
526251	2	381 15.0000	508 20.0000	139.7 5.5000	88.9 3.5000	1.5	6.4
581097	4	381 15.0000	590.55 23.2500	244.475 9.6250	193.675 7.6250	1.5	6.4
547099	2	381 15.0000	590.55 23.2500	244.475 9.6250	193.675 7.6250	1.5	6.4
579745	4	384.175 15.1250	546.1 21.5000	222.25 8.7500	177.8 7.0000	1.5	6.4
505611B	1	396.875 15.6250	546.1 21.5000	158.75 6.2500	117.475 4.6250	1.5	6.4
525845	2	406.4 16.0000	546.1 21.5000	185.738 7.3125	147.638 5.8125	1.5	6.4
515494	2	406.4 16.0000	609.524 23.9970	177.8 7.0000	133.35 5.2500	1.5	8.1
578129	4	415.925 16.3750	590.55 23.2500	244.475 9.6250	193.675 7.6250	1.5	6.4
517498A	2	415.925 16.3750	590.55 23.2500	244.475 9.6250	193.675 7.6250	1.5	6.4
527127	2	431.8 17.0000	571.5 22.5000	155.575 6.1250	111.125 4.3750	1.5	3.3
579097	3	447.675 17.6250	635 25.0000	257.175 10.1250	206.375 8.1250	1.5	6.4
521467A	2	447.675 17.6250	635 25.0000	257.175 10.1250	206.375 8.1250	1.5	6.4





Ausführung 3
Design 3

Ausführung 4
Design 4

Tragzahl · Faktor Load rating · Factor			**Vergleichstragzahl[1]) Equivalent load rating[1])**		**Axialfaktor Thrust factor**	**Gewicht Weight ≈**	**Vergleichsbezeichnung Equivalent number**
dyn. C ISO 281	stat. C_0	e	C_{r90}	C_{a90}	K		
kN			kN			kg	TDO-Type
1290	3200	0.53	375	196	1.1	66.8	EE192150.201CD
3550	8800	0.34	1040	345	1.71	247	M268730.710CD
3350	8300	0.34	1000	335	1.71	238	M268730.710CD
3050	7800	0.33	900	290	1.75	159	HM266449.410CD
1800	4300	0.47	530	245	1.23	96.5	EE234156.216D
2280	6300	0.45	670	300	1.3	117	M667944.911CD
2500	5500	0.47	735	335	1.25	167	EE736160.239CD
3550	8800	0.34	1040	345	1.71	205	M268749.710CD
3600	9150	0.33	1060	345	1.75	200	M268749.710CD
2000	4800	0.55	585	315	1.07	95.5	LM869448.410CD
4300	10600	0.33	1270	405	1.79	251	
4150	10400	0.33	1250	400	1.79	241	M270749.710CD

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.

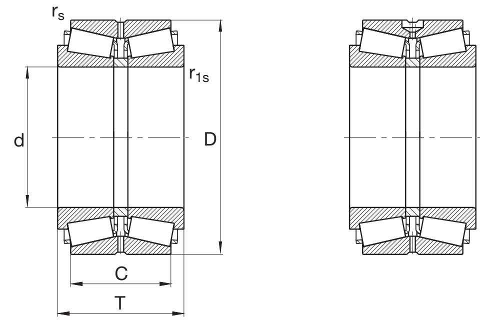
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, zweireihig, in O-Anordnung

in Zollabmessungen

FAG Tapered Roller Bearings, double row, O-arrangement

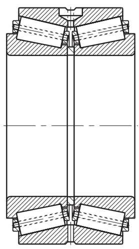
in inch dimensions



Ausführung 1
Design 1

Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	T	C	r_s min	r_{1s} min
FAG		mm/inch					
529635	2	457.2 18.0000	596.9 23.5000	165.1 6.5000	120.65 4.7500	1.5	9.7
541705	2	457.2 18.0000	660.4 26.0000	228.6 9.0000	171.45 6.7500	1.5	6.4
517499A	2	479.425 18.8750	679.45 26.7500	276.225 10.8750	222.25 8.7500	1.5	6.4
578647	4	479.425 18.8750	679.45 26.7500	276.225 10.8750	222.25 8.7500	1.5	6.4
515917A	2	488.95 19.2500	634.873 24.9950	180.975 7.1250	136.525 5.3750	1.5	6.4
505610	1	488.95 19.2500	660.4 26.0000	206.375 8.1250	158.75 6.2500	1.5	6.4
515127A	2	498.475 19.6250	634.873 24.9950	177.8 7.0000	142.875 5.6250	1.5	6.4
578586	4	501.65 19.7500	711.2 28.0000	292.1 11.5000	231.775 9.1250	1.5	6.4
528996	2	501.65 19.7500	711.2 28.0000	292.1 11.5000	231.775 9.1250	1.5	6.4
518884	1	508 20.0000	838.2 33.0000	304.8 12.0000	222.25 8.7500	3.3	9.7
528407	2	520.7 20.5000	736.6 29.0000	186.502 7.3426	114.3 4.5000	1.5	6.4
577417	4	536.575 21.1250	761.873 29.9950	311.15 12.2500	247.65 9.7500	1.5	6.4



Ausführung 4
Design 4

Tragzahl · Faktor **Load rating · Factor** dyn. C ISO 281 kN	 stat. C_0	 e	**Vergleichstragzahl[1])** **Equivalent load rating[1])** C_{r90} kN	 C_{a90}	**Axialfaktor** **Thrust factor** K	**Gewicht** **Weight** ≈ kg	**Vergleichsbezeichnung** **Equivalent number** TDO-Type
2040	5600	0.4	600	236	1.46	107	EE244180.236CD
3750	9000	0.35	1100	375	1.68	238	M271648.610CD
4400	11200	0.35	1290	450	1.66	296	M272749.710CD
4550	11800	0.35	1340	465	1.66	304	M272749.710CD
2500	6800	0.47	735	345	1.23	135	LM772748.710CD
2600	6950	0.45	765	335	1.29	184	EE640192.261D
2000	5600	0.43	585	245	1.36	122	EE243196.251CD
5000	13200	0.35	1460	510	1.66	354	M274149.110CD
4900	12700	0.35	1460	500	1.66	352	M274149.110CD
5500	11800	0.49	1630	780	1.20	589	EE426200.331D
2550	5700	0.48	750	345	1.23	210	EE982051.901CD
6000	15300	0.3	1800	520	1.97	427	M276449.410CD

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

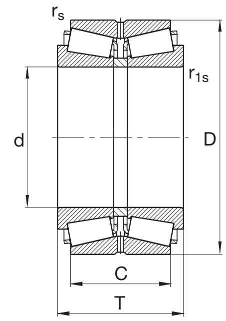
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, zweireihig, in O-Anordnung

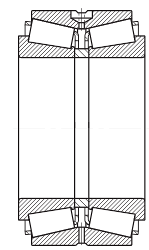
in Zollabmessungen

FAG Tapered Roller Bearings, double row, O-arrangement

in inch dimensions

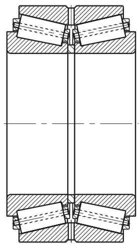


Ausführung 1
Design 1

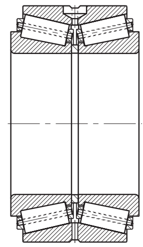


Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					
		d	D	T	C	r_s min	r_{1s} min
FAG		mm/inch					
581098	4	536.575 21.1250	761.873 29.9950	311.15 12.2500	247.65 9.7500	1.5	6.4
536948	2	558.8 22.0000	736.6 29.0000	187.328 7.3751	138.112 5.4375	1.5	6.4
521229B	2	558.8 22.0000	736.6 29.0000	225.425 8.8750	177.8 7.0000	1.5	6.4
541361	4	558.8 22.0000	736.6 29.0000	225.425 8.8750	177.8 7.0000	1.5	6.4
536529	2	571.5 22.5000	812.8 32.0000	333.375 13.1250	263.525 10.3750	1.5	3.3
566721	4	571.5 22.5000	812.8 32.0000	333.375 13.1250	263.525 10.3750	1.5	6.4
524528	2	602.945 23.7380	787.4 31.0000	206.375 8.1250	158.75 6.2500	1.5	6.4
513974	2	609.6 24.0000	787.4 31.0000	206.375 8.1250	158.75 6.2500	1.5	6.4
533433	1	609.6 24.0000	812.8 32.0000	190.5 7.5000	146.05 5.7500	3.3	6.4
574101	3	635 25.0000	990.6 39.0000	339.725 13.3750	212.725 8.3750	1.5	6.4
514502	2	660.4 26.0000	812.8 32.0000	203.2 8.0000	158.75 6.2500	1.5	6.4
512516	2	685.8 27.0000	876.3 34.5000	200.025 7.8750	152.4 6.0000	1.5	6.4



Ausführung 3
Design 3



Ausführung 4
Design 4

Tragzahl · Faktor Load rating · Factor dyn. C ISO 281 kN	stat. C_0	e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90} kN	C_{a90}	Axialfaktor Thrust factor K	Gewicht Weight ≈ kg	Vergleichsbezeichnung Equivalent number TDO-Type
6000	15300	0.3	1800	520	1.97	427	M276449.410CD
2400	6550	0.4	710	275	1.47	190	EE843220.291CD
3900	10800	0.35	1140	390	1.68	244	LM377449.410CD
3900	11200	0.35	1160	390	1.68	255	LM377449.410CD
6550	16600	0.33	1930	630	1.75	483	M278749.710CD
6800	18000	0.33	2040	655	1.75	520	M278749.710CD
3100	9000	0.5	900	440	1.17	248	EE649237.311CD
3100	9000	0.5	900	440	1.17	237	EE649240.311CD
3100	8000	0.33	915	300	1.75	244	EE743240.321D
7100	15600	0.87	2120	1800	0.67	908	
3550	10600	0.33	1020	335	1.75	207	L281148.110CD
3350	10000	0.41	980	390	1.44	275	EE655270.346CD

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

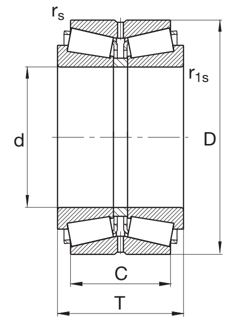
Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, zweireihig, in O-Anordnung

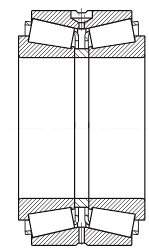
in Zollabmessungen

FAG Tapered Roller Bearings, double row, O-arrangement

in inch dimensions

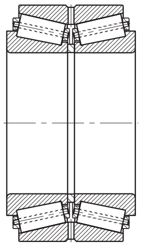


Ausführung 1
Design 1



Ausführung 2
Design 2

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm/inch	D	T	C	r_s min	r_{1s} min
521233	1	711.2 28.0000	914.4 36.0000	190.5 7.5000	139.7 5.5000	1.5	6.4
512878	1	723.9 28.5000	914.4 36.0000	187.325 7.3750	139.7 5.5000	1.5	5.6
514528	1	762 30.0000	965.2 38.0000	187.325 7.3750	133.35 5.2500	1.5	6.4
512407	1	774.7 30.5000	965.2 38.0000	187.325 7.3750	133.35 5.2500	1.5	6.4
576448	2	774.7 30.5000	965.2 38.0000	187.325 7.3750	133.35 5.2500	1.5	6.4
521084	1	812.8 32.0000	1016 40.0000	190.5 7.5000	133.35 5.2500	1.5	6.4
518817	1	812.8 32.0000	1066.8 42.0000	190.5 7.5000	146.05 5.7500	3.3	6.4
512406	1	914.4 36.0000	1066.8 42.0000	139.7 5.5000	101.6 4.0000	3.3	6.4
579565	3	914.4 36.0000	1066.8 42.0000	139.7 5.5000	101.6 4.0000	3.3	6.4
579534	3	1160 45.6693	1430 56.2992	240 9.4488	180 7.0866	5.0	9.5
563113	3	1320.8 52.0000	1727.2 68.0000	412.75 16.2500	254 10.0000	3.0	1.0



Ausführung 3
Design 3

Tragzahl · Faktor Load rating · Factor dyn. C ISO 281 kN	stat. C_0	e	Vergleichstragzahl[1]) Equivalent load rating[1]) C_{r90} kN	C_{a90}	Axialfaktor Thrust factor K	Gewicht Weight ≈ kg	Vergleichsbezeichnung Equivalent number TDO-Type
3350	9500	0.38	980	365	1.53	285	EE755280.361D
3350	9500	0.38	980	365	1.53	261	EE755285.361D
3450	10000	0.4	1000	400	1.44	295	EE752300.381D
3450	10000	0.4	1000	400	1.44	277	EE752305.381D
3450	10000	0.4	1000	400	1.44	272	EE752305.381CD
3550	11200	0.48	1020	480	1.22	420	EE762320.401D
3550	11200	0.48	1020	480	1.22	430	EE762320.420D
2500	8150	0.41	720	290	1.41	191	LL686947.910D
2600	8500	0.41	735	300	1.41	200	LL686947.910D
6550	22400	0.4	1930	765	1.45	812	
13200	40000	0.83	3900	3150	0.7	2365	

[1]) Zum Vergleich mit radialen Tragzahlen C_{r90} und axialen Tragzahlen C_{a90} geeignet, denen eine nominelle Lebensdauer von $90 \cdot 10^6$ Umdrehungen (3000 h bei 500 min^{-1}) zugrunde liegt.
Suitable for comparison with radial and axial load ratings C_{r90} and C_{a90} which are based on a rating life of $90 \cdot 10^6$ revolutions (3000 hours at 500 min^{-1}).

Die Vergleichsbezeichnungen wurden uns zugänglichen Unterlagen entnommen. Sie informieren nur über gleiche Hauptabmessungen und Kantenabstände. Käfig- und Lagerausführungen sind nicht immer identisch. Außerdem erhebt die Tabelle keinen Anspruch auf Vollständigkeit.

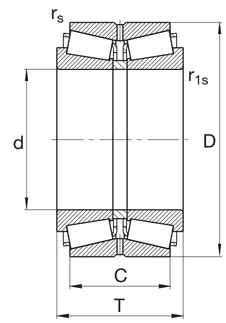
The equivalent numbers have been taken from documents available to us. They only list competitors' bearings with the same main dimensions and chamfers. Cage and bearing design are not always identical. Furthermore the data do not claim completeness.

FAG Kegelrollenlager, zweireihig, in O-Anordnung

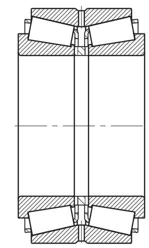
in metrischen Abmessungen

FAG Tapered Roller Bearings, double row, O-arrangement

in metric dimensions



Ausführung 1
Design 1



Ausführung 2
Design 2

Kurzzeichen Code FAG	Ausführung Design	Abmessung Dimension d mm	D	T	C	r_s min	r_{1s} min	Tragzahl · Faktor Load rating · Factor dyn. C kN	stat. C_0	e	Gewicht Weight ≈ kg
538177	2	100	180	111.25	92	0.6	3	570	950	0.42	12
549970	2	105	190	118	96	0.6	3	655	1100	0.42	14.8
532950	2	130	210	109.25	90	0.6	2	695	1270	0.28	13.7
547492	2	130	230	150	120	1	4	965	1730	0.44	24.7
548876	1	130	235	145	115	1.5	3	880	1630	0.37	25.6
565734	1	135	220	106.6	81	1	3	600	1220	0.46	15.2
511976	2	150	250	138	112	1	3	930	1800	0.25	25.5
539097	2	150	255	145	110	1.5	5	1000	1930	0.41	28.9
549971	2	150	270	172	138	1	4	1270	2320	0.44	41.6
539098	1	160	270	140	110	1	3	1000	1930	0.39	31
511977	2	160	270	150	120	1.5	4	1120	2120	0.36	33.8
549963	2	180	250	95	76	2	2.5	570	1340	0.4	14
511978	2	180	280	134	108	1	3	1080	2200	0.42	30.2
511979	1	180	300	164	134	1.5	4	1400	2650	0.36	43.7
511980	2	190	260	95	76	1	3	655	1400	0.35	13.5
577350	1	190	320	172	134	1.5	4	1500	2850	0.36	52
538178	2	200	280	117	97	0.6	3	850	1860	0.39	21.6
511981	2	200	310	152	123	1.5	4	1290	2750	0.43	40.1
511982	1	200	340	184	150	1.5	4	1700	3150	0.26	61.1
511983	2	220	300	109	88	1	3	780	1800	0.38	21.2
511984	2	220	340	165	130	1.5	4	1530	3250	0.43	51.7
580871	1	220	370	200	166	1.5	5	1930	3750	0.24	79.7
541910	2	230	355	145	110	2.5	6	1320	2650	0.33	48.7
568648	1	240	320	110	87	1	3	880	2040	0.29	22.3
511985	2	240	360	165	130	1	3	1460	3350	0.31	58.5
511986	1	240	400	210	168	1.5	5	2320	4650	0.37	100
511987	1	260	360	134	108	1	3	1290	3000	0.41	39.2
514164	1	260	400	150	110	2.5	6	1250	2550	0.44	60.9
511988	2	260	400	186	146	3	5	2000	4300	0.43	81
539099	2	260	430	180	130	2.5	10	1860	3550	0.33	93.5
511989	1	260	440	225	180	1	4	2850	5500	0.28	130
538180	1	280	420	189	154	2	5	2080	4650	0.46	85.2
511990	2	300	420	159	128	1	4	1560	3800	0.32	63.8
565735	1	300	500	180	125	2.5	9.5	2240	4050	0.26	121
511991	2	300	500	205	152	2.5	6	2650	5200	0.37	136

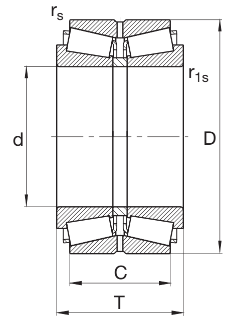
Ausführung/Design 2: Zwischenring mit radialen Schmiernuten / spacer with radial lubrication grooves

FAG Kegelrollenlager, zweireihig, in O-Anordnung

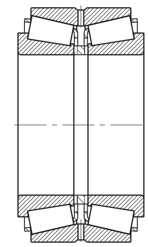
in metrischen Abmessungen

FAG Tapered Roller Bearings, double row, O-arrangement

in metric dimensions



Ausführung 1
Design 1



Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension						Tragzahl · Faktor Load rating · Factor			Gewicht Weight ≈
		d	D	T	C	r_s min	r_{1s} min	dyn. C	stat. C_0	e	
FAG		mm						kN			kg
532655	1	340	460	160	128	1.5	4	1900	4900	0.4	72.6
549929	1	340	520	180	135	2	6	2280	4900	0.31	126
511992	1	340	580	242	170	2	6	3350	6200	0.47	228
541911	2	350	590	200	140	2.5	12	2800	5300	0.56	208
511993	2	360	480	160	128	1.5	4	1900	4750	0.32	73.3
525858	1	360	540	185	140	1.5	5	2550	5500	0.3	135
538179	2	380	520	149	112	2	5	1600	3900	0.36	86.4
511994	1	380	620	242	170	2	5	3600	6950	0.46	251
565736	1	400	590	185	125	2.5	6	2500	5200	0.33	146
511995	2	400	600	206	150	2	6	3000	6700	0.46	188
549965	2	420	620	206	150	5	6	2900	6300	0.43	192
511996	2	420	700	275	200	2	6	4550	9000	0.42	384
511997	2	440	650	212	152	3	8	3100	6800	0.48	219
549964	2	460	620	170	131	4	5	2500	6100	0.38	135
534866	2	460	680	230	175	3	7.5	3800	8650	0.31	265
511998	2	480	650	180	130	2	5	2600	6400	0.4	152
541912	2	490	640	180	144	3	9.5	2600	6400	0.40	141
539031	2	500	670	180	130	2	5	2600	6550	0.41	162
544199	1	500	720	236	180	3	7.5	4000	9300	0.33	281
539117	2	520	740	190	120	3	3	2550	5700	0.48	225
510043	2	530	710	190	136	2.5	6	3050	7800	0.41	194
532951	2	560	750	213	156	2.5	6	3100	8000	0.43	217
578732	2	560	820	260	185	3	7.5	4650	11200	0.49	418
541806	1	560	820	270	190	3	9.5	4650	11200	0.49	432
538181	2	600	800	208.5	160	2.5	6	3650	9000	0.32	262
538183	2	600	870	270	198	3	6	5000	12000	0.41	473
538182	2	630	850	242	182	2.5	7.5	4400	11400	0.4	360
510041	2	710	950	240	175	3	7.5	5100	12900	0.46	422
534867	1	710	1030	315	220	4	9.5	7100	16600	0.43	753
564801	2	800	1060	270	204	2.5	6	6000	16000	0.35	604
538339	2	850	1120	268	190	3	7.5	5500	15300	0.46	638
538341	2	950	1250	298	220	4	9.5	7350	20800	0.32	883
568323	1 BK	1250	1500	250	190	1.5	6	6950	23600	0.37	795
572139	1 BK	1450	1770	290	170	5	9.5	7350	25500	0.87	1385

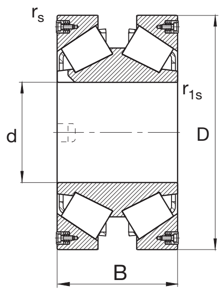
Ausführung/Design 2: Zwischenring mit radialen Schmiernuten / spacer with radial lubrication grooves
BK Bolzenkäfig / pin type cage

FAG Kegelrollenlager, zweireihig

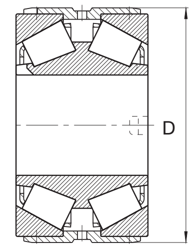
Axiallager für Arbeitswalzen

FAG Tapered Roller Bearings, double row

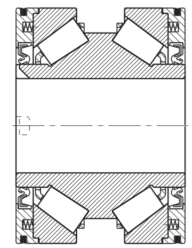
thrust bearings for work rolls



Ausführung 1
Design 1



Ausführung 2
Design 2



Ausführung 3
Design 3

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					Tragzahl · Faktor Load rating · Factor			Gewicht Weight
		d	D	B	r_s min	r_{1s} min	dyn. C	Y	stat. C_0	≈
FAG		mm					kN			kg
803422	1	160	343	160	2	2	1370	1.25	2280	66
801948	1	190	370	170	2	2	1430	1.16	2600	77.5
801984	3	190	370	210	2	2	1430	1.16	2600	97
800942	1	230	404	152*)	2	2	1430	0.96	2600	73
803185	3	230	404	152	2	2	1040	1.16	1930	78
803722	2	300	460	105	2	4	915	1.17	2000	62
801521	1	300	480	180	3	2	1900	1.16	3900	112
801555	2	300	480	180	2	3	1830	1.16	4000	123
801925	3 KH	300	480	220	4	5	2000	1.16	4250	140
801250	1	320	480	160	2	2	1630	1.16	3650	92.3
801949	1	365.6	514.35	140	2	2	1460	1.16	3800	86.6
801926	1	380	570	180	2	2	2120	1.16	5500	155
801999	3 KH	380	590	260	3	2.5	2900	1.16	6800	245
578815	2	390	568	180	2	2	2120	1.16	5500	151
801249	1	390	570	180	2	2	2120	1.16	5500	146
800967	1	390	590	200	5	5	2400	1.16	5600	180
579673	2	390	590	200	2	5	2400	1.16	5600	191
801950	1	400	650	240	6	6	3450	1.16	6950	278

*) Innenringbreite = 144 mm / inner ring width = 144 mm
KH keine Haltenuten am Innenring / without retaining grooves on the inner ring

Ausführung: 1 Innenring, Außenringe und Rollen aus Einsatzstahl
Design: inner ring, outer rings and rollers made of case hardening steel
2, 3 Innenring aus Einsatzstahl
inner ring made of case hardening steel

Dynamisch äquivalente Belastung
Equivalent dynamic load

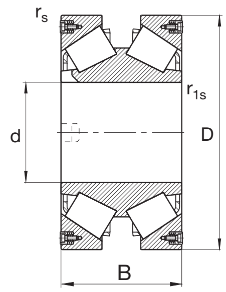
$P = Y \cdot F_a$ [kN]

FAG Kegelrollenlager, zweireihig

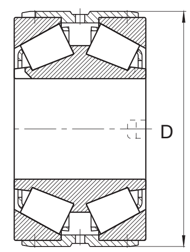
Axiallager für Arbeitswalzen

FAG Tapered Roller Bearings, double row

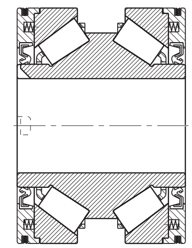
thrust bearings for work rolls



Ausführung 1
Design 1



Ausführung 2
Design 2



Ausführung 3
Design 3

Kurzzeichen Code	Ausführung Design	Abmessung Dimension					Tragzahl · Faktor Load rating · Factor			Gewicht Weight
		d	D	B	r_s min	r_{1s} min	dyn. C	Y	stat. C_0	≈
FAG		mm					kN			kg
803312	3 AD	406.4	546.1	138.113	3	1.5	1160	1.16	2850	80
801951	1	406.4	566.1	150	4	2	1600	1.16	4300	107
578243	2	420	540	112	2.5	1.5	1140	1.44	3450	56
803169	3	440	615.95	200	4.8	3.3	2200	1.16	5000	164
801946	3 KH	440	615.95	220	4.8	3.3	2400	1.16	5700	182
803717	1	445	620	160	2	2	1900	1.16	4750	135
578242	2	445	620	160	5	2	1900	1.16	4750	123
801674	2	450	702	180	6	2.5	2650	1.16	5850	248
578619	2	460	710	180	6	5	2750	1.16	6100	249
801495	1	482	640	160	2	2	2000	1.16	6000	137
580901	2	482	640	160	5	2	1760	1.07	5600	127
578620	2	540	710	146	4	3	1960	1.16	6100	152

AD Außendurchmesser der Dichtungsträger = 547 mm / outer diameter of seal carriers = 547 mm
KH keine Haltenuten am Innenring / without retaining grooves on the inner ring

Ausführung: 1 Innenring, Außenringe und Rollen aus Einsatzstahl
Design: inner ring, outer rings and rollers made of case hardening steel
2, 3 Innenring aus Einsatzstahl
inner ring made of case hardening steel

Dynamisch äquivalente Belastung
Equivalent dynamic load

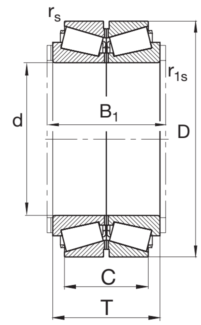
$P = Y \cdot F_a$ [kN]

FAG Kegelrollenlager, zweireihig

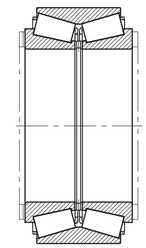
für Vertikalwalzen in Universal-Walzgerüsten

FAG Tapered Roller Bearings, double row

for vertical rolls in universal roll stands



Ausführung 1
Design 1



Ausführung 2
Design 2

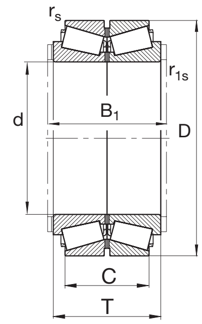
Kurz-zeichen Code	Aus-führung Design	Abmessung Dimension							Tragzahl · Faktor Load rating · Factor				Gewicht Weight
		d	D	T	B_1	C	r_s min	r_{1s} min	dyn. C ISO 281	dyn. C¹)	stat. C_0	e	≈
FAG		mm							kN				kg
573588	1	120	215	133		110	1	2.5	865	1000	1530	0.34	20.1
549735	2	127	196.85	101.6		85.725	0.8	3.6	540	630	1140	0.34	11.5
575042	1	160	290	145		110	1	3	1180	1370	1960	0.4	39
543034	1	165.1	336.55	194.15		149.7	1.5	3.3	1930	2240	3100	0.32	77
580798	1	177.8	288.925	142.875		111.125	1.5	5.6	1160	1340	2120	0.32	33
578794	1	190	260	100		78	1	2.5	640	750	1530	0.48	14.6
564889	1	200	280	112		88	1	3	850	1000	1860	0.39	20
800116	1	200	360	218		174	1.5	5	2240	2650	4150	0.41	91
577083	1	203.2	393.7	212		171.45	1	3	2240	2650	3900	0.35	110
567227	2	206.375	336.55	211.138		169.863	1.5	3.3	1930	2240	4000	0.34	72
566204	1	220	340	154		120	1	4	1460	1700	3100	0.43	48.6
548864	1	220	340	196		160	1	3	1800	2080	3900	0.35	60
573103	1	220	370	225		184	1	3	2450	2850	4900	0.35	92
566443A	2 DR, ZW	240	440	268	278	214	0.3	5	3250	3800	6550	0.44	174
803101	2	242	406	206		160	1.5	6	2320	2700	4650	0.37	101
543185A	2 DR, ZW	242	406	206	216	162	1.5	6	2320	2700	4650	0.37	102
564234	1 DR	242	406	206	216	162	1	5	2320	2700	4650	0.37	102
543325A	2 DR	242	406	206	216	160	1.5	6	2320	2700	4650	0.37	102
576107	1	255	440	265		214	1	3	3200	3750	6550	0.35	158

Innenringe, Außenringe und Rollen aus Einsatzstahl / Inner rings, outer rings and rollers made of case hardening steel

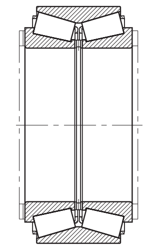
¹) Tragzahlen gültig für winkeleinstellbare Gehäuse / load ratings be of value for housings with angular freedom

DR Distanzring auf beiden Seiten / spacer on both sides
ZW Zwei Außenringe mit Zwischenring / Two outer rings with spacer

FAG Kegelrollenlager, zweireihig
für Vertikalwalzen in Universal-Walzgerüsten
FAG Tapered Roller Bearings, double row
for vertical rolls in universal roll stands



Ausführung 1
Design 1


Ausführung 2
Design 2

Kurzzeichen Code	Ausführung Design	Abmessung Dimension d	D	T	B_1	C	r_s min	r_{1s} min	Tragzahl · Faktor / Load rating · Factor dyn. C ISO 281	dyn. $C^{1)}$	stat. C_0	e	Gewicht Weight ≈
FAG		mm							kN				kg
577881	1	260	400	196		160	1	3	2160	2500	4650	0.35	84
579708	1 DR	260	400	194	204	150	1	3	1930	2240	4250	0.43	84
564746	1 DR	260	480	282	292	220	1.5	6	3800	4400	7500	0.43	220
564747	2 DR, ZW	260	480	282	292	220	1.5	6	3800	4400	7500	0.43	220
565251	2 DR	260	480	284	294	220	1.5	6	3800	4400	7500	0.43	219
573594	2 DR	260	480.5	284	294	220	1.5	6	3800	4400	7500	0.43	220
800117	1	280	500	284		222	2	6	3900	4550	7800	0.45	231
566764	1 BK	367.5	647.7	410		336	3.3	4.8	7350	8500	15600	0.29	540
566765	2 BK	367.5	647.7	410		336	3.3	4.8	7350	8500	15600	0.29	540
579097	2 BK	447.675	635	257.175		206.375	1.5	6.4	4300	5000	10600	0.33	251
573216	1 BK	480	680	238		190	3	4	4250	5200	10600	0.32	255

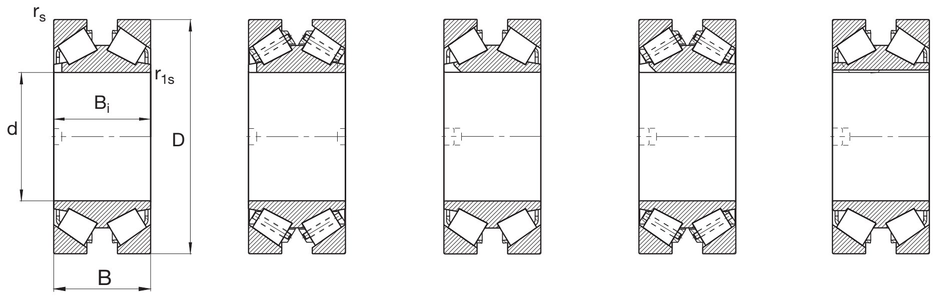
Innenringe, Außenringe und Rollen aus Einsatzstahl / Inner rings, outer rings and rollers made of case hardening steel

[1]) Tragzahlen gültig für winkeleinstellbare Gehäuse / load ratings be of value for housings with angular freedom

BK Bolzenkäfig / pin-type cage
DR Distanzring auf beiden Seiten / spacer on both sides
ZW Zwei Außenringe mit Zwischenring / two outer rings with spacer

FAG Kegelrollenlager, zweireihig
Axiallager, z. B. für Ölflutlager

FAG Tapered Roller Bearings, double row
thrust bearings, e. g. for oil film bearings



Ausführung 1 Design 1 | Ausführung 2 Design 2 | Ausführung 3 Design 3 | Ausführung 4 Design 4 | Ausführung 5 Design 5

Kurzzeichen Code	Ausführung Design	Abmessung Dimension						Tragzahl · Faktor Load rating · Factor			Gewicht Weight ≈
		d	D	B	B_i	r_s min	r_{1s} min	dyn. C	Y	stat. C_0	
FAG		mm						kN		kN	kg
566447	1	160	220	50	50	2	2	245	1.16	510	5.66
573959	1	160	270	86	86	2	2	550	1.16	930	19.9
539570	1	190.09	265	58	58	2	2.5	375	1.16	750	9.2
539571	1	220.09	310	67	67	2	3	490	1.16	1020	14.9
564447	1	250	340	76	76	2	2.5	560	1.05	1220	19.1
566446	1	250	350	67	67	2	2.5	425	1.07	880	17.8
549122	1	250	350	76	76	2	2.5	560	1.05	1220	21.5
567453	1	280	420	130	130	2	2.5	1250	1.27	2450	57.3
575386	1	285	380	92	92	2	2.5	720	1.07	1700	28.1
531529	5	300	440	105	105	4	4	915	1.17	2000	49
525154	2	305.069	560	200	200	6.4	6.4	2550	1.16	4800	205
533062	4 JP	305.07	500	200	200	6	5	2240	1.16	4650	150
531296A	5	305.08	500	200	200	6	6	2240	1.16	4650	153
575342	3	380	590	210	210	5	2.5	2900	1.16	6800	207
535533	4 JP	400	650	200.025	200	5	2.5	2850	1.16	6300	270
531295A	5	400	650	240	240	6	6	3450	1.16	6950	279
801317	3	445	620	160	160	5	2	2040	1.16	5000	135
525155	2	482.651	733.501	200	200	6.4	6.4	3000	1.01	6550	310
524209A	3 BK	510	733.5	200.025	200.025	4.8	3.3	3200	1.07	8500	269
531530	5	510.13	800	285	285	6	7.5	5000	1.16	11000	484
524241	4 ZW	635	939.8	304.8	304.8	6.4	3.3	6100	1.16	16000	761
531531	3	635.08	939.9	305.181	305.181	6	3	5850	1.16	15300	748
524210	4	685.876	939.876	228.575	235.077	6.4	3.3	4550	1.26	14000	475
535959	3 BK	800	1100	300	300	6	1	6550	1.26	20800	876

BK Bolzenkäfige / pin-type cages
JP Stahlblechkäfige / pressed steel cages
ZW Zwischenring / spacer

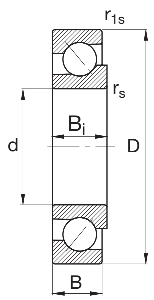
Dynamisch äquivalente Belastung / Equivalent dynamic load
$P = Y \cdot F_a$ [kN]

FAG Schrägkugellager, ein- und zweireihig nicht zerlegbar

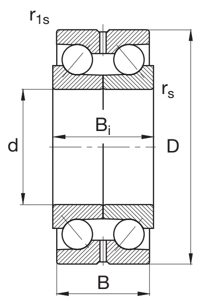
Axiallager, z. B. für Ölflutlager

FAG Angular Contact Ball Bearings, single and double row non-separable

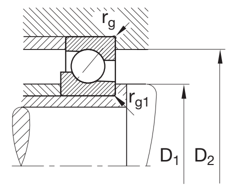
Thrust bearings. e. g. for oil film bearings

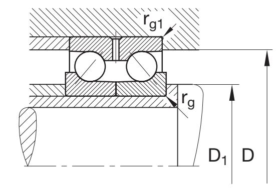


Ausführung 1
Design 1



Ausführung 2
Design 2





Kurzzeichen Code	Ausführung[1]) Design[1])	Abmessung Dimension						Tragzahl · Faktor Load rating · Factor				Einbaumaß Abutment				Gewicht Weight
		d	D	B	B_i	r_s min	r_{1s} min	dyn. C	Y	stat. C_0	Y_0	D_1 min	D_2 max	r_g max	r_{g1} max	≈
FAG		mm						kN		kN		mm				kg
508091A	1	150	210	25	28	1.8	1.8	91.5	0.57	110	0.26	159	201	1.8	1.8	2.74
511538	1	160	215	25	28	1.8	1.8	80	0.57	102	0.26	167	208	1.8	1.8	2.57
514478	2	160	215	50	56	1.8	1.8	132	0.93	204	0.52	167	208	1.8	1.8	5.24
509098A	1	175	235	27	30	1.8	1.8	96.5	0.57	122	0.26	184	226	1.8	1.8	3.4
506497A	1	190	255	29	33	1.8	1.8	110	0.57	143	0.26	199	246	1.8	1.8	4.23
514479	2	190	255	58	66	1.1	1.1	180	0.93	285	0.52	196	249	1.1	1.1	8.73
507686A	1	220	300	35	38	1.1	1.1	163	0.57	216	0.26	226	294	1.1	1.1	7.18
514480	2	220	300	70	76	1.1	1.1	265	0.93	430	0.52	226	294	1.1	1.1	14.6
507342A	1	250	340	35	38	2.1	1.5	186	0.57	255	0.26	260	333	2.1	1.5	9.46
514481	2	250	340	70	76	2.1	1.5	300	0.93	510	0.52	260	333	2.1	1.5	18.9
507343A	1	285	380	46	46	2.1	1.0	196	0.57	285	0.26	295	370	2.1	1.0	13.6
509091A	1	335	450	56	56	2.1	1.5	255	0.57	405	0.26	345	440	2.1	1.5	23.6
509092A	1	380	520	65	65	2.5	2.5	355	0.57	630	0.26	390	510	2.5	2.5	41.3
509093A	1	410	560	70	70	3.5	3.5	380	0.57	695	0.26	423	547	3.5	3.5	47.5
509094A	1	440	600	74	74	3.5	3.5	440	0.57	865	0.26	453	587	3.5	3.5	56.9
510289A	1	465	635	76	76	3.5	3.5	450	0.57	900	0.26	478	622	3.5	3.5	68.4

[1]) Lager der Ausführung 1 eignen sich nur für den Einbau in O-Anordnung.
Bearings of design 1 are suitable only for mounting in O-arrangement.

Dynamisch äquivalente Belastung
Equivalent dynamic load

$P = Y \cdot F_a$ [kN]

Statisch äquivalente Belastung
Equivalent static load

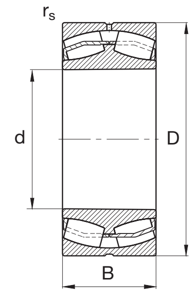
$P_0 = Y_0 \cdot F_a$ [kN]

FAG Pendelrollenlager für Kaltpilgermaschinen

für Arbeitswalzen

FAG Spherical Roller Bearings for Cold Pilger Rolling Mills

for work rolls



Ausführung/Design
ASK Kegel/taper 1:12
ASK30, AK30 Kegel/taper 1:30

Kurzzeichen Code	Abmessung Dimension				Tragzahl · Faktor Load rating · Factor						Gewicht Weight
					dyn.				stat.		≈
	d	D	B	r_s min	C	e	Y_1	Y_2	C_0	Y_0	
FAG	mm				kN				kN		kg
22310ASK.578623	50	110	40	2	156	0.4	1.68	2.5	170	1.64	1.73
23218ASK.801440	90	160	52.4	2	305	0.34	2	2.98	455	1.96	4.54
24122ASK30.533310	110	180	69	2	430	0.39	1.74	2.59	695	1.7	7
24126ASK30.535611	130	210	80	2	560	0.37	1.8	2.69	950	1.76	11
24128ASK30.527487	140	225	85	2.1	680	0.37	1.8	2.69	1180	1.76	13
24130ASK30.514243	150	250	100	2.1	850	0.4	1.68	2.5	1430	1.64	20
24132ASK30.527488	160	270	109	2.1	980	0.41	1.65	2.46	1630	1.61	25.6
24134ASK30.527489	170	280	109	2.1	980	0.39	1.73	2.58	1660	1.69	26.4
24136ASK30.525605	180	300	118	3	1160	0.4	1.68	2.5	2000	1.64	33
24138AK30.518393	190	320	128	3	1340	0.41	1.66	2.47	2360	1.62	41.3
24140AK30.527490	200	340	140	3	1560	0.42	1.62	2.42	2700	1.59	50.4
24144AK30.514842	220	370	150	4	1760	0.41	1.63	2.43	3100	1.6	63.6
24148AK30.527491	240	400	160	4	1960	0.41	1.66	2.47	3450	1.62	77.6
24152AK30.514242	260	440	180	4	2500	0.42	1.61	2.4	4650	1.58	114
24160AK30.526655	300	500	200	5	3000	0.4	1.67	2.49	5700	1.63	159
24164AK30.523187	320	540	218	5	3550	0.41	1.65	2.46	6550	1.61	197
24172AK30.801462	360	600	243	5	4250	0.41	1.63	2.43	8150	1.6	269
24184AK30.525933	420	700	280	6	5700	0.4	1.67	2.49	11600	1.63	431

Lager mit verstärktem Käfig; Radialluft im Bereich der Luftgruppe C2, Istwert aufsigniert.
Bearings with reinforced cage; radial clearance group C2, actual value marked.

Dynamisch äquivalente Belastung
Equivalent dynamic load

$P = F_r + Y_1 \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} \le e$

$P = 0.67\ F_r + Y_2 \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} > e$

Statisch äquivalente Belastung
Equivalent static load

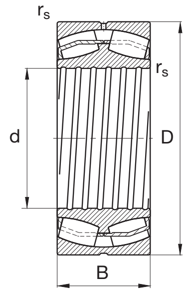
$P_0 = F_r + Y_0 \cdot F_a$ [kN]

FAG Pendelrollenlager für Feineisenstraßen

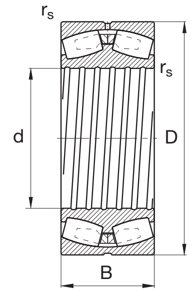
für losen Sitz auf dem Walzenzapfen

FAG Spherical Roller Bearings for Bar Mills

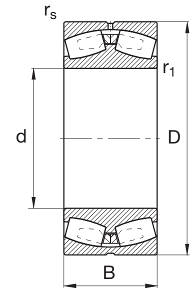
for loose fit on the roll neck



Ausführung 1
Design 1



Ausführung 2
Design 2



Ausführung 3
Design 3

Kurzzeichen Code	Aus-führung Design	Abmessung Dimension				Tragzahl · Faktor Load rating · Factor						Gewicht Weight
		d	D	B	r_s min	dyn. C	e	Y_1	Y_2	stat. C_0	Y_0	≈
FAG		mm				kN				kN		kg
24124S.578744	1	120	200	80	2	585	0.4	1.68	2.5	965	1.64	10
24028S.528857	2	140	210	69	2	530	0.32	2.1	3.13	950	2.06	8.5
24128S.541505	1	140	225	85	2.1	680	0.37	1.8	2.69	1180	1.76	13.1
24130BS.523822	1	150	250	100	2.1	915	0.4	1.68	2.5	1560	1.64	20
24032S.523823	3	160	240	80	2.1	670	0.32	2.09	3.11	1250	2.04	13
24134BS.523378	1	170	280	109	2.1	1060	0.39	1.73	2.58	1830	1.69	26.4
24136BS.523817	1	180	300	118	3	1250	0.4	1.68	2.5	2200	1.64	33.7
23236B.568924	2	180	320	112	4	1320	0.36	1.87	2.79	2160	1.83	39
23136S.579251	2	180	300	96	3	1040	0.32	2.1	3.13	1800	2.06	28.2
24038BS.523792	2	190	290	100	2.1	1040	0.34	2	2.98	1960	1.96	24.5
24138B.536423	1	190	320	128	3	1400	0.41	1.66	2.47	2500	1.62	42.1
23140B.568923	2	200	340	112	3	1320	0.35	1.95	2.9	2280	1.91	42.8
24140B.522444	1	200	340	140	3	1700	0.42	1.62	2.42	3000	1.59	51.4
24140B.541020	1 ES	200	340	140	3	1700	0.42	1.62	2.42	3000	1.59	51.4
24040BS.525392	2	200	310	109	2.1	1200	0.35	1.94	2.88	2280	1.89	31.3
24044B.572037	2	220	340	118	3	1400	0.34	1.96	2.92	2700	1.92	40.7
24144B.527514	1	220	370	150	4	1900	0.41	1.63	2.43	3450	1.6	67
24148B.517299	1	240	400	160	4	2120	0.41	1.66	2.47	3900	1.62	81
24148B.541021	1 ES	240	400	160	4	2120	0.41	1.66	2.47	3900	1.62	81
24052B.572036	2	260	400	140	4	1900	0.35	1.94	2.88	3800	1.89	66
24152B.530662	1	260	440	180	4	2700	0.42	1.61	2.4	5100	1.58	111
24152B.561779	1 ES	260	440	180	4	2700	0.42	1.61	2.4	5100	1.58	111
24156B.531079	1	280	460	180	5	2700	0.39	1.71	2.54	5200	1.67	119
24056B.538565	2	280	420	140	4	2000	0.33	2.04	3.04	4000	2	70
24160B.541538	1	300	500	200	5	3250	0.4	1.67	2.49	6300	1.63	160
24060B.531119	2	300	460	160	4	2500	0.35	1.95	2.9	5200	1.91	101

Innenringe der Lager aus Einsatzstahl; Lager mit Radialluft C2
Bearing inner rings made of case hardening steel; bearings with radial clearance C2
ES Innen- und Außenring aus Einsatzstahl; Lager mit Radialluft C2
Inner ring and outer ring made of case hardening steel; bearings with radial clearance C2

Dynamisch äquivalente Belastung
Equivalent dynamic load

$P = F_r + Y_1 \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} \leq e$

$P = 0.67\ F_r + Y_2 \cdot F_a$ [kN] für/for $\frac{F_a}{F_r} > e$

Statisch äquivalente Belastung
Equivalent static load

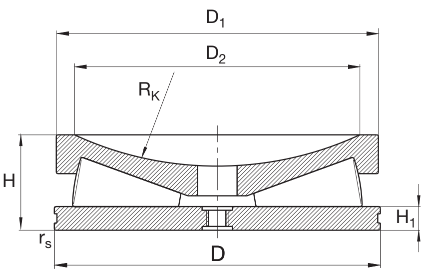
$P_0 = F_r + Y_0 \cdot F_a$ [kN]

FAG Axial-Kegelrollenlager, vollrollig

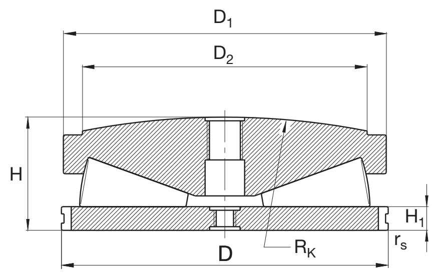
für Druckspindeln

FAG Tapered Roller Thrust Bearings, full complement

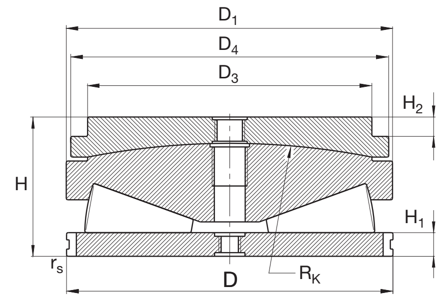
for screw down mechanisms



Ausführung 1
Design 1



Ausführung 2
Design 2



Ausführung 3
Design 3

Kurzzeichen Code	Ausführung Design	Abmessung Dimension										Tragzahl Load rating stat.	Gewicht Weight ≈
		D	D_1	D_2	D_3	D_4	H	H_1	H_2	R_K	r_s min	C_0	
FAG		mm										kN	kg
537778	2 KH	174.63	172.26	152.4			61.39	12.7		457.2	1.6	3350	10
543535	2 KH	174.63	172.26	152.4			61.39	12.7		650	1.6	3350	10
568410	3 KH	174.63	172.26		150	173	76	12.7	7	457.2	1.6	3350	12.5
565775	2 KH	203.2	200.84	177.8			75.62	15.88		508	1.6	4800	17
572049	3 KH	203.2	200.84		170	200	90	15.88	12	508	1.6	4800	19.5
543655	2 KH	215.9	215.9	175			74.63	15.88		650	1.6	4800	18.5
524088	1	266.7	264.34	228.6			80.95	19.05		304.8	1.6	8300	31
522978	2	266.7	264.34	228.6			94.41	19.05		609.6	1.6	8300	35.5
525469	2	320.68	318.31	279.4			110.97	22.23		762	1.6	12500	62
567355	3 KH	320.68	318.31		275	318.31	135	22.23	6	762	1.6	12500	75
534470	2	377.825	375.46	330.2			129.01	25.4		914.4	1.6	17000	100
573271	3 KH	377.825	375.46		300	370	164.01	25.4	10	914.4	1.6	17000	125
524192	2 KH	409.58	407.21	355.6			140.77	28.58		1016	6	20400	128
580635	3	409.58	407.21		355	355	188	28.58		1016	2.3	20400	169
565300	1	438.15	435.79	381			149.23	50.4		1270	3.2	23600	156
517113	2 KH	438.15	435.79	381			150.673	31.75		1016	3.2	23600	157
528348	2	482.6	482.6	444.5			145.54	38.1		1905	1.6	26500	185
580692	3	482.6	482.6		425	508	205.54	38.1	44	1905	1.6	26500	260
517982	2	495.3	492.94	431.8			170.61	34.93		1066.8	3.2	30500	228
573917	2	495.3	492.94	431.8			170.61	34.93		1066.8	3.2	30500	228
525914	4	495.3	495.3			476	210	100		885		30500	274
517979	2 KH	523.875	521.51	457.2			175.768	34.925		1270	3.2	36000	258
531555	2 KH	533.4	533.4	457.2			177.8	31.75		1981.2	3.2	36000	274
512525A	2 KH	533.4	533.4	495			177.8	31.75		1981.2	1.6	39000	274
566306	3 KH	533.4	533.4		416	530	237.8	31.75	8.8	1981.2	3.2	39000	373
800901	3	533.4	533.4		410	500	245	31.75	45	1981.2	3.2	39000	378
534972	2 KH	533.45	533.4	495			190.5	31.75		1219.2	3.2	36000	292

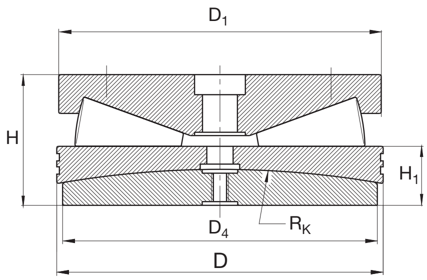
KH keine Haltenut in Planscheibe / no retaining groove in plane washer

FAG Axial-Kegelrollenlager, vollrollig

für Druckspindeln

FAG Tapered Roller Thrust Bearings, full complement

for screw down mechanisms

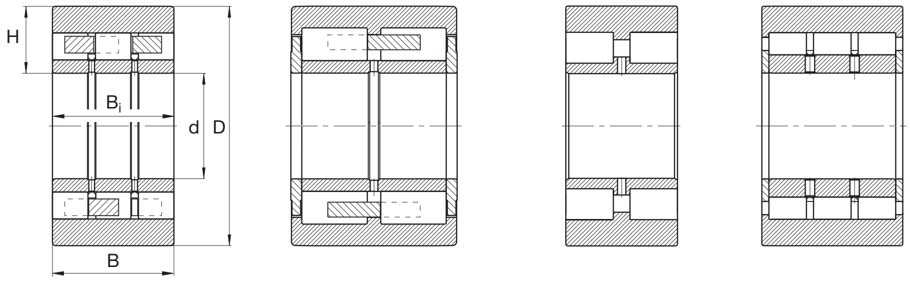


Ausführung 4
Design 4

Kurzzeichen Code	**Ausführung Design**	**Abmessung Dimension** D	D_1	D_2	D_3	D_4	H	H_1	H_2	R_K	r_s min	**Tragzahl Load rating** stat. C_0	**Gewicht Weight** ≈
FAG		mm										kN	kg
527805	1	551.69	539.75	406.4			158.75	25.4		635	3	36000	260
527795	1	555.63	553.26	482.6			165.1	38.1		635	3.2	38000	274
524340	2 KH	555.63	553.26	482.5			190.86	38.1		1270	3.2	38000	318
547440	2 KH	581.02	578.66	508			196.65	38.1		1308.1	3.2	42500	355
531065	2 KH	581.03	578.66	508			193.78	38.1		1422.4	3.2	42500	355
525652	4 K	581.03	581.03			571.5	240.77	108		1270		31000	435
525652V	4	581.03	581.03			571.5	240.77	108		1270		42500	435
800903	3	581.03	578.66		500	570	243.78	38.1	39	1422.4	3.2	42500	450
565906	3 KH	581.03	578.66		460	570	243.78	38.1	5	1422.4	3.2	42500	450
526199	2	609.6	607.24	533.4			204.01	38.1		1524	3.2	48000	413
533179A	4	609.6	609.6			582.6	249.96	108		1270		47500	503
526198	2 KH	641.35	638.99	558.8			212.67	38.1		1524	3.2	54000	474
578367A	3	641.35	638.99		560	635	260	38.1	45	1524	3.2	54000	565
563648	3	609.6	607.24		585	710	254.01	38.1	40	1524	3.2	48000	512
801496	2	768.35	765.81	609.6			295.275	70		1524	3.2	68000	900
527184	4 K	800	800			740	320	175		1500		52000	1100
527184V	4	800	800			740	320	175		1500		62000	1100
523387	4	850	850			775	360	195		1500		57000	1390
544992	4 K	900	900			830	390	220		1500		78000	1650
544992V	4	900	900			830	390	220		1500		90000	1650
543242	3 K	920	920		768	915	370	70	20	2300	7.5	65500	1742
543242V	3	920	920		768	915	370	70	20	2300	7.5	95000	1670
565979	4	1095	1100			1050	380	175		3000		129000	2490

K mit Käfig / with cage
KH keine Haltenut in Planscheibe / no retaining groove in plane washer

FAG Stützrollen
für Vielwalzen-Kaltwalzgerüste
FAG Support Rollers
for multi-roll cold rolling mills



Ausführung 1 Design 1 | Ausführung 2 Design 2 | Ausführung 3 Design 3 | Ausführung S Design S

Kurzzeichen Code Stützrolle Support roller FAG	Ausführung[1]) Design[1])	Werkstoff Außenring[2]) Material outer ring[2])	Abmessung Dimension d	D	B	B_i	H Bauhöhe Height	Tragzahl Load rating dyn. C Lager Bearing	C Stützrolle Support roller	Max. Belastung Max. load $F_{r\,max}$	Gewicht Weight ≈
			mm					kN		kN	kg
578167	2 D2	W	70	160.02	89.2	90	45	320	280	320	10.5
540268A	1 VR	E	70	160.02	90	90	44.971	455	415	475	10
574324	2	W	90	220.02	94	94	65	550	480	405	20.7
541332A	3	W	90	220.02	94	94	65	630	550	425	21
801941	2	W	90	220.02	94	96	65	550	480	405	20.8
567709	2 D1	W	90	220.02	94	96	65	455	425	390	20
517329A	S VR	W	90	220.02	120	120	65	800	695	600	22.8
801644	2 D1	W	100	225	119	120	62.5	655	570	540	26
566148	2 D2	W	100	225	119	120	62.5	710	610	550	26
543638A	1	W	100	225	120	120	62.5	735	670	655	27.7
575633	2	W	110	260	98	120	75	695	600	490	30
577888	2 D1	W	130	300.02	129	130	85.01	1040	880	720	52.7
567998A	2 D2	E	130	300.02	171.6	172.65	85.01	1430	1180	1200	70
549722	2 D2	W	130	300.02	171.6	172.65	85.01	1430	1180	950	70
801788	2 D1	W	130	300.02	171.6	172.65	85	1430	1200	980	70
564604	2	W	130	300.02	149	150	85	1140	1000	965	60
548963	2 D1	W	130	300.02	160.5	161.5	85	1200	1060	950	63
512497C	1	SH	130	300.02	172.64	172.64	84.955	1500	1340	1290	71.5
512497D	1	W	130	300.02	172.64	172.64	84.955	1500	1340	1040	71.5
567455A	2	W	130	300.02	171.6	172.65	85	1430	1180	950	70
564247	2	W	180	406.4	170	171.04	113.2	1700	1460	1460	125
800115A	2 D1	W	180	406.42	170	171.04	113.143	1560	1370	1430	128
527502B	1	W	180	406.42	171.04	171.04	113.2	2080	1830	1500	130
527502C	1	SH	180	406.42	171.04	171.04	113.143	2080	1830	1860	130
543307A	1	E	180	406.42	171.04	171.04	113.2	2080	1830	1860	130
514278A	1	SH	180	406.42	217	217	113.143	2500	2200	2360	150
523247B	1	SH	180	406.42	224	224	113.2	2550	2240	2450	169
523247C	1	E	180	406.42	224	224	113.2	2550	2240	2450	169

[1]) D1 Abdichtung mit Radial-Wellendichtringen bei Öl- oder Fettschmierung (geschlossenes Schmiersystem)
sealing with shaft seals at oil lubrication or closed system grease lubrication
D2 Abdichtung mit (Fey)-Lamellenringen bei Ölnebelschmierung
sealing with (Fey) lamellar rings at oil mist lubrication
S Sonderausführung / special design
VR vollrollige Ausführung / full-complement design

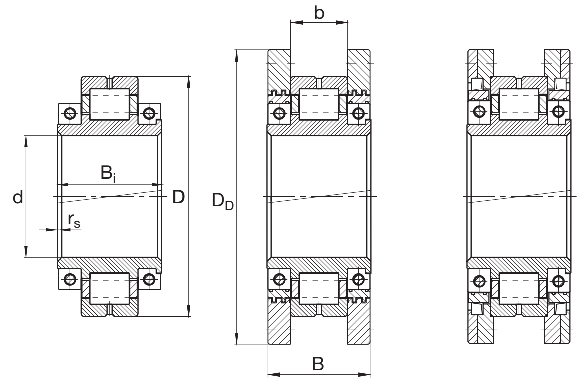
[2]) E Einsatzstahl / case hardening steel
SH Sonderhärtungsverfahren / special hardening
W Wälzlagerstahl (Chromstahl) / rolling bearing steel (chromium steel)

Geteilte FAG Zylinderrollenlager

für Kurbelwellen in Kaltpilgermaschinen

Split FAG Cylindrical Roller Bearings

for crankshafts in cold pilger rolling mills



Ausführung 1 / Design 1 — Ausführung 2 / Design 2 — Ausführung 3 / Design 3

Kurzzeichen Code	Ausführung Design	Abmessung Dimension d	D	D_D	b	B_i	B	r_s min	Tragzahl Load rating dyn. C	stat. C_0	Gewicht Weight ≈
FAG		mm							kN		kg
532376	3	127	254	320	63.5	114.3	112	5x45°	550	695	35
545937	3	177.8	330.2	406.4	83.344	139.7	137.7	5x45°	900	1220	75
532392	2	177.8	330.2	406.4	83.344	139.7	137.7	5x45°	915	1290	75
532309	3	220	393.757	460	90.5	156	153.5	8x45°	1140	1600	105
539260	2	220	393.757	460	90.5	156	153.5	8x45°	1140	1600	105
536629	3	240	440	510	90.5	156	152	8x45°	1220	1700	130
534370A	2	240	440	510	90.5	156	152	8x45°	1250	1760	130
536586	3	300	558.8	640	139.7	220	214.2	12x45°	2400	3400	280
536164	2	300	558.8	640	139.7	220	218	12x45°	2400	3400	280
532241	3	320	622.3	700	160.4	272	270	12x45°	3100	4900	480
539232	2	320	622.3	700	160.4	272	270	12x45°	3350	5100	480
800885	2	413	740	820	190	320	319	12x45°	4050	6800	680
539205	3	420	740	820	190	320	319	12x45°	4050	6800	670
532301	2	420	740	820	190	320	319	12x45°	4050	6800	670
546551	1	500	850.9		210	360	340	12x45°	5300	9300	760
532341	2	500	850.9	930	210	360	358	12x45°	5500	9500	980

Die Lager (Ausführung 2 und 3) sind auch ohne Deckel, Dichtungen, Dichtungslaufringe etc. erhältlich.
The bearings (design 2 and 3) are also available without covers, seals, seal contact rings etc.

Wegen der Ausführung und der Verfügbarkeit der Dichtungen bitte bei FAG rückfragen.
Information on design and availability of the seals will be supplied on request.

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24028S.528857	101
24032S.523823	101
24038BS.523792	101
24040BS.525392	101
24044B.572037	101
24052B.572036	101
24056B.538565	101
24060B.531119	101
24122ASK30.533310	100
24124S.578744	101
24126ASK30.535611	100
24128ASK30.527487	100
24128S.541505	101
24130ASK30.514243	100
24130BS.523822	101
24132ASK30.527488	100
24134ASK30.527489	100
24134BS.523378	101
24136ASK30.525605	100
24136BS.523817	101
24138AK30.518393	100
24138B.536423	101
24140AK30.527490	100
24140B.522444	101
24140B.541020	101
24144AK30.514842	100
24144B.527514	101
24148AK30.527491	100
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24148B.541021	101
24152AK30.514242	100
24152B.530662	101
24152B.561779	101
24156B.531079	101
24160AK30.526655	100
24160B.541538	101
24164AK30.523187	100
24172AK30.801462	100
24184AK30.525933	100
500857A	13
500860	13
500861	13
500909	19
501359A	40
501657	19
502279	13
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502284	13
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503288	20
503316	78
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504083	20
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507343A	99
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507686A	99
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508368	5
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508657	4
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508726	4
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512516	88
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512580	4
512601	82
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527634	6
527795	103
527805	103
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527934	32
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528294	22
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528407	86
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533487	12	538179	93	541941	62
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533578	12	538182	93	541983	20
533683	8	538183	93	542048	74
533780	53	538204	18	542129	76
533792	52	538205	18	542146	76
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533808	11	538339	93	542648	7
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561271	12
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566148	104
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574469	6
574472	60
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WL 17200/3 D FAG Wälzlager in Walzgerüsten

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WL 17-5 D-E Abgedichtete vierreihige Kegelrollenlager

WL 17-6 D-E Abgedichtete Pendelrollenlager für Stranggießanlagen

WL 17-7 D-E Geteilte Zylinderrollenlager für die Lagerung von Walzwerks-Antriebswellen

Referenzblätter

WL 17501 D Steifigkeit der Lagerung, eine Voraussetzung beim Richten von Profilmaterial

WL 17502 D Zangenträger eines Schmiedemanipulators mit FAG Wälzlagern ausgerüstet

WL 17503 D Große Radial- und Axiallager stützen Pfannendrehtürme für Stranggießanlagen ab

WL 17504 D Geteilte FAG Pendelrollenlager im Vierrollentreiber einer Brammen-Stranggießanlage

WL 17505 D Lagerung der Walzen eines Quarto-Einweg-Kaltwalzgerüstes für Aluminium

WL 17506 D Lagerung der Walzen eines Quarto-Reversier-Kaltwalzgerüstes

WL 17507 D Lagerung der Duo-Walzen eines Dressiergerüsts für Kupfer- und Messingbänder

WL 17508 D Kostensenkung bei einem Quarto-Walzgerüst durch Umstellung der Antriebswellen-Lagerung von Gleitlagern auf FAG Zylinderrollenlager

WL 17509 D Rotorlagerung einer Rohrverseilmaschine

WL 17510 D FAG Walzenlagerungen für eine neuartige Profilstraße. Erhöhte Walzgenauigkeit durch hydraulisch über die Walzenständer gegeneinander vorgespannte Einbaustücke

WL 17511 D Walzenlagerung eines Duo-Block-Brammengerüstes oder Block-Knüppelgerüstes

WL 17512 D FAG Spezial-Zylinderrollenlager mit 1,6 Meter Durchmesser stützen Rotor einer schnellaufenden Rohrverseilmaschine

WL 17513 D Schwenkarm für Verteilerwanne einer Stranggießanlage in FAG Zylinderrollenlagern gelagert

WL 17514 D Lagerung der Walzen eines Quarto-Kaltwalzgerüstes für Aluminium

WL 17515 D Große FAG Wälzlager für eine Stranggießanlage in Japan

WL 17516 D Arbeitswalzenlagerung der 7-gerüstigen Fertigstaffel einer Warmbandstraße

WL 17517 D Walzenlagerung des Reversier-Vorgerüsts einer Warmbandstraße

WL 17518 D FAG Wälzlager für ein Quarto-Reversier-Kaltwalzgerüst

WL 17519 D Lagerung einer zweisträngigen Brammen-Stranggießanlage

WL 17520 D Arbeitswalzenlagerung der 7-gerüstigen Fertigstaffel einer 84" Warmbandstraße mit Biegung und Axialverschiebung

WL 17521 D Arbeitswalzenlagerung der 6-gerüstigen Fertigstraße CSP-Anlage (Compact Strip Production)

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WL 17523 D Traglagerung eines 100-t-CLU-Konverters für nichtrostende Stähle

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WL 17112 E Work Rolls with Sealed Four-Row Tapered Roller Bearings

WL 17200/3 E FAG Rolling Bearings for Rolling Mill Applications

TI No.

WL 17-5 D-E Sealed Four Row Tapered Roller Bearings

WL 17-6 D-E Sealed Spherical Roller Bearings for Continuous Casting Plants

WL 17-7 D-E Split Cylindrical Roller Bearings for Rolling Mill Drive Shafts

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WL 17501 E Bearing Rigidity – A Precondition for Straightening of Section Material

WL 17502 E Tongs Carrier of a Forging Manipulator with FAG Rolling Bearings

WL 17503 E Large-size Radial and Thrust Bearings for Support of Ladle Turrets in Continuous Casting Machines

WL 17504 E Split FAG Spherical Roller Bearings in the 4-Roll Pinch Roll Stands of a Continuous Plant for Slabs

WL 17505 E Roll Neck Bearing Mounting of a Single Way Four-High Cold Rolling Mill for Aluminum

WL 17506 E Roll Neck Mounting of a Four-High Reversing Cold Rolling Stand

WL 17507 E Roll Neck Mounting of a Two-High Skin Pass Mill

WL 17508 E Cost Reduction in a Four-High Cold Rolling Mill by Conversion from Plain Bearings to FAG Cylindrical Roller Bearings for Drive Shaft Support

WL 17509 E Rotor Bearing Mounting of a Tubular Strander

WL 17510 E FAG Roll Neck Mountings for a Novel Section Steel Mill. Preloaded Chocks Provide for Increased Rolling Precision

WL 17511 E Roll Neck Mounting of a Two-High Blooming and Slabbing Stand

WL 17512 E FAG Special Cylindrical Roller Bearings of 1.6 Metres Diameter Support the Rotor of a High-Speed Tubular Strander

WL 17513 E Swivel Arm for the Tundish of a Continuous Casting Plant Mounted in Cylindrical Roller Bearings

WL 17514 E Bearings of the rolls of a four-high cold rolling stand for aluminium

WL 17515 E Large-Size FAG Bearings for a Continuous Casting Plant in Japan

WL 17516 E Work roll bearing arrangement of a 7-stand finishing section of a hot strip mill

WL 17517 E Roll Bearing Arrangement of a Reversing Rough-Stand of a Hot Strip Mill

WL 17518 E FAG Rolling Bearings for a Four-High Reversing Rolling Mill

WL 17519 E Bearings for a twin-strand continuous casting mill for slabs

WL 17520 E Work roll bearing arrangement of the 7-stand finishing section of a 84" hot strip mill with bending and shifting

WL 17521 E Work roll bearing arrangement of the 6-stand finishing mill CSP-machine (Compact Strip Production)

WL 17522 E Bull gear bearing mounting for a 100-ton CLU converter for stainless steels

WL 17523 E Trunnion bearing mounting for a 100-ton CLU converter for stainless steel

FAG Wälzlager für Walzgerüste
FAG Rolling Bearings for Rolling Mills

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WL 41 140/6 D-E/96/4/98
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Deep Groove Ball Bearings

FAG

World champions in the field of application

Deep groove ball bearings are the most frequently used rolling bearings. They have proven their worth, for instance in electric motors, transmissions, household appliances, automobile engines, rolling stands, motor saws, boring and drilling machines, conveyor plants, ventilators, compressors, inline skates ...

FAG is continuously improving the quality of these bearings, adapting them to the increasing, often very diverse requirements of industry. This also includes that deep groove ball bearings are reasonably priced, available at short notice, and require little maintenance. As a rule, the following applies for all FAG deep groove ball bearings:

- very good value
- suitable for extremely high speeds
- quiet running
- long service life
- minimum requirements on lubrication and maintenance

By directly implementing the FAG research results in practical application, the internal design of the FAG deep groove ball bearings was continuously perfected.
This is shown by the continuously reduced running noise, even that of misaligned bearings, as the cycling conditions were significantly improved.
The running noise is also reduced by the improved microstructure and macrostructure of the ball and raceway surfaces.

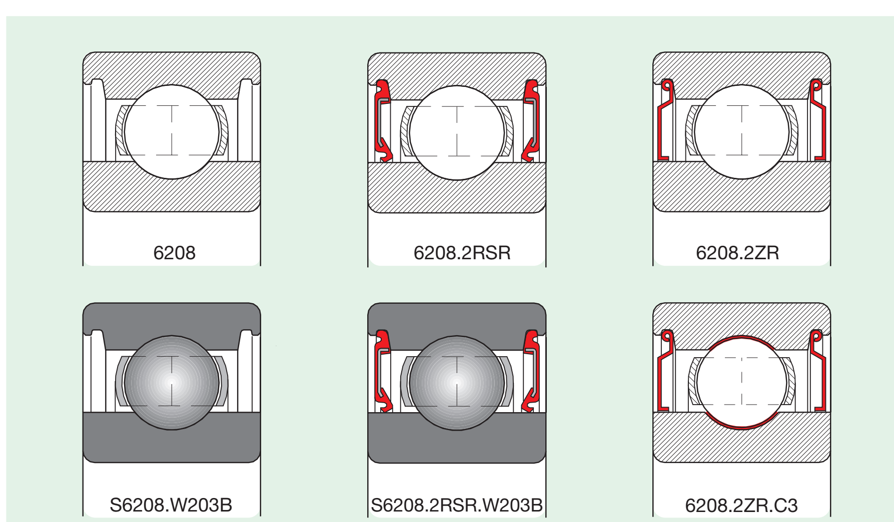
Delivery programme

Series	Pressed steel cage (without cage suffix)	Polyamide cage (with cage suffix T)	Machined brass cage (with cage suffix M)
	Bore reference number	Bore reference number	Bore reference number
60	up to 30, 34		32, from 36
62	up to 30		from 32
63	up to 24		from 26
64	up to 14		from 15
160	up to 52		from 56
161	00, 01		
618	30 up to 56	00 up to 28	from 60
619	up to 48, 56		52, from 60
622	up to 12		
623	up to 10		
630	up to 09		

Standardized variety

FAG manufacture numerous designs in series production. They are easily identified by their suffixes:

C3	radial clearance larger than normal
M	machined brass cage
2RSR	seals on both sides
2ZR	shields on both sides
W203B	stainless steel bearing

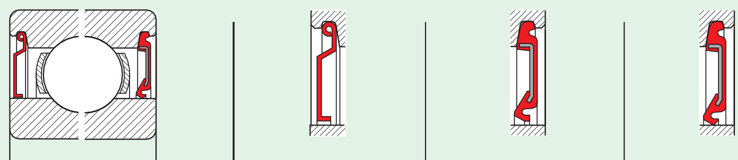


Sealing and lubrication

The simplest and safest way is to use sealed deep groove ball bearings which are greased for life. In these, the grease type, grease quantity and sealing are optimally coordinated.

Seals and shields

FAG seals (RSR) and shields (ZR) for deep groove ball bearings are designed according to the same criteria as radial shaft seals and labyrinths. RSR seals provide a good balance between friction and sealing effect. RSD seals with a minimized sealing gap have a small coefficient of friction as open bearings. ZR shields are cost-effective solutions for applications where requirements on the sealing effect are not so high and where friction is to be reduced considerably.

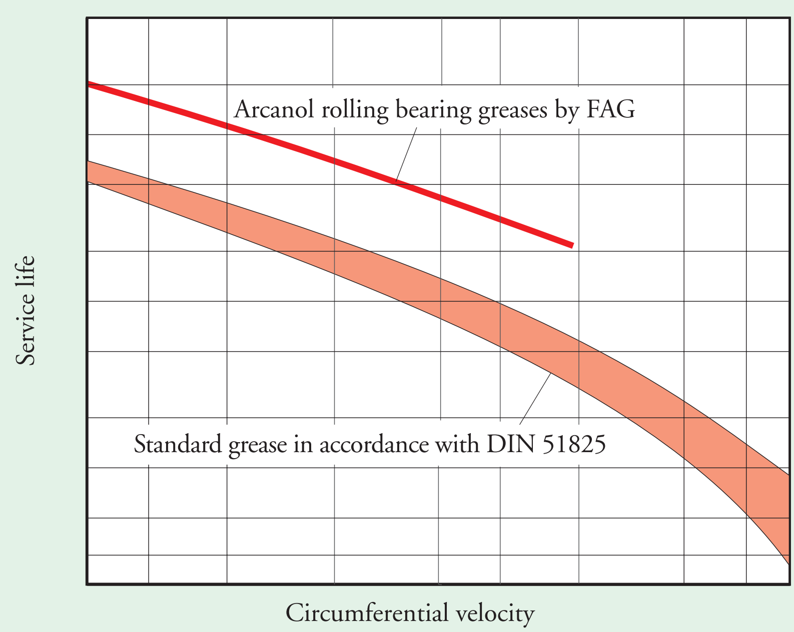


Sealing effect	ZR	RSD	RSR
retain grease in the bearing	suitable	suitable	suitable
dust, dry dirt	suitable	suitable	suitable
moist atmosphere	less suitable	less suitable	suitable
occasional splashes	unsuitable	unsuitable	suitable
rotating outer ring	unsuitable	suitable	suitable
slight pressure differences	unsuitable	unsuitable	suitable

suitable · less suitable · unsuitable, problems cannot be ruled out

Lubrication

Sealed FAG deep groove ball bearings are filled, when being assembled at the production plant, with a high-quality grease tested in accordance with FAG specifications. The grease, if suitably adapted to the operating conditions, counteracts premature wear and fatigue, reduces the running noise and protects the bearings from corrosion. In addition to the standard greases, a number of special greases for specific applications are available.
Arcanol rolling bearing greases by FAG clearly surpass the requirements defined in DIN 51825.



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The FAG quality management system is certified in accordance with DIN EN ISO 9001.

New!

FAG Deep Groove Ball Bearings with an Integrated Sensor

Precise and cost-effective speed measurement in an extremely limited space

FAG FAG FAG FAG FAG FAG

Your Partner:

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WL 43 163 EA/95/5/97 · Printed in Germany by Weppert GmbH & Co. KG

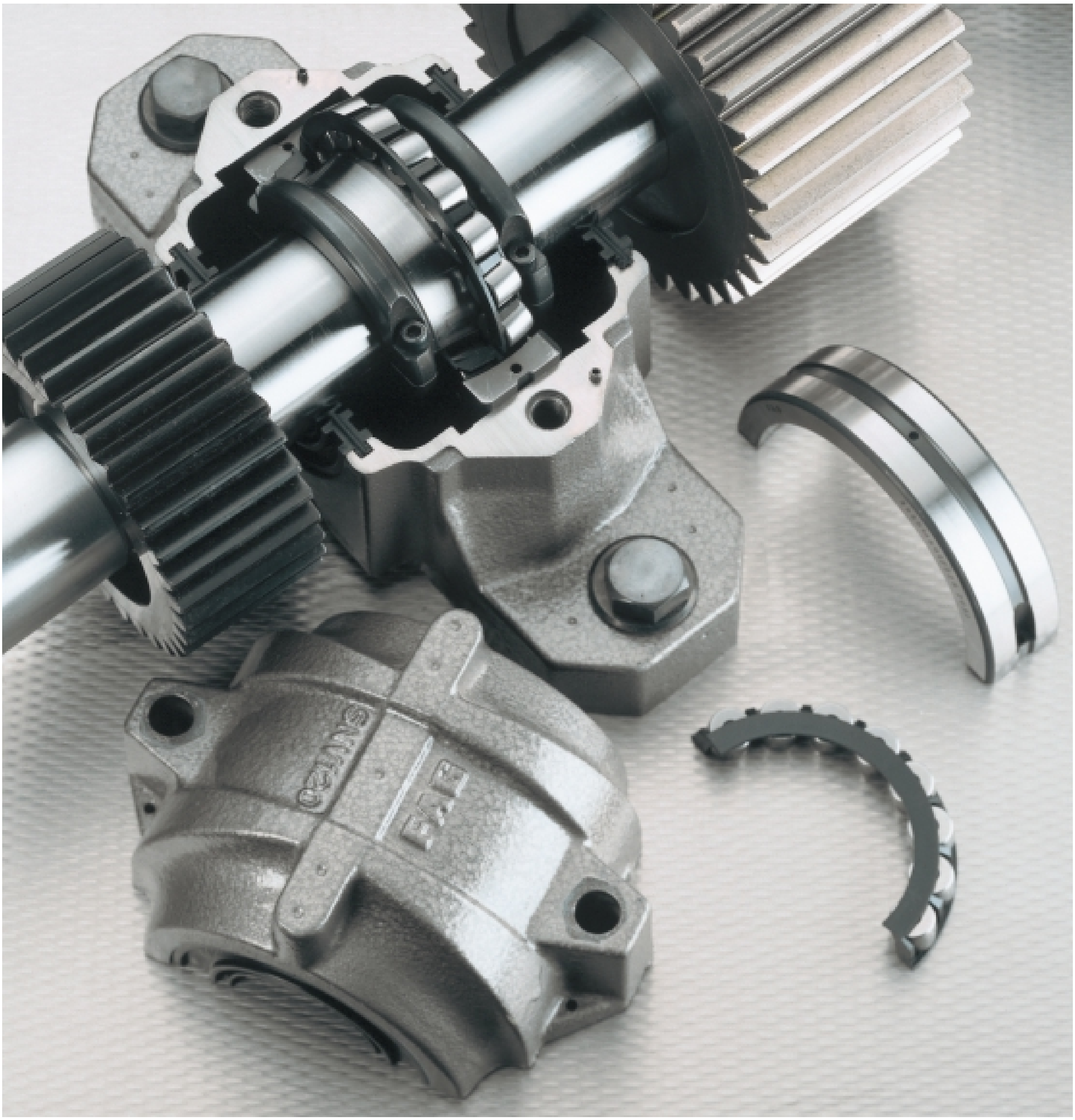
Saving cost by rapid bearing replacement at locations of restricted access

FAG Split Spherical Roller Bearings

FAG Rolling Bearings

FAG Norge A/S · FAG Svenska AB

Publ. No. WL 43 165 Enosv



Saving cost by rapid bearing replacement
at locations of restricted access

FAG Split Spherical Roller Bearings

Publ. No. WL 43 165 EA

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Preface

The OEM und Handel company of FAG Kugelfischer Georg Schäfer AG supplies rolling bearings, accessories and services to original equipment customers in the machine and plant construction sector as well as customers in the distribution and replacement sector. Broad rolling bearing know-how, competent advice for specific applications and extensive customer service for more operational reliability make FAG an indispensable partner to its customers. The development and progressive development of our products is based on the requirements of their future operation in the field. Ideally, the outline of requirements is drawn up jointly by our researchers and application engineers in cooperation with the machine manufacturers and operators. This forms the basis for convincing solutions both technically and economically speaking.

Our production sites are situated in Germany, Italy, Portugal, the USA and India. Marketing is effected through a network of subsidiaries and business partners spanning almost the whole world.

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Time-saving bearing replacement · Cost reduction · Ranges of application · Fitting into split plummer block housings

Time-saving bearing replacement at locations of restricted access

Split spherical roller bearings are mainly used for applications where the replacement of an unsplit spherical roller bearing would require intricate additional work, e.g. where gearwheels or couplings have to be withdrawn, drives dismounted, and shaftings disassembled. With split spherical roller bearings the downtimes of machines and plants is reduced and thus the production cost as well.

Cost reduction

Calculation examples on pages 26 and 27 show the extent of cost reduction which can be achieved by using split spherical roller bearings instead of unsplit ones. In one case the cost reduction amounts to about DM 80,000.00, in the other one even to about DM 430,000.00.

We have provided a form on page 28 which you may use to draw up a similar cost comparison for one of your applications. The filled-in form is a useful basis for talks with our service engineers.

With new constructions split spherical roller bearings help in many cases to save considerable cost since they simplify the assembly and facilitate mounting.

Ranges of application

Applications range from shafts supported by several bearings to bearing locations of restricted access, for example:

- belt drives
- ships
- conveyor plants
- rolling mills
- ventilation systems
- paper machines

Replacement bearings for spherical roller bearings with adapter sleeve

The dimensions of FAG split spherical roller bearings were adapted so that they can be used instead of unsplit spherical roller bearings and their adapter sleeves.

Outside diameter, outer ring width and shaft seat diameter are identical.

Fitting into split plummer block housings

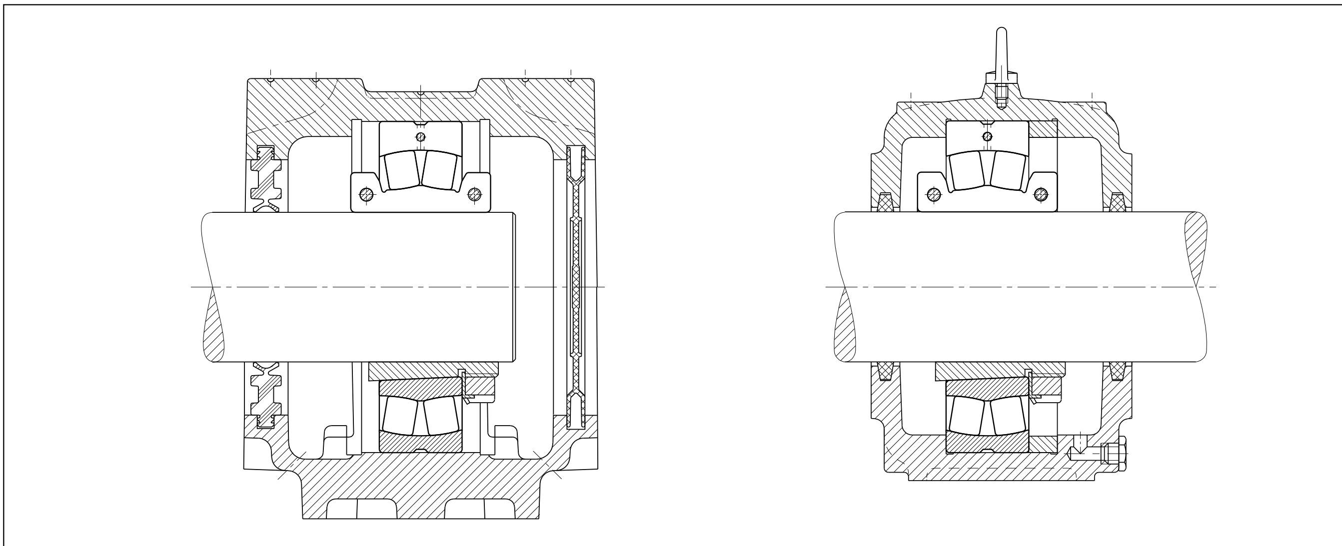
FAG split spherical roller bearings can be mounted into FAG split plummer block housings without requiring any further machining of the housings. The same applies to housings from other manufacturers provided that the internal dimensions are identical.

Conveyor plant drive unit

Ventilator drive unit

Time-saving bearing replacement · Fitting into split plummer block housings

1: Easy bearing replacement as split spherical roller bearings (top) require the same mounting space as unsplit bearings with adapter sleeves (bottom).



2: Easy to inspect, fast and easy mounting – the FAG split spherical roller bearing directly before mounting into an SNV housing.

Bearing design

FAG split spherical roller bearings have a cylindrical bore. Inner ring, outer ring and roller/cage assembly are split into halves. The split bearing rings are bolted together.

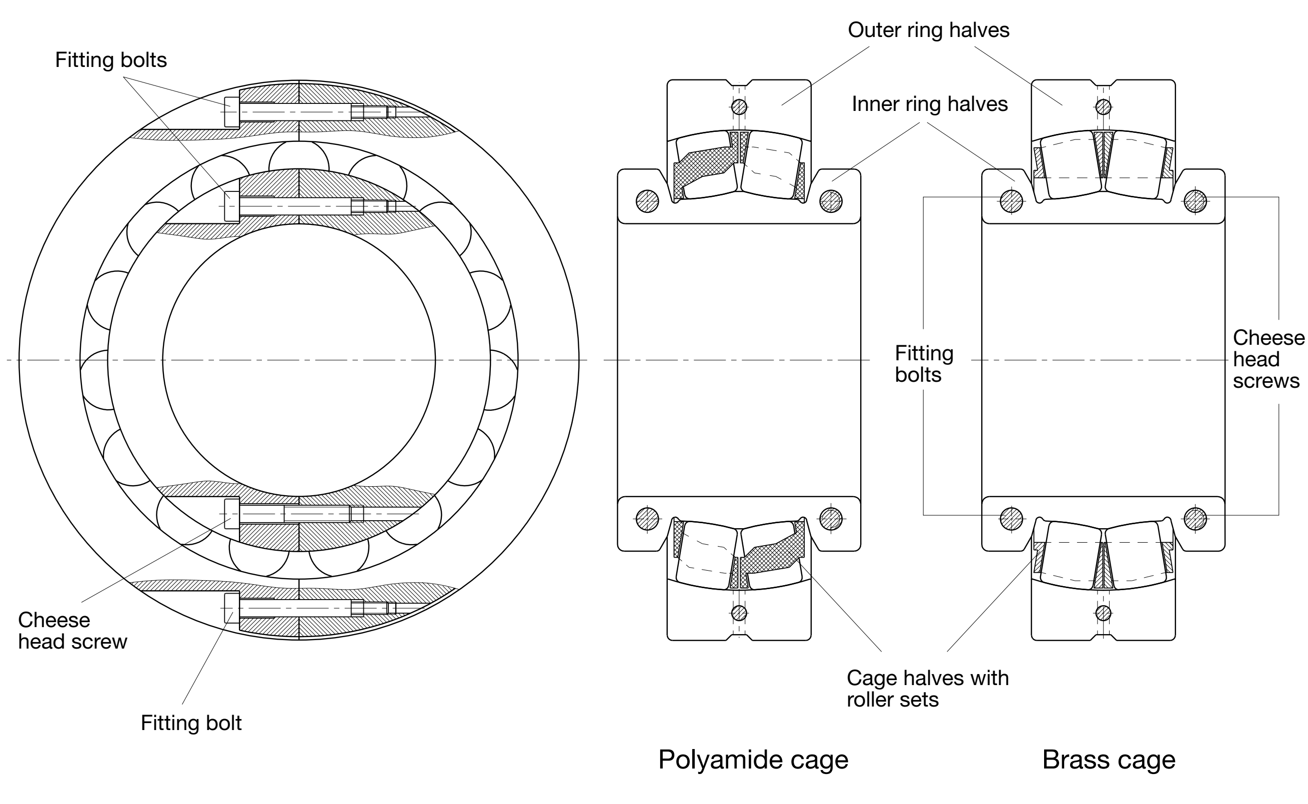
The internal design of the split spherical roller bearings was adapted from the well-proven spherical roller bearings of design E so that the bearings have maximum load carrying capacity.

The bearings are equipped either with a split moulded cage of glass-fibre reinforced polyamide (suitability for high temperatures, see FAG catalogue WL 41 520) or with a split machined brass cage.

Split spherical roller bearings have the normal tolerances of unsplit radial bearings and the normal clearance of unsplit spherical roller bearings with a cylindrical bore (DIN 620).

In this publication the standard design of split spherical roller bearings is described where the locking rings are integrated in the inner rings. FAG split spherical roller bearings with separate locking rings are recommended for applications where considerable temperature differences between shaft and inner ring halves may have to be accommodated, e.g. dryer rolls of paper machines. Information on this special design will be supplied by FAG on request (cp. FAG video ”The Installation of Split Spherical Roller Bearings in the Dryer Section of a Paper Mill“).

3: The internal design corresponds to the well-proven E design.



Load carrying capacity

The load carrying capacity of split spherical roller bearings is smaller than that of unsplit spherical roller bearings since the pitch circle for the roller/cage assembly is reduced due to the outer ring bolting. Nevertheless, a high load carrying capacity is achieved by providing the largest possible number of rollers with the largest possible diameter (E design).

Cycling of the separating joint is taken into consideration in calculating the equivalent dynamic load by the impact factor 1.1.

Bearing dimensioning is effected in accordance with the usual calculation procedure indicated in FAG catalogue WL 41 520.

High-speed suitability

The bearing tables indicate the kinematically permissible speeds. These values take into account the cage strength and the vibrations caused by cycling of the seperating joints. In cases where the kinematically permissible speeds are exceeded FAG Application Engineering must be consulted.

Fits

The shaft has to be machined to h6...h9 in order to attain the required tight inner ring fit after bolting. These shaft tolerances are also used for unsplit bearings mounted with adapter sleeves. Usually, the housing bore is machined to H7 or H8.

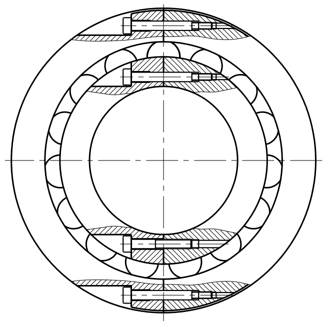
Lubrication

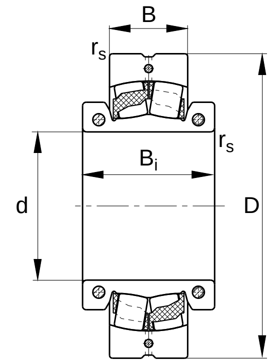
FAG split spherical roller bearings are usually lubricated with a lithium soap base grease of penetration class 2 with EP additives. The lubrication intervals are identical with those of unsplit bearings.

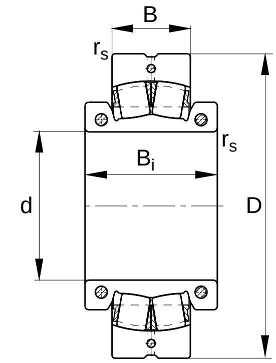
Split spherical roller bearings may be relubricated via a groove and holes in the outer ring.

FAG spherical roller bearings

split, in metric dimensions







Suffix:

Moulded polyamide cage
T

Machined brass cage
MA

Shaft	Dimensions					Load rating · Factor						Weight	Permissible	Kinematically
						dyn.				stat.		≈	axial loads*)	permissible speeds
	d	D	B	B_i	r_s min	C	e	Y $F_a/F_r \le e$	Y $F_a/F_r > e$	C_0	Y_0			
	mm					kN				kN		kg	kN	min^{-1}
55	55	110	28	52	1.5	120	0.23	2.9	4.4	146	2.9	1.7	5.4	3000
60	60	120	31	55	1.5	143	0.24	2.8	4.2	166	2.8	2.7	5.4	2800
65	65	130	31	60	1.5	173	0.24	2.8	4.2	208	2.8	2.8	5.4	2400
70	70	140	33	62	2	180	0.23	3	4.4	228	2.9	3	5.4	2400
75	75	150	36	68	2	183	0.22	3.1	4.6	236	3	4	7.6	2200
80	80	160	40	70	2	212	0.22	3.1	4.7	270	3.1	4.9	7.6	2000
85	85	170	43	74	2	260	0.22	3	4.5	325	3	5.7	7.6	1900
90	90	180	46	76	2.1	285	0.23	2.9	4.3	360	2.8	6.1	7.6	1700
100	100	180	56	90	2	310	0.28	2.4	3.5	430	2.3	8	7.6	1100
	100	200	53	92	2.1	360	0.24	2.8	4.2	465	2.8	9.8	13.8	1500
110	110	180	46	86	2	270	0.23	2.9	4.3	390	2.8	7	7.6	1100
	110	200	62	102	2	390	0.28	2.4	3.6	570	2.3	9.55	14	1000
	110	215	58	98	2.1	455	0.25	2.7	4	585	2.7	10.7	13.8	1300
115	115	200	52	90	2	305	0.22	3	4.5	455	3	9.5	7.6	1100
	115	210	64	104	2	490	0.28	2.4	3.6	710	2.3	11.2	7.6	900
	115	230	64	104	3	540	0.25	2.7	4	720	2.7	14.2	13.8	1200
125	125	210	53	94	2	390	0.23	3	4.4	600	2.9	10	7.6	950
	125	225	68	110	2.1	510	0.28	2.5	3.6	750	2.4	13.5	13.8	850
	125	250	68	110	3	630	0.26	2.6	3.9	880	2.6	18.8	13.8	1100

The designs printed in **bold face** are produced in series.
Information on other designs will be supplied on request.

*) For inner rings which are not axially supported.

Equivalent dynamic load

$P = 1.1\ (F_r + Y \cdot F_a)$ [kN] $F_a/F_r \le e$

$P = 1.1\ (0.67 \cdot F_r + Y \cdot F_a)$ [kN] $F_a/F_r > e$

Equivalent static load

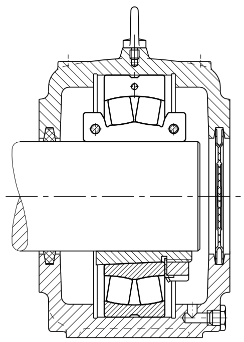
$P_0 = F_r + Y_0 \cdot F_a$ [kN]

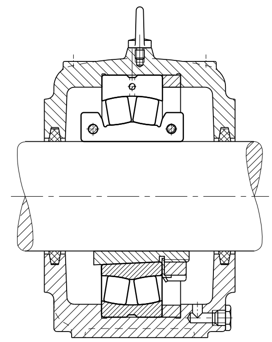
P/C must be equal to or less than 0.2 to prevent the inner rings from creeping on the shaft in circumferential direction. Higher values are permissible if the speed is much lower than the kinematically permissible speed. Please consult our experts in such cases.

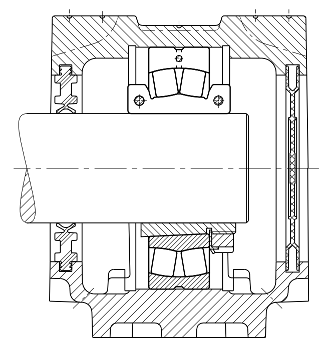
Examples for bearing exchange in plummer block housings

split bearings

unsplit bearings







Housing:	Floating bearing S30	Locating bearing S30	Floating bearing SNV

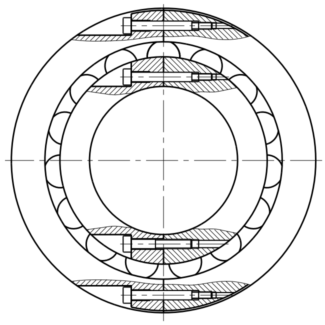
Bolt tightening torque		**Code**		**Can replace unsplit spherical roller bearings with adapter sleeve**		**Matching plummer block housings**)**
Inner ring M_i N m	Outer ring M_a N m	Bearing **FAG**	**FAG**	Bearing	Adapter sleeve	**FAG**
8.5	1.5	222SM55T		22212K	H312	SNV110
8.5	4	222SM60T		22213K	H313	SNV120
8.5	4	**222SM65T**		22215K	H315	SNV130
8.5	4	**222SM70T**		22216K	H316	SNV140
14	8.5	**222SM75T**		22217K	H317	SNV150
14	8.5	**222SM80T**		22218K	H318	SNV160
14	8.5	222SM85T		22219K	H319	SNV170
14	14	**222SM90T**		22220K	H320	SNV180
14	4		231SM100MA	23122K	H3122	-
35	14	**222SM100T**		22222K	H322	SNV200
14	4		230SM110MA	23024K	H3024	S3024K
35	8		231SM110MA	23124K	H3124	-
35	14	222SM110T		22224K	H3124	SNV215[1])
14	8.5		230SM115MA	23026K	H3026	S3026K
14	4		231SM115MA	23126K	H3126	-
35	14	**222SM115T**		22226K	H3126	SNV230[1])
14	4		230SM125MA	23028K	H3028	S3028K
35	8		231SM125MA	23128K	H3128	-
35	14	**222SM125T**		22228K	H3128	SNV250[1])

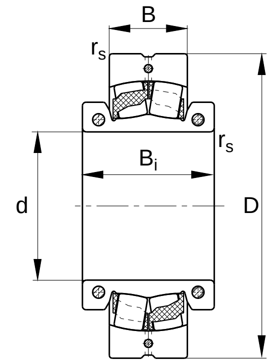
**) The bearings also fit into housings from other manufacturers provided the inside dimensions are the same. Seals, covers and locating rings for SNV housings, see FAG catalogue WL 41 520

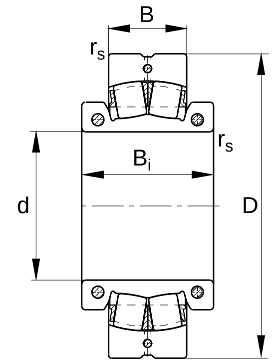
[1]) Housing with eye bolt

FAG spherical roller bearings

split, in metric dimensions







Suffix:

Moulded polyamide cage
T

Machined brass cage
MA

Shaft	Dimensions					Load rating · Factor dyn.				stat.		Weight ≈	Permissible axial loads*)	Kinematically permissible speeds
	d	D	B	B_i	r_s min	C	e	Y $F_a/F_r \le e$	Y $F_a/F_r > e$	C_0	Y_0			
	mm					kN				kN		kg	kN	min^{-1}
135	135	225	56	100	2.1	405	0.22	3.1	4.6	620	3	13	13.8	950
	135	250	80	123	2.1	570	0.27	2.5	3.7	850	2.4	19.5	22.2	800
	135	270	73	122	3	735	0.25	2.7	4	1020	2.6	22.3	22.2	1000
140	140	240	60	106	2.1	450	0.22	3.1	4.6	680	3	15.5	13.8	900
	140	270	86	135	2.1	710	0.29	2.3	3.5	1040	2.3	25.8	22	700
	140	290	80	124	3	850	0.25	2.7	4	1200	2.6	28.5	22.2	950
150	150	260	67	112	2.1	510	0.22	3.1	4.6	800	3	20.5	13.8	800
	150	280	88	133	2.1	710	0.29	2.3	3.5	1040	2.3	26.4	22	700
	150	310	86	128	4	965	0.26	2.6	3.9	1370	2.6	36.5	22.2	900
160	160	280	74	123	2.1	640	0.23	3	4.4	1000	2.9	25.5	22.2	750
	160	300	96	140	2.1	830	0.29	2.3	3.5	1220	2.3	32.7	22	670
	160	320	86	131	4	965	0.26	2.6	3.9	1370	2.6	35.7	22.2	900
170	170	290	75	120	2.1	780	0.23	2.9	4.3	1250	2.8	23.6	22.2	700
	170	320	104	142	2.1	915	0.28	2.4	3.5	1430	2.3	40.6	22	630
	170	340	92	142	4	1140	0.25	2.7	4	1630	2.7	43.6	22.2	800
180	180	310	82	134	2.1	800	0.23	3	4.4	1270	2.9	35	22	670
	180	340	112	160	3	1020	0.29	2.3	3.5	1530	2.3	48.4	22	600
	180	360	98	154	4	1140	0.25	2.7	4	1630	2.7	52.8	22.2	600
200	200	340	90	136	3	965	0.23	2.9	4.3	1530	2.8	37.2	22	630
	200	370	120	175	4	1320	0.31	2.2	3.3	2040	2.2	61.8	32	530
	200	400	108	162	4	1340	0.25	2.7	4	1900	2.6	77.5	32	560
220	220	360	92	156	3	1100	0.23	2.9	4.3	1830	2.8	53	32	560
	220	400	128	190	4	1630	0.3	2.3	3.3	2600	2.2	86	32	480
	220	440	120	170	4	1460	0.25	2.7	4	2080	2.7	89.3	32	500

The designs printed in **bold face** are produced in series.
Information on other designs will be supplied on request.

*) For inner rings which are not axially supported.

Equivalent dynamic load

$P = 1.1\ (F_r + Y \cdot F_a)$ [kN] $F_a/F_r \le e$

$P = 1.1\ (0.67 \cdot F_r + Y \cdot F_a)$ [kN] $F_a/F_r > e$

Equivalent static load

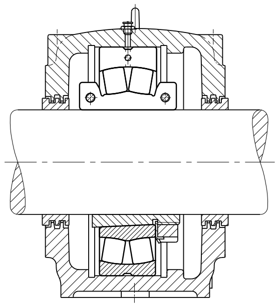
$P_0 = F_r + Y_0 \cdot F_a$ [kN]

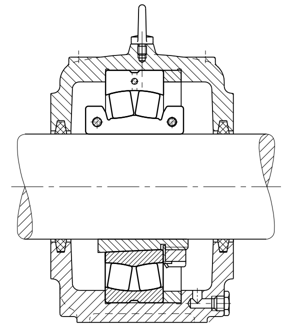
P/C must be equal to or less than 0.2 to prevent the inner rings from creeping on the shaft in circumferential direction. Higher values are permissible if the speed is much lower than the kinematically permissible speed. Please consult our experts in such cases.

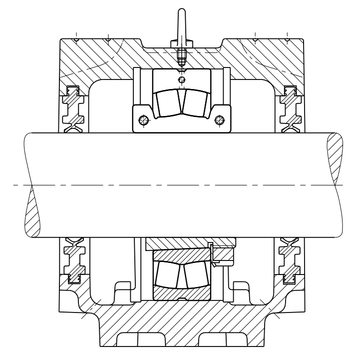
Examples for bearing exchange in plummer block housings

split bearings

unsplit bearings







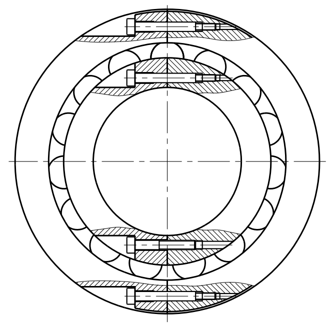
Housing:	Floating bearing SD	Locating bearing S30	Floating bearing SNV

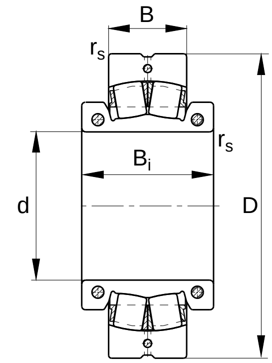
Bolt tightening torque		**Code**		**Can replace unsplit spherical roller bearings with adapter sleeve**		**Matching plummer block housings**)**
Inner ring M_i N m	Outer ring M_a N m	Bearing **FAG**	**FAG**	Bearing	Adapter sleeve	**FAG**
35	8.5		230SM135MA	23030K	H3030	S3030K
69	14		231SM135MA	23130K	H3130	-
69	35	222SM135T		22230K	H3130	SNV270
35	8.5		230SM140MA	23032K	H3032	S3032K
69	14		231SM140MA	23132K	H3132	-
69	35	**222SM140T**		22232K	H3132	SNV290
35	8.5		230SM150MA	23034K	H3034	S3034K
69	35		231SM150MA	23134K	H3134	SD3134TS
69	35	222SM150T		22234K	H3134	SD534
69	14		230SM160MA	23036K	H3036	S3036K
69	35		231SM160MA	23136K	H3136	SD3136TS
69	35	222SM160T		22236K	H3136	SD536
69	14		230SM170MA	23038K	H3038	S3038K
69	35		231SM170MA	23138K	H3138	SD3138TS
69	35	222SM170T		22238K	H3138	SD538
69	14		230SM180MA	23040K	H3040	S3040K
69	35		231SM180MA	23140K	H3140	SD3140TS
69	35		222SM180MA	22240K	H3140	SD540
69	35		230SM200MA	23044K	H3044X	S3044K
120	69		231SM200MA	23144K	H3144X	SD3144TS
120	69		222SM200MA	22244K	H3144X	SD544
120	35		230SM220MA	23048K	H3048	S3048K
120	69		231SM220MA	23148K	H3148X	SD3148TS
120	69		222SM220MA	22248K	H3148X	SD548

**) The bearings also fit into housings from other manufacturers provided the inside dimensions are the same. Seals, covers and locating rings for SNV housings, see FAG catalogue WL 41 520

FAG spherical roller bearings

split, in metric dimensions





Suffix: Machined brass cage MA

Shaft	Dimensions					Load rating · Factor						Weight	Permissible	Kinematically
						dyn.				stat.		≈	axial loads*)	permissible speeds
	d	D	B	B_i	r_s min	C	e	Y $F_a/F_r \le e$	Y $F_a/F_r > e$	C_0	Y_0			
	mm					kN				kN		kg	kN	min^{-1}
240	240	400	104	160	4	1220	0.22	3	4.5	2120	3	57.4	32	560
	240	440	144	210	4	1860	0.3	2.3	3.4	3050	2.2	114	32	450
	240	480	130	200	5	1860	0.26	2.6	3.9	2600	2.6	136	60	450
260	260	420	106	170	4	1460	0.23	2.9	4.4	2450	2.9	72	32	500
	260	460	146	190	5	2280	0.3	2.2	3.3	3800	2.2	110	32	400
	260	500	130	200	5	2200	0.25	2.7	4	3100	2.6	143	60	430
280	280	460	118	175	4	1600	0.22	3	4.5	2800	3	96	32	480
	280	500	160	218	5	2320	0.29	2.3	3.5	3900	2.3	160	44	400
	280	540	140	200	5	2400	0.24	2.8	4.2	3550	2.7	175	60	430
300	300	480	121	186	4	1860	0.23	2.9	4.3	3200	2.8	106	32	430
	300	540	176	225	5	2750	0.29	2.3	3.4	4750	2.3	184	60	360
	300	580	150	212	5	2650	0.24	2.8	4.2	4050	2.8	214	60	380
320	320	520	133	200	5	2040	0.22	3	4.5	3650	3	120	32	430
	320	580	190	235	5	3100	0.3	2.3	3.4	5200	2.2	226	60	340
	320	620	165	230	6	3100	0.24	2.8	4.1	4750	2.7	244	60	360
340	340	540	134	205	5	2360	0.22	3	4.5	4150	2.9	150	60	380
	340	600	192	270	5	3900	0.3	2.3	3.3	6800	2.2	285	60	300
	340	650	170	240	6	3450	0.25	2.7	4	5100	2.6	267	60	340
360	360	560	135	218	5	2550	0.22	3.1	4.6	4650	3	137	60	380
	360	620	194	270	5	3900	0.3	2.3	3.4	6950	2.2	292	60	300
380	380	600	148	225	5	2700	0.21	3.2	4.8	5100	3.1	169	60	380
	380	650	200	270	6	4050	0.28	2.4	3.6	7200	2.3	365	60	300

The designs printed in **bold face** are produced in series.
Information on other designs will be supplied on request.

*) For inner rings which are not axially supported.

Equivalent dynamic load

$P = 1.1\,(F_r + Y \cdot F_a)$ [kN] $F_a/F_r \le e$

$P = 1.1\,(0.67 \cdot F_r + Y \cdot F_a)$ [kN] $F_a/F_r > e$

Equivalent static load

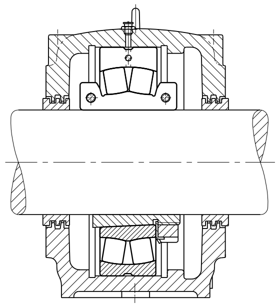
$P_0 = F_r + Y_0 \cdot F_a$ [kN]

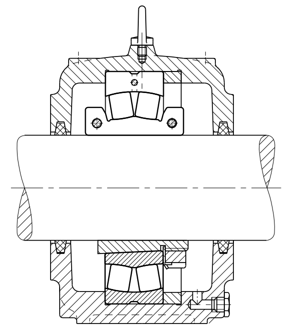
P/C must be equal to or less than 0.2 to prevent the inner rings from creeping on the shaft in circumferential direction. Higher values are permissible if the speed is much lower than the kinematically permissible speed. Please consult our experts in such cases.

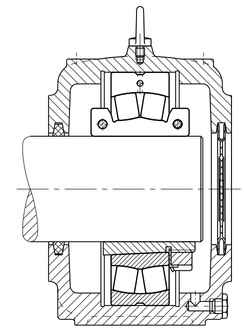
Examples for bearing exchange in plummer block housings

split bearings

unsplit bearings







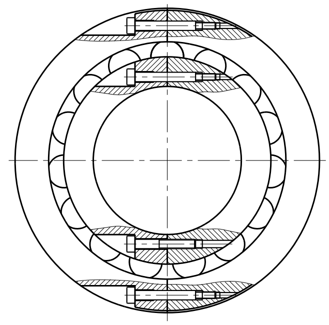
Housing:	Floating bearing SD	Locating bearing S30	Floating bearing S30

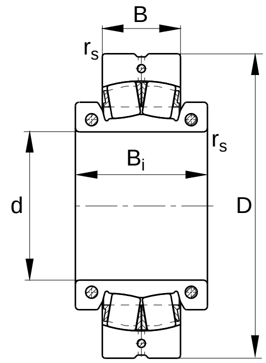
Bolt tightening torque		**Code**	**Can replace unsplit spherical roller bearings with adapter sleeve**		**Matching plummer block housings**)**
Inner ring M_i N m	Outer ring M_a N m	Bearing **FAG**	Bearing	Adapter sleeve	**FAG**
120	69	230SM240MA	23052K	H3052	S3052K
120	69	231SM240MA	23152K	H3152X	SD3152TS
295	120	222SM240MA	22252K	H3152X	SD552
120	35	230SM260MA	23056K	H3056	S3056K
120	35	231SM260MA	23156K	H3156X	SD3156TS
295	69	222SM260MA	22256K	H3156X	SD556
120	69	230SM280MA	23060K	H3060	S3060K
190	120	231SM280MA	23160K	H3160HG	SD3160TS
295	120	222SM280MA	22260K	H3160HG	SD560
120	69	230SM300MA	23064K	H3064HG	S3064K
295	120	231SM300MA	23164K	H3164HG	SD3164TS
295	120	222SM300MA	22264K	H3164HG	SD564
295	69	230SM320MA	23068K	H3068HG	S3068K
295	190	231SM320MA	23168K	H3168HG	SD3168TS
295	120	222SM320MA			
295	69	230SM340MA	23072K	H3072HG	
295	69	231SM340MA	23172K	H3172HG	SD3172TS
295	120	222SM340MA			
295	69	230SM360MA	23076K	H3076HG	
295	69	231SM360MA	23176K	H3176HG	SD3176TS
295	120	230SM380MA	23080K	H3080HG	
295	120	231SM380MA	23180K	H3180HG	SD3180TS

**) The bearings also fit into housings from other manufacturers provided the inside dimensions are the same.

FAG spherical roller bearings

split, in metric dimensions





Suffix: | Machined brass cage MA

Shaft	Dimensions					Load rating · Factor dyn.				stat.		Weight ≈	Permissible axial loads*)	Kinematically permissible speeds
	d	D	B	B_i	r_s min	C	e	Y $F_a/F_r \leq e$	Y $F_a/F_r > e$	C_0	Y_0			
	mm					kN				kN		kg	kN	min^{-1}
400	400	620	150	225	5	3100	0.22	3.1	4.6	5700	3	210	60	340
	400	700	224	285	6	4400	0.28	2.4	3.6	7650	2.3	415	60	280
410	410	650	157	225	5	3100	0.21	3.2	4.8	5850	3.1	250	60	340
	410	720	224	315	6	5400	0.29	2.3	3.4	9650	2.3	475	94	260
420	420	650	157	235	5	3100	0.21	3.2	4.8	5850	3.1	246	60.5	340

The designs printed in **bold face** are produced in series.
Information on other designs will be supplied on request.

*) For inner rings which are not axially supported.

Equivalent dynamic load

$P = 1.1\ (F_r + Y \cdot F_a)$ [kN] $F_a/F_r \leq e$

$P = 1.1\ (0.67 \cdot F_r + Y \cdot F_a)$ [kN] $F_a/F_r > e$

Equivalent static load

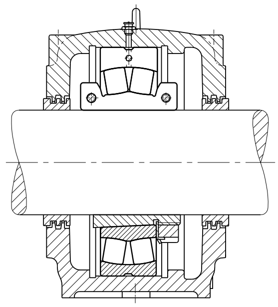
$P_0 = F_r + Y_0 \cdot F_a$ [kN]

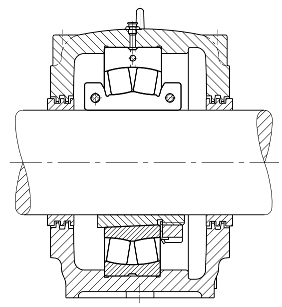
P/C must be equal to or less than 0.2 to prevent the inner rings from creeping on the shaft in circumferential direction. Higher values are permissible if the speed is much lower than the kinematically permissible speed. Please consult our experts in such cases.

Examples for bearing exchange in plummer block housings

split bearings

unsplit bearings





Housing:

Floating bearing
SD

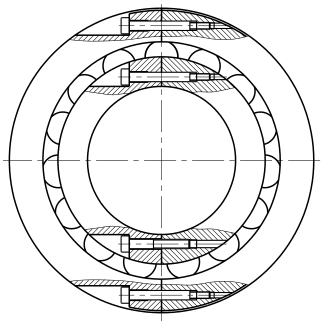
Locating bearing
SD

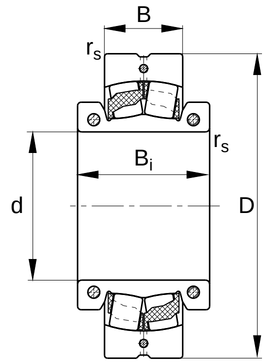
Bolt tightening torque		Code	Can replace unsplit spherical roller bearings with adapter sleeve		Matching plummer block housings**)
Inner ring M_i N m	Outer ring M_a N m	Bearing FAG	Bearing	Adapter sleeve	FAG
295	69	230SM400MA	23084K	H3084HG	
295	190	231SM400MA	23184K	H3184HG	SD3184TS
295	120	230SM410MA	23088K	H3088HG	
500	120	231SM410MA	23188K	H3188HG	
295	120	230SM420MA			

**) The bearings also fit into housings from other manufacturers provided the inside dimensions are the same.

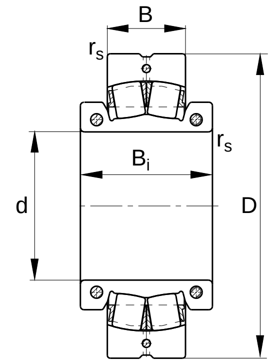
FAG spherical roller bearings

split, in inch dimensions





Moulded polyamide cage
-



Machined brass cage
MA

Suffix:

Shaft	Dimensions					Load rating · Factor dyn.				stat.		Weight ≈	Permissible axial loads*)	Kinematically permissible speed
	d	D	B	B_i	r_s min	C	e	Y	Y	C_0	Y_0			
inch	inch mm					lbs kN		$F_a/F_r \le e$	$F_a/F_r > e$	lbs kN		lbs kg	lbs kN	min^{-1}
2 3/16	2.1875 55.563	4.7244 120	1.2205 31	2.1654 55	0.06 1.5	32500 143	0.24	2.8	4.2	37500 166	2.8	5.1 2.3	1200 5.4	2800
2 1/4	2.2500 57.15	4.7244 120	1.2205 31	2.1654 55	0.06 1.5	32500 143	0.24	2.8	4.2	37500 166	2.8	4.3 1.95	1200 5.4	2800
2 7/16	2.4375 61.913	5.1181 130	1.2205 31	2.3622 60	0.06 1.5	39000 173	0.24	2.8	4.2	47500 208	2.8	6.2 2.8	1200 5.4	2400
2 1/2	2.5000 63.5	5.1181 130	1.2205 31	2.3622 60	0.06 1.5	39000 173	0.24	2.8	4.2	47500 208	2.8	5.5 2.5	1200 5.4	2400
2 11/16	2.6875 68.263	5.5118 140	1.2992 33	2.4409 62	0.08 2	40500 180	0.23	3	4.4	51000 228	2.9	6.6 3	1200 5.4	2400
2 15/16	2.9375 74.613	5.9055 150	1.4173 36	2.6772 68	0.08 2	41500 183	0.22	3.1	4.6	53000 236	3	8.8 4	1700 7.6	2200
3	3.0000 76.2	5.9055 150	1.4173 36	2.6772 68	0.08 2	41500 183	0.22	3.1	4.6	53000 236	3	8.8 4	1700 7.6	2200
3 3/16	3.1875 80.963	6.2992 160	1.5748 40	2.7559 70	0.08 2	47500 212	0.22	3.1	4.7	60000 270	3.1	10.6 4.8	1700 7.6	2000
3 1/4	3.2500 82.55	6.2992 160	1.5748 40	2.7559 70	0.08 2	47500 212	0.22	3.1	4.7	60000 270	3.1	9.15 4.15	1700 7.6	2000
3 7/16	3.4375 87.313	7.0866 180	1.8110 46	2.9921 76	0.08 2.1	58500 260	0.23	2.9	4.3	72000 320	2.8	14.2 6.45	1700 7.6	1300
	3.4375 87.313	7.0866 180	1.8110 46	2.9921 76	0.08 2.1	64000 285	0.23	2.9	4.3	81500 360	2.8	14.2 6.45	1700 7.6	1700

The designs printed in **bold face** are produced in series.
Information on other designs will be supplied on request.

*) For inner rings which are not axially supported.

Equivalent dynamic load

$P = 1.1\,(F_r + Y \cdot F_a)$ [lbs, kN] $F_a/F_r \le e$

$P = 1.1\,(0.67 \cdot F_r + Y \cdot F_a)$ [lbs, kN] $F_a/F_r > e$

Equivalent static load

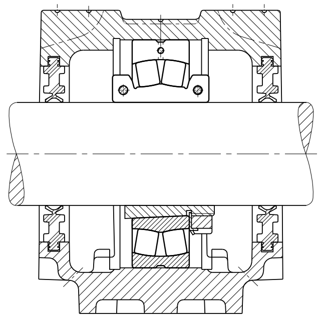
$P_0 = F_r + Y_0 \cdot F_a$ [lbs, kN]

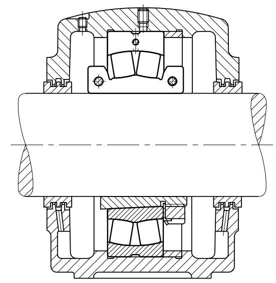
P/C must be equal to or less than 0.2 to prevent the inner rings from creeping on the shaft in circumferential direction. Higher values are permissible if the speed is much lower than the kinematically permissible speed. Please consult our experts in such cases.

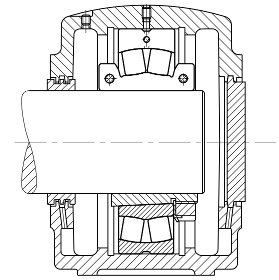
Examples for bearing exchange in plummer block housings

split bearings

unsplit bearings







Housing:	Floating bearing SNV	Locating bearing SAF5	Floating bearing SAF5

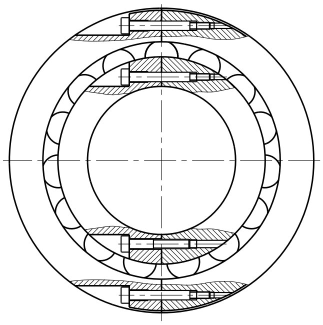
Bolt tightening torque		**Code**		**Can replace unsplit spherical roller bearings with adapter sleeve**		**Matching plummer block housings**)**
Inner ring M_i ft lbs N m	Outer ring M_a ft lbs N m	Bearing **FAG**	**FAG**	Bearing	Adapter sleeve	**FAG**
6 8.5	1.1 1.5	**222S.203**		22213K	•SNW13 H313.203	•SAF513 SNV120
6 8.5	1.1 1.5	222S.204		22213K	H313.204	SNV120
6 8.5	3 4	**222S.207**		22215K	•SNW15 H315.207	•SAF515 SNV130
6 8.5	3 4	222S.208		22215K	H315.208	SNV130
6 8.5	3 4	**222S.211**		22216K	•SNW16 H316.211	•SAF516 SNV140
10 14	6 8.5	**222S.215**		22217K	•SNW17 H317.215	•SAF517 SNV150
10 14	6 8.5	**222S.300**		22217K	H317.300	SNV150
10 14	6 8.5	**222S.303**		22218K	•SNW18 H318.303	•SAF518 SNV160
10 14	6 8.5	**222S.304**		22218K	H318.304	SNV160
10 14	10 14		222S.307MA	22220K	•SNW20 H320.307	•SAF520 SNV180
10 14	10 14	**222S.307**		22220K	•SNW20 H320.307	•SAF520 SNV180

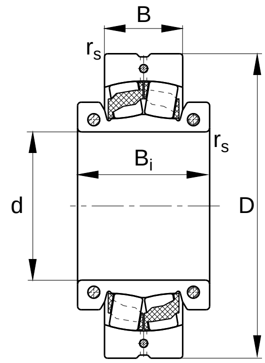
**) The bearings also fit into housings from other manufacturers provided the inside dimensions are the same. Seals, covers and locating rings for SNV housings, see FAG catalogue WL 41 520

- Designs for the North American market. The split seals for the SAF housings are supplied together with the bearing.

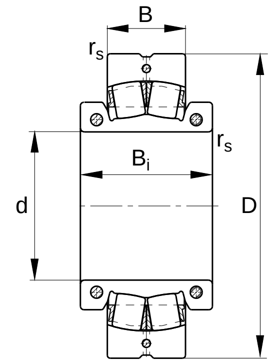
FAG spherical roller bearings

split, in <u>inch</u> dimensions





Moulded polyamide cage
-



Machined brass cage
MA

Suffix:

Shaft	Dimensions					Load rating · Factor						Weight	Permissible	Kinematically
						dyn.				stat.		≈	axial loads*)	permissible speed
	d	D	B	B_i	r_s min	C	e	Y	Y	C_0	Y_0			
inch	inch mm					lbs kN		$F_a/F_r \le e$	$F_a/F_r > e$	lbs kN		lbs kg	lbs kN	min^{-1}
3 1/2	3.5000 88.9	7.0866 180	1.8110 46	2.9921 76	0.08 2.1	58500 260	0.23	2.9	4.3	72000 320	2.8	13.6 6.15	1700 7.6	1300
	3.5000 88.9	7.0866 180	1.8110 46	2.9921 76	0.08 2.1	64000 285	0.23	2.9	4.3	81500 360	2.8	13.6 6.15	1700 7.6	1700
3 15/16	3.9375 100.013	7.8740 200	2.0866 53	3.6220 92	0.08 2.1	80000 360	0.24	2.8	4.2	104000 465	2.8	21.6 9.8	3100 13.8	1500
4	4.0000 101.6	7.8740 200	2.0866 53	3.6220 92	0.08 2.1	80000 360	0.24	2.8	4.2	104000 465	2.8	21.4 9.7	3100 13.8	1500
4 3/16	4.1875 106.363	8.4646 215	2.2835 58	3.8583 98	0.08 2.1	102000 455	0.25	2.7	4	132000 585	2.7	25.6 11.6	3100 13.8	1300
4 7/16	4.4375 112.713	9.0551 230	2.5197 64	4.0945 104	0.12 3	120000 540	0.25	2.7	4	163000 720	2.7	32.2 14.6	3100 13.8	1200
4 1/2	4.5000 114.3	9.0551 230	2.5197 64	4.0945 104	0.12 3	120000 540	0.25	2.7	4	163000 720	2.7	31.1 14.1	3100 13.8	1200
4 15/16	4.9373 125.413	9.8425 250	2.6772 68	4.3307 110	0.12 3	129000 585	0.26	2.6	3.9	176000 780	2.6	41.2 18.7	3100 13.8	850
	4.9373 125.413	9.8425 250	2.6772 68	4.3307 110	0.12 3	143000 630	0.26	2.6	3.9	196000 880	2.6	41.2 18.7	3100 13.8	1100
5	5.0000 127	9.8425 250	2.6772 68	4.3307 110	0.12 3	143000 630	0.26	2.6	3.9	196000 880	2.6	40.8 18.5	3100 13.8	1100
5 3/16	5.1875 131.763	10.6299 270	2.8740 73	4.8031 122	0.12 3	166000 735	0.25	2.7	4	228000 1020	2.6	53.1 24.1	5000 22.2	1000

The designs printed in **bold face** are produced in series.
Information on other designs will be supplied on request.

*) For inner rings which are not axially supported.

Equivalent dynamic load

$P = 1.1\,(F_r + Y \cdot F_a)$ [lbs, kN] $F_a/F_r \le e$

$P = 1.1\,(0.67 \cdot F_r + Y \cdot F_a)$ [lbs, kN] $F_a/F_r > e$

Equivalent static load

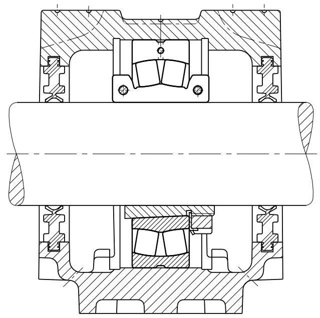
$P_0 = F_r + Y_0 \cdot F_a$ [lbs, kN]

P/C must be equal to or less than 0.2 to prevent the inner rings from creeping on the shaft in circumferential direction. Higher values are permissible if the speed is much lower than the kinematically permissible speed. Please consult our experts in such cases.

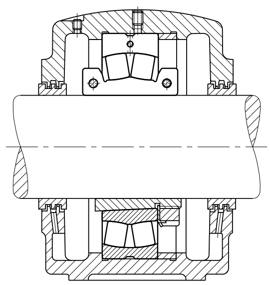
Examples for bearing exchange in plummer block housings

split bearings

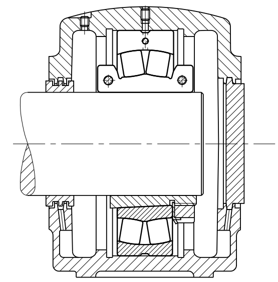
unsplit bearings



Floating bearing
SNV



Locating bearing
SAF5



Floating bearing
SAF5

Housing: SNV / SAF5 / SAF5

Bolt tightening torque		**Code**		**Can replace unsplit spherical roller bearings with adapter sleeve**		**Matching plummer block housings**)**
Inner ring M_i ft lbs N m	Outer ring M_a ft lbs N m	Bearing **FAG**	 **FAG**	Bearing	Adapter sleeve	 **FAG**
10 14	10 14		222S.308MA	22220K	H320.308	SNV180
10 14	10 14	**222S.308**		22220K	H320.308	SNV180
26 35	10 14	**222S.315**		22222K	•SNW22 H322.315	•SAF522 SNV200
26 35	10 14	**222S.400**		22222K	•SNW22x4 H322.400	•SAF522 SNV200
26 35	10 14	222S.403		22224K	•SNW24 H3124.403	•SAF524 SNV215[1])
26 35	10 14	**222S.407**		22226K	•SNW26 H3126.407	•SAF526 SNV230[1])
26 35	10 14	**222S.408**		22226K	•SNW26x4 1/2 H3126.408	•SAF526 SNV230[1])
26 35	10 14		222S.415MA	22228K	•SNW28 H3128.415	•SAF528 SNV250[1])
26 35	10 14	**222S.415**		22228K	•SNW28 H3128.415	•SAF528 SNV250[1])
26 35	10 14	**222S.500**		22228K	H3128.500	SNV250[1])
51 69	26 35	**222S.503**		22230K	•SNW30 H3130.503	•SAF530 SNV270[1])

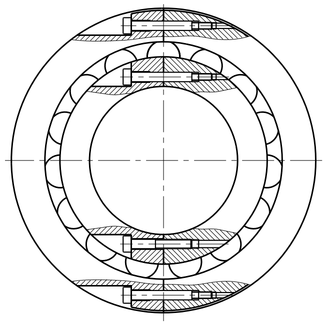
**) The bearings also fit into housings from other manufacturers provided the inside dimensions are the same. Seals, covers and locating rings for SNV housings, see FAG catalogue WL 41 520

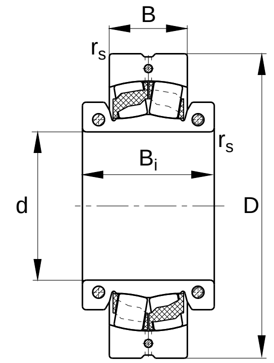
• Designs for the North American market. The split seals for the SAF housings are supplied together with the bearing.

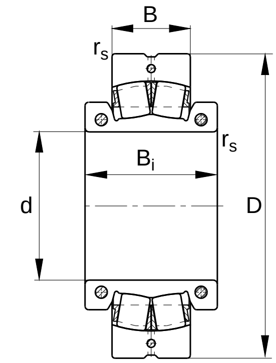
[1]) Housing with eye bolt

FAG spherical roller bearings

split, in inch dimensions







Suffix:	Moulded polyamide cage	Machined brass cage
	-	MA

Shaft	**Dimensions**					**Load rating · Factor** dyn.				stat.		**Weight** ≈	**Permissible axial loads*)**	**Kinematically permissible speed**
	d	D	B	B_i	r_s min	C	e	Y	Y	C_0	Y_0			
inch	inch mm					lbs kN		$F_a/F_r \le e$	$F_a/F_r > e$	lbs kN		lbs kg	lbs kN	min^{-1}
5 7/16	5.4375 138.113	11.4173 290	3.1496 80	4.8819 124	0.12 3	173000 780	0.25	2.7	4	240000 1060	2.6	58.4 26.5	5000 22.2	750
	5.4375 138.113	11.4173 290	3.1496 80	4.8819 124	0.12 3	190000 850	0.25	2.7	4	270000 1200	2.6	58.4 26.5	5000 22.2	950
5 1/2	5.5000 139.7	9.4488 240	2.3622 60	4.1732 106	0.08 2.1	100000 450	0.22	3.1	4.6	153000 680	3	30.2 13.7	3100 13.8	900
	5.5000 139.7	11.4173 290	3.1496 80	4.8819 124	0.12 3	190000 850	0.25	2.7	4	270000 1200	2.6	63.1 28.6	5000 22.2	950
5 15/16	5.9375 150.813	12.2047 310	3.3858 86	5.0394 128	0.16 4	200000 880	0.26	2.6	3.9	275000 1220	2.6	74.7 33.9	5000 22.2	900
6	6.0000 152.4	12.2047 310	3.3858 86	5.0394 128	0.16 4	216000 965	0.26	2.6	3.9	310000 1370	2.6	74.7 33.9	5000 22.2	900
6 7/16	6.4375 163.513	11.4173 290	2.9528 75	4.7244 120	0.08 2.1	173000 780	0.23	2.9	4.3	285000 1250	2.8	48.3 21.9	5000 22.2	700
	6.4375 163.513	11.8110 300	3.7795 96	5.5118 140	0.08 2.1	186000 830	0.29	2.3	3.5	275000 1220	2.3	81.6 37	5000 22.2	670
	6.4375 163.513	12.5984 320	3.3858 86	5.1575 131	0.16 4	216000 965	0.26	2.6	3.9	310000 1370	2.6	79.4 36	5000 22.2	900
6 1/2	6.5000 165.1	12.5984 320	3.3858 86	5.1575 131	0.16 4	216000 965	0.26	2.6	3.9	310000 1370	2.6	79.4 36	5000 22.2	900
6 15/16	6.9375 176.213	13.3858 340	3.6220 92	5.5905 142	0.16 4	255000 1140	0.25	2.7	4	365000 1630	2.7	98.5 44.7	5000 22.2	800
7	7.0000 177.8	11.4173 290	2.9528 75	4.7244 120	0.08 2.1	173000 780	0.23	2.9	4.3	285000 1250	2.8	68.3 31	5000 22.2	700

The designs printed in **bold face** are produced in series.
Information on other designs will be supplied on request.

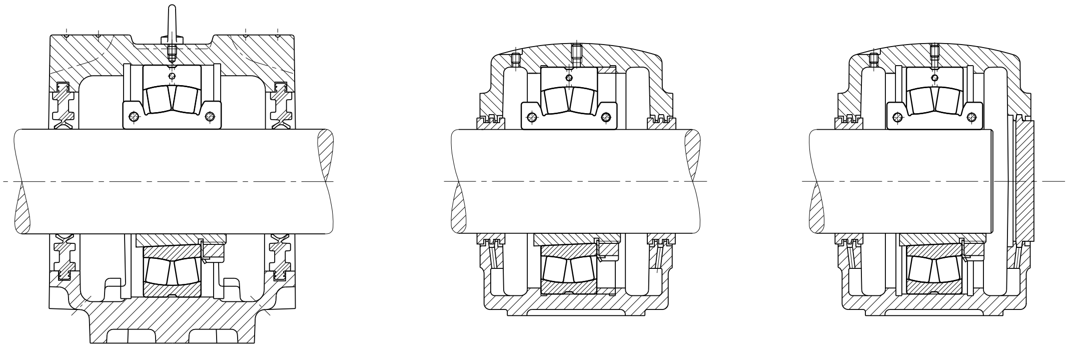
*) For inner rings which are not axially supported.

Equivalent dynamic load			**Equivalent static load**	
$P = 1.1\ (F_r + Y \cdot F_a)$	[lbs, kN]	$F_a/F_r \le e$	$P_0 = F_r + Y_0 \cdot F_a$	[lbs, kN]
$P = 1.1\ (0.67 \cdot F_r + Y \cdot F_a)$	[lbs, kN]	$F_a/F_r > e$		

P/C must be equal to or less than 0.2 to prevent the inner rings from creeping on the shaft in circumferential direction. Higher values are permissible if the speed is much lower than the kinematically permissible speed. Please consult our experts in such cases.

Examples for bearing exchange in plummer block housings

split bearings



unsplit bearings

Housing:	Floating bearing SNV	Locating bearing SAF5	Floating bearing SAF5

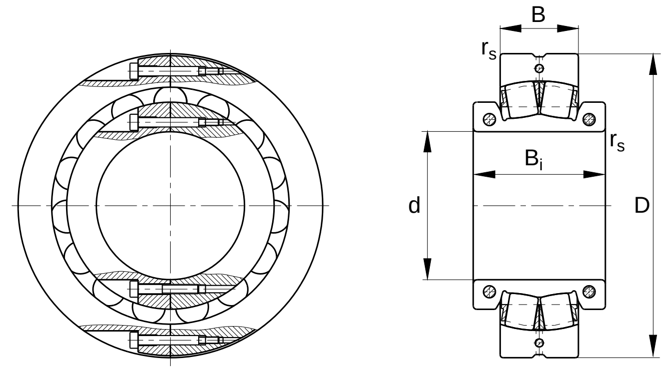
Bolt tightening torque		**Code**		**Can replace unsplit spherical roller bearings with adapter sleeve**		**Matching plummer block housings**)**
Inner ring M_i ft lbs N m	Outer ring M_a ft lbs N m	Bearing **FAG**	 **FAG**	Bearing	Adapter sleeve	 **FAG**
51 69	26 35		222S.507MA	22232K	•SNW32 H3132.507	•SAF532 SNV290
51 69	26 35	**222S.507**		22232K	•SNW32 H3132.507	•SAF532 SNV290
26 35	6 8.5		230S.508MA	23032K	•SNP3032x5 1/2 H3032.508	•SAF032K/5 1/2
51 69	26 35	**222S.508**		22232K	H3132.508	SNV290
51 69	26 35	**222S.515**		22234K	•SNW34 H3134.515	•SAF534
51 69	26 35	**222S.600**		22234K	•SNW34x6 H3134.600	•SAF534
51 69	10 14	230S.607		23038K	•SNP3038x6 7/16 H3038.607	•SAF038K/6 7/16
51 69	26 35		231S.607MA	23136K	•SNP3136x6 7/16 H3136.607	•SDAF3136K/6 7/16
51 69	26 35	**222S.607**		22236K	•SNW36 H3136.607	•SAF536
51 69	26 35	**222S.608**		22236K	•SNW36x6 1/2 H3136.608	•SAF536
51 69	26 35	222S.615		22238K	•SNW38 H3138.615	•SAF538
51 69	10 14	**230S.700**		23038K	•SNP3038x7 H3038.700	•SAF038K/7

**) The bearings also fit into housings from other manufacturers provided the inside dimensions are the same. Seals, covers and locating rings for SNV housings, see FAG catalogue WL 41 520

• Designs for the North American market. The split seals for the SAF housings are supplied together with the bearing.

FAG spherical roller bearings

split, in inch dimensions



Machined brass cage
(no suffix if d > 7 inch)

Shaft	**Dimensions**					**Load rating · Factor**						**Weight**	**Permissible axial loads*)**	**Kinematically permissible speed**
						dyn.				stat.		≈		
	d	D	B	B_i	r_s min	C	e	Y	Y	C_0	Y_0			
inch	inch mm					lbs kN		$F_a/F_r \leq e$	$F_a/F_r > e$	lbs kN		lbs kg	lbs kN	min^{-1}
7 3/16	7.1875 182.563	14.1732 360	3.8583 98	6.0630 154	0.16 4	255000 1140	0.25	2.7	4	365000 1630	2.7	130 59	5000 22.2	600
7 1/2	7.5000 190.5	15.7480 400	4.2520 108	6.3779 162	0.16 4	300000 1340	0.25	2.7	4	425000 1900	2.6	162 73.3	7200 32	560
7 15/16	7.9375 201.613	15.7480 400	4.2520 108	6.3779 162	0.16 4	300000 1340	0.25	2.7	4	425000 1900	2.6	169 76.5	7200 32	560
8	8.0000 203.2	15.7480 400	4.2520 108	6.3779 162	0.16 4	300000 1340	0.25	2.7	4	425000 1900	2.6	168 76	7200 32	560
8 1/2	8.5000 215.9	14.1732 360	3.6220 92	6.1417 156	0.12 3	250000 1100	0.23	2.9	4.3	415000 1830	2.8	117 53	7200 32	560
9	9.0000 228.6	14.1732 360	3.6220 92	6.2992 160	0.12 3	250000 1100	0.23	2.9	4.3	415000 1830	2.8	106 48	7200 32	560
9 1/2	9.5000 241.3	15.7480 400	4.0945 104	6.2992 160	0.16 4	275000 1220	0.22	3	4.5	480000 2120	3	154 70	7200 32	560
10	10.0000 254	16.5354 420	4.1732 106	6.6929 170	0.16 4	325000 1460	0.23	3	4.4	550000 2450	2.9	165 75	7200 32	500
11	11.0000 279.4	18.1102 460	4.6457 118	6.9291 176	0.16 4	360000 1600	0.22	3	4.5	620000 2800	3	211 96	7200 32	480
	11.0000 279.4	19.6850 500	6.2992 160	8.5827 218	0.2 5	520000 2320	0.29	2.3	3.5	880000 3900	2.3	353 160	9900 44	400

The designs printed in **bold face** are produced in series.
Information on other designs will be supplied on request.

*) For inner rings which are not axially supported.

Equivalent dynamic load

$P = 1.1\ (F_r + Y \cdot F_a)$ [lbs, kN] $F_a/F_r \leq e$

$P = 1.1\ (0.67 \cdot F_r + Y \cdot F_a)$ [lbs, kN] $F_a/F_r > e$

Equivalent static load

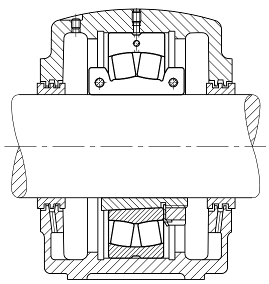
$P_0 = F_r + Y_0 \cdot F_a$ [lbs, kN]

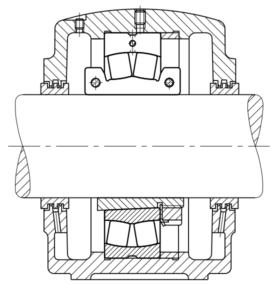
P/C must be equal to or less than 0.2 to prevent the inner rings from creeping on the shaft in circumferential direction. Higher values are permissible if the speed is much lower than the kinematically permissible speed. Please consult our experts in such cases.

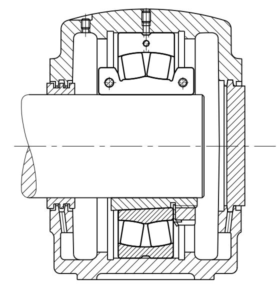
Examples for bearing exchange in plummer block housings

split bearings

unsplit bearings







Housing:	Floating bearing SAF5	Locating bearing SAF5	Floating bearing SAF5

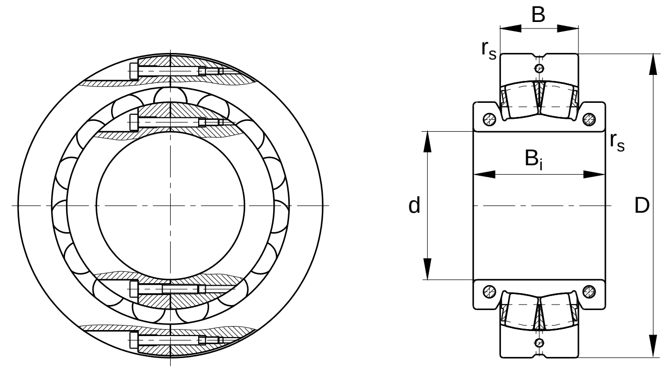
Bolt tightening torque		**Code**	**Can replace unsplit spherical roller bearings with adapter sleeve**		**Matching plummer block housings****)
Inner ring M_i ft lbs N m	Outer ring M_a ft lbs N m	Bearing **FAG**	Bearing	Adapter sleeve	 **FAG**
51 69	26 35	222S.703	22240K	•SNW40 H3140.703	•SAF540
88 120	51 69	**222S.708**	22244K	•SNW44x7 1/2 H3144X.708	•SAF544
88 120	51 69	222S.715	22244K	•SNW44 H3144X.715	•SAF544
88 120	51 69	**222S.800**	22244K	•SNW44x8 H3144X.800	•SAF544
88 120	26 35	230S.808	23048K	•SNP3048x8 1/2 H3048.808	•SAF048K/8 1/2 •SD048K/8 1/2
88 120	26 35	**230S.900**	23048K	•SNP3048x9 H3048.900	•SAF048K/9 •SD048K/9
88 120	51 69	230S.908	23052K	•SNP3052x9 1/2 H3052X.908	•SAF052K/9 1/2 •SD052K/9 1/2
88 120	26 35	**230S.1000**	23056K	•SNP3056x10 H3056.1000	•SAF056K/10 •SD056K/10
88 120	51 69	**230S.1100**	23060K	•SNP3060x11 H3060.1100	•SDAF060K/11 •SD060K/11
140 190	88 120	231S.1100	23160K	•SNP3160x11 H3160HG.1100	•SDAF3160K/11 •SD3160K/11

**) The bearings also fit into housings from other manufacturers provided the inside dimensions are the same.

- Designs for the North American market. The split seals for the SAF and SDAF housings are supplied together with the bearing.

FAG spherical roller bearings

split, in inch dimensions



Machined brass cage
(no suffix if d > 7 inch)

Shaft	Dimensions					Load rating · Factor dyn.				stat.		Weight ≈	Permissible axial loads*)	Kinematically permissible speed
	d	D	B	B_i	r_s min	C	e	Y	Y	C_0	Y_0			
inch	inch mm					lbs kN		$F_a/F_r \le e$	$F_a/F_r > e$	lbs kN		lbs kg	lbs kN	min^{-1}
12	12.0000 304.8	18.8976 480	4.7638 121	7.3228 186	0.16 4	425000 1860	0.23	2.9	4.3	720000 3200	2.8	227 103	7200 32	430
	12.0000 304.8	21.2598 540	6.9291 176	8.8583 225	0.2 5	620000 2750	0.29	2.3	3.4	1060000 4750	2.3	441 200	13500 60	360
13	13.0000 330.2	21.2598 540	5.2756 134	8.0709 205	0.2 5	530000 2360	0.22	3	4.5	930000 4150	2.9	317 144	13500 60	380
	13.0000 330.2	23.6220 600	7.5590 192	10.6299 270	0.2 5	880000 3900	0.3	2.3	3.3	1530000 6800	2.2	573 260	13500 60	300
14	14.0000 355.6	22.0472 560	5.3150 135	8.5827 218	0.2 5	570000 2550	0.22	3.1	4.6	1040000 4650	3	311 141	13500 60	380
	14.0000 355.6	24.4094 620	7.6378 194	10.6299 270	0.2 5	880000 3900	0.3	2.3	3.4	1560000 6950	2.3	600 272	13500 60	300

The designs printed in **bold face** are produced in series.
Information on other designs will be supplied on request.

*) For inner rings which are not axially supported.

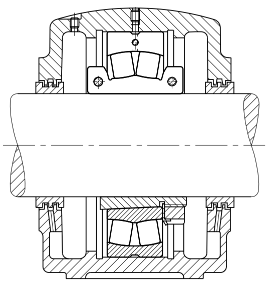
Equivalent dynamic load			**Equivalent static load**	
$P = 1.1\ (F_r + Y \cdot F_a)$	[lbs, kN]	$F_a/F_r \le e$	$P_0 = F_r + Y_0 \cdot F_a$	[lbs, kN]
$P = 1.1\ (0.67 \cdot F_r + Y \cdot F_a)$	[lbs, kN]	$F_a/F_r > e$		

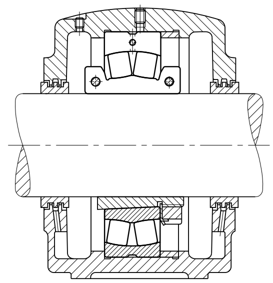
P/C must be equal to or less than 0.2 to prevent the inner rings from creeping on the shaft in circumferential direction. Higher values are permissible if the speed is much lower than the kinematically permissible speed. Please consult our experts in such cases.

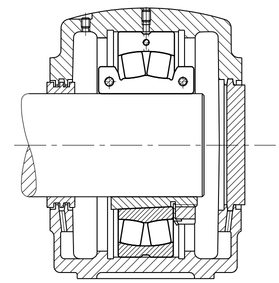
Examples for bearing exchange in plummer block housings

split bearings

unsplit bearings







Housing:	Floating bearing SDAF5	Locating bearing SDAF5	Floating bearing SDAF5

Bolt tightening torque		**Code**	**Can replace unsplit spherical roller bearings with adapter sleeve**		**Matching plummer block housings**)**
Inner ring M_i ft lbs N m	Outer ring M_a ft lbs N m	Bearing **FAG**	Bearing	Adapter sleeve	 **FAG**
88 120	51 69	**230S.1200**	23064K	•SNP3064x12 H3064HG.1200	•SDAF064K/12 •SD064K/12
212 295	88 120	231S.1200	23164K	•SNP3164x12 H3164HG.1200	•SDAF3164K/12 •SD3164K/12
212 295	51 69	230S.1300	23072K	•SNP3072x13 H3072HG.1300	•SDAF072K/13 •SD072K/13
212 295	88 120	231S.1300	23172K	•SNP3172x13 H3172HG.1300	•SDAF3172K/13 •SD3172K/13
212 295	51 69	230S.1400	23076K	•SNP3076x14 H3076HG.1400	•SDAF076K/14 •SD076K/14
212 295	51 69	231S.1400	23176K	•SNP3176x14 H3176HG.1400	•SDAF3176K/14 •SD3176K/14

**) The bearings also fit into housings from other manufacturers provided the inside dimensions are the same.

- Designs for the North American market. The split seals for the SAF and SDAF housings are supplied together with the bearing.

Cost reduction due to shorter downtimes

Example 1: Exhaust gas ventilator

Existing bearing with sleeve: 22226EK.C3+H3126 at drive end and opposite end
FAG split bearing: 222SM115T

Required steps in bearing mounting and dismounting **Unsplit bearing** 22226EK.C3 + H3126	**Split bearing** 222SM115T
Disassemble couplings	not required
Loosen fastening bolts (housing bases)	not required
Remove coupling (mounted with feather key and shrink fit)	not required
Remove bearing at drive end (replaced as a precaution)	not required
Remove bearing at opposite end	yes
Install new bearing at opposite end	yes
Install new bearing at drive end	not required
Assembly in reverse order	–

Cost factors	**Unsplit bearing** 22226EK.C3 + H3126	**Split bearing** 222SM115T
Downtime	14 hours	3 hours
Downtime cost (disruption of production) (DM 39,000.00/h of ventilator downtime)	14 x DM 39,000.00 = DM 546,000.00	3 x DM 39,000.00 = DM 117,000.00
Man hours (2 men working 14 h each, 2 men working 3 h each) (hourly rate: DM 39.00)	2 x 14 = 28 h 28 x DM 39.00 = DM 1,090.00	2 x 3 = 6 h 6 x DM 39.00 = DM 235.00
Alignment (hourly rate: DM 65.00)	3 hours 3 x DM 65.00 = DM 195.00	not required
Crane rental	4 x DM 200.00 = DM 800.00	not required
Replacement bearing (drive end) as a precaution	DM 650.00	not required
Replacement bearing (opposite end)	DM 650.00	DM 1,600.00
Total cost of bearing replacement	**DM 549,385.00**	**DM 118,835.00**

Cost saved by using FAG split spherical roller bearings	**DM 430,550.00**

Example 2: Exhaust ventilator

Existing bearing with sleeve: 23152K.MB + H3152XHG at drive end and opposite end
FAG split bearing: 231SM240MA

Required steps in bearing mounting and dismounting **Unsplit bearing** 23152K.MB + H3152XHG	**Split bearing** 231SM240MA
Disassemble couplings at transmission input and output ends	not required
Loosen connection between foundation and electric motor	not required
Loosen fastening bolts (housing bases)	not required
Remove cover for easier lifting	not required
Use loops to suspend impeller	not required
Lift rotor using a crane	not required
Remove transmisssion using a crane (access to coupling)	not required
Remove coupling (mounted with feather key and shrink fit)	not required
Remove bearing at drive end (replaced as a precaution)	no
Remove bearing at opposite end	yes
Install new bearing at opposite end	yes
Install new bearing at drive end	not required
Assembly in reverse order	–

Cost factors	**Unsplit bearing** 23152K.MB + H3152XHG	**Split bearing** 231SM240MA
Downtime	36 h	6 h
Downtime cost (DM 2,600.00/h)	36 x DM 2,600.00 = DM 93,600.00	6 x DM 2,600.00 = DM 15,600.00
Man hours (3 men working 18 h each, 2 men working 6 h each) (hourly rate: DM 39.00)	3 x 18 = 54 h 54 x DM 39.00 = DM 2,105.00	2 x 6 = 12 h 12 x DM 39.00 = DM 470.00
Alignment (hourly rate DM 65.00)	3 hours 3 x DM 65.00 = DM 195.00	not required
Crane rental	24 x DM 200.00 = DM 4,800.00	not required
Replacement bearing (drive end)	DM 4,300.00	not required
Replacement bearing (opposite end)	DM 4,300.00	DM 17,200.00
Hydraulic nut RKP 260	DM 4,900.00	not required
Total cost of bearing replacement	**DM 114,200.00**	**DM 33,270.00**
Cost saved by using FAG split spherical roller bearings	**DM 80,930.00**	

Cost reduction due to shorter downtimes

Firm/contact partner . . . .
Application . . . .
Existing bearing with sleeve . . . .
FAG split bearing . . . .

Required steps in bearing mounting and dismounting	**Unsplit bearing**	**Split bearing**
Disassemble drive unit (transmission, belt/chain, electric motor)		not required
Remove coupling halves/pulley/sprocket		not required
Support rotor on trestles	not required	
Detach housing bases		not required
Lift rotor		not required
Remove housing cover		
Remove housing base		not required
Clean components, install and inspect new bearing		
Assemble housing		
Align housing relative to shaft		not required
Mount housing on foundation		not required
Mount coupling halves/pulley/sprocket		not required
Assemble drive unit (transmission, belt/chain, electric motor)		not required
Align drive train		not required
Total downtime in hours		

Cost comparison	**Unsplit bearing**	**Split bearing**
Downtime cost		
Lifting equipment		
Special mounting tools (e.g. hydraulic nut)		
Labour cost (man hours)		
Replacement bearing (split or unsplit with adapter sleeve)		
Alignment (equipment and labour cost)		
Total cost of bearing replacement		

Costs saved by using FAG split spherical roller bearings

Saving cost by rapid bearing replacement at locations of restricted access

FAG Split Spherical Roller Bearings

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in this publication but no liability can be accepted for any errors or omissions.
We reserve the right to make changes in the interest of technical progress.
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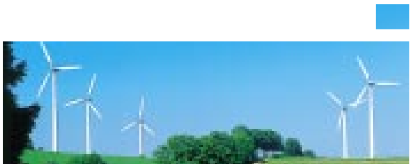
EVERYTHING THAT KEEPS US GOING.



FAG OEM und Handel AG

FAG

A company on the move

We are specialists in the field of movement: Machines worldwide are working with FAG rolling bearings and perform their intended movements with supreme precision of up to a thousandth of a millimetre. However, movement is also a basic principle of our company management. FAG stands for change, innovation and optimisation – with respect to products and services.

Quality and price are not the only factors which are decisive in international competition: services, advice, individual solutions and branch-specific knowhow are equally important to be able to hold one's own in the global markets.

We have set ourselves ambitious goals: We want to expand our position continuously. We want to grow faster than the market. We approach our tasks with passion and an entrepreneurial attitude.

We orient ourselves by our customers – worldwide. Therefore we have reorganised FAG OEM und Handel AG (OEM and Distribution), the largest Business Unit within the FAG Group, and equipped it with a new industry segment management concept.

Our main activities are now focused on the following industry segments:

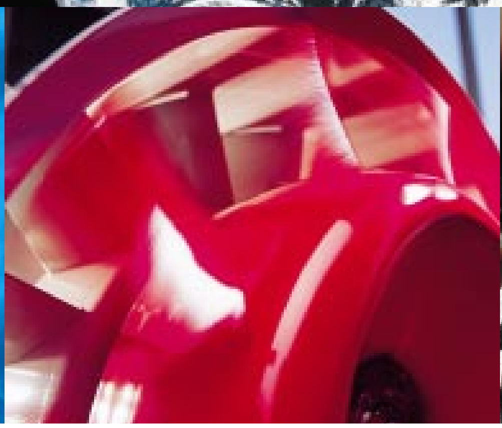
- ***Mining & Construction***
- ***Pulp & Paper***
- ***Steel***
- ***Railway & Transport***
- ***Mechanical Transmission & Electrical Machinery***
- ***Special OE Industries***
- ***Distribution Partners***

At the same time we have concentrated the European distribution activities of our twelve subsidiaries in FAG Sales Europe GmbH. Europe-wide, the logistic sector was optimised through our four warehouses located at Schweinfurt, Milan, Brussels and Stockholm. Furthermore, global logistic activities with focus on North America and Asia were also reorganised.

To an increasing extent, we are supporting the trade sector with training and sales promotion measures. We regard the trade to be an equal partner; OEMs and users are our mutual customers.

The brochure on hand is aimed at informing you about these developments and about the new industry segment management concept within FAG OEM und Handel AG. Yet it will also show that – despite all changes – there is continuity in competence, performance, quality and services. This is what FAG OEM und Handel AG with its 7,400 employees worldwide stands for.

Georg Konstantinou
Chairman of the Managing Board of FAG OEM und Handel AG, Member of the Managing Board of FAG Kugelfischer Georg Schäfer AG



The development of FAG OEM und Handel is characterised by the interplay of aiming at and achieving goals. Without being self-complacent, we can justly maintain that we have reached an outstanding level in products and services. But this does not alter the fact that we strive for even bigger medium- and long-term goals. There is always room for improvement.

Our Mission Statement

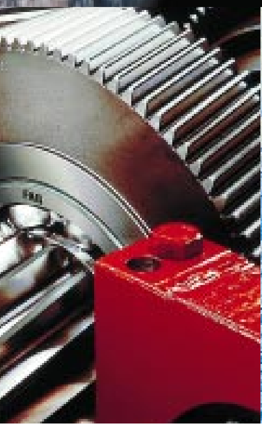
On the basis of high-quality products, FAG OEM und Handel AG will become the leading services and systems supplier among the rolling bearing manufacturers worldwide.

FAG OEM und Handel AG aims to enhance the success of its industrial customers and distribution partners through application engineering competence and comprehensive customer services.

- *We are the largest Business Unit within the FAG Group with manufacturing sites in Germany, Italy, Portugal, India, Korea and the USA*

FAG

Mission Statement
Everything that keeps us going ...

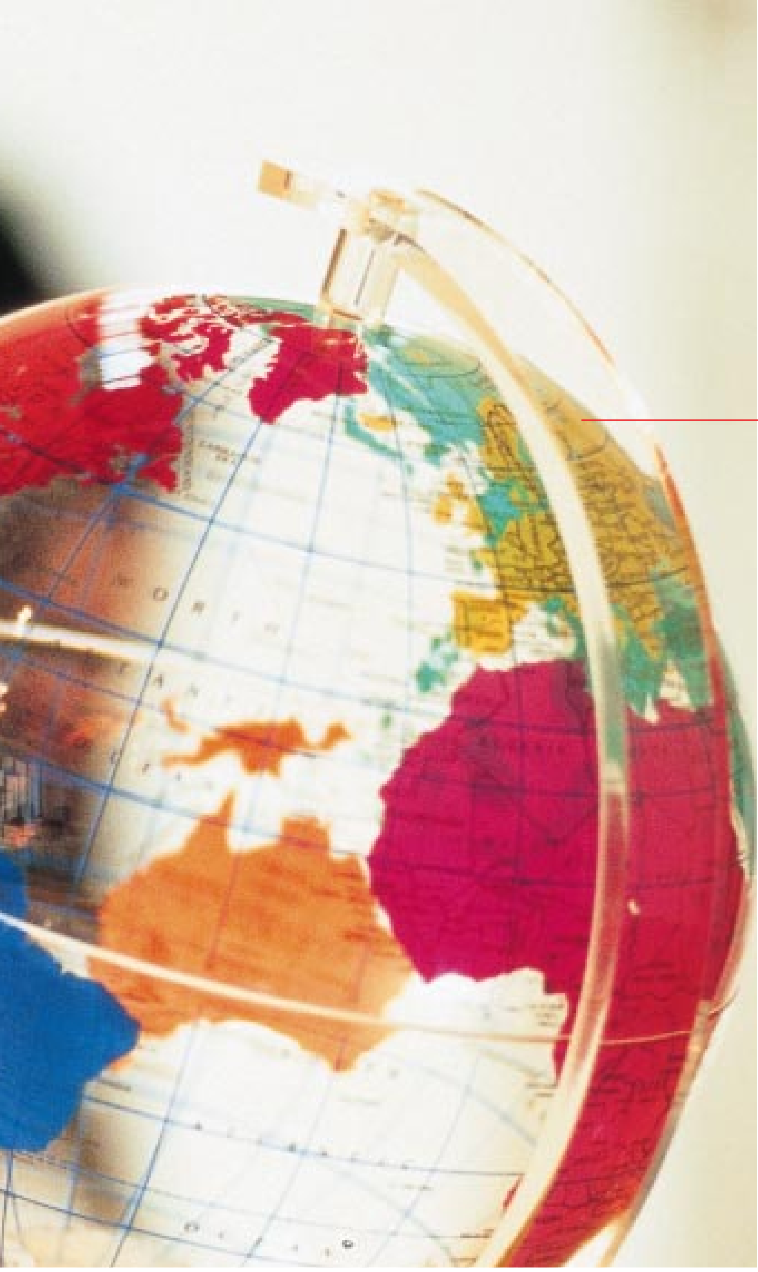


- *We offer first-class quality products, services and logistics*
- *Our ball bearings, roller bearings, housings and the corresponding accessories are available worldwide, just as the services that go with them*
- *We attend to OEM customers of the mechanical engineering industry, our distribution partners and to the aftermarket*
- *We employ our technical competence for the benefit of our customers*
- *We practise customer proximity through:*
  1. *geographical presence*
  2. *customer-oriented industry segment management*
  3. *flexibility in distribution, production and logistic processes*

Only in geographical terms can our world be still described as the often quoted "wide" world. From the economic point of view all continents have become close together – very close. Whoever wants to maintain his leading role in international competition, has to go beyond the limits – those of his thinking and those of his entrepreneurial action.

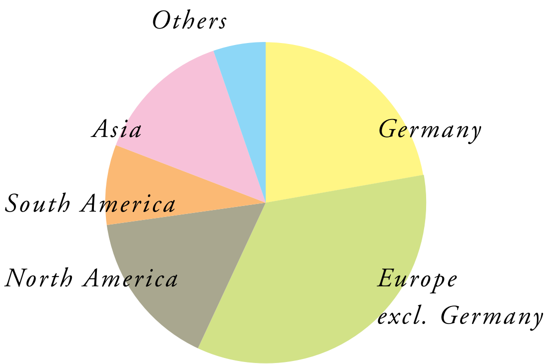
The map of a Global Player

One of the basic principles of FAG has always been to be as close to the customer as possible - also in the literal sense. Customer proximity can only be practised if competent contacts are at hand nearby who are flexible in their reaction to customer demands. For this reason FAG is present in all continents. The global network of company-owned manufacturing sites, sales companies and sales offices is continuously being extended. The same applies to the worldwide network of distributors – 75 per cent of our sales are being achieved in export markets.



FAG

Distribution/ Manufacturing sites/Locations



Main external sales regions

Worldwide presence

FAG OEM und Handel AG has manufacturing sites in Germany, the USA, Portugal, Italy, Korea and India. Distribution worldwide is organised through 26 sales companies in the most important markets. In addition there is a closely-meshed network of distribution partners in all markets.

In 1999, the trend-setting industry segment management was introduced at FAG OEM und Handel. This fundamental restructuring has resulted in an even closer orientation towards customer requirements in all different industrial branches. More than ever can we offer our customers special knowhow related to their specific application tasks.

Branches and traces

Let us take a short philological excursion with respect to these "branches". The history of the word "branch" leads us to the French "branche" which stands for "branch" or "twig". When tracing back the roots of the word to an even earlier point in time, we arrive at the Latin word "branca" which means "footprint". Branches and traces are the symbols for the basic idea of industry segment management at FAG OEM und Handel. The knowhow which we have acquired in working out solutions for innumerable branch-specific tasks, branches out widely and has left its traces in our company. On the one hand these traces document our experience, but on the other they also serve as guide when we approach new challenges with proven methods. Our customers can be sure that we know their industrial branch inside out; that we are well familiar with all the processes and technologies and possess excellent references. Industry segment management means a maximum of customer proximity and intimate knowledge of the requirements specific to the particular branch.

The world of our customers and their own customers

- ***Mechanical Transmission & Electrical Machinery***
  Our customers manufacture gears and electrical machinery, ships and wind power plants or belong to the non-specific operator industries (e.g. chemical industry, sugar industry or mineral oil industry)
- ***Special OE Industries***
  Our customers manufacture pumps and compressors, floor conveyors and industrial vehicles as well as printing machines, textile machinery, agricultural machinery, medical-technological equipment and other special machinery and equipment
- ***Distribution Partners***
  Always close at hand, our distribution partners attend to customers from industry and commerce on site

We are at home in the following industry segments

- ***Mining & Construction***
  Our customers manufacture or operate ore transporting equipment, mines, cement plants, oil platforms, hard crushers, construction machinery and large-scale building sites
- ***Pulp & Paper***
  Our customers manufacture or operate paper mills, wood pulp works and papermaking machines
- ***Steel***
  Our customers manufacture or operate steel works and rolling mills
- ***Railway & Transport***
  Our customers manufacture or operate rail-bound vehicles

A wag once maintained that the only motivation for building tunnels is human laziness – people simply prefer the direct short cut to walking round an obstacle. Although there is some truth in this assessment, it fails to recognise the tremendous efforts which people and machinery have to undertake before a railway or road tunnel becomes passable. For instance, the tunnelling machines with their immense drilling pressure show performances which cannot be described in terms of human work. It is not at all uncommon for the incorporated FAG rolling bearings to have an outside diameter of up to 4,250 millimetres – more than four metres!

Under the earth, under the sea

FAG bearings accommodate the entire forward thrust exerted by the cutter head against the rock. In many applications the axial-radial cylindrical roller bearings or tapered roller bearings have outside diameters of more than three metres. Machines used for building subways and water tunnels incorporate similar FAG rolling bearings. Also in the case of the 50 km-Euro Tunnel, which connects France and England and runs 40 metres below the sea bed, FAG technology was employed.

FAG

The cutter head of a tunnelling machine which was operated from the French side was equipped with a three-row FAG axial-radial cylindrical roller bearing. A forward thrust of up to 12,000 kN permitted the tunnel construction works to proceed up to five metres per hour under favourable geological conditions. To be prepared for a possible inrush of water, all bearings had to be equipped with seals which would resist a water pressure of 12 bar.

Underground and above ground

Also in the underground mining of coal, salt, ore and other types of rock, tunnelling and cutting machines which are equipped with FAG bearings have been in operation for decades. Finally, hoisting facilities will bring the mineral resources to daylight.

No fear of large rocks

In coarse and fine grinding of rocks, FAG bearings are exposed to enormous shocks. Despite these adverse conditions, their design and an optimum sealing against fine dust permit extremely long maintenance intervals. The cement industry, too, relies on FAG bearing technology for crushing hard materials.

When the heavy material is hoisted from depths as low as 3,500 metres, FAG bearings ensure that the friction in the winding cable sheaves is kept to a minimum. In above-ground mining, gigantic bucket wheel and dragline excavators are employed. These imposing machines incorporate particularly low-friction FAG bearings with long maintenance intervals which make their contribution to an economic production of raw materials.
Also in the several kilometre-long belt conveyors plants FAG bearings operate in the usual reliable way – worldwide.

In several processes even the hardest rock is ground to a grain size of just a few hundredths of a millimetre. Various FAG rolling bearings fulfil central functions in these crushers and mills. The same applies to the application of FAG bearings in vibrating screens which grade solid matter.

Mineral oil and natural gas from depths of more than ten kilometres

In oil and gas production drilling depths of more than ten kilometres have been nothing unusual for a long time now. This applies to on-shore and off-shore production alike. FAG ball and roller bearings are used to ensure safe guidance of the drill string in the aggregates of the derrick. They are designed in such a way that they carry several tonnes of the drill string weight without being impeded in their function.

FAG success factors

- *High load carrying capacity in extremely limited mounting space*
- *Application-oriented designs*
- *Complete solutions through bearing units (housings, bearings, sleeves, lubrication, sealing)*
- *Reduction of downtime resulting in cost reduction, for instance through the use of split bearings*
- *Designs suitable for vibrating stress*
- *Coatings which reduce the coefficient of friction*

A German saying holds that "Paper is patient". However somebody who has seen a papermaking machine in operation, will quickly revise this view of things. At least in paper production there is no such thing as patience. It rather calls for the highest possible productivity with perfect and friction-less operation of all machinery components. When the huge papermaking machines run at their highest speeds, they produce almost two kilometres of paper per minute with a width of 10 metres and more – at speeds of more than 100 km/h. Despite its enormous weight, the roll which takes up the finished product at the end of the machine rotates at a breathtaking speed.

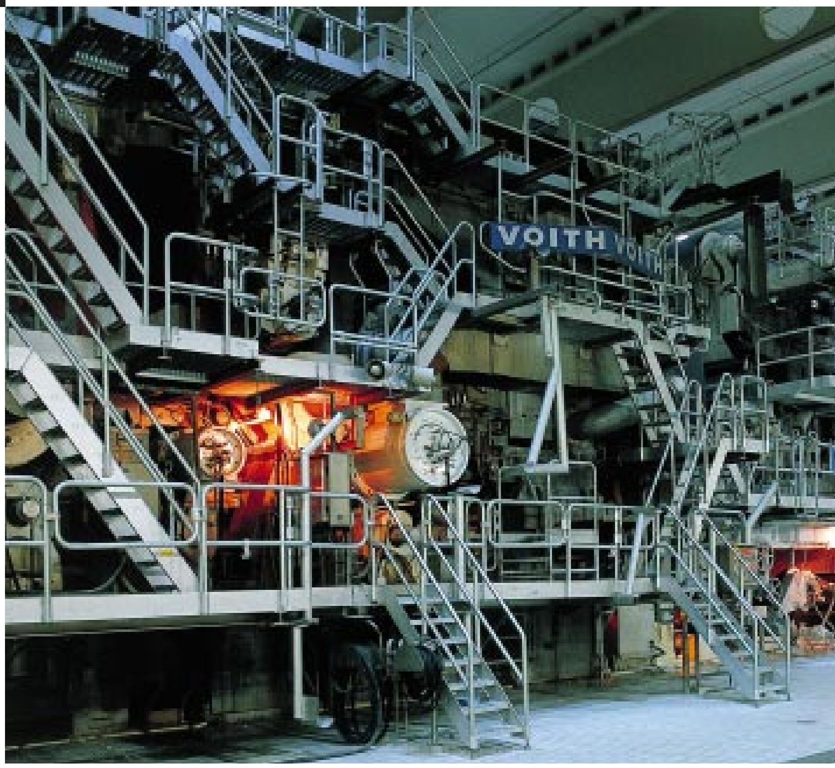
The immense demand for paper of all kinds can only be covered by means of cost-effective paper machines which operate without downtime. Here, too, FAG bearings make an important contribution.

From wood to cellulose

The papermaking industry needs enormous amounts of cellulose for the production of different paper qualities. To produce cellulose, wood (mainly pine, fir, birch and beech) is chopped in pieces and cooked until it has become a mushy pulp.

Pulp & Paper

The peeling and grinding machines applied for this purpose require especially robust rolling bearings which work with absolute reliability under even the most adverse operating conditions. To ensure that the FAG bearings are neither affected by humidity nor by dust, they exhibit particularly safe sealing and thus are protected against corrosion. Having passed the wire and press section, the cellulose sheet is dried and pressed in the dryer section. This incorporates FAG bearings which can even cope with temperatures as high as 150 °C without problems.



Permanent operation

Some of the larger machines for the production of paper and cardboard measure up to 200 metres in length. Due to these enormous dimensions and the consequently large distances between the bearings it is essential that the bearing arrangements are capable of accommodating major changes in the linear expansion of rolls and cylinders and can compensate for errors of alignment. Spherical roller bearings are the most commonly used bearings in papermaking machines. But also cylindrical roller bearings, tapered roller bearings, deep groove ball bearings and angular contact ball bearings are used, in particular in auxiliary equipment such as motors, gears, ventilators and pumps. As papermaking machines incorporate a great number of rolls and cylinders, it is possible that in some cases up to 2,000 FAG rolling bearings are present to ensure low friction at the same time as maximum precision.

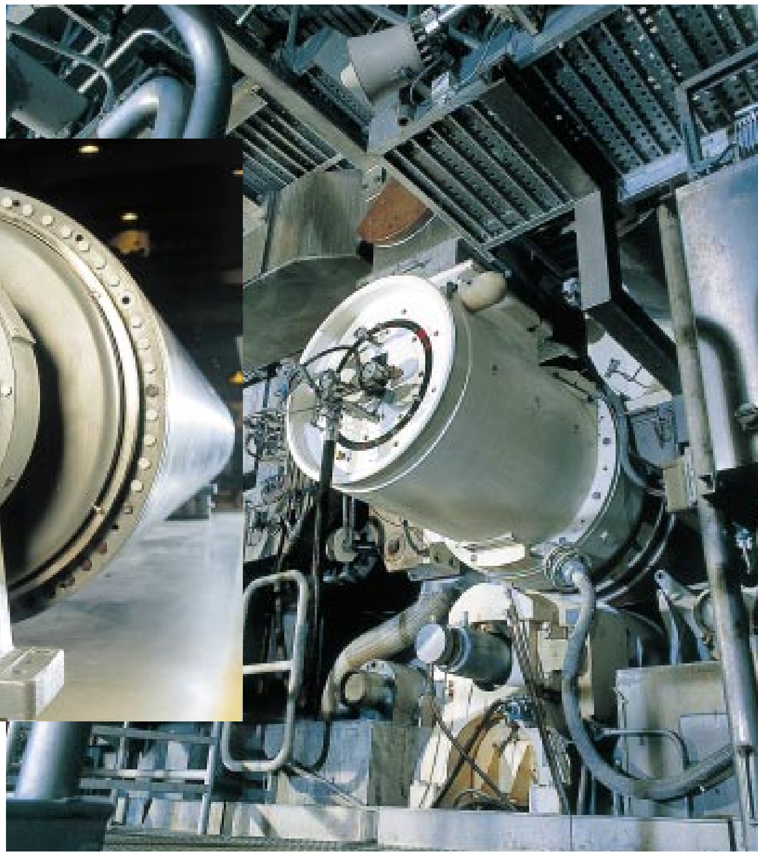
24 hours a day

For economic and technical reasons papermaking machines usually work around the clock. Only during major maintenance and repair work is their operation interrupted. For the rolling bearings and all other construction components this means that the demands with respect to operational reliability are particularly high. Furthermore, they are suitable for high speeds and easily maintained and exchanged.

Resistant against corrosion and heat

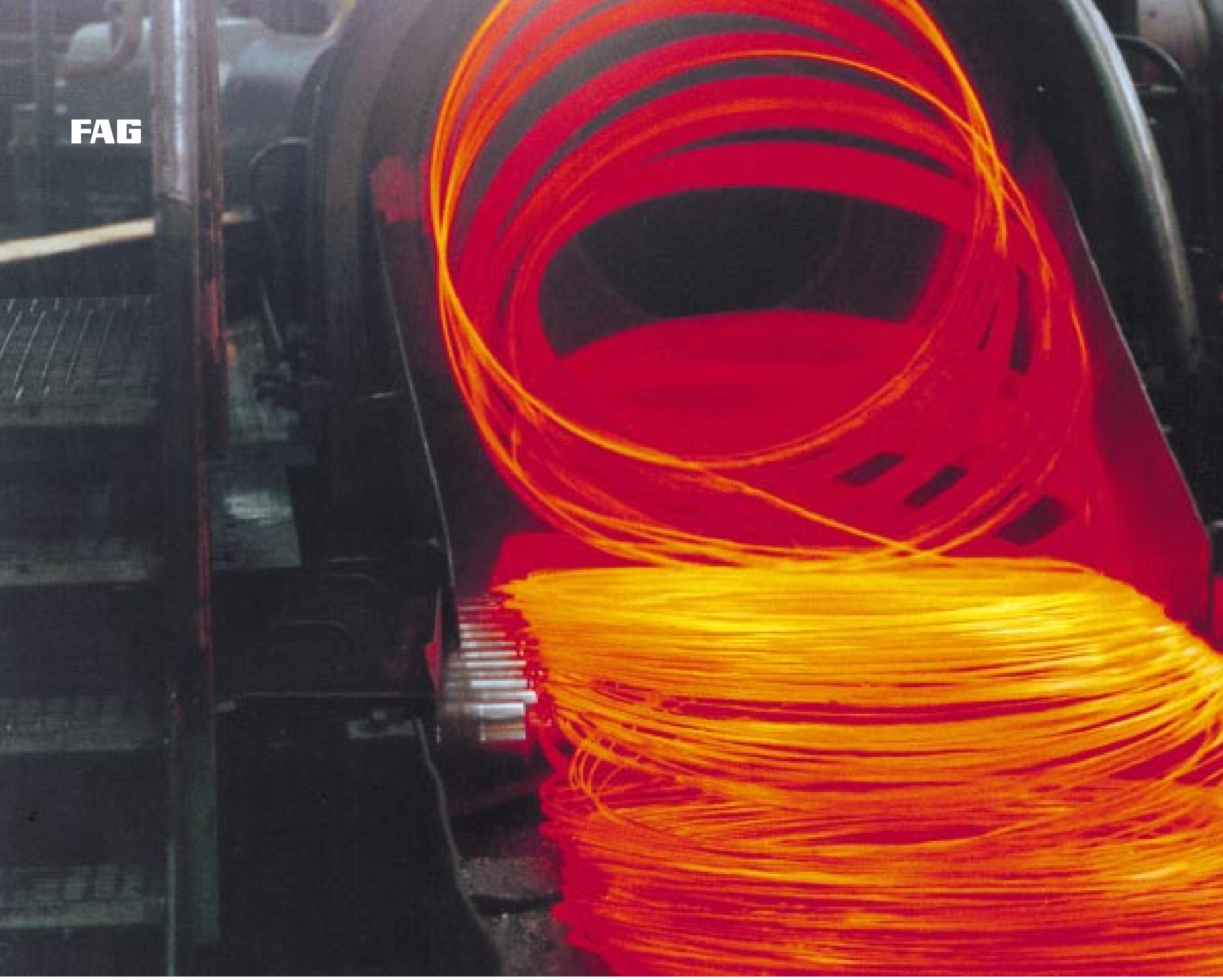
As in the case of machines for cellulose production, papermaking machines are divided into a wet and a dryer section. Naturally, the ambient humidity is extremely high in the wet section. To protect the FAG bearing arrangements against water intrusion and corrosion, they are completely sealed. This design feature extends their life to a considerable degree. In the dryer section the bearings are exposed to entirely different conditions.

At an extremely high humidity and ambient temperatures of more than 100 °C, a substantial linear expansion of the dryer roll cannot be avoided. Several millimetres is nothing unusual. For this application FAG develops and manufactures floating bearing concepts which permit easy compensation of the length differences. The self-aligning cylindrical roller bearings which can be radially stressed in each direction allow this compensation even at temperatures of 200 °C.



FAG success factors

- *High product quality*
- *Particularly cost-effective solutions*
- *Extended bearing life, yet less maintenance requirements*
- *Maximum precision for all fields of application*
- *Worldwide availability of important bearings in papermaking machines through Paper Scope*
- *Skilled personnel for technical advice and services on site*



As far as geological standards are concerned, the Iron Age is over and done with, but not so in industrial everyday life – on the contrary! Year by year, steelworks produce hundreds of millions of tonnes of raw steel in ore processing and supply it to the rolling mills for further treatment. Without iron and steel there would be nothing on in our modern-day society. For FAG, steel production is important in two respects. On the one hand FAG bearings in steelworks and rolling mills contribute to the energy-saving production of high-performance steel products.

On the other hand FAG itself depends on high-performance alloys in order to produce even its enhanced rolling bearings. This is how the wheel comes full circle.

Extreme stress and infernal temperatures

The supporting bearing arrangements of steel converters are exposed to heavy shocks during tilting and dumping. In the converter, which often weighs up to 300 tonnes itself, liquid raw iron is converted into different steel alloys.

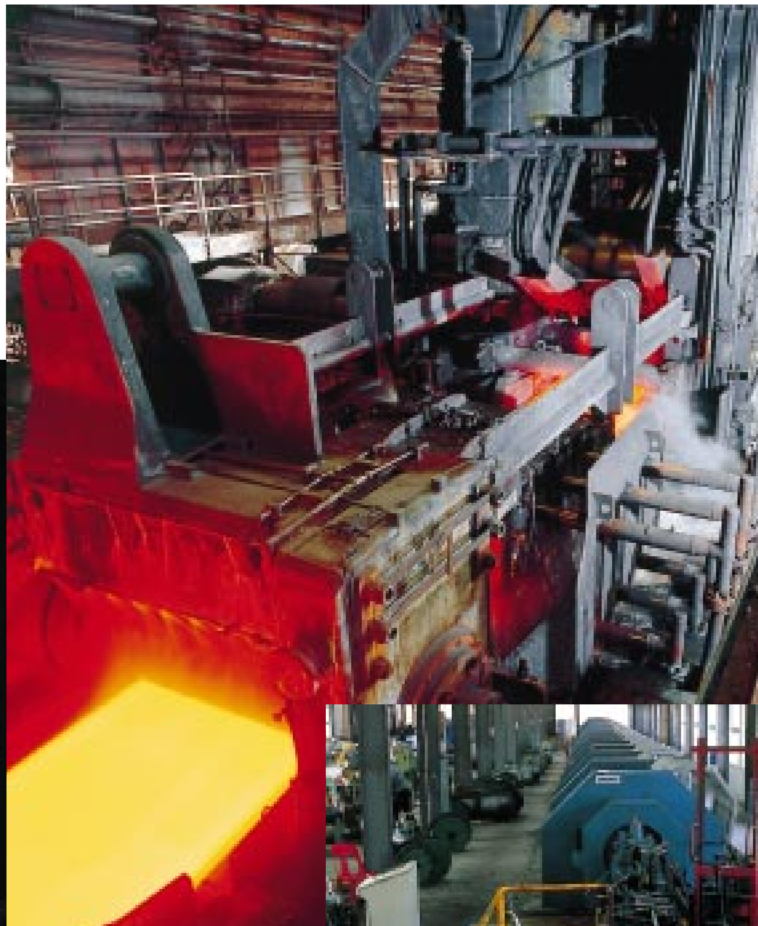
Steel

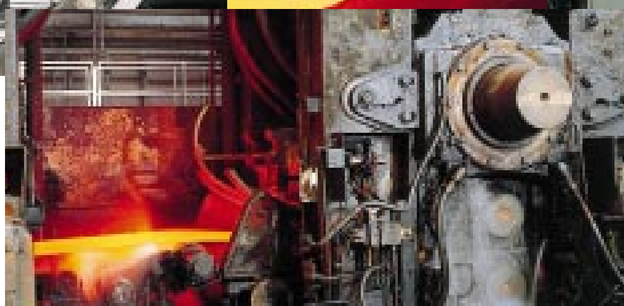
Continuous casting plants where bearings are exposed to high forces and extreme temperatures are similarly impressive. One should bear in mind that only as from temperatures over 900 °C, iron will reach its liquid state and that this "infernal mash" heats up its surroundings to a considerable degree. To ensure that the operation of FAG bearings is not impeded they are mounted in housings with special water cooling.

Heaviest labour in rolling mills

One can hardly imagine what forces are required in a rolling mill to roll a 2 millimetre steel sheet from a 300 mm slab. Or what precision is required to produce a wafer-thin foil of 0.006 millimetres. Here the radial load of the rolling mill bearings can exceed 30,000 kN, and the multi-row FAG tapered and cylindrical roller bearings – usually four-row bearings - have to do heavy labour – in the true sense of the word. This does not mean that precision goes by the board; in the case of foils the thickness tolerance is a matter of a few thousandths of a millimetre. FAG meets these demands, too. Roll forming places particularly high demands on bearing technology.

If high loads are being transferred during the rolling of heavy sections, the bearings have to rotate quickly in wire rolling in order to achieve rolling speeds of up to 150 metres per second – this corresponds to 540 km/h.





FAG success factors

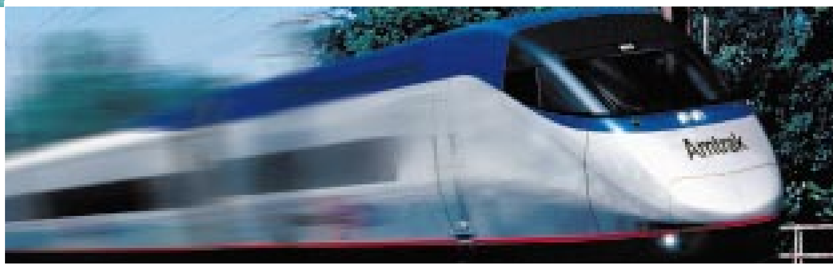
- *Stress optimised bearing arrangements for converters, continuous casting plants, rolling stands*
- *Special bearing arrangements for maximum conveyor speeds*
- *Special bearing designs for high shock loads and vibration*
- *Bearings from case hardening steel of highest purity*
- *Maximum load carrying capacity through optimum internal design*
- *Less maintenance requirements and reduction of operating costs through environmentally-friendly sealed bearings*
- *On-line monitoring to prevent unpredictable downtime of equipment*

Modern human thinking is strongly linked to the concepts of space and time. The interpretation of this pattern comes to a clear quintessence: We want to and have to travel longer and longer distances in less and less time. For people as well as goods, the "go signal" means that distances can be covered quickly and safely. Yet for the operators of rail vehicles it has another dimension – they do not associate it with the green light but more with the basic technical requirements for the reliable and smooth operation of their vehicles. Downtime is expensive.

Extreme stress on axlebox roller bearings

Axlebox roller bearings belong to the major safety components of rail vehicles. At the intersecting point of axlebox and bogie frame they are exposed to extreme stresses while having to fulfil a variety of entirely different demands. In close cooperation with the manufacturers and operators of rail vehicles, FAG develops axlebox roller bearings which are precisely adjusted to their special surroundings.
The bearing types primarily used here are cylindrical and tapered roller bearings.

FAG



Maintenance intervals of 1.2 million kilometres

Through continuous improvements it has been possible to extend the life and maintenance intervals of rolling bearings to a considerable degree. For rail vehicles which are used on long-distance routes, a maintenance-free operation of 1.2 million kilometres is the FAG standard. As the lubricant is of decisive influence on rolling bearing life, FAG maintains close cooperation with renowned lubricant manufacturers in developing new types of heavy-duty grease which will further reduce the friction and wear inside the rolling bearing.

More than 500 km/h

FAG axlebox bearings which are incorporated in long-distance vehicles have achieved speeds of up to 506.8 km/h on test routes. In everyday operation of the German ICE and other high-speed trains 280 km/h is nothing unusual. A stable guidance of the axleboxes in terms of kinematics and travelling comfort of passengers is of the utmost importance.

The reliability of the bearings under extreme conditions is tested on FAG test rigs which simulate travelling speeds of up to 550 km/h and wind speeds of up to 180 km/h.

Lightweight design in short-distance traffic

Frequent stop and go of short-distance vehicles places increased demands on the lubrication of axlebox bearings. Furthermore the weight of underground and suburban trains as well as of city railways and trams must be kept low so that top speeds can be reached as quickly as possible on the short route sections. For this reason, FAG has been using aluminium as housing material since the nineteen-fifties, thus making an important contribution to energy saving.

Bearing arrangements in transmission gears and traction motors

In addition, FAG develops and manufactures rolling bearings which are incorporated in transmission gears and traction motors.

The transmission gears in rail vehicles incorporate practically all types of ball and roller bearings for shaft guidance while traction motors primarily include cylindrical roller bearings at the pinion end and cylindrical roller bearings or deep groove ball bearings at the locating bearing end.

FAG success factors

- *High reliability of components through state-of-the-art design methods*
- *High economic efficiency through low operating costs and extended maintenance intervals*
- *Quiet and smooth operation*
- *Stable guidance*
- *Energy saving through weight reduction*
- *Use of environmentally acceptable materials*

The economic efficiency of a bearing arrangement incorporated in electrical machinery and transmission aggregates is essentially determined by two factors: performance capability and costs. On the other hand, load carrying capacity, guiding accuracy, speed strength and low noise are the decisive parameters for the quality of a bearing. No matter whether the operating loads are high or low, whether a standard bearing or a special design is required, the wide selection of different types of FAG ball and roller bearings makes it relatively easy to choose the best suitable bearing for a specific customer application.

The right bearing design or system solution for each field of application

The extensive FAG bearing range meets all kinds of different demands. It is addressed to the manufacturers and operators of electric motors and generators, electric household appliances, wind power plants and gears for all kinds of industrial facilities. If certain requirements cannot be fulfilled by bearings from our standard product range, we will develop an individual tailor-made solution in cooperation with the customer.

FAG

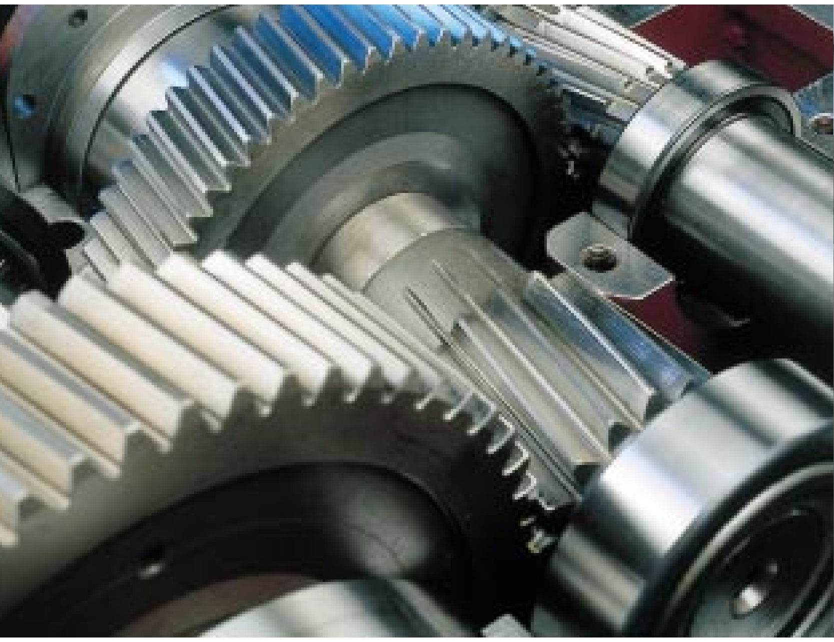
Mechanical Transmission
& Electrical Machinery

Often, complete system solutions are the obvious choice. Here we depend on the branch-specific knowhow of our application engineers as well as the all-embracing competence of our experts from the research and development sector. One example of a product developed in this way is the sensor bearing, an integration of rolling bearing and modern sensor technology, enabling control, regulation and monitoring functions.

Our package of services

Each of our customers benefits from attractive services centred around the rolling bearing. In close cooperation with our experts, he can take advantage of their branch-specific experience in order to select reliable and cost-effective bearing arrangements.

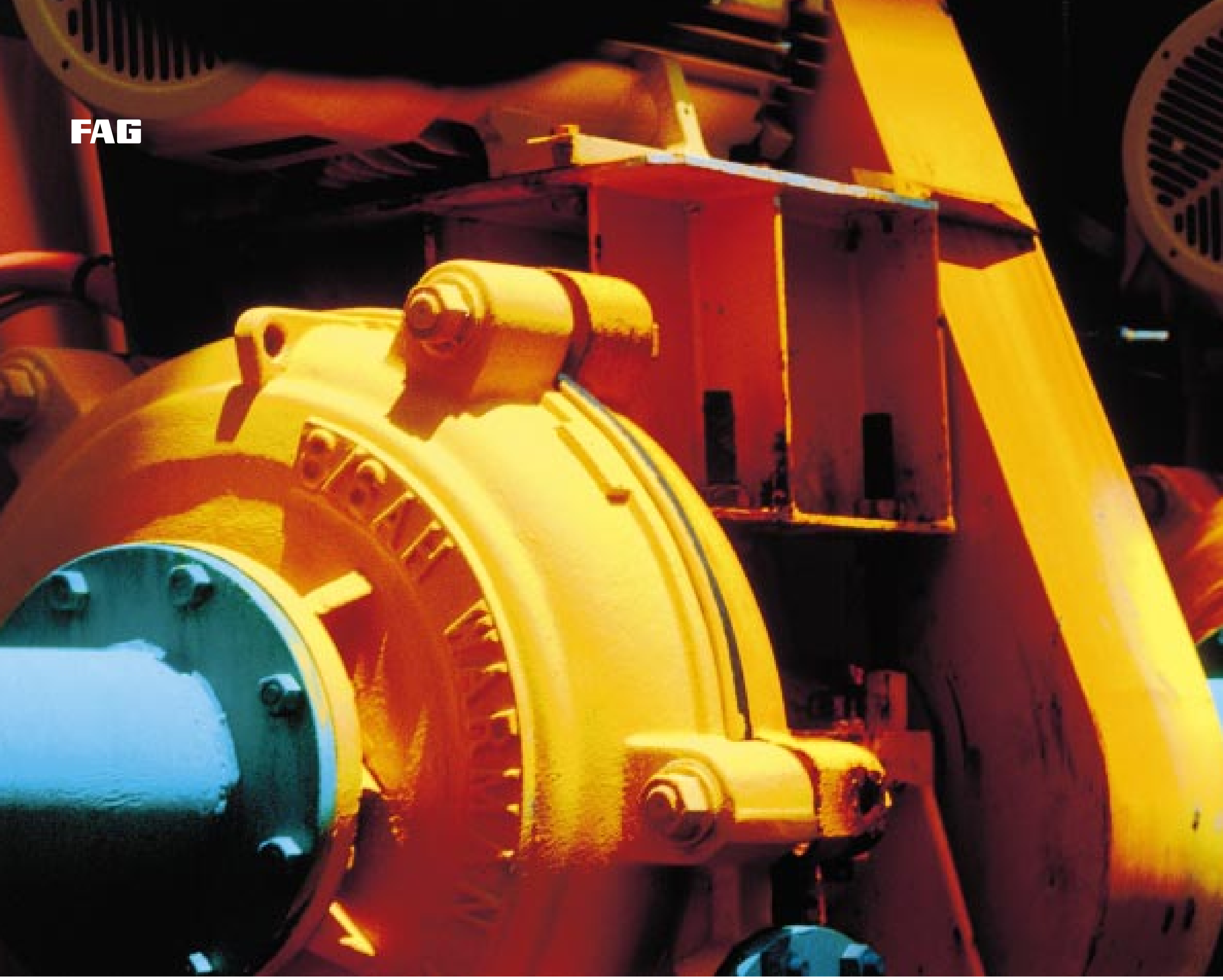
On request, FAG service technicians will train the staff of our customers and take over the mounting and monitoring of bearings. The FAG Bearing Analyser, a notebook with vibration sensor and analysis software, is a typical example from our package of services related to the rolling bearing.



Prior to the final determination of the bearing type, there are usually extensive special calculations to ensure that all operating conditions have been taken into consideration. For this purpose, FAG can call upon a wide selection of modern in-house calculation programs including a calculation service. But our advisory service goes far beyond the field of bearing selection. We also clarify all questions related to the design of adjacent components, the lubrication, sealing and mounting or dismounting of bearings.

FAG success factors

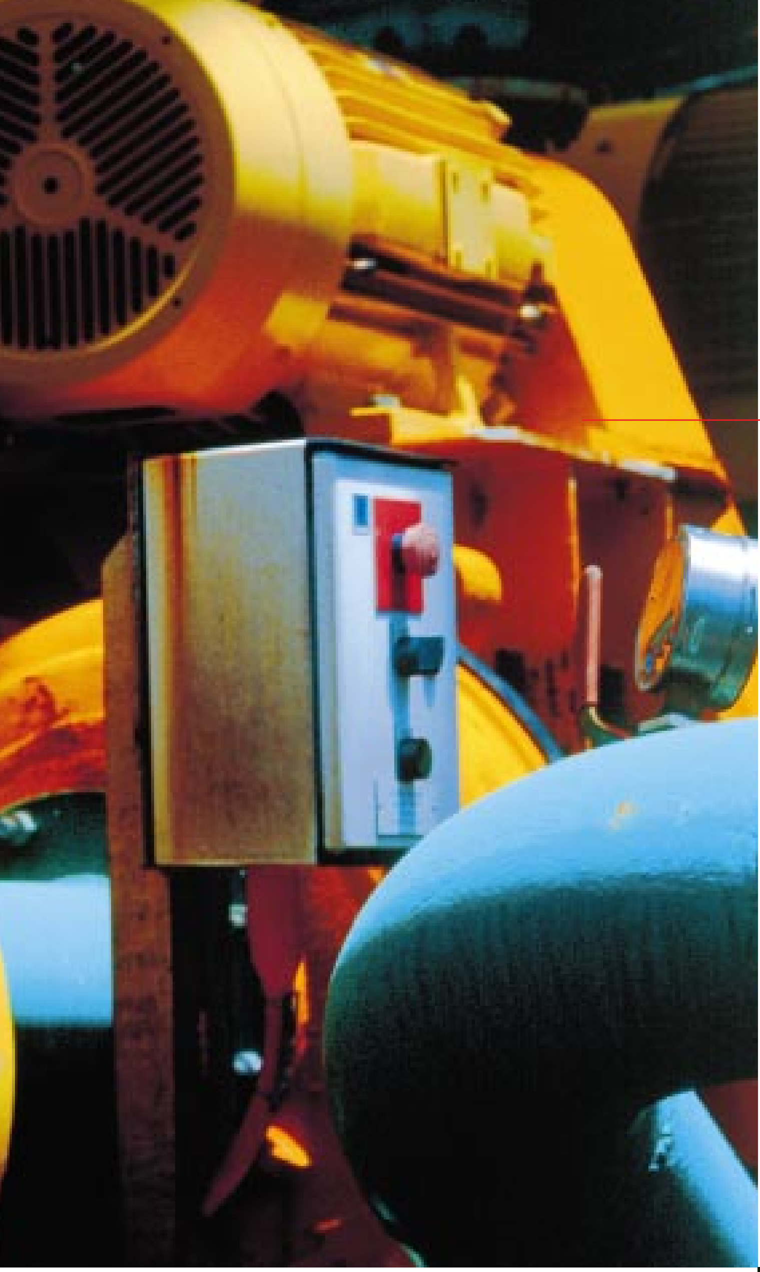
- *Development partnerships with our customers*
- *Practice-oriented life calculations for bearing selection and documentation*
- *Extensive range of advanced calculation programs*
- *Wide and standardised selection of all popular bearing designs and dimensions*
- *Worldwide availability of our products*
- *Supreme manufacturing quality, ensuring lowest possible noise level for electrical equipment*
- *Ceramic insulation against passage of electric current*
- *Complete range of services all around bearings*



Just like a conveyor belt which keeps transporting one part after another, FAG keeps developing bearing solutions. However, FAG also develops bearing arrangement solutions for conveyor belts since wherever things are in motion, FAG rolling bearings are not too far off. The term Special OE Industries embraces all those manufacturers and users who are at home in special branches of the mechanical and apparatus engineering industry, for instance in the sectors of pumps and compressors, printing machines, textile machinery, agricultural machinery, machine tools, conveyor belts and vehicles, communal antennae, medicine technology, etc.

100 kilometres through the desert

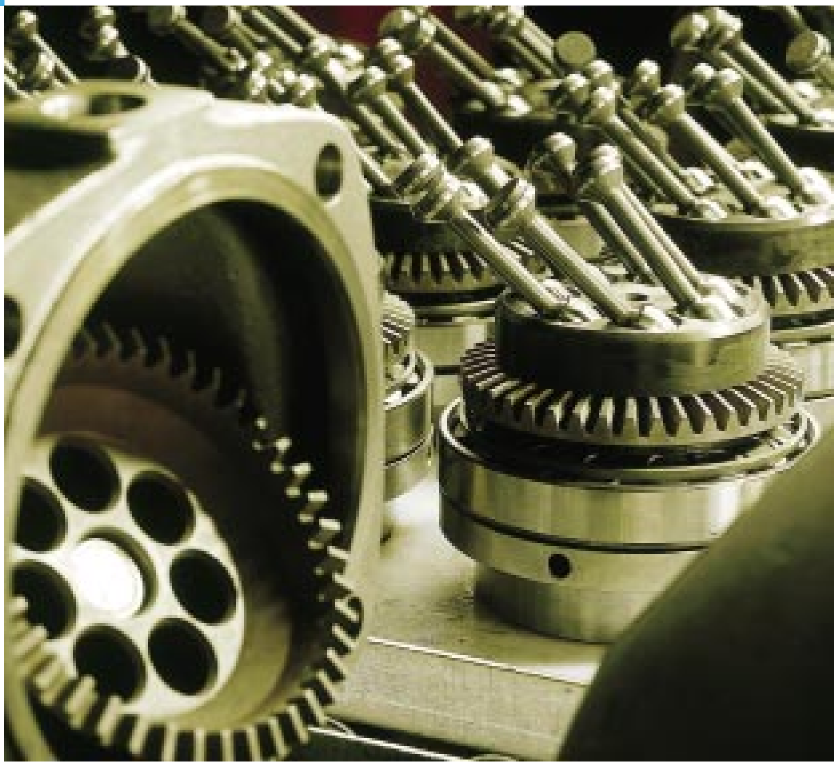
In factories, working processes would be unthinkable without conveyor belts and assembly lines. They function according to the principle "If the mounting personnel won't come to the workpiece, the workpiece will come to the mounting personnel". In this way they make work easier for innumerable people. The dimensions of the longest conveyor belt system in the world are not quoted in metres but in kilometres. At the Northwest coast of Africa, in Spanish Sahara, it transports rock phosphate over a distance of 100 kilometres! It goes without saying that reliable and easy running FAG bearings are particularly sought after when such distances are involved. Any trouble in operation or any unnecessary friction increases the energy demand of the conveyor belts which in any case is extremely high.



FAG

Special OE Industries

The distances that have to be covered by paper sheets are much shorter but then they are led with an enormous pressure through the cylinders of the printing machines. With high running accuracy, the low-friction bearings ensure that the printing quality leaves nothing to be desired. For the bearing arrangement of the main cylinder FAG has developed locating/floating bearing concepts in numerous variations. On a smaller scale but just as efficient and precise, special FAG bearings for office and communication technology do their work in printers, copying machines, computers etc. Precision à la FAG also makes an essential contribution to the smooth functioning of many medical instruments. The utmost smoothness and quietness of operation and a low frictional moment are some of the characteristic features of special bearings which FAG delivers as complete ready-to-mount units for computer tomographs.



Plenty of wind and air

While solid materials can be transported by means of belts, pumps of different capacity are required for the transport of liquid or gaseous substances. FAG has developed a wide selection of maintenance-free rolling bearings for incorporation in pumps used in the home for water supply or in heating systems.

Bearings in large pumping stations which ensure the oil or gas transport through pipelines, work under considerably tougher conditions. Also in the case of compressors and ventilating fans the different dimensions place totally different demands on bearing technology. In a "harmless" desk fan simple ball bearings ensure fresh air. However, the blasts required in brown coal fired power stations have to move up to 800,000 cubic metres of smoke and fumes.

Here, rotational speeds measure up to 400 kilometres per hour. The relatively small FAG spherical roller bearings which are incorporated in these blasts have a nominal life of more than 100,000 hours.

FAG success factors

- *Maximum load carrying capacity in a minimum of space*
- *Application-oriented designs*
- *Complete system solutions through bearing units (housings, bearings, sleeves, lubrication, sealing)*
- *Wear-reducing rolling bearing coatings*
- *Special applications for rolling bearings with rolling elements made from 100Cr6 and rings made from W220 as well as bearings with rolling elements made from ceramics and rings from Cronidur 30®*
- *S-type bearing range in line with market requirements*
- *Quick implementation of FAG research results*

All over the world, our distribution partners keep a wide selection of FAG bearings in stock. The composition of these regional stocks depends on the customer structure of the respective distributor. Stock-keeping is adjusted to individual customer requirements and planned well ahead.

Partnership in the foreground

Sufficient and appropriate stocks together with quick availability and the resulting short-term deliveries are the decisive criteria for the performance capability of our distribution partners. Each will ensure that all rolling bearings are at the right place at the right time, even in the case of unscheduled maintenance works.

Products will be delivered within 24 hours – 365 days a year. In top urgent cases our distribution partners will deliver from one hour to the next, thus avoiding expensive downtime. Modern on-line networks and EDP connection to FAG ensure flexibility and smooth flow of information and goods. Many FAG distribution partners are in a position to supply the entire FAG range, i.e., in addition to rolling bearings, they also deliver the complete range of products from power transmission engineering, lubrication engineering, safety engineering and sealing engineering. FAG distributors are regarded as being our partners who do not only sell our goods but also convey knowhow. The distributors are at the centre of the "Customer-Trade-Manufacturer Axis" and take over important consulting and service functions.

Distribution Partners

Transport and logistics play of course an equally important role in the distribution sector. Our distribution partners have long years of experience in the forwarding business. For them speed is not a piece of witchcraft but often the decisive factor in order placing.

For this reason their regular instruction by FAG experts takes place as a matter of course.

On-time delivery from manufacturing site to distribution partner / On-time delivery from distribution partner to customer

The flawless logistic concept ensures the worldwide availability of FAG bearings. Here, the four European FAG warehouses play a central role. Since the beginning of 1999 all activities of transport logistics have been controlled in Schweinfurt, Milan, Brussels and Stockholm. For the markets in North America and Asia, FAG has only recently reorganised transport logistics.

FAG success factors

- *Worldwide presence through a close-meshed network of sales companies*
- *High availability of all bearings*
- *Extensive delivery service*
- *Training sessions for distribution partners and their own customers*
- *Cooperation with international logistic partners*

For the users of FAG bearings, service is more than just an optional and temporary extra but rather a performance procedure which is already employed in the design of a bear-ing. For what use is a clever design if the bearing itself can only be mounted in a complicated and thus uneconomic way?

Service right from the beginning

During their entire life, FAG services will accompany the bearings. The FAG motto "Service for increased operational reliability" means that at any time a user can rely on personal support and advice or on being equipped with all the instruments required for independent mounting, measuring, diagnosis and maintenance works.

FAG

Service

Well trained and experienced fitters and chief fitters

On request, experienced FAG fitters undertake the mounting of all types of rolling bearings, the acceptance inspection of the mating components (shafts and housings), failure diagnosis in the case of bearing arrangements working incorrectly and dismounting of bearings of all kinds. They are also prepared to instruct the fitting personnel and give advice in terms of mounting procedure rationalisation. The fitters also assist in selecting the suitable tools and introduce the devices and corresponding procedures.

A complete range of quality tools

Supreme caution during mounting and cleanliness at the mounting location are essential requirements for long bearing life. Here, a large variety of suitable mounting instruments and other equipment is required; for instance induction heating devices, special extractors, hydraulic nuts or, for hydraulic procedures, modern hand pump sets and high-pressure pumps. Which mounting procedure is suited best will be decided for each particular application. Furthermore, FAG has compiled a measuring device programme which corresponds precisely to the needs of everyday work. It includes simple feeler gauges and taper master rings as well as taper measuring instruments, boundary circle measuring instruments, temperature measuring devices, speed counters and sound locators. They can be applied for checking the bearing seating, adjusting the radial clearance, monitoring the temperature during mounting and, when in operation later, for measuring speeds and analysing bearing noise etc. To enable all machine operators to avail themselves of the economic advantages of condition-dependent maintenance, FAG offers different diagnosis systems. The FAG Detector has been designed for simple bearing arrangements while the Bearing Analyser, a synthesis of Detector and laptop, offers enhanced comfort, mobility and interpretation reliability.

Boundary curve spectrum and time signal make damage visible and damage progress predictable. The diagnosis system VibroCheck was designed for on-line monitoring and long-distance diagnosis of rolling bearing arrangements and gears. The entire monitoring system is adjusted and controlled via a PC.

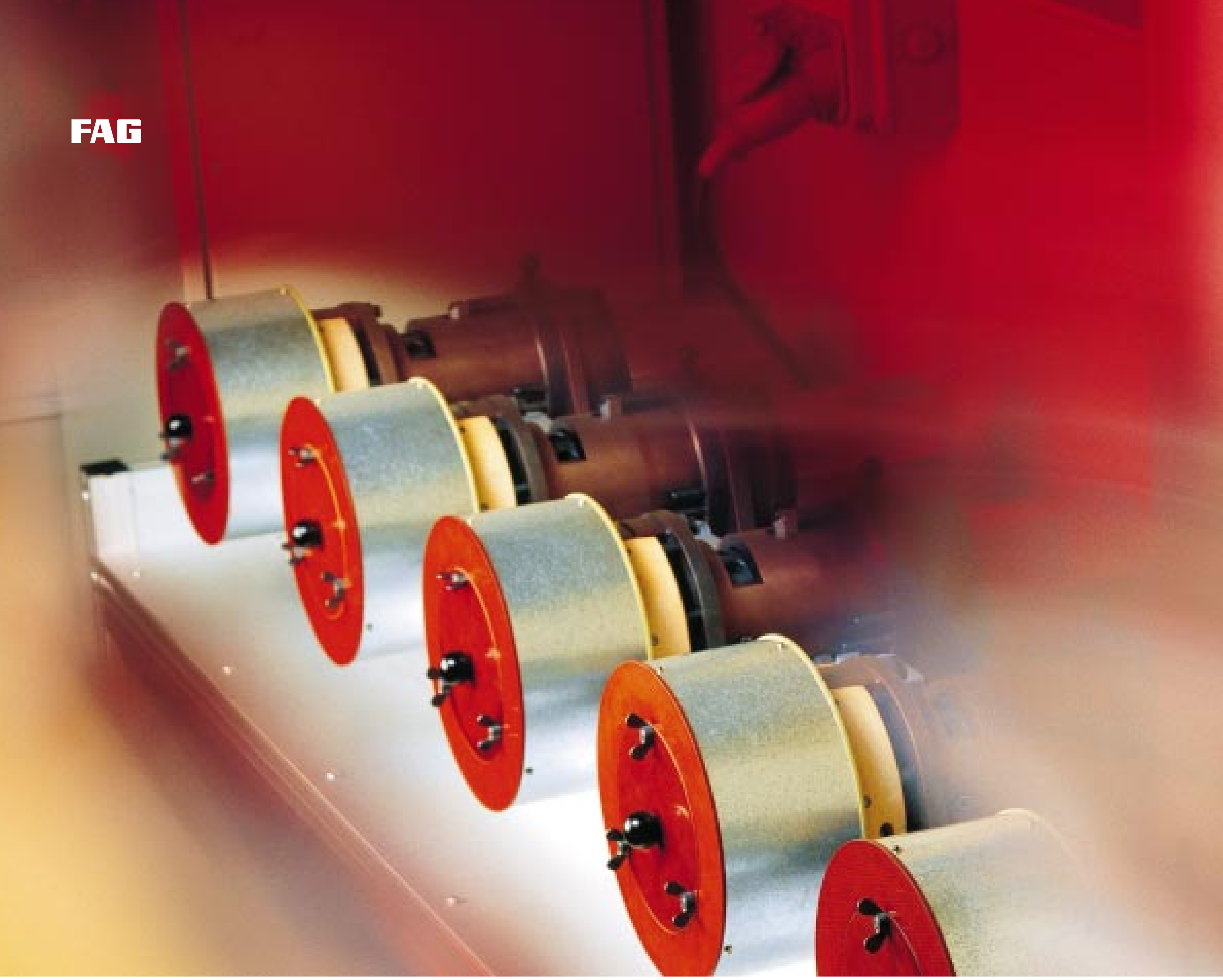
Good service all round

Increased technical knowledge helps to avoid bearing damage and extend bearing life. Therefore FAG offers a wide range of publications, starting from catalogues via branch information through to specialised literature.

Selection and calculation programs, a training programme, video films, practice-oriented training sessions as well as a basic rolling bearing course for professional training round the programme off.

FAG success factors

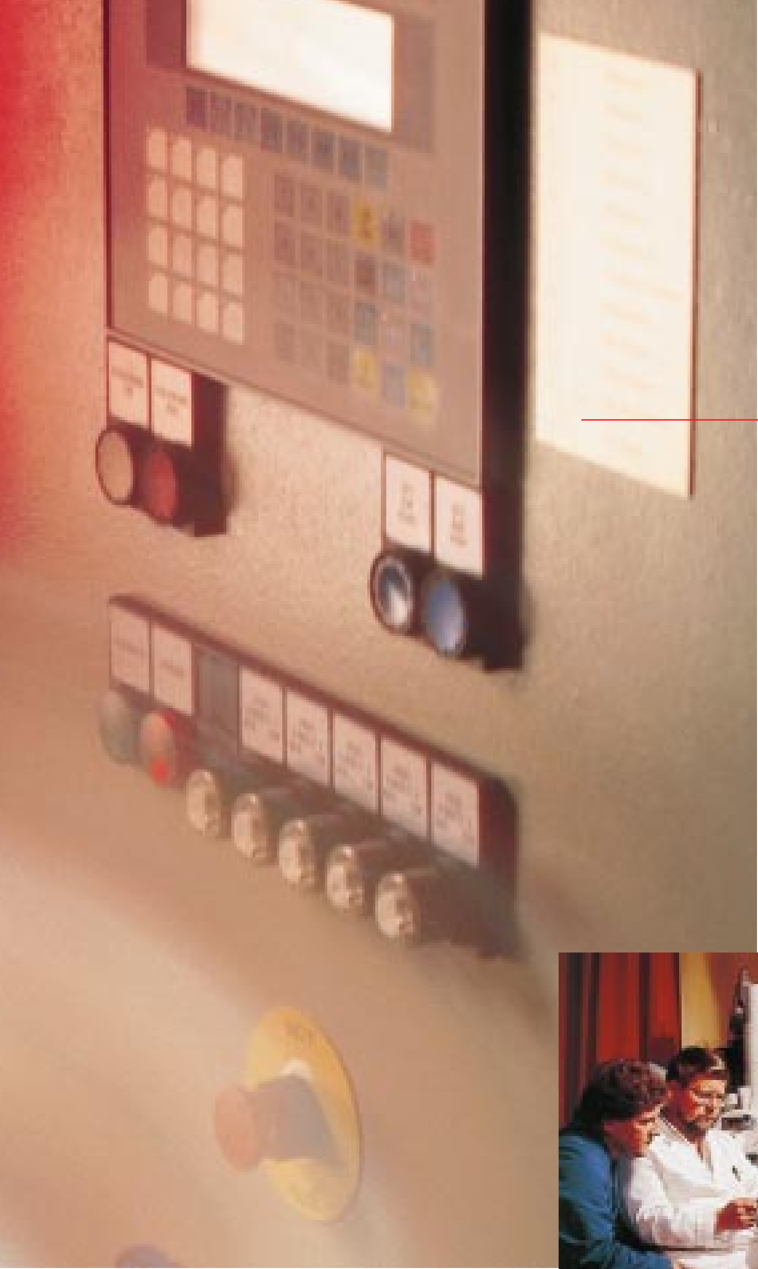
- *FAG offers "Service for increased operational reliability"*
- *The customer gets all services from one place*
- *FAG service technicians are well trained and equipped*
- *An electronic catalogue for bearing selection and calculation of a bearing arrangement, a shaft and a shaft system*
- *State-of-the-art diagnosis systems for condition-oriented monitoring of facilities and machinery*
- *Cooperative stock management*



Somebody once said "Research and development bring knowledge out of money; innovations bring money out of knowledge." Admittedly there is always some blurredness to such formulas but one cannot deny that there is a certain degree of truth in them. Each FAG innovation is the result of extensive research activities; new solutions are not available free of charge. No matter how high the level of a product, it will be the starting point for further improvements. Whenever the market defines new requirements, FAG will find the unprecedented solution. Only Research and Development will buy us the ticket for our company's future. Little wonder that the investments in this sector will see a spectacular increase in the coming years.

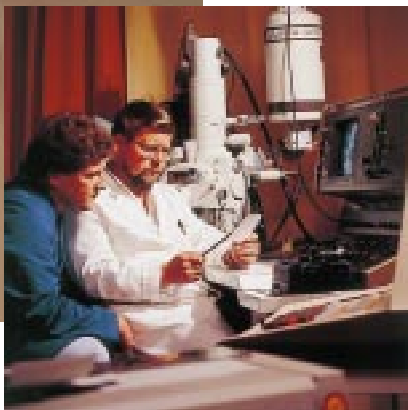
For the operational practice

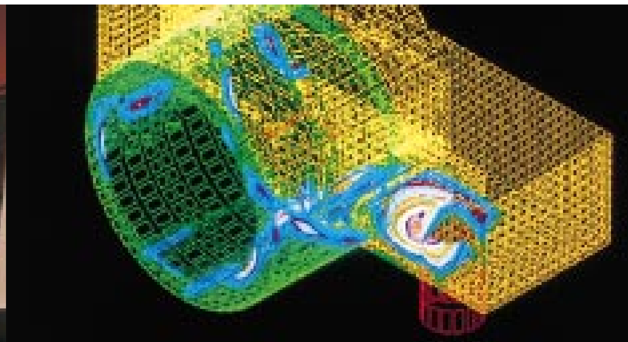
At FAG, Research and Development is not practised in an isolated ivory tower. Starting point for all activities are the requirements of the ultimate practical operation. Scientists and application engineers work closely together. The central themes of R&D activities are tribology and the development of modern calculation methods as well as the material, stress and damage analysis. The FAG research centre with its entire equipment is also open to external users.



Research and Development

- *On standardised grease test rigs developed in-house, we examine the life, friction and wear of grease by applying FAG test methods.*
- *FAG methods of rolling bearing life calculation, which take into consideration failure probability, material, lubrication, load, bearing type and cleanliness*





FAG success factors

- *New materials such as Cronidur 30®, which stand out for particular strength, corrosion resistance, durability and high-temperature hardness*
- *Hybrid bearings with rings made from steel and balls from ceramics offer considerably enhanced operational speeds and/or longer service life than conventional bearings*
- *Special coatings improve the tribological behaviour of rolling bearings, increase the resistance to wear and corrosion and ensure insulation against passage of electric current*

Quality assurance

Quality is created in the manufacturing process

No FAG product will leave the manufacturing site before its quality has been verified through examination at a number of different test rigs.

All procedures are described in our quality handbook and certified in accordance with DIN EN ISO 9000 ff. However, we can only test what we have produced beforehand. In particular this applies to the quality of an FAG bearing and its components. In other words: Quality is created in the manufacturing process and not as a result of subsequent inspection.

For a long time companies regarded it as a strenuous and painful undertaking to assure the quality of their goods. But is that really true? On the contrary! The experience made by FAG proves that quality on the part of both the supplier and the customer brings a high degree of gratification. The better the quality, the more motivated and satisfied are all the people involved. This has absolutely nothing to do with strenuousness and pain but more with efforts and the willingness to accept responsibility for the result.

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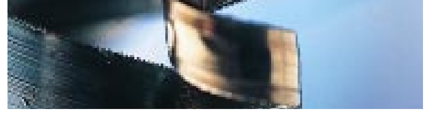

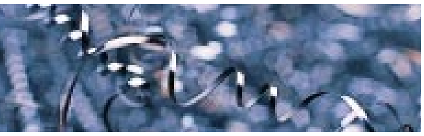

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Tenfold service life under the severest conditions

Rolling Bearings Made of Cronidur 30®

FAG

FAG OEM und Handel AG

Cronidur 30® is a new rolling bearing material which one has yet to become accustomed to – in the positive sense. For rolling bearings made from this material do not merely exceed all known standards relating to corrosion resistance and fatigue life.

In the sports field you might say: "Rolling bearings made of Cronidur 30® pulverise all previous records".

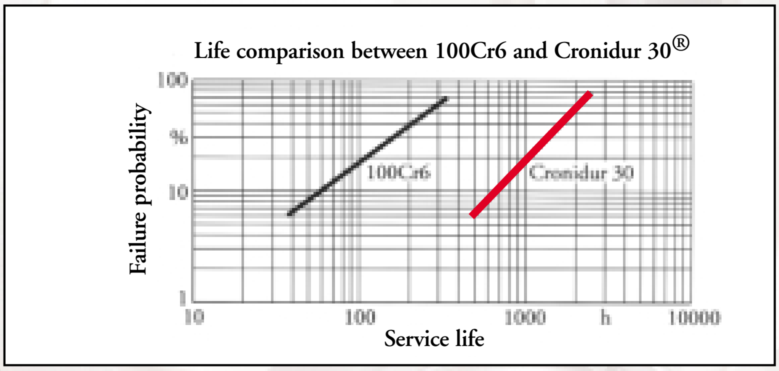
A new material

Cronidur 30® is a new material employed in the manufacture of severely stressed rolling bearings. It was developed by FAG in cooperation with Ruhr-Universität Bochum and VSG Energie- und Schmiedetechnik Essen. The development of Cronidur 30® achieved recognition in the form of the Steel Innovation Award of the German Stahlinformationszentrum (steel information centre).

Stahl-Innovationspreis

Rolling bearings today are normally manufactured from the well-proven standard rolling bearing material 100Cr6 or the corrosion-resistant steel X102CrMo17 (AISI 440C). Nevertheless it had become necessary to create a material which could accept a higher load at the rolling bearing surface and elevate the limiting values relating to life, especially under difficult ambient conditions. Cronidur 30® meets these demands admirably.

Ten times the service life



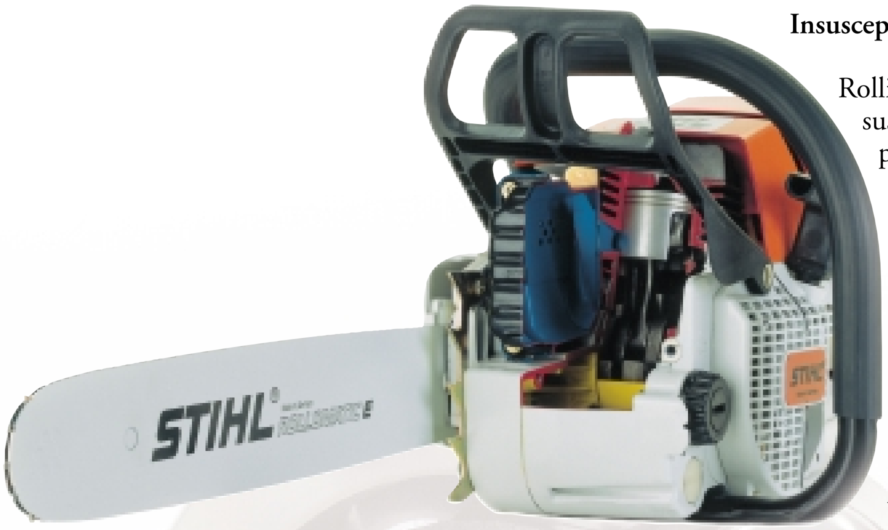
Considerable improvements

The most important alloying components of Cronidur 30® are nitrogen, carbon, chromium and molybdenum. Their new quantitative composition resulted in a material which offers considerable improvements when compared to former alloys. In particular this applies to the criteria cycling strength, corrosion resistance and high-temperature hardness. Cronidur 30® is a martensitic through-hardening steel which has been remelted in a special process. Cronidur 30® has an extremely fine grain structure.

Multiple service life of Cronidur 30® bearings:
At least Factor 10 in the space shuttle
At least Factor 10 in motor saws
At least Factor 4 in mining pumps

Heat treatment

The heat treatment used gives Cronidur 30® excellent hardness values even at higher temperatures. Consequently, rolling bearings of Cronidur 30® can be used at higher temperatures than bearings made of 100Cr6.



Insusceptible to dirt

Rolling bearings of Cronidur 30® are less susceptible to contaminants. Although dirt particles that penetrate into the bearings leave indentations in the raceways, these indentations do not cause premature fatigue damage. Any bearing damage that does develop spreads four times slower than in conventional bearings.

Media lubrication possible

Due to the small amount of wear particles there is hardly any contamination of the lubricant. As the few wear particles do not corrode, there is no catalytic effect – both with grease and oil lubrication the quality of the lubricant remains at a constant level over a long period. The favourable characteristics with respect to mixed friction and corrosion resistance also permit Cronidur 30® to be used with medium lubrication in many applications, for instance with liquid hydrogen or liquid oxygen. The use in pumps for hydrous hydraulic fluids was especially useful.

Ultimate life with Cronidur 30®

Tests document that rolling bearings of Cronidur 30® stand out for their substantially extended material fatigue life. At a contact pressure of 2,800 MPa under EHD conditions the calculated life values are exceeded by the factor of 80 without failure. In hybrid bearings incorporating ceramic balls, Cronidur 30® accepts a 25 per cent higher contact pressure. This would relate to a 40 per cent increase in rolling element with point contact.

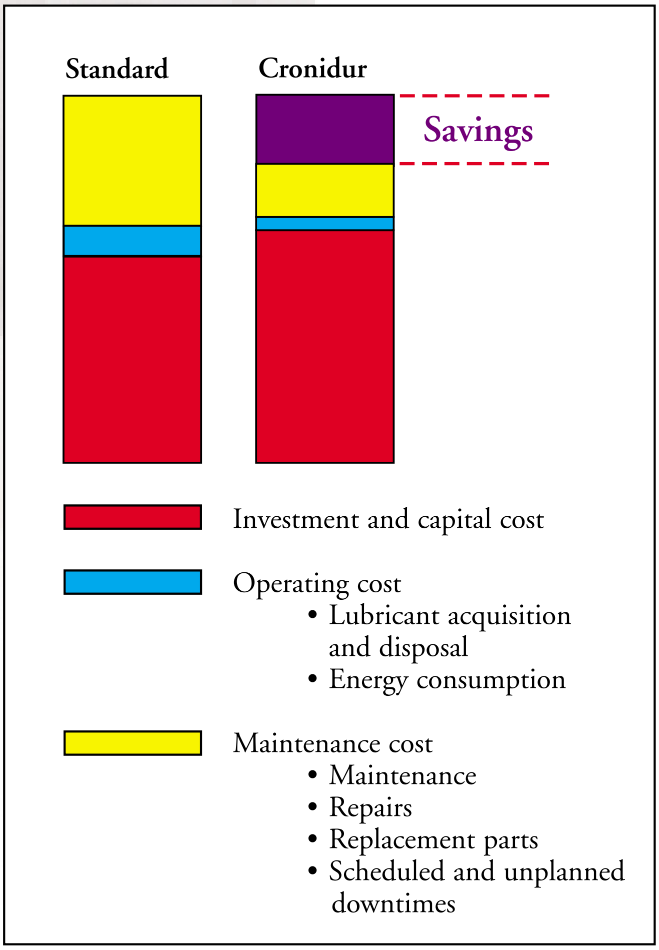
Reliability under conditions of mixed friction

Even in the mixed friction range, Cronidur 30® proves its superiority. Tests carried out under a defined condition of mixed friction (p_0 = 2,500 MPa) have shown that bearings of Cronidur 30® reach a tenfold service life compared with bearings made of standard material 100Cr6. Furthermore, the wear behaviour of the bearing is considerably improved with Cronidur 30®. This becomes particularly apparent in the case of hybrid bearings with rings consisting of the new material and ceramic rolling elements. Here, the wear rate lies considerably below the former usual values.

Corrosion-resistant

Although the amount of chromium is lower in Cronidur 30® than in rolling bearing steel 440C, which has so far been used as standard material for corrosion-resistant bearings, the combined effect of its other components makes Cronidur 30® far more corrosion-resistant. In a sulphuric acid solution, its passive current density – a measure for the corrosion resistance – is 100 times lower than that of 440C.

Comparison of the two systems' life cycle costs



Fields of application and system cost

Cronidur 30® was developed for applications in the aircraft and aerospace field, for instance for the main engines of the Space Shuttle, where the cost of bearing replacement is several times that of the material cost of the bearings.

The life cycle cost of complete systems including rolling bearings made of Cronidur 30® is clearly reduced:

- Fewer unexpected bearing failures, and consequently fewer machine standstill periods due to
  - a reduced damage probability
  - a slowdown in the progress of damage
- Fewer scheduled machine downtime periods for bearing replacement due to
  - longer service lives, even under extremely adverse ambient conditions
  - corrosion resistance
  - insusceptibility to contamination
- Reduced cost of lubricant acquisition and disposal
- Reduced personnel cost for mounting and dismounting
- Reduced demand for replacement bearings

Cronidur 30® also makes possible an increase in the power density of machines as well as downsizing and light-weight constructions.

The fields of application for rolling bearings of Cronidur 30® or bearing components made of this material are very diverse, and individual solutions are developed to every problem.

Rolling bearing components made of Cronidur 30® are used for many applications, including:

- swashplate bearings in helicopters
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- hydraulic pumps
- wire guiding rollers
- cutter head bearings in oil production
- spindle bearings
- turbine bearings
- bearings in turbomolecular pumps
- bearings in bordering tools for beverage cans
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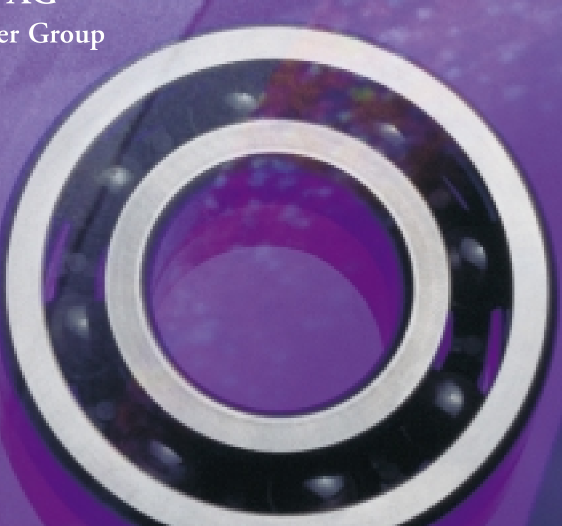

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Mounting and Dismounting of Rolling Bearings

Publl. No. WL 80 100/3 EA

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A company of the FAG Kugelfischer Group

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Mounting and Dismounting of Rolling Bearings

Publ. No. WL 80 100/3 EC/ED

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Preface

Rolling bearings are heavy-duty machine elements with high-precision components. In order to fully utilize their capacity, the design engineer must select the right bearing type and design and match the bearing properties to those of the mating components. Mounting and dismounting, lubrication, sealing and maintenance must also be given special attention.

Appropriate means for mounting and dismounting of rolling bearings as well as utmost cleanliness and care at the assembly site are necessary in order to enable the bearings to reach a long service life.

This publication is intended to inform bearing servicemen and maintenancemen on handling, mounting and dismounting, lubrication and maintenance of rolling bearings. A special chapter deals with bearing failures and their causes. The tables in the annex specify bearing numbers, tolerances of bearings and their mating components, bearing clearance and FAG rolling bearing greases Arcanol.

For information on special mounting and dismounting tools and methods and on measuring instruments, further publications are available. Bearing mounting problems beyond the scope of this publication should be referred to our Engineering Service.

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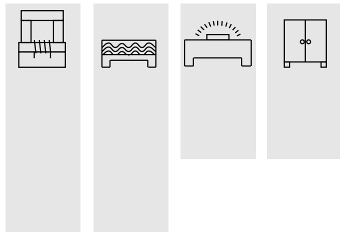
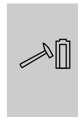
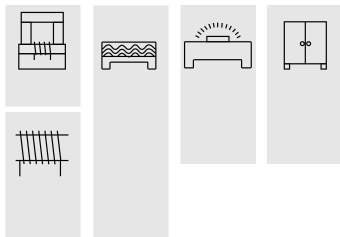
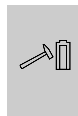
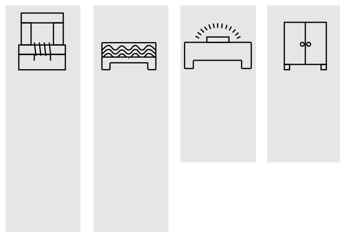
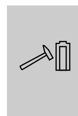
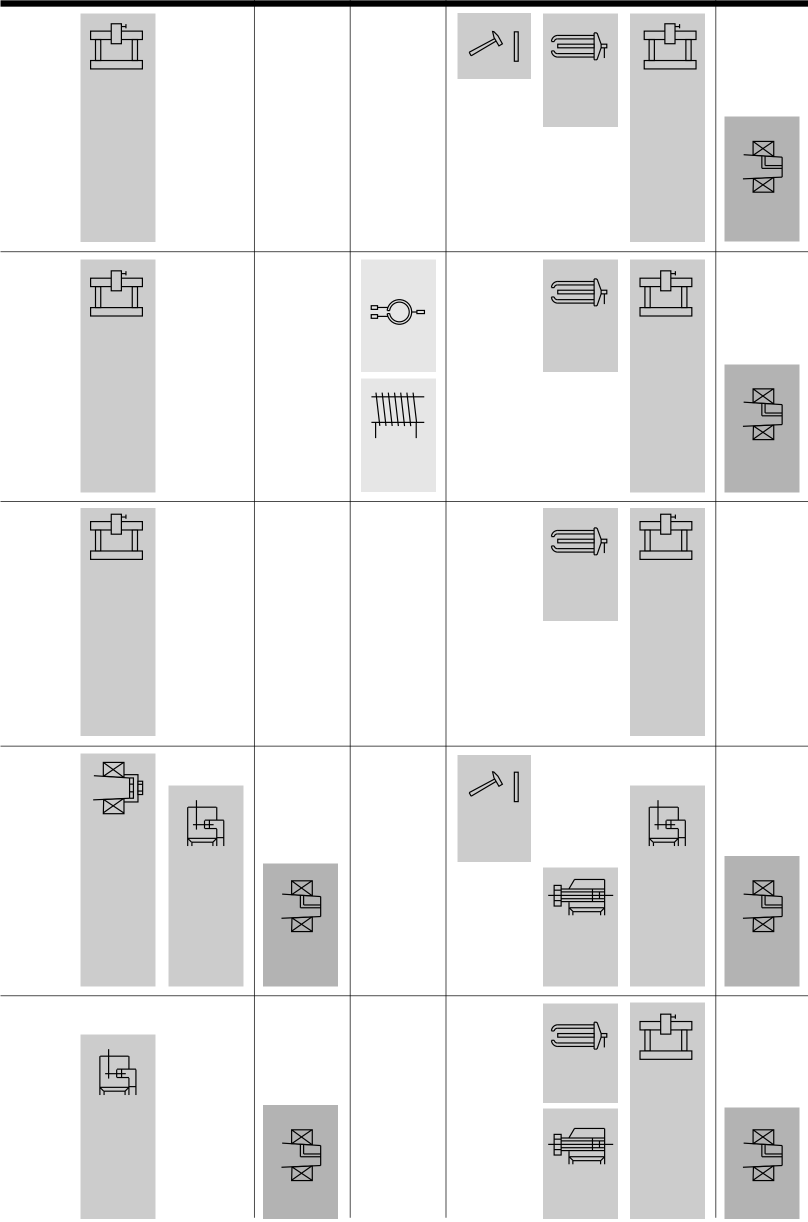
Chart: Tools and Methods for Mounting and Dismoun

Bearing type	Bearing bore	Bearing size	Mounting: with heating	Mounting: without heating
Deep groove ball bearing Magneto bearing Angular contact ball bearing Spindle bearing Four-point bearing Self-aligning ball bearing Tapered roller bearing Barrel roller bearing Spherical roller bearing	cylindrical	small		
		medium		
		large		
Cylindrical roller bearing Needle roller bearing	cylindrical	small		
		medium		
		large		
Thrust ball bearing Angular contact thrust ball bearing Cylindrical roller thrust bearing Spherical roller thrust bearing	cylindrical	small		
		medium		
		large		
Self-aligning ball bearing Self-aligning ball bearing with adapter sleeve Barrel roller bearing Barrel roller bearing with adapter sleeve Spherical roller bearing Spherical roller bearing with adapter sleeve Spherical roller bearing with withdrawal sleeve Adapter sleeve Withdrawal sleeve	tapered	small		
		medium		
		large		
Cylindrical roller bearing, double row	tapered	small		
		medium		
		large		

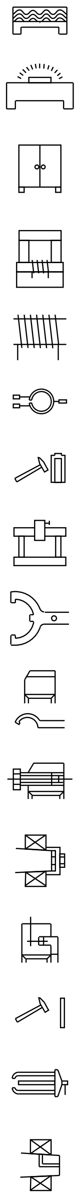
ting

Dismounting

	Hydraulic method	with heating	without heating	Hydraulic method



Symbols



- Oil bath
- Heating plate
- Hot air cabinet
- Induction heating device
- Induction coil
- Heating ring
- Hammer and mounting sleeve
- Mechanical and hydraulic presses
- Double hook wrench
- Nut and hook wrench
- Nut and thrust bolts
- Axle cap
- Hydraulic nut
- Hammer and metal drift
- Extractor
- Hydraulic method

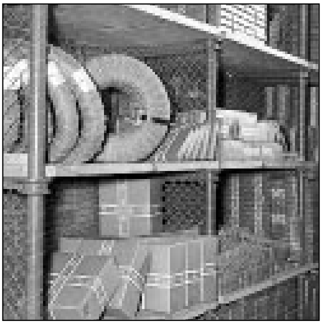
1. Rolling Bearing Storage

1: Rolling bearing storage

a: Large bearings especially should not be stored upright.

b: They should be stored flat and supported over their entire circumference.

a



b

Leave bearings in their original package

Store bearings in their original package in order to protect them against contamination and corrosion. Open package only at the assembly site immediately prior to mounting.

Store larger bearings flat

Larger bearings with relatively thin-walled rings should not be stored upright (Figure 1a) but flat and supported over their whole circumference (Figure 1b).

Prior to packing, FAG rolling bearings are dipped in anticorrisive oil. This oil does not gum and harden and is compatible with all commercial rolling bearing greases. In their original package rolling bearings are safely protected against external influences.

Store bearings in dry rooms

During storage, the bearings must not be exposed to the effects of aggresive media such as gases, mists or aerosols of acids, alkaline solutions or salts. Direct sunlight should be avoided. The formation of condensation water is avoided under the following conditions:

– Temperatures + 6 to + 25 °C,
  for a short time 30 °C

– temperature difference day/night ≤ 8 K,
  relative air humidity ≤ 65 %.

With standard preservation, bearings can be stored up to 5 years if the said conditions are met.

If the permissible storage period is exceeded, it is recommended to check the bearings for its preservation state and corrosion prior to use. On request, FAG will help to judge the risk of longer storage or use of older bearings.

Bearings with shields or seals on both sides should not be kept to their very limit of storage time. The lubricating greases contained in the bearings may change their chemico-physical behaviour due to aging (see FAG catalogue WL 41 520).

2.1 Work Planning

Prior to mounting and dismounting of rolling bearings, several preparatory steps should be taken.

Study shop drawing and phase individual operations

Study the shop drawing to familiarize yourself with the design details of the application and the assembly sequence. Phase the individual operations and get reliable information on heating temperatures, mounting and dismounting forces and the amount of grease to be packed into the bearing.

Whenever rolling bearing mounting and dismounting require special measures, the bearing serviceman should be provided with comprehensive instructions on mounting details, including means of transport for the bearing, mounting and dismounting equipment, measuring devices, heating facilities, type and quantity of lubricant.

2.2 The „Right“ Bearing

Compare inscription on package with data on drawing

Prior to mounting, the bearing serviceman must make sure that the bearing number stamped on the package agrees with the designation given on the drawing and in the parts list. He should therefore be familiar with the bearing numbering and identification system (see tables 7.1 and 7.2, pp. 83 to 85).

Standard bearings are identified by the bearing number listed in the pertinent standards and rolling bearing catalogues. Its structure is a system of numerals and letters. The first group in the system identifies the bearing type and diameter series, also the width series for some bearings. The second group constitutes the bore reference number; for bearings of 20 to 480 mm bore, the actual bore diameter in millimetres is five times the bore reference number.

If operating conditions call for a bearing with special design features, the required bearing characteristics are indicated by suffixes added to the bearing number (see table 7.1, p. 83).

Non-standardized FAG bearings are identified by code numbers from the 500 000 or 800 000 series.

2.3 Handling of Rolling Bearings before Mounting

FAG rolling bearings are preserved in their original package, with an anticorrisive oil. The oil need not be washed out, when mounting the bearing. In service, the oil combines with the bearing lubricant and provides for sufficient lubrication in the run-in period.

Wipe clean seats and mating surfaces of anticorrosive oil

The seats and mating surfaces must be wiped clean of anticorrisive oil before mounting.

Wash out anticorrisive oil with cold-cleaning agent from tapered bearing bores prior to mounting in order to ensure a safe and tight fit on the shaft or sleeve. Then thinly coat the bore with a machine oil of medium viscosity.

Wash out used and contaminated bearings

Prior to mounting, wash used and contaminated bearings carefully with kerosene or cold-cleaning agent and oil or grease them immediately afterwards.

Do not rework rings

Do not perform any rework on the bearing. Subsequent drilling of lubrication holes, machining of grooves, flats and the like will disturb the stress distribution in the ring resulting in premature bearing failure. There is also the risk of chips or grit entering the bearing.

2.4 Cleanliness in Mounting

Keep work area dust-free and dry

Absolute cleanliness is essential! Dirt and humidity are dangerous offenders, since even the smallest particles penetrating into the bearing will damage the rolling surfaces. The work area must, therefore, be dust-free, dry and well removed from machining operations. Avoid cleaning with compressed air.

Wipe clean seats and mating surfaces of anticorrosive oil

Ensure cleanliness of shaft, housing and any other mating parts. Castings must be free from sand. Bearing seats on shaft and in housing should be carefully cleaned from anti-rust compounds and residual paint. Turned parts must be free from burrs and sharp edges. After cleaning, the housing bore should receive a protective coating.

2.5 Surrounding Parts

Check mating parts for dimensional and form accuracy prior to bearing mounting

All surrounding parts should be carefully checked for dimensional and form accuracy prior to assembly

Non-observance of the tolerances for shaft and housing seat diameters, out-of-roundness of these parts, out-of-square of abutment shoulders etc. impair bearing performance and may lead to premature failure. The responsibility of such faults for bearing failure is not always easy to establish and much time can be lost in looking for the cause of failure.

2.6 Fits

Observe ring fits specified on drawing

Good bearing performance is largely dependent on adherence to the fits specified for the rings in the drawing (see table 7.3 and 7.4, pp. 86 to 100).

No one can give a straight answer to the question of the "right" fit; indeed the selection of fits is determined by the operating conditions of the machine and the design characteristics of the bearing assembly. Basically, both rings should be well supported over their seating areas and should therefore be tight fits. This is, however, not always possible, since it makes mounting and dismounting more difficult and is unfeasible with applications calling for easy axial displacement of one ring, for instance with floating bearings.

The interference produced by tight fits expands the inner ring and contracts the outer ring resulting in a reduction of radial clearance. Therefore, the radial clearance should be adapted to the fits.

Check shaft and housing tolerances

The shaft and housing tolerances should be checked. Too loose a fit causes the ring to creep on the shaft which tends to damage both ring and shaft. It also affects the working accuracy of the machine or causes premature raceway fatigue from poor support. On the other hand, too tight a fit may result in detrimental preload and hot running of the bearing.

Check form tolerance of shaft and housing seats

As the walls of rolling bearing rings are relatively thin, possible poor geometry of the mating parts is transmitted to the raceways. The seats must therefore be checked for diameter and form tolerances. For cylindrical seats, cylindricity is checked (DIN ISO 1101). For tapered seats, roundness (DIN ISO 1101), taper angle and straightness (DIN 7178) are checked.

Check roughness of bearing seats

The seating surfaces of shaft and housing smoothen, when joined, the bearing surfaces usually to a lesser degree. The rougher the surfaces, the more marked is the loss in interference. Therefore, the roughness of the bearings seats (DIN 4768) is also checked.

2.7 Inspection of Bearing Seats

For all measurements ensure that the measuring instrument has approximately the same temperature as the parts to be measured.

2.7.1 Cylindrical Seats

Shafts are generally checked with external micrometers (Fig. 2); The measuring accuracy must be checked by calibration.

2: External micrometer for measuring shaft diameters

3: A snap gauge ensures safe positioning and perfect measurement of cylindrical seats. The diameter for setting the gauge is marked on the master ring.

Another useful instrument is the snap gauge shown in fig. 3. It functions as a comparator and its correct setting is checked with master rings. These master rings are supplied by FAG for each diameter.

Bores are checked with internal micrometers (Fig. 4).

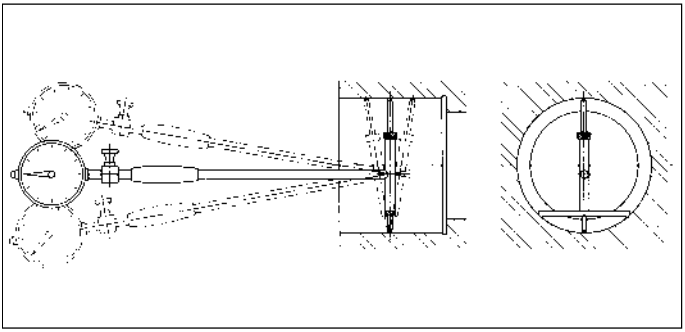
Conventional comparative measuring instruments are also used (Figs. 5 to 7).

4: Internal micrometer for bore measurements

5: Comparative measuring instruments are especially suitable for bore measurements. The master ring is used for setting.

6: A housing bore is measured with a bore measuring instrument.

7: Principle of the measurement with a bore measuring instrument (determination of the minimum dimension).

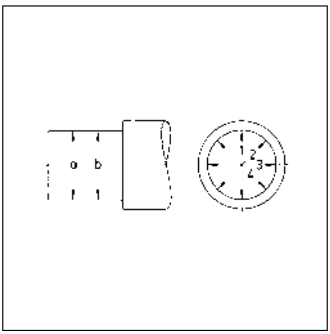


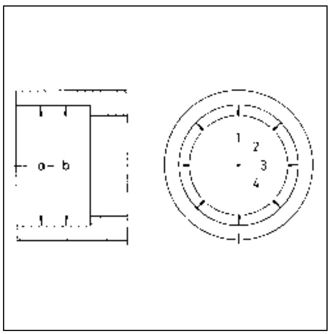
Check diameter and cylindricity of shaft and housing seats

Shaft and housing seats are checked for their diameter and their cylindricity.

Normally, the diameter is measured in two different cross sections and several planes (two-point measurement) (Figs. 8 and 9).

8, 9: Usually the cylindricity of shaft and housing seats is checked by measuring the diameter in two cross sections and several planes (two-point measurement).





Unless otherwise specified in the shop drawing, the cylindricity tolerance should not exceed half the diameter tolerance (two-point measurement).

According to DIN ISO 1101, the cylindricity tolerance refers to the radius. The tolerance values specified according to this standard must therefore be doubled for two-point measurements.

2.7.2 Tapered Seats

Full inner ring support on the shaft requires exact coincidence of shaft taper and inner ring bore taper.

The taper of rolling bearing rings is standardized. For most bearing series it is 1:12, for some large width series 1:30.

The master taper ring (Fig. 10) is the simplest measuring device.

Conformity of shaft and master taper is ascertained by blueing. An inadequate shaft taper must be improved, until the master ring shows full width support. FAG supply master tapers for taper diameters from 25 to 150 mm.

Bearing inner rings should not be used as master rings.

Do not use bearing inner rings as master taper rings
Use FAG taper measuring instruments MGK 133 and MGK 132 for exact checking

For the exact checking of tapered shaft seats FAG developed the taper measuring instruments MGK 133 and MGK 132. The use of a reference taper or segment enables exact measurement of the bearing seat taper and diameter. Both instruments are easy to handle; the workpiece to be measured need not be removed from the machine.

10: Master taper ring for checking small tapered bearing seats

11: Taper measuring instrument FAG MGK 133 for tapers with outside diameters of 27 to 205 mm and lengths of less than 80 mm

The taper measuring instrument FAG MGK 133 is provided for tapers of less than 80 mm length (Fig. 11).

Measuring Ranges

Taper measuring instrument	MGK 133A	MGK 133B	MGK 133C	MGK 133D	MGK 133E	MGK 133F	MGK 133G
Taper dia. [mm]	27...47	47...67	67...87	87...115	115...145	145...175	175...205
Taper	Taper 1:12 and 1:30 (other angles on request)						
Min. taper length [mm]	17	21	28	34	42	52	65
Dist. betw. meas. planes [mm]	12	15	20	25	33	45	58

12: Taper measuring instrument FAG MGK 132 for tapers with outside diameters of 90 to 820 mm and lengths of more than 80 mm

The taper measuring instrument FAG MGK 132 is used for tapers of a minimum length of 80 mm and a minimum diameter of 90 mm (Fig. 12).

Measuring Ranges

Taper measuring instrument	MGK 132B	MGK 132C	MGK 132D	MGK 132E	MGK 132F
Taper dia. [mm]	90...210	190...310	290...410	390...510	490...820
Taper	Taper 1:12 and 1:30 (other angles on request)				
Min. taper length [mm]	80	80	110	125	140
Dist. betw. meas. planes [mm]	20	20	25	30	36

3. Rolling Bearing Mounting

The various bearing types and sizes require different mounting methods. Depending on the individual conditions these can be mechanical, hydraulic or thermal.

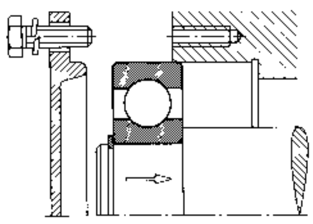
Do not subject bearing rings to hammer blows

As the hardened bearing rings are sensitive to blows, these must never be applied directly to the rings.

For non-separable bearings apply mounting force directly to the ring to be mounted

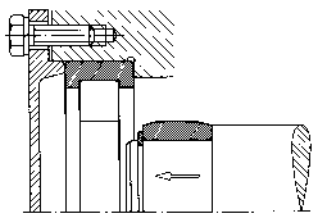
On mounting of non-separable bearings (Fig. 13), the mounting forces must always be applied to the ring which will have the tight fit and therefore is the first to be mounted. Forces applied to the ring with the loose fit would be transmitted by the rolling elements, thus damaging raceways and rolling elements.

Mounting of separable bearings (Fig. 14) is easier, since the two rings can be mounted separately. In order to avoid score marks during assembly, slightly rotate the parts.



13

13: If a tight fit is required for the inner ring of a non-separable bearing, the bearing will first be mounted on the shaft; then the shaft and bearing assembly is pushed into the housing.



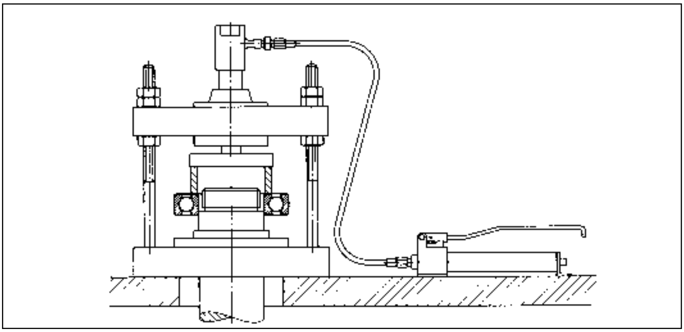
14

14: With separable bearings the rings can be mounted independently. This is especially advantageous when both rings get a tight fit. In order to avoid score marks, slightly rotate the parts when installing inner ring and shaft into outer ring and housing.

3.1 Mechanical Methods

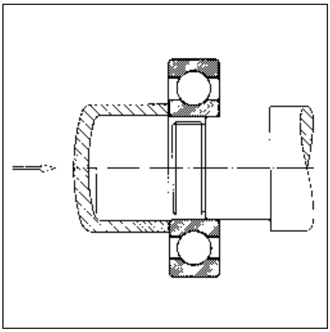
3.1.1 Mounting of Cylindrical Bore Bearings

Bearings with a maximum bore of approximately 80 mm can be mounted cold. The use of a mechanical or hydraulic press is recommended (Fig. 15).



15: Bearings with a max. bore of 80 mm can be mounted on the shaft with a hydraulic press.

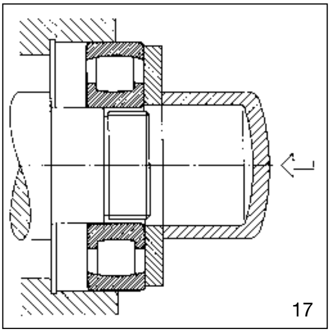
If no press is available, the bearing can be driven on the shaft by gentle taps with a hammer or mallet. However, a mounting sleeve of soft steel and with a flat face must be used in order to distribute the mounting force evenly over the entire ring circumference and to avoid damage to the bearing (Fig. 16).



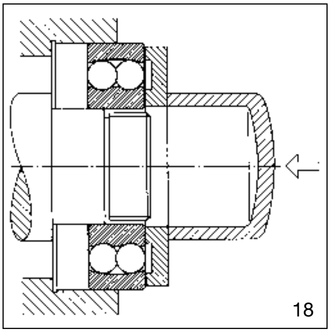
16: If necessary, small bearings can be driven on the shaft with gentle hammer taps, using an appropriate mounting sleeve.

The inside diameter of the sleeve should just be little larger than the bearing bore and, to avoid damage to the cage, its outside diameter should not exceed the inner ring shoulder height.

If a self-aligning bearing has to be pressed on the shaft and pushed into the housing at the same time, a disk should be used which bears against both bearing rings, thus avoiding misalignment of the outer ring in the housing (Fig. 17).



17: Simultaneous shaft and housing assembly of a bearing with the aid of a mounting disk.



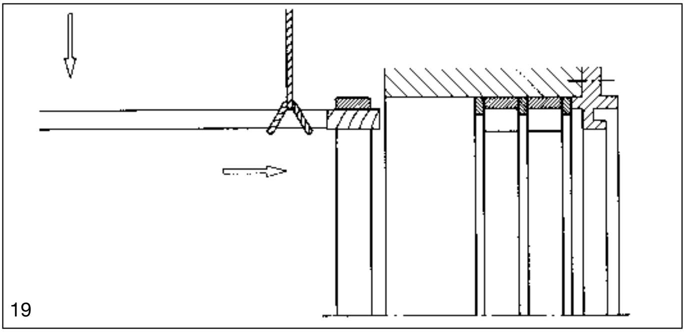
18: For some self-aligning ball bearings, the mounting disk must be relieved.

In some self-aligning ball bearings, the balls protrude beyond the rings. In such cases, the disk must be relieved (Fig. 18).

Heat also small bearings to achieve heavy interference fits

If very tight fits are required, even small bearings should be heated for mounting, chapter 3.2.

With light metal housings the seating areas might be damaged by press-fitting the outer ring in the housing bore. In such cases, the housing should be heated or the bearing cooled.



19: The outer rings of large cylindrical roller bearings are positioned by means of a mounting lever.

Heavy bearing outer rings with sliding fit can be mounted with a mounting lever (Fig. 19).

In order to avoid damage to the raceway and roller surfaces the end of the mounting lever should be wrapped with cloths (do not use cotton waste).

Mounting of Needle Roller Bearings

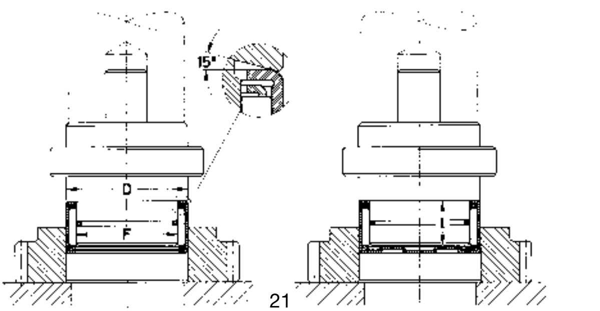
Needle Roller Bearings with Machined Rings

The same mounting principles apply to needle roller bearings as to cylindrical roller bearings. Bearings mounted in groups must have the same radial clearance to ensure uniform load distribution.

Drawn Cup Needle Roller Bearings

Due to their thin outer rings the form accuracy for the drawn cup needle roller bearings is achieved by means of tight fits in the housing, making a lateral location unnecessary.

For mounting drawn cup needle roller bearings, special mounting mandrels are used. Usually the mandrel abuts the stamped bearing face which is hardened with smaller sizes. If the mounting mandrel is accurately dimensioned, it can be applied to an unhardened lip without deforming or jamming the needle roller and cage assembly (Figs. 20 and 21).



20 21

Drawn cup needle roller bearings are pressed into the housing with a mounting mandrel.

20: Drawn cup needle roller bearing, open ends

21: Drawn cup needle roller bearing, closed end

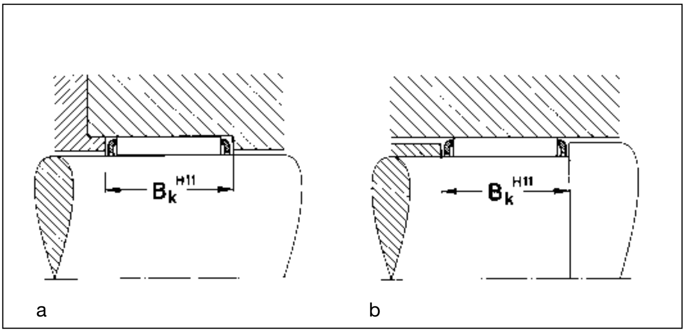
Needle Roller and Cage Assemblies

Needle roller and cage assemblies are mounted between shaft and housing. In order to avoid score marks on the raceways and needle rollers, the needle roller and cage assemblies should be slightly turned and remain unloaded on mounting.

Needle roller and cage assemblies can be axially guided in the housing or on the shaft (Fig. 22).

The distance between the lateral cage guiding surfaces must be large enough (tolerance H11) to prevent the needle roller and cage assembly from jamming.

The radial clearance of needle roller and cage assemblies depends on the machining tolerances of the hardened and ground raceways on the shaft and in the housing. Needle roller and cage assemblies mounted in groups must be fitted with needle rollers of the same tolerance group.



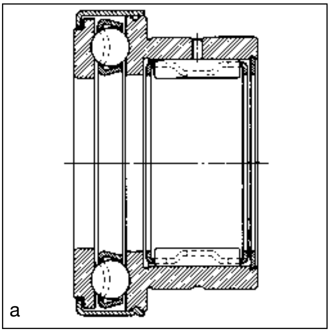
22: Needle roller and cage assemblies can be guided in the housing or on the shaft.

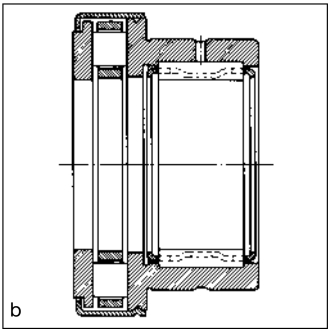
a: Guidance in the housing

b: Guidance on the shaft

Combined Needle Roller Bearings

The tight fits for the combined needle roller bearings require relatively high mounting forces. This must be borne in mind especially for needle roller-thrust ball bearings and needle roller-cylindrical roller thrust bearings with dust shield, where the ball or roller assembly of the thrust bearing is non-separable. It is advantageous to heat the housings for pressing-in these bearings.





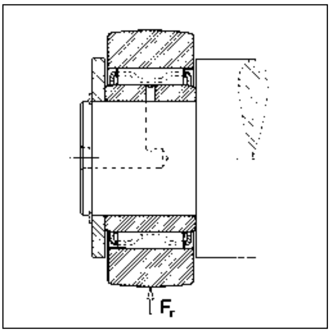
23: Combined needle roller - thrust ball bearings and needle roller - cylindrical roller thrust bearings with dust shield must be pressed into the housing.

a: Needle roller - thrust ball bearing

b: Needle roller - cylindrical roller thrust bearing

Yoke Type Track Rollers

Since, in most cases, the inner ring of yoke type track rollers is subjected to point load, a tight fit on the shaft is not required. On mounting, ensure that the lubricating hole is located in the unloaded raceway zone. The outer ring of yoke type track rollers without axial guidance must be guided by lateral backing surfaces.



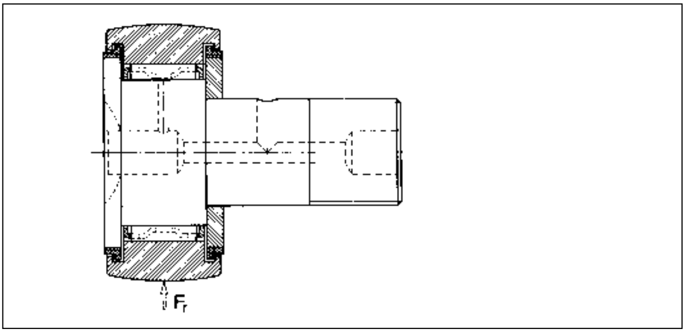
24: On mounting yoke type track rollers, the lubricating hole must be located in the unloaded zone of the raceway. The outer rings of yoke type track rollers without axial guidance must be guided by lateral backing surfaces.

Stud Type Track Rollers

On mounting stud type track rollers, the radial lubricating hole should be located in the unloaded zone of the raceway.

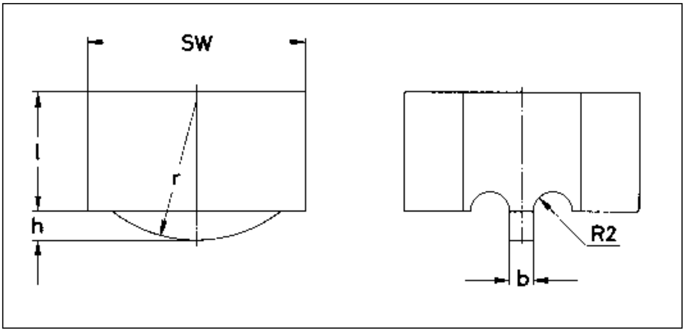
On mounting a stud type track roller in the through-hole of a machine frame, the stud must usually be secured against rotating when tightening the nut. This is enabled by a slot at the flanged end of the stud (Fig. 25).

25: Rotation of the stud during tightening of a stud type track roller is prevented by the slot at the flanged end of the stud.



When a stud type track roller is screwed into a blind hole, the tightening torque must be applied through the slot. For this purpose, an appropriate tool is required (Fig. 26). About 75% of the tightening torques listed in the catalogues can be safely applied with these tools.

26: The stud of a stud type track roller can be screwed into a blind hole with special tools.



3.1.2 Mounting of Tapered Bore Bearings

Bearings with tapered bore are either fitted directly on the tapered shaft journal or, if the shaft is cylindrical, on an adapter sleeve or a withdrawal sleeve.

Apply just a thin oil film to washed out bearing bore and seats on shaft and sleeve

The oil film applied to the washed out bearing bore, shaft and sleeve should be very thin. A heavier coating would reduce friction and thus ease mounting; however, in operation the lubricant would be gradually forced out from the joint with a slackening effect on the tight fit, causing the ring or sleeve to creep and corrosion to develop on the surfaces.

Forcing the bearing onto the tapered seat expands the inner ring and reduces radial clearance. Therefore the reduction in radial clearance can be used as a measure of the seating condition of the inner ring.

The reduction in radial clearance is the difference between the radial clearance prior to mounting and the radial clearance after bearing mounting. It is necessary to determine the initial radial clearance before mounting and then to check the clearance repeatedly during mounting until the proper amount of reduction and thus the required tight fit are obtained.

Check radial clearance reduction, drive-up distance or expansion

Instead of measuring the reduction in radial clearance the distance the bearing is forced onto the tapered seat can be measured. For the standard inner ring bore taper of 1:12 the ratio of axial drive-up to radial clearance reduction is approximately 15:1. This ratio considers the fact that the expansion of the inner ring is more than 75 to 80% of the amount of interference existing between the fitted parts.

If, with small bearings, the exact axial drive-up cannot be measured, the bearing should be mounted outside the housing. The bearing should be driven up the tapered seat just enough to still turn smoothly and to allow the outer ring to be easily swivelled by hand. The serviceman must have a "touch" for the smooth running feature.

Check radial clearance reduction, drive-up distance or expansion also during reassembly

The radial clearance reduction, the axial drive-up distance or the expansion should also be measured, when a bearing is being refitted.

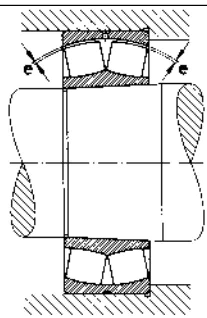
Special attention should be given to the locknut, the position of which may have changed due to the broaching effect in the seating areas and the settling of the threads. The values for the recommended reduction of radial clearance are listed in the appendix (tables 7.21 and 7.22, pp. 111 and 112).

Check radial clearance with feeler gauges

The radial clearance is measured with feeler gauges (Fig. 27).

In case of spherical roller bearings, the clearance must be measured simultaneously over both rows of rollers (Fig. 28). Identity of clearance values, such as measured over both rows of rollers, ensures that there is no lateral offset of the inner ring relative to the outer ring. Aligning of the ring faces alone is, because of the width tolerances of the rings, no guarantee against such an offset position.

27



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27: measuring radial clearance with feeler gauges before mounting

28: For spherical roller bearings, the radial clearance must be measured simultaneously over both rows of rollers.

Check inner ring expansion of separable bearings

Cylindrical roller bearings offer the advantage of separate installation of inner and outer rings; the inner ring expansion can be measured - by means of an external micrometer - instead of the reduction of radial clearance (Fig. 29).

29: Measuring the expansion of a cylindrical roller bearing inner ring with an external micrometer

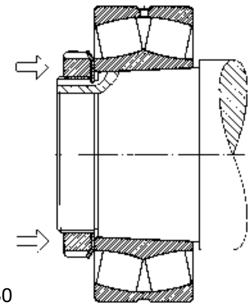
Mechanical and hydraulic equipment is available to pressfit the bearing on its tapered seat or to press a sleeve in place. Which method is the best to a given application depends on the mounting conditions.

Mount small bearings with shaft nut and hook spanner

Press fit small and medium-size bearings with shaft nut on the tapered seat (Fig. 30). Tighten nut with hook spanner.

The adapter sleeve nut and hook spanner are used for driving small bearings onto the tapered seat of the sleeve (Fig. 31).

Shaft nuts are also used to press small withdrawal sleeves into the space between shaft and bearing inner ring (Fig. 32).



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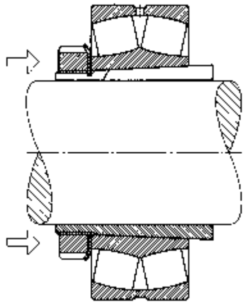

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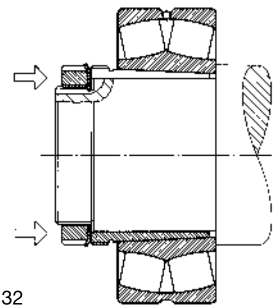
30: Press-fitting a spherical roller bearing with a shaft nut

31: Press-fitting an adapter sleeve mounted spherical roller bearing with the adapter sleeve nut

Double hook spanners

The double hook spanner sets FAG 173556 and 173557 are used for mounting self-aligning ball bearings onto adapter sleeves. Both sets include torque wrenches for more exactly determining the starting position before the bearing is driven onto the shaft.

On every double hook spanner there are rotation angles engraved for the self-aligning ball bearings that have to be mounted by means of these spanners so that the drive-up distance and radial clearance reduction can be adjusted accurately (Fig. 33).



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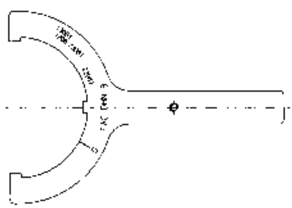

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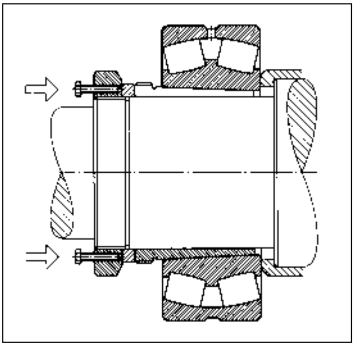
32: Press-fitting a withdrawal sleeve with the shaft nut

33: Double hook spanner with engraved rotation angles for fitting self-aligning ball bearings



34: Mounting nuts with thrust bolts facilitate mounting of large withdrawal sleeves. Between nut and sleeve a ring is inserted.

For larger bearings, considerable forces are required to tighten the nut. In such cases, the mounting nut with thrust bolts shown in Fig. 34 facilitates mounting.

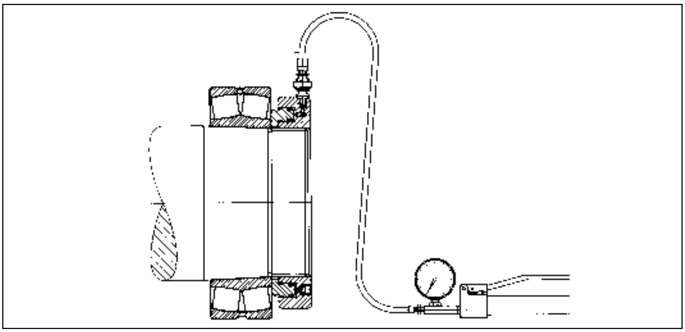
To avoid tilting of the bearing or sleeve, the mounting nut should just be tightened enough to make nut and ring bear flush against their mating part. Then the thrust bolts of hardened steel, evenly spaced around the circumference of the nut, - their number depending on the forces required - are diagonally tightened, until the required reduction in radial clearance is obtained.

As the taper connection is self-locking, the mounting nut can then be removed and be replaced by the locknut. The procedure can also be applied to bearings mounted on an adapter sleeve or directly on the tapered journal.

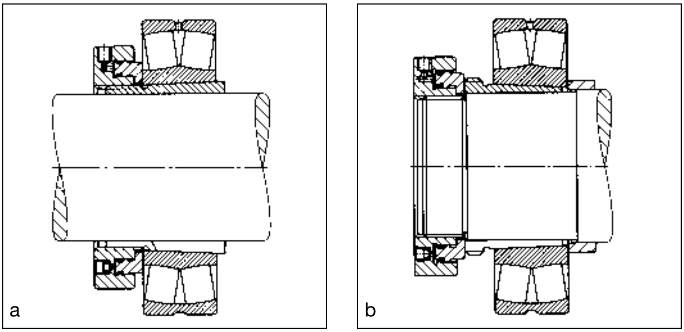
Use FAG hydraulic nuts for mounting of larger bearings

When mounting larger bearings, it may be advisable to use a hydraulic press. Figs. 35 and 36 show how a spherical roller bearing is being press-fitted with the aid of a hydraulic nut [1)]. Hydraulic nuts are available for all regular sleeve and shaft threads. The hydraulic pro-

[1)] See „FAG Hydraulic Nuts“, Publ. No. WL 80 103 for nomenclature and dimensions.



35: Hydraulic nut for mounting tapered bore bearings on a tapered shaft



36: Mounting of a spherical roller bearing with an annular piston press.

a: Mounting on an adapter sleeve

b: Press fitting of a withdrawal sleeve

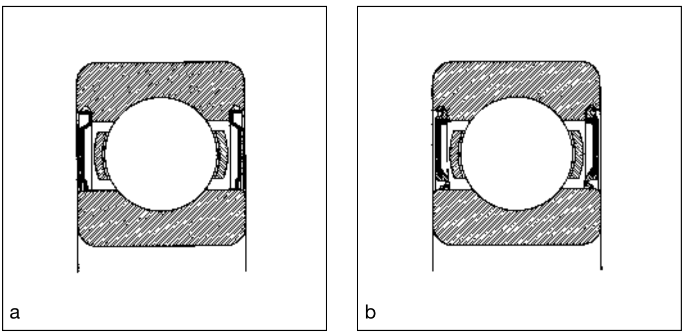
cedure described in chapters 3.3 and 4.3 is another valuable mounting and particularly dismounting aid.

3.2 Thermal Methods

If tight fits are specified for the inner rings on cylindrical shaft seats, the bearings are heated for mounting. Sufficient expansion is obtained when heated between 80 and 100°C. Accurate temperature control is essential in heating the bearings. If the temperature exceeds 120°C there is the risk of alteration of bearing grain structure resulting in a drop of hardness and dimensional instability.

For bearings with moulded cages of glass fibre reinforced polyamide the same temperature limits are valid as for the other rolling bearings.

Bearings with shields (Fig. 37a) and with seals (Fig. 37b) are packed with grease during manufacture. They can be heated up to 80°C maximum, but never in an oil bath.

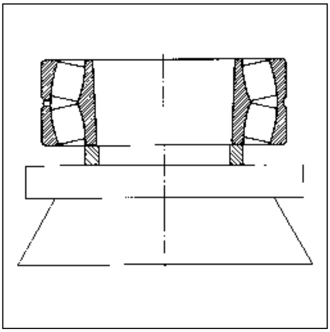


37: Never heat bearings with shields or seals in an oil bath. The maximum heating temperature is 80°C.

a: Bearing with shields

b: Bearing with seals

38: A ring is inserted between a heating plate without thermostatic control and the inner ring of an E spherical roller bearing with polyamide cage.



3.2.1 Heating Plate

Provisionally, rolling bearings can be heated on a heating plate which should be thermostatically controlled. Turn the bearing over several times in order to ensure uniform heating.

If the temperature of a heating plate without thermostatic control exceeds 120°C, polyamide cages must not contact the heating plate. This can be avoided by inserting a ring between the plate and the bearing inner ring (Fig. 38).

3.2.2 Oil Bath

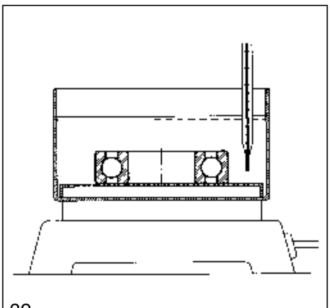
For uniform heating, rolling bearings are generally immersed in an oil bath which is thermostatically controlled to a temperature of 80 to 100°C. The bearing should not be in direct contact with the heat source. The best arrangement is to have a screen several inches off the bottom of the oil tank which will prevent uneven heating of the bearing and protect it from contaminants settling on the tank bottom (Fig. 39).

The bearings may also be suspended in the oil bath (Fig. 40). After heating, any oil adhering to the bearing should be well drained off and the fitting surfaces should be carefully wiped clean.

39, 40: Heating in an oil bath ensures uniform heating of the bearings: A temperature of 80 to 100°C can be easily controlled. Disadvantage: Risk of contamination.

39: Heating a deep groove ball bearing in an oil bath

40: Heating cylindrical roller bearing inner rings in oil bath



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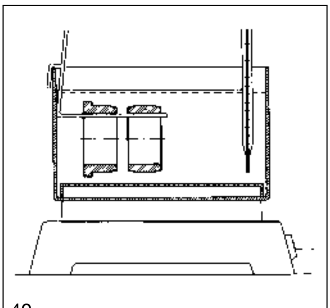


40

Mounting of heated rings or bearings requires some skill (Fig. 41). The parts should be rapidly pushed on the shaft and positioned squarely against the shoulder. A slight twisting motion during fitting facilitates the work. It is advisable to use heat-protective gloves or non-fraying cloths, but never cotton waste.

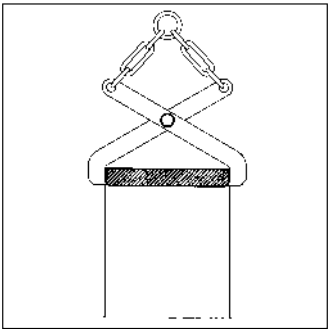
Heat larger bearings for mounting

Do not use cotton waste in mounting work

Larger bearings are generally transported with a crane. In this case the bearing is suspensed in mounting grippers (Fig. 42) or in a rope sling. Working with the rope sling is not easy. Ensure alignment of ring and shaft in order to prevent tilting.

41: Heated bearing parts are rapidly pushed on the shaft and positioned squarely against the shoulder. This is facilitated by a slight twisting motion.

42: Mounting grippers



Provide for immediate axial location of mounted ring

When positioning, the inner ring should be immediately held tight against the shaft shoulder, until it has cooled down to avoid any clearance between ring face and shoulder after cooling. This also applies to a pair of rings mounted side by side.

3.2.3 Hot Air Cabinet

A safe and clean method of heating rolling bearings is by use of a hot air cabinet. Thermostat regulation enables accurate temperature control. Careful operation excludes contamination of the bearings. However, heating the bearings in hot air takes considerable time, therefore adequately dimensioned hot air cabinets should be provided for bath mounting.

3.2.4 Induction Heating Device*)

With the FAG induction heating devices A45EA020DV220 (Fig. 43) and A45EA110 (Fig. 44) rolling bearings are brought up to mounting temperature in a fast, secure and clean manner. The devices can be used for any rolling bearing types including greased and sealed bearings. They operate on the transformer principle. Power supply is low. The devices can be connected to a socket of 220V/50 Hz or 60 Hz; maximum amperage is 16 A (device A45EA020 V110: 110 V/50 Hz or 60 Hz).

The heating device is suitable for rolling bearings of a minimum bore diameter of 20 mm. The weight can be up to 40 kg.**)

The device can also be used to heat other ring-shaped steel parts such as shrink rings or labyrinth rings.

After heating, the parts are automatically demagnetized.

*) For details see publication: "Induction Heating Device for Rolling Bearings FAG A45EA020DV220", Publ. No. WL 80132.

**) Parts having a weight of up to 250 kg can be heated with the induction heating device FAG A45EA110, see Publ. No. WL 80 126.

43,44: The induction heating devices ensure fast, clean and secure heating up to mounting temperature.

43: FAG A45EA020DV220

44: FAG A45EA110

45: Induction coil for 380 V with bearing inner ring

3.2.5 Induction Coil*)

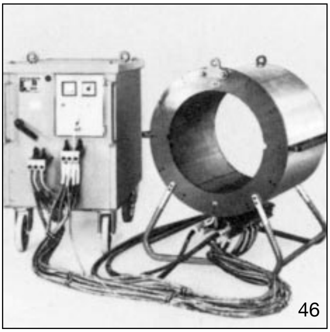
Induction coils heat the inner rings of cylindrical roller and needle roller bearings of 100 mm bore onward.

The induction coils shown in this chapter can be used for both mounting and dismounting. They are, however, mainly used for ring withdrawal (chapter 4.2.2). Since heating for dismounting tight-fitted inner rings is very fast, the amount of heat transferred to the shaft is minimized so that the rings such as axle box roller bearings in rail vehicles, or for frequent dismounting and remounting of large-size bearings, as is the case for roll exchange in rolling mills.

FAG induction coils can be connected between two phases to the common three-phase current mains (50 or 60 Hz). For heating inner rings of a bore up to approximately 200 mm, coils are used which are connected directly to the 380 V mains (Fig. 45). For larger bearings the harmless low voltage equipment with 20 to 40 V at 50 Hz (60 Hz) should be used.

Low voltage induction coils are connected to the mains (380 V) via transformer (Fig. 46). The water-cooled winding provides for a better efficiency, easier handling and lower weight of the device.

*) For details see Publ. No. WL 80107 EA "FAG Induction Heating Equipment".



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47

46: Low-voltage induction coil with transformer EFB 125/1, for cylindrical roller bearing inner rings of 635 mm bore

Ring weight:	390 kg
Approx. coil weight:	70 kg

47: Demagnetization of the inner ring of a cylindrical roller bearing by means of the induction coil

When the induction coils are used for mounting work, ensure that the rings are not overheated. The heatup times are indicated in the operating instructions.

See operating instructions for heatup times

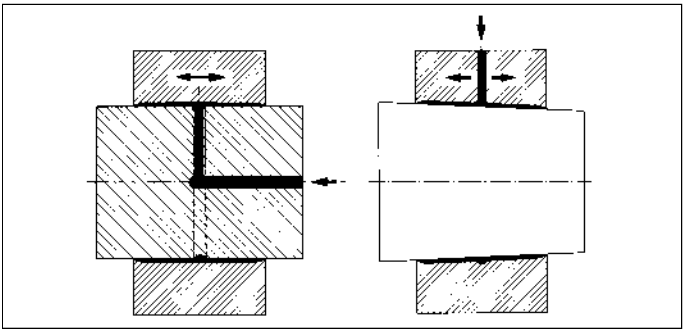
The operating instructions also describe the use of the coil for demagnetization of the bearing rings upon completion of induction heating (Fig. 47).

3.2.6 Cooling

For a tight fit of the outer ring, the housing is heated in most cases to mounting temperature. With large and bulky housings, this may cause problems. In this case, the rolling bearing is cooled in a mixture of dry ice and alcohol. The temperature should not drop below -50°C.

Never cool bearings below -50°C

The condensation water resulting from temperature equalization must be completely rinsed out of the bearing with oil in order to prevent corrosion.



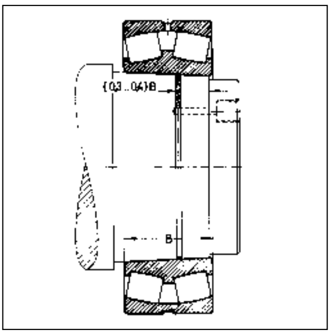
48: Principle of hydraulic mounting; fluid film buildup between the mating surfaces.

3.3 Hydraulic Method

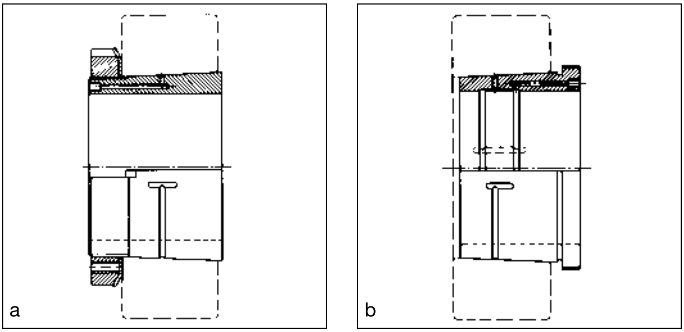
With the hydraulic method, oil is injected between the mating surfaces. This may be machine oil, or oil containing rust dissolving additives. The oil film greatly reduces the friction between the mating parts which can then be easily displaced in relation to one another without the risk of surface damage. Fretting corrosion can be dissolved by means of kerosene or rust-dissolving additives to the oil.

Tapered bore bearings can be mounted on, and dismounted from, their tapered counterpart by the hydraulic method. Cylindrical bore bearings or sleeves are heated for mounting, whilst dismounting is performed hydraulically. For oil injection, oil grooves, feed channels and threaded connections for the pump are machined into shaft or the sleeve (Figs. 49, 50). See FAG publication WL 80 102 EA "How to Mount and Dismount Rolling Bearings Hydraulically" for technical details.

Hydraulic mounting of tapered bore bearings which are directly fitted on the tapered shaft end, requires but a small amount of oil. Simple, low feed injectors are therefore satisfactory (Fig. 51). FAG supply two sizes of oil injectors with connecting threads G 3/8 and G 3/4. The smaller oil injector is good for shaft diameters up to 80 mm, the larger for diameter up to 150 mm.



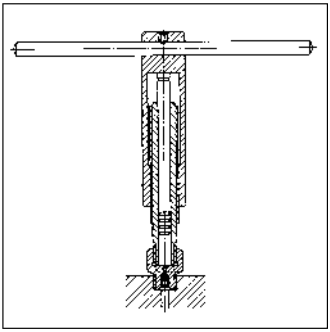
49: Position of the oil groove for a tapered bore bearing



50: Larger adapter and withdrawal sleeves feature oil grooves and oil collecting grooves.

a: Adapter sleeve, design HG

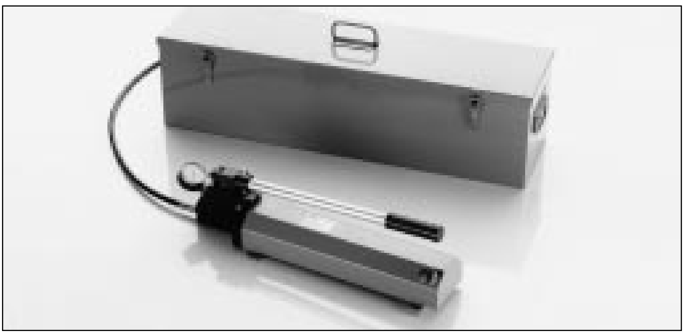
b: Withdrawal sleeve, design H



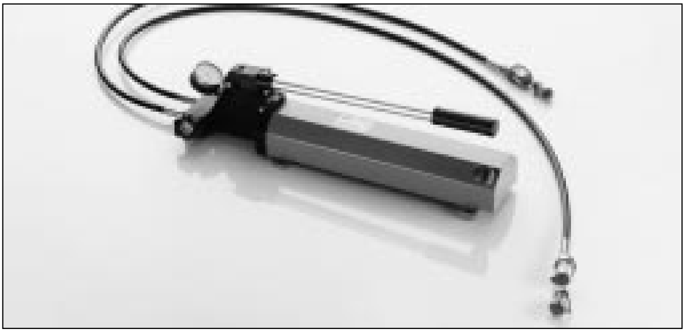
51: Oil injector and valve nipple for connecting thread G 3/8:
Injector: FAG No. 107640
Nipple: FAG No. 107642
for connecting thread G 3/4:
Injector: FAG No. 107641
Nipple: FAG No. 107643

It is different with cylindrical bore bearings and with adapter and withdrawal sleeves. Here, the oil loss occurring at the edges of the mating surfaces must be compensated by a higher rate of oil feed. This is achieved by an oil pump (Figs. 52 to 54).

The fluid used is a machine oil of medium viscosity. Mounting work should be performed with an oil having a viscosity of about 75 mm^2/s at 20°C (nominal viscosity 32 mm^2/s at 40°C).



52: Hand pump set FAG 173746, consisting of a two-step piston pump (800 bar) with 3-litre oil container, manometer, extreme pressure hose and fitting (connecting thread G 1/4)



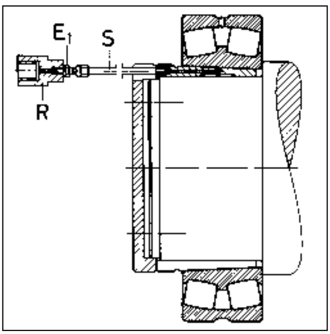
53: Hand pump set FAG 173747, consisting of a two-step piston pump (800 bar), with 3-litre oil container, manometer, 2 extreme pressure hoses and fittings (connecting thread G 1/4)

54: Hand pump set FAG 173748, consisting of a two-step piston pump (1500 bar), with 3-litre oil container, manometer, extreme pressure hose and fitting (connecting thread G 1/4)

Mounting of Tapered Bore Bearings

Use shaft nut, thrust bolts or FAG hydraulic nut for mounting

The bearing is pressed into position by a shaft nut, thrust bolts or the FAG hydraulic nut (see Fig. 35). Hydraulic withdrawal sleeves and adapter sleeves are provided with threaded oil bore connections M6, M8, G 1/8, G 1/4, depending on sleeve size (see FAG Publ. No. WL 80200/3). The pumps shown in Figs. 52 to 54 feature an extreme pressure hose and are connected to the sleeve by reducing socket R, ERMETO tube E1 and steel pipe S (Fig. 55).



55: Hydraulic connection of a withdrawal sleeve

56: Mounting of a tapered bore spherical roller bearing by the hydraulic method

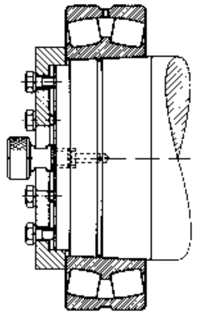
For mounting, oil is pumped between the mating surfaces. The axial forces required for mounting are applied through six or eight bolts located in the shaft nut or the adapter sleeve nut (Figs. 56 to 59).

A spacer between the bolts and the sleeve or bearing ring prevents damage to the latter. When pressing in a withdrawal sleeve as shown in Fig. 58, the pipe for the hydraulic fluid passes through the shaft nut. The amount of axial drive-up of the bearing or the withdrawal sleeve depends on the required reduction of radial clearance (tables 7.21 and 7.22, pages 111 and 112). The bearing must not, of course, be under oil pressure, when the radial clearance is being measured.

Relieve bearing of oil pressure prior to measuring radial clearance

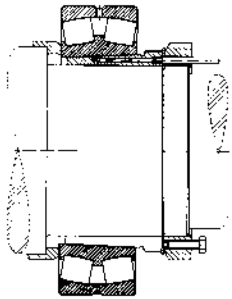
After relieving the oil pressure, the bearing is still kept under axial preload. Wait for 10 to 30 minutes, until oil has completely drained off from the fitting surfaces. As a final step, the mounting device (nut with thrust bolts or hydraulic nut) is removed and the shaft or sleeve nut put in place and locked.

Keep bearing under axial preload for 10 to 30 minutes after relief of the oil pressure



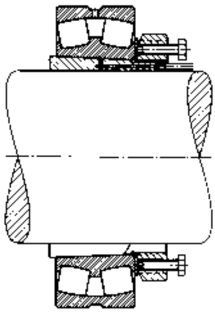
57

57: Bearing seated on shaft: The oil is pumped between the mating surfaces; at the same time pressure from bolts or a nut drives the bearing up the tapered journal. The reduction in radial clearance or the axial drive-up distance is measured.

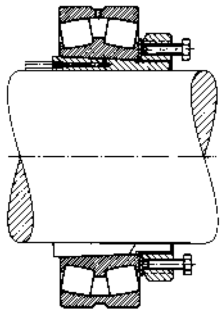


58

58: Bearing seated on withdrawal sleeve: The oil is pumped between the mating surfaces. The sleeve is pressed into the bearing bore with bolts and the reduction in radial clearance is measured.



59a



59b

59: Bearing seated on adapter sleeve: The oil is pumped between the mating surfaces. Bolts drive the bearing up the sleeve and the radial clearance reduction is measured.

a: Oil bore in small end of sleeve

b: Oil bore in large end of sleeve

3.4 Clearance Adjustment on Mounting

3.4.1 Angular Contact Ball Bearings and Tapered Roller Bearings

Angular contact ball bearings and tapered roller bearings are always mounted in pairs. The axial and radial clearance of two bearings mounted in opposition is adjusted on mounting, the clearance or preload depending on the operating conditions. Angular contact ball bearings of universal design can be mounted in pairs or groups in any arrangement.

High loads and high speeds cause a temperature rise at the bearing location. This leads to thermal expansion and clearance variation. The type of clearance variation, i. e. an increase or a decrease, depends on arrangement and size of the bearings, the shaft and housing material and on bearing centre distance.

If close shaft guidance is required, the clearance is adjusted by stages. Each adjustment should be followed by a trial run and a temperature check. Thus, it is ensured that the clearance does not become too small, resulting in a higher running temperature.

A welcome effect of trial runs is that the whole bearing mounting "settles" and that, afterwards, the clearance practically remains stable (see also page 51).

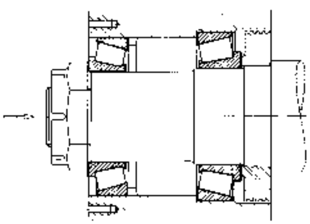
A high speeds, adjust axial clearance by stages

The right temperature for a bearing, operating in the medium to high speed range under medium load, can, indicatively, be defined as follows: In the absence of extraneous heat, a correctly adjusted bearing is allowed to attain, during the trial runs, a temperature of about 60 to 70°C. After 2 or 3 hours running, this temperature should, however, drop, especially when in the case of grease lubrication, the churning action diminishes, after the excess grease is expelled from the bearing interior.

Provide for zero-clearance or preload of a bearing exposed to vibration at low speeds

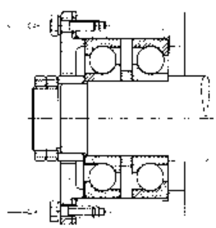
Bearings exposed to vibration at low speeds are mounted with zero clearance or even preloaded to avoid the risk of the balls or rollers brinelling the raceways. Angular contact ball bearings and tapered roller bearings are adjusted against one another by nuts on the shaft (Fig. 60), by shims (Fig. 61) or threated rings in the housing.

Axial clearance or preload of adjustable bearings is established by loosening or tightening the adjusting nut or by the insertion of calibrated shims. From the thread pitch, axial clearance and preload can be converted into turns of the adjusting nut.



60

60: Adjustment of tapered roller bearings of a loose wheel with the shaft nut



61

61: Axial location of paired angular contact ball bearings; clearance adjustment with shim

The changeover from clearance to preload during adjustment is found by constant manual rotation of the shaft. Simultaneously, a dial gauge is applied to check the axial freedom of the shaft.

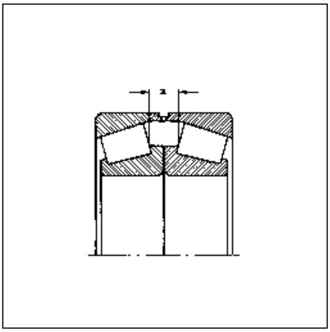
Adjust with torque wrench

A simpler method for correct bearing adjustment is the use of a torque wrench. The adjusting nut is tightened to the appropriate torque (e. g. for passenger car front wheel bearings 30 or 50 Nm. The right torque is determined in tests; the values are specified in the repair instructions).

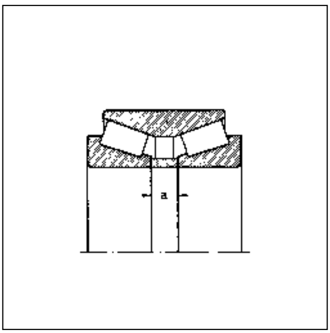
Loosening of the nut by approximately 1/12th of a turn provides for the required clearance. In tapered roller bearings, the rollers should bear against the cone back face rib during assembly. If the rollers were to contact the rib only after mounting is completed, i. e. when the bearing should therefore be alternatively turned in both directions during mounting.

In matched, multi row tapered roller bearings (Figs. 62 and 63), the axial clearance is a function of the spacer width. To determine distance "a" FAG developed the measuring devices of series MGS 155. Details are gladly supplied on request.

62: Matched tapered roller bearings in X arrangement (suffix N11CA)

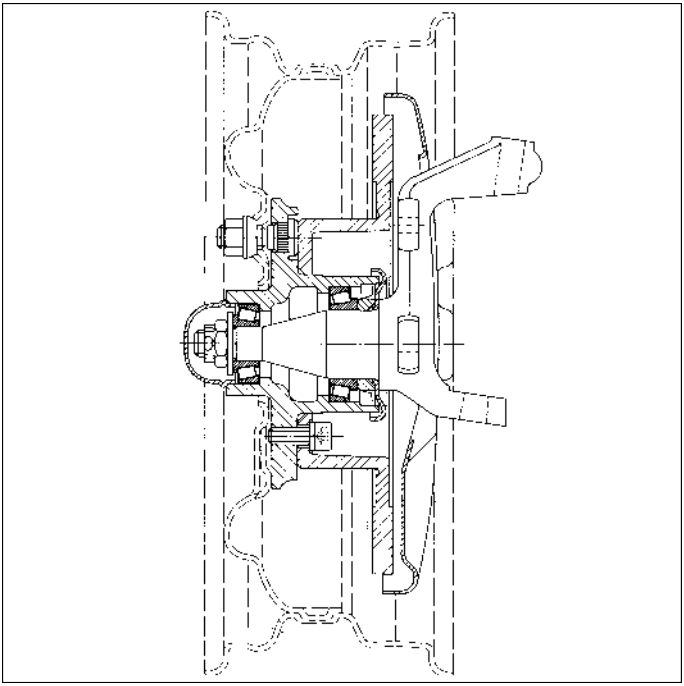


63: Double row tapered roller bearing in O arrangement



Example:

Installation and adjustment of tapered roller bearings in the wheel hubs of motor vehicles (Fig. 64).

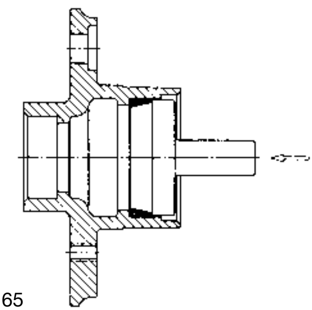


64: Passenger car front wheel with adjusted tapered roller bearings

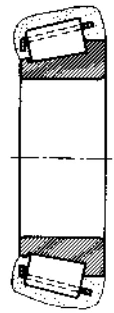
Proceed as follows:

1. Clean hub and carefully remove any chips and burrs.
2. Apply thin oil film to bearing seats. Press the two cups in place with a die. Make sure the die contacts only the cup face. Take care that the cup faces fit well against the hub shoulders (Fig. 65).
3. Grease cone of inner bearing.

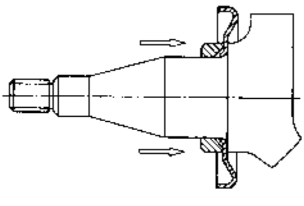
   Pack grease also in the spaces between cage, cone, and rollers (Fig. 66).
4. Insert cone into hub.
5. Press shaft seal ring into hub with sealing lip pointing towards bearing.
6. Mount protective cap and spacer on the shaft. Make sure spacer face has full support against shaft shoulder (Fig. 67).
7. Mount hub on shaft; make sure seal is not damaged.


65

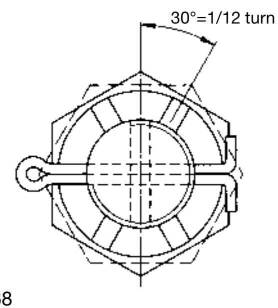
65: Fitting of the bearing cup with a die.


66

66: Pack roller/cage assembly of tapered roller bearing with grease


67

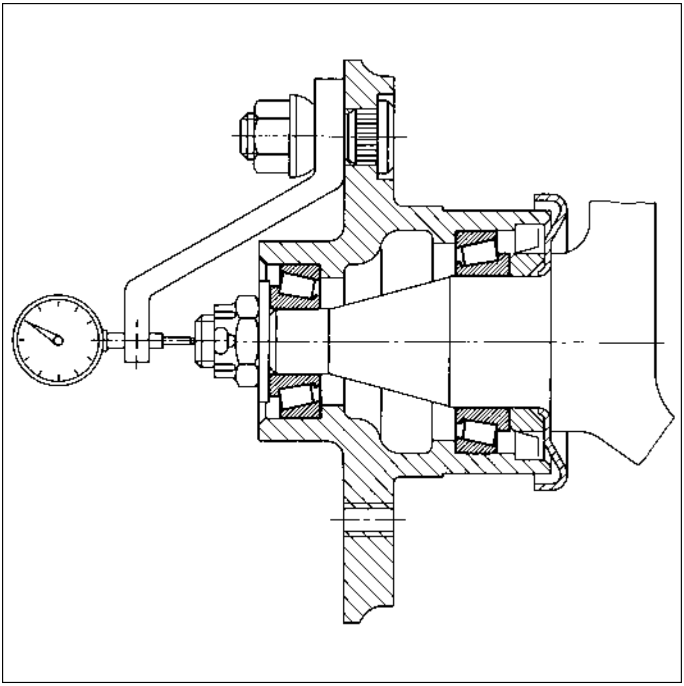
67: After the protective cap, the spacer is mounted on the shaft.



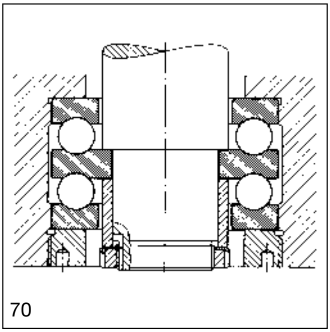
68

68: Tighten castle nut while rotating the wheel, until drag is felt. Back off castle nut by 1/12 turn at the most, until alignment with next cotter pin hole is obtained and fit cotter pin

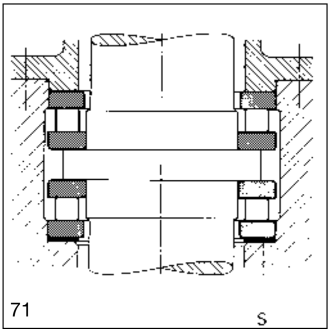
8. Apply grease well to cone of outside bearing and mount on shaft.
9. Mount safety plate.
10. Fit castle nut.
11. Tighten castle nut while the wheel is being rotated until drag is felt (use torque wrench, if possible; follow repair instructions).
12. Back off castle nut approximately 1/12 turn, until alignment with the next cotter pin hole is obtained and fit cotter pin (Fig. 68).
13. Check bearing for running smoothness and wobble. The wheel must not drag, but rotate freely. Be sure the wheel does not wobble. If necessary, change safety plate or nut. If the illustrated dial gauge (Fig. 69) is available, check axial clearance. 0 to 0.05 mm are optimum values.
14. Mount cover.
15. Perform test run to check for change of bearing clearance. Readjust, if necessary.



69: Measurement of axial clearance



70: Zero clearance double direction thrust ball bearing



71: Cylindrical roller thrust bearing preloaded with shim S

This is a field-proven method of adjusting wheel bearings requiring no special tools. There are other methods which, however, necessitate mounting tools and measuring instruments. They are primarily intended for batch mounting.

3.4.2 Thrust Bearings

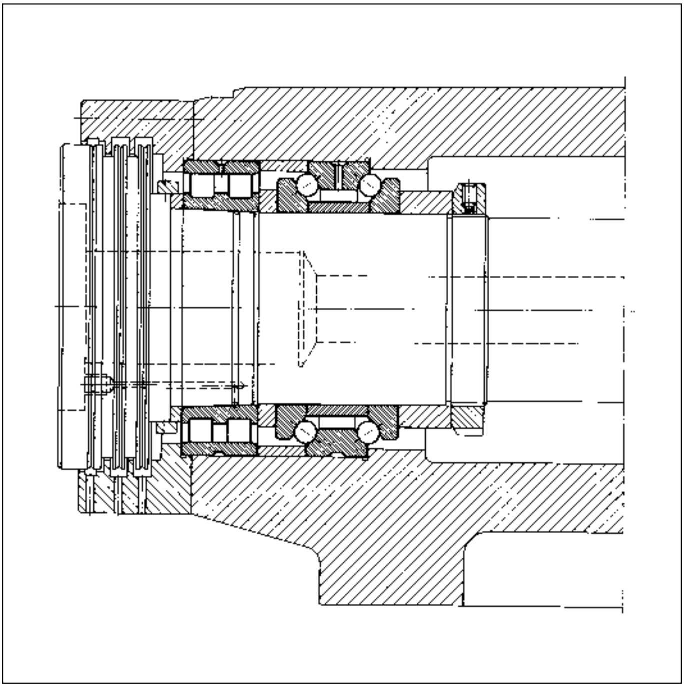
With thrust bearings, the shaft washers are generally transition fits, tight fits being the exception. The housing washers are always loose fits. The shaft washer of double direction thrust bearings should always be positively locked axially (Fig. 70). The mounting and dismounting of thrust bearings offers no difficulties.

3.4.3 Machine Tool Bearings

For machine tool spindles, the correct adjustment of bearing clearance is of paramount importance because it controls the quality of the machined workpieces. For correct adjustment, on mounting, of the operating clearance or preload specified by the designer, FAG developed special measuring devices. These are used for today's widely employed spindle bearing arrangements with double row cylindrical roller bearings (Fig. 72). The correct preload of double direction angular contact thrust ball bearings is automatically adjusted during mounting.

The radial clearance of a mounted cylindrical roller bearing is equal to the difference between the boundary circle diameter of the rollers, and the raceway diameter of the lipless ring. For gauging the boundary circle, FAG supply the boundary circle measuring instruments MGI 21 and MGA 31.

The raceway diameter of cylindrical roller bearings NNU49SK is measured with a snap gauge, the raceway diameter of series NN30ASK with a plug gauge.



72: Bearing assembly of a fineboring spindle (work end). The radial clearance of the double row cylindrical roller bearing is adjusted on mounting.

FAG boundary circle measuring instruments are comparators allowing to measure the radial clearance within a measuring accuracy of ±1 micron.

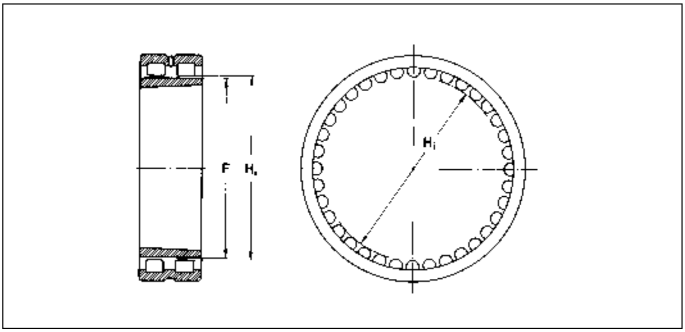
For precise adjustment of the radial clearance, the form accuracy of the bearing seats, i. e. their roundness, cylindricity or taper, is important (also see p. 12 "Inspection of bearing seats").

Boundary Circle Measuring Instrument MGI 21

The radial clearance or preload of cylindrical roller bearings with separable inner ring (NNU49SK) is the difference between the diameter of the circle under the rollers H_i and the raceway diameter F. The circle under the rollers is the circle which contacts all rollers from inside, when they are in contact with the outer ring raceway (Fig. 73).

The circle under the rollers is measured with the aid of the instrument MGI21; the radial clearance of the mounted bearing can be determined together with a snap gauge (Fig. 74).

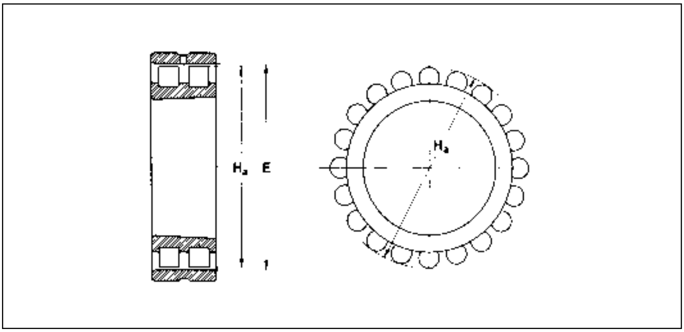
The two opposed steel segments of the boundary circle measuring instrument form the measuring surfaces. The lower segment is stationary, the upper can be displaced; the movement being read from the dial gauge.



73: Diameter under rollers H_i of cylindrical roller bearings NNU49SK (separable inner ring)

After having determined the boundary circle of the mounted outer ring roller assembly, this value is transmitted to the snap gauge. During inner ring mounting on the tapered shaft seat, the expansion of its raceway diameter is constantly checked with the aid of the snap gauge. Positive values on the dial gauge indicate preload, negative values indicate radial clearance; a zero value indicates a clearance-free bearing.

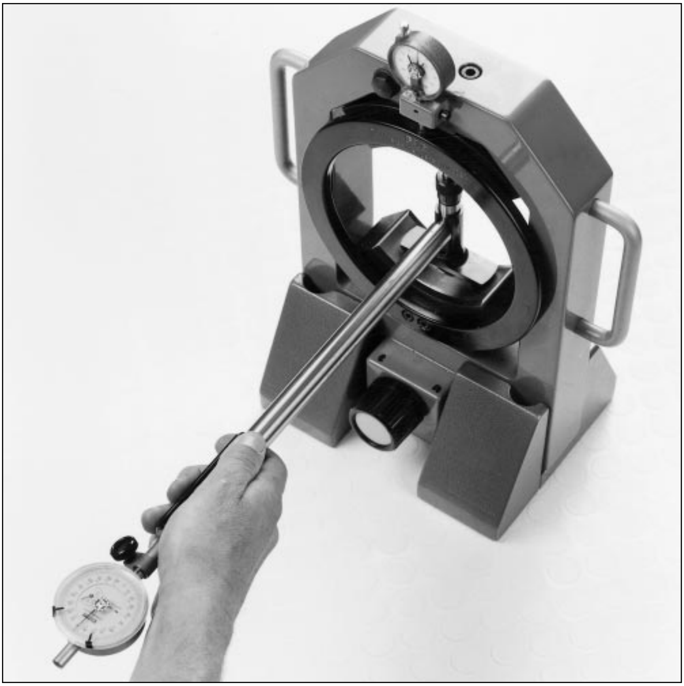
74: The measured diameter under rollers is transmitted to the dial indicator snap gauge. The boundary circle measuring instrument FAG MGI 21 is used for cylindrical roller bearings with separable inner ring, such as FAG NNU49SK.



75: Diameter over rollers H_a of cylindrical roller bearings NN30ASK (separable outer ring)

Boundary Circle Measuring Instrument MGA 31

The radial clearance or preload of cylindrical roller bearings with separable outer ring (NN30ASK) is the difference between the diameters of the raceway E and the circle over the rollers H_a. The circle over the rollers is the circle which circumscribes all rollers when they are in contact with the inner ring raceway (Fig. 75).



76: The measured raceway diameter is transmitted to the boundary circle measuring instrument with the aid of an internal dial gauge. The boundary circle measuring instrument FAG MGA 31 is used for cylindrical roller bearings with separable outer ring, such as FAG NN30ASK.

The circle over the rollers is measured with the instrument MGA 31; the radial clearance of the mounted bearing can thus be determined together with an internal dial gauge (Fig. 76).

The two opposed steel segments of the boundary circle measuring instrument form the measuring surfaces. One segment is stationary; the other can be displaced. The movement can be read from the dial gauge.

During measuring, the bearing outer ring has to be mounted in the housing. After having determined the outer ring raceway diameter with the aid of an internal dial gauge, this value is transmitted to the boundary circle measuring instrument.

During mounting, the inner ring with cage and roller assembly is pushed onto the tapered shaft seat until positive contact is established. The boundary circle measuring instrument is applied and the inner ring driven onto the taper seat, until the dial gauge indicates the required value.

Positive values indicate preload, negative values indicate radial clearance; a zero value indicates a clearance-free bearing.

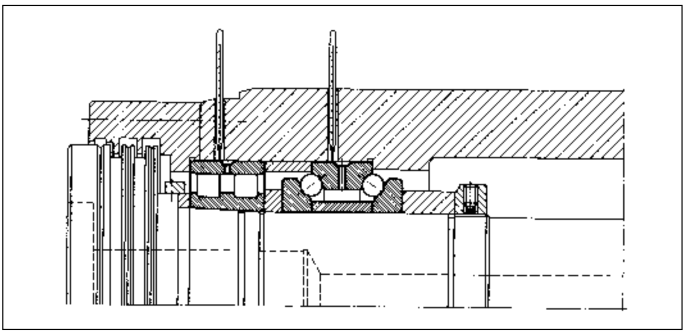
The Steady-State Temperature as a Means of Clearance Control

In the case of high-speed spindles, the operating clearance or preload can be verified from the bearing temperature registered during trial runs.

Sensors should contact bearing rings

For temperature control, the bearing housing must be provided with bores for the insertion of temperature sensors (Fig. 77). These bores should be drilled prior to bearing installation. To obtain the true bearing temperature, the sensors must be in direct contact with the bearing rings. Controlling merely the temperature of the cylindrical roller bearing will not do; the temperature of the preloaded angular contact thrust ball bearing should also be measured.

77: Arrangement of heat sensors



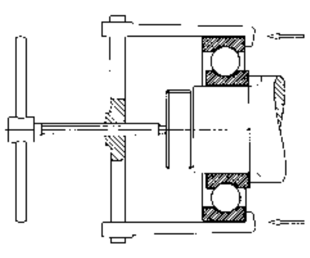
The trial run should be long enough to allow the operating temperature to come to a steady state; this will happen after half an hour to three hours depending on machine size. Steady-state temperatures from 50 to 60°C are acceptable, when the spindle operates at its top speed; experience has shown that at this temperature bearing clearance is optimum.

4. Rolling Bearing Dismounting

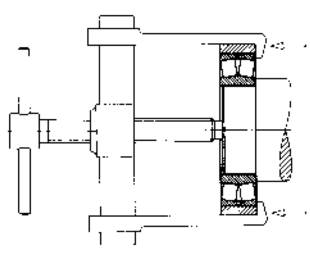
If the bearings are intended for re-use, dismounting must be performed most carefully; it is imperative that the extracting tool be applied to the ring to be extracted to prevent the rolling elements from brinelling the raceways (Fig. 78a). In addition, thin-walled outer rings involve the risk of ring fracture (Fig. 78b).

Apply tool to the ring to be extracted

With non-seperable bearings, first withdraw the ring with sliding fit from its seat and then dismount the tight-fitted ring. The force required for dismounting is generally higher than the mounting force, since, as time passes, the ring becomes embedded on its seat. Even with loose-fitted rings, fretting corrosion may make dismounting work difficult.



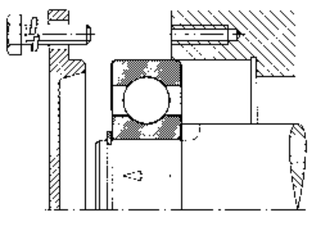
78 a



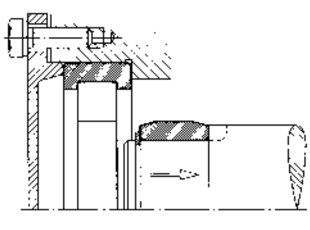
78 b

78a: Wrong! Do not apply dismounting force through the rolling elements, if you want to re-use the bearing.

78b: If dismounting through the rolling elements is unavoidable, put a collar of unhardened steel round the outer ring (thickness 1/4 greater than bearing cross section height). This applies especially to bearings with small cross section height and small contact angle (such as tapered roller and spherical roller bearings). The bearings shall not be reused.



79



80

79: Start dismounting of nonseparable bearings with the loose-fitted ring.

80: The ring of separable bearings can be dismounted separately.

4.1 Mechanical Methods

4.1.1 Dismounting of Cylindrical Bore Bearings

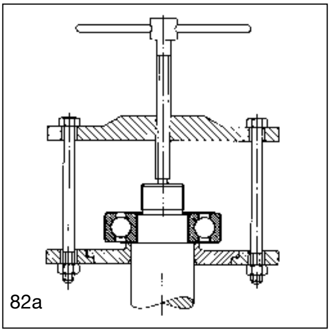
Small bearings are usually dismounted with the aid of mechanical extracting devices (Figs. 81, 82) or hydraulic presses (Fig. 83). These are applied either directly to the tight-fitted ring or to the mating parts, such as the labyrinth ring.

81: Dismounting of a barrel roller bearing with an extractor

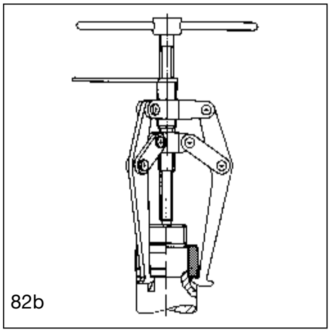
82: Extracting devices for rolling bearings

a: Extractor with puller arms for split ring

b: Extractor with three adjustable arms

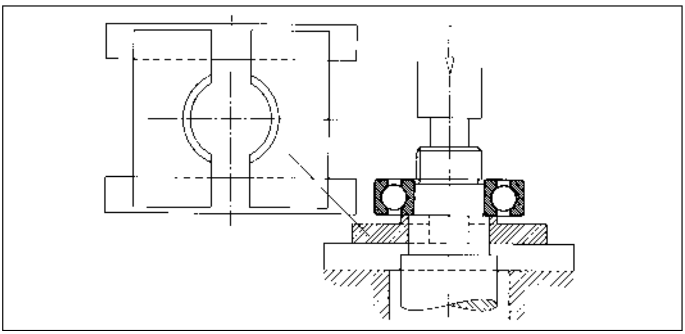


82a



82b

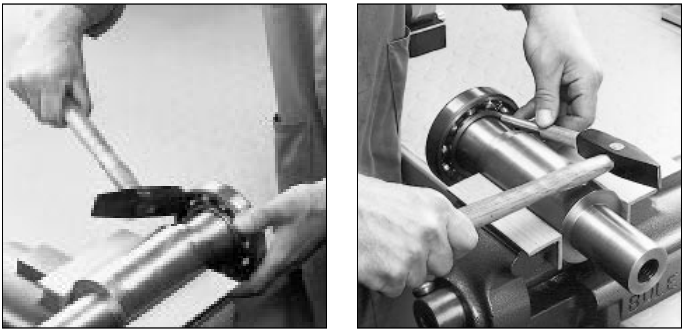
83: Dismounting is facilitated by use of a press.



Provisionally, small bearings can be driven off their seat with a hammer and a metal drift (Fig. 84, right). The light hammer blows should be applied evenly round the whole circumference of the tight-fitted ring.

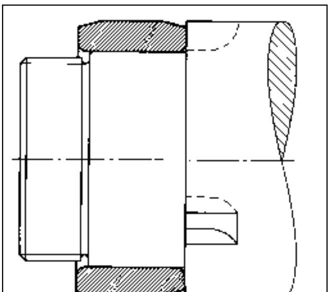
Dismounting is greatly facilitated, if extracting slots are provided so that the extractor can be directly applied to the tight-fitted bearing ring (Figs. 85, 86 and 87).

Provide extracting slots

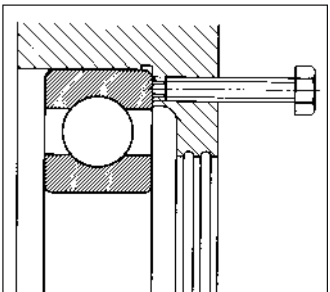


84: Provisional bearing dismounting by hammering
left: wrong
right: correct
(use soft metal drift)

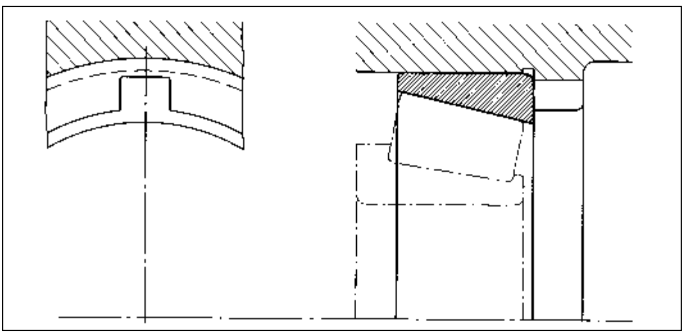
Do not subject the bearing rings to hammer blows


85

85: Slots in the shaft shoulder to apply bearing extractor


86

86: Bores for extraction nuts



87: Slots for bearing outer ring removal

When the inner ring abuts the shaft shoulder and when no extracting slots are provided, ball bearings, tapered roller bearings and cylindrical roller bearings can be dismounted with a special extractor. With the ball bearing extractor (Figs. 88, 89c), the clamping piece inserted in the extractor engages with finger-shaped extensions between the balls at the inner ring raceway edge; with extractors for cylindrical and tapered roller bearings the clamping piece engages behind the rollers (Fig. 89a).

88: Ball bearing extractor with clamping piece

89a: Collet for tapered roller bearings and cylindrical roller bearings with separable outer rings/cups

89b: Collet for tapered roller bearings and N-type cylindrical roller bearings with unseparable outer rings (cups).

89c: Collet for deep groove ball bearings

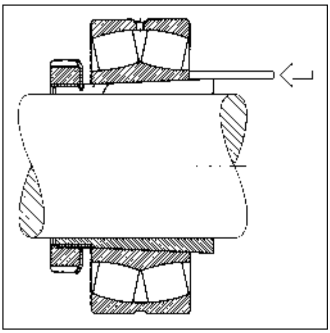
The clamping piece forms part of a collet and is clamped against the inner ring with a tapered clamping ring. The extraction force is generated by a spindle. This extractor enables bearings mounted in the housing to be withdrawn from the shaft.

4.1.2 Dismounting of Tapered Bore Bearings

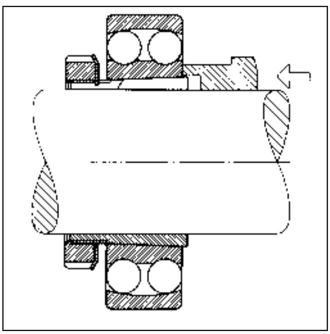
4.1.2.1 Dismounting of Adapter Sleeve Mounted Bearings

For dismounting bearings directly seated on the tapered shaft or an adapter sleeve, loosen the locking device of the shaft or sleeve nut. Loosen nut by an amount corresponding to the drive-up distance. Drive inner ring off the adapter sleeve or tapered shaft seat by gentle hammer taps, using a soft metal drift (Fig. 90) or, even better, a piece of tubing (Fig. 91).

When a press is used, support the adapter sleeve or the loosened adapter sleeve nut and withdraw the bearing from the sleeve.

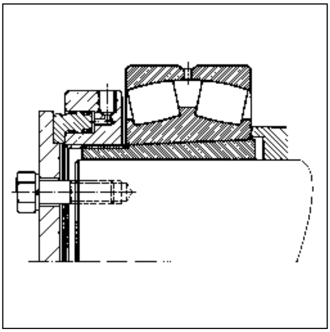


90: Dismounting of a small, adapter sleeve mounted spherical roller bearing. The inner ring is driven off the sleeve by means of a metal drift.



91: Dismounting of an adapter sleeve mounted self-aligning ball bearing. The use of a piece of tubing prevents damage to the bearing.

92: Hydraulic nut for dismounting an adapter sleeve mounted spherical roller bearing



Adapter sleeves can be released with a hydraulic nut provided the bearing rests against an angular support ring. The nut should take support on a plate or the like (Fig. 92).

4.1.2.2 Dismounting of Withdrawal Sleeve Mounted Bearings

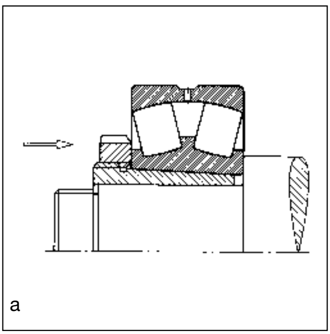
Withdrawal sleeve mounted bearings are removed by means of the extraction nut (Fig. 93a). For this purpose, the shaft nut must be removed. In difficult cases (for large-size bearings), extraction nuts with additional thrust bolts can be used (Fig. 93b). A washer is inserted between inner ring and thrust bolts.

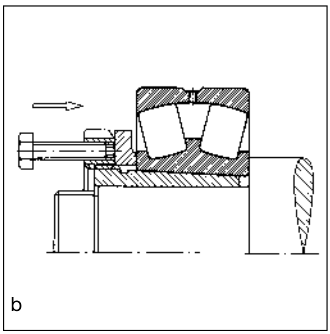
Dismounting of withdrawal sleeves is much easier and less costly with hydraulic nuts (Fig. 94). Withdrawal sleeves projecting beyond the shaft end, should be backed up by a thick-walled support ring.

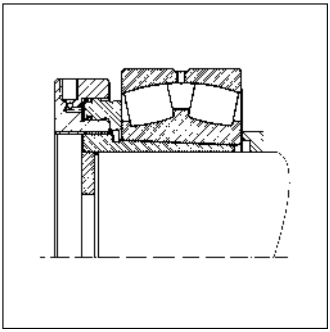
93: Dismounting of a withdrawal sleeve

a: with extraction nut

b: with nut and thrust bolts applied to the inner ring through a washer







94: Hydraulic nut for dismounting a withdrawal sleeve mounted spherical roller bearing. The projecting portion of the sleeve is backed up by a thick-walled support ring.

4.2 Thermal Methods

4.2.1 Heating Ring

Heating rings are used for dismounting cylindrical roller bearing and needle roller bearing inner rings without lip or with one lip only. The heating rings of light alloy are radially slotted. Their insulated handles provide for easy handling (Fig. 95).

With an electric heating plate, the heating rings are heated to a temperature of 200 to 300 °C, placed around the inner ring to be extracted and clamped by means of the handles. The heat is rapidly transferred from the heating ring to the inner ring. When the tight inner ring fit on the shaft is loosened, withdraw both rings simultaneously. After extraction, remove the inner ring immediately from the heating ring to avoid overheating. Heating rings are of great advantage for occasional withdrawal of small or medium-size bearing rings, each bearing size requiring its own heating ring.

95: Heating rings are used for dismounting cylindrical roller and needle roller bearing inner rings.

4.2.2 Induction Coil*)

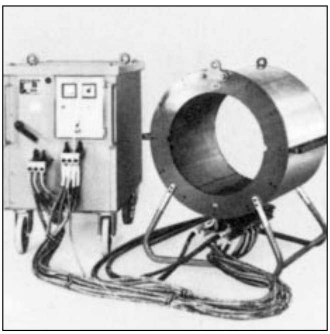
Induction coils (also see chapter 3.2.5) are used for withdrawing shrunk-on cylindrical roller and needle roller bearing inner rings of 100 mm bore onward from the shaft. Since the coil heats up at a very fast rate, the amount of heat transferred to the shaft is minimized so that the rings can be easily withdrawn.

Induction coils can be connected between two phases to the common three-phase mains (50 Hz or 60 Hz). For dismounting rolling bearings with a maximum bore of 200 mm, coils are used which are connected directly to the 380 V mains. For larger bearings, the harmless low voltage equipment - 20 to 40 V/50 Hz (60 Hz) - should be used.

Low voltage induction coils are connected to the mains (380 V) via a transformer (Fig. 96). The water-cooled winding provides for a better efficiency, easier handling and lower weight of the coil.

For extraction, the induction coil is pushed over the inner ring and the fingers provided on the coil grip the ring at its back face. The labyrinth ring features milled recesses to allow positioning of the fingers. The current is switched on and, as soon as the ring is heated to 80 to 100°C, the current is disconnected and the ring together with the appliance removed from the shaft.

*) For details see publ. no. WL 80107 EA "FAG Induction Heating Equipment".



96: Low-voltage induction coil with transformer EFB 125/1, for cylindrical roller bearing inner rings of 635 mm bore:

Ring weight	390 kg
Approx. coil weight	70 kg

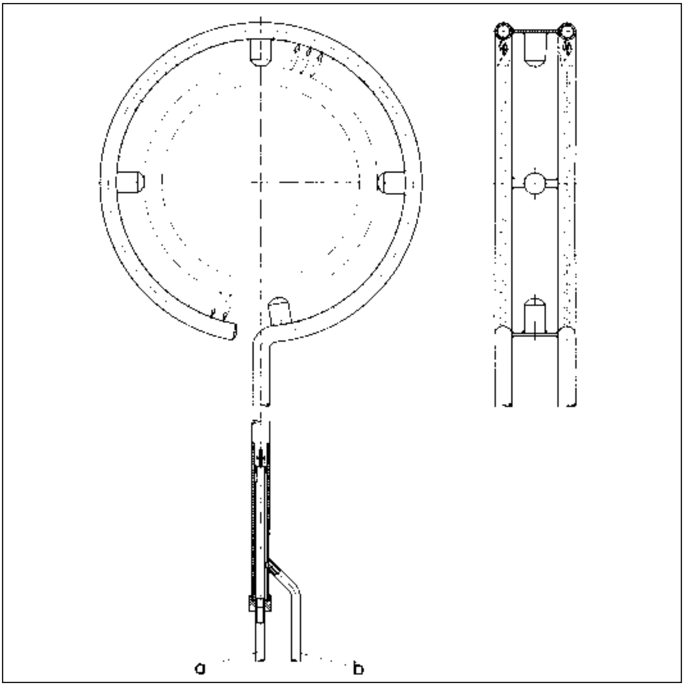
4.2.3 Ring Burner

If no oil grooves are provided in the shaft for hydraulic mounting, and if electric devices are not economical, inner rings of larger separable bearings can also be dismounted by heating them with a flame.

Never should a welding torch be used because of the danger of overheating or unequal heating of the ring. The uniform, high hardness and dimensional stability of the bearing ring could be affected.

Use ring burner

Ring burners (fig. 97) have proven to be an acceptable solution. The burner should clear the ring surface by 40 to 50 mm. At the usual gas pressure, the diameter of the burner jet is 2 mm. Flame temperature and flame length are adjusted by the addition of air. The burner jets should be bored in staggered arrangement and be spaced 20 to 45 mm apart. For small rings and heavy interference fits, the burner should be operated for maximum heat output. Air should only be added after burner ignition. There must be provisions for the air pressure to be delicately adjustable, since excessive pressure may force the gas back into the mains.



97: Ring burner for dismounting inner rings
a = gas, b = air

The surfaces of the hardened bearing rings are susceptible to overheating which reduces hardness and changes the dimensions. The burner should, therefore, always be held concentric to the bearing ring. The burner should be moved slowly and evenly across the bearing ring in the axial direction. This will avoid a tempering effect and additional stressing in the ring.

Crack unserviceable rings for a removal

Sometimes heavy fretting corrosion or cold welding can make the regular removal of bearing rings impossible. In such cases which, of course, only apply to unserveiceable rings, these are heated by a welding torch to 350°C and hosed with cold water. The heavy internal stresses thus produced in the ring will make it crack. Since the ring is likely to burst, the area of dismounting must be well screened or covered to avoid accidents.

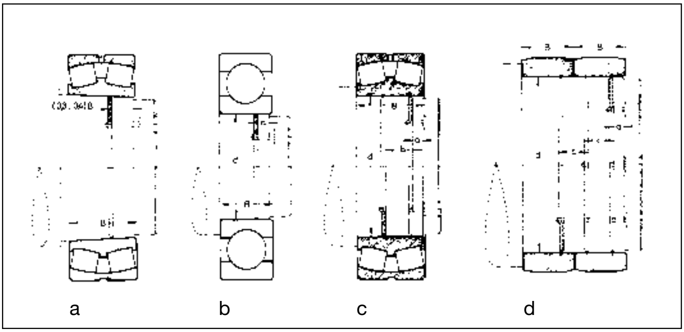
Safety information

If - for example when a bearing is dismounted by means of a welding torch - a temperature of approx. 300°C and above is reached, fluorinated materials can release gases and vapours that are detrimental to human health. FAG uses fluorinated materials for seals made of flurocaoutchouc (FKM, FPM, e. g. Viton®) or for fluorinated lubricating greases such as the rolling bearing grease Arcanol L79V. If high temperatures cannot be avoided, the safety data sheet valid for the fluorinated material in question has to be observed that can be obtained on request.

4.3 Hydraulic Method

With the hydraulic method, oil is injected between the mating surfaces. The oil film greatly reduces the friction between the mating parts which can then be conveniently displaced in relation to one another without the risk of damaging the mating surfaces (see chapter 3.3).

The hydraulic method is suitable for dismounting bearings with tapered and cylindrical bore. In both cases, oil grooves, ducts and threaded connections for the pump must be provided (Fig. 98). Larger adapter and withdrawal sleeves feature the corresponding grooves and holes (Figs. 101, 102).



98: Position of oil grooves for dismounting by the hydraulic method.

a: Tapered shaft seat;

b: Cylindrical shaft seat, bearing width B ≤ 80 mm, a ≈ √d;

c: Cylindrical shaft seat, bearing width B > 80 mm, a ≈ √d; b ≈ (0.5 to 0.6) B;

d: Cylindrical shaft seat, two inner rings mounted side by side; bearing width B > 80 mm; a ≈ √d, c ≈ B - (1.5 to 2) √d

For dismounting tapered bore bearings directly seated on the shaft, injectors will do for pressure generation (Fig. 51). Cylindrical bore bearings and adapter and withdrawal sleeve mounted bearings require a pump (Fig. 52, chapter 3.3).

For dismounting, a thicker oil with a viscosity of about 150 mm^2/s (cSt) at 20°C (nominal viscosity 46 mm^2/s at 40°C) can be used. If the contact surfaces are damaged, a high-viscosity oil of about 1,150 mm^2/s (cSt) at 20°C (nominal viscosity 320 mm^2/s at 40°C) should be used. Fretting corrosion can be dissolved by anti-corrisive additives in the oil.

4.3.1 Dismounting of Tapered Bore Bearings

For hydraulic dismounting of bearings, mounted on a tapered journal, a withdrawal sleeve or an adapter sleeve, oil is pumped between the surfaces in contact. This releases the press fit instantly. The release being rather abrupt, a stop should be provided to control the movement. This may be a shaft or sleeve nut or any other convenient means (Figs. 99 to 102).

Restrict axial movement!

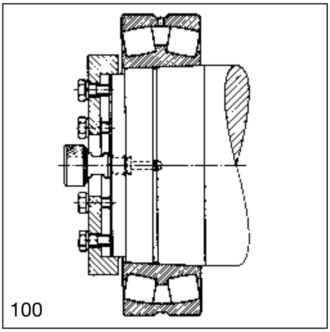
99: Dismounting a withdrawal sleeve mounted spherical roller bearing by the hydraulic method.

Dismounting

Dissolve fretting corrosion by the addition of rust solvents

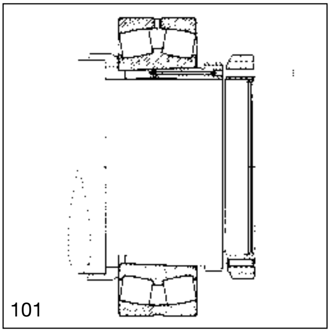
The incidence of fretting corrosion may render dismounting more difficult. In this case, a rust-dissolving hydraulic oil should be used, especially for bearings of long service. For a seized withdrawal sleeve, the extra force required to set it moving can be applied through the withdrawal nut. If the withdrawal nut features thrust bolts (Fig. 103), a plate or washer should be inserted between the bolts and the bearing, to avoid damaging the lips of the bearing ring.

100: Bearing seated on shaft; the oil is pumped between the surfaces in contact; bearing disengages spontaneously. Stop to be left on shaft to restrict bearing movement.



100

101: Bearing seated on withdrawal sleeve: Oil is pumped into withdrawal sleeve bore and O. D.; withdrawal sleeve disengages spontaneously. Nut to be left on shaft.

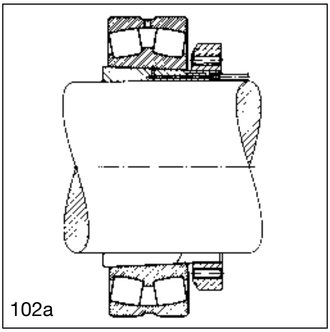


101

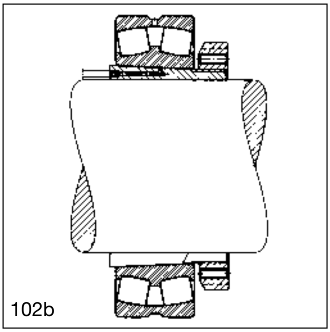
102 a-b: Adapter sleeve mounted bearing: Oil is pumped between adapter sleeve O. D. and bearing bore; Bearing disenganges spontaneously. Stop to be left on sleeve.

a: Oil connection in small end of sleeve

b: Oil connection in large end of sleeve

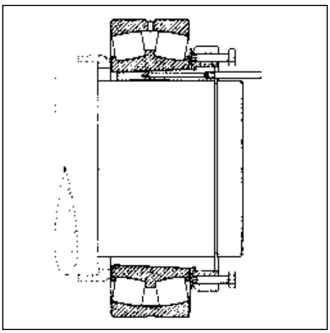


102a



102b

103: Dismounting in difficult cases: Oil containing rust solvents is pumped between the mating surfaces. Higher-viscosity oils should be used. Sleeve extraction is facilitated by applying nut provided with thrust bolts.

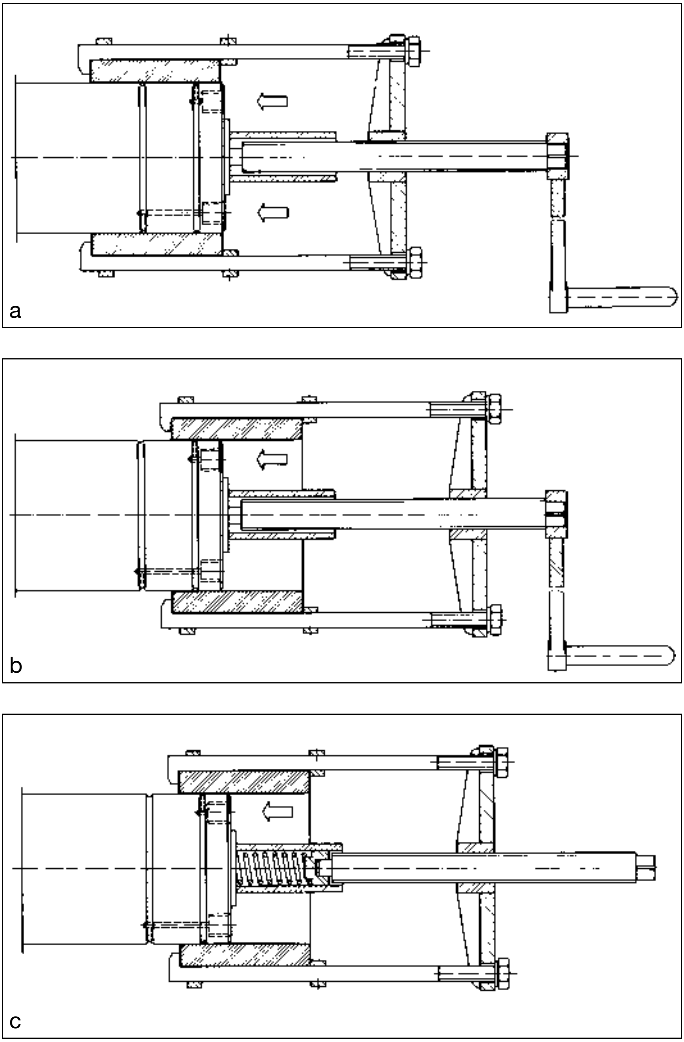


4.3.2 Dismounting of Cylindrical Bore Bearings

For cylindrical bore bearings, the use of the hydraulic technique is generally limited to dismounting.

The first step is to apply a bearing extractor to the bearing ring (Figs. 104 a-c). Then, hydraulic oil is pumped into the oil grooves.

When the bearing ring moves easily, it should be displaced far enough to expose the rear oil groove; the oil feed to this groove is stopped.



104: dismounting of a cylindrical bore inner ring with the hydraulic method

a: Apply extractor to the inner ring and pump oil into the two oil grooves.

b: Pull ring far enough to expose the rear oil groove and stop oil feed to this groove.
The ring is given a further pull, until it covers the forward oil groove at either side by an identical length. The oil feed is stopped so that the ring will freeze.

c: The extracting device is preloaded with a spring. Rebuilding the oil film enables the ring to slide off the shaft.

Then the ring is given a further pull, until the ring covers the forward oil groove at either side by an identical length (Fig. 104 b).

The oil feed to the forward groove is stopped which means that the ring will freeze again. A spring is inserted into the guide sleeve of the extractor and preloaded (Fig. 104 c).

Catch ring on its way off the shaft

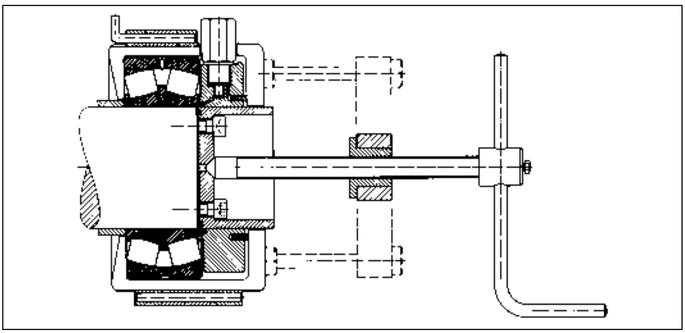
The travel stroke of the extractor spring should be a little greater than the length occupied by the ring on the shaft. Rebuilding the oil film by vigorous pumping enables the extractor to slide the ring off the shaft. It is recommended to catch the ring on its way off.

The spring preload should be approximately F = 20 · d (F in N and d in mm). Whenever several rings are mounted on the shaft side by side, they are dismounted separately.

The displacement of the ring up to the point where the forward oil groove is still covered evenly, can generally be done by hand, since upon injection of the hydraulic oil, the rings are easily displaceable. The better the ring "floats" in the extraction phase, when the spring pressure pulls it from the shaft, the less the probability of its getting caught at the shaft end.

Use oil injection ring for the removal of bearing from plain shafts

In the absence of oil grooves and ducts in the shaft, the oil can be injected between the mating surfaces from the inner ring front face (Fig. 105). To this effect, a sealed oil injection ring is placed in front of the bearing feeding pressurized oil into the fitting joint. Mounting a sleeve to the shaft end allows oil to be pumped between the mating surfaces all the time the dismounting operation lasts. If the use of such a sleeve is not possible, a high-viscosity oil of 320 mm^2/s (cSt) at 40°C must be used. An oil of this viscosity maintains an adequate oil film for approximately 5 minutes which is sufficient for bearing removal.



105: Special device for extracting a cylindrical bore spherical roller bearing from a shaft without oil grooves. The oil is fed into the fitting joint from the inner ring front face.

These special extracting devices are relatively complicated. They are, for example, used for applications where no oil grooves are provided in the shafts or axles for strength reasons, but which require frequent dismounting (e. g. for rail vehicles).

5. Lubrication

The primary purpose of the lubricant is to build a load-carrying film separating the bearing components in rolling and sliding contact in order to minimize friction and wear. The lubricant should also protect the bearing against corrosion. If required, it should also act as a sealant, and in case of circulating oil lubrication, as a coolant.

Due to deterioration and mechanical stressing, the lubricants become unuseable. Change of oil or grease or replenishment, i. e. bearing maintenance, has a favorable influence on the bearing service life. Under certain sealing and environmental conditions, appropriate lubricant selection allows for a lubrication for life. For detailed information see also FAG Publ. No. WL 81115 "The Lubrication of Rolling Bearings".

5.1 Greases

Only high-grade greases - generally on a metal soap basis - should be used. Rolling bearing greases for extreme temperatures contain different thickeners and a synthetic oil instead of the mineral oil.

Only use time-tested greases

Greases containing extreme pressure (EP) additives are used in high-load and low-speed applications. High-speed bearings and bearings which ask for low friction, are lubricated with greases containing a thin synthetic base oil.

The operating temperatures specified by the grease supplier should be kept in mind. Rolling bearing greases should be stable against deterioration and must not change their structure, even after long periods of operation.

Consider grease application range

The table 7.23 on p. 113 lists the FAG rolling bearing greases Arcanol and their properties.

5.2 Oils

Only use time-tested oils

For rolling bearing lubrication, mineral oils are generally used. They should have the following properties:

Utmost cleanliness, stability against deterioration, good viscosity-temperature behaviour and good water repellency. In addition, the lubricating oil must ensure satisfactory protection of the bearing against corrosion. Very high and very low operating temperatures require the use of synthetic oils. Oils for highly loaded and low-speed bearings should contain EP-additives.

5.3 Selection of Lubricant

Greases are generally preferred to oils because they simplify maintenance and can be used as sealants. The asset of oil is that it readily feeds into all areas of contact and carries off heat. Its disadvantage is that it involves a more complex design of the bearing location and especially of the sealing system.

The following factors determine the selection of lubricant:

Operating Temperature

Depending on the speed, the temperature of a bearing location is a function of bearing friction, lubricant friction, heat dissipation to the outside, and, as the case may be, heat supply from the outside.

Watch steady-state temperature

A bearing mounting is reliable, if the steady-state temperature settles at a level acceptable for the application. A continuous temperature increase, on the other hand, necessitates special measures (extra cooling, change-over to a different lubricant etc.). A short-term temperature rise occurs with grease relubrication.

The viscosity of lubricating oils decreases with increasing temperature and increases when the temperature drops. Preference should be given to oils the viscosity of which varies little with temperature (good V-T behaviour).

Watch viscosity at operating temperature

The higher the expected operating temperature, the higher should be the nominal viscosity of the oil. The nominal or mid-point viscosity is the viscosity for oils at 40°C. The oils are classified in viscosity grades (ISO VG) (DIN 51519).

The permissible temperature range of greases varies with the saponification bases. As a rule, the upper limits are:

Exact values of greases with different saponification bases are available from manufacturers' catalogues

Calcium soap base: + 50°C (120°F)

Sodium soap base: + 70°C (160°F) to 120°C (250°F)

Lithium soap base: + 110°C (230°F) to 130°C (265°F)

Diverse complex soap greases, gels, and greases containing entirely synthetic thickeners feature temperature limits beyond 130°C (265°F). Greases with thin synthetic base oils are especially applicable for low temperatures.

Exact values for the commercial greases are available from manufacturers' catalogues.

In selecting oils and greases, it should be borne in mind that a high temperature speeds up deterioration and decreases the lubricant service life.

Loads and speed

Under the given operating conditions, the lubricant must form a load carrying lubricating film. With oil, the load carrying capacity of the film is primarily a function of viscosity. The lower the bearing speed, the higher the oil viscosity in operating condition. Information on viscosity ν_1 can be seen in the FAG catalogue WL 41520. Consideration must be given to the fact that bearing temperatures depend on load and speed. The operating temperature required for determination of the nominal viscosity must be estimated.

High-viscosity oils for low speeds

Increases in speed are associated with increasing lubricant friction and accordingly, increasing bearing temperature. The friction will be higher, the more viscous the lubricant is. On the other hand, higher temperatures lower viscosity which decreases the load carrying capacity of the lubricant film.

Observe relationship between speed, lubricant friction, temperature and viscosity

The permissible speeds for the various types and sizes of rolling bearings for grease and oil lubrication are listed in the FAG catalogues.

Permissible speeds for oil and grease lubrication see FAG Rolling Bearing Catalogues

The use of solid lubricants as e. g. graphite and MoS_2 is limited to ultralow speeds and creeping motions only.

Solid lubricants only for creeping speeds

High-load applications call for oils containing EP additives. Greases for high-load applications are characterized by base oils of high viscosity and EP additives.

Bearing Size

Small bearings are generally lubricated with a low-viscosity oil or with a very soft grease to minimize lubricant friction in the bearing. In large bearings, the lubricant friction plays a minor role, and the choice between oil or grease is, in this respect, of secondary importance.

Moisture

Consider lubricant behaviour with moisture

The reaction of rolling bearing greases against moisture is different from one grease to the other. Only the water-repellent calcium base greases (Ca-greases) possess a safe sealing action against water. They are used, therefore, in labyrinths for operating temperatures not exceeding 50°C, acting as sealing agents.

The sodium base greases feature a higher limiting temperature than the calcium greases. They emulsify with water and are indicated for applications with a limited amount of moisture (e. g. condensation water). Since the sodium base greases are water-absorbing, there is the risk that so much water will be absorbed that they will wash out of the bearing.

Lithium base greases do not absorb as much water as sodium base greases. Because of their reasonable resistance to water and their wide temperature range they have become the greases of preference for rolling bearings.

Also with oils, their moisture and water resisting properties must be considered. Oils that separate water well should be preferred, because they allow the water to settle in the oil sump or reservoir when the machine is at rest.

The protection against corrosion is improved by anti-corrosive additives in the oils or greases.

Contamination

Maintain cleanliness of lubricant reservoir, lubricators and grease nipples.

Relubrication involves the risk of bearing contamination. High standards of cleanliness should, therefore, be maintained for the lubricant reservoir and the lubricators and also when handling the lubricant. Grease nipples should be cleaned before relubrication.

Mixing of Lubricants

Never mix different lubricants

Lubricants of different saponification bases should not be mixed to avoid impairment of temperature stability and lubricating properties. The same applies to oils.

Lubricant Quantity

With grease lubrication, the bearing cavities should be packed to capacity. Only partly fill (20 to 35% of free space) extremely fast running bearings. The amount of grease to be filled into both lateral housing cavities depends on $n \cdot d_m$.

(n = maximum operating speed

$d_m = \frac{D+d}{2}$ mean bearing diameter)

Speed index	Amount of grease filled in the housing space
$n \cdot d_m < 50000\ min^{-1} \cdot mm$	full
$n \cdot d_m = 50000$ up to $500000\ min^{-1} \cdot mm$	60%

Overgreasing at medium and higher speeds causes churning resulting in an undesirable temperature rise which may harm both bearing and lubricant.

Rolling bearings with seals or shields are packed with grease to approx. 35% only during manufacture.

With oil lubrication, too much oil in the housing has similarly detrimental effects: the churning action overheats the oil and exposes it to air oxygen, causing oxidation and foaming.

With sump lubrication, the oil level in the housing should be no higher than the centre point of the lowest ball or roller when the bearing is at rest.

6. Rolling Bearing Damage

The life of a rolling bearing depends on the total number of stress cycles and the loads incurred by rolling elements and raceways.

The standardized calculation method for dynamically stressed bearings is based on material fatigue (pitting) causing the damage.

Normal fatigue manifests itself by flaking or spalling of the rolling surfaces (Fig. 106). An increasing local stress may result in fracture of the ring (Fig. 107).

If the bearing fails earlier than predicted by the life calculation, it should be checked for overloading. With this failure cause excluded, faulty mounting or poor maintenance or wear might be the cause for the damage. The following pages describe some of the more common forms of bearing damage and their causes.

106

106: Flaked inner ring of a deep groove ball bearing

107

107: Fracture of the inner ring of a deep groove ball bearing as final stage of fatigue

6.1 Why Does a Bearing Fail?

6.1.1 Faulty Mounting

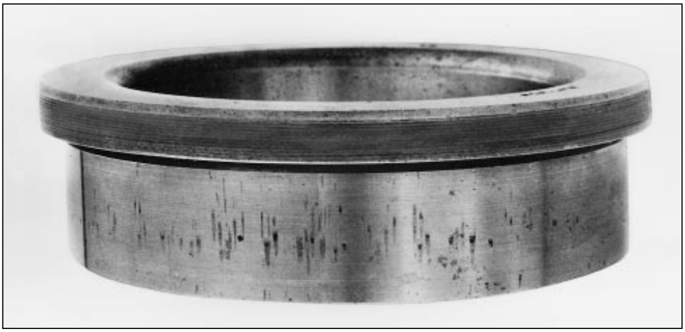
Local damage to the raceways, such as nicks, score marks or indentations suggest faulty mounting. This type of damage occurs, if, for instance, the inner ring of a cylindrical roller bearing is inserted out-of-square into the outer ring, or if the mounting force is applied through the rolling elements (Figs. 108 to 111).

Surface damage is also caused, when foreign particles enter the bearing and are cycled (see chapter 6.1.2).

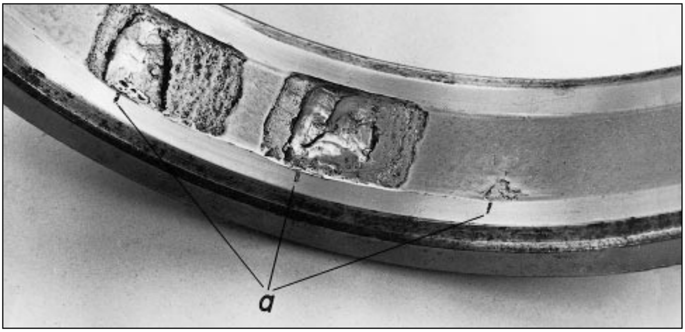
The damage can be recognized for instance by a louder running noise; in the long run, it may lead to premature fatigue of the functional surfaces.

The typical sign for surface damage are the raised edges of the indentations.

108: Ball indentations in the raceway of a deep groove ball bearing resulting from faulty mounting



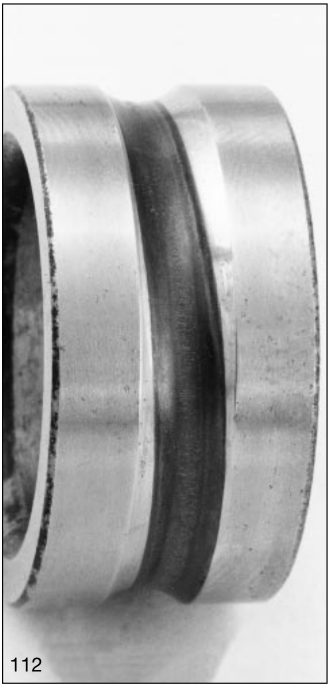
109: Scored raceway of a cylindrical roller bearing inner ring



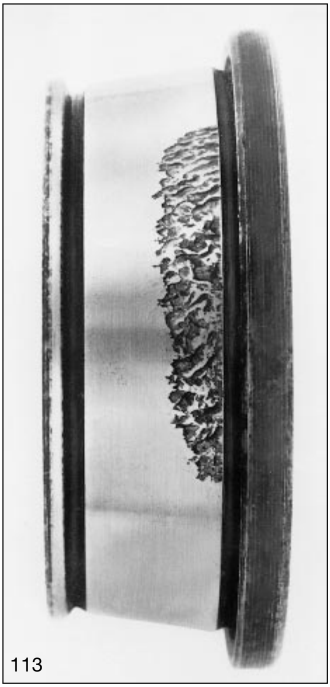
110: Premature fatigue of a cylindrical roller bearing outer ring caused by score marks visible at "a"

111: Fractured lip of a barrel roller bearing inner ring driven up its seat by hammer blows

The location of the load zone in a bearing ring results from the direction of the externally applied loads and from the conditions of rotation. The load zone can soon be recognized by slight frosting on the raceways indicating whether the bearing was loaded as specified.



112: Running tracks caused by off-square mounting of a stationary deep groove ball bearing inner ring



113: One-sided flaking caused by off-square mounting of a stationary tapered roller bearing cone

Unusual running tracks suggest detrimental preloading which may be caused by too tight fits, excessive axial adjustment, form inaccuracies of shaft or housing, misalignment or by a tight fit of the floating bearing (Figs. 112 and 113).

6.1.2 Contamination

Foreign particle indentations in the functional surfaces may lead to premature fatigue (see chapter 6.1.1). Foreign particles with abrasive effect, however, accelerate bearing failure due to wear. The surfaces are roughened and look dull. Progressive wear causes excessive clearance.

Possible causes:

Contaminated parts
Moulding sand in housings
Inadequate seals
Contaminated lubricants
Metallic abrasion from gears brought into the bearing by the lubricant.

6.1.3 Corrosion

Corrosion in rolling bearings may occur in various forms and have different causes. The damage shows in an uneven and loud running noise. The rust abraded by the rolling elements causes wear.

Figures 114 and 115 show corrosion damage due to moisture or other corrosive media.

Possible causes:

Inadequate sealing against moisture,
acid fumes,
lubricants containing acids,
condensation,
unsuitable storage of the rolling bearings in the warehouse.

False brinelling is identified by marks in the raceways at rolling element spacing. In contrast to the rolling element indentations caused by incorrect mounting, they have no raised edges (Fig. 116). The increased number of indentations shown in Fig. 117 is a result of occasional turning of the bearing.
False brinelling is caused by vibrations in the contact areas of parts while these are stationary, resulting in wear. Susceptible to such damage are machines which are subjected to vibrations while stationary or during transportation. Possible remedy: Securing by wedges

114

114: Corrosion of tapered roller bearing cone

115

115: Corrosion marks in the raceway of a self-aligning ball bearing outer ring

or similar means for transportation or keeping the bearing in rotation (e. g. on ships).
Fretting corrosion, however, occurs at the fitting surfaces, i. e. in the bearing bore or at the bearing outside diameter. It is caused by relatively loose fits or too soft mating components. Minute motions (micro-slipping) in the fitting joint may cause heavy wear resulting in an impeded floating bearing function or fracture of the shaft due to notch stresses. Possible remedy: Tight bearing fits or reinforcement of mating structure.

6.1.4 Passage of Electric Current

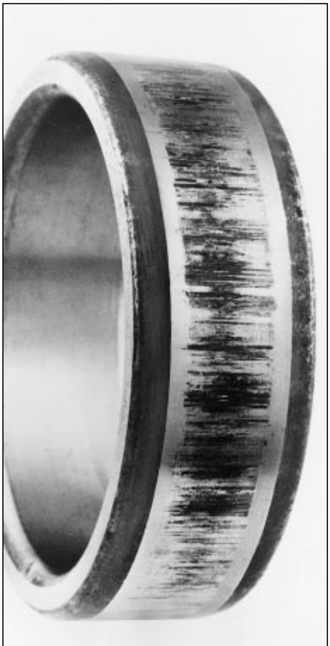
Continuous passage of electric current causes brownish flutes parallel to the axis over the entire circumference of one or both raceways as well as on the rolling elements (Fig. 118 and 119).

6.1.5 Imperfect Lubrication

Starved lubrication is caused by an insufficient lubricant supply or by use of an improper lubricant. If the lubricating film does not sufficiently separate the parts in rolling contact, sliding motion and wear result. Since maximum material stressing occurs at the raceway surfaces, micro pits and consequently large-area superficial flaking is produced (Fig. 120).

116

116: Indents caused by false brinelling of the raceway of a self-aligning ball bearing outer ring

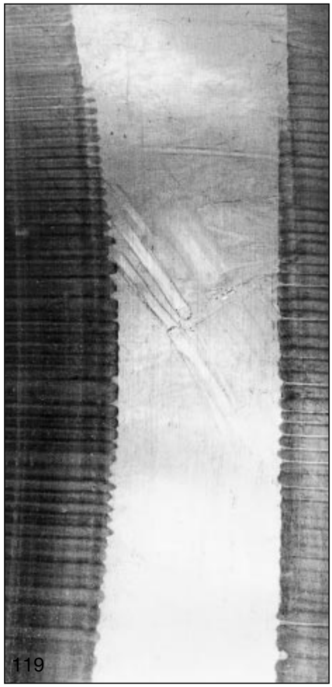


117

117: False brinelling in the raceway of a cylindrical roller bearing inner ring - due to vibrations

118

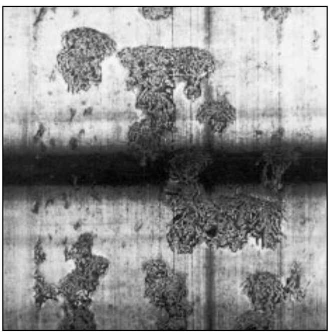
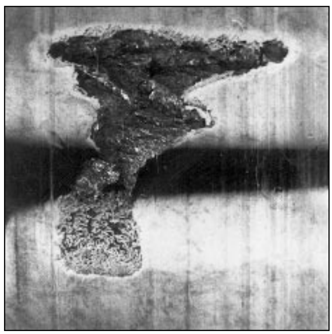
118: Fluted rollers of a spherical roller bearing due to the passage of electric current


119

119: Fluted raceway of a spherical roller bearing outer ring due to the passage of electric current

In the case of overlubrication, the lubricant heats up due to the churning action and looses its lubricity. Overheating, i. a. catastrophic failure of the bearing, may be the result. Prevent lubricant retention within the bearing, especially for high-speed bearings.

The possible consequences of contaminated lubricants are described in chapter 6.1.2.

120: A non load-carrying lubricating film causes large-area superficial flaking on cylindrical rollers.

6.2 How to Recognize Bearing Damage in Operation?*

Symtoms	**Source of Trouble**	**Examples**
Uneven running	Damaged rings or rolling elements Contamination Excessive clearance	Motor vehicles: Increased wheel wobble and vibration of steering system Fans: Increasing vibration Sawmills: Increasing knocking in connection rods Combustion engines: Increased vibration in crankshaft
Reduced working accuracy	Wear due to contaminants or insufficient lubrication Damaged rings or rolling elements	Lathe: Gradual development of chatter marks on workpiece Grinders: Waviness of ground surface Cold Rolling Mill: Period surface defects on rolled material such as stretcher strains, ghost lines etc.
Unusual running noise: Whining or high pitched noise	Insufficient operating clearance	Electric motors, gears; with gearboxes, the bearing noise is hard to identify, since it is generally drowned in the running noise of the gears
Low pitched rumbling or irregular noise	Excessive operating clearance Damaged running surfaces Contamination Inadequate lubricant	
Gradual change in running noise	Changes in operating clearance caused by temperature. Damaged raceway (from contamination or fatigue)	

*) See also Publ. No. WL 80136 "Diagnosis of rolling bearings in machines and plants, 'FAG Rolling Bearing Analyser'" and WL 80137 "Rolling bearing diagnosis with the FAG Detector".

6.3 How to Pinpoint Bearing Damage?

The examples shown in Figs. 106 to 120 are striking damage cases. They can be clearly defined and diagnosed. A detailed discussion of all imaginable combinations of bearing damage would certainly go beyond the scope of this manual.

In the field, the diagnosis of the primary cause of failure is not always easy. In many cases an examination of, for instance, the running tracks, allows certain conclusions to be drawn. Advice for the avoidance of future trouble can, however, hardly be given without knowing operating conditions, lubrication and overall design of the machine. Information should, moreover, be available on the damage symptoms in evidence and on relevant secondary phenomena.

6.3.1 Observations prior to Dismounting

Keep track of operating behaviour and record observations

Prior to dismounting, the following four conditions should be surveyed and the survey result be made a matter of record. The importance of this procedure cannot be overemphasized, since, after bearing dismounting and cleaning of bearing and housing, this evidence is irretrievably lost.

Contamination

What are the overall conditions of the machine, particularly near the bearing location? Are there deposits of dirt or residues of the machined or processed material? Could water, causics, cutting fluids, vapours and fumes have entered the bearing housing?

Loss of Lubricant

Was there any chance of lubricant escape? To find out, check the oil gauge level and the sealing gaps at the shaft outlet, all joints between housing and cover, and the seals of the oil pipes, drain plug and oil gauge.

Running Noise

Bearing damage can frequently be recognized by changes in the running noise. The nature of the noise should be specified as exactly as possible by indicating whether it is even or pulsating, recurrent or nonrecurrent, rumbling, whining, singing, or knocking. If the noise is recurrent, its frequency should be recorded. For higher speeds, this may require complicated recording equipment; for low speeds, however, it has been found practical to tap with a pencil on a piece of paper at the rate of noise recurrency, and to count the dots after a given number of seconds. The result should give a clue as to whether the trouble occurs, for instance, at inner ring or cage frequency. An attempt should also be made to assess the noise level.

Keep track of behaviour and record observations

Before disassembly, the bearing should once more be turned by hand. Often this allows easy identification and accurate characterization of running irregularities.

Case History and Secondary Evidence

The damage should be recorded, while still fresh in mind. It is important that all details be listed, i. e. the time the malfunction was first noticed, the initial symptoms and the alterations in noise or temperature occurring with time. If the trouble starts suddenly, the position of the control handles and the operating position of the machine should be noted. Any former modifications made on the machine, for instance clearance adjustment, installation of new shafts, sleeves, or spacers, increases in capacity and speed should be included in the analysis. When these modifications and the onset of the bearing trouble coincide, the expert will certainly be able to draw significant conclusions.

6.3.2 Observations during Dismounting

The following four conditions should be watched:

Lubrication

Do not wash out lubricant, but take samples

In order to examine the cause of failure of the dismounted bearing, the lubricant must not be removed. Even an expert cannot define the cause of failure of a damaged, but cleaned bearing. Avoid additional contamination of the damaged bearing.

Oil Lubrication

With oil-lubricated bearings, the oil and, as the case may be, the coolant, are drained. The oil should be collected in a clean container, especially, if there is suspicion of dirt, metal chips or an unusual amount of grit from nearby gears. If the suspicion proves true, enough oil will thus be available for a thorough investigation.

Grease Lubrication

Dismounting of grease-lubricated bearings starts with the removal of covers, caps or shields. These parts should not be immediately washed out, but stored in a clean place, until the nature of bearing failure is clarified. The same applies to felt and rubber seals and to any other seals and shields. Even if maintenance instructions call for the installation of new seals at each overhaul, the old ones should be kept for some time, as their condition may be indicative of the efficiency of the sealing system.

Two grease samples should be taken, one from the bearing interior and another from the housing. Dirty grease nipples may contaminate grease used for relubrication; in this case a sample should be taken from the grease duct.

A generous quantity should always be sampled. The sampled grease should be kept in clean containers or spread on clean oil-paper and identified such that its origin can be traced back any time.

Looseness of Locating Devices

Check tightness of locating nuts

As dismounting progresses, check tightness of the nuts which provide for axial location of the bearing inner ring. This is of particular importance with double row angular contact ball bearings with split inner ring, and with four-point bearings. Any loosening of axial location entails a change in bearing kinematics and clearance. This also applies to tapered roller bearings and angular contact ball bearings mounted in opposition. In the case of adapter and withdrawal sleeves and tapered seats, the tightness of the clamping or locknuts should be checked.

Position of Bearing Rings

Upon removal of the nuts, the ring faces should be cleaned to check the position of the rings relative to the housing and the shaft.

Prepare sketch of bearing arrangement

Generally, the running tracks on the raceways give sufficient evidence of the direction of load; this evidence is, however, of little value, if the running tracks are unusual and nothing is known on how the outer ring was mounted in the housing and the inner ring on the shaft. For this purpose, a sketch should be made showing the position of the bearing number stamping relative to a reference point in the housing or on the shaft. The sketch should also show the direction into which the stamped face of the bearing ring points, i. e. towards the shaft center or the shaft end. For separable bearings, such as cylindrical roller bearings, magneto bearings and four-point bearings, this applies to both rings. If, upon disassembly, the running tracks are found to be unusual, conclusions can be drawn as to the type and direction of load, perhaps also on detrimental preload, furnishing a clue to the cause of damage.

Examination of Bearing Seats

When extracting the bearing, a note should be made of any unusually easy or difficult removal of the rings from their seats. The bearing components of separable bearings must be kept together and not be mixed up with parts of other bearings.

An inspection of the adjacent machine parts should be made at the same time, especially when the machine has to be quickly reassembled with the new bearings to avoid a prolonged close-down. The shaft and housing seat diameters should always be measured. Special care should be given to the roundness of the seats. The condition of the driving and the driven machine elements, especially of gears and other moving parts, should also be inspected. Sliding marks and the contact pattern will frequently furnish evidence on the shaft misalignment.

Measure shaft and housing diameter, check roundness of seat

6.3.3 Bearing Inspection

Upon completion of dismounting, the damaged bearing itself should be examined. Check cleanliness, condition of the mating surfaces (dimensional stability) and function (bearing clearance, smooth running) of the complete bearing. The damage in evidence on the bearing and the recorded secondary phenomena are, in most cases, sufficient to obtain a clear picture of the damage history. Doubtful cases should be reported to the nearest FAG Engineering Office.

In case of doubt, contact the nearest FAG Engineering Office

There are, of course, many applications where no necessity exists for going into such detail. This is the case with machines built in large numbers, where the "weak points" are known. Neither will one go to great lengths with low-cost bearings. However, in customer built or special purpose machines where a seemingly unexplainable bearing damage occurs, the described secondary evidence should, in any case, be a valuable diagnostic aid.

7.1 Bearing Designation

62 05 .2RSR .N .C2

Prefixes for Parts of Standardized Bearings

K.	Cage with rolling elements, completely assembled
L	Separable ring of cylindrical and tapered roller bearings
R	Ring of cylindrical and tapered roller bearings with roller set, ring not separable
WS.	Shaft washer of a thrust bearing
GS.	Housing washer of a thrust bearing

See next page for designation of bearing series

Bore Reference Number	Bore Diameter mm
3 to 9	3 to 9
00	10
01	12
02	15
03	17
04 … 96	20 … 480: Bore reference number x 5 = Bore diameter
/500	500
/530	530

Suffixes for Special Designs

K	Tapered bore 1:12
K30	Tapered bore 1:30
E	Maximum capacity design
A, B	New, modified internal design
S	Lubricating groove and holes in outer ring
DA	Split inner ring
ZR	One shield
.2ZR	Two shields
RSR	One seal
.2RSR	Two seals
N	Circular groove in O.D. for snap ring

Suffixes for Cage Design

F	Machined steel cage
L	Machined light metal cage
M	Machined brass cage
T	Textile laminated phenolic cage
TV	Moulded cage of glass fibre reinforced polyamide 66
J	Pressed steel cage
Y	Pressed brass cage
P	Window type cage
H	Snap type cage
A	Outer ring riding
B	Inner ring riding

(P, H, A, B: is added to the material symbol)

Suffixes for Tolerances and Bearing Clearance

no suffix	Tolerance class PN (normal tolerance) and clearance group CN (normal)
P6	Tolerance class P6
P5	Tolerance class P5
P4	Tolerance class P4
P2	Tolerance class P2
SP	Tolerance class SP
UP	Tolerance class UP
C1	Clearance group C1 (<C2)
C2	Clearance group C2 (<normal)
C3	Clearance group C3 (>normal)
C4	Clearance group C4 (>C3)

The suffixes for tolerance and clearance are combined, e. g.:
P52 = tolerance class P5 and clearance group C2

Special Suffixes

S1-S4	Special heat treatment

7.2 Designation of Bearing Series: Ball Bearings

Bearing Series	Ball Bearings										
	Type									Width or Height Series	Diameter Series
	Deep Groove Ball Bearings	Angular Contact Ball Bearings	Self-Aligning Ball Bearings	Thrust Ball Bearings	Angular Contact Thrust Ball Bearings	Single Row or Single Direction	Double Row or Double Direction	With Flat Housing Washer	With Spherical Housing Washer		
618	x					x				1	8
160	x					x				0	0
60	x					x				1	0
62	x					x				0	2
63	x					x				0	3
64	x					x				0	4
42	x						x			2	2
43	x						x			2	3
12			x				x			0	2
112			x				x			0	2
13			x				x			0	3
113			x				x			0	3
22			x				x			2	2
23			x				x			2	3
B 719		x				x				1	9
B 70		x				x				1	0
B 72		x				x				0	2
72		x				x				0	2
73		x				x				0	3
QJ 2		x				x				0	2
QJ 3		x				x				0	3
32		x					x			3	2
33		x					x			3	3
511				x		x		x		1	1
512				x		x		x		1	2
513				x		x		x		1	3
514				x		x		x		1	4
532				x		x			x		2
533				x		x			x		3
534				x		x			x		4
522				x			x	x		2	2
523				x			x	x		2	3
524				x			x	x		2	4
542				x			x		x		2
543				x			x		x		3
544				x			x		x		4
2344					x		x				
2347					x		x				
7602					x	x					
7603					x	x					

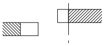
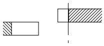
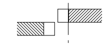
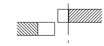
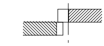
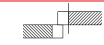
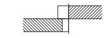
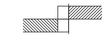
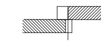
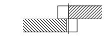
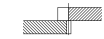
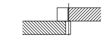
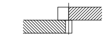
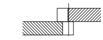
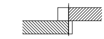
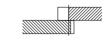
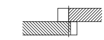
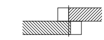
7.2 Designation of Bearing Series: Roller Bearings

Bearing Series	Roller Bearings									
	Type								Width or Height Series	Diameter Series
	Cylindrical Roller Bearings	Tapered Roller Bearings	Barrel Roller Bearings	Spherical Roller Bearings	Cylindrical Roller Thrust Bearings	Spherical Roller Thrust Bearings	Single Row	Double Row		
N 2; NU 2; NJ 2; NUP 2	x						x		0	2
N 3; NU 3; NJ 3; NUP 3	x						x		0	3
N 4; NU 4; NJ 4; NUP 4	x						x		0	4
NU 10	x						x		1	0
NU 22; NJ 22; NUP 22	x						x		2	2
NU 23; NJ 23; NUP 23	x					x		2	3	
NN 30	x							x	3	0
NNU 49	x							x	4	9
302		x					x		0	2
303		x					x		0	3
313		x					x		1	3
320		x					x		2	0
322		x					x		2	2
323		x					x		2	3
329		x					x		2	9
330		x					x		3	0
331		x					x		3	1
332		x					x		3	2
202			x				x		0	2
203			x				x		0	3
204			x				x		0	4
213				x				x	0	3
222				x				x	2	2
223				x				x	2	3
230				x				x	3	0
231				x				x	3	1
232				x				x	3	2
233				x				x	3	3
239				x				x	3	9
240				x				x	4	0
241				x				x	4	1
292							x		9	2
293							x		9	3
294							x		9	4
811					x		x		1	1
812					x		x		1	2

7.3 Shaft Tolerances

Dimensions in mm

Nominal shaft diameter	over / to	3 / 6	6 / 10	10 / 18	18 / 30	30 / 50	50 / 65	65 / 80	80 / 100	100 / 120	120 / 140	140 / 160	160 / 180	180 / 200
		Tolerance in microns (normal tolerance)												
Bearing bore diameter Deviation Δ_{dmp}		0 / −8	0 / −8	0 / −8	0 / −10	0 / −12	0 / −15	0 / −15	0 / −20	0 / −20	0 / −25	0 / −25	0 / −25	0 / −30

Diagram of fit: Shaft	Bearing	Shaft tolerance in microns												
e 7		−20 / −32	−25 / −40	−32 / −50	−40 / −61	−50 / −75	−60 / −90	−60 / −90	−72 / −107	−72 / −107	−85 / −125	−83 / −125	−85 / −125	−100 / −146
e 8		−20 / −38	−25 / −47	−32 / −59	−40 / −73	−50 / −89	−60 / −106	−60 / −106	−72 / −126	−72 / −126	−85 / −148	−85 / −148	−85 / −148	−100 / −172
f 6		−10 / −18	−13 / −22	−16 / −27	−20 / −33	−25 / −41	−30 / −49	−30 / −49	−36 / −58	−36 / −58	−43 / −68	−43 / −68	−43 / −68	−50 / −79
f 7		−10 / −22	−13 / −28	−16 / −34	−20 / −41	−25 / −50	−30 / −60	−30 / −60	−36 / −71	−36 / −71	−43 / −83	−43 / −83	−43 / −83	−50 / −96
g 5		−4 / −9	−5 / −11	−6 / −14	−7 / −16	−9 / −20	−10 / −23	−10 / −23	−12 / −27	−12 / −27	−14 / −32	−14 / −32	−14 / −32	−15 / −35
g 6		−4 / −12	−5 / −14	−6 / −17	−7 / −20	−9 / −25	−10 / −29	−10 / −29	−12 / −34	−12 / −34	−14 / −39	−14 / −39	−14 / −39	−15 / −44
h 5		0 / −5	0 / −6	0 / −8	0 / −9	0 / −11	0 / −13	0 / −13	0 / −15	0 / −15	0 / −18	0 / −18	0 / −18	0 / −20
h 6		0 / −8	0 / −9	0 / −11	0 / −13	0 / −16	0 / −19	0 / −19	0 / −22	0 / −22	0 / −25	0 / −25	0 / −25	0 / −29
j 5		+3 / −2	+4 / −2	+5 / −3	+5 / −4	+6 / −5	+6 / −7	+6 / −7	+6 / −9	+6 / −9	+7 / −11	+7 / −11	+7 / −11	+7 / −13
j 6		+6 / −2	+7 / −2	+8 / −3	+9 / −4	+11 / −5	+12 / −7	+12 / −7	+13 / −9	+13 / −9	+14 / −11	+14 / −11	+14 / −11	+16 / −13
js 3		+1,25 / −1,25	+1,25 / −1,25	+1,5 / −1,5	+2 / −2	+2 / −2	+2,5 / −2,5	+2,5 / −2,5	+3 / −3	+3 / −3	+4 / −4	+4 / −4	+4 / −4	+5 / −5
js 4		+2 / −2	+2 / −2	+2,5 / −2,5	+3 / −3	+3,5 / −3,5	+4 / −4	+4 / −4	+5 / −5	+5 / −5	+6 / −6	+6 / −6	+6 / −6	+7 / −7
js 5		+2,5 / −2,5	+3 / −3	+4 / −4	+4,5 / −4,5	+5,5 / −5,5	+6,5 / −6,5	+6,5 / −6,5	+7,5 / −7,5	+7,5 / −7,5	+9 / −9	+9 / −9	+9 / −9	+10 / −10
js 6		+4 / −4	+4,5 / −4,5	+5,5 / −5,5	+6,5 / −6,5	+8 / −8	+9,5 / −9,5	+9,5 / −9,5	+11 / −11	+11 / −11	+12,5 / −12,5	+12,5 / −12,5	+12,5 / −12,5	+14,5 / −14,5
k 3		+2,5 / 0	+2,5 / 0	+3 / 0	+4 / 0	+4 / 0	+5 / 0	+5 / 0	+6 / 0	+6 / 0	+8 / 0	+8 / 0	+8 / 0	+10 / 0
k 4		+5 / +1	+5 / +1	+6 / +1	+8 / +2	+9 / +2	+10 / +2	+10 / +2	+13 / +3	+13 / +3	+15 / +3	+15 / +3	+15 / +3	+18 / +4
k 5		+6 / +1	+7 / +1	+9 / +1	+11 / +2	+13 / +2	+15 / +2	+15 / +2	+18 / +3	+18 / +3	+21 / +3	+21 / +3	+21 / +3	+24 / +4
k 6		+9 / +1	+10 / +1	+12 / +1	+15 / +2	+18 / +2	+21 / +2	+21 / +2	+25 / +3	+25 / +3	+28 / +3	+28 / +3	+28 / +3	+33 / +4

200 225	**225 250**	**250 280**	**280 315**	**315 355**	**355 400**	**400 450**	**450 500**	**500 560**	**560 630**	**630 710**	**710 800**	**800 900**	**900 1000**	**1000 1120**	**1120 1250**
0 -30	0 -30	0 -35	0 -35	0 -40	0 -40	0 -45	0 -45	0 -50	0 -50	0 -75	0 -75	0 -100	0 -100	0 -125	0 -125
-100 -146	-100 -146	-110 -162	-110 -162	-125 -182	-125 -182	-135 -198	-135 -198	-145 -215	-145 -215	-160 -240	-160 -240	-170 -260	-170 -260	-195 -300	-195 -300
-100 -172	-100 -172	-110 -191	-110 -191	-125 -214	-125 -214	-135 -232	-135 -232	-145 -255	-145 -255	-160 -285	-160 -285	-170 -310	-170 -310	-195 -360	-195 -360
-50 -79	-50 -79	-56 -88	-56 -88	-62 -98	-62 -98	-68 -108	-68 -108	-76 -120	-76 -120	-80 -130	-80 -130	-86 -142	-86 -142	-98 -164	-98 -164
-50 -96	-50 -96	-56 -108	-56 -108	-62 -119	-62 -119	-68 -131	-68 -131	-76 -146	-76 -146	-80 -160	-80 -160	-86 -176	-86 -176	-98 -203	-98 -203
-15 -35	-15 -35	-17 -40	-17 -40	-18 -43	-18 -43	-20 -47	-20 -47	-22 -51	-22 -51	-24 -56	-24 -56	-26 -62	-26 -62	-28 -70	-28 -70
-15 -44	-15 -44	-17 -49	-17 -49	-18 -54	-18 -54	-20 -60	-20 -60	-22 -66	-22 -66	-24 -74	-24 -74	-26 -82	-26 -82	-28 -94	-28 -94
0 -20	0 -20	0 -23	0 -23	0 -25	0 -25	0 -27	0 -27	0 -29	0 -29	0 -32	0 -32	0 -36	0 -36	0 -42	0 -42
0 -29	0 -29	0 -32	0 -32	0 -36	0 -36	0 -40	0 -40	0 -44	0 -44	0 -50	0 -50	0 -56	0 -56	0 -66	0 -66
+7 -13	+7 -13	+7 -16	+7 -16	+7 -18	+7 -18	+7 -20	+7 -20								
+16 -13	+16 -13	+16 -16	+16 -16	+18 -18	+18 -18	+20 -20	+20 -20	+22 -22	+22 -22	+25 -25	+25 -25	+28 -28	+28 -28	+33 -33	+33 -33
+5 -5	+5 -5	+6 -6	+6 -6	+6,5 -6,5	+6,5 -6,5	+7,5 -7,5	+7,5 -7,5								
+7 -7	+7 -7	+8 -8	+8 -8	+9 -9	+9 -9	+10 -10	+10 -10								
+10 -10	+10 -10	+11,5 -11,5	+11,5 -11,5	+12,5 -12,5	+12,5 -12,5	+13,5 -13,5	+13,5 -13,5	+14,5 -14,5	+14,5 -14,5	+16 -16	+16 -16	+18 -18	+18 -18	+21 -21	+21 -21
+14,5 -14,5	+14,5 -14,5	+16 -16	+16 -16	+18 -18	+18 -18	+20 -20	+20 -20	+22 -22	+22 -22	+25 -25	+25 -25	+28 -28	+28 -28	+33 -33	+33 -33
+10 0	+10 0	+12 0	+12 0	+13 0	+13 0	+15 0	+15 0								
+18 +4	+18 +4	+20 +4	+20 +4	+22 +4	+22 +4	+25 +5	+25 +5								
+24 +4	+24 +4	+27 +4	+27 +4	+29 +4	+29 +4	+32 +5	+32 +5	+29 0	+29 0	+32 0	+32 0	+36 0	+36 0	+42 0	+42 0
+33 +4	+33 +4	+36 +4	+36 +4	+40 +4	+40 +4	+45 +5	+45 +5	+44 +0	+44 +0	+50 +0	+50 +0	+56 +0	+56 +0	+66 +0	+66 +0

7.3 Shaft Tolerances (continuation)

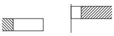
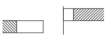
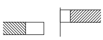
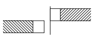
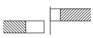
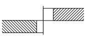
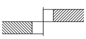
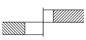
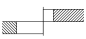
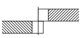
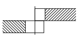
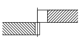
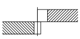
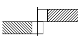
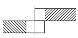
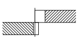
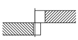
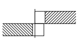
	Dimensions in mm												
Nominal shaft diameter over to	**3** **6**	**6** **10**	**10** **18**	**18** **30**	**30** **50**	**50** **65**	**65** **80**	**80** **100**	**100** **120**	**120** **140**	**140** **160**	**160** **180**	**180** **200**
	Tolerance in microns (normal tolerance)												
Bearing bore diameter Deviation Δ_{dmp}	0 –8	0 –8	0 –8	0 –10	0 –12	0 –15	0 –15	0 –20	0 –20	0 –25	0 –25	0 –25	0 –30
Diagram of fit Shaft Bearing	Shaft tolerance in microns												
m 5	+9 +4	+12 +6	+15 +7	+17 +8	+20 +9	+24 +11	+24 +11	+28 +13	+28 +13	+33 +15	+33 +15	+33 +15	+37 +17
m 6	+12 +4	+15 +6	+18 +7	+21 +8	+25 +9	+30 +11	+30 +11	+35 +13	+35 +13	+40 +15	+40 +15	+40 +15	+46 +17
n 5	+13 +8	+16 +10	+20 +12	+24 +15	+28 +17	+33 +20	+33 +20	+38 +23	+38 +23	+45 +27	+45 +27	+45 +27	+51 +31
n 6	+16 +8	+19 +10	+23 +12	+28 +15	+33 +17	+39 +20	+39 +20	+45 +23	+45 +23	+52 +27	+52 +27	+52 +27	+60 +31
p 6	+20 +12	+24 +15	+29 +18	+35 +22	+42 +26	+51 +32	+51 +32	+59 +37	+59 +37	+68 +43	+68 +43	+68 +43	+79 +50
p 7	+24 +12	+30 +15	+36 +18	+43 +22	+51 +26	+62 +32	+62 +32	+72 +37	+72 +37	+83 +43	+83 +43	+83 +43	+96 +50
r 6	+23 +15	+28 +19	+34 +23	+41 +28	+50 +34	+60 +41	+62 +43	+73 +51	+76 +54	+88 +63	+90 +65	+93 +68	+106 +77
r 7	+27 +15	+34 +19	+41 +23	+49 +28	+59 +34	+71 +41	+73 +43	+86 +51	+89 +54	+103 +63	+105 +65	+108 +68	+123 +77
s 6	+27 +19	+32 +23	+39 +28	+48 +35	+59 +43	+72 +53	+78 +59	+93 +71	+101 +79	+117 +92	+125 +100	+133 +108	+151 +122
s 7	+31 +19	+38 +23	+46 +28	+56 +35	+68 +43	+83 +53	+89 +59	+106 +71	+114 +79	+132 +92	+140 +100	+148 +108	+168 +122
	Shaft tolerance for withdrawal sleeves and adapter sleeves (microns)												
h7/$\frac{IT5}{2}$	0 –12 2,5	0 –15 3	0 –18 4	0 –21 4,5	0 –25 5,5	0 –30 6,5	0 –30 6,5	0 –35 7,5	0 –35 7,5	0 –40 9	0 –40 9	0 –40 9	0 –46 10
h8/$\frac{IT5}{2}$	0 –18 2,5	0 –22 3	0 –27 4	0 –33 4,5	0 –39 5,5	0 –46 6,5	0 –46 6,5	0 –54 7,5	0 –54 7,5	0 –63 9	0 –63 9	0 –63 9	0 –72 10
h9/$\frac{IT6}{2}$	0 –30 4	0 –36 4,5	0 –43 5,5	0 –52 6,5	0 –62 8	0 –74 9,5	0 –74 9,5	0 –87 11	0 –87 11	0 –100 12,5	0 –100 12,5	0 –100 12,5	0 –115 14,5
h10/$\frac{IT7}{2}$	0 –48 6	0 –58 7,5	0 –70 9	0 –84 10,5	0 –100 12,5	0 –120 15	0 –120 15	0 –140 17,5	0 –140 17,5	0 –160 20	0 –160 20	0 –160 20	0 –185 23

The cylindricity tolerance (blue numbers) refers to the radius (DIN ISO 1101).
Double the tolerance values for measuring the shaft diameter.
For general mechanical engineering, h7 and h8 values are preferable.

200 225	**225 250**	**250 280**	**280 315**	**315 355**	**355 400**	**400 450**	**450 500**	**500 560**	**560 630**	**630 710**	**710 800**	**800 900**	**900 1000**	**1000 1120**	**1120 1250**
0 -30	0 -30	0 -35	0 -35	0 -40	0 -40	0 -45	0 -45	0 -50	0 -50	0 -75	0 -75	0 -100	0 -100	0 -125	0 -125
+37 +17	+37 +17	+43 +20	+43 +20	+46 +21	+46 +21	+50 +23	+50 +23	+55 +26	+55 +26	+62 +30	+62 +30	+70 +34	+70 +34	+82 +40	+82 +40
+46 +17	+46 +17	+52 +20	+52 +20	+57 +21	+57 +21	+63 +23	+63 +23	+70 +26	+70 +26	+80 +30	+80 +30	+90 +34	+90 +34	+106 +40	+106 +40
+51 +31	+51 +31	+57 +34	+57 +34	+62 +37	+62 +37	+67 +40	+67 +40	+73 +44	+73 +44	+82 +50	+82 +50	+92 +56	+92 +56	+108 +66	+108 +66
+60 +31	+60 +31	+66 +34	+66 +34	+73 +37	+73 +37	+80 +40	+80 +40	+88 +44	+88 +44	+100 +50	+100 +50	+112 +56	+112 +56	+132 +66	+132 +66
+79 +50	+79 +50	+88 +56	+88 +56	+98 +62	+98 +62	+108 +68	+108 +68	+122 +78	+122 +78	+138 +88	+138 +88	+156 +100	+156 +100	+186 +120	+186 +120
+96 +50	+96 +50	+108 +56	+108 +56	+119 +62	+119 +62	+131 +68	+131 +68	+148 +78	+148 +78	+168 +88	+168 +88	+190 +100	+190 +100	+225 +120	+225 +120
+109 +80	+113 +84	+126 +94	+130 +98	+144 +108	+150 +114	+166 +126	+172 +132	+194 +150	+199 +155	+225 +175	+235 +185	+266 +210	+276 +220	+316 +250	+326 +260
+126 +80	+130 +84	+146 +94	+150 +98	+165 +108	+171 +114	+189 +126	+195 +132	+220 +150	+225 +155	+255 +175	+265 +185	+300 +210	+310 +220	+355 +250	+365 +260
+159 +130	+169 +140	+190 +158	+202 +170	+226 +190	+244 +208	+272 +232	+292 +252	+324 +280	+354 +310	+390 +340	+430 +380	+486 +430	+526 +470	+586 +520	+646 +580
+176 +130	+186 +140	+210 +158	+222 +170	+247 +190	+265 +208	+295 +232	+315 +252	+350 +280	+380 +310	+420 +340	+460 +380	+520 +430	+560 +470	+625 +520	+685 +580
0 –46 10	0 –46 10	0 –52 11,5	0 –52 11,5	0 –57 12,5	0 –57 12,5	0 –63 13,5	0 –63 13,5	0 –70 14,5	0 –70 14,5	0 –80 16	0 –80 16	0 –90 18	0 –90 18	0 –105 21	0 –105 21
0 –72 10	0 –72 10	0 –81 11,5	0 –81 11,5	0 –89 12,5	0 –89 12,5	0 –97 13,5	0 –97 13,5	0 –110 14,5	0 –110 14,5	0 –125 16	0 –125 16	0 –140 18	0 –140 18	0 –165 21	0 –165 21
0 –115 14.5	0 –115 14.5	0 –130 16	0 –130 16	0 –140 18	0 –140 18	0 –155 20	0 –155 20	0 –175 22	0 –175 22	0 –200 25	0 –200 25	0 –230 28	0 –230 28	0 –260 33	0 –260 33
0 –185 23	0 –185 23	0 –210 26	0 –210 26	0 –230 28,5	0 –230 28,5	0 –250 31,5	0 –250 31,5	0 –280 35	0 –280 35	0 –320 40	0 –320 40	0 –360 45	0 –360 45	0 –420 52,5	0 –420 52,5

7.4 Housing Tolerances

Nomin. housing bore diameter		Dimensions in mm												
	over	**6**	**10**	**18**	**30**	**50**	**65**	**80**	**100**	**120**	**140**	**160**	**180**	**200**
	to	**10**	**18**	**30**	**50**	**65**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**225**
		Tolerance in microns (normal tolerance)												
Bearing outside dia. Deviation Δ_{Dmp}		0 –8	0 –8	0 –9	0 –11	0 –13	0 –13	0 –15	0 –15	0 –18	0 –18	0 –25	0 –30	0 –30

Diagram of fit Housing	Bearing	Housing tolerance in microns												
D 10		+98 +40	+120 +50	+149 +65	+180 +80	+220 +100	+220 +100	+260 +120	+260 +120	+305 +145	+305 +145	+305 +145	+355 +170	+355 +170
E 8		+47 +25	+59 +32	+73 +40	+89 +50	+106 +60	+106 +60	+126 +72	+126 +72	+148 +85	+148 +85	+148 +85	+172 +100	+172 +100
F 7		+28 +13	+34 +16	+41 +20	+50 +25	+60 +30	+60 +30	+71 +36	+71 +36	+83 +43	+83 +43	+83 +43	+96 +50	+96 +50
G 6		+14 +5	+17 +6	+20 +7	+25 +9	+29 +10	+29 +10	+34 +12	+34 +12	+39 +14	+39 +14	+39 +14	+44 +15	+44 +15
G 7		+20 +5	+24 +6	+28 +7	+34 +9	+40 +10	+40 +10	+47 +12	+47 +12	+54 +14	+54 +14	+54 +14	+61 +15	+61 +15
H 5		+6 0	+8 0	+9 0	+11 0	+13 0	+13 0	+15 0	+15 0	+18 0	+18 0	+18 0	+20 0	+20 0
H 6		+9 0	+11 0	+13 0	+16 0	+19 0	+19 0	+22 0	+22 0	+25 0	+25 0	+25 0	+29 0	+29 0
H 7		+15 0	+18 0	+21 0	+25 0	+30 0	+30 0	+35 0	+35 0	+40 0	+40 0	+40 0	+46 0	+46 0
H 8		+22 0	+27 0	+33 0	+39 0	+46 0	+46 0	+54 0	+54 0	+63 0	+63 0	+63 0	+72 0	+72 0
J 6		+5 –4	+6 –5	+8 –5	+10 –6	+13 –6	+13 –6	+16 –6	+16 –6	+18 –7	+18 –7	+18 –7	+22 –7	+22 –7
J 7		+8 –7	+10 –8	+12 –9	+14 –11	+18 –12	+18 –12	+22 –13	+22 –13	+26 –14	+26 –14	+26 –14	+30 –16	+30 –16
JS 4		+2 –2	+2,5 –2,5	+3 –3	+3,5 –3,5	+4 –4	+4 –4	+5 –5	+5 –5	+6 –6	+6 –6	+6 –6	+7 –7	+7 –7
JS 5		+3 –3	+4 –4	+4,5 –4,5	+5,5 –5,5	+6,5 –6,5	+6,5 –6,5	+7,5 –7,5	+7,5 –7,5	+9 –9	+9 –9	+9 –9	+10 –10	+10 –10
JS 6		+4,5 –4,5	+5,5 –5,5	+6,5 –6,5	+8 –8	+9,5 –9,5	+9,5 –9,5	+11 –11	+11 –11	+12,5 –12,5	+12,5 –12,5	+12,5 –12,5	+14,5 –14,5	+14,5 –14,5
JS 7		+7,5 –7,5	+9 –9	+10,5 –10,5	+12,5 –12,5	+15 –15	+15 –15	+17,5 –17,5	+17,5 –17,5	+20 –20	+20 –20	+20 –20	+23 –23	+23 –23
K 4		+0,5 –3,5	+1 –4	0 –6	+1 –6	+1 –7	+1 –7	+1 –9	+1 –9	+1 –11	+1 –11	+1 –11	0 –14	0 –14
K 5		+1 –5	+2 –6	+1 –8	+2 –9	+3 –10	+3 –10	+2 –13	+2 –13	+3 –15	+3 –15	+3 –15	+2 –18	+2 –18
K 6		+2 –7	+2 –9	+2 –11	+3 –13	+4 –15	+4 –15	+4 –18	+4 –18	+4 –21	+4 –21	+4 –21	+5 –24	+5 –24

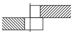
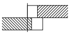
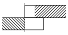
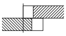
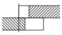
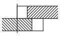
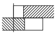
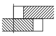
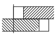
225 250	**250 280**	**280 315**	**315 355**	**355 400**	**400 450**	**450 500**	**500 560**	**560 630**	**630 710**	**710 800**	**800 900**	**900 1000**	**1000 1120**	**1120 1250**	**1250 1400**
0 -30	0 -35	0 -35	0 -40	0 -40	0 -45	0 -45	0 -50	0 -50	0 -75	0 -75	0 -100	0 -100	0 -125	0 -125	0 –160
+355 +170	+400 +190	+400 +190	+440 +210	+440 +210	+480 +230	+480 +230	+540 +260	+540 +260	+610 +290	+610 +290	+680 +320	+680 +320	+770 +350	+770 +350	+890 +390
+172 +100	+191 +110	+191 +110	+214 +125	+214 +125	+232 +135	+232 +135	+255 +145	+255 +145	+285 +160	+285 +160	+310 +170	+310 +170	+360 +195	+360 +195	+415 +220
+96 +50	+108 +56	+108 +56	+119 +62	+119 +62	+131 +68	+131 +68	+144 +76	+144 +76	+160 +80	+160 +80	+176 +86	+176 +86	+203 +98	+203 +98	+235 +110
+44 +15	+49 +17	+49 +17	+54 +18	+54 +18	+60 +20	+60 +20	+66 +22	+66 +22	+74 +24	+74 +24	+82 +26	+82 +26	+94 +28	+94 +28	+108 +30
+61 +15	+69 +17	+69 +17	+75 +18	+75 +18	+83 +20	+83 +20	+92 +22	+92 +22	+104 +24	+104 +24	+116 +26	+116 +26	+133 +28	+133 +28	+155 +30
+20 0	+23 0	+23 0	+25 0	+25 0	+27 0	+27 0									
+29 0	+32 0	+32 0	+36 0	+36 0	+40 0	+40 0	+44 0	+44 0	+50 0	+50 0	+56 0	+56 0	+66 0	+66 0	+78 0
+46 0	+52 0	+52 0	+57 0	+57 0	+63 0	+63 0	+70 0	+70 0	+80 0	+80 0	+90 0	+90 0	+105 0	+105 0	+125 0
+72 0	+81 0	+81 0	+89 0	+89 0	+97 0	+97 0	+110 0	+110 0	+125 0	+125 0	+140 0	+140 0	+165 0	+165 0	+195 0
+22 –7	+25 –7	+25 –7	+29 –7	+29 –7	+33 –7	+33 –7									
+30 –16	+36 –16	+36 –16	+39 –18	+39 –18	+43 –20	+43 –20									
+7 –7	+8 –8	+8 –8	+9 –9	+9 –9	+10 –10	+10 –10									
+10 –10	+11,5 –11,5	+11,5 –11,5	+12,5 –12,5	+12,5 –12,5	+13,5 –13,5	+13,5 –13,5									
+14,5 –14,5	+16 –16	+16 –16	+18 –18	+18 –18	+20 –20	+20 –20	+22 –22	+22 –22	+25 –25	+25 –25	+28 –28	+28 –28	+33 –33	+33 –33	+39 –39
+23 –23	+26 –26	+26 –26	+28,5 –28,5	+28,5 –28,5	+31,5 –31,5	+31,5 –31,5	+35 –35	+35 –35	+40 –40	+40 –40	+45 –45	+45 –45	+52 –52	+52 –52	+62 –62
0 –14	0 –16	0 –16	0 –17	0 –17	0 –20	0 –20									
+2 –18	+3 –20	+3 –20	+3 –22	+3 –22	+2 –25	+2 –25									
+5 –24	+5 –27	+5 –27	+7 –29	+7 –29	+8 –32	+8 –32	0 –44	0 –44	0 –50	0 –50	0 –56	0 –56	0 –66	0 –66	0 –78

7.4 Housing Tolerances (continuation)

Dimensions in mm

Nomin. housing bore diameter	over / to	6 10	10 18	18 30	30 50	50 65	65 80	80 100	100 120	120 140	140 160	160 180	180 200	200 225
Tolerance in microns (normal tolerance)														
Bearing outside dia. Deviation Δ_{Dmp}		0 –8	0 –8	0 –9	0 –11	0 –13	0 –13	0 –15	0 –15	0 –18	0 –18	0 –25	0 –30	0 –30

Diagram of fit

Housing	Bearing	Housing tolerance in microns												
K 7		+5 -10	+6 -12	+6 -15	+7 -18	+9 -21	+9 -21	+10 -25	+10 -25	+12 -28	+12 -28	+12 -28	+13 -33	+13 -33
M 6		-3 -12	-4 -15	-4 -17	-4 -20	-5 -24	-5 -24	-6 -28	-6 -28	-8 -33	-8 -33	-8 -33	-8 -37	-8 -37
M 7		0 -15	0 -18	0 -21	0 -25	0 -30	0 -30	0 -35	0 -35	0 -40	0 -40	0 -40	0 -46	0 -46
N 6		-7 -16	-9 -20	-11 -24	-12 -28	-14 -33	-14 -33	-16 -38	-16 -38	-20 -45	-20 -45	-20 -45	-22 -51	-22 -51
N 7		-4 -19	-5 -23	-7 -28	-8 -33	-9 -39	-9 -39	-10 -45	-10 -45	-12 -52	-12 -52	-12 -52	-14 -60	-14 -60
P 6		-12 -21	-15 -26	-18 -31	-21 -37	-26 -45	-26 -45	-30 -52	-30 -52	-36 -61	-36 -61	-36 -61	-41 -70	-41 -70
P 7		-9 -24	-11 -29	-14 -35	-17 -42	-21 -51	-21 -51	-24 -59	-24 -59	-28 -68	-28 -68	-28 -68	-33 -79	-33 -79
R 6		-16 -25	-20 -31	-24 -37	-29 -45	-35 -54	-37 -56	-44 -66	-47 -69	-56 -81	-58 -83	-61 -86	-68 -97	-71 -100
S 6		-20 -29	-25 -36	-31 -44	-38 -54	-47 -66	-53 -72	-64 -86	-72 -94	-85 -110	-93 -118	-101 -126	-113 -142	-121 -150

225 250	**250 280**	**280 315**	**315 355**	**355 400**	**400 450**	**450 500**	**500 560**	**560 630**	**630 710**	**710 800**	**800 900**	**900 1000**	**1000 1120**	**1120 1250**	**1250 1400**
0 -30	0 -35	0 -35	0 -40	0 -40	0 -45	0 -45	0 -50	0 -50	0 -75	0 -75	0 -100	0 -100	0 -125	0 -125	0 –160
+13 -33	+16 -36	+16 -36	+17 -40	+17 -40	+18 -45	+18 -45	0 -70	0 -70	0 -80	0 -80	0 -90	0 -90	0 -105	0 -105	0 -125
-8 -37	-9 -41	-9 -41	-10 -46	-10 -46	-10 -50	-10 -50	-26 -70	-26 -70	-30 -80	-30 -80	-34 -90	-34 -90	-40 -106	-40 -106	-48 -126
0 -46	0 -52	0 -52	0 -57	0 -57	0 -63	0 -63									
-22 -51	-25 -57	-25 -57	-26 -62	-26 -62	-27 -67	-27 -67	-44 -88	-44 -88	-50 -100	-50 -100	-56 -112	-56 -112	-66 -132	-66 -132	-78 -156
-14 -60	-14 -66	-14 -66	-16 -73	-16 -73	-17 -80	-17 -80									
-41 -70	-47 -79	-47 -79	-51 -87	-51 -87	-55 -95	-55 -95	-78 -122	-78 -122	-88 -138	-88 -138	-100 -156	-100 -156	-120 -186	-120 -186	-140 -218
-33 -79	-36 -88	-36 -88	-41 -98	-41 -98	-45 -108	-45 -108	-78 -148	-78 -148	-88 -168	-88 -168	-100 -190	-100 -190	-120 -225	-120 -225	-140 -265
-75 -104	-85 -117	-89 -121	-97 -133	-103 -139	-113 -153	-119 -159	-150 -194	-155 -199	-175 -225	-185 -235	-210 -266	-220 -276	-250 -316	-260 -326	-300 -378
-131 -160	-149 -181	-161 -193	-179 -215	-197 -233	-219 -259	-239 -279									

7.5 Normal Tolerances of FAG Radial Bearings (Except Tapered Roller Bearings)

Inner ring

Dimensions in mm

Nominal bore diameter d	over to	2,5 10	10 18	18 30	30 50	50 80	80 120	120 180	180 250	250 315	315 400	400 500	500 630	630 800	800 1000	1000 1250

Tolerance class PN (normal tolerance)

Tolerance in microns

Bore, cylindrical Deviation	Δ_{dmp}	0 –8	0 –8	0 –10	0 –12	0 –15	0 –20	0 –25	0 –30	0 –35	0 –40	0 –45	0 –50	0 –75	0 –100	0 –125
Variation V_{dp}	diameter series 7 · 8 · 9	10	10	13	15	19	25	31	38	44	50	56	63			
	0 · 1	8	8	10	12	19	25	31	38	44	50	56	63			
	2 · 3 · 4	6	6	8	9	11	15	19	23	26	30	34	38			
Variation	V_{dmp}	6	6	8	9	11	15	19	23	26	30	34	38			
Bore, taper 1:12 Deviation	Δ_{dmp}	+15 0	+18 0	+21 0	+25 0	+30 0	+35 0	+40 0	+46 0	+52 0	+57 0	+63 0	+70 0	+80 0	+90 0	+105 0
Deviation	Δ_{d1mp} – Δ_{dmp}	+15 0	+18 0	+21 0	+25 0	+30 0	+35 0	+40 0	+46 0	+52 0	+57 0	+63 0	+70 0	+80 0	+90 0	+105 0
Variation	V_{dp}	10	10	13	15	19	25	31	38	44	50	56				
Bore, taper 1:30 Deviation	Δ_{dmp}					+15 0	+20 0	+25 0	+30 0	+35 0	+40 0	+45 0	+50 0	+75 0	+100 0	+125 0
Deviation	Δ_{d1mp} – Δ_{dmp}					+35 0	+40 0	+50 0	+55 0	+60 0	+65 0	+75 0	+85 0	+100 0	+100 0	+115 0
Variation	V_{dp}					19	25	31	38	44	50	56	63			
Width deviation	Δ_{Bs}	0 –120	0 –120	0 –120	0 –120	0 –150	0 –200	0 –250	0 –300	0 –350	0 –400	0 –450	0 –500	0 –750	0 –1000	0 –1250
Width variation	V_{Bs}	15	20	20	20	25	25	30	30	35	40	50	60	70	80	100
Radial runout	K_{ia}	10	10	13	15	20	25	30	40	50	60	65	70	80	90	100

Bore diameter

Δ_{dmp} Single plane mean bore diameter deviation
Δ_{d1mp} Deviation of mean large diameter from nominal dimension (tapered bore)
V_{dp} Bore diameter variation in a single radial plane
V_{dmp} Mean bore diameter variation; difference between maximum and minimum mean bore diameter

Outside diameter

Δ_{Dmp} Single plane mean outside diameter deviation
V_{Dp} Outside diameter variation in a single radial plane
V_{Dmp} Mean outside diameter variation; difference between maximum and minimum mean outside diameter

Outer ring

		Dimensions in mm															
Nominal outside diameter D	over to	**6** **18**	**18** **30**	**30** **50**	**50** **80**	**80** **120**	**120** **150**	**150** **180**	**180** **250**	**250** **315**	**315** **400**	**400** **500**	**500** **630**	**630** **800**	**800** **1000**	**1000** **1250**	**1250** **1600**

Tolerance class PN (normal tolerance)

		Tolerance in microns															
Deviation	Δ_{Dmp}	0 –8	0 –9	0 –11	0 –13	0 –15	0 –18	0 –25	0 –30	0 –35	0 –40	0 –45	0 –50	0 –75	0 –100	0 –125	0 –160
Variation V_{Dp}	diameter series 7·8·9	10	12	14	16	19	23	31	38	44	50	56	63	94	125		
	0·1	8	9	11	13	19	23	31	38	44	50	56	63	94	125		
	2·3·4	6	7	8	10	11	14	19	23	26	30	34	38	55	75		
	sealed bearings 2·3·4	10	12	16	20	26	30	38									
Variation	V_{Dmp}	6	7	8	10	11	14	19	23	26	30	34	38	55	75		
Radial runout	K_{ea}	15	15	20	25	35	40	45	50	60	70	80	100	120	140	160	190

The width tolerances Δ_{Cs} and V_{Cs} are identical to Δ_{Bs} and V_{Bs} for the pertinent inner ring.

Width

Δ_B, Δ_{Cs} Deviation of a single ring width (inner and outer ring) from nominal dimension
V_{Bs}, V_{Cs} Variation of inner ring width and outer ring width

Running accuracy

K_{ia} Radial runout of assembled bearing inner ring
K_{ea} Radial runout of assembled bearing outer ring

7.6 Normal Tolerances of FAG Tapered Roller Bearings in Metric Dimensions

Cone

Dimensions in mm

Nominal bore diameter d	over to	10 18	18 30	30 50	50 80	80 120	120 180	180 250	250 315	315 400	400 500	500 630

Tolerance class PN (normal tolerance)

Tolerance in microns

Deviation	Δ_{dmp}	0 –12	0 –12	0 –12	0 –15	0 –20	0 –25	0 –30	0 –35	0 –40	0 –45	0 –50
Variation	V_{dp}	12	12	12	15	20	25	30	35	40	45	50
	V_{dmp}	9	9	9	11	15	19	23	26	30		
Width deviation	Δ_{Bs}	0 –120	0 –120	0 –120	0 –150	0 –200	0 –250	0 –300	0 –350	0 –400	0 –450	0 –500
Radial runout	K_{ia}	15	18	20	25	30	35	50	60	70	70	85
Width deviation	Δ_{Ts}	+200 0	+200 0	+200 0	+200 0	+200 –200	+350 –250	+350 –250	+350 –250	+400 –400	+400 –400	+500 –500
	Δ_{T1s}	+100 0	+100 0	+100 0	+100 0	+100 –100	+150 –150	+150 –150	+150 –150	+200 –200		
	Δ_{T2s}	+100 0	+100 0	+100 0	+100 0	+100 –100	+200 –100	+200 –100	+200 –100	+200 –200		

Cup

Dimensions in mm

Nominal outside diameter D	over to	18 30	30 50	50 80	80 120	120 150	150 180	180 250	250 315	315 400	400 500	500 630	630 800	800 1000

Tolerance class PN (normal tolerance)

Tolerance in microns

Deviation	Δ_{Dmp}	0 –12	0 –14	0 –16	0 –18	0 –20	0 –25	0 –30	0 –35	0 –40	0 –45	0 –50	0 –75	0 –100
Variation	V_{Dp}	12	14	16	18	20	25	30	35	40	45	50	75	100
	V_{Dmp}	9	11	12	14	15	19	23	26	30	34	38		
Radial runout	K_{ea}	18	20	25	35	40	45	50	60	70	80	100	120	120

The width tolerance Δ_{Cs} is identical with Δ_{Bs} for the pertinent inner ring.

T_s Overall width of a tapered roller bearing, measured at a single position
T_{1s} Overall width of a tapered roller bearing, measured at a single position by cone and master cup
T_{2s} Overall width of a tapered roller bearing, measured at a single position by cup and master cone
$\Delta_{TS} = T_s–T$, $\Delta_{T1S} = T_{1s}–T_1$, $\Delta_{T2s} = T_{2s}–T_2$ Deviation of a single tapered roller bearing overall width from nominal dimension
H_s, H_{1s}, H_{2s}, H_{3s}, H_{4s} Overall thrust bearing height measured at a single position
$\Delta_{Hs} = H_s–H$, $\Delta_{H1s} = H_{1s}–H_1$, $\Delta_{H2s} = H_{2s}–H_2$.... Deviation of a single overall thrust bearing height from nominal dimension
H Overall height of a single direction thrust bearing
H_1 Overall height of a single direction thrust bearing with seating ring
H_2 Overall height of a double direction thrust bearing
H_3 Overall height of a double direction thrust bearing with seating rings
H_4 Overall height of a spherical roller thrust bearing

7.7 Normal Tolerances of FAG Thrust Bearings

Shaft washer

Dimensions in mm

Nominal bore diameter d_w	over to	 **18**	**18** **30**	**30** **50**	**50** **80**	**80** **120**	**120** **180**	**180** **250**	**250** **315**	**315** **400**	**400** **500**	**500** **630**	**630** **800**	**800** **1000**	**1000** **1250**

Tolerance class PN (normal tolerance)

Tolerance in microns

Deviation	Δ_{dmp}	0 –8	0 –10	0 –12	0 –15	0 –20	0 –25	0 –30	0 –35	0 –40	0 –45	0 –50	0 –75	0 –100	0 –125
Variation	V_{dp}	6	8	9	11	15	19	23	26	30	34	38			
Wall thickness variation	$S_{i^{*)}}$	10	10	10	10	15	15	20	25	30	30	35	40	45	50
Seating ring deviation	Δ_{du}	+70 0	+70 0	+85 0	+100 0	+120 0	+140 0	+140 0	+160 0	+180 0	+180 0				

Housing washer

Dimensions in mm

Nominal outside diameter D_g	over to	**18** **30**	**30** **50**	**50** **80**	**80** **120**	**120** **180**	**180** **250**	**250** **315**	**315** **400**	**400** **500**	**500** **630**	**630** **800**	**800** **1000**	**1000** **1250**	**1250** **1600**

Tolerance class PN (normal tolerance)

Tolerance in microns

Deviation	Δ_{Dmp}	0 –13	0 –16	0 –19	0 –22	0 –25	0 –30	0 –35	0 –40	0 –45	0 –50	0 –75	0 –100	0 –125	0 –160
Variation	V_{Dp}	10	12	14	17	19	23	26	30	34	38	55	75		
Seating ring deviation	Δ_{Du}	0 –30	0 –35	0 –45	0 –60	0 –75	0 –90	0 –105	0 –120	0 –135	0 –180				

*) The values of the wall thickness variation apply to shaft and housing washers

Construction Heights of Thrust Bearings

Dimensions in mm

Nominal bore diameter d_w	over to	 **30**	**30** **50**	**50** **80**	**80** **120**	**120** **180**	**180** **250**	**250** **315**	**315** **400**	**400** **500**	**500** **630**	**630** **800**	**800** **1000**	**1000** **1250**

Tolerance classes PN ... P4

Tolerance in microns

Deviation	Δ_{Hs}	+20 –250	+20 –250	+20 –300	+25 –300	+25 –400	+30 –400	+40 –400	+40 –500	+50 –500	+60 –600	+70 –750	+80 –1000	+100 –1400
	Δ_{H1s}	+100 –250	+100 –250	+100 –300	+150 –300	+150 –400	+150 –400	+200 –400	+200 –500	+300 –500	+350 –600	+400 –750	+450 –1000	+500 –1400
	Δ_{H2s}	+150 –400	+150 –400	+150 –500	+200 –500	+200 –600	+250 –600	+350 –700	+350 –700	+400 –900	+500 –1100	+600 –1300	+700 –1500	+900 –1800
	Δ_{H3s}	+300 –400	+300 –400	+300 –500	+400 –500	+400 –600	+500 –600	+600 –700	+600 –700	+750 –900	+900 –1100	+1100 –1300	+1300 –1500	+1600 –1800
	Δ_{H4s}	+20 –300	+20 –300	+20 –400	+25 –400	+25 –500	+30 –500	+40 –700	+40 –700	+50 –900	+60 –1200	+70 –1400	+80 –1800	+100 –2400

7.8 Limit Dimensions of Chamfer

Symbols

r_{1s}, r_{3s}	chamfer in radial direction
r_{2s}, r_{4s}	chamfer in axial direction
r_{smin}	general symbol for the minimum chamfer r_{1smin}, r_{2smin}, r_{3smin}, r_{4smin}
r_{1smax}, r_{3smax}	maximum chamfer in radial direction
r_{2smax}, r_{4smax}	maximum chamfer in axial direction

Chamfer of radial bearings (except tapered roller bearings)

Dimensions in mm

r_{smin}		0,1	0,15	0,2	0,3		0,6		1		1,1		1,5	
Nominal bore diameter d	over					40		40		50		120		120
	to				40		40		50		120		120	
r_{1smax}		0,2	0,3	0,5	0,6	0,8	1	1,3	1,5	1,9	2	2,5	2,3	3
r_{2smax}		0,4	0,6	0,8	1	1	2	2	3	3	3,5	4	4	5

Chamfer of tapered roller bearings in metric dimensions
Cone

Dimensions in mm

r_{smin}		0,3		0,6		1		1,5			2		
Nominal bore diameter d	over		40		40		50		120	250		120	250
	to	40		40		50		120	250		120	250	
r_{1smax}		0,7	0,9	1,1	1,3	1,6	1,9	2,3	2,8	3,5	2,8	3,5	4
r_{2smax}		1,4	1,6	1,7	2	2,5	3	3	3,5	4	4	4,5	5

Cup

Dimensions in mm

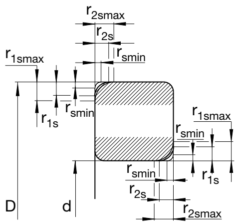
r_{smin}		0,3		0,6		1		1,5			2		
Nominal outside diameter D	over		40		40		50		120	250		120	250
	to	40		40		50		120	250		120	250	
r_{3smax}		0,7	0,9	1,1	1,3	1,6	1,9	2,3	2,8	3,5	2,8	3,5	4
r_{4smax}		1,4	1,6	1,7	2	2,5	3	3	3,5	4	4	4,5	5

Chamfer of thrust bearings

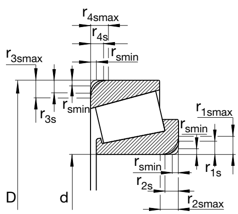
Dimensions in mm

r_{smin}	0,1	0,15	0,2	0,3	0,6	1	1,1	1,5	2	2,1	3	4	5	6	7,5	9,5	12	15	19
r_{1smax}, r_{2smax}	0,2	0,3	0,5	0,8	1,5	2,2	2,7	3,5	4	4,5	5,5	6,5	8	10	12,5	15	18	21	25

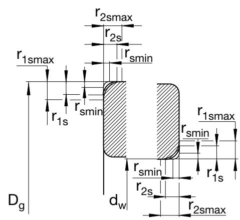
Radial bearings



Tapered roller bearings



Thrust bearings



	2			**2,1**		**2,5**			**3**		**4**	**5**	**6**	**7,5**	**9,5**	**12**	**15**	**19**
	80	**80 220**	**220**	**280**	**280**	**100**	**100 280**	**280**	**280**	**280**								
	3	3,5	3,8	4	4,5	3,8	4,5	5	5	5,5	6,5	8	10	12,5	15	18	21	25
	4,5	5	6	6,5	7	6	6	7	8	8	9	10	13	17	19	24	30	38

	2,5			**3**				**4**				**5**		**6**	
	120	**120 250**	**250**	**120**	**120 250**	**250 400**	**400**	**120**	**120 250**	**250 400**	**400**	**180**	**180**	**180**	**180**
	3,5	4	4,5	4	4,5	5	5,5	5	5,5	6	6,5	6,5	7,5	7,5	9
	5	5,5	6	5,5	6,5	7	7,5	7	7,5	8	8,5	8	9	10	11

	2,5			**3**				**4**				**5**		**6**	
	120	**120 250**	**250**	**120**	**120 250**	**250 400**	**400**	**120**	**120 250**	**250 400**	**400**	**180**	**180**	**180**	**180**
	3,5	4	4,5	4	4,5	5	5,5	5	5,5	6	6,5	6,5	7,5	7,5	9
	5	5,5	6	5,5	6,5	7	7,5	7	7,5	8	8,5	8	9	10	11

7.9 Radial Clearance of FAG Deep Groove Ball Bearings

Dimensions in mm

Nominal bore diameter		over to	**2,5 6**	**6 10**	**10 18**	**18 24**	**24 30**	**30 40**	**40 50**	**50 65**	**65 80**	**80 100**	**100 120**	**120 140**	**140 160**	**160 180**	**180 200**
Bearing clearance in microns																	
Clearance group C2		min max	0 7	0 7	0 9	0 10	1 11	1 11	1 11	1 15	1 15	1 18	2 20	2 23	2 23	2 25	2 30
Clearance group CN (norm.)		min max	2 13	2 13	3 18	5 20	5 20	6 20	6 23	8 28	10 30	12 36	15 41	18 48	18 53	20 61	25 71
Clearance group C3		min max	8 23	8 23	11 25	13 28	13 28	15 33	18 36	23 43	25 51	30 58	36 66	41 81	46 91	53 102	63 117
Clearance group C4		min max		14 29	18 33	20 36	23 41	28 46	30 51	38 61	46 71	53 84	61 97	71 114	81 130	91 147	107 163

Dimensions in mm

Nominal bore diameter		over to	**200 225**	**225 250**	**250 280**	**280 315**	**315 355**	**355 400**	**400 450**	**450 500**	**500 560**	**560 630**	**630 710**	**710 800**	**800 900**	**900 1000**	**1000 1120**	**1120 1250**
Bearing clearance in microns																		
Clearance group C2		min max	4 32	4 36	4 39	8 45	8 50	8 60	10 70	10 80	20 90	20 100	30 120	30 130	30 150	40 160	40 170	40 180
Clearance group CN (norm.)		min max	28 82	31 92	36 97	42 110	50 120	60 140	70 160	80 180	90 200	100 220	120 250	130 280	150 310	160 340	170 370	180 400
Clearance group C3		min max	73 132	87 152	97 162	110 180	120 200	140 230	160 260	180 290	200 320	220 350	250 390	280 440	310 490	340 540	370 590	400 640
Clearance group C4		min max	120 187	140 217	152 237	175 260	200 290	230 330	260 370	290 410	320 460	350 510	390 560	440 620	490 690	540 760	590 840	640 910

7.10 Radial Clearance of FAG Self-Aligning Ball Bearings

Dimensions in mm

Nominal bore diameter		over/to	2,5 6	6 10	10 14	14 18	18 24	24 30	30 40	40 50	50 65	65 80	80 100	100 120	120 140	140 160

with cylindrical bore

Bearing clearance in microns

		2,5–6	6–10	10–14	14–18	18–24	24–30	30–40	40–50	50–65	65–80	80–100	100–120	120–140	140–160
Clearance group C2	min	1	2	2	3	4	5	6	6	7	8	9	10	10	15
	max	8	9	10	12	14	16	18	19	21	24	27	31	38	44
Clearance group CN (norm.)	min	5	6	6	8	19	11	13	14	16	18	22	25	30	35
	max	15	17	19	21	23	24	29	31	36	40	48	56	68	80
Clearance group C3	min	10	12	13	15	17	19	23	25	30	35	42	50	60	70
	max	20	25	26	28	30	35	40	44	50	60	70	83	100	120
Clearance group C4	min	15	19	21	23	25	29	34	37	45	54	64	75	90	110
	max	25	33	35	37	39	46	53	57	69	83	96	114	135	161

with tapered bore

Bearing clearance in microns

		2,5–6	6–10	10–14	14–18	18–24	24–30	30–40	40–50	50–65	65–80	80–100	100–120	120–140	140–160
Clearance group C2	min					7	9	12	14	18	23	29	35	40	45
	max					17	20	24	27	32	39	47	56	68	74
Clearance group CN (norm.)	min					13	15	19	22	27	35	42	50	60	65
	max					26	28	35	39	47	57	68	81	98	110
Clearance group C3	min					20	23	29	33	41	50	62	75	90	100
	max					33	39	46	52	61	75	90	108	130	150
Clearance group C4	min					28	33	40	45	56	69	84	100	120	140
	max					42	50	59	65	80	98	116	139	165	191

7.11 Radial Clearance of FAG Cylindrical Roller Bearings

Dimensions in mm

Nominal bore diameter															
	over		**24**	**30**	**40**	**50**	**65**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**225**
	to	**24**	**30**	**40**	**50**	**65**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**225**	**250**

with cylindrical bore

Bearing clearance in microns

Clearance group															
C1NA[1])	min	5	5	5	5	5	10	10	10	10	10	10	15	15	15
	max	15	15	15	18	20	25	30	30	35	35	40	45	50	50
C2	min	0	0	5	5	10	10	15	15	15	20	25	35	45	45
	max	25	25	30	35	40	45	50	55	60	70	75	90	105	110
CN (norm.)	min	20	20	25	30	40	40	50	50	60	70	75	90	105	110
	max	45	45	50	60	70	75	85	90	105	120	125	145	165	175
C3	min	35	35	45	50	60	65	75	85	100	115	120	140	160	170
	max	60	60	70	80	90	100	110	125	145	165	170	195	220	235
C4	min	50	50	60	70	80	90	105	125	145	165	170	195	220	235
	max	75	75	85	100	110	125	140	165	190	215	220	250	280	300

with tapered bore

Bearing clearance in microns

Clearance group															
C1NA[1])	min	10	15	15	17	20	25	35	40	45	50	55	60	60	65
	max	20	25	25	30	35	40	55	60	70	75	85	90	95	100
C2	min	15	20	20	25	30	35	40	50	55	60	75	85	95	105
	max	40	45	45	55	60	70	75	90	100	110	125	140	155	170
CN (norm.)	min	30	35	40	45	50	60	70	90	100	110	125	140	155	170
	max	55	60	65	75	80	95	105	130	145	160	175	195	215	235
C3	min	40	45	55	60	70	85	95	115	130	145	160	180	200	220
	max	65	70	80	90	100	120	130	155	175	195	210	235	260	285
C4	min	50	55	70	75	90	110	120	140	160	180	195	220	245	270
	max	75	80	95	105	120	145	155	180	205	230	245	275	305	335

	250 **280**	**280** **315**	**315** **355**	**355** **400**	**400** **450**	**450** **500**	**500** **560**	**560** **630**	**630** **710**	**710** **800**	**800** **900**	**900** **1000**	**1000** **1120**	**1120** **1250**	**1250** **1400**	**1400** **1600**	**1600** **1800**	**1800** **2000**
	20 55	20 60	20 65	25 75	25 85	25 95	25 100	30 110	30 130	35 140	35 160	35 180	50 200	60 220	60 240	70 270	80 300	100 320
	55 125	55 130	65 145	100 190	110 210	110 220	120 240	140 260	145 285	150 310	180 350	200 390	220 430	230 470	270 530	330 610	380 700	400 760
	125 195	130 205	145 225	190 280	210 310	220 330	240 360	260 380	285 425	310 470	350 520	390 580	430 640	470 710	530 790	610 890	700 1020	760 1120
	190 260	200 275	225 305	280 370	310 410	330 440	360 480	380 500	425 565	470 630	520 690	580 770	640 850	710 950	790 1050	890 1170	1020 1340	1120 1480
	260 330	275 350	305 385	370 460	410 510	440 550	480 600	500 620	565 705	630 790	690 860	770 960	850 1060	950 1190	1050 1310	1170 1450	1340 1660	1480 1840

	75 110	80 120	90 135	100 150	110 170	120 190	130 210	140 230	160 260	170 290	190 330	210 360	230 400	250 440	270 460	300 500	320 530	340 560
	115 185	130 205	145 225	165 255	185 285	205 315	230 350	260 380	295 435	325 485	370 540	410 600	455 665	490 730	550 810	640 920	700 1020	760 1120
	185 255	205 280	225 305	255 345	285 385	315 425	350 470	380 500	435 575	485 645	540 710	600 790	665 875	730 970	810 1070	920 1200	1020 1340	1120 1480
	240 310	265 340	290 370	330 420	370 470	410 520	455 575	500 620	565 705	630 790	700 870	780 970	865 1075	960 1200	1070 1330	1200 1480	1340 1660	1480 1840
	295 365	325 400	355 435	405 495	455 555	505 615	560 680	620 740	695 835	775 935	860 1030	960 1150	1065 1275	1200 1440	1330 1590	1480 1760	1660 1980	1840 2200

1) Clearance group C1NA applies to single and double row cylindrical roller bearings of tolerance classes SP and UP.

7.12 Radial Clearance of FAG Spherical Roller Bearings

Dimensions in mm

Nominal bore diameter	over / to		24	30	40	50	65	80	100	120	140	160	180	200	225
		24	30	40	50	65	80	100	120	140	160	180	200	225	250

with cylindrical bore

Bearing clearance in microns

Clearance group C2	min	10	15	15	20	20	30	35	40	50	60	65	70	80	90
	max	20	25	30	35	40	50	60	75	95	110	120	130	140	150
Clearance group CN (norm.)	min	20	25	30	35	40	50	60	75	95	110	120	130	140	150
	max	35	40	45	55	65	80	100	120	145	170	180	200	220	240
Clearance group C3	min	35	40	45	55	65	80	100	120	145	170	180	200	220	240
	max	45	55	60	75	90	110	135	160	190	220	240	260	290	320
Clearance group C4	min	45	55	60	75	90	110	135	160	190	220	240	260	290	320
	max	60	75	80	100	120	145	180	210	240	280	310	340	380	420

with tapered bore

Bearing clearance in microns

Clearance group C2	min	15	20	25	30	40	50	55	65	80	90	100	110	120	140
	max	25	30	35	45	55	70	80	100	120	130	140	160	180	200
Clearance group CN (norm.)	min	25	30	35	45	55	70	80	100	120	130	140	160	180	200
	max	35	40	50	60	75	95	110	130	160	180	200	220	250	270
Clearance group C3	min	35	40	50	60	75	95	110	135	160	180	200	220	250	270
	max	45	55	65	80	95	120	140	170	200	230	260	290	320	350
Clearance group C4	min	45	55	65	80	95	120	140	170	200	230	260	290	320	350
	max	60	75	85	100	120	150	180	220	260	300	340	370	410	450

250 **280**	**280** **315**	**315** **355**	**355** **400**	**400** **450**	**450** **500**	**500** **560**	**560** **630**	**630** **710**	**710** **800**	**800** **900**	**900** **1000**	**1000** **1120**	**1120** **1250**	**1250** **1400**	**1400** **1600**

100 170	110 190	120 200	130 220	140 240	140 260	150 180	170 310	190 350	210 390	230 430	260 480	290 530	320 580	350 630	380 700
170 260	190 280	200 310	220 340	240 370	260 410	180 440	310 480	350 530	390 580	430 650	480 710	530 770	580 840	630 910	700 1020
260 350	280 370	310 410	340 450	370 500	410 550	440 600	480 650	530 700	580 770	650 860	710 930	770 1050	840 1140	910 1240	1020 1390
350 460	370 500	410 550	450 600	500 660	550 720	600 780	650 850	700 920	770 1010	860 1120	930 1220	1050 1430	1140 1560	1240 1700	1390 1890

150 220	170 240	190 270	210 300	230 330	260 370	290 410	320 460	350 510	390 570	440 640	490 710	540 780	600 860	660 940	740 1060
220 300	240 330	270 360	300 400	330 440	370 490	410 540	460 600	510 670	570 750	640 840	710 930	780 1020	860 1120	940 1220	1060 1380
300 390	330 430	360 470	400 520	440 570	490 630	540 680	600 760	670 850	750 960	840 1070	930 1190	1020 1300	1120 1420	1220 1550	1380 1750
390 490	430 540	470 590	520 650	570 720	630 790	680 870	760 980	850 1090	960 1220	1070 1370	1190 1520	1300 1650	1420 1800	1550 1960	1750 2200

7.13 Radial Clearance of FAG Barrel Roller Bearings

Dimensions in mm

Nominal bore diameter																
	over		**30**	**40**	**50**	**65**	**80**	**100**	**120**	**140**	**160**	**180**	**225**	**250**	**280**	**315**
	to	**30**	**40**	**50**	**65**	**80**	**100**	**120**	**140**	**160**	**180**	**225**	**250**	**280**	**315**	**355**

with cylindrical bore

Bearing clearance in microns

Clearance group C2	min	2	3	3	4	5	7	10	15	20	25	30	35	40	40	45
	max	9	10	13	15	20	25	30	35	40	45	50	55	60	70	75
Clearance group CN (norm.)	min	9	10	13	15	20	25	30	35	40	45	50	55	60	70	75
	max	17	20	23	27	35	45	50	55	65	70	75	80	85	100	105
Clearance group C3	min	17	20	23	27	35	45	50	55	65	70	75	80	85	100	105
	max	28	30	35	40	55	65	70	80	95	100	105	110	115	135	140
Clearance group C4	min	28	30	35	40	55	65	70	80	95	100	105	110	115	135	140
	max	40	45	50	55	75	90	95	110	125	130	135	140	145	170	175

with tapered bore

Bearing clearance in microns

Clearance group C2	min	9	10	13	15	20	25	30	35	40	45	50	55	60	70	75
	max	17	20	23	27	35	45	50	55	65	70	75	80	85	100	105
Clearance group CN (norm.)	min	17	20	23	27	35	45	50	55	65	70	75	80	85	100	105
	max	28	30	35	40	55	65	70	80	95	100	105	110	115	135	140
Clearance group C3	min	28	30	35	40	55	65	70	80	95	100	105	110	115	135	140
	max	40	45	50	55	75	90	95	110	125	130	135	140	145	170	175
Clearance group C4	min	40	45	50	55	75	90	95	110	125	130	135	140	145	170	175
	max	55	60	65	75	95	120	125	140	155	160	165	170	175	205	210

7.14 Axial Clearance of FAG Double Row Angular Contact Ball Bearings

Series 32, 32B, 33 and 33B

Dimensions in mm

Nominal bore	over	**6**	**10**	**18**	**24**	**30**	**40**	**50**	**65**	**80**	**100**	**120**
diameter	to	**10**	**18**	**24**	**30**	**40**	**50**	**65**	**80**	**100**	**120**	**140**

Bearing clearance in microns

Clearance	min	1	1	2	2	2	2	3	3	3	4	4
group C2	max	11	12	14	15	16	18	22	24	26	30	34
Clearance	min	5	6	7	8	9	11	13	15	18	22	25
group CN (norm.)	max	21	23	25	27	29	33	36	40	46	53	59
Clearance	min	12	13	16	18	21	23	26	30	35	42	48
group C3	max	28	31	34	37	40	44	48	54	63	73	82
Clearance	min	25	27	28	30	33	36	40	46	55	65	74
group C4	max	45	47	48	50	54	58	63	71	83	96	108

Series 32DA and 33 DA

Bearing clearance in microns

Clearance	min	5	6	7	8	9	11	13	15	18	22	25
group C2	max	22	24	25	27	29	33	36	40	46	53	59
Clearance	min	11	13	14	16	18	22	25	29	35	42	48
group CN (norm.)	max	28	31	32	35	38	44	48	54	63	73	82
Clearance	min	20	23	24	27	30	36	40	46	55	65	74
group C3	max	37	41	42	46	50	58	63	71	83	96	108

7.15 Axial Clearance of FAG Four-Point Bearings

Dimensions in mm

Nominal bore diameter															
over		**18**	**40**	**60**	**80**	**100**	**140**	**180**	**220**	**260**	**300**	**355**	**400**	**450**
to	**18**	**40**	**60**	**80**	**100**	**140**	**180**	**220**	**260**	**300**	**355**	**400**	**450**	**500**
Bearing clearance in microns														
Clearance group C2 min	20	30	40	50	60	70	80	100	120	140	160	180	200	220
Clearance group C2 max	60	70	90	100	120	140	160	180	200	220	240	270	290	310
Clearance group CN (norm.) min	50	60	80	90	100	120	140	160	180	200	220	250	270	290
Clearance group CN (norm.) max	90	110	130	140	160	180	200	220	240	280	300	330	360	390
Clearance group C3 min	80	100	120	130	140	160	180	200	220	260	280	310	340	370
Clearance group C3 max	120	150	170	180	200	220	240	260	300	340	360	390	430	470

Dimensions in mm

Nominal bore diameter						
over	**500**	**560**	**630**	**710**	**800**	**900**
to	**560**	**630**	**710**	**800**	**900**	**1000**
Bearing clearance in microns						
Clearance group C2 min	240	260	280	300	330	360
Clearance group C2 max	330	360	390	420	460	500
Clearance group CN (norm.) min	310	340	370	400	440	480
Clearance group CN (norm.) max	420	450	490	540	590	630
Clearance group C3 min	400	430	470	520	570	620
Clearance group C3 max	510	550	590	660	730	780

7.16 Radial Clearance Reduction of FAG Cylindrical Roller Bearings with Tapered Bore

Nominal bore diameter		**Radial clearance prior to mounting**						**Reduction in radial clearance** [1]		**Axial displacement on 1:12 taper** [1]				**Smallest radial clearance after mounting**		
d		Clearance group CN (normal)		C3		C4				Shaft		Sleeve		CN	C3	C4
over	to	min	max	min	max	min	max	min	max	min	max	min	max	min	min	min
mm		mm						mm		mm				mm		
24	**30**	0,035	0,06	0,045	0,07	0,055	0,08	0,015	0,02	0,3	0,35	0,3	0,4	0,02	0,025	0,035
30	**40**	0,04	0,065	0,055	0,08	0,07	0,095	0,02	0,025	0,35	0,4	0,35	0,45	0,02	0,025	0,04
40	**50**	0,045	0,075	0,06	0,09	0,075	0,105	0,025	0,03	0,4	0,45	0,45	0,5	0,02	0,03	0,045
50	**65**	0,05	0,08	0,07	0,1	0,09	0,12	0,03	0,035	0,45	0,55	0,5	0,65	0,02	0,035	0,05
65	**80**	0,06	0,095	0,085	0,12	0,11	0,145	0,035	0,04	0,55	0,6	0,65	0,7	0,025	0,04	0,07
80	**100**	0,07	0,105	0,095	0,13	0,12	0,155	0,04	0,045	0,6	0,7	0,65	0,8	0,03	0,05	0,075
100	**120**	0,09	0,13	0,115	0,155	0,14	0,18	0,045	0,055	0,7	0,85	0,8	0,95	0,045	0,065	0,085
120	**140**	0,1	0,145	0,13	0,175	0,16	0,205	0,055	0,065	0,85	1	0,95	1,1	0,045	0,07	0,095
140	**160**	0,11	0,16	0,145	0,195	0,18	0,23	0,06	0,075	0,9	1,2	1	1,3	0,05	0,075	0,105
160	**180**	0,125	0,175	0,16	0,21	0,195	0,245	0,065	0,085	1	1,3	1,1	1,5	0,06	0,08	0,11
180	**200**	0,14	0,195	0,18	0,235	0,22	0,275	0,075	0,095	1,2	1,5	1,3	1,7	0,065	0,09	0,125
200	**225**	0,155	0,215	0,2	0,26	0,245	0,305	0,085	0,105	1,3	1,6	1,4	1,8	0,07	0,1	0,14
225	**250**	0,17	0,235	0,22	0,285	0,27	0,335	0,095	0,115	1,5	1,8	1,6	2	0,075	0,105	0,155
250	**280**	0,185	0,255	0,24	0,31	0,295	0,365	0,105	0,125	1,6	2	1,7	2,3	0,08	0,125	0,17
280	**315**	0,205	0,28	0,265	0,34	0,325	0,4	0,115	0,14	1,8	2,2	1,9	2,4	0,09	0,13	0,185
315	**355**	0,225	0,305	0,29	0,37	0,355	0,435	0,13	0,16	2	2,5	2,2	2,7	0,095	0,14	0,195
355	**400**	0,255	0,345	0,33	0,42	0,405	0,495	0,14	0,17	2,2	2,6	2,5	2,9	0,115	0,165	0,235
400	**450**	0,285	0,385	0,37	0,47	0,455	0,555	0,15	0,185	2,3	2,8	2,6	3,1	0,135	0,19	0,27
450	**500**	0,315	0,425	0,41	0,52	0,505	0,615	0,16	0,195	2,5	3	2,8	3,4	0,155	0,215	0,31
500	**560**	0,35	0,47	0,455	0,575	0,56	0,68	0,17	0,215	2,7	3,4	3,1	3,8	0,18	0,24	0,345
560	**630**	0,38	0,5	0,5	0,62	0,62	0,74	0,185	0,24	2,9	3,7	3,5	4,2	0,195	0,26	0,38
630	**710**	0,435	0,575	0,565	0,705	0,695	0,835	0,2	0,26	3,1	4,1	3,6	4,7	0,235	0,305	0,435
710	**800**	0,485	0,645	0,63	0,79	0,775	0,935	0,22	0,28	3,4	4,4	3,9	5,3	0,26	0,35	0,495
800	**900**	0,54	0,71	0,7	0,87	0,86	1,03	0,24	0,31	3,7	4,8	4,3	5,5	0,3	0,39	0,55
900	**1000**	0,6	0,79	0,78	0,97	0,96	1,15	0,26	0,34	4,1	5,3	4,8	6,2	0,34	0,44	0,62
1000	**1120**	0,665	0,875	0,865	1,075	1,065	1,275	0,28	0,37	4,4	5,8	5,2	7	0,385	0,5	0,7
1120	**1250**	0,73	0,97	0,96	1,2	1,2	1,44	0,31	0,41	4,8	6,4	5,7	7,6	0,42	0,55	0,79
1250	**1400**	0,81	1,07	1,07	1,33	1,33	1,59	0,34	0,45	5,3	7	6,3	8,3	0,47	0,62	0,85

[1]) Valid only for solid steel shafts and hollow shafts whose bore diameter does not exceed half the shaft diameter.

Note: Bearings whose radial clearance is in the upper half of the tolerance range are mounted with the greater value of radial clearance reduction/axial drive-up distance. Bearings whose radial clearance is in the lower half of the tolerance range are mounted with the smaller value of radial clearance reduction/axial drive-up distance.

7.17 Radial Clearance Reduction of FAG Spherical Roller Bearings with Tapered Bore

Nominal bore diameter d over mm	to	Radial clearance prior to mounting, Clearance group CN (normal) min mm	max	C3 min	max	C4 min	max	Reduction in radial clearance [1] min mm	max	Axial displacement on 1:12 taper [1] Shaft min mm	max	Sleeve min	max	Axial displacement on 1:30 taper [2] Shaft min mm	min	Sleeve min	max	Smallest radial clearance after mounting CN min mm	C3 min	C4 min
24	**30**	0,03	0,04	0,04	0,055	0,055	0,075	0,015	0,02	0,3	0,35	0,3	0,4	-	-	-	-	0,015	0,02	0,035
30	**40**	0,035	0,05	0,05	0,065	0,065	0,085	0,02	0,025	0,35	0,4	0,35	0,45	-	-	-	-	0,015	0,025	0,04
40	**50**	0,045	0,06	0,06	0,08	0,08	0,1	0,025	0,03	0,4	0,45	0,45	0,5	-	-	-	-	0,02	0,03	0,05
50	**65**	0,055	0,075	0,075	0,095	0,095	0,12	0,03	0,04	0,45	0,6	0,5	0,7	-	-	-	-	0,025	0,035	0,055
65	**80**	0,07	0,095	0,095	0,12	0,12	0,15	0,04	0,05	0,6	0,75	0,7	0,85	-	-	-	-	0,025	0,04	0,07
80	**100**	0,08	0,11	0,11	0,14	0,14	0,18	0,045	0,06	0,7	0,9	0,75	1	1,7	2,2	1,8	2,4	0,035	0,05	0,08
100	**120**	0,1	0,135	0,135	0,17	0,17	0,22	0,05	0,07	0,7	1,1	0,8	1,2	1,9	2,7	2	2,8	0,05	0,065	0,1
120	**140**	0,12	0,16	0,16	0,2	0,2	0,26	0,065	0,09	1,1	1,4	1,2	1,5	2,7	3,5	2,8	3,6	0,055	0,08	0,11
140	**160**	0,13	0,18	0,18	0,23	0,23	0,3	0,075	0,1	1,2	1,6	1,3	1,7	3	4	3,1	4,2	0,055	0,09	0,13
160	**180**	0,14	0,2	0,2	0,26	0,26	0,34	0,08	0,11	1,3	1,7	1,4	1,9	3,2	4,2	3,3	4,6	0,06	0,1	0,15
180	**200**	0,16	0,22	0,22	0,29	0,29	0,37	0,09	0,13	1,4	2	1,5	2,2	3,5	4,5	3,6	5	0,07	0,1	0,16
200	**225**	0,18	0,25	0,25	0,32	0,32	0,41	0,1	0,14	1,6	2,2	1,7	2,4	4	5,5	4,2	5,7	0,08	0,12	0,18
225	**250**	0,2	0,27	0,27	0,35	0,35	0,45	0,11	0,15	1,7	2,4	1,8	2,6	4,2	6	4,6	6,2	0,09	0,13	0,2
250	**280**	0,22	0,3	0,3	0,39	0,39	0,49	0,12	0,17	1,9	2,6	2	2,9	4,7	6,7	4,8	6,9	0,1	0,14	0,22
280	**315**	0,24	0,33	0,33	0,43	0,43	0,54	0,13	0,19	2	3	2,2	3,2	5	7,5	5,2	7,7	0,11	0,15	0,24
315	**355**	0,27	0,36	0,36	0,47	0,47	0,59	0,15	0,21	2,4	3,4	2,6	3,6	6	8,2	6,2	8,4	0,12	0,17	0,26
355	**400**	0,3	0,4	0,4	0,52	0,52	0,65	0,17	0,23	2,6	3,6	2,9	3,9	6,5	9	5,8	9,2	0,13	0,19	0,29
400	**450**	0,33	0,44	0,44	0,57	0,57	0,72	0,2	0,26	3,1	4,1	3,4	4,4	7,7	10	8	10,4	0,13	0,2	0,31
450	**500**	0,37	0,49	0,49	0,63	0,63	0,79	0,21	0,28	3,3	4,4	3,6	4,8	8,2	11	8,4	11,2	0,16	0,23	0,35
500	**560**	0,41	0,54	0,54	0,68	0,68	0,87	0,24	0,32	3,7	5	4,1	5,4	9,2	12,5	9,6	12,8	0,17	0,25	0,36
560	**630**	0,46	0,6	0,6	0,76	0,76	0,98	0,26	0,35	4	5,4	4,4	5,9	10	13,5	10,4	14	0,2	0,29	0,41
630	**710**	0,51	0,67	0,67	0,85	0,85	1,09	0,3	0,4	4,6	6,2	5,1	6,8	11,5	15,5	12	16	0,21	0,31	0,45
710	**800**	0,57	0,75	0,75	0,96	0,96	1,22	0,34	0,45	5,3	7	5,8	7,6	13,3	17,5	13,6	18	0,23	0,35	0,51
800	**900**	0,64	0,84	0,84	1,07	1,07	1,37	0,37	0,5	5,7	7,8	6,3	8,5	14,3	19,5	14,8	20	0,27	0,39	0,57
900	**1000**	0,71	0,93	0,93	1,19	1,19	1,52	0,41	0,55	6,3	8,5	7	9,4	15,8	21	16,4	22	0,3	0,43	0,64
1000	**1120**	0,78	1,02	1,02	1,3	1,3	1,65	0,45	0,6	6,8	9	7,6	10,2	17	23	18	24	0,32	0,48	0,7
1120	**1250**	0,86	1,12	1,12	1,42	1,42	1,8	0,49	0,65	7,4	9,8	8,3	11	18,5	25	19,6	26	0,34	0,54	0,77
1250	**1400**	0,94	1,22	1,22	1,55	1,55	1,96	0,55	0,72	8,3	10,8	9,3	12,1	21	27	22,2	28,3	0,36	0,59	0,84

[1]) Valid only for solid steel shafts and hollow shafts whose bore diameter does not exceed half the shaft diameter.

Note: Bearings whose radial clearance is in the upper half of the tolerance range are mounted with the greater value of radial clearance reduction/axial drive-up distance. Bearings whose radial clearance is in the lower half of the tolerance range are mounted with the smaller value of radial clearance reduction/axial drive-up distance.

7.23 FAG Rolling Bearing Greases Arcanol – Chemico-physical data and directions for use

Grease	Colour RAL	Thickener	Base oil viscosity at 40°C mm^2/s	Consistency NLGI Class	Temperature range °C	Main characteristics	Typical applications
Arcanol L78V	1018 zinc yellow	Lithium soap	ISO VG 100	2	–30 ... +130	Standard grease for small bearings (D ≤ 62 mm)	Small electric motors, agricultural machines and construction machinery, household appliances
Arcanol L71V	4008 signal violet	Lithium soap	ISO VG 100	3	–30 ...+140	Standard grease for larger bearings (D > 62 mm)	Large electric motors, wheel bearings for motor vehicles, ventilators
Arcanol L135V	2000 yellow-orange	Lithium soap with EP additives	85	2	–40 ... +150	Special grease for high speeds, high loads, high temperatures	Rolling mills, construction machines, motor vehicles, rail vehicles, spinning and grinding spindles
Arcanol L186V	7005 mouse–grey	Lithium soap with EP additives	ISO VG 460	2	–20 ...+140	Special grease for extremely high loads, medium speeds, medium temperatures	Mining machines, construction machines, machines with oscillating parts
Arcanol L223V	5005 signal blue	Lithium soap with EP additives	ISO VG 1000	2	–10 ... +140	Special grease for extremely high loads low speeds	Heavily stressed mining machi-nery, particularly for impact loads and large bearings
Arcanol L74V	6018 yellow–green	Special soap	ISO VG 22	2	–40 ... +120	Special grease for high speeds, low temperatures	Machine tools, spindle bearings, instrument bearings
Arcanol L12V	2002 vermilion	Polyurea	115	2	–30 ... +160	Special grease for high temperatures	Couplings, electric machines (motors, generators)
Arcanol L79V	1024 yellow ochre	Synthetic	390	2	–30 ... +270	Special grease for ex–tremely high temperatures (safety information, see page 60) chemically aggressive environment	Track rollers in bakery machines, piston pins in compressors, kiln trucks, chemical plants

Fundamental Course for Vocational Training

Plenty of literature is available on the correct mounting of rolling bearings. In most cases, however, the apprentices lack means and components for practical training. Therefore, the instructors of the FAG apprentice shops have prepared a fundamental course.

The target of this fundamental course is to impart the knowledge of the selection of the suitable bearing, appropriate mounting and dismounting, and maintenance. Therefore, the course has two parts.

The theoretical part deals with rolling bearing fundamentals, the practical part with the basic skill required for mounting and dismounting.

For the theoretical part, great store has been set by reasonably combining technical drawing, arithmetic, and instruction in mechanical engineering. For the practical part, simplified models of the mating parts of rolling bearings (shafts and housings) are available by means of which the mounting and dismounting of the current bearing types can be practised with mechanical and hydraulic equipment.

The subjects taught are based on instruction records and do not exceed the degree of difficulty required today in vocational training.

Based on this fundamental course, other units such as transmissions, pumps, spindles, motor car wheels etc. can be prepared for practical training.

Theoretical Part

Instructions in mechanical engineering
Technical arithmetic
Technical drawing

Practical Part

Mounting of bearings with cylindrical bore
Mounting of bearings with tapered bore
Hydraulic technique
Mounting of heated bearings
Practical training with shafts and housings

Technical Data

Mounting cabinet:
Dimensions 1135x710x380 mm
Weight (with contents) 94 kg
Angle plate: Dimensions 500x300x300 mm
Weight 40 kg
suitable for 10 mounting exercises:
5 with shafts, 2 with housings,
3 with shafts and housings
Smallest shaft diameter 15 mm
Largest shaft diameter 55 mm

Selection of FAG Publications

The following publications are selected from the numerous FAG publications available. Further information on request.

Catalogue WL 41520 EA	FAG Rolling Bearings
Publ. No. MT 55135 EA	Measuring Instruments for Mounting and Inspection of Rolling Bearings
Publ. No. WL 80102 EA	How to Mount and Dismount Rolling Bearings Hydraulically
Publ. No. WL 80103 EA	FAG Hydraulic Nuts
Publ. No. WL 80107 EA	FAG Induction Heating Equipment
Publ. No. WL 80126 EA	FAG Induction Heating Device A45EA110
Publ. No. WL 80132 EA	FAG Induction Heating Device A45EA020DV220
Publ. No. WL 80200 EA	Methods and Equipment for the Mounting and Maintenance of Rolling Bearings

7.6 STANDARD TOLERANCES OF METRIC FAG RADIAL BEARINGS IN 0.0001 INCH (EXCEPT METRIC TAPERED ROLLER BEARINGS)

INNER RING

NOMINAL d MM		TOLERANCES Bore cylindrical Δ_{dmp}		V_{dp} diameter series			V_{dmp}	Bore, taper 1:12 Δ_{dmp}		$\Delta_{d1mp}-\Delta_{dmp}$		V_{dp}	Bore, taper 1:30 Δ_{dmp}		$\Delta_{d1mp}-\Delta_{dmp}$		V_{dp}	Δ_{Bs}		V_{Bs}	K_{ia}
				7·8·9	0·1	2·3·4															
over	to	low	high					low	high	low	high		low	high	low	high		low	high		
2.5	10	−3	0	4	3	2.5	2.5	0	+6	0	+6	4						−47	0	6	4
10	18	−3	0	4	3	2.5	2.5	0	+7	0	+7	4						−47	0	8	4
18	30	−4	0	5	4	3	3	0	+8	0	+8	5						−47	0	8	5
30	50	−5	0	6	5	3.5	3.5	0	+10	0	+10	6						−47	0	8	6
50	80	−6	0	7.5	7.5	4.5	4.5	0	+12	0	+12	7.5	0	+6	0	+14	7.5	−59	0	10	8
80	120	−8	0	10	10	6	6	0	+14	0	+14	10	0	+8	0	+16	10	−79	0	10	10
120	180	−10	0	12	12	7.5	7.5	0	+16	0	+16	12	0	+10	0	+19.5	12	−100	0	12	12
180	250	−12	0	15	15	9	9	0	+18	0	+18	15	0	+12	0	+21.5	15	−120	0	12	16
230	315	−14	0	17	17	10	10	0	+20.5	0	+20.5	17	0	+14	0	+23.5	17	−140	0	14	20
315	400	−16	0	20	20	12	12	0	+22	0	+22	20	0	+16	0	+25.5	20	−160	0	16	24
400	500	−18	0	22	22	13.5	13.5	0	+25	0	+25	22	0	+18	0	+29.5	22	−180	0	20	25
500	630	−20	0	25	25	15	15	0	+27.5	0	+27.5		0	+19.5	0	+33.5	25	−200	0	24	28
630	800	−29.5	0					0	+31.5	0	+31.5		0	+29.5	0	+39		−295	0	28	32
800	1000	−39	0					0	+35	0	+35		0	+39	0	+39		−395	0	32	35
1000	1250	−49	0					0	+41	0	+41		0	+49	0	+45		−490	0	39	39

OUTER RING

NOMINAL D MM		TOLERANCES Δ_{Dmp}		V_{Dp} diameter series				V_{Dmp}	K_{ea}
				7·8·9	0·1	2·3·4	sealed bearings 2·3·4		
over	to	low	high						
6	18	−3	0	4	3	2.5	4	2.5	6
18	30	−3.5	0	5	3.5	3	5	3	6
30	50	−4	0	5.5	4	3	6	3	8
50	80	−5	0	6	5	4	8	4	10
80	120	−6	0	7.5	7.5	4	10	4	14
120	150	−7	0	9	9	5.5	12	5.5	16
150	180	−10	0	12	12	7.5	15	7.5	18
180	250	−12	0	15	15	9		9	20
250	315	−14	0	17	17	10		10	24
315	400	−16	0	20	20	12		12	28
400	500	−18	0	22	22	13.5		13.5	31
500	630	−20	0	25	25	15		15	39
630	800	−29.5	0	37	37	21.5		21.5	47
800	1000	−39	0	49	49	29.5		29.5	55
1000	1250	−49	0						63
1250	1600	−63	0						75

The width tolerances Δ_{Cs} and V_{Cs} are identical with Δ_{Bs} and V_{Bs} for the pertinent inner ring.

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7.18 FAG Rolling Bearing Greases Arcanol – Chemico-physical data and directions for use

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Arcanol L71V	4008 signal violet	Lithium soap	ISO VG 100	3	–30 ...+140	Standard grease for larger bearings (D > 62 mm)	Large electric motors, wheel bearings for motor vehicles, ventilators
Arcanol L135V	2000 yellow-orange	Lithium soap with EP additives	85	2	–40 ... +150	Special grease for high speeds, high loads, high temperatures	Rolling mills, construction machines, motor vehicles, rail vehicles, spinning and grinding spindles
Arcanol L186V	7005 mouse–grey	Lithium soap with EP additives	ISO VG 460	2	–20 ...+140	Special grease for extremely high loads, medium speeds, medium temperatures	Mining machines, construction machines, machines with oscillating parts
Arcanol L223V	5005 signal blue	Lithium soap with EP additives	ISO VG 1000	2	–10 ... +140	Special grease for extremely high loads low speeds	Heavily stressed mining machi- nery, particularly for impact loads and large bearings
Arcanol L74V	6018 yellow–green	Special soap	ISO VG 22	2	–40 ... +120	Special grease for high speeds, low temperatures	Machine tools, spindle bearings, instrument bearings
Arcanol L12V	2002 vermilion	Polyurea	115	2	–30 ... +160	Special grease for high temperatures	Couplings, electric machines (motors, generators)
Arcanol L79V	1024 yellow ochre	Synthetic	390	2	–30 ... +270	Special grease for ex– tremely high temperatures (safety information, see page 60) chemically aggressive environment	Track rollers in bakery machines, piston pins in compressors, kiln trucks, chemical plants

Selection of FAG Publications

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Catalogue WL 41520	FAG Rolling Bearings
Publ. No. WL 00106	W.L.S. Rolling Bearing Learning System
Publ. No. WL 40135	W.A.S. Rolling Bearing Selection and Calculation with the PC
Publ. No. WL 80102	How to Mount and Dismount Rolling Bearings Hydraulically
Publ. No. WL 80103	FAG Hydraulic Nuts
Publ. No. WL 80107	FAG Induction Heating Equipment
Publ. No. WL 80111	Rolling Bearings and Rolling Bearing Mounting – A fundamental course for vocational training
Publ. No. WL 80123	All about the Rolling Bearing – FAG Training Courses on Rolling Bearings Theory and Practice
Publ. No. WL 80126	FAG Induction Heating Device A45EA110V380
Publ. No. WL 80132	FAG Induction Heating Device A45EA020DV220
Publ. No. WL 80134	FAG Video: Mounting and Dismounting of Rolling Bearings
Publ. No. WL 80135	FAG Video: Hydraulic Methods for the Mounting and Dismounting of Rolling Bearings
Publ. No. WL 80136	Rolling Bearing Diagnosis in Machines and Plants ”FAG Rolling Bearing Analyser“
Publ. No. WL 80137	Rolling Bearing Diagnosis with the FAG Detector
Publ. No. WL 80200	Methods and Equipment for the Mounting and Maintenance of Rolling Bearings
Publ. No. WL 81115	Rolling Bearing Lubrication
Publ. No. WL 82102	Rolling Bearing Damage
TI No. WL 00-11	FAG Videos on Rolling Bearings
TI No. WL 80-3	Mechanical Extracting Devices
TI No. WL 80-9	Aluminium Heating Ring for Cylindrical Roller Bearing Inner Rings
TI No. WL 80-14	Mounting and Dismounting of Spherical Roller Bearings with Tapered Bore
TI No. WL 80-38	Mounting of Self-aligning Ball Bearings on Adapter Sleeves

Rolling Bearing Lubrication

FAG

Rolling Bearings

FAG OEM und Handel AG

Publ. No. WL 81 115/4 EA

Rolling Bearing Lubrication

Publ. No. WL 81 115/4 EA

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1. Lubricant in Rolling Bearings

1.1 Functions of the Lubricant in Rolling Bearings

The lubrication of rolling bearings – similar to that of sliding bearings – mainly serves one purpose: to avoid or at least reduce metal-to-metal contact between the rolling and sliding contact surfaces, i.e. to reduce friction and wear in the bearing.

Oil, adhering to the surfaces of the parts in rolling contact, is fed between the contact areas. The oil film separates the contact surfaces preventing metal-to-metal contact (»physical lubrication«).

In addition to rolling, sliding occurs in the contact areas of the rolling bearings. The amount of sliding is, however, much less than in sliding bearings. This sliding is caused by elastic deformation of the bearing components and by the curved form of the functional surfaces.

Under pure sliding contact conditions, existing for instance between rolling elements and cage or between roller faces and lip surfaces, the contact pressure, as a rule, is far lower than under rolling contact conditions. Sliding motions in rolling bearings play only a minor role. Even under unfavourable lubrication conditions energy losses due to friction, and wear are very low. Therefore, it is possible to lubricate rolling bearings with greases of different consistency and oils of different viscosity. This means that wide speed and load ranges do not create any problems.

Sometimes, the contact surfaces are not completely separated by the lubricant film. Even in these cases, low-wear operation is possible, if the locally high temperature triggers chemical reactions between the additives in the lubricant and the surfaces of the rolling elements or rings. The resulting tribochemical reaction layers have a lubricating effect (»chemical lubrication«).

The lubricating effect is enhanced not only by such reactions of the additives but also by dry lubricants added to the oil or grease, and even by the grease thickener.

In special cases, it is possible to lubricate rolling bearings with dry or solid lubricants only.

Additional functions of rolling bearing lubricants are: protection against corrosion, heat dissipation from the bearing (oil lubrication), discharge of wear particles and contaminants from the bearing (oil circulation lubrication; the oil is filtered), enhancing the sealing effect of the bearing seals (grease collar, oil-air lubrication).

1.1.1 The Different Lubricating Conditions in Rolling Bearings

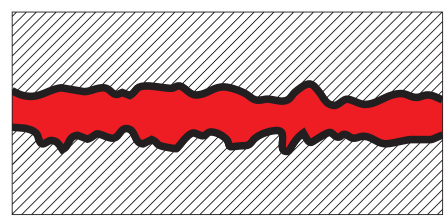
Friction and wear behaviour and the attainable life of a rolling bearing depend on the lubricating condition. The following lubricating conditions exist in a rolling bearing:

– Full fluid film lubrication: The surfaces of the components in relative motion are completely or nearly completely separated by a lubricant film (fig. 1a).
  This is a condition of almost pure fluid friction. For continuous operation this type of lubrication, which is also referred to as fluid lubrication, should always be aimed at.
– Mixed lubrication: Where the lubricant film gets too thin, local metal-to-metal contact occurs, resulting in mixed friction (fig. 1b).
– Boundary lubrication: If the lubricant contains suitable additives, reactions between the additives and the metal surfaces are triggered at the high pressures and temperatures in the contact areas. The resulting reaction products have a lubricating effect and form a thin boundary layer (fig. 1c).

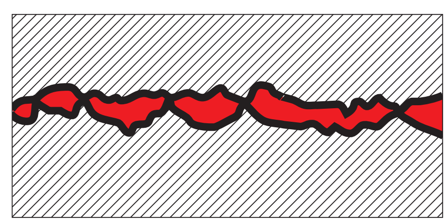
Full fluid film lubrication, mixed lubrication and boundary lubrication occur both with grease lubrication and with oil lubrication. The lubricating condition with grease lubrication depends mainly on the viscosity of the base oil. Also, the grease thickener has a lubricating effect.

– Dry lubrication: Solid lubricants (e.g. graphite and molybdenum disulphide), applied as a thin layer on the functional surfaces, can prevent metal-to-metal contact. Such a layer can, however, be maintained over a long period only at moderate speeds and low contact pressure. Solid lubricants, added to oils or greases, also improve the lubricating efficiency in cases of metal-to-metal contact.

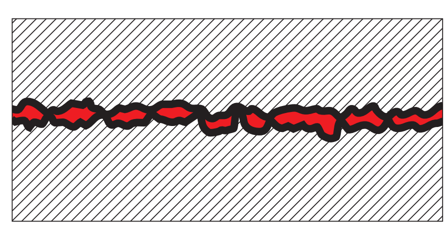
1: The different lubricating conditions



a) Full fluid film lubrication
The surfaces are completely separated by a load carrying oil film



b) Mixed lubrication
Both the load carrying oil film and the boundary layer play a major role



c) Boundary lubrication
The lubricating effect mainly depends on the lubricating properties of the boundary layer

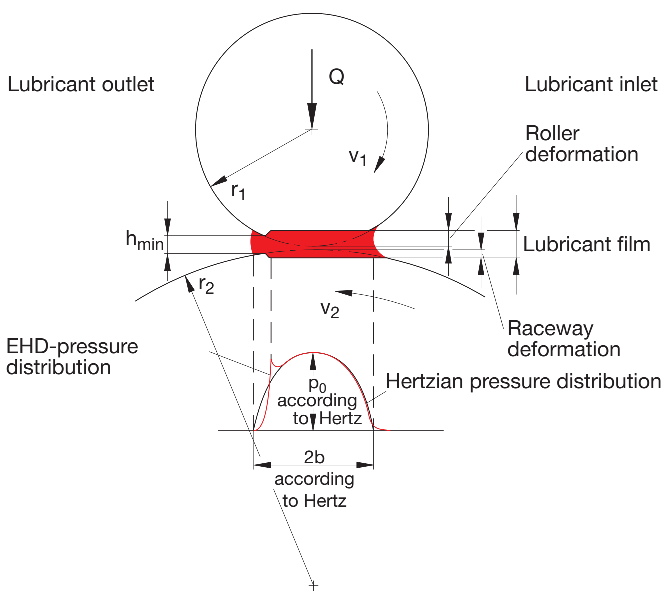
Boundary layer   Lubricant layer

1.1.2 Lubricating Film with Oil Lubrication

Main criterion for the analysis of the lubricating condition is the lubricating film thickness between the load transmitting rolling and sliding contact surfaces. The lubricant film between the rolling contact surfaces can be described by means of the theory of elastohydrodynamic (EHD) lubrication. The lubrication under sliding contact conditions which exist, e.g. between the roller faces and lips of tapered roller bearings, is adequately described by the hydrodynamic lubrication theory as the contact pressure in the sliding contact areas is lower than in the rolling contact areas.

The minimum lubricant film thickness h_{min} for EHD lubrication is calculated using the equations for point contact and line contact shown in fig. 2. The equation for point contact takes into account the fact that the oil escapes from the gap on the sides. The equation shows the great influence of the rolling velocity ν, the dynamic viscosity η_0 and the pressure-viscosity coefficient α on h_{min}. The load Q has little influence because the viscosity rises with increasing loads and

2: Elastohydrodynamic lubricant film. Lubricant film thicknesses for point contact and line contact



Point contact according to Hamrock and Dowson

$h_{min} = 3{,}63 \cdot U^{0{,}68} \cdot G^{0{,}49} \cdot W^{-0{,}073} \cdot (1 - e^{-0{,}68 \cdot k}) \cdot R_r$ [m]

Line contact according to Dowson

$h_{min} = 2{,}65 \cdot U^{0{,}7} \cdot G^{0{,}54} \cdot W'^{-0{,}13} \cdot R_r$ [m]

with
$U = \eta_0 \cdot v/(E' \cdot R_r)$
$G = \alpha \cdot E'$
$W = Q/(E' \cdot R_r^2)$ for point contact
$W' = Q/(E' \cdot R_r \cdot L)$ for line contact

where

h_{min}	[m]	minimum lubricant film thickness in the area of rolling contact
U		speed parameter
G		material parameter
W		load parameter for point contact
W'		load parameter for line contact
e		e = 2,71828..., base of natural logarithms
k		k = a/b, ratio of the semiaxes of the contact areas
α	[m^2/N]	pressure viscosity coefficient
η_0	[Pa · s]	dynamic viscosity
v	[m/s]	$v = (v_1 + v_2)/2$, mean rolling velocity v_1 = rolling element velocity v_2 = velocity at inner ring or outer ring contact
E'	[N/m^2]	$E' = E/[1 - (1/m)^2]$, effective modulus of elasticity E = modulus of elasticity = $2{,}08 \cdot 10^{11}$ [N/m^2] for steel 1/m = Poisson's ratio = 0,3 for steel
R_r	[m]	reduced curvature radius $R_r = r_1 \cdot r_2/(r_1 + r_2)$ at inner ring contact $R_r = r_1 \cdot r_2/(r_1 - r_2)$ at outer ring contact r_1 = rolling element radius [m] r_2 = radius of the inner and outer ring raceways [m]
Q	[N]	roller load
L	[m]	gap length or effective roller length

the contact surfaces are enlarged due to elastic deformation.
The calculation results can be used to check whether a sufficiently strong lubricant film is formed under the given conditions. Generally, the minimum thickness of the lubricant film should be one tenth of a micron to several tenths of a micron. Under favourable conditions the film is several microns thick.
The viscosity of the lubricating oil changes with the pressure in the rolling contact area:

$\eta = \eta_0 \cdot e^{\alpha p}$

η dynamic viscosity at pressure p [Pa s]
η_0 dynamic viscosity at normal pressure [Pa s]
e (= 2,71828) base of natural logarithms
α pressure-viscosity coefficient [m^2/N]
p Pressure [N/m^2]

The calculation of the lubricating condition in accordance with the EHD theory for lubricants with a mineral oil base takes into account the great influence of pressure. The pressure-viscosity behaviour of a few lubricants is shown in the diagram in fig. 3. The a_{23} diagram shown in fig. 7 (page 7) is based on the zone a-b for mineral oils. Mineral oils with EP-additives also have α values in this zone.

If the pressure-viscosity coefficient has considerable influence on the viscosity ratio, e.g. in the case of diester, fluorocarbon or silicone oil, the correction factors B1 and B2 have to be taken into account in the calculation of the viscosity ratio $\varkappa$.

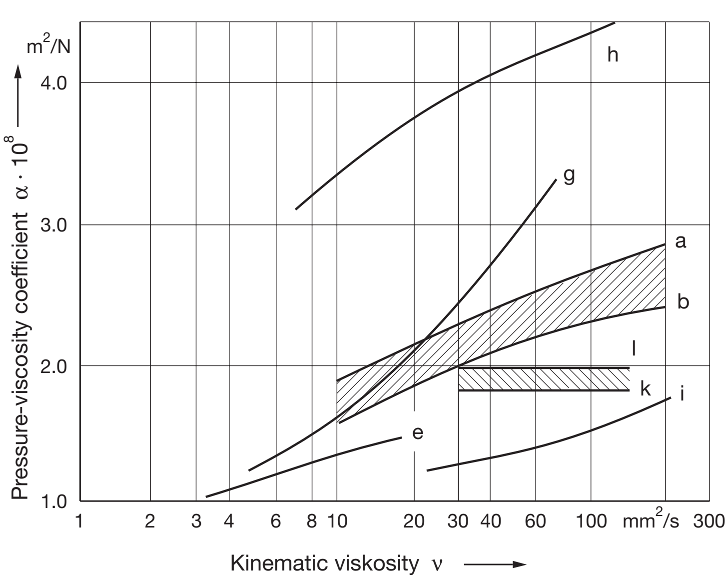
$\varkappa_{B1,2} = \varkappa \cdot B_1 \cdot B_2$

$\varkappa$ viscosity ratio for mineral oil (see section 1.1.3)
B_1 correction factor for pressure-viscosity behaviour $= \alpha_{\text{synthetic oil}}/\alpha_{\text{mineral oil}}$ (α values, see fig. 3)
B_2 correction factor for varying density $= \rho_{\text{synthetic oil}}/\rho_{\text{mineral oil}}$

The diagram, fig. 4, shows the curve for density ρ as a function of temperature for mineral oils. The curve for a synthetic oil can be assessed if the density ρ at 15°C is known.

3: Pressure-viscosity coefficient α as a function of kinematic viscosity ν, for pressures from 0 to 2000 bar
4: Density ρ of mineral oils as a function of temperature t

a–b Mineral oils
e Diester
g triaryl phosphate ester
h Fluorocarbon
i Polyglycol
k, l Silicones



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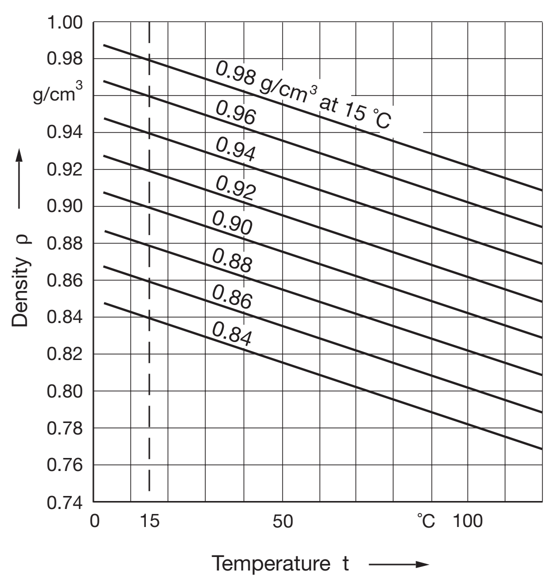

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1.1.3 Influence of the Lubricant Film and Cleanliness on the Attainable Bearing Life

Since the sixties, experiments and field application have made it increasingly clear that, with a separating lubricant film without contaminants in the rolling element/raceway contact areas, the service life of a moderately loaded bearing is considerably longer than that calculated by means of the classical life equation $L = (C/P)^p$. In 1981, FAG was the first bearing manufacturer to prove that rolling bearings can be fail-safe. Based on these findings, international standard recommendations and practical experience, a refined procedure for calculating the attainable life of bearings was developed.

The preconditions for endurance strength are:

- full separation of the surfaces in rolling contact by the lubricant film ($\varkappa \geq 4$)
- utmost cleanliness in the lubricating gap corresponding to V = 0.3
- stress index $f_{s*} \geq 8$.

$f_{s*} = C_0/P_{0*}$
C_0 static load rating [kN] see FAG catalogue
P_{0*} equivalent bearing load [kN] determined by the formula
$P_{0*} = X_0 \cdot F_r + Y_0 \cdot F_a$ [kN] where X_0 and Y_0 are factors from the FAG catalogue and
F_r dynamic radial force
F_a dynamic axial force

Attainable life in accordance with the FAG method:

$L_{na} = a_1 \cdot a_{23} \cdot L$ [10^6 revolutions]
or
$L_{hna} = a_1 \cdot a_{23} \cdot L_h$ [h]

The **a_1 factor** is 1 for the usual failure probability of 10%.

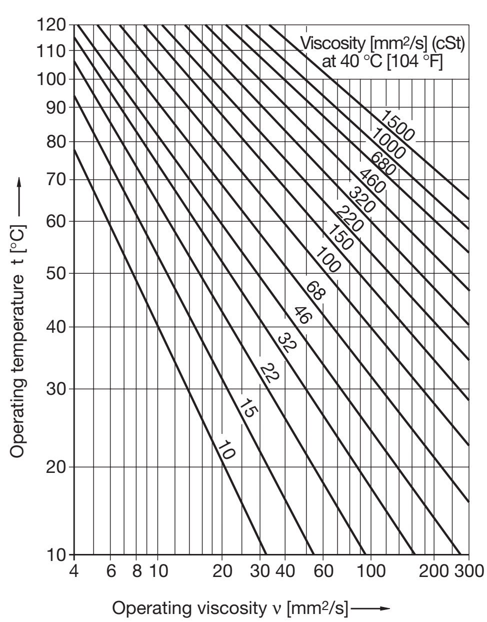
The **a_{23} factor** (product of the basic a_{23II} factor and the cleanliness factor s, see below) takes into account the effects of material and operating conditions, i.e. also that of lubrication and of the cleanliness in the lubricating gap, on the attainable life of a bearing.

The **nominal life L** (DIN ISO 281) is based on the viscosity ratio $\varkappa = 1$.

The **viscosity ratio $\varkappa = \nu/\nu_1$** is used as a measure of the lubricating film development for determining the basic a_{23II} factor (diagram, fig. 7).

ν is the viscosity of the lubricating oil or of the base oil of the grease used at operating temperature (diagram, fig. 5) and ν_1 is the **rated viscosity** which depends on the bearing size (mean diameter dm) and speed n (diagram, fig. 6).

5: Viscosity-temperature diagram for mineral oils
6. Rated viscosity ν_1 depending on bearing size and speed; D = bearing O.D., d = bore diameter



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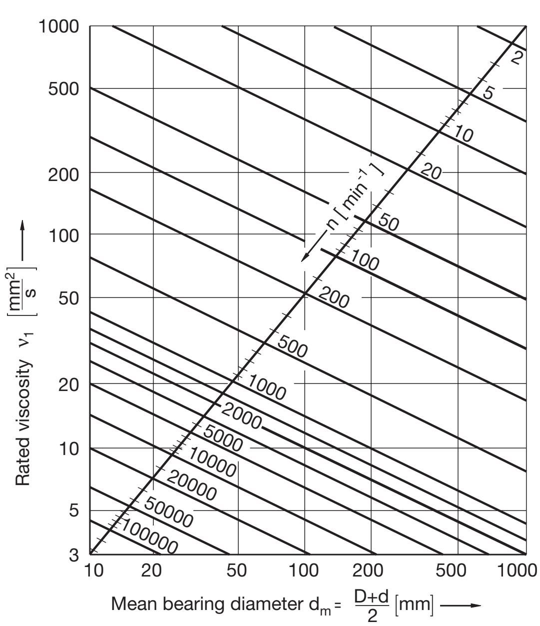

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The equation for the attainable life Lna and the diagram in fig. 7 show how an operating viscosity which deviates from the rated viscosity affects the attainable bearing life. With a viscosity ratio of $\varkappa$ = 2 to 4 a fully separating lubricant film is formed between the contact areas. The farther $\varkappa$ lies below these values the larger is the mixed friction share and the more important a suitably doped lubricant.

The **operating viscosity** ν of the oil or of the base oil of the grease used, i.e. its kinematic viscosity at operating temperature, is indicated in the data sheets supplied by oil and grease manufacturers. If only the viscosity at 40°C is known the viscosity of mineral oils with an average viscosity-temperature behaviour at operating temperature can be determined from the diagram in fig. 5.

The operating temperature for determining n depends on the frictional heat generated, cp. section 1.2. If no temperature measurements from comparable bearing locations are available the operating temperature can be assessed by means of a heat balance calculation, see section 1.3.

As the real temperature on the surface of the stressed elements in rolling contact is not known, the temperature measured on the stationary ring is assumed as the operating temperature. For bearings with favourable kinematics (ball bearings, cylindrical roller bearings) the viscosity can be approximated based on the temperature of the stationary ring. In the case of external heating, the viscosity is determined from the mean temperatures of the bearing rings.

In heavily loaded bearings and in bearings with a high percentage of sliding (e.g. full-complement cylindrical roller bearings, spherical roller bearings and axially loaded cylindrical roller bearings) the temperature in the contact area is up to 20 K higher than the measurable operating temperature. The difference can be approached by using half the operating viscosity ν read off the V-T diagram for the formula $\varkappa = \nu/\nu_1$.

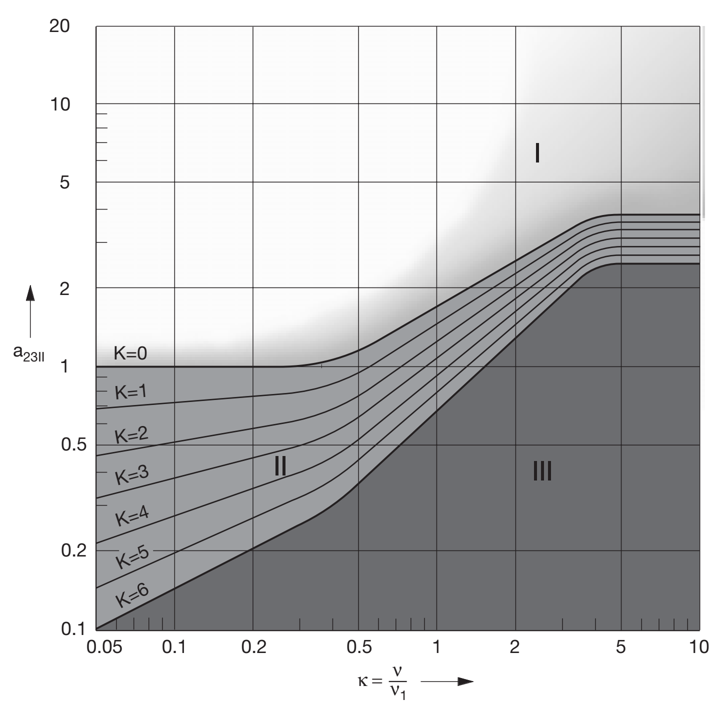
7: Basic a_{23II} factor for determining the a_{23} factor

Zones

I Transition to endurance strength
Precondition: Utmost cleanliness in the lubricating gap and loads which are not too high, suitable lubricant

II Normal degree of cleanliness in the lubricating gap (with effective additives tested in rolling bearings, a_{23} factors > 1 are possible even with $\chi < 0.4$)

III Unfavourable lubricating conditions
Contaminated lubricant
Unsuitable lubricants



Limits of adjusted rating life calculation
As in the case of the former life calculation, only material fatigue is taken into consideration as a cause of failure for the adjusted rating life calculation as well. The calculated "attainable life" can only correspond to the actual service life of the bearing if the lubricant service life or the life limited by wear is not shorter than the fatigue life.

The **value K** = $K_1 + K_2$ is required for locating the **basic a_{23II} factor** in the diagram shown in fig. 7.

K_1 can be read off the diagram in fig. 8 as a function of the bearing type and the stress index f_{s*}.

K_2 depends on the viscosity ratio $\varkappa$ and the index f_{s*}. The values in the diagram, fig. 9, apply to lubricants without additives or lubricants with additives whose special effect in rolling bearings was not tested.

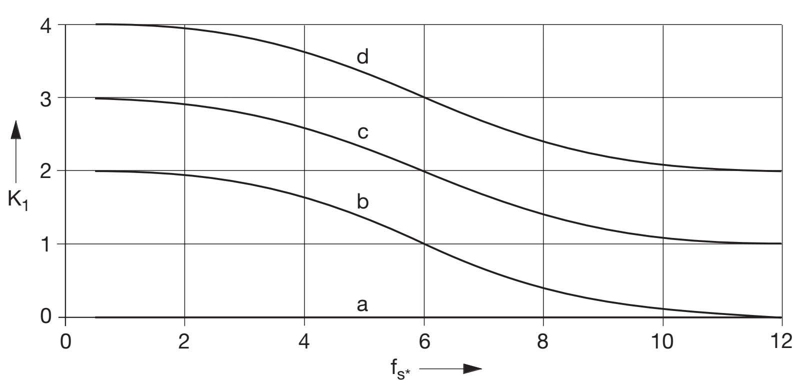
With K = 0 to 6, a_{23II} is found on one of the curves in zone II of the diagram shown in fig. 7.

With K > 6, a_{23II} must be expected to be in zone III. In such a case a smaller K value and thus zone II should be aimed at by improving the conditions.

About the **additives:**

If the surfaces are not completely separated by a lubricant film the lubricants should contain, in addition to additives which help prevent corrosion and increase ageing resistance, also suitable additives to reduce wear and increase loadability. This applies especially where $\varkappa \leq 0.4$ as then wear dominates.

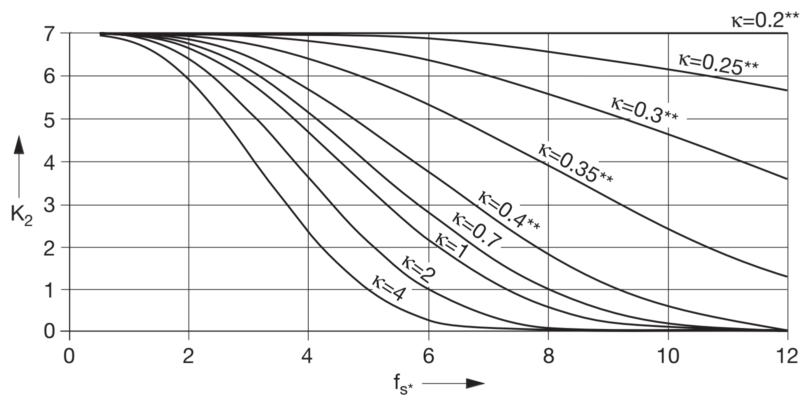
8: Value K_1 depending on the index f_{s*} and the bearing type
9: Value K_2 depending on the index f_{s*} for lubricants without additives and lubricants with additives whose effect in rolling bearings was not tested



a ball bearings
b tapered roller bearings
cylindrical roller bearings
c spherical roller bearings
spherical roller thrust bearings [3]
cylindrical roller thrust bearings [1), 3)]
d full complement cylindrical
roller bearings [1), 2)]

[1)] Attainable only with lubricant filtering corresponding V < 1, otherwise $K_1 \geq 6$ must be assumed.
[2)] To be observed for the determination ν: the friction is at least twice the value in caged bearings. This results in higher bearing temperature.
[3)] Minimum load must be observed.

8



K_2 equals 0 for lubricants with additives with a corresponding suitability proof.

** With $\kappa \leq 0.4$ wear dominates unless eliminated by suitable additives.

9

The additives in the lubricants react with the metal surfaces of the bearing and form separating reaction layers which, if fully effective, can replace the missing oil film as a separating element. Generally, however, separation by a sufficiently thick oil film should be aimed at.

Cleanliness factor s

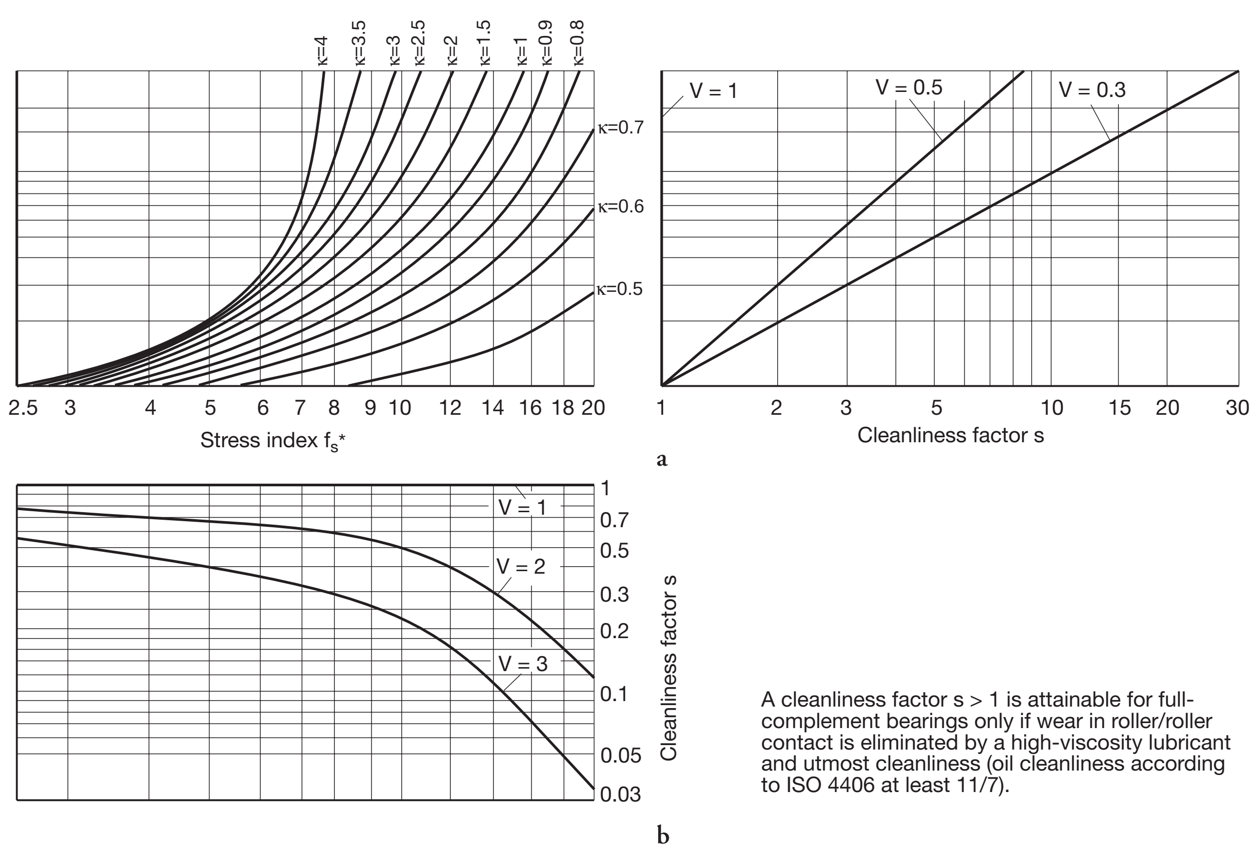
Cleanliness factor s quantifies the effect of contamination on the life. Contamination factor V is required to obtain s.

s = 1 always applies to "normal cleanliness" (V = 1), i.e. $a_{23II} = a_{23}$.

With "improved cleanliness" (V = 0.5) and "utmost cleanliness" (V = 0.3) a cleanliness factor s ≥ 1 is obtained from the right diagram (a) in fig. 10, based on the index f_{s*} and depending on the viscosity ratio $\varkappa$.
s = 1 applies to $\varkappa \leq 0.4$.

With V = 2 (moderately contaminated lubricant) and V = 3 (heavily contaminated lubricant), s is obtained from zone b of the diagram, fig. 10.

10: Diagram for determining the cleanliness factor s
a Diagram for improved (V = 0.5) and utmost (V = 0.3) cleanliness
b Diagram for moderately contaminated lubricant (V = 2) and heavily contaminated lubricant (V = 3)



A cleanliness factor s > 1 is attainable for full-complement bearings only if wear in roller/roller contact is eliminated by a high-viscosity lubricant and utmost cleanliness (oil cleanliness according to ISO 4406 at least 11/7).

Contamination factor V

Contamination factor V depends on the bearing cross section, the type of contact between the mating surfaces and the cleanliness level of the oil, table in fig. 11.

If hard particles from a defined size on are cycled in the most heavily stressed contact area of a rolling bearing, the resulting indentations in the contact surfaces lead to premature material fatigue. The smaller the contact area, the more damaging the effect of a particle of a defined size.

At the same contamination level small bearings react, therefore, more sensitively than larger ones and bearings with point contact (ball bearings) are more vulnerable than bearings with line contact (roller bearings).

The necessary oil cleanliness class according to ISO 4406 (fig. 12) is an objectively measurable level of the contamination of a lubricant. It is determined by the standardized particle-counting method.

The numbers of all particles > 5 µm and all particles > 15 µm are allocated to a certain oil cleanliness class. An oil cleanliness 15/12 according to ISO 4406 means that between 16000 and 32000 particles > 5 µm and between 2000 and 4000 particles > 15 µm are present per 100 ml of a fluid. The step from one class to the next is by doubling or halving the particle number.

Specially particles with a hardness of > 50 HRC reduce the life of rolling bearings. These are particles of hardened steel, sand and abrasive particles. Abrasive particles are particularly harmful.

If the major part of foreign particles in the oil samples is in the life-reducing hardness range, which is the case in many technical applications, the cleanliness class determined with a particle counter can be compared directly with the valves of the table on page 46. If, however, the filtered out contaminants are found, after counting, to be almost exclusively mineral matter as, for example, the particularly harmful moulding sand or abrasive grains, the measured values must be increased by one to two cleanliness classes before determining the contamination factor V. On the other hand, if the greater part of the particles found in the lubricant are soft materials such as wood, fibres or paint, the measured value of the particle counter should be reduced correspondingly.

A defined filtration ratio β_x should exist in order to reach the oil cleanliness required (cp. Section 5.1.3). A filter of a certain filtration ratio, however, is not automatically indicative of an oil cleanliness class.

Cleanliness scale

Normal cleanliness (V = 1) is assumed for frequently occurring conditions:

– Good sealing adapted to the environment

– Cleanliness during mounting

– Oil cleanliness according to V = 1

– Observing the recommended oil change intervals

Utmost cleanliness (V = 0.3): cleanliness, in practice, is utmost in

– bearings which are greased and protected by seals or shields against dust by FAG. The life of fail-safe types is usually limited by the service life of the lubricant.

– bearings greased by the user who observes that the cleanliness level of the newly supplied bearing will be maintained throughout the entire operating time by fitting the bearing under top cleanliness conditions into a clean housing, lubricates it with clean grease and takes care that dirt cannot enter the bearing during operation (for suitable FAG Arcanol rolling bearing greases see page 57).

– bearings with circulating oil system if the circulating system is flushed prior to the first operation of the cleanly fitted bearings (fresh oil to be filled in via superfine filters) and oil cleanliness classes according to V = 0.3 are ensured during the entire operating time.

Heavily contaminated lubricant (V = 3) should be avoided by improving the operating conditions. Possible causes of heavy contamination:

– The cast housing was inadequately or not at all cleaned (foundry sand, particles from machining left in the housing).

– Abraded particles from components which are subject to wear enter the circulating oil system of the machine.

– Foreign matter penetrates into the bearing due to an unsatisfactory seal.

– Water which entered the bearing, also condensation water, caused standstill corrosion or deterioration of the lubricant properties.

The intermediate values V = 0.5 (improved cleanliness) and V = 2 (moderately contaminated lubricant) must only be used where the user has the necessary experience to judge the cleanliness conditions accurately.

Worn particles also cause **wear.** FAG selected the heat treatment of the bearing parts in such a way that, in the case of V = 0.3, bearings with low sliding motion percentage (e.g. radial ball bearings and radial cylindrical roller bearings) show hardly any wear even after very long periods of time.

Cylindrical roller thrust bearings, full-complement cylindrical roller bearings and other bearings with high sliding motion shares react strongly to small hard contaminants. In such cases, superfine filtration of the lubricant can prevent critical wear.

11: Guide values for the contamination factor V

(D-d)/2 mm	V	Point contact required oil cleanliness class according to ISO 4406[1])	guide values for filtration ratio according to ISO 4572	Line contact required oil cleanliness class according to ISO 4406[1])	guide values for filtration ratio according to ISO 4572
≤ 12.5	0.3	11/8	$\beta_3 \geq 200$	12/9	$\beta_3 \geq 200$
	0.5	12/9	$\beta_3 \geq 200$	13/10	$\beta_3 \geq 75$
	1	14/11	$\beta_6 \geq 75$	15/12	$\beta_6 \geq 75$
	2	15/12	$\beta_6 \geq 75$	16/13	$\beta_{12} \geq 75$
	3	16/13	$\beta_{12} \geq 75$	17/14	$\beta_{25} \geq 75$
> 12.5 ... 20	0.3	12/9	$\beta_3 \geq 200$	13/10	$\beta_3 \geq 75$
	0.5	13/10	$\beta_3 \geq 75$	14/11	$\beta_6 \geq 75$
	1	15/12	$\beta_6 \geq 75$	16/13	$\beta_{12} \geq 75$
	2	16/13	$\beta_{12} \geq 75$	17/14	$\beta_{25} \geq 75$
	3	18/14	$\beta_{25} \geq 75$	19/15	$\beta_{25} \geq 75$
> 20 ... 35	0.3	13/10	$\beta_3 \geq 75$	14/11	$\beta_6 \geq 75$
	0.5	14/11	$\beta_6 \geq 75$	15/12	$\beta_6 \geq 75$
	1	16/13	$\beta_{12} \geq 75$	17/14	$\beta_{12} \geq 75$
	2	17/14	$\beta_{25} \geq 75$	18/15	$\beta_{25} \geq 75$
	3	19/15	$\beta_{25} \geq 75$	20/16	$\beta_{25} \geq 75$
> 35	0.3	14/11	$\beta_6 \geq 75$	14/11	$\beta_6 \geq 75$
	0.5	15/12	$\beta_6 \geq 75$	15/12	$\beta_{12} \geq 75$
	1	17/14	$\beta_{12} \geq 75$	18/14	$\beta_{25} \geq 75$
	2	18/15	$\beta_{25} \geq 75$	19/16	$\beta_{25} \geq 75$
	3	20/16	$\beta_{25} \geq 75$	21/17	$\beta_{25} \geq 75$

The oil cleanliness class can be determined by means of oil samples by filter manufacturers and institutes. It is a measure of the probability of life-reducing particles being cycled in a bearing. Suitable sampling should be observed (see e.g. DIN 51 750). Today, on-line measuring instruments are available. The cleanliness classes are reached if the entire oil volume flows through the filter within a few minutes. To ensure a high degree of cleanliness flushing is required **prior to bearing operation.**

For example, filtration ratio $\beta_3 \geq 200$ (ISO 4572) means that in the so-called multi-pass test only one of 200 particles ≥ 3 µm passes through the filter. Filters with coarser filtration ratios than $\beta_{25} \geq 75$ should not be used due to the ill effect on the other components within the circulation system.

[1]) Only particles with a hardness > 50 HRC have to be taken into account.

12: Oil cleanliness classes according to ISO 4406 (excerpt)

Number of particles per 100 ml				Code
over 5 µm		over 15 µm		
more than	up to	more than	up to	
500000	1000000	64000	130000	20/17
250000	500000	32000	64000	19/16
130000	250000	16000	32000	18/15
64000	130000	8000	16000	17/14
32000	64000	4000	8000	16/13
16000	32000	2000	4000	15/12
8000	16000	1000	2000	14/11
4000	8000	500	1000	13/10
2000	4000	250	500	12/9
1000	2000	130	250	11/8
1000	2000	64	130	11/7
500	1000	32	64	10/6
250	500	32	64	9/6

1.1.4 Lubricating Film with Grease Lubrication

With lubricating greases, bearing lubrication is mainly effected by the base oil, small quantities of which are separated by the thickener over time. The principles of the EHD theory also apply to grease lubrication. For calculating the viscosity ratio ν/ν_1 the operating viscosity of the base oil is applied. Especially with low $\varkappa$ values the thickener and the additives increase the lubricating effect.

If a grease is known to be appropriate for the application in hand – e.g. the FAG Arcanol rolling bearing greases (see page 57) – and if good cleanliness and sufficient relubrication are ensured the same K_2 values can be assumed as for suitably doped oils. If such conditions are not given, a factor from the lower curve of zone II should be selected for determining the a_{23II} value, to be on the safe side. This applies especially if the specified lubrication interval is not observed. The selection of the right grease is particularly important for bearings with a high sliding motion rate and for large and heavily stressed bearings. In heavily loaded bearings the lubricating effect of the thickener and the right doping are of particular importance.

Only a very small amount of the grease participates actively in the lubricating process. Grease of the usual consistency is for the most part expelled from the bearing and settles at the bearing sides or escapes from the bearing via the seals. The grease quantity remaining on the running areas and clinging to the bearing insides and outsides continuously separates the small amount of oil required to lubricate the functional surfaces. Under moderate loads the grease quantity remaining between the rolling contact areas is sufficient for lubrication over an extended period of time.

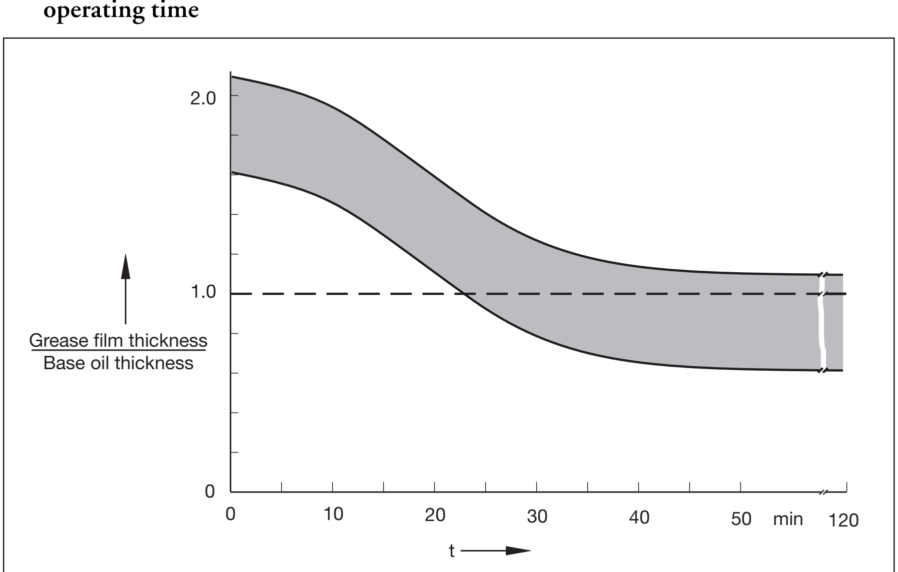
The oil separation rate depends on the grease type, the base oil viscosity, the size of the oil separating surface, the grease temperature and the mechanical stressing of the grease.

The effect of the grease thickener becomes apparent when the film thickness is measured as a function of operating time. On start-up of the bearing a film thickness, depending on the type of thickener, develops in the contact areas which is clearly greater than that of the base oil. Grease alteration and grease displacement quickly cause the film thickness to be reduced, fig. 13.

In spite of a possibly reduced film thickness a sufficient lubricating effect is maintained throughout the lubrication interval. The thickener and the additives in the grease decisively enhance the lubricating effect so that no life reduction has to be expected. For long lubrication intervals, the grease should separate just as much oil as needed for bearing lubrication. In this way, oil separation over a long period is ensured. Greases with a base oil of very high viscosity have a smaller oil separation rate. In this case, adequate lubrication is only possible by packing the bearing and housing with grease to capacity or short relubrication intervals.

The lubricating effect of the thickener becomes particularly evident in the operation of rolling bearings in the mixed friction range.

13: Ratio of the grease film thickness to the base oil film thickness as a function of operating time



1.1.5 Lubricating Layers with Dry Lubrication

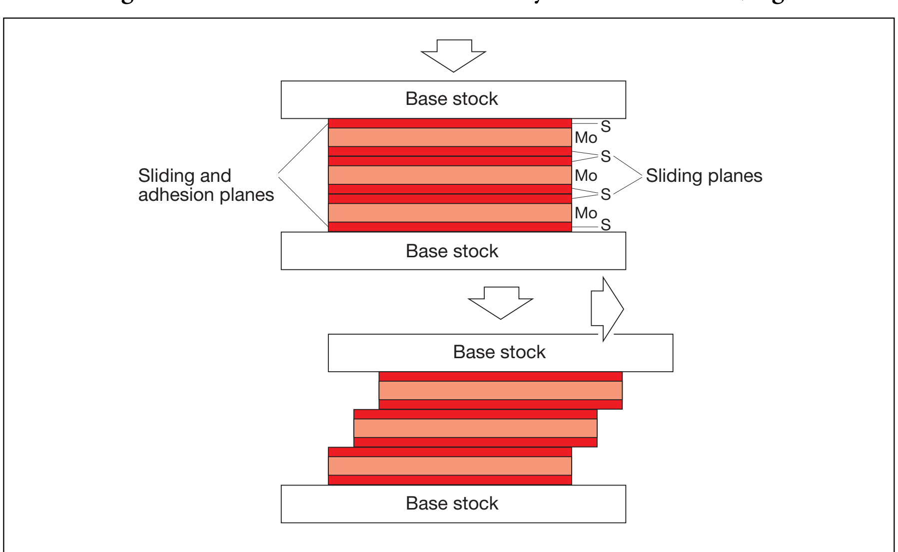
The effect of dry lubrication mainly consists of compensating for surface roughness as a result of which the effective roughness depth of the surfaces is reduced. Depending on the load and type of material, the dry lubricant is either rubbed into the metal surface or chemical reactions with the surface are released during sliding and rolling.

In dry lubricants with layer lattice structure, the lamellas of the dry lubricant slide relative to one another under pressure. Therefore, sliding occurs away from the metal surfaces, within the lubricant layers (fig. 14). The compressible dry lubricant layer distributes the pressure uniformly on a larger surface. Dry lubricants without layer-lattice structure are phosphates, oxides, hydroxides and sulphides. Other dry lubricants are soft metal films. Due to their low shear strength, they have a positive frictional behaviour. Generally, lives are considerably shorter with dry lubrication than with oil or grease lubrication. The dry lubricant layer is worn off by sliding and rolling stressing.

Oil and grease reduce the service life of dry lubricant layers depending on the treatment of the surface and the type of dry lubricant used. Sliding lacquers can soften and change their structure; this causes the friction between the surfaces to increase. Many lubricants are available with dry lubricant additives, preferably MoS2. The most commonly used quantities are 0.5 to 3 weight percent colloidal MoS2 in oils and 1 to 10 weight percent in greases. A greater concentration of MoS2 is necessary for high-viscosity oils, in order to noticeably improve the lubricating efficiency. The dispersions with particles smaller than 1 micron are very stable; the dispersed particles remain in suspension.

Dry lubricants in oil or grease contribute to the lubrication only where the contact surfaces are not fully separated by the lubricant film (mixed lubrication). The load is accommodated more easily in the contact area, i.e. it is transmitted with less friction and less wear. Dry lubricant in oil can be advantageous during the run-in period when an uninterrupted lubricating oil film has not yet formed due to the surface roughness. With high-speed bearings, dry lubricant additives can have a negative effect on high-speed operation because they increase bearing friction and temperature.

14: Working mechanism of solid lubricants with layer-lattice structure, e.g. MoS2



1.2 Calculation of the Frictional Moment

The frictional moment M of a rolling bearing, i.e. the sum total of rolling friction, sliding friction and lubricant friction, is the bearing's resistance to motion. The magnitude of M depends on the loads, the speed and the lubricant viscosity (fig. 15). The frictional moment comprises a load-independent component M_0 and a load-dependent component M_1. The black triangle to the left of the dot-dash line shows that with low speeds and high loads a considerable mixed friction share R_M can be added to M_0 and M_1 as in this area the surfaces in rolling contact are not yet separated by a lubricant film. The zone to the right of the dot-dash line shows that with a separating lubricating film which develops under normal operating conditions the entire frictional moment consists only of M_0 and M_1.

$M = M_0 + M_1$ [N mm]

M	[N mm]	total frictional moment of the bearing
M_0	[N mm]	load-independent component of the frictional moment
M_1	[N mm]	load-dependent component of the frictional moment

Mixed friction can occur in the raceway, at the lips and at the cage of a bearing; under unfavourable operating conditions it can be very pronounced but hard to quantify.

In deep groove ball bearings and purely radially loaded cylindrical roller bearings with a cage the mixed friction share according to fig. 15 is negligible. The frictional moment of axially loaded cylindrical roller bearings is determined by means of the equations given at the end of section 1.2.

Bearings with a **high sliding motion rate** (full-complement cylindrical roller bearings, tapered roller bearings, spherical roller bearings, thrust bearings) run, after the run-in period, outside the mixed friction range if the following condition is fulfilled:

$n \cdot \nu / (P/C)^{0,5} \geq 9000$

n	$[min^{-1}]$	speed
ν	$[mm^2/s]$	operating viscosity of the oil or grease base oil
P	[kN]	equivalent dynamic load
C	[kN]	dynamic load rating

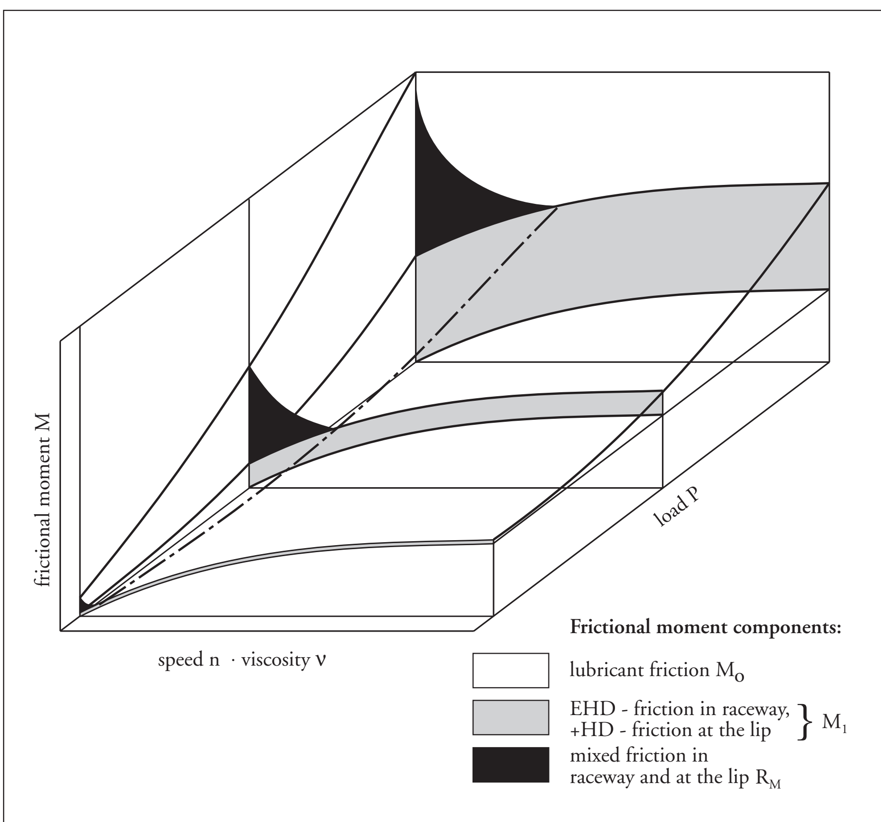
The **load-independent component of the frictional moment,** M_0, depends on the operating viscosity ν of the lubricant and on the speed n. The operating viscosity, in turn, is influenced by the bearing friction through the bearing temperature. In addition, the mean bearing diameter d_m and especially the width of the rolling contact areas – which considerably varies from type to type – have an effect on M_0. The load-independent component M_0 of the frictional moment is determined, in accordance with the experimental results, from

$M_0 = f_0 \cdot 10^{-7} \cdot (\nu \cdot n)^{2/3} \cdot d_m^3$ [N mm]

where

M_0	[N mm]	load-independent component of the frictional moment
f_0		index for bearing type and lubrication type (table, fig. 16).

15: Frictional moment in rolling bearings as a function of speed, lubricant viscosity and loads.
In ball bearings (except thrust ball bearings) and purely radially loaded cylindrical roller bearings the mixed friction triangle (left) is negligible, i.e. $R_M \approx 0$.



ν	[mm²/s]	operating viscosity of the oil or grease base oil fig. 5, page 6)
n	[min⁻¹]	bearing speed
d_m	[mm]	(D + d)/2 mean bearing diameter

The index f_0 is indicated in the table, fig. 16, for oil bath lubrication where the oil level in the stationary bearing reaches the centre of the bottommost rolling element. F_0 increases – for an identical d_m – with the size of the balls or with the length of the rollers, i.e. it also increases, indirectly, with the size of the bearing cross section. Therefore, the table indicates higher f_0 values for wide bearing series than for narrow ones. If radial bearings run on a vertical shaft under radial load, twice the value given in the table (fig. 16) has to be assumed; the same applies to a large cooling-oil flow rate or an excessive amount of grease (i.e. more grease than can displaced laterally).

The f_0 values of freshly greased bearings resemble, in the starting phase, those of bearings with oil bath lubrication. After the grease is distributed within the bearing, half the f_0 value from the table (fig. 16) has to be assumed. Then it is as low as that obtained with oil throwaway lubrication. If the bearing is lubricated with a grease which is appropriate for the application, the frictional moment M_0 is obtained mainly from the internal frictional resistance of the base oil.

Exact M_0 values for the most diverse greases can be determined in field trials. On request FAG will conduct such tests using the friction moment measurement instrument R 27 which was developed especially for this purpose.

16: Index f_0 for the calculation of M_0, depending on bearing type and series, for oil bath lubrication; for grease lubrication after grease distribution and with oil throwaway lubrication these values have to be reduced by 50 %.

Bearing type Series	Index f_0 for oil bath lubrication
deep groove ball bearings	1,5...2
self-aligning ball bearings	
12	1,5
13	2
22	2,5
23	3
angular contact ball bearings, single row	
72	2
73	3
angular contact ball bearings, double row	
32	3,5
33	6
four point bearings	4
cylindrical roller bearings with cage:	
2, 3, 4, 10	2
22	3
23	4
30	2,5
full complement	
NCF29V	6
NCF30V	7
NNC49V	11
NJ23VH	12
NNF50V	13

Bearing type Series	Index f_0 for oil bath lubrication
needle roller bearings	
NA48, NA49	5...5,5
tapered roller bearings	
302, 303, 313	3
329, 320, 322, 323	4,5
330, 331, 332	6
spherical roller bearings	
213, 222	3,5...4
223, 230, 239	4,5
231, 232	5,5...6
240, 241	6,5...7
thrust ball bearings	
511, 512, 513, 514	1,5
522, 523, 524	2
cylindrical roller thrust bearings	
811	3
812	4
spherical roller thrust bearings	
292E	2,5
293E	3
294E	3,3

The **load-dependent frictional moment component, M_1,** results from the rolling friction and the sliding friction at the lips and guiding areas of the cage. The calculation of M_1 (see following equation) using the index f_1 (table, fig. 17) requires a separating lubricating film in the rolling contact areas ($\varkappa = \nu/\nu_1 \geq 1$). Under these conditions, M_1 barely varies with speed, but it does vary with the size of the contact areas and consequently with the rolling element/raceway curvature ratio and the loading of the bearing. Additional parameters are bearing type and size.

The load-dependent frictional moment M_1 is calculated as follows:

$M_1 = f_1 \cdot P_1 \cdot d_m$ [N mm]

where

M_1	[N mm]	load-dependent component of the frictional moment
f_1		index taking into account the amount of load, see table (fig. 17)
P_1	[N]	load ruling M_1, see table (fig. 17)
d_m	[mm]	(D + d)/2 mean bearing diameter

The index f_1 for ball bearings and spherical roller bearings is – due to the curvature of the contact areas – in proportion to the expression $(P_{0*}/C_0)^s$; for cylindrical roller bearings and tapered roller bearings f_1 remains constant. P_{0*} represents the equivalent load (with dynamic forces), und C_0 represents the static load rating. The magnitude of the exponent s for ball bearings depends on the spinning friction component; for ball bearings with a low spinning friction, s = 0.5; for ball bearings with a high spinning friction, e.g. angular contact ball bearings with a contact angle of α_0 = 40°, s = 0.33, cp. Table (fig. 17).

17: Factors for the calculation of the load-dependent frictional moment component M_1

Bearing type, series	f_1 *)	P_1 ¹)
deep groove ball bearings	$(0.0005...0.0009) \cdot (P_{0*}/C_0)^{0,5}$	F_r or $3.3\ F_a - 0.1\ F_r$ ²)
self-aligning ball bearings	$0.0003\ (P_{0*}/C_0)^{0,4}$	F_r or $1,37\ F_a/e - 0.1\ F_r$ ²)
angular contact ball bearings		
single row, α = 15°	$0.0008\ (P_{0*}/C_0)^{0,5}$	F_r or $3,3\ F_a - 0.1\ F_r$ ²)
single row, α = 25°	$0.0009\ (P_{0*}/C_0)^{0,5}$	F_r or $1,9\ F_a - 0.1\ F_r$ ²)
single row, α = 40°	$0.001\ (P_{0*}/C_0)^{0,33}$	F_r or $1,0\ F_a - 0.1\ F_r$ ²)
double row or matched single row	$0.001\ (P_{0*}/C_0)^{0,33}$	F_r or $1.4\ F_a - 0.1\ F_r$ ²)
four point bearings	$0.001\ (P_{0*}/C_0)^{0,33}$	F_r or $1.5\ F_a + 3.6\ F_r$ ²)
cylindrical roller bearings with cage	0.0002...0.0004	F_r ³)
cylindrical roller bearings, full complement	0.00055	F_r ³)
needle roller bearings	0.0015	F_r
tapered roller bearings, single row	0.0004	$2\ Y\ F_a$ or F_r ²)
tapered roller bearings, double row or two single-row ones in X or O arrangement	0.0004	$1.21\ F_a/e$ or F_r ²)
spherical roller bearings		
series 213, 222	$0.0005\ (P_{0*}/C_0)^{0,33}$	} $1.6\ F_a/e$, if $F_a/F_r > e$; $F_r\ \{1 + 0.6\ [F_a/(e \cdot F_r)]^3\}$, if $F_a/F_r \leq e$
series 223	$0.0008\ (P_{0*}/C_0)^{0,33}$	
series 231, 240	$0.0012\ (P_{0*}/C_0)^{0,5}$	
series 230, 239	$0.00075\ (P_{0*}/C_0)^{0,5}$	
series 232	$0.0016\ (P_{0*}/C_0)^{0,5}$	
series 241	$0.0022\ (P_{0*}/C_0)^{0,5}$	
thrust ball bearings	$0.0012\ (Fa/C_0)^{0,33}$	F_a
cylindrical roller thrust bearings	0.0015	F_a
spherical roller thrust bearings	0.00023...0,00033	F_a where $F_r \leq 0.55\ F_a$)

*) the higher value applies to the wider series
¹) Where $P_1 < F_r$, the equation $P_1 = F_r$ is used.
²) The higher of the two values is used.
³) Only radially loaded. For cylindrical roller bearings which also accomodate axial loads, the frictional moment M_1 has to be added to M_a: $M = M_0 + M_1 + M_a$, see fig. 18.

Symbols used:

P_{0*}	[N]	equivalent load, determined from the dynamic radial load F_r and the dynamic axial load F_a as well as the static factors X_0 and Y_0 (see FAG catalogue WL 41420 EA, adjusted rating life calculation)
C_0	[N]	static load rating (see FAG catalogue WL 41420 EA)
F_a	[N]	axial component of the dynamic bearing load
F_r	[N]	radial component of the dynamic bearing load
Y, e		factors (see FAG catalogue WL 41420 EA)

The larger the bearings, the smaller the rolling elements in relation to the mean bearing diameter d_m. So the spinning friction between rolling elements and raceways increases underproportionally to d_m. With these formulas, large-size bearings, especially those with a thin cross section, feature higher frictional moments M_1 than are actually found in field application.

The load P_1, which rules the load-dependent frictional moment M_1, takes into account that M_1 changes with the load angle β = arc tan (F_a/F_r). For the sake of simplification the axial factor Y was introduced as a reference value which also depends on F_a/F_r and on the contact angle α.

The frictional moment calculated for **bearings with integrated rubbing seals** increases by a considerable supplementary factor. For small, grease-lubricated bearings the factor can be 8 (e.g. 62012.RSR with standard grease after grease distribution), for larger bearings it can be 3 (e.g. 6216.2RSR with standard grease after grease distribution). The frictional moment of the seal also depends on the penetration class of the grease and on the speed.

The FAG measuring system R27 is also suitable for exactly determining the frictional moment of the sealing.

When determining the frictional moment of **cylindrical roller bearings which also have to accommodate axial loads** the axial load-dependent fricional moment component M_a has to be added to M_0 and M_1. Consequently,

$M = M_0 + M_1 + M_a$ [N mm]

and

$M_a = f_a \cdot 0{,}06 \cdot F_a \cdot d_m$ [N mm]

f_a index, depending on the axial load F_a and the lubricating condition (fig. 18)

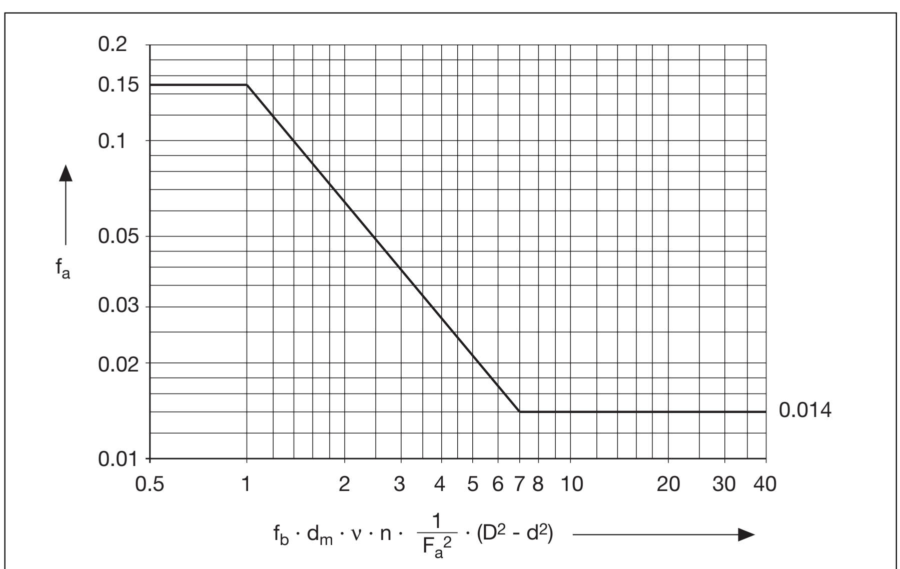
With these equations the frictional moment of a bearing can be assessed with adequate accuracy. In field applications certain deviations are possible if the aimed-at full fluid film lubrication cannot be maintained and mixed friction occurs. The most favourable lubricating condition is not always achieved in operation.

The breakaway torque of rolling bearings on start-up of a machine can be considerably above the calculated values, especially at low temperatures and in bearings with rubbing seals.

18: Coefficient of friction f_a for determining the axial load-dependent frictional moment M_a of axially loaded cylindrical roller bearings

The following parameters are required for determining M_a:

f_b =		0,0048 for bearings with a cage
		0,0061 for full-complement bearings (without a cage)
d_m	[mm]	mean bearing diameter = 0,5 · (D + d)
ν	[mm²/s]	operating viscosity of the oil or grease base oil
n	[min⁻¹]	inner ring speed
F_a	[N]	axial loading
D	[mm]	bearing O.D.
d	[mm]	bearing bore



1.3 Operating temperature

The operating temperature of a bearing increases after start-up and remains constant when an equilibrium has been achieved between heat generation and heat emission (steady-state temperature).

The steady-state temperature t can be calculated based on the equation for the heat flow Q_R [W] generated by the bearing and the heat flow Q_L [W] which is dissipated into the environment. The bearing temperature t heavily depends on the heat transition between bearing, adjacent parts and environment. The equations are explained in the following. If the required data K_t and q_{LB} are known (possibly determined in tests), the bearing operating temperature t can be deduced from the heat balance equation.

The heat flow Q_R generated by the bearing is calculated from the frictional moment M [N mm] (section 1.2) and the speed n [min^{-1}].

$Q_R = 1.047 \cdot 10^{-4} \cdot n \cdot M$ [W]

The heat flow Q_L dissipated to the environment is calculated from the difference [K] between bearing temperature t and ambient temperature t_u, the size of the heat transfer surfaces ($2\, d_m \cdot \pi \cdot B$) and the heat flow density q_{LB} customarily assumed for normal operating conditions (fig. 19) as well as the cooling factor K_t. For heat dissipation conditions found in the usual plummer block housings, $K_t = 1$, for cases where the heat dissipation is better or worse, see below.

$Q_L = q_{LB} \cdot [(t - t_u)/50] \cdot K_t \cdot 2 \cdot 10^{-3} \cdot d_m \cdot \pi \cdot B$ [W]

q_{LB} [kW/m^2] rated heat flow density, see diagram, fig. 19
d_m [mm] $(D + d)/2$
B [mm] bearing width

K_t cooling factor
= 0.5 for poor heat dissipation (warm environment, external heating)
= 1 for normal heat dissipation (self-contained bearing housing)
= 2.5 for very good heat dissipation (relative wind)

With oil circulation lubrication, the oil dissipates an additional share of the heat. The dissipated heat flow $Q_{öl}$ is the result of the inlet temperature t_E and the outlet temperature t_A, the density ρ and the specific heat capacity c of the oil as well as the amount of oil m [cm^3/min]. The density usually amounts to 0.86 to 0.93 kg/dm^3, whereas the specific entropy c – depending on the oil type – is between 1.7 and 2.4 kJ/(kg . K).,

$Q_{Öl} = m \cdot \rho \cdot c \cdot (t_A - t_E)/60$ [W]

For a standard mineral oil with ρ = 0.89 kg/dm3 and c = 2 kJ/(kg . K) the following simplified equation is used:

$Q_{Öl} = 30 \cdot V_{Öl} \cdot (t_A - t_E)$ [W]

where

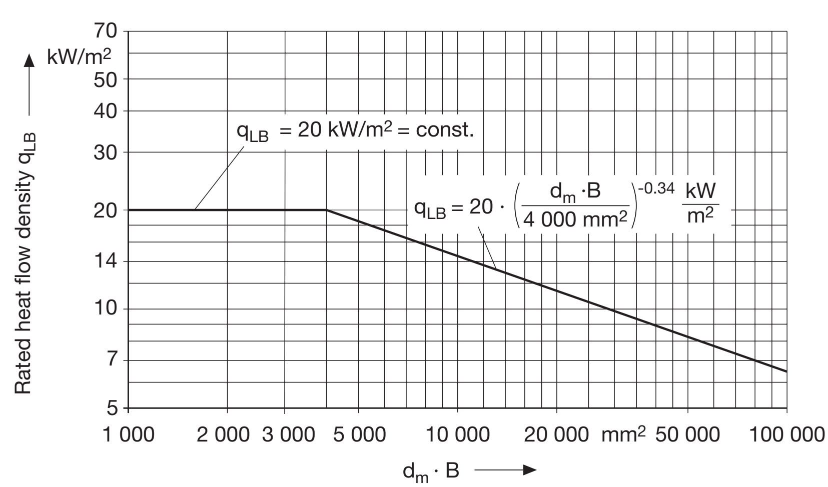
$V_{öl}$ amount of oil flowing through the bearing [l/min]

The bearing temperature t can be calculated as follows

$Q_R = Q_L + Q_{Öl}$ [W]

The result of such a temperature calculation is usually not accurate enough since the quantities entered into the calculation, especially q_L and K_t, are, as a rule, not accurately known. A useful basis is only obtained by determining the steady-state temperature in an operating test and then determining the cooling factor K_t on the basis of the steady-state temperature. Thus the steady-state temperatures of different bearing types under comparable mounting and operating conditions can be estimated with sufficient accuracy for different loads and speeds.

19: Bearing-specific rated heat flow density for the operating conditions: 70°C on the stationary bearing ring, 20°C ambient temperature, load 4...6 % of C_0



2 Lubricating System

When designing a new machine, the lubricating system for the rolling bearings should be selected as early as possible. It can be either grease or oil lubrication. In special cases, bearings are lubricated with solid lubricants. The table in fig. 20 gives a survey of the commonly used lubricating systems (page 20).

2.1 Grease Lubrication

Grease lubrication is used for 90 % of all rolling bearings. The main advantages of grease lubrication are:

– a very simple design
– grease enhances the sealing effect
– long service life with maintenance-free lubrication and simple lubricating equipment
– suitable for speed indexes $n \cdot d_m$ of up to $1{,}8 \cdot 10^6$ $min^{-1} \cdot mm$ (n = speed, d_m = mean bearing diameter)
– at moderate speed indexes, grease can be used for some time until complete deterioration after its service life has terminated
– low frictional moment

With normal operating and environmental conditions, for-life grease lubrication is often possible.

If high stresses are involved (speed, temperature, loads), relubrication at appropriate intervals must be planned. For this purpose grease supply and discharge ducts and a grease collecting chamber for the spent grease must be provided, for short relubrication intervals a grease pump and a grease valve may have to be provided as well.

2.2 Oil Lubrication

Oil lubrication is recommended if adjacent machine components are supplied with oil as well or if heat must be dissipated by the lubricant. Heat dissipation can be necessary if high speeds and/or high loads are involved or if the bearing is exposed to extraneous heat.

Oil lubrication systems with small quantities of oil (throwaway lubrication), designed as drip feed lubrication, oil mist lubrication or oil-air lubrication systems, permit an exact metering of the oil rate required.

This offers the advantage that churning of the oil is avoided and the friction in the bearing is low.

If the oil is carried by air, it can be fed directly to a specific area; the air current has a sealing effect.

With oil jet or injection lubrication, a larger amount of oil can be used for a direct supply of all contact areas of bearings running at very high speeds; it provides for efficient cooling.

2.3 Dry Lubrication

For-life lubrication with solid or dry lubricants is achieved when the lubricant is bonded to the functional surfaces, e.g. as **sliding lacquers,** or when the lubricant layer wears down only slightly due to the favourable operating conditions. If **pastes** or **powders** are used as dry lubricants, the bearings can be relubricated. Excess lubricant, however, impedes smooth running.

With **transfer lubrication,** the rolling elements pick up small amounts of the solid lubricant and carry them into the contact area. The solid lubricant either revolves along with the rolling element set as a solid mass or is contained, in special cases, as an alloying constituent in the bearing cage material. This type of lubrication is very effective and yields relatively long running times. It ensures continuous relubrication until the solid lubricants are used up.

2.4 Selection of the Lubricating System

For the selection of a lubricating system the following points should be taken into account

– operating conditions for the rolling bearings
– requirements on running, noise, friction and temperature behaviour of the bearings
– requirements on safety of operation, i.e. safety against premature failure due to wear, fatigue, corrosion, and against damage caused by foreign matter having penetrated into the bearing (e.g. water, sand)
– cost of installation and maintenance of a lubricating system

An important precondition for high operational reliability are an unimpeded lubricant supply of the bearing and a permanent presence of lubricant on all functional surfaces. The quality of lubricant supply is not the same with the different lubricating systems. A monitored continuous oil supply is very reliable. If the bearings are lubricated by an oil sump, the oil level should be checked regularly to ensure high safety standards in operation.

Grease-lubricated bearings operate reliably if the specified relubrication intervals or, in the case of for-life lubricated bearings, the service life of the grease are not exceeded. If the lubricant is replenished at short intervals, the operational reliability of the bearing depends on the lubricating equipment functioning properly. With dirt-protected bearings, i.e. rolling bearings with two seals (e.g. Clean Bearings for oil-lubricated transmissions) operational reliability is ensured even after the grease has reached the end of its service life due to the lubricating effect of the oil.

Detailed information on the lubricating systems commonly used is provided in the table, fig. 20.

20: Selection of Lubrication System

Lubricant	Lubrication systems	Lubricating equipment	Design measures	Index of attainable speed $n \cdot d_m$ in $min^{-1} \cdot mm$ [1])	Suitable bearing types, operational behaviour
Dry lubricant	For-life lubrication	-	-	≈ 1500	Mainly deep groove ball bearings
	Relubrication	-	-		
Grease	For-life lubrication	-	-	≈ $0,5 \cdot 10^6$ ≈ $1,8 \cdot 10^6$ for suitable special greases and bearings, lubrication intervals according to diagram fig. 33 (page 36)	All bearing types depending on rotational speed and grease type, with the exception of spherical roller thrust bearings. Special low friction and low noise greases
	Relubrication	Hand operated press, grease gun	Inlet holes, if necessary grease valve, collecting chamber for spent grease		
	Spray lubrication	Central lubricating plant[2])	Feed pipes or holes, collecting chamber for spent grease		
Oil (larger volumes)	Oil sump lubrication	Dipstick, tube, and level indicator	Housing space sufficient for certain oil volume, overflow outlet holes, connection for moni-toring equipment	≈ $0,5 \cdot 10^6$	All bearing types. Noise damping effect depending on oil viscosity; higher energy losses due to increased friction caused by churning, good cooling effect, discharge of wear particles by circulating oil and oil jet lubrication.
	Circulating oil lubri-cation due to pumping action of the bearings or special conveying elements		Oil supply holes, housing space sufficient for certain oil volume; conveying elements adapted to the oil viscosity and rational speed.	must be determined individually	
	Circulating oil lubrication	Circulation plant[2])	Sufficiently large oil inlet and outlet holes	≈ $1 \cdot 10^6$	
	Oil jet lubrication	Circulation plant with nozzles[5])	Nozzles for direct oil injection, sufficiently large oil outlet holes	proven up to $4 \cdot 10^6$	
Oil (minimum volumes)	Intermittent drip oil lubrication Drip feed lubrication	Central lubricating plant[2]), drip feed lubricator, oil spray lubrication equip-ment	Outlet holes	≈ $2 \cdot 10^6$ depending on bearing type, oil viscosity, amount of oil, design	All bearing types. Noise damping effect depending on oil viscosity; friction depending on oil quantity and oil viscosity.
	Oil mist lubrication	Oil mist lubrication plant[3]), if necessary oil separator	Extraction equipment, if necessary		
	Oil-air lubrication	Oil-air lubrication plant[4])	Extraction equipment, if necessary		

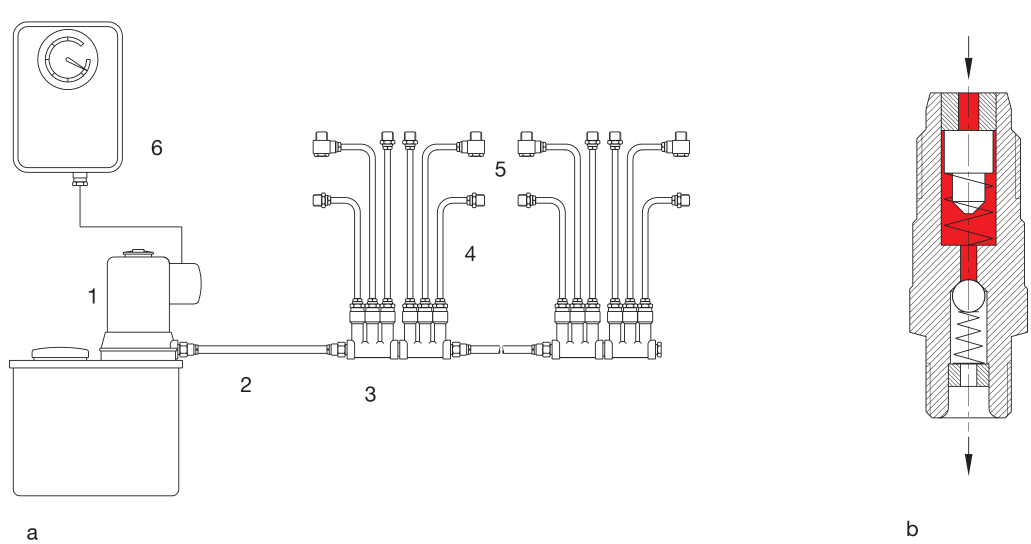
[1]) Depending on bearing type and mounting conditions.
[2]) Central lubrication plant consisting of pump, reservoir, filters, pipelines, valves, flow restrictors. Circulation plant with oil return pipe, cooler if required (see figs. 21, 22).
Central lubricating plant with metering valves for small lubricant rates (5 to 10 mm^3/stroke).
[3]) Oil mist lubrication plant consisting of reservoir, mist generators, piplines, recompressing nozzles, control unit, compressed air supply (see fig. 23).
[4]) Oil-air lubrication system consisting of pump, reservoir, pipelines, volumetric air metering elements, nozzles, control unit, compressed air supply (see fig. 24).
[5]) Number and diameter of nozzles (see fig 51, page 45).

2.5 Examples of the Different Lubrication Systems

2.5.1 Central Lubrication System

Fig. 21: It is used for throwaway lubrication and circulating lubrication. A pump, which is intermittently switched on by a control device, conveys oil or semi-fluid grease to the dosing valves. These valves deliver volumes of 5 to 500 mm3 per stroke. One single pump supplies several bearing locations which require different amounts of lubricant with metered volumes of oil or semi-fluid greases, by setting feed cycles and volume to be delivered by the valve accordingly. For greases of penetration classes 2 to 3, dual-line pumping systems, progressive systems and multi-line systems are suitable. With multi-line systems, each of the pumping units supplies one bearing location with grease or oil.

21a: Schematic drawing of a central lubricating system (single-line system). 1 = pump, 2 = main pipe, 3 = dosing valve, 4 = secondary pipes to areas to be lubricated, 5 = lubricant exits, 6 = control device.
21b: Dosing valve (example)



2.5.2 Oil Circulation System

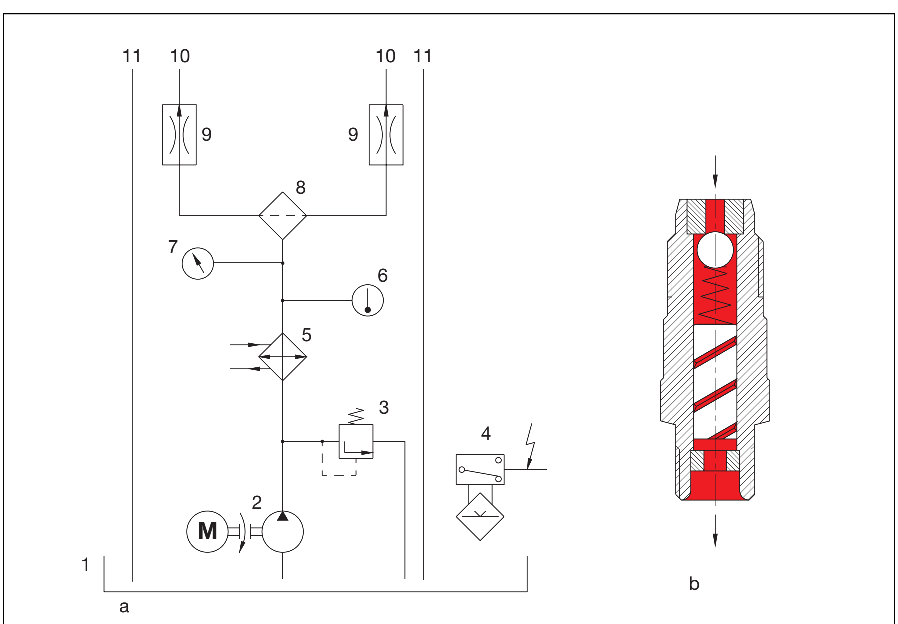
Fig. 22: If larger oil rates are needed for circulating lubrication, the oil can be distributed and delivered by flow restrictors because the oil volume fed to the bearings can vary slightly. Several litres of oil per minute can be delivered via the flow restrictors (cooling lubrication). According to the amount of oil required and the demands on operational reliability, the circulation system includes pressure limiting valve, cooler, filter, pressure gauge, thermometer, oil level control and reservoir heating. The oil flow rate of the bearing depends on the oil viscosity and consequently the oil temperature.

2.5.3 Oil Mist Lubrication System

Fig. 23: Compressed air, cleaned in an air filter, passes through a Venturi tube and takes in oil from an oil reservoir via a suction pipe. Part of the oil is atomized and carried on as mist and fine droplets. Larger drops not atomized by the air stream return to the oil reservoir. The drops in the oil mist are between 0.5 and 2 µm in size. The oil mist can be easily fed through pipes, but has poor adhesive properties. Therefore, the pipe terminates in a nozzle where the micronic oil particles form into larger droplets which are carried into the bearing by the air stream.

In some cases, the oil mist does not entirely form into droplets and is carried with the air out of the bearing into the environment. Oil mist is an air pollutant. Oils with viscosity grades of up to ISO VG 460 are used for oil mist lubrication. Tough oils must be heated so before atomizing that their viscosity is lower than 300 mm^2/s.

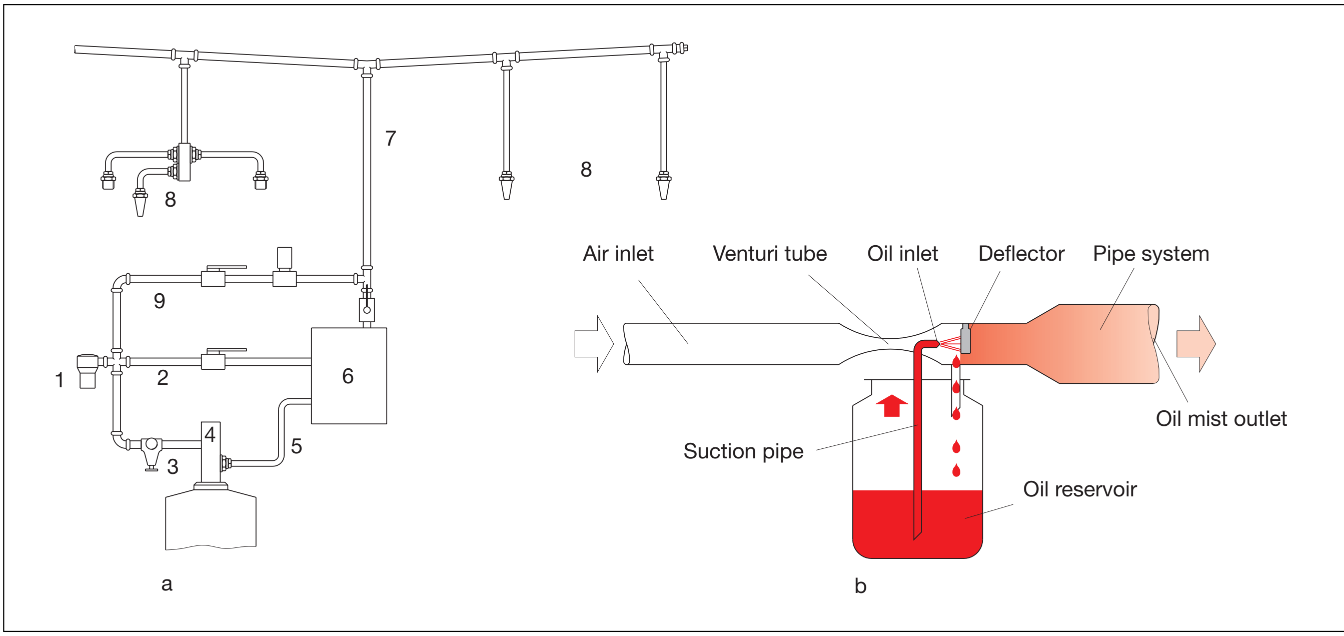
22a: Schematic drawing of a circulating system (example). 1 = reservoir, 2 = oil pump, 3 = pressure limiting valve, 4 = electric oil level control, 5 = cooler, 6 = thermometer, 7 = pressure gauge, 8 = filter, 9 = adjustable flow restrictor, 10 = lubricant exit, 11 = oil return pipe.
22b: Flow restrictor (example)



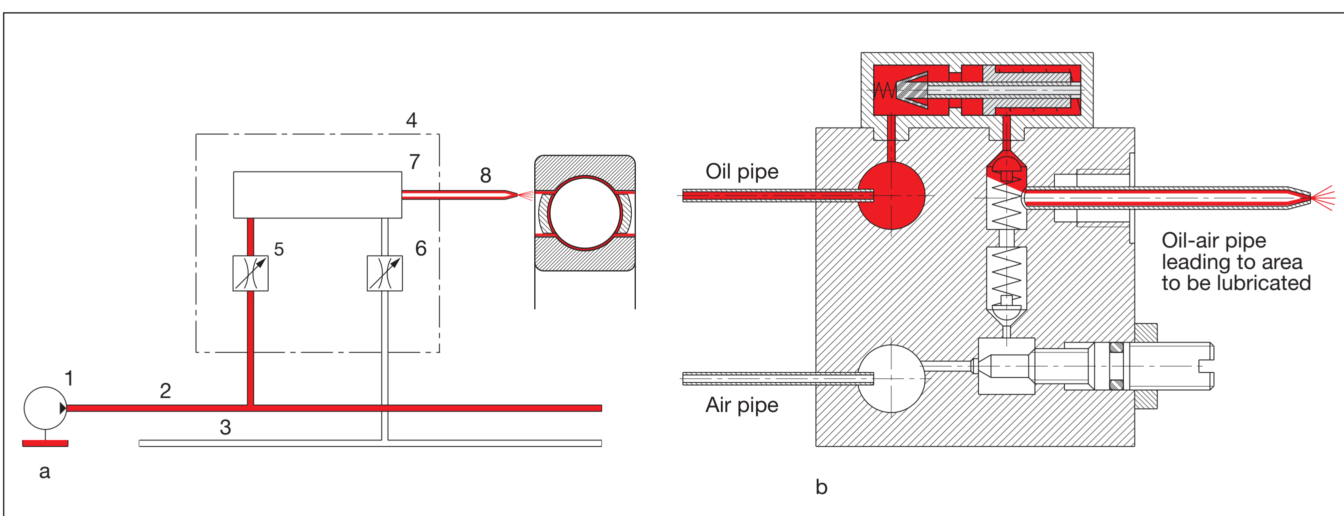
2.5.4 Oil-air lubrication system

Fig. 24: In an oil-air mixing unit (fig. 24b), oil is periodically added to an uninterrupted air stream via a metering valve. A control and monitoring unit switches on the oil pump intermittently. The injected oil is safely carried by the air current along the pipe wall to the bearing location. A transparent plastic hose is recommended as oil-air pipeline which permits the oil flow to be observed. The hose should have an inside diameter of 2 to 4 mm and a minimum length of 400 mm to ensure a continuous oil supply. Formation of oil mist is largely avoided. Oils of up to ISO VG 1500 (viscosity at ambient temperature approx. 7,000 mm^2/s) can be used. In contrast to oil mist lubrication, oil-air lubrication has the advantage that the larger oil particles adhere better to the bearing surfaces and most of the oil remains in the bearing. This means that only a small amount of oil escapes to the outside through the air vents.

23a: Schematic drawing of an oil mist lubrication system. 1 = air filter, 2 = air supply pipe, 3 = pressure control, 4 = pump, 5 = main pipe, 6 = atomizer, 7 = oil mist pipe, 8 = nozzles at point of lubrication, 9 = air pipe.
23b: Atomizer (Venturi tube)



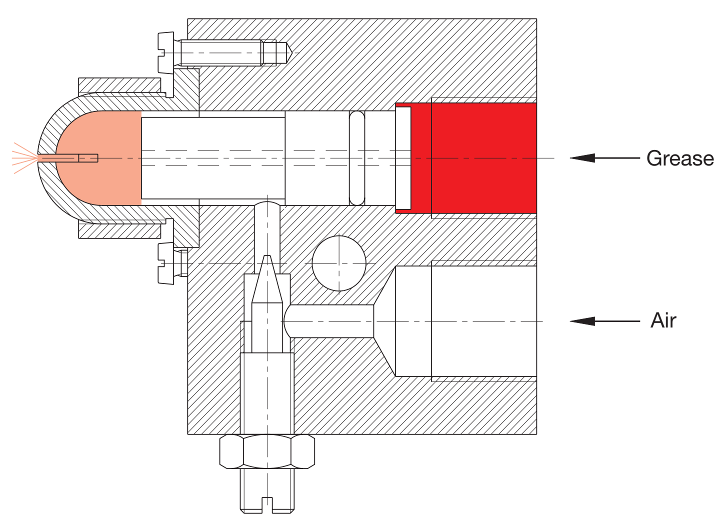
24a: Schematic drawing of an air-oil lubrication system (according to Woerner). 1 = automatic oil pump, 2 = oil pipe, 3 = air pipe, 4 = oil-air mixing unit, 5 = oil metering element, 6 = air metering element, 7 = mixing chamber, 8 = oil-air pipe.
24b: Oil-air mixing unit



2.5.5 Oil and grease spray lubrication

The equipment required for spray lubrication is identical with the oil-air lubrication equipment. A control device opens a solenoid valve for air. The air pressure opens a pneumatic lubricant check valve for the duration of the spray pulse. By means of a central lubricating press, the lubricant is fed to the lubricant-air mixing unit from where it is carried off by the air stream (fig. 25). The resulting spray pattern depends on the shape and size of the opening. An air pressure of 1 to 2 bar is required. Fine spray patterns are obtained with 1 to 5 bar. Greases of consistency classes 000 to 3 and oils up to ISO VG 1500 (viscosity at ambient temperature approximately 7000 mm²/s) can be sprayed.

25: Lubricant-air mixing unit



3 Lubricant Selection

Under most of the operating conditions found in field application, rolling bearings pose no special requirements on lubrication. Many bearings are even operated in the mixed-friction range. If, however, the capacity of the rolling bearings is to be fully utilized, the following has to be observed.

The greases, oils or solid lubricants recommended by the rolling bearing manufacturers meet the specifications for rolling bearing lubricants stated in the survey on page 25. Appropriately selected, they provide reliable lubrication for a wide range of speeds and loads.

Rolling bearing greases are standardized in DIN 51825. For instance, they must reach a certain life F_{50} at the upper operating temperature limit on the FAG rolling bearing test rig FE9 (DIN 51821).

Lubricants for the mixed friction range under high loads or with a low operating viscosity at high temperatures are evaluated on the basis of their friction and wear behaviour. Here, wear can be avoided only if separating boundary layders are generated in the contact areas, e.g. as a result of the reaction of additives with the metal surfaces due to high pressure and a temperature in the rolling contact area for which the additive is suitable. These lubricants are tested on FAG FE8 test rigs (E DIN 51819).

When using especially highly doped mineral oils, e.g. hypoid oils, and with synthetic oils, their compatibility with seal and bearing materials (particularly the cage material) must be checked.

26: Criteria for grease selection

Criteria for grease selection	Properties of the grease to be selected (see also section 3.1)
Operating conditions Speed index $n \cdot d_m$ Load ratio P/C	Grease selection according to diagram, fig. 28 (page 27) For high speed indices $d \cdot d_m$: consistency class 2-3, for high P/C load ratios: consistency class 1-2
Running properties	
Low friction, also during starting	Grease of penetration class 1 to 2 with synthetic base oil of low viscosity
Low constant friction at steady-state condition, but higher starting friction admissible	Grease of penetration class 3 to 4, grease quantity ≈ 30 % of the free bearing space or class 2 to 3, grease quantity < 20 % of the free bearing space
Low noise level	Low-noise grease (high degree of cleanliness) of penetration class 2
Mounting conditions	
Inclined or vertical position of bearing axis	Grease with good adhesion properties of penetration classes 3 to 4
Outer ring rotating, inner ring stationary, or centrifugal force on bearing	Grease with a large amount of thickener, penetration classes 2 to 4 Grease fill quantity depending on speed
Maintenance	
Frequent relubrication	Soft grease of penetration class 1 to 2
Infrequent relubrication, for-life relubrication	Grease retaining its penetration class 2 to 3 unter stressing, upper operating temperature limit higher than the operating temperature
Environmental conditions	
High temperatures, for-life lubrication	Heat resistant grease with synthetic base oil and hea resistant (e.g. synthetic) thickener
High temperature, relubrication	Grease which does not form any residues at high temperatures
Low temperature	Grease with low-viscosity base oil and suitable thickener, penetration class 1 to 2
Dusty environments	Stiff grease of penetration class 3
Condensate	Emulsifying grease, e.g. sodium or lithium soap base greases
Splash water	Water-repellent grease, e.g. calcium soap base grease of penetration class 3
Aggresive media (acids, bases, etc.)	Special grease, please consult FAG or lubricant manufacturer
Radiation	Up to absorbed dose rate $2 \cdot 10^4$ J/kg, rolling bearing greases to DIN 51 825, up to absorbed dose rate $2 \cdot 10^7$ J/kg, consult FAG.
Vibratory stressing	EP lithium soap base grease of consistency class 2, frequent relubrication. with moderate vibratory stresses, barium complex grease of consistency class 2 with solid lubricant additives or lithium soap base grease of consistency class 3.
Vacuum	Up to 10^{-5} mbar, depending on temperature and base oil, rolling bearing greases according to DIN 51 825, consult FAG.

27: Grease properties

Grease type: Thickener – Type	Soap	Base oil	Properties: Temperature range °C	Drop point °C	Water resistance	Load carrying capacity	Price relation*	Suitability for rolling bearings	Remarks
normal	aluminium	mineral oil	-20...70	120	++	+	2.5...3	+	Swells with water
	calcium		-30...50	80...100	+++	+	0,8	+	Good sealing action against water
	lithium		-35...130	170...200	+++	+	1	+++	Multipurpose grease
	sodium		-30...100	150...190	-	++	0.9	++	Emulsifies with water
	lithium	PAO	-60...150	170...200	+++	++	4...10	+++	For low and higher temperatures, high speeds
	lithium	ester	-60...130	190	++	+	5...6	+++	For low temperatures, high speeds
complex	aluminium	mineral oil	-30...160	260	+++	+	2,5...4	+++	Multipurpose grease
	barium		-30...140	220	++	++	4...5	+++	Multipurpose grease, resistant to vapour
	calcium		-30...140	240	++	++	0.9...1.2	+++	Multipurpose grease, may harden
	lithium		-30...150	240	++	++	2	++	Multipurpose grease
	sodium		-30...130	220	+	+	3.5	+++	Multipurpose grease for high temperatures
	aluminium	PAO	-60...160	260	+++	++	10...15	+	For wide temperature range, good supply
	barium		-60...160	220	+++	+++	15...20	+++	For low and higher temperatures, high speeds
	calcium		-60...160	240	+++	+++	15...20	+++	For low and higher temperatures, high speeds
	lithium		-40...180	240	++	+++	15	+++	For wide temperature range
	barium	ester	-40...130	200	++	++	7	+++	For low temperature
	calcium		-40...130	200	+++	++	7	+++	and higher speeds at moderate loads
	lithium		-40...180	240	++	+	10	+++	For especially wide temperature range
	lithium	silicone oil	-40...180	240	++	-	20	++	For especially wide temperature range, P/C<0.03
Bentonites		mineral oil	-20...150	without	+++	+	2...6	++	For higher temperatures at low speeds
		PAO	-50...180	without	+++	+	12...15	++	For wide temperature range
Polyurea		mineral oil	-25...160	250	+++	++	3	+++	For higher temperatures at medium speeds
		PAO	-30...200	250	+++	+++	10	+++	High temperature grease with good long-term effectiveness
		silicone oil	-40...200	250	+++	-	20	++	For high and low temperatures, low loads
		fluoro-silicone oil	-40...200	250	+++	+	100	+++	For high and low temperatures, moderate loads
PTFE or FEP		alkoxy-fluoro oil	-50...250	without	+++	++	100...150	+++	Both greases for very high and low temperatures
		fluoro-silocone-oil	-40...200	without	+++	++	80...100	+++	Very good resistance to chemicals and solvents

* reference grease: lithium soap base grease/mineral base oil =1

+++ very good
++ good
+ moderate
- poor

3.1 Selection of Suitable Greases

Lubricating greases are mainly distinguished by their main constituents, i.e. the thickener and the base oil. Usually, normal metal soaps are used as thickeners, but also complex soaps such as bentonite, polyurea, PTFE or FEP. Either mineral oils or synthetic oils are used as base oils. The viscosity of a base oil determines, together with the amount of thickener used, the consistency of the lubricating grease and the development of the lubricating film.

Like the lubricating oils, lubricating greases contain additives which improve their chemical or physical properties such as oxidation stability, protection against corrosion or protection from wear under high loads (EP additives).

The table in fig. 27 lists the principal grease types suitable for rolling bearing lubrication. The data contained in the table provides average values. Most of the greases listed are available in several penetration classes (worked penetration). Grease manufacturers supply the precise data regarding the individual greases. The table provides some basic information for initial orientation.

More details on grease selection are given in the following text and in table 26 (page 25).

3.1.1 Grease Stressing by Speed and Load

The influence of speed and load on grease selection is shown in the diagram (fig. 28). The following parameters are needed for evaluation:

C	[kN]	dynamic load rating
P	[kN]	equivalent dynamic load acting on the bearing (for calculating, see FAG catalogue)
n	[min^{-1}]	speed
d_m	[mm]	mean bearing diameter (D+d)/2
k_a		factor taking into account the sliding motion share of the bearing type

The diagram in fig. 28 is divided into three load ranges. For radial loads, the left-hand ordinate is used, for axial loads the right-hand one.

Rolling bearings operating under load conditions of **range N** can be lubricated with nearly all rolling bearing greases K according to DIN 51 825. Excluded are greases with an extremely low or high base oil viscosity, extremely stiff or soft greases, and some special greases, e.g. silicone greases, which can only be used up to loads of P/C = 0,03.

In the high speed and load range, that is in the upper right corner of range N, higher operating temperatures necessitate the use of thermally stable greases. The grease should be resistant to temperatures which are noticeably higher than the expected bearing operating temperature.

The loads in **range HL** are high. For these bearings greases with a higher base oil viscosity, EP additives, and, possibly, solid lubricant additives should be selected. In the case of high loads and low speed, these additives provide "chemical lubrication" or dry lubrication where the

28: Grease selection from the load ratio P/C and the relevant bearing speed index $k_a \cdot n \cdot d_m$

Range N
Normal operating conditions.
Rolling bearing greases K according to DIN 51825.

Range HL
Range of heavy loads.
Rolling bearing greases KP according to DIN 51825 or other suitable greases.

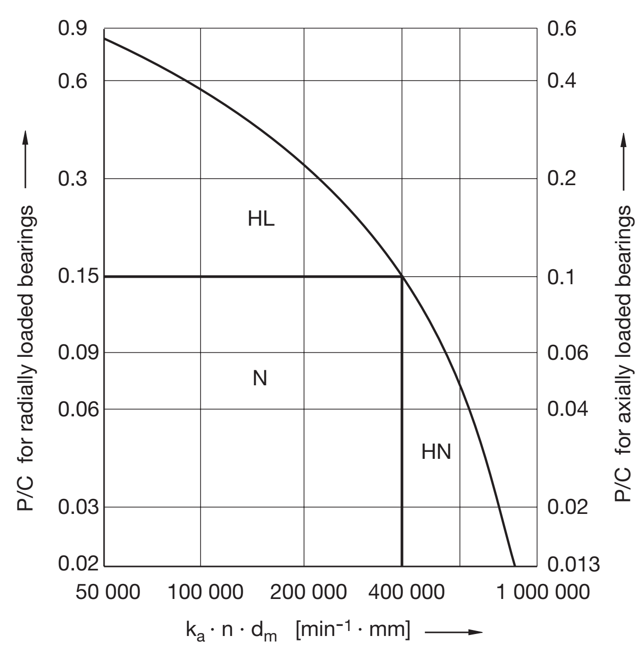
Range HN
High-speed range.
Greases for high-speed bearings.
For bearing types with $k_a > 1$ greases KP according to DIN 51825 or other suitable greases.

k_a values

$k_a = 1$ deep groove ball bearings, angular contact ball bearings, four-point bearings, self-aligning ball bearings, radially loaded cylindrical roller bearings, thrust ball bearings.

$k_a = 2$ spherical roller bearings, tapered roller bearings, needle roller bearings.

$k_a = 3$ axially loaded cylindrical roller bearings, full complement cylindrical roller bearings.



lubricating film has been interrupted (mixed lubrication).

The stresses in **Range HN** are characterized by high speeds and low loads. At high speeds, the friction caused by the grease should be low, and the grease should have good adhesion properties. These requirements are met by greases with ester oil of low viscosity as base oil. Generally, the lower the base oil viscosity of a grease, the higher are the permissible speed indices recommended by the grease suppliers.

3.1.2 Running Properties

A low, constant friction is vital for bearings having to perform stick-slip free motions, such as the bearings for telescopes. For such applications EP lithium greases with a base oil of high viscosity and MoS_2 additive are used. Low friction is also required from bearings installed in machines whose driving power is primarily determined by the bearing friction to be overcome, as is the case with fractional HP motors. If such bearings start up rapidly from cold, they are best served by greases of consistency class 2 with a synthetic base oil of low viscosity.

At normal temperatures, low friction can be obtained by selecting a stiffer grease of consistency class 3 to 4, except for the short period of grease distribution. These greases do not tend to circulate in the bearing along with the bearing components if excess grease can settle in the housing cavities.

Lubricating greases for low-noise bearings must not contain any solid particles. Therefore these greases should be filtered and homogenized. A higher base oil viscosity reduces the running noise, especially in the upper frequency range.

The standard grease for low-noise deep groove ball bearings at normal temperatures is usually a filtered, lithium soap base grease of consistency class 2 with a base oil viscosity of approximately 60 mm²/s at 40 °C. FAG bearings which are as a standard fitted with dust shields or seals are filled with a particularly low-noise grease.

3.1.3 Special Operating and Environmental Conditions

High temperatures occur if the bearings are exposed to high stressing and/or high circumferential velocities and to extraneous heating.

For such applications, high-temperature greases should be selected. It must be taken into account that the grease service life is strongly affected if the upper temperature limit of the grease is exceeded (see 4.1.3). The critical temperature limit is approximately 70 °C for lithium soap base greases and approximately 80 to 110 °C for high-temperature greases containing a mineral base oil and a thermally stable thickener, depending on the grease type. High-temperature greases with a synthetic base oil can be used at higher temperatures than those with a mineral base oil because synthetic oils evaporate less and do not deteriorate so quickly. Greases with high-viscosity alkoxyfluoro oil as base oil are suitable for deep groove ball bearings up to a speed index of $n \cdot d_m = 140{,}000\ min^{-1} \cdot mm$, even at temperatures of up to 250 °C. At moderate temperatures, high-temperature greases can be less favourable than standard greases.

Occasionally, the bearings are lubricated, at high operating temperatures, with thermally less stable greases; in these cases, frequent relubrication is necessary. Greases must be chosen which do not solidify in the bearing thereby impairing the grease exchange and, possibly, causing the bearing to seize.

At **low temperatures,** a lower starting friction can be obtained with low-temperature greases than with standard greases. Low-temperature greases are lubricating greases with a low-viscosity base oil and lithium soap thickener. Multi-purpose greases, if used in the low-temperature range, are very stiff and, therefore, cause an extremely high starting friction. If, at the same time, bearing loads are low, slippage can occur resulting in wear on the rolling elements and raceways. The oil separation, and consequently the lubricating effect of standard greases, high-load greases and high-temperature greases, is clearly reduced at low temperatures.

The lower operating temperature limit of a grease is specified, in accordance with DIN 51 825, on the basis of its conveyability. This limitation does not mean that the bearing is sufficiently lubricated at this temperature. If, however, a certain minimum speed is combined with sufficient loading, the low temperature has usually no harmful effect. After a short running period, the temperature even of multi-purpose greases increases to normal values. After the grease has been distributed, the friction decreases to normal values.

Generally critical are, however, bearings which are operated under extreme cooling effect, especially if they rotate only occasionally or very slowly.

Condensate can form in the bearings and cause corrosion, if the machine operates in a humid environment, e.g. in the open air, and the bearings cool down during prolonged idle times of the machine. Condensate forms especially where there are large free spaces within the bearing or in the housing. In such cases, sodium and lithium soap base greases are recommended. Sodium grease absorbs large amounts of water, i.e. it emulsifies with water, but it may soften to such an extent that it flows out of the bearing. Lithium soap base grease does not emulsify with water so that, with suitable additives, it provides good protection against corrosion.

If the seals are exposed to **splash water,** a water-repellent grease should be used, e.g. a calcium soap base grease of penetration class 3. Since calcium soap base greases do not absorb any water, they contain an anti-corrosion additive.

Certain special greases are resistant to **special media** (boiling water, vapour, bases, acids, aliphatic and chlorinated hydrocarbons). Where such conditions are found, FAG should be consulted.

Grease, **acting as a sealing agent,** prevents contaminants from penetrating into the bearing. Stiff greases (consistency class 3 or higher) form a protective grease collar at the shaft passage, remain in the sealing gap of labyrinths and retain foreign particles. If the seals are of the rubbing type, the grease must also lubricate the surfaces of the sealing lip and the shaft which are in sliding contact. The compatibility of the grease with the seal material has to be checked.

Radiation can affect the bearings, and consequently the grease as well, e.g. in nuclear power plants. The total absorbed dose is the measure for radiation stressing of the grease, that is either the radiation of low intensity over a long period of time or of a high intensity over a short period of time (absorbed dose rate). The absorbed dose rate must not, however, exceed a value of 10 J/kg · h. The consequences of stressing by radiation are a change in grease consistency and drop point, evaporation losses, and the development of gas. The service life of a grease stressed by radiation is calculated from t = S/R, unless the service life is still shorter due to other stresses. In this equation, t is the service life in hours, S the absorbed dose in J/kg permissible for the grease, and R the absorbed dose rate in J/(kg · h). Standard greases resist an absorbed dose of up to $S = 2 \cdot 10^4$ J/kg, especially radiation-resistant special greases resist an absorbed dose of up to $S = 2 .10^7$ J/kg with gamma rays (see also Glossary of Terms, heading "Radiation"). In the primary circle of nuclear power plants, certain substances such as molybdenum disulphide, sulphur, halogenes) are subjected to strong changes. It must, therefore, be ensured that greases used in the primary circle do not contain these substances.

In the case of **vibratory stresses,** the grease is moved and displaced in and around the bearing which has the effect of frequent irregular regreasing of the contact surfaces; they can break down the grease into oil and thickener. It is good practice to select a grease from the table, fig. 26, and to relubricate the bearings at short intervals, e.g. once a week. Vibrationally stable multi-purpose greases of consistency class 3 have also proved to be suitable, for instance in vibration motors.

The base oil of the grease gradually evaporates in **vacuum,** depending on negative pressure and temperature. Shields and seals retain the grease in the bearing and reduce evaporation losses. The grease should be selected in accordance with table 26.

Inclined or vertical shafts can cause the grease to escape from the bearing due to gravity. Therefore, a grease with good adhesive properties of consistency class 3 to 4 should be selected in accordance with table 26 (page 25) which is retained in the bearing by means of baffle plates.

Where frequent **impact loads** or very high loads have to be accommodated, greases of consistency classes l to 2 of high base oil viscosity (ISO VG 460 to ISO VG 1500) are suitable. These greases form a thick, hydrodynamic lubricant film which absorbs shocks well and prevents wear better than a chemical lubrication achieved by means of EP additives. The drawback of greases with a high base oil viscosity is that, due to their slight oil separation, the effective presence of the lubricant has to be ensured by a large grease fill quantity or relubrication at short intervals.

Greases used for the purpose of **for-life lubrication** or **frequent relubrication** should be selected in accordance with the table, fig. 26 (page 25). The tables in figs. 26 and 27 help to specify the required properties of the lubricating grease based on the stresses listed there, so that a suitable FAG grease or a grease from the lists provided by the grease manufacturers can be selected. In cases of doubt, please consult FAG.

29: Effects of lubricant additives

Additives	Effects of the additives
Oxidation inhibitors	prevent premature formation of oxidation products
Corrosion inhibitors	prevent corrosion of metal surfaces
Detergents	remove oxidation products
Dispersants	keep sludge-forming insoluble compounds in suspension and prevent deposits on metal surfaces Water is also held in suspension as a stable emulsion
Popular lubricity improvers	reduce friction and wear during operation in the mixed friction range
Anti-wear and EP additives	reduce friction and wear, and the tendency towards seizure
Rust inhibitors	prevent rust forming on metal surfaces during idle times
Metal deactivators	prevent action of metallic particles as catalysts in oxidation processes
Pour point depressants	reduce the pour point
Viscosity index improvers	reduce the decline of the viscosity curve with rising temperature
Defoamers	reduce foaming

3.2 Selection of Suitable Oils

Both mineral and synthetic oils are generally suitable for the lubrication of rolling bearings. Lubricating oils based on mineral oils are the ones most commonly used today. These mineral oils must at least meet the requirements indicated in DIN 51501. Special oils, often synthetic oils, are used for extreme operating conditions or special demands on the stability of the oil under aggravating environmental conditions (temperature, radiation etc.). Renowned oil manufacturers carry out successful FE8 tests themselves. The major chemico-physical properties of oils and information on their suitability are listed in table 30. The effects of additives are listed in table 29. Of particular importance are the additives for bearing operation in the mixed friction range.

3.2.1 Recommended Oil Viscosity

The attainable fatigue life and safety against wear increase, the better the contact surfaces are separated by a lubricant film. Since the lubricant film thickness increases with rising oil viscosity, an oil with a high operating viscosity should be selected. A very long fatigue life can be reached if the operating viscosity $\varkappa = \nu/\nu_1 = 3 \ldots 4$, see diagrams 5 to 7. High-viscosity oils, however, also have drawbacks. A higher viscosity means higher lubricant friction; at low and normal temperatures, supply and drainage of the oil can cause problems (oil retention).

30: Properties of various oils

Oil type	Mineral oil	Polyalpha olefin	Polyglycol (water insoluble)	Ester	Silicone oiol	Alkoxy fluoro oil
Viscosity at 40 °C [mm²/s]	2...4500	15...1500	20...2000	7...4000	4...100 000	20...650
Max. temperature [°C] for oil sump lubrication	100	150	100...150	150	150...200	150...220
Max. temperature [°C] for circulating oil lubrication	150	200	150...200	200	250	240
Pour point [°C]	-20[2])	-40[2])	-40	-60[2])	-60[2])	-30[2])
Flash point [°C]	220	230...260[2])	200...260	220...260	300[2])	-
Evaporation losses	moderate	low	moderate to high	low	low[2])	very low[2])
Resistance to water	good	good	good[2]), hard to separate due to same density	moderate to good[2])	good	good
V-T-behaviour	moderate	moderate to good	good	good	very good	moderate to good
Suitablility for high temperatures (≈ 150 °C)	moderate	good	moderate to good[2])	good[2])	very good s	very good
Suitability for high loads	very good[1])	very good[1])	very good[1])	good	poor[2])	good
Compatibility with elastomers	good	good[2])	moderate, to be checked when used with paint	moderate to poor	very good	good
Price caomparison	1	6	4...10	4...10	40...100	200...800

[1]) with EP additives
[2]) depending on the oil type

Therefore, the oil viscosity should be selected so that a maximum fatigue life is attained and an adequate supply of oil to the bearings is ensured.

In isolated cases, the required operating viscosity cannot be attained

- if the oil selection also depends on other machine components which require a thin-bodied oil,
- if, for circulating oil lubrication, the oil must be thin enough to dissipate heat and carry off contaminants from the bearing,
- if, in the case of temporarily higher temperaturs or very low circumferential speeds, the required operating viscosity cannot be obtained even with an oil of the highest possible viscosity.

In such cases, an oil with a lower viscosity than recommended for the application can be used. It must, however, contain effective EP additives, and its suitability must have been proved by tests on the FAG test rig FE8. Otherwise, depending on the degree of deviation from the specified value, a reduced fatigue life and wear on the functional surfaces have to be expected as is proved by "attainable life" calculation. If mineral oils with an especially large amount of additives are used, the compatibility with sealing and cage materials has to be checked.

3.2.2 Oil Selection According to Operating Conditions

- Normal operating conditions:
  Under normal operating conditions (atmospheric pressure, max. temperature 100°C for oil sump lubrication and 150°C for circulating oil lubrication, load ratio $P/C < 0.1$, speeds up to limiting speed), straight oils and preferably inhibited oils can be used (corrosion and deterioration inhibitors, letter L in DIN 51 502). If the recommended viscosity values are not maintained, oils with suitable EP additives and anti-wear additives should be selected.
- **High speed indices:**
  For high circumferential velocities ($k_a \cdot n \cdot d_m > 500\,000\ \text{min}^{-1} \cdot \text{mm}$), an oil should be used which is stable to oxidation, has good defoaming properties, and a positive viscosity-temperature behaviour whose viscosity decreases at a slower rate with rising temperature. Suitable synthetic oils with positive V-T behaviour are esters, polyalphaolefines and polyglycols. On starting, when the temperature is generally low, high churning friction and consequently high temperatures are avoided; the viscosity at steady-state temperature is sufficient to ensure adequate lubrication.
- **High loads:**
  If the bearings are heavily loaded ($P/C > 0.1$) or if the operating viscosity ν is smaller than the rated viscosity ν_1, oils with anti-wear additives should be used (EP oils, letter P in DIN 51 502). EP additives reduce the harmful effects of metal-to-metal contact which occurs in some places. The suitability of EP additives varies and usually depends largely on the temperature. Their effectiveness can only be evaluated by means of tests in rolling bearings (FAG test rig FE8).
- **High temperatures:**
  The selection of oils suitable for high operating temperatures mainly depends on the operating temperature limit and on the V-T behaviour of the oil. The oils have to be selected based on the oil properties, see section 3.2.3.

3.2.3 Oil Selection According to Oil Properties

Mineral oils are stable only up to temperatures of approx. 150°C. Depending on the temperature and the period of time spent in the hot area, deterioration products form which impair the lubricating efficiency of the oil and settle as solid residual matter (oil carbon) in or near the bearing. Mineral oils are suitable to a limited extent only, if contaminated with water, even if they contain detergents to improve their compatibility with water. Although corrosion damage is avoided, the water which is present in the form of a stable emulsion can reduce the service life of the oil and lead to increased formation of residues. The permissible amount of water can vary between a few per mil and several percent, depending on the oil composition and the additives.

Esters (diesters and sterically hindered esters) are thermally stable (–60 to +200 °C), have a positive V-T behaviour and low volatility and are, therefore, recommended for high speed indices and temperatures. In most cases, esters are miscible with mineral oils and can be treated with additives. The various ester types react differently with water. Some types saponify and split up into their various constituents, especially if they contain alkaline additives.

Polyalkylenglycols have a good V-T behaviour and a low setting point. They are, therefore, suitable for high and low temperatures (–50 to +200 °C). Due to their high oxidation stability oil exchange intervals in high-temperature operation can be twice to five times the usual interval for mineral oils. Most of the polyalkylenglycols used as lubricants are not water-soluble, and their ability to separate water is poor. Polyalkylenglycols are, as a rule, not miscible with mineral oils. Their pressure-viscosity coefficient is lower than that of other oils. Polyalkylenglycols may affect seals and lacquered surfaces in housings, and cages, for instance those made of aluminium.

Polyalphaolefins are synthetic hydrocarbons which can be used in a wide temperature range (–40 to +200°C). Due to their good oxidation stability, they attain a multiple of the life of mineral oils of similar viscosity under identical conditions. Polyalphaolefins have a positive viscosity-temperature behaviour.

Silicone oils (methyl phenyl siloxanes) can be used at extremely high and extremely low temperatures (–60 to +250 °C) because of their positive V-T behaviour; they have a low volatility and a high thermal stability. Their load carrying capacity, however, is low ($P/C \leqq 0.03$), and their anti-wear properties are poor.

Alkoxyfluorinated oils resist oxidation and water, but they are expensive. Their pressure-viscosity coefficient and density are higher than those of mineral oils of the same viscosity. They can be used at temperatures ranging from –30 to +240 °C.

Fire-resistant hydraulic fluids play a special role. For safety reasons, they have been used for many years in drift mining, on ships, in aeroplanes and fire-prone industrial plants. They are increasingly used for the following reasons:

– they are easier to dispose of than mineral oils
– price
– availability
– fire protection

Fire-resistant hydraulic fluids must meet various defined requirements concerning fire resistance, work hygiene and ecological safety. The different groups of fire-resistant hydraulic fluids are defined in the 7th Luxembourg Report, see table in fig. 31.
Typical applications:

The fluids of types HFA-E and HFA-S with up to 99 percent by volume of water are mainly used in chemical plants, hydraulic presses and in hydraulic long wall face working.

Fluids of type HFC with up to 45 percent by volume of water are mainly used in machines, e.g. in hydroloaders, drilling hammers and printing presses.

The synthetic HFD fluids are used in ropeway machines, shearer loaders, hydrostatic couplings, pumps and printing presses.

31: Classification of fire-resistant hydraulic fluids in accordance with the 7th Luxembourg Report and other characteristics

Fluid-group	Composition	ISO VG Class	Usual operating temperature range °C	Fire resistance	Density at 15 °C g/cm³	Standards and specifications	Attainable a_{23} factor
HFA-E	Oil-in-water emulsion, max. emulsifying oil content is 20 percent by volume, usual content 1 to 5 percent by volume	no specification	+5 ... +55	very good	ca. 1	DIN 24 320	< 0.05
HFA-S	Concentrated fluids dissolved in water, usual content ≤ 10 percent by volume						
HFB	Oil-in-water emulsion, water content approx. 40 percent by volume	32, 46, 68, 100	+5 ... +60	good	0,92 ... 1,05		-
HFB-LT*							
HFC	Aqueous polymer solution (polyglycols), water content at least 35 percent by volume	15, 22, 32, 46, 68, 100	-20 ... +60	very good	1,04 ... 1,09		< 0.2
HFD	Unhydrous fluids	15, 22, 32, 46, 68, 100	-20 ... +150	good	1,10 ... 1,45	VDMA 24317	
HFD-R	Phosphoric esters						< 0.8
HFD-S	Chlorinated hydrocarbons						< 0.5
HFD-T	Mixture of phosphoric esters and chlorinated hydrocarbons						< 1
HFD-U	other compounds						≤ 1 (z. B. synth. esters)

* LT indicates HFB fluids with a good emulsion persistence at low temperatures and which consequently are more suitable for longterm storage.

3.3 Selection of Dry Lubricants

Dry lubricants are of interest only in special cases, for instance where ceramic bearings are used or where oils and greases are unsuitable, e.g.:

– in vacuum where oil evaporates intensively

– under extremely high temperatures, e.g. kiln trucks used in the ceramic industry

– where oil or grease would be retained in the bearings only for a short period, e.g. blade bearings in controllable pitch blade fans which are exposed to centrifugal forces

– in nuclear and aerospace technology where the lubricant is exposed to intensive radiation

The most commonly used dry lubricants are graphite and molybdenum disulphide (MoS_2). They are applied as powders, bonded with oil as paste, or together with plastics material as sliding lacquer. Other solid lubricants are polytetrafluoroethylene (PTFE) and soft metal films (e.g. copper and gold) which are, however, used rarely.

The surfaces are usually bonderized to ensure better ad<hesion of the powder film. More stable films are obtained by applying sliding lacquer on bonderized surfaces. These sliding lacquer films can, however, be used only with small loads. Especially stable are metal films which are applied by electrolysis or by cathodic evaporation in an ultra high vacuum. It is advantageous to additionally treat the surface with molybdenum disulphide. The bearing clearance is reduced by four times the amount of the dry lubricant film thickness in the contact area. Therefore, bearings with larger-than-normal clearance should be used if dry lubrication is provided. The thermal and chemical stability of dry lubricants is limited.

Bearings operating at low velocities ($n \cdot d_m < 1\,500$ min^{-1} · mm) can be lubricated with molybdenum disulphide or graphite pastes. The oil contained in the paste evaporates at a temperature of about 200°C leaving only a minute amount of residue. Rolling bearings with a velocity higher than $n \cdot d_m = 1\,500$ min^{-1} · mm are in most cases lubricated with powder or sliding lacquer instead of pastes. A smooth powder film is formed by rubbing solid lubricant into the microscopically rough surface.

Graphite can be used for operating temperatures of up to 450°C as it is stable to oxidation over a wide temperature range. Graphite is not very resistant to radiation.

Molybdenum disulphide can be used up to 450°C. It keeps its good sliding properties even at low temperatures. In the presence of water, it can cause electrolytic corrosion. It is only little resistant to acids and bases.

The compatibility of **sliding lacquers** with the environmental agents has to be checked. Organic binders of sliding lacquers soften at high temperatures affecting the adhesive properties of the sliding lacquer. Inorganic lacquers contain inorganic salts as binder. These lacquers have a high thermal stability and do not evaporate in a high vacuum. The protection against corrosion, which is only moderate with all lacquers, is less with inorganic lacquers than with organic lacquers.

Pastes become doughy and solidify if dust penetrates into the bearings. In a dusty environment, sliding lacquers are better.

In special cases, rolling bearings can also be fitted with "self-lubricating" cages, i.e. cages with embedded dry lubricants or with a filling consisting of a mixture of dry lubricant and binder. The lubricant is transferred to the raceways by the rolling elements.

3.4 Quickly Biodegradable Lubricants

For some years now, lubricant manufacturers have offered a number of greases and oils for the lubrication of rolling bearings some of which have a vegetable base oil (usually rapeseed oil); the majority, however, have a synthetic base oil (ester oils). Their biodegradability is tested in accordance with CED-L33-A93 and on the basis of DIN 51828. Usually, demands on them include a low water pollution class and often they must be nondeleterious to health as well. This often prevents effective doping.

Biodegradable lubricants on a vegetable oil base are suitable only for a limited range of temperatures.

Synthetic lubricants on an ester base, in contrast, offer a greater capacity and are approximately equal to lubricants with traditional base oils. Due to their biodegradability they are preferably used for throwaway lubrication, i.e. where spent lubricant can be discharged directly into the environment. Generally, a quality scatter similar to that of traditional lubricants can be assumed.

4 Lubricant Supply

Rolling bearings need extremely little lubricant. In practical application, however, the bearings are supplied with a more ample amount of lubricant for the sake of operational reliability. However, too much lubricant in the bearing can have harmful effects. If excessive lubricant cannot escape from the bearing, churning or working cause the temperature to increase to such an extent that the lubricant can be impaired or even destroyed.

Generally, adequate lubricant supply is ensured by
- selecting the appropriate amount and distribution of lubricant within the bearing
- taking into account the lubricant service life, lubricant replenishment or exchange intervals
- the design of the bearing location
- the lubricating system and the related equipment (see table 20, page 20)

4.1 Grease Supply

4.1.1 Equipment

Only few lubricating tools, if any, are required for adequate bearing lubrication with grease. Unless greased by the manufacturer, the bearings are greased on mounting, generally by hand. In some cases, grease syringes or guns are used.

Equipment for relubrication is described in section 4.1.5.

4.1.2 Initial Grease Charge and Grease Renewal

For the greasing of bearings, the following instructions should be observed:

- Pack bearings to capacity with grease to ensure that all functional surfaces are supplied with grease.
- Fill the housing space on both sides of the bearing with grease to such an extent that it can still accommodate the grease expelled from the bearing. In this way no excessive amount of grease will circulate through the bearing. If there is a major, empty housing space beside the bearing, the grease escaping from the bearing leaves the immediate bearing vicinity, and can no longer enhance the lubricating effect. In such a case, bearings with shields or seals should be used, or baffle plates should be provided to ensure that a sufficient amount of grease stays within the bearing. It is recommended to fill approx. 30% of the free bearing space with grease.
- Fill high-speed bearings, e.g. spindle bearings, only partially with grease (20 to 30% of the free space) to facilitate and accelerate the grease distribution during bearing start-up.
- Pack low-velocity bearings ($n \cdot d_m < 50{,}000$ $min^{-1} \cdot mm$) and the housing cavities to capacity with grease. The lubricant friction due to working is negligible.

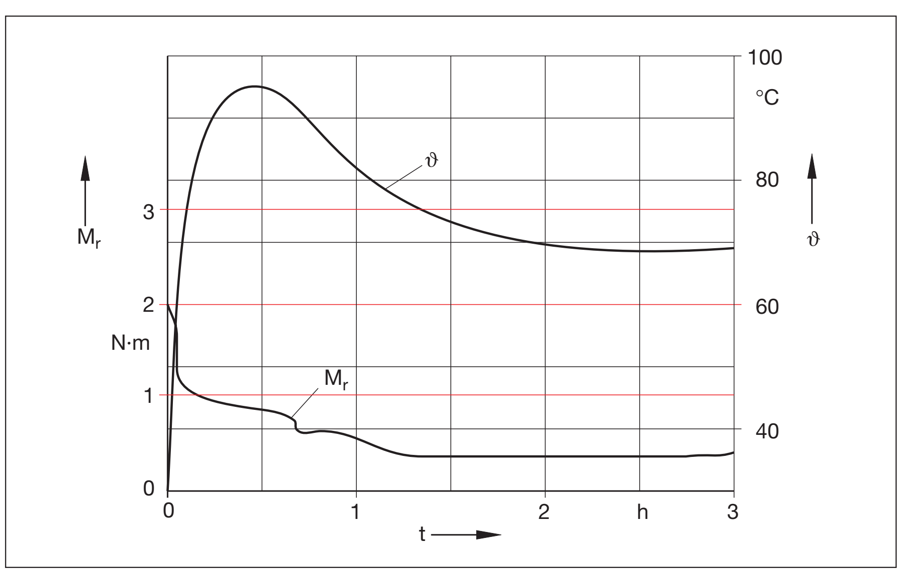
Deep groove ball bearings sealed on either side with seals (2RSR or 2RS) or shields (2ZR or 2Z) are supplied pre-greased (see explanations on fig. 39, page 40). About 30% of the free bearing space is filled with grease. This amount is retained well inside the bearing even at high speed indices ($n \cdot d_m > 400{,}000$ $min^{-1} \cdot mm$). For bearings running at even higher velocities, about 20% of the free bearing space is filled with grease. If sealed bearings are filled with more grease than specified above, the excess grease will escape more or less continuously until the normal grease fill is achieved.

Bearings with a rotating outer ring can retain, at high circumferential velocities, only an amount of grease which fills approx. 15% of the free bearing space.

Bearings filled with a suitable amount of grease will display a favourable frictional behaviour and lose only little grease.

With higher speed indices, bearing temperatures usually increase during the run-in period, occasionally even over several hours, fig. 32.

32: Frictional moment M_r and temperature ϑ of a freshly greased deep groove ball bearing



These effects are even more intensive, the larger the grease quantity in and beside the bearing and the more the movement of the grease out of the bearing is obstructed. They can be counteracted by an interval lubricant supply system with accordingly specified downtimes for cooling such as is used for spindle bearings in machine tools.

If for-life lubrication is required, the grease must be retained in or near the bearing by means of seals or baffle plates. Grease deposited in the bearing vicinity can result in longer lubrication intervals because, at increased temperatures, the external grease separates oil which contributes, at least in part, to bearing lubrication, and, due to vibrations, fresh grease from the housing is occasionally fed into the bearing (relubrication).

If high temperatures are to be expected near a bearing it is recommendable to provide some extra grease beside the bearing with as large an oil-separating area towards the bearing as possible. This can be achieved, for instance, by means of an angular baffle plate, fig. 40 (page 40). The amount of extra grease should ideally be 3 to 5 times that of the normal grease fill quantity and should be located either on one side of the bearing or, better, equally divided to the right and to the left of the bearing.

If the pressure on one side of the bearing differs from that on the other side, the grease, and the separated base oil, are likely to be expelled from the bearing. Also, dirt can penetrate into the bearing. In such cases openings and holes must be machined into the surrounding structure for pressure compensation.

4.1.3 Grease Service Life

The grease service life is the period from start-up until the failure of a bearing as a result of lubrication breakdown. It is determined by the

- amount of grease
- type of grease (thickener, base oil, additives)
- bearing type and size
- amount and type of loading
- speed index
- bearing temperature
- mounting conditions

The service life of greases is determined by laboratory tests, e.g. with the FAG rolling bearing grease test rig FE9. Such tests must be carried out on a statistical basis since, even under comparable test conditions (identical operating parameters, bearings of the same quality, identical grease quantity), depending on the type of grease used, a scatter of the grease life values of up to 1:10 must be taken into account. Therefore, the calculation of the grease service life values is based on a certain failure probability, similar to the calculation of the bearing fatigue life. The grease service life F_{10} of a certain grease applies to a failure probability of 10%.

4.1.4 Lubrication Intervals

Lubrication intervals are defined as the minimum grease service life F_{10} of standard greases which meet the minimum requirements of DIN 51 825. Upon expiry of the lubricating interval at the latest, the bearing has to be regreased or lubricated, see section 4.1.5.

Diagram 33 shows the lubrication interval tf for standard lithium soap base greases for the usual field applications under favourable environmental conditions. It applies to lithium soap base greases of penetration classes 2–3 and operating temperatures of up to 70 °C (measured at the outer ring), which are lower than the limiting temperature of the grease, and a mean bearing load corresponding to P/C < 0.1.

In the case of higher bearing loads or temperatures, the lubrication intervals are shorter.

At temperatures of 70°C and up (limiting temperature), the lubrication intervals for lithium soap base greases with a mineral base oil is reduced to $f_3 \cdot t_f$. The limiting temperatures for sodium and calcium soap base greases are 40 to 60 °C, those of high-temperature greases are 80 to 100 °C or higher.

Diagram 33 shows the lubrication intervals as a function of $k_f \cdot n \cdot d_m$. Different k_f values apply to the individual bearing types. Where ranges of k_f values are indicated, the higher values apply to the heavier series, and the lower values to the lighter series of a bearing type.

Compared to the grease service life achieved under ideal conditions, fig. 33 takes into account certain safety margins for the lubrication interval under favourable operating conditions. Rolling bearing users assume the lubrication interval if the grease service life F_{10} of the grease used is not known. If the capacity of a grease is to be utilized fully, one can assume, for ideal operating conditions, the grease service life F_{10}, which was determined in tests, or one orients oneself by experimental values.

Poor operating and environmental conditions reduce the lubrication interval. The reduced lubrication interval t_{fq} is obtained from the equation

$$t_{fq} = t_f \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_4 \cdot f_5 \cdot f_6$$

The reduction factors f_1 to f_6 are explained in table 34 (page 37).

With gap-type seals, an air current passing through the bearing considerably reduces the lubrication interval. The air current deteriorates the lubricant, carries oil or grease from the bearing and conveys contaminants inside the bearing.

A grease of a high base oil viscosity ($\nu_{40} \geq 400$ mm²/s) separates only little oil, especially at low temperatures. Therefore, its use requires short lubrication intervals. Contaminants (including water) penetrating through the seals also affect the grease service life.

An overall reduction factor q which takes into account all poor operating and environmental conditions (table 35 on page 37) can be applied to certain bearing applications. The reduced lubrication interval t_{fq} is obtained from

$$t_{fq} = q \cdot t_f$$

In the case of unusual operating and environmental conditions (high or low temperatures, high loads, high circumferential velocities) the use of special greases appropriate for these operating conditions usually result in the lubrication intervals shown in diagram 33.

The lubrication interval reduction factors f_1, f_2, f_5 and f_6 generally apply to special greases as well. The reduction factors taking into account load and temperature, f_3 and f_4, as well as the relevant limiting temperatures will be indicated by the lubricant manufacturers – for Arcanol greases by FAG upon inquiry.

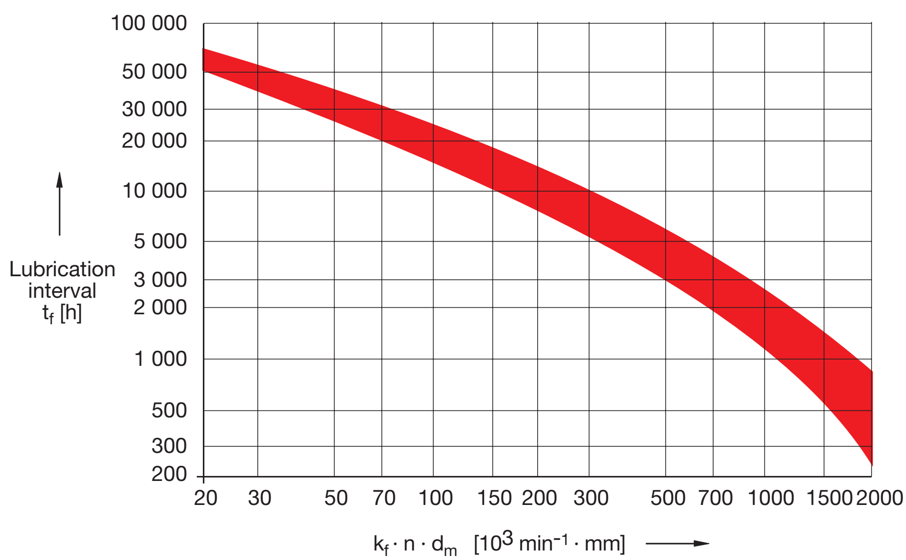
4.1.5 Relubrication, Relubrication Intervals

Grease replenishment or exchange is required if the grease service life is shorter than the anticipated bearing life.

The bearings are relubricated by means of grease guns through lubricating nipples. If frequent relubrication is required, grease pumps and volumetric metering units must be used (central lubrication system, grease spray lubrication, see pages 21 and 24). It is essential that the fresh grease displaces the spent grease so that the grease is exchanged, but overgreasing is prevented.

If the lubrication intervals determined in accordance with figs. 33 to 35 are noticeably exceeded, a higher rate of bearing failures due to starved lubrication must be taken into account, depending on the grease quality. Therefore, grease renewal or replenishment must be scheduled in time. Grease renenwal intervals should be shorter than the reduced lubrication intervals t_{fq}.

33: Lubrication intervals under favourable environmental conditions. Grease service life F_{10} for standard lithium soap base grease according to DIN 51825, at 70 °C, failure probatility 10 %.



Bearing type		k_f	Bearing type		k_f
Deep groove ball bearing	single row	0.9...1.1	Cylindrical roller bearing	einreihig	3...3.5*)
	double row	1.5		zweireihig	3.5
Angular contact ball bearing	single row	1.6		vollrollig	25
	double row	2	Cylindrical roller thrust bearing	90	
Spindle bearing	α = 15°	0.75	Needle roller bearing		3.5
	α = 25°	0.9	Tapered roller bearing		4
Four-point bearing		1.6	Barrel roller bearing		10
Self-aligning ball bearing		1.3...1.6	Spherical roller bearing without lip (E design)		7...9
Thrust ball bearing		5...6	Spherical roller bearing with centre lip		9...12
Angular contact thrust ball bearing	double row	1.4			

*) for bearings which are loaded radially and constantly axially; for varying axial loads k_f = 2

34: Reduction factors f_1 to f_6 for poor operating and environmental conditions

Effect of dust and moisture on the bearing contact surfaces

moderate	f_1 = 0.9...0.7
stron	f_1 = 0.7...0.4
very strong	f_1 = 0.4...0.1

Effect of shock loads and vibrations

moderate	f_2 = 0.9...0.7
strong	f_2 = 0.7...0.4
very strong	f_2 = 0.4...0.1

Effect of high bearing temperature

moderate (up to 75 °C)	f_3 = 0.9...0.6
strong (75 to 85 °C)	f_3 = 0.6...0.3
very strong (85 to 120 °C)	f_3 = 0.3...0.1

Effect of high loads

P/C = 0.1...0.15	f_4 = 1.0...0.7
P/C = 0.15...0.25	f_4 = 0.7...0.4
P/C = 0.25...0.35	f_4 = 0.4...0.1

Effect of air current passing through the bearing

slight current	f_5 = 0.7...0.5
strong current	f_5 = 0.5...0.1

Centrifugal effect or vertical shaft depending on the sealing f_6 = 0.7...0.5

35: Overall reduction factors q for certain applications

	Dust moisture	Shocks vibrations	High running temperature	Heavy loads	Air current	Factor q
Stationary electric motor	-	-	-	-	-	1
Tailstock spindle	-	-	-	-	-	1
Grinding spindle	-	-	-	-	-	1
Surface grinder	-	-	-	-	-	1
Circular saw shaft	•	-	-	-	-	0.8
Flywheel of a car body press	•	-	-	-	-	0.8
Hammer mill	•	-	-	-	-	0.8
Dynamometer	-	-	•	-	-	0.7
Axle box roller bearings for locomotives	•	•	-	-	-	0.7
Electric motor, ventilated	-	-	-	-	•	0.6
Rope return sheaves of aerial ropeway	• •	-	-	-	-	0.6
Car front wheel	•	•	-	-	-	0.6
Textile spindle	-	• • •	-	-	-	0.3
Jaw crusher	• •	• •	-	•	-	0.2
Vibratory motor	•	• • •	•	-	-	0.2
Suction roll (paper making machine)	• • •	-	-	-	-	0.2
Press roll in the wet section (paper making machine)	• • •	-	-	-	-	0.2
Work roll (rolling mill)	• • •	-	•	-	-	0.2
Centrifuge	•	-	-	• •	-	0.2
Bucket wheel reclaimer	• • •	-	-	•	-	0.1
Saw frame	•	• • •	-	-	-	<0.1
Vibrator roll	•	• • •	• • •	-	-	<0.1
Vibrating screen	•	• • •	-	-	-	<0.1
Slewing gear of an excavator	• •	-	-	• • •	-	<0.1
Pelleting machine	•	-	•	• • •	-	<0.1
Belt conveyor pulley	• • •	-	-	•	-	<0.1

• = moderate effect   • • = strong effect   • • • = very strong effect

In most cases, it is difficult to remove the spent grease entirely from the bearing when **relubricating** it. Consequently, the relubrication intervals must be shorter (usual relubrication intervals 0.5 to 0.7 t_{fq}). The appropriate amounts of grease for replenishment are shown in fig. 36.

36: Grease relubrication quantities

Relubrication quantitiy m_1 for weekly to yearly relubrication

$m_1 = D \cdot B \cdot x$ [g]

Relubrication	x
weekly	0.002
monthly	0.003
yearly	0.004

Quantity m_2 for extremely short relubrication intervals

$m_2 = (0,5...20) \cdot V$ [kg/h]

Relubrication quantitiy m_3 prior to restarting after several years of standstill

$m_3 = D \cdot B \cdot 0,01$ [g]

V = free space in the bearings
$\approx \pi/4 \cdot B \cdot (D^2 - d^2) \cdot 10^{-9} - G/7800$ [m^3]
$\approx \pi/4 \cdot B \cdot (D^2 - d^2) \cdot 10^{-9} - G' \cdot 0.4536/7800$ [m^3]

d = bearing bore diameter [mm]
D = bearing outside diameter [mm]
B = bearing width [mm]
G = bearing weight [kg]
G' = bearing weight [lb]

Replenishment is required where the used grease cannot be removed during relubrication (no empty housing spaces, no grease escape bores, no grease valve). The amount of grease supplied should be limited to prevent overgreasing.

Large relubrication amounts are recommended with large free housing spaces, grease valves, grease escape bores, or with low speeds corresponding to $n \cdot d_m \leq 100\,000$ min^{-1} · mm. In such cases, the risk of temperature increases due to working of the grease is reduced. Ample grease amounts improve the exchange of used grease for fresh grease and contribute to the sealing against the ingress of dust and moisture. Relubrication with the bearing rotating at operating temperature is favourable.

Grease renewal is recommended for long lubrication intervals. This is largely achieved by pressing in a greater amount of grease than that which is in the bearing, thereby expelling the spent grease. A particularly large amount of grease is required if, due to high temperatures, the old grease has been damaged to some degree. In order to drain as much of the used grease as possible by flushing, an amount of up to three times the grease quantity indicated in fig. 36 is used for relubrication. Not all greases are suitable for this flushing. Suitable greases are recommended by the lubricant manufacturers. The grease exchange is facilitated by a grease feed and flow which ensures uniform grease exchange over the bearing circumference. Design examples are shown in figs. 42 to 46. During grease exchange, the grease must be able to escape easily to the outside or into a space of sufficient size for the accommodation of the spent grease.

Very short relubrication intervals are required if stressing is very high ($n \cdot d_m > 500\,000$ min^{-1} · mm; $P/C > 0,3$; $t > 140$ °C; or combinations of lower values). Under such conditions, the use of a grease pump is justified. Care must be taken that the grease in the bearing, housing and feed pipe maintains a pumpable consistency. At extremely high temperatures, the grease may solidify, obstructing the passage of fresh grease and resulting in blocking of the metering valves.

The **escaping grease can act as a sealing agent** if small quantities are continuously supplied at short intervals. The relubrication quantities supplied per hour can be half the amount to several times the amount of grease which the cavities of the bearing can hold. By applying the quantities m_2 recommended in fig. 36 for extremely short relubrication intervals, the grease escapes at a rate of 2 cm per day or more depending on the sealing gap width.

If **temperatures** are **high,** either a cheap grease which is stable only for a short period, or en expensive, thermally stable grease can be used. When using the former greases, relubrication quantities of 1 to 2% of the free bearing space per hour have proved appropriate. With thermally stable and very expensive special greases, significantly smaller amounts will do. With such small quantities, however, direct grease supply into the bearing is absolutely essential. Small relubrication quantities are also possible with high circumferential velocities. They increase the frictional moment and the temperature only slightly. Also, they are less harmful to the environment. They do, however, require more maintenance and complicated lubricating equipment. Very small grease quantities can be supplied to specific locations by means of grease spray lubrication (fig. 25, page 24).

A **mixture of different grease types** often cannot be avoided. Mixtures which have proved to be relatively safe are those of greases with identical soap bases. The basic miscibility of oils and greases is indicated in the tables in figs. 37 and 38.

If incompatible greases are mixed, their structure can change drastically, and the greases may even soften considerably. If a different grease type is selected deliberately, the old grease should be flushed out with a large amount of the new grease, provided this can be done with the existing design of the bearing location. Another supply of the new grease should be pressed in after a relatively short period of time.

37: Miscibility of oils

Base oils	Mineral oil	Polyalpha-olefin	Ester oil	Polyglycol oil	Silicone oil (methyl)	Silicone oil (phenyl)	Polyphenyl-ether oil	Alkoxy-flourinated oil
Mineral oil	+	+	+	2)	-	o	o	-
Polyalphaolefin	1)	+	+	2)	-	o	o	-
Ester oil	1)	+	+	o	-	o	+	-
Polyglycol oil	2)	2)	o	+	-	-	-	-
Silicone oil (methyl)	-	-	-	-	+	+	-	-
Silicone oil (phenyl)	o	o	o	2)	+	+	+	-
Polyphenyl-ether oil	1)	1)	1)	2)	-	1)	+	-
Alkoxyfluorinated oil	-	-	-	-	-	-	-	+

+ may be mixed
o usually compatible, must be checked for specific application
- must not be mixed
1) miscible; however, bearings shall not be relubricated with a lubricant of an inferior capacity than the original lubricant
2) generally not compatible, must be checked for specific application

38: Miscibility of lubricating greases

Thickener Original grease	**Thickener relubrication grease** (Li)thium-soap	(Li)thium-complex soap	(So)dium soap	(So)dium-complex soap	(Ca)lcium complex soap	(Ba)rium complex soap	(Al)umin-ium com-plex soap	Bentonite/ Hectorite	Polyurea	PTFE
(Li)thium soap	+	+	-	o	o	o	-	-	o	-
(Li)thium complex soap	1)	+	-	o	o	o	o	-	o	-
(So)dium soap	-	-	+	+	o	o	-	-	+	-
(So)dium complex soap	-	o	1)	+	o	o	o	-	o	-
(Ca)lcium complex soap	1)	o	-	o	+	+	o	-	o	-
(Ba)rium complex soap	1)	o	-	o	+	+	o	-	o	-
(Al)uminium complex soap	1)	o	-	o	o	o	+	-	o	-
Bentonite/ Hectorite	-	o	-	o	o	o	-	+	o	-
Polyurea	1)	o	-	o	o	o	-	-	+	-
PTFE	-	-	-	-	-	-	-	-	-	+

+ generally well compatible
o usually compatible, must be checked for specific application
- generally not compatible
1) miscible; however, bearings shall not be relubricated with a lubricant of an inferior capacity than the original lubricant

4.1.6 Examples of Grease Lubrication

Fig. 39: Structures can be uncomplicated if sealed and pre-greased rolling bearings are used. Depending on the application, shields or seals can be used singly or in combination with a preseal. Rubbing seals (designs RSR or RS) increase the bearing temperature due to the seal friction. Shields (ZR or Z) and non-rubbing seals (RSD) form a gap with the inner ring and do not add to the friction. The standard grease for deep groove ball bearings sealed on either side is a lithium soap base grease of consistency class 2 or 3, the softer grease being used for small bearings. Approx. 30% of the free bearing space is filled with grease. Under normal operating and environmental conditions, this amount of grease is sufficient for a long service life. The grease is distributed during a short run-in period and settles mainly on the inner surfaces of the shields or seals, which form an undisturbed area. After the grease has settled, circulation is negligible, and the bearing runs at low friction. Upon completion of the run-in period, friction is only 30 to 50 % of the starting friction.

Fig. 40: The deep groove ball bearing is sealed on one side. On the other side, a grease deposit is formed by means of a baffle plate. Thus a major amount of grease is near the bearing but not inside it. At high temperatures, the grease deposited separates oil which lubricates the deep groove ball bearing adequately and over a long period. In this way a longer life is reached during which additional lubricant friction need not be taken into account. FAG will indicate suitable greases on inquiry.

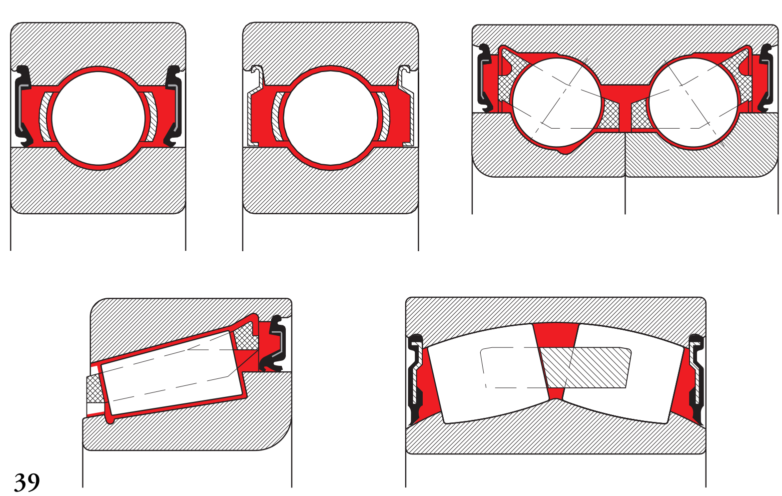
Fig. 41: A baffle plate prevents the grease from escaping from bearings with grease pumping or conveying effect or with a vertical axis. Especially for bearing types which have a high rate of sliding friction and an intensive grease pumping or conveying effect (e.g. tapered roller bearings), a baffle plate is advantageous at higher speeds, though not always sufficient. Grease supply can be further improved by short lubrication intervals.

Fig. 42: The grease is fed into the bearing through a lubricating groove and several lubricating holes in the bearing outer ring. The direct and symmetrical grease feeding ensures a uniform supply to the two rows of rollers. Spaces or grease discharge holes of sufficient size must be provided to allow the spent grease to be expelled on either side.

Fig. 43: The spherical roller bearing is relubricated from one side. During relubrication, grease escapes from the opposite side. Grease escape bores or grease valves prevent the retention of grease when replenishment of large quantities is required. During the run-in period, the temperature rises for one or several hours (about 20 to 30 K above the operating temperature). Grease type and consistency play a large part in determining the pattern of the temperature curve.

Fig. 44: If a grease valve is provided, there is a risk – with rather long relubrication intervals, high circumferential velocities and a pumpable grease – that only

39: Sealed bearings greased by the rolling bearing manufacturer
40: A grease deposit can form between tdhe baffle plate and the bearing



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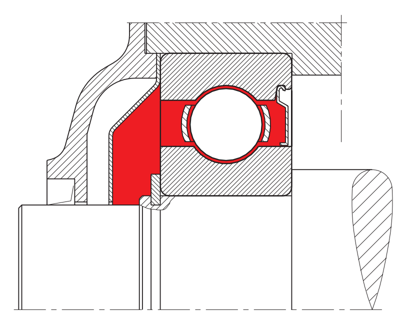

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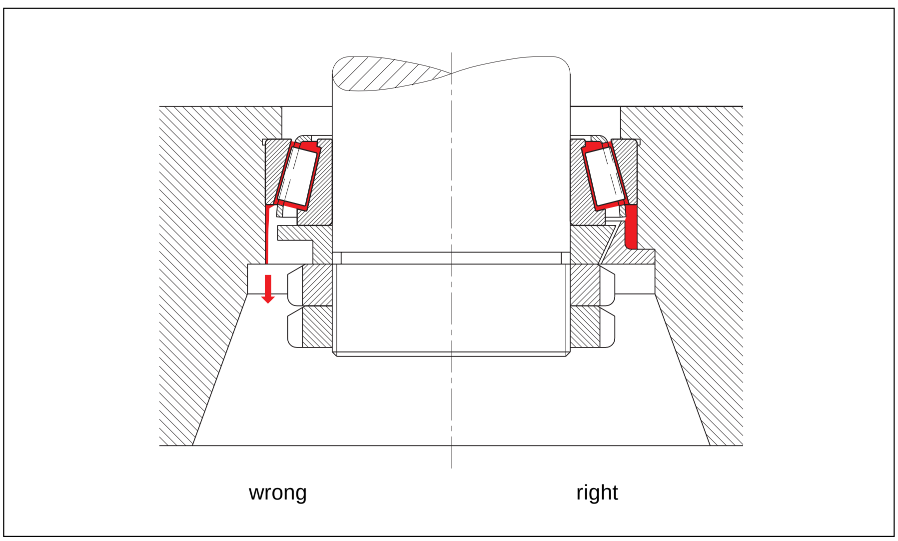
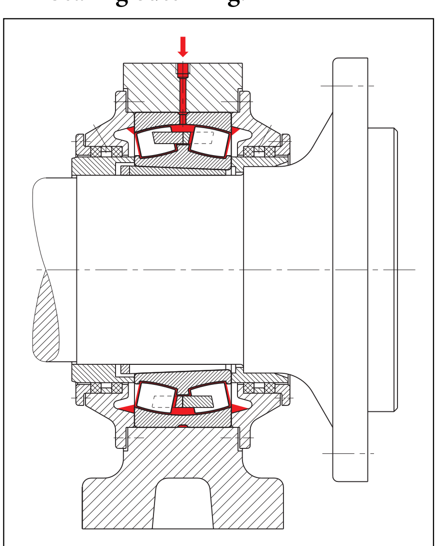
little grease remains in the bearing at the side facing the grease valve. This can be avoided by displacing the gap between the rotating grease valve and its stationary counter part nearer to the shaft. A normal grease valve where the gap is at bearing outer ring level (fig. 44a) has a strong pumping effect. The pumping effect is moderate if the gap is positioned at bearing pitch circle level (fig. 44b), and the pumping effect is practically zero if the gap is at inner ring level (fig. 44c). The grease valve then acts as a baffle plate and retains the grease in the bearing.

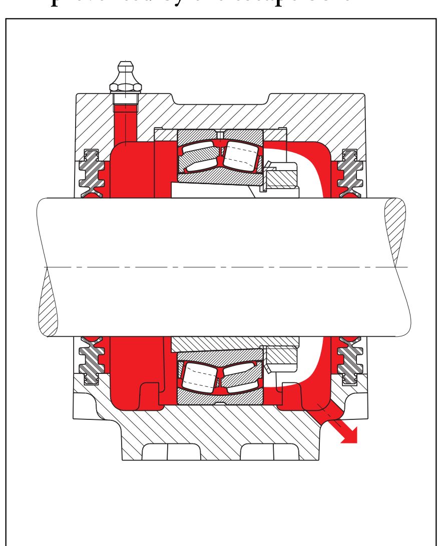
41: A baffle plate retains the grease inside and near the bearing.



42: The grease is fed through the bearing outer ring.



43: Relubrication. Overlubrication is prevented by the escape bore



44: The pumping effect of the grease valve depends on the washer diameter.

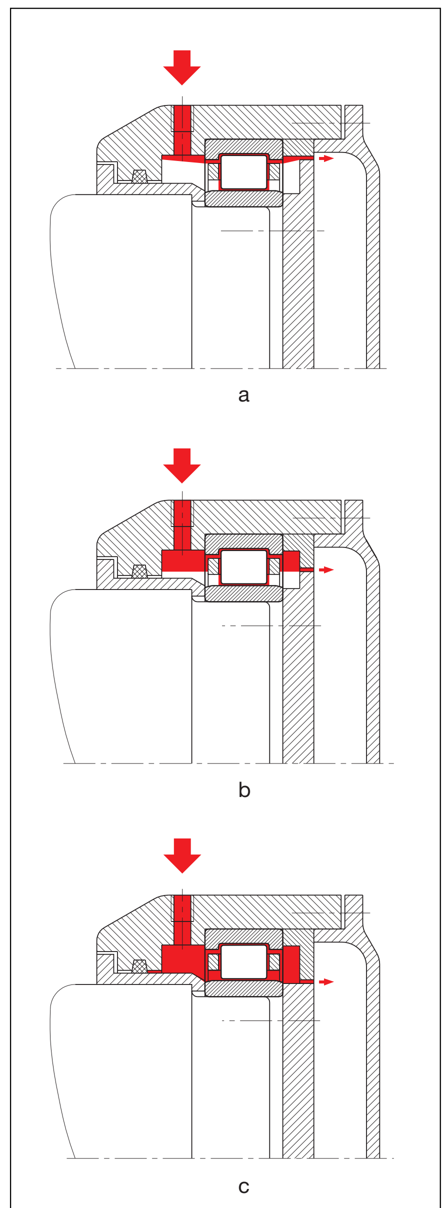
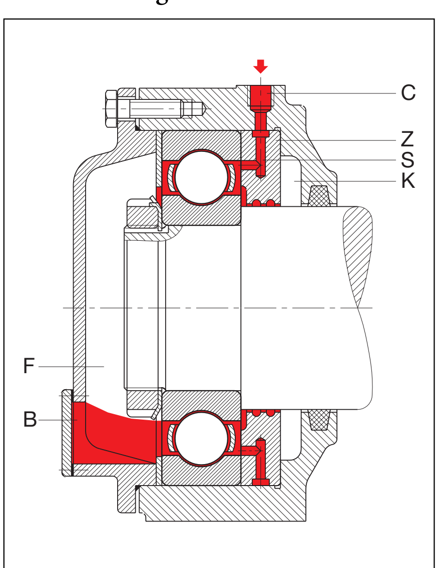


Fig. 45: The relubricating grease is pressed through hole S in disk Z directly between the cage and outer ring. The spent grease is pushed by the fresh grease into space F between bearing and cover; it must be regularly emptied through opening B. On mounting, chamber K on the right bearing side is packed with grease in order to improve sealing. The bearing is best relubricated while stationary. Holes S should be distributed on disk Z in such a way that the grease is uniformly supplied to the bearing thereby effectively displacing the spent grease. Holes S in disk Z which are located close to filling hole C must therefore be spaced at a greater distance than the diametrically opposed holes for a uniform distribution of the grease on the bearing circumference. This ensures uniform flow resistance; the new grease expels the used grease evenly from the bearing. Large quantities of fresh grease help displace the old grease.

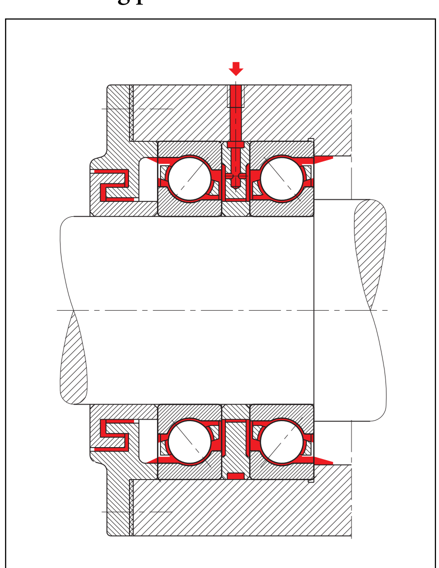
Fig. 46: A pair of angular contact ball bearings is supplied with fresh grease through lubricating holes in the spacer between the bearings. Trapping of grease is avoided by introducing the grease at the small inner ring diameter from where centrifugal forces convey it via the large diameter to the outside. Only bearings with an asymmetrical cross section, i.e. angular contact ball bearings and tapered roller bearings, produce this conveying effect. If a bearing pair with a symmetrical cross section is relubricated between the two bearings, grease valves or escape holes should be provided on both sides of the pair. It is important that the resistance the escaping grease meets with is roughly the same everywhere. Otherwise, grease will escape mainly on the side where it meets with less resistance, and starved lubrication threatens on the other side.

These examples show that a functional grease guidance usually involves some expense. Therefore, such grease guidance is provided preferably where expensive machines or difficult operating conditions such as high speeds, loads, or temperatures are involved. In these cases, replacement of the spent grease must be ensured, and overgreasing must be ruled out. For normal applications, no such expense is required; this is proved by dependable bearing arrangements flanked by batches of grease on both sides of the bearings. They gradually separate oil for lubricating the contact areas and provide extra protection against contaminants which might otherwise penetrate into the bearings. However, when the bearings are relubricated one cannot be certain that the fresh grease reaches all contact areas. Since contaminants may penetrate into the bearings on these occasions, it is better in such cases to provide for-life lubrication instead. On the occasion of machine overhauling, the bearings can be dismounted, washed, and filled with fresh grease.

45: Direct supply of grease from the side through holes in a feed disk



46: The grease is supplied between a bearing pair.



4.2 Oil Supply

4.2.1 Lubricating Equipment

Unless oil sump lubrication is provided, the oil must be fed to the bearing locations by means of lubricating devices depending on the lubrication system selected. Large and smaller oil volumes are fed to the bearings by means of pumps, small and very small oil volumes are supplied by oil-mist, oil-air, and central lubrication plants. The oil volume can be measured by means of metering elements, flow restrictors and nozzles. Detailed information on the most commonly used lubrication systems is provided in chapter 2 "Lubrication System".

4.2.2 Oil Sump Lubrication

In an oil sump or, as it is also called, an oil bath, the bearing is partly immersed in oil. When the shaft is in the horizontal position, the bottom rolling element should be half or completely covered when the bearing is stationary, fig. 47.

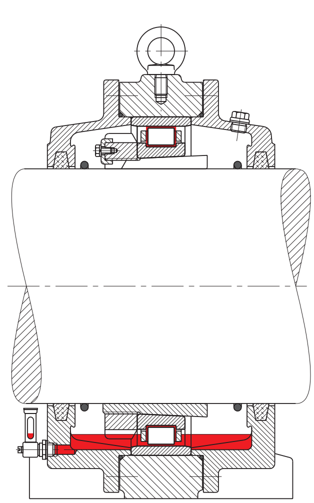
When the bearing rotates, oil is conveyed by the rolling elements and the cage and distributed over the circumference. For bearings with an asymmetrical cross section which, due to their geometry, have a pumping effect, oil return holes or ducts should be provided to ensure circulation of the oil. If the oil level rises above the bottom roller and, especially, if circumferential velocities are high, the friction due to churning raises the bearing temperature and can cause foaming. At speed indices of $n \cdot d_m < 150\,000\ \text{min}^{-1} \cdot \text{mm}$, the oil level may be higher. If complete immersion of a bearing in the oil sump cannot be avoided, as is the case with the shaft in the vertical position, the friction moment doubles or triples depending on the oil viscosity. As a rule, oil sump lubrication can be used up to a speed index of $n \cdot d_m = 300\,000\ \text{min}^{-1} \cdot \text{mm}$; if the oil is renewed frequently, a speed index of up to $500\,000\ \text{min}^{-1} \cdot \text{mm}$ is possible. At a speed index of $n \cdot d_m = 300\,000\ \text{min}^{-1} \cdot \text{mm}$ and above, the bearing temperatures often exceed 70 °C. The oil sump level should be checked regularly.

The **oil renewal schedule** depends on contamination and ageing of the oil. Ageing is accelerated by the presence of oxygen, rubbed-off metal particles (catalyst) and high oil temperatures. The alteration of the neutralization number NZ and the saponification number VZ indicate to oil manufacturers and engineers to what degree the oil has deteriorated.

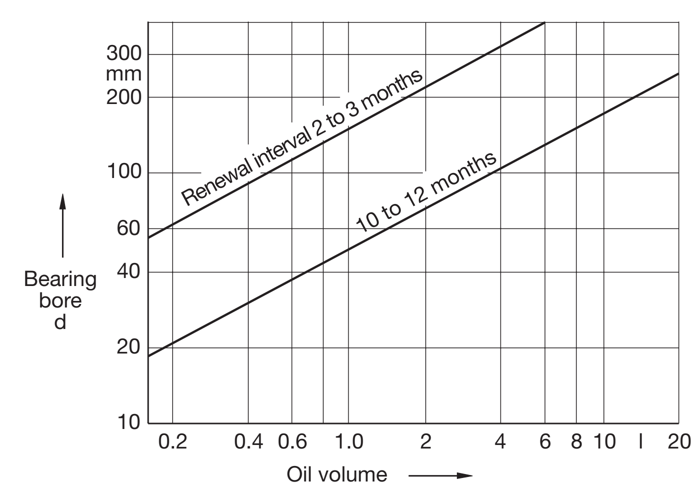
Under normal conditions, the oil renewal intervals indicated in fig. 48 should be observed. It is important that the bearing temperature does not exceed 80°C and that contamination due to foreign particles and water is low. As the diagram shows, frequent oil changes are necessary if the oil volume is small. During the run-in period, an early oil change may be required due to the higher temperature and heavy contamination by wear particles. This applies particularly to rolling bearings lubricated together with gears. Increasing content of solid and liquid foreign particles often require premature oil renewal. The permissible amount of solid foreign particles depends on the size and hardness of the particles, see also section 5.1.1 "Solid Foreign Particles", page 54).

The permissible amount of water in the oil depends on the oil type, and will

47: Oil level in an oil sump



48: Oil volume and renewal interval vs. bearing bore



be indicated by the oil manufacturers upon inquiry. Water in the oil leads to corrosion, accelerates oil deterioration by hydrolysis, forms aggressive substances together with the EP additives, and affects the formation of a load carrying lubricating film. Water which has entered the bearing through the seals or condensate having formed in the bearing must be rapidly separated from the oil; an oil with positive water separation ability is advantageous. Water is separated by treating the oil in a separator or by evaporation in a vacuum. The separation of water and oil is, however, difficult with polyglycol oils, because their density is approximately 1. Therefore, the water does not settle in the oil reservoir; at oil temperatures above 90 °C the water evaporates.

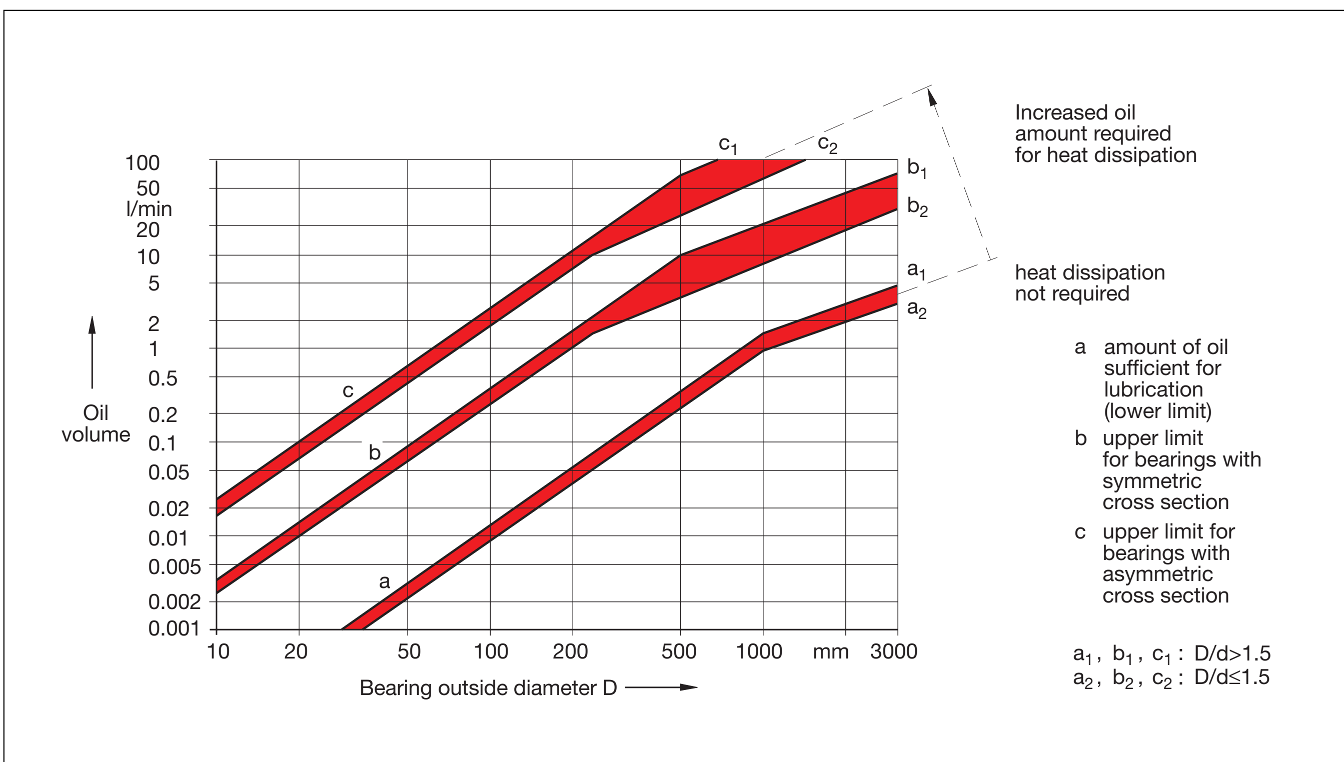
For extreme applications it is advisable to determine the oil change intervals individually based on repeated oil analyses. It is good practice to analyse the oil after one to two months and, depending on the results of the first analysis, to determine, after a certain period, the neutralization number NZ, the saponification number VZ, the content of solid foreign particles and water, and the viscosity of the oil. The service life of a bearing can be drastically reduced by the constant presence of even little water in the oil. The degree of deterioration and contamination can be roughly estimated by comparing a drop each of fresh and used oil on a sheet of blotting paper. Major differences in colour are indicative of oil deterioration or contamination.

4.2.3 Circulating Lubrication with Average and Above Average Oil Volumes

Having passed through the bearings, the oil is collected in an oil reservoir and recirculated to the bearings. If oil circulation lubrication is provided, a filter is imperative to screen out wear particles and contaminants, see also section 5.1.3. The negative effect of contaminants on the attainable life is described in more detail in section 1.1.3.

The **oil volume** required depends on the operating conditions. Diagram 49 shows the quantities which, at viscosity ratios of $\varkappa = \nu/\nu_1$ of 1 to 2.5, generate a moderate flow resistance in the bearing. Only a small amount of oil is required for lubricating the bearings. In comparison, the quantities indicated in diagram 49 as being sufficient for lubrication (line a) are large. These oil volumes are recommended to ensure appropriate lubrication of all contact areas even if the oil supply to the bearings is inadequate, i.e. oil is not fed directly into the bearings. The minimum volumes indicated are used for lubrication if low friction is required. The result-

49: Oil volumes for circulating lubrication



ing temperatures are the same as with oil sump lubrication.

If heat dissipation is required, larger oil volumes are provided. Since every bearing offers a certain resistance to the passage of oil, there are upper limits for the oil volume. For bearings with an asymmetrical cross section (angular contact ball bearings, tapered roller bearings, spherical roller thrust bearings) larger flow rates are permissible than for bearings with a symmetrical cross section, because their flow resistance is lower due to their pumping action. For the oil volumes indicated in diagram 49, oil supply and retention at the feed side is supposed to take place without pressure up to an oil level of just below the shaft. The oil volume required for a specific application in order to ensure a sufficiently low bearing temperature depends on the conditions of heat generation and dissipation. The required oil volume can be determined by recording the bearing temperatures during machine start-up and setting it accordingly.

The flow resistance of bearings with a symmetrical cross section increases with rising circumferential velocity. If, in this case, larger oil volumes are required, the oil is injected directly between cage and bearing ring.

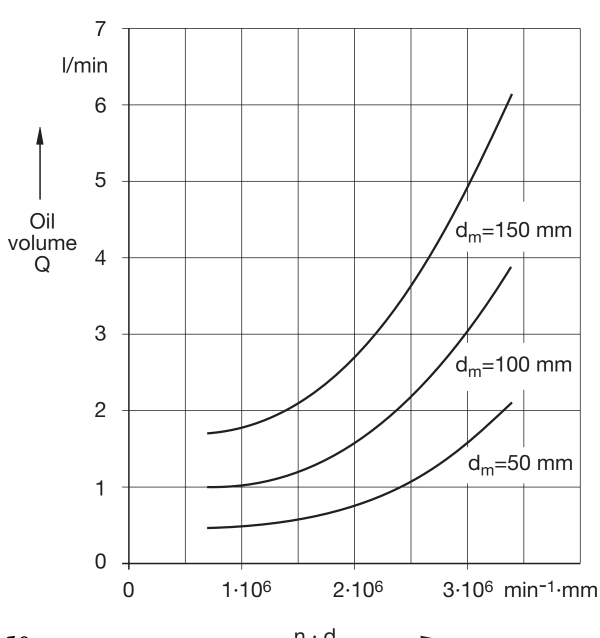
Oil jet lubrication reduces the energy losses due to churning. Diagram 50 shows the recommended oil volumes for oil jet lubrication versus the speed index and the bearing size. The diameter and number of nozzles are indicated in diagram 51. Oil entrapment in front of the bearing is prevented by injecting the oil into the bearings where free passage is assured. Discharge ducts with sufficient diameter allow the oil not absorbed by the bearing and the oil flown through the bearing to drain freely (figs. 62 and 63).

For the high circumferential velocities usual with oil jet lubrication, oils with an operating viscosity of ν = 5 to 10 mm^2/s ($\varkappa$ = 1 to 4) have proven their efficiency. The diagrams in fig. 52 show the oil volume Q and the jet velocity v for a nozzle length of L = 8.3 mm, operating viscosities of 7.75 and 15.5 mm^2/s and different nozzle diameters as a function of the pressure drop Δp.

This data was determined in tests. The oil flow rate through bearings rotating at high speed decreases as speed increases. It increases with increasing injection velocity, with 30 m/s being a sensible upper limit.

Rolling bearings must be **lubricated before going into operation.** With circulating oil lubrication, this is achieved by starting the oil pump before the machine is put into operation. This is not necessary where provisions have been made to ensure that the oil is not entirely drained

50: Recommended oil volume for oil jet lubrication
51: Diameter and number of nozzles for oil jet lubrication



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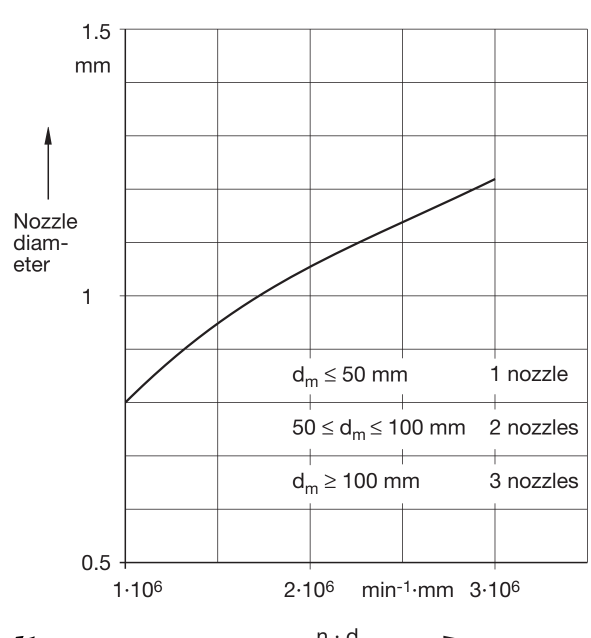

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from the bearing and a certain amount of oil is present. A combination of an oil sump with a circulation system increases the operational reliability, because, in the case of pump failure, the bearing continues to be supplied with oil from the sump for some time. At low temperatures, the oil flow rate can be reduced to the quantity required for lubrication until the oil has heated in the reservoir (fig. 49, curve a). This helps to simplify the circulating oil system (pump drive, oil return pipe).

If major oil quantities are used for lubrication, retention of the oil must be avoided by means of **discharge pipes** because retention would lead to substantial energy losses due to churning and friction especially at high circumferential velocities. The diameter of the discharge ducts depends on the oil viscosity and the angle of inclination of the discharge pipes. For oils with an operating viscosity of up to 500 mm²/s, the discharge diameter can be roughly calculated as follows:

$$d_a = (15...25) \cdot \sqrt{m} \text{ [mm]}$$

For dimensioning the discharge pipes more accurately for gradients from 1 to 5 % the following equation is used:

$$d_a = 11{,}7 \cdot \sqrt[4]{m \cdot \nu / G} \text{ [mm]}$$

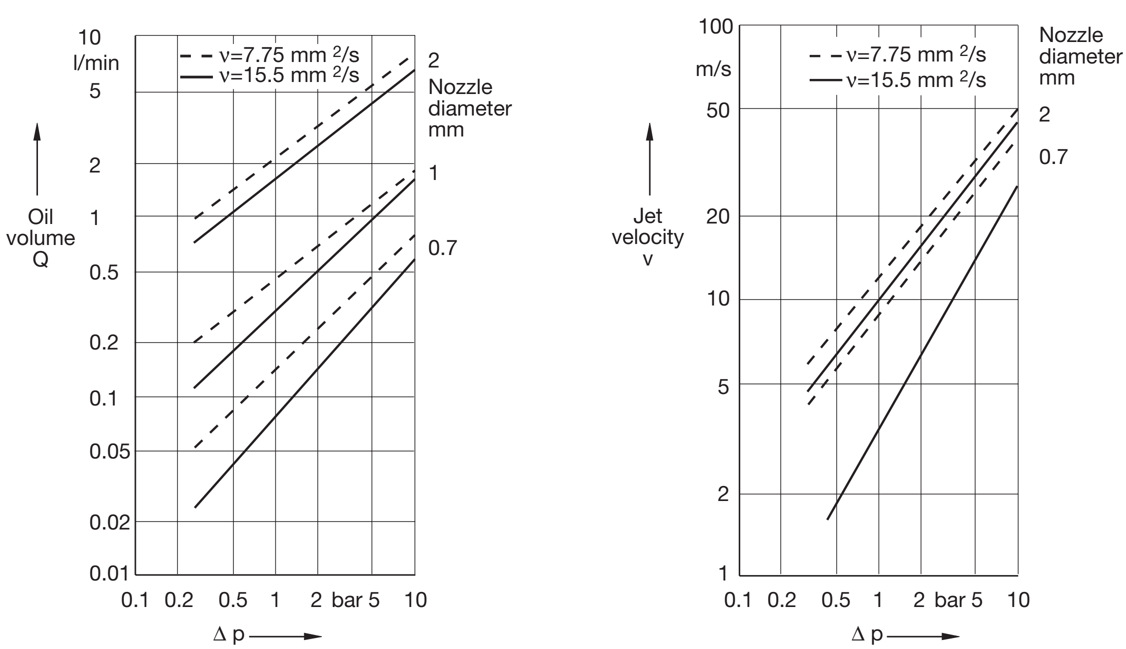
where d_a [mm] is the inside diameter of the discharge pipe, m [l/m] is the oil flow rate, ν [mm²/s] is the operating viscosity, and G [%] is the inclination.

The **amount of oil M in the oil reservoir** depends on the flow rate m. As a rule, the fill of the reservoir should be circulated z = 3 to 8 times per hour.

$$M = m \cdot 60/z \quad \text{[l]}$$

If the z value is low, foreign matter settles in the reservoir, the oil can cool down and and does not deteriorate so quickly.

52: Pressure drop and jet velocity versus oil volume, operating viscosity and nozzle diameter



4.2.4 Throwaway Lubrication

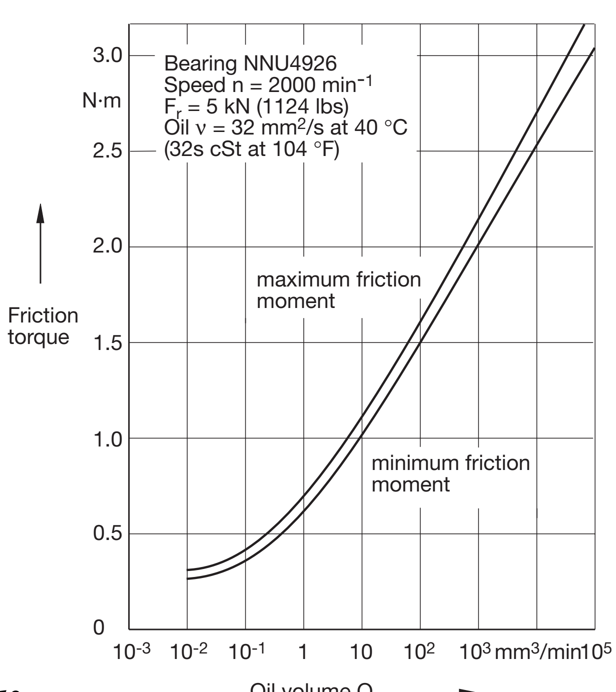
The oil volume fed to the bearing can be reduced below the lower limit indicated in diagram 49, if a low bearing temperature is required without a large volume of oil. This, however, requires suitable bearing friction and heat dissipation conditions. In figs. 53 and 54 the change of friction moment and bearing temperature depending on the oil volume used for throwaway lubrication is illustrated by the example of a double-row cylindrical roller bearing. This example shows particularly well how sensitive to overlubrication double-row cylindrical roller bearings with lips on the outer ring are. More suitable are double-row cylindrical roller bearings with lips on the inner ring (NN3O..) or single-row cylindrical roller bearings of series N10 and N19. The state of minimum friction and minimum temperature, that is when full fluid film lubrication sets in, is already reached with an oil volume of 0.01 to 0.1 mm^3/min. The bearing temperature rises up to an oil volume of 10^4 mm^3/min. Beyond that volume heat is dissipated from the bearing.

The oil quantity required for an adequate oil supply largely depends on the bearing type. Bearings where the direction of the oil flow coincides with the pumping direction of the bearing require a relatively large oil supply. Double-row bearings without conveying effect require an extremely small amount of oil if it is fed between the two rows of rolling elements. The rotating rolling elements prevent the oil from escaping.

Lubrication with very small amounts of oil requires that all contact areas in the bearing, especially the tribologically demanding sliding contact areas (lip and cage guiding surfaces) are adequately covered with oil. In the case of machine tools with ball bearings and cylindrical roller bearings, it is advantageous to feed oil directly to the bearings, and in the direction of conveyance of angular contact ball bearings. Diagramm 55 shows minimum oil quantities versus the bearing size, the contact angle (conveying effect) and the speed index for some bearing types. For bearings with a conveying effect, the oil volume should be increased as a function of speed as the minimum oil quantity required and the conveying effect increase with the speed.

For bearings with lip-roller face contact (e.g. tapered roller bearings), direct oil supply to the roller faces, opposite to the conveying direction, has proved to be suitable.

53: Friction moment versus oil volume with throwaway lubrication
54: Bearing temperaure versus oil volume with throwaway lubrication



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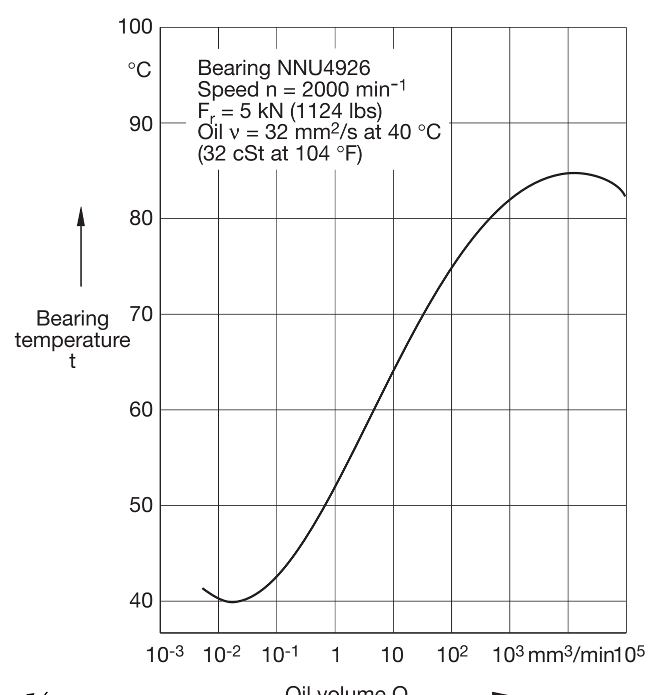

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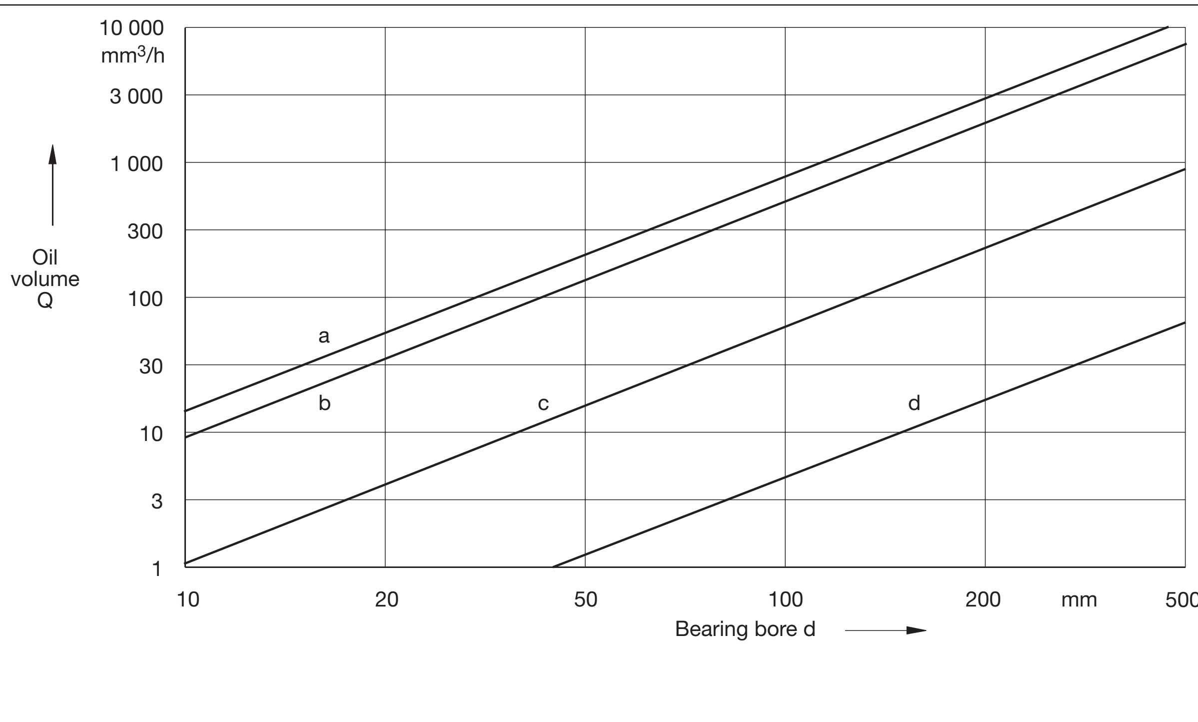
The extremely small oil quantities require an assured supply of the oil-air mixture between cage and inner ring as well as extremely accurate mating parts. The oil should have a viscosity which corresponds to the viscosity ratio $\varkappa = \nu/\nu_1$ = 8 bis 10 and contain suitable EP additives.

Continuous supply of a large oil quantity or the intermittent supply even of small quantities at high circumferential velocities lead to a sharp rise in lubricant friction and a temperature difference between inner and outer rings of cylindrical roller bearings. This can result in detrimental radial preloading and eventually in the failure of bearings which have a small radial clearance (e.g. machine tool bearings).

Fig. 56 shows an example of the selection of the suitable oil volume for throwaway lubrication for double-row cylindrical roller bearings NNU4926. Line a shows the minimum oil volume as a function of the speed index. Line b represents the maximum oil volume; beyond this line excessive radial preloading can occur. The diagram is based on the assumption of a continuous oil supply (oil-air lubrication) and average heat dissipation.

The point of intersection of lines a and b represents the maximum speed index for throwaway lubrication. The adequate

55: Oil volumes for throwaway lubrication



Zone a-b: Angular contact ball bearings with contact angles α = 40°
Angular contact thrust ball bearings with contact angle α = 60 bis 75°
Thrust ball bearings with contact angle α = 90°
$n \cdot d_m$ up to 800 000 $min^{-1} \cdot mm$

Zone b-c: Spindle bearings with contact angles of α =15 – 25°
$n \cdot d_m \leq 2 \cdot 10^6\ min^{-1} \cdot mm$

Zone c-d: Siongle-row and double-row cylindrical roller bearings
Line c: Bearings with lips on the inner ring and $n \cdot d_m \leq 10^6\ min^{-1} \cdot mm$
Line d: Bearings wich lips on the outer ring and $n \cdot d_m \leq 600\,000\ min^{-1} \cdot mm$

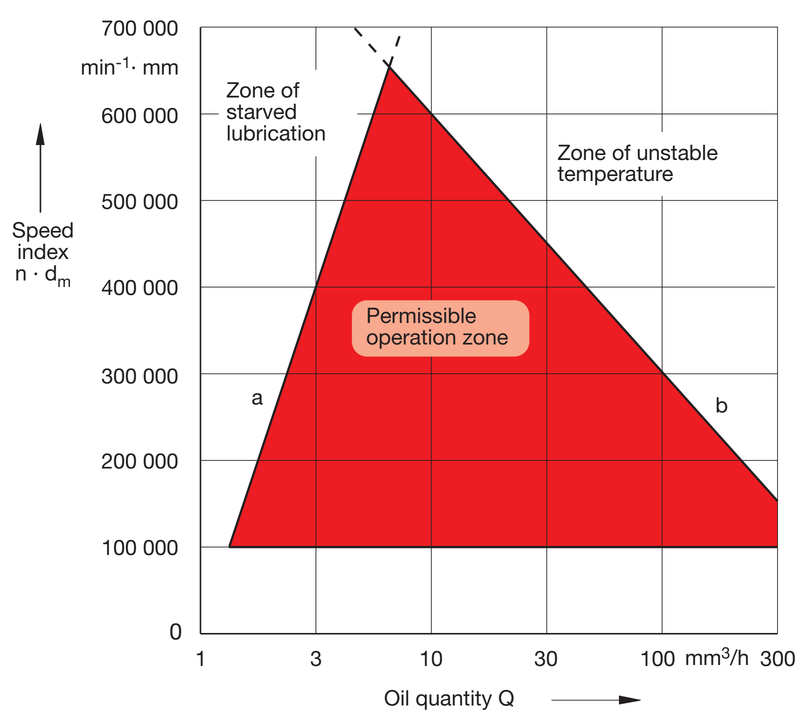
oil volume for double-row cylindrical roller bearings is shown by line d in diagram 55. Since the minimum and maximum oil volumes depend not only on the bearing but also on the oil type, the oil supply and heat dissipation it is not possible to furnish a general rule for determination of the speed index and the optimum small oil quantities. The viscosity of the oil selected should result in a viscosity ratio of $\varkappa$ = 2 to 3.

The oil-air lubrication system used for rolling mill bearings is usually combined with an oil sump and is not some kind of throwaway lubrication. The oil volume supplied adds to the oil sump and should be larger than 1,000 mm^3/h.

4.2.5 Examples of Oil Lubrication

Fig. 57: Larger housings with a correspondingly large amount of oil should be provided with baffle plates forming compartments interconnected by holes. This prevents undue agitation of the whole oil sump especially at higher circumferential velocities and allows foreign matter to settle in the lateral compartments without being constantly stirred up.

56: Selection of oil volume for throwaway lubrication (example: double row cylindrical roller bearing NNU4926 (d = 130 mm, small radial clearance)



Line a = minimum oil volume
Line b = permissible oil volume with uniform oil supply

57: Bearing housing with baffle plates

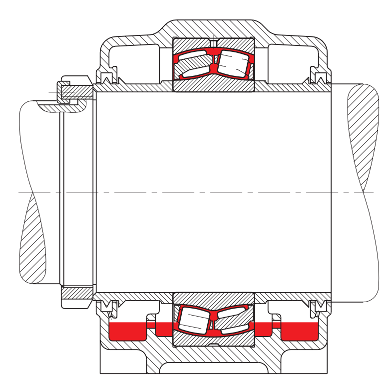


Fig. 58: The bottom rollers of the spherical roller bearing are immersed in a small oil sump. Oil losses are compensated for by oil supplied from the larger oil sump below the spherical roller bearing. The ring oiler R has a diameter which is considerably larger than the shaft diameter; it dips into the lower oil sump which is not connected with the bearing. In operation, the ring oiler R turns on the shaft and feeds the oil to the bearing. Excess oil returns to the lower oil sump through bores A. Ring oilers can be used up to a speed index of $n \cdot d_m$ = 400 000 $min^{-1} \cdot mm$. At higher speeds, the ring oiler shows heavy wear.

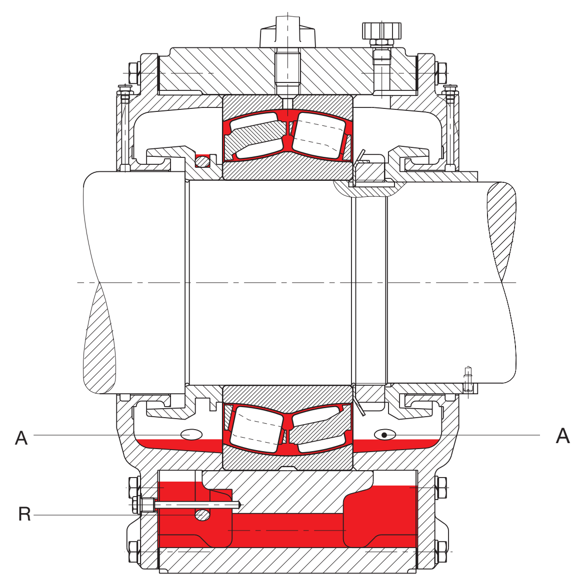
Fig. 59: Like all bearing types with an asymmetrical cross section, tapered roller bearings have a pumping effect. It depends heavily on the circumferential velocity of the bearing and can be utilized for circulating oil lubrication. The drain holes must be large enough to prevent oil retention at the bearing sides.

Fig. 60: Vertical high-speed spindles are sometimes designed with a tapered end, or a separate cone which rotates along with the spindle is fitted to them, the tapered end dipping into the oil reservoir. The oil is pumped up through the gap S into the circular groove from where it flows into an overhead dispenser. With this arrangement, relatively large oil quantities can be supplied, if the feed height is short and the oil viscosity is low.

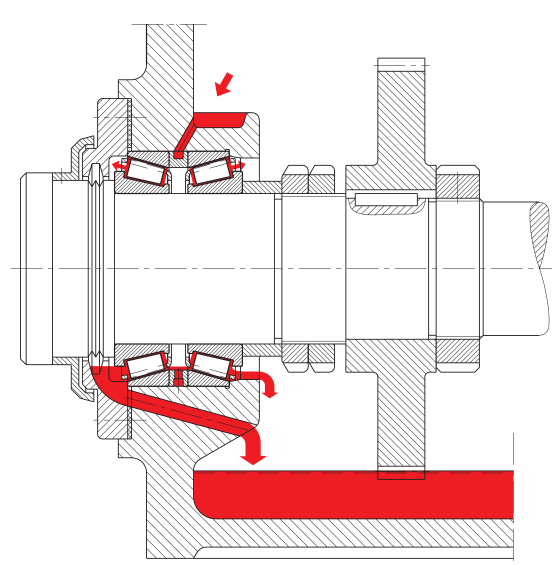
Fig. 61: In gearboxes, transmissions etc., the oil thrown off the gears often provides for adequate bearing lubrication. However, the oil must actually enter the bearings under all operating conditions. In the example shown, the oil thrown off is collected in a pocket above the cylindrical roller bearing and fed to the bearing through grooves. A baffle plate is arranged beside the cylindrical roller bearing. It ensures that a certain amount of oil is always retained in the bearing and that the bearing is lubricated at start-up.

Figs. 62 and 63: With oil jet lubrication, the oil jet is forced between cage and inner ring. Oil drain ducts prevent oil from being trapped at the bearing sides. If the bearings have a pumping effect, the oil is introduced at the smaller raceway

58: Oil circulation with ring oiler

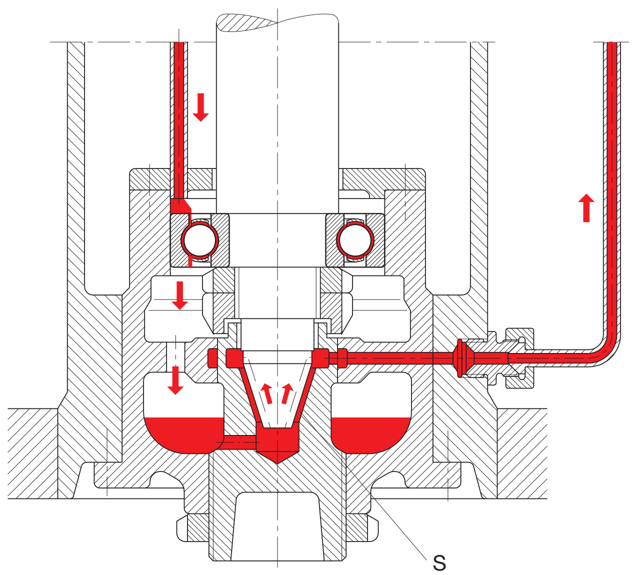


59: Oil circulation in bearings with conveying or pumping effect

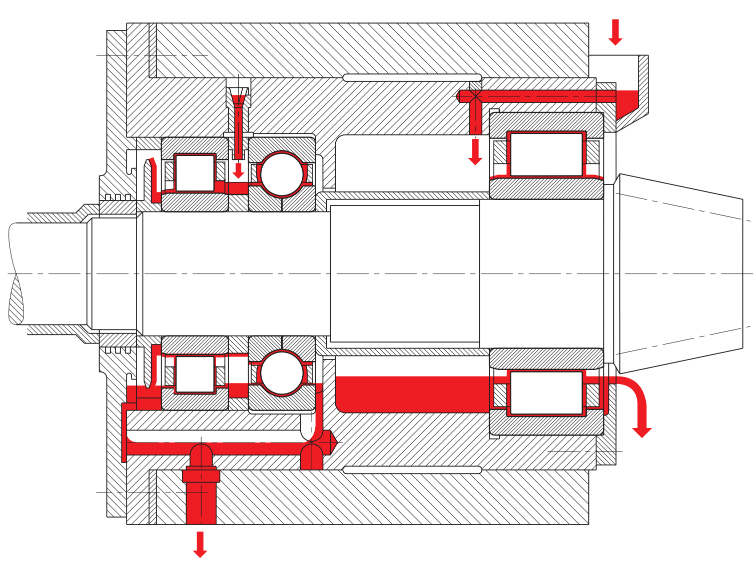


diameter. Oil is injected between the roller faces and the lip at the large raceway diameter of high-speed tapered roller bearings. This counteracts starved lubrication between lip surfaces and roller faces.

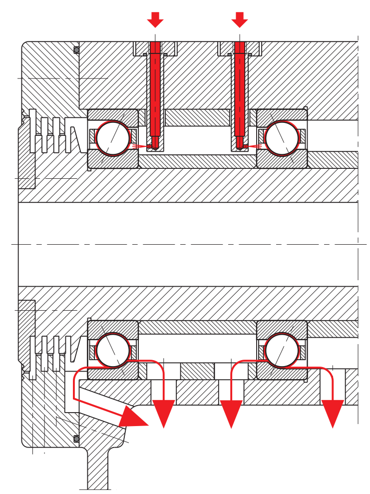
60: Oil circulation by tapered spindle end



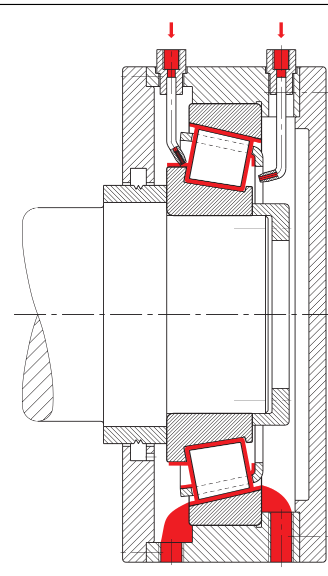
61: Oil thrown off is collected in a pocket and fed through grooves into the cylindrical roller bearing.



62: Oil jet lubrication with nozzles



63: Oil jet lubrication: Oil supply at either side of a high-speed tapered roller bearing



4.3 Dry Lubricante Application

The most currently used dry lubricants are graphite and molybdenum disulphide. These lubricants are applied to the raceway surfaces in the form of loose powder, sliding lacquer or paste. When applying a powder coating, a brush, leather or cloth can be used; sliding lacquers are sprayed on the functional surfaces with a spray gun. The service life of many sliding lacquers can be increased by baking in the lacquer on the surfaces. Pastes are applied with a paint brush. Generally, the bearings are bonderized (manganese phosphate coating, phosphate coating) before the dry lubricants are applied. The phosphate coating allows for better adhesion of dry lubricants, protects against corrosion and provides, to a certain extent, for emergency running properties. If high standards of protection against corrosion are required, the bearings are coated with a zinc-iron compound. Powders and lacquers only partially adhere to greasy bearings if at all. Perfect and uniform application is only possible at the bearing production plant before the individual components are assembled. Pastes can be applied prior to bearing mounting. Paste layers can be touched up or renewed. Overgreasing with pastes should be avoided.

An effective lubricant supply is provided by **transfer lubrication.** By filling the bearing with a solid lubricant compound which revolves along with the cage after solidifying, the rolling elements are regularly supplied with lubricant. This constant "relubrication" yields a long service life which far exceeds that reached by means of a sliding lacquer coating or a paste. The dry lubricant released by the rolling elements in the form of a powder escapes through the sealing gap. If this is an unwanted effect, a space can be provided between seal and preseal where the rubbed-off particles will collect.

5 Damage Due to Imperfect Lubrication

More than 50% of all rolling bearing damage is due to imperfect lubrication. In numerous other cases which cannot be directly traced back to imperfect lubrication, it is one of the underlying causes of damage. Imperfect lubrication in the contact areas leads to wear, smearing, scoring, and seizure marks. In addition, fatigue damage (flaking) can occur. Sometimes, bearing overheating occurs if, in the case of starved lubrication or overlubrication, the bearing rings are heated to different temperatures due to unfavourable heat dissipation, resulting in a reduction of radial clearance or even detrimental preload.

The main causes of the damage shown in fig. 64 are:

- unsuitable lubricant (oil of too low a viscosity, lack of additives, unsuitable additives, corrosive action of additives)
- starved lubrication in the contact areas
- contaminants in the lubricant (solid and liquid)
- alteration of lubricant properties
- overlubrication

Starved lubrication and overlubrication can be remedied by selecting a lubricant supply system adapted to the relevant application. Damage due to unsuitable lubricant or changes of the lubricant properties can be avoided by taking into account all operating conditions in lubricant selection and by renewing lubricant in good time. Details have been given in the preceding chapters. The effects of contaminants in the lubricant and the resulting conclusions are described in this chapter.

5.1 Contaminants in the Lubricant

There are hardly any lubrication systems that are completely free from contaminants. The effects of contaminants on the life of a bearing are described in section 1.1.3. All lubricants contain a certain amount of contaminants stemming from their manufacture.

64: Damage due to inadequate lubrication

Damage symptom	Cause	Notes
Noise	Starved lubrication	Local metal-to-metal contact; interrupted lubricating film without load transmitting and damping effect.
	Unsuitable lubricant	Lubricating film too thin, due to too low a viscosity of the oil or base oil of the grease. The structure of the grease thickener can be unsuitable. Particles can produce noise.
	Contaminants	Dirt particles disrupt the lubricating film and produce a noise.
Cage wear	Starved lubrication	Local metal-to-metal contact; interrupted lubricating film without load transmitting and damping effect.
	Unsuitable lubricant	Too low a viscosity of the oil or base oil, no boundary layer formation.
Wear on rolling elements, raceways, lip surfaces	Starved lubrication	Local metal-to-metal contact; interrupted lubricating film without load transmitting and damping effect. Tribocorrosion due to oscillating relative motions, slip marks.
	Unsuitable lubricant	Too low a viscosity of the oil or base oil. Lubricants without anti-wear or EP additives (high loads or high amount of sliding).
	Contaminants	Solid hard particles or liquid, corrosive media.
Fatigue	Starved lubrication	Local metal-to-metal contact, and high tangential stresses at the surface. Wear.
	Unsuitable lubricant	Too low a viscosity of the oil or base oil. Lubricant contains substances whose viscosity increases only slightly unter pressure (e.g. water). Ineffective additives.
	Contaminants	Hard particles are rolled in, resulting in high local contact pressure. Corrosive media produce corrosion spots which are particularly fatigue promoting.
High bearing temperature, discoloured bearing parts, seizure marks (overheating)	Starved lubrication	Local metal-to-metal contact; interrupted lubricating film without load transmitting and damping effect.
	Unsuitable lubricant	High friction and temperature due to local metal-to-metal contact.
	Overlubrication	At medium or high rotational speed, high lubricant friction, especially in the case of sudden overlubrication.
Damaged lubricant (discolouration, solidification, loss of lubricity)	Starved lubrication	Operating temperature higher than the temperature permissible for the lubricant (formation of residues).
	Excessive operating time	Excessively long relubrication or lubricant renewal intervals.
	Contaminants, alteration of the lubricant	Foreign or wear particles in tshe bearing. Reaction between lubricant and bearing material.

The minimum requirements for lubricants specified in DIN standards list, among others, limits for the permissible contamination at the time of lubricant supply. In most cases, contaminants enter the bearing on mounting due to insufficient cleaning of the machine components, oil pipelines etc., and during operation due to insufficient seals or openings in the lubrication unit (oil reservoir, pump). During maintenance, contaminants can also penetrate into the bearing, for example through dirt on the grease nipple and on the mouthpiece of the grease gun, during manual greasing, etc.

For assessing the detrimental effect of contaminants it is essential to know:

– the type and hardness of the foreign particles
– the concentration of the foreign particles in the lubricant
– the size of foreign particles

5.1.1 Solid Foreign particles

Solid foreign particles lead to running noise, wear and premature fatigue. Hard particles in rolling bearings cause abrasive wear, particularly in contact areas with a high rate of sliding friction, for example between the roller faces and the lip surfaces of tapered roller bearings or between the contact surfaces of raceway edges and rollers in cylindrical roller thrust bearings. Wear increases with the particle hardness and more or less proportionately with the concentration of the particles in the lubricant and the particle size. Wear even occurs with extremely small particles. Abrasive wear in rolling bearings is acceptable to a certain extent, the permissible amount of wear depending on the application. Cycling of larger particles (in the order of 0.1 mm) causes indentations in the raceways. Plastically deformed material is rolled out at the edges and only partly removed during subsequent cycling. Each subsequent load cycle causes higher stresses in the area of the indentation which result in a reduced fatigue life. The greater the hardness of the cycled particles (e.g. file dust, grinding chips, mould sand, corundum) and the smaller the bearings, the shorter the life, see fig. 65.

5.1.2 How to Reduce the Concentration of Foreign Particles

The following precautions have to be taken:

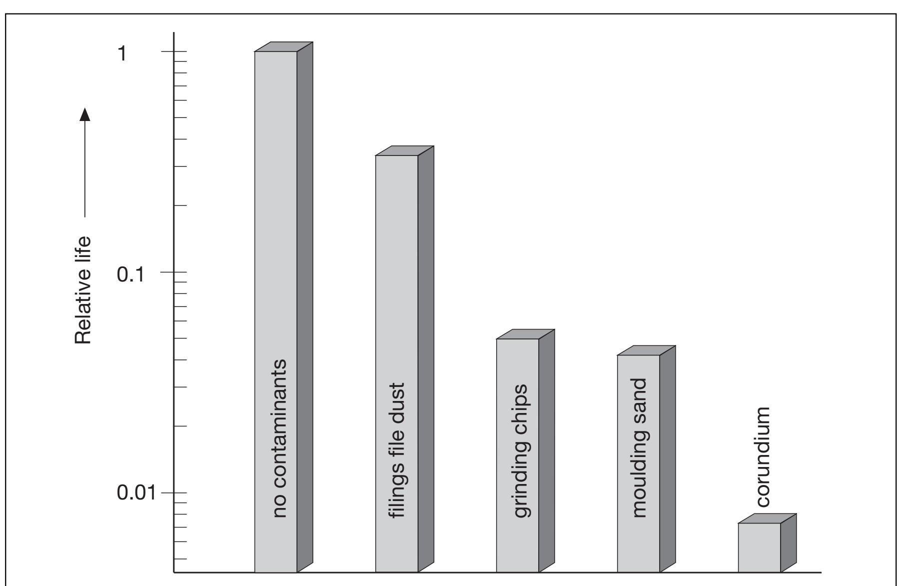
– thorough cleaning of the bearing mating parts
– cleanliness in mounting, operation and maintenance
– with oil lubrication, filtering the oil (see section 1.1.3)
– with grease lubrication, sufficiently short grease renewal intervals

5.1.3 Oil filters

Modern filtering elements retain a wide spectrum of particles every time the oil volume passes through them. Therefore, test methods were standardized which take into account this particle spectrum and the multipass effect. The filtration ratio β_x indicates the ability of the filter to retain particles of certain sizes. The β_x value, measured in accordance with ISO 4572, represents the ratio of all particles > x µm before and after filtering, fig. 66. For instance, $\beta_{12} = 75$ means that of 75 dirt particles which are 12 µm in size only one particle passes through the filter.

The effects of solid contaminants on the attainable life of rolling bearings is described in more detail in section 1.1.3.

65: Life reduction due to solid contaminants –– demonstrated by the example of a 7205B angular contact ball bearing



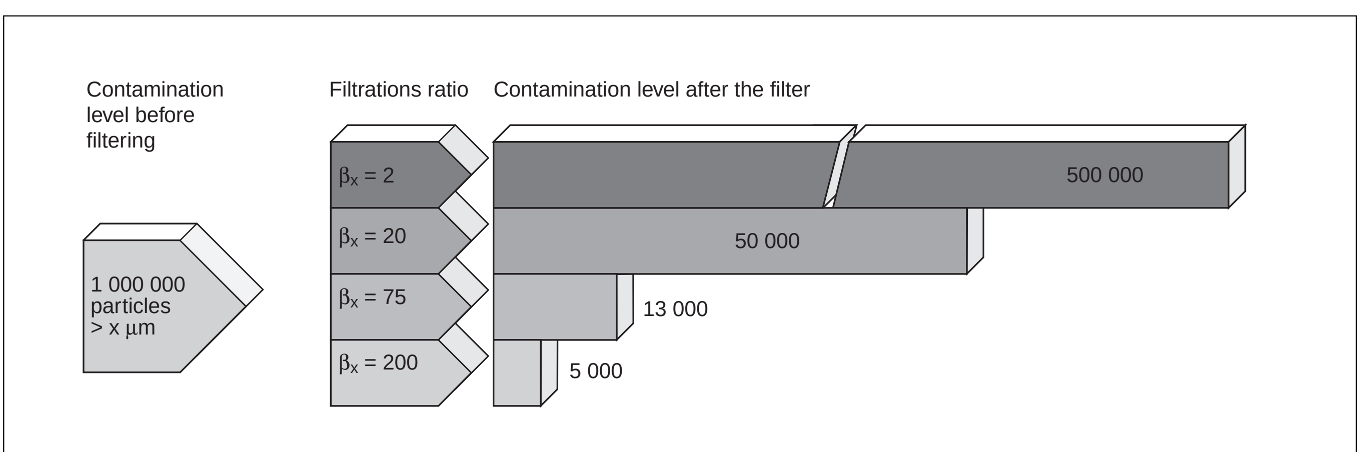
5.1.4 Liquid Contaminants

The main liquid contaminants in lubricants are water or aggressive fluids, such as acids, bases or solvents. Water may be free, dispersed or dissolved in oils. With free water in oil, visible by the oil discolouration (white-grey), there is the risk of corrosion. This risk is accelerated by hydrolysis of the sulphur bonded with the lubricant. Dispersed water in form of a water-in-oil emulsion affects the lubricating condition significantly. Experience has shown that the fatigue life of bearings lubricated with these aqueous oils decreases considerably. It can be reduced to a very small percentage of the normal fatigue life. Water in greases causes structural changes depending on the thickener. As is the case with water-in-oil emulsions, the fatigue life is reduced. With contamination by water, the grease renewal intervals must be shortened depending on the amount of water. Aggressive agents (acids, bases), solvent, etc. can drastically alter the chemo-physical characteristics and eventually deteriorate the lubricant. Information and recommendations on the compatibility of lubricants with these agents, which are given by the lubricant manufacturers, must be observed. On areas in the bearings which are not protected by the lubricant, corrosion develops and finally destroys the surface, depending on the aggressiveness of the contaminants.

5.2 Cleaning Contaminated Rolling Bearings

For cleaning rolling bearings, naphta, petroleum, ethanol, dewatering fluids, aqueous neutral or alkaline cleansing agents can be used. Petroleum, naphta, ethanol and dewatering fluids are inflammable, and alakaline agents are caustic. When washing out bearings, paint brushes or brushes, or lint-free cloth should be used. Immediately after washing and evaporation of the solvent, which should be as fresh as possible, the bearings must be preserved in order to avoid corrosion. The compatibility of the preservative with the subsequently used lubricant has to be ensured. If gummed oil and grease residues stick to a bearing, it should be mechanically precleaned and soaked for an extended period of time in an aqueous, strong alkaline cleansing agent.

66: Filtration ratio β_x



Damage Due to Imperfect Lubrication

5.3 Prevention and Diagnosis of Incipient Bearing Damage by Monitoring

Bearing failures due to imperfect lubrication can be avoided by monitoring the bearing:

– by measuring vibrations, wear and temperature
– by monitoring the bearing lubrication, analysing lubricant samples and checking the lubricant supply system.

Temperature measurements are a very reliable and relatively easy method of detecting lubricant-related damage. The temperature behaviour is normal if the bearing reaches steady-state temperature in stationary operation. Starved lubrication is indicated by a sudden temperature increase. An erratic temperature curve whose peaks tend to increase indicates a general impairment of the lubricating condition, e.g. when the grease service life reaches its end.

Temperature measurements are not suitable for detecting fatigue damage early. Such locally restricted damage is best detected by means of vibration measurements.

Bearing damage which involves wear can be spotted by means of nonintermittent or intermittent lubricant analyses.

Monitoring the bearing lubrication also provides important data for maintenance. Table 67 lists the common methods for bearing monitoring and the type of damage they can detect. Table 68 gives information on lubrication monitoring.

67: Bearing monitoring

Measurable variables	Measuring method, measuring devices	Detectable types of damage
Oscillations Vibrations Airborne sound Structure-borne sound	Search for source of trouble Frequency analysis (amplitude, velocity, acceleration) shock pulse measurements	Fatigue Fracture Flutes Scores
Wear	Monitoring of abrasion by measuring the displacement of the bearing components relative to one another (inductive, capacitive, eddy current measuring methods) Radionuclide measurement Lubricant analysis	Wear of bearing components
Temperature	Thermometer Thermocouple Resistance thermometer Thermoplates Comparison of measured values	Overheating Dry running Seizure

68: >Lubrication monitoring

Monitored variables	Method	Detectable and avoidable
Lubricant	Analysis (content of water, solid foreign particles, neutralization number, saponification number)	Fatigue Wear Corrosion Deteriorated or unsuitable lubricant
Lubrication system	Oil pressure Oil level Oil flow rate Oil temperature	Overheating Wear

6 Definition of Tribological Terms

Additives

Oil soluble substances added to mineral oils or mineral oil products. By chemical and/or physical action, they change or improve the lubricant properties (oxidation stability, EP properties, foaming, viscosity-temperature behaviour, setting point, flow properties, etc.).

Additive-treated Lubricants

Lubricating oils or greases which contain one or several additives to improve special properties. -> Additives.

Adhesive Oils

Tough and sticky, generally bituminous lubricants with a high viscosity; as a rule, must be used in a diluted form.

Ageing

-> Deterioration

Aluminium Complex Soap Base Greases

Their resistance to water is good; when doped with EP additives, they have a high load carrying capacity. Depending on their base oil, they can be used for temperatures up to approximately 160 °C.

Aluminium Soap Base Greases

Lubricating greases consisting of aluminium soap and mineral oils. They are mainly used in gearboxes for gear lubrication.

Anti-Oxidants

Additives which considerably retard lubricating oil deterioration.

Anti-Stick-Slip Additives

Additives which are added to lubricants to prevent stick-slip operation, e.g. carriage tracks and guideways in machine tools.

Antiwear Additives

Additives to reduce wear in the mixed friction range. Distinction is made between

- mild additives, e.g. fatty acids, fatty oils
- EP additives, e.g. sulphuric, phosphorous and zinc compounds,
- dry lubricants, e.g. graphite, molybdenum disulphide.

Arcanol

FAG rolling bearing greases are field-proven lubricating greases. Their scopes of application were determined by FAG by means of the latest test methods (test rigs FE8 and FE9) under a large variety of operating conditions and with rolling bearings of all types. The eight Arcanol greases listed in the table on page 58 cover almost all demands on the lubrication of rolling bearings.

Aromatics

Unsaturate hydrocarbons with a molecular ring structure (benzene, toluol, naphtalene). Aromatics have poor viscosity-temperature properties and affect the oxidation stability of lubricants.

Ash Content

refers to the incombustible residues of a lubricant. The ash can be of different origins: it can stem from additives dissolved in the oil; graphite and molybdenum disulphide, soaps and other grease thickeners are ash products. Fresh, straight mineral oil raffinates must be completely ash free. Used oils also contain insoluble metal soaps produced during operation, incombustible residues of contaminants, e.g. wear particles from bearing components and seals, etc. Sometimes, incipient bearing damage can be diagnosed from the ash content.

Arcanol rolling bearing greases · Chemo-physical data and directions for use

Arcanol	Thickener Base oil	Base oil viscosity at 40 °C mm^2/s	Consistency NLGI-class DIN 51818	Temperature range °C	Main characteristics Typical applications
L12V	Calcium/ polyurea PAO	130	2	–40...+160	Special greease for high temperatures Couplings, electric machines (motors, generators)
L71V	Lithium soap Mineral oil	ISO VG 100	3	–30...+140	Standard grease for bearings with O.D.s > 62 mm large electric motors, wheel bearings for motor vehicles, ventilators
L74V	Special soap Synthetic oil	ISO VG 22	2	–40...+100	Special grease for high speeds and low temperatures Machine tools, spindle bearings, instruments
L78V	Lithium soap Mineral oil	ISO VG 100	2	–30...+140	Standard grease for bearings with O.D.s ≤ 62 mm Small electric motors, agricultural and construction machinery, household appliances
L79V	PTFE Synthetic oil	400	2	–40...+260	Special grease for extremely high temperatures and chemically aggressive environment Track rollers in bakery machines, piston pins in compressors, kiln trucks, chemical plants
L135V	Lithium soap with EP additives Mineral oil + Ester	85	2	–40...+150	Special grease for high loads, high speeds, high temperatures Rolling mills, construction machinery, motor vehicles, rail vehicles, spinning and grinding spindles
L166V	Lithium soap with EP additives Mineral oil	170	3	–30...+150	Special grease for high temperatures. high loads, oscillating movements Rotor blade adjusting mechanisms for wind power stations, packaging machinery
L186V	Lithium soap with EP additives Mineral oil	ISO VG 460	2	–20...+140	Special grease for extremely high loads, medium speeds, medium temperatures Heavily stressed mining machinery, construction machinery, machines with oscillating movements
L195V	Polyurea with EP additives Synthetic oil	ISO VG 460	2	–35...+180	Special grease for high temperatures, high loads Continuous casting plants
L215V	Lithium-/ Calcium soap with EP additives Mineral oil	ISO VG 220	2	–20...+140	Special grease for high loads, wide speed range, high humidity Rolling mill bearings, rail vehicles
L223V	Lithium-/ Calcium soap with EP additives Mineral oil	ISO VG 1000	2	–20...+140	Special grease for extremely high loads, low speeds Heavily stressed mining machinery, construction machinery, particularly for impact loads and large bearings

ASTM
Abbreviation for American Society for Testing Materials. Institution which draws up, among other things, the U.S. mineral oil standards.

ATF
Abbreviation for Automatic Transmission Fluid. Special lubricants adapted to the requirements in automatic transmissions.

Barium Complex Soap Base Greases
Lubricating greases consisting of barium complex soaps and mineral oils or synthetic oils. They are water-repellent, retain their consistency, and form a lubricating film with a high load carrying capacity.

Base Oil
is the oil contained in a grease. The amount of oil varies with the type of thickener and the grease application. The penetration number and the frictional behaviour of the grease vary with the amount of base oil and its viscosity.

Bentonites
Minerals (e.g. aluminium silicates) which are used for the production of thermally stable greases with good low-temperature properties.

Bleeding
The oil contained in the lubricating grease separates from the thickener. This can be caused, e.g. by low resistance to working and/or low temperature stability of the grease.

Brightstock
Refined oil of high viscosity, a product of vacuum destillation. Compound for lubricating oils, improves the lubricity.

Calcium Soap Base Greases
Calcium soap base greases are completely water-repellent and are therefore excellent sealants against the ingress of water. However, since their corrosion protection is limited, they must contain anti-corrosion additives. Doped calcium soap base greases are appropriate even in applications where they are exposed to large amounts of water. Temperature limits of normal calcium soap base greases: approx. –20°C to +50°C.

Centipoise (cP)
Former unit for the dynamic viscosity.
1 cP = 1 mPa s

Centistoke (cSt)
Former unit for the kinematic viscosity.
1 eSt = 1 mm^2ls

Characteristics
The following are the characteristics of lubricating oils: flash point, density, nominal viscosity, setting point and additive data.
Lubricating greases are defined by: type of thickener, type and viscosity of base oil, drop point, worked penetration and, where present, additives.

Circulating Effect
If grease is carried along by rotating parts the rotation causes lumps of grease to be pulled between rolling elements and raceways with a corresponding increase in friction due to grease working. High-speed applications therefore require greases which are not likely to be carried along. The circulating effect depends on the type of thickener, penetration, temperature and the bearing type. Especially sodium soap base greases tend to participate in the circulating movement.

Colour of Oils
Spent oils are often judged by their colour. However, caution should be exercised in using this criterion because even fresh oil can be more or less dark. Whether the discolouration is due to oxidation can only be confirmed by comparing it with a fresh sample of the same oil type. Contamination by dust and soot, however small the quantity, may also be a cause of discolouration.

Complex Greases
Besides metal soaps of high-molecular fatty acids, complex soap base greases contain metal salts of low-molecular orgnic acids. These salts and the soap form a complex compound which outperforms conventional greases as far as thermal stability, water resistance, anti-corrosive action and load carrying capacity are concerned.

Consistency
is defined as the resistance of a grease to being deformed. -> Penetration.

Copper Corrosion Test
Method for determining active sulphur in mineral oils (DIN 51 759) and in greases (DIN 51811).

Corrosion Inhibiting Greases, Corrosion Inhibiting Oils
They protect corrodible metal surfaces against moisture and atmospheric oxygen.

Demulsifying Ability
Ability of oils to separate from oil-water mixtures.

Density
The density r of mineral oil products is expressed in g/cm^3 at 15 °C. The density of mineral lubricating oils $\rho = 0.9\ g/cm^3$. It depends on the chemical composition of the oil. For oils of the same origin it increases with viscosity and decreases with increasing degree of refining. Density in itself is no criterion of quality.

Glossary of Terms

Detergents
Additives which emulsify oxidation products, keep them in suspension, and prevent them from settling on surfaces to be lubricated.

Deterioration
is the undesirable chemical alteration of mineral and synthetic products (e.g. lubricants, fuels) during operation and storage; triggered by reactions with oxygen (formation of peroxides, hydrocarbon radicals); heat, light and catalytic influences of metals and other contaminants accelerate oxidation. Formation of acids and sludge.
-> Anti-Oxidants (AO) retard the deterioration process.

Dispersants
Additives in lubricating oils which hold fine dirt particles in suspension until they are filtered out or removed when the oil is changed.

Dispersion Lubrication
Method of applying the lubricant. The rolling bearing is dipped into the dispersion bath (disperging agent and grease). After the disperging agent has evaporated, a 1 to 100 µm thick lubricant layer remains on the bearing surfaces. Advantage: minimum friction. Drawback: reduced grease service life.

Distillates
Hydrocarbon compounds obtained from crude oil distillation.

Drop Point
Temperature at which a grease sample, when heated under standard test conditions, passes into a liquid state, flows through the opening of a grease cup and drops to the bottom of the test tube.
Grease: DIN ISO 2176.

Dry Lubricants
Substances, such as graphite and molybdenum disulphide, suspended in oils and greases or applied directly.

Dynamic Viscosity
-> Viscosity.

Emcor Method
Testing of corrosion preventing properties of rolling bearing greases according to DIN 51 802.

Emulsibility
Tendency of an oil to emulsify with water.

Emulsifiers
Additives which help to form an emulsion.

Emulsion
Mixture of insoluble substances, usually mineral oils with water, which is activated by emulsifiers.

Elastic Behaviour of Lubricating Greases
The elastic properties of lubricating greases indicate the suitability of a grease for centralized lubrication systems (DIN 51 816T2).

EP Lubricants
Extreme pressure lubricants. Oils or greases which contain EP additives against wear.

Esters (Synthetic Lubricating Oils)
Compounds of acids and alcohols with water eliminated. Esters of higher alcohols with divalent fatty acids form the so-called diester oils (synthetic lubricating oils). Esters of polyhydric alcohols and different organic acids are particularly heat stable.

Evaporation Loss
Lubricating oil losses occurring at increased temperatures due to evaporation. It can lead to an increase in oil consumption and also to an alteration of the oil properties.

Extreme-Pressure Lubricants
-> EP lubricants.

Fire Point
Fire point is the minimum temperature under a certain pressure at which a uniformly heated fluid gives off sufficient vapour to burn continuously for at least five seconds: DIN ISO 2592.

Flash Point
Flash point is the minimum temperature to which, under specified test conditions, an oil must be heated for sufficient vapour to be given off to form an inflammable mixture with air. The flash point is one of the characteristics of oils; it is not a criterion for their quality.

Flow Pressure
Pressure required to press grease in a continuous stream from a nozzle. It is a measure of the consistency and fluidity of a grease. It is determined according to DIN 51 805 (in accordance with DIN 51 825 used for determining the lower operating temperature).

Foaming
Foaming in mineral oils should be avoided. Foaming promotes deterioration of the oil. Excessive foaming can lead to oil losses.

Four Ball Test Rig
Machine for lubricant testing (DIN 51 350). Four balls are arranged in a pyramid shape, with the upper ball rotating. The load applied can be increased until welding occurs between the balls (welding load). The load, expressed in N,

is the four ball welding load. The diameter of the weld scar on the three stationary balls measured after one hour of testing is the four ball wear value which is used for wear evaluation. Suitable for the identification testing of lubricants.

Gear Greases

Gear greases are usually sodium soap based, stringy, soft to semifluid greases (NLGI 0 and 00) for gears and gear motors. Some greases are treated with EP additives.

Gear Oils

Lubricating oils for all kinds of gears in accordance with DIN 51 509, 51 51711/12/13 (Lubricating Oils C, CL, CLP).

Gel Greases

Gel greases contain an anorganic-organic thickener made up of finely dispersed solid particles; the porous surface of these particles tends to absorb oil. Gel greases are suitable for a wide temperature range and are water resistant. Caution is recommended at high speeds and loads.

Grease Service Life

The grease service life is the period from start-up until the failure of a bearing as a result of lubrication breakdown. The grease service life is determined by the
- amount of grease,
- grease type (thickener, base oil, additives),
- bearing type and size,
- type and amount of loading,
- speed index,
- bearing temperature.

Grease Service Life Curve, F_{10}

The F_{10} value represents the service life of a certain grease and applies to a failure probability of 10 %. The grease service life F_{10} is determined in laboratory tests, e.g. on the FAG rolling bearing grease test rig FE9.

HD Oils

Heavy-duty oils are additive-treated engine oils particularly adapted to the rugged conditions in internal combustion engines.

High-Temperature Greases

Lithium soap base greases can be used at steady-state temperatures of up to 130 °C and polyurea greases up to 200 °C. Special synthetic greases can be used up to 270 °C.

Homogenizing

Final step in grease production. In order to obtain a uniform structure and fine dispersion of the thickener, the grease is thoroughly worked in a special machine where it is subjected to a great shearing force.

Hydraulic Fluids

Pressure fluids for hydraulic load transmission and control. Fire-resistant hydraulic fluids -> page 32.

Hydraulic Oils

Non-ageing, thin-bodied, non-foaming, highly refined hydraulic fluids produced from mineral oil, with a low setting point, for use in hydraulic systems.

Hypoid Oils

High-pressure oils with EP additives for hypoid gears, mainly for axle drive systems in motor vehicles.

Inhibitors

Additives which retard certain reactions of a lubricant. They are used preferably as a protection against deterioration and corrosion in lubricants.

Kinematic Viscosity

-> Viscosity.

Lithium Soap Base Greases

have definite performance merits in terms of water resistance and width of temperature range. Frequently, they incorporate oxidation inhibitors, corrosion inhibitors and EP additives. Due to their favourable properties, lithium soap base greases are widely used as rolling bearing greases. Standard lithium soap base greases can be used at temperatures ranging from –35 to +130 °C.

Low-Temperature Properties

-> Setting point and flow pressure.

Lubricant Additives

-> Additives.

Lubricant Analysis Data

The analysed data of lubricants are: density, flash point, viscosity, setting point, drop point, penetration, neutralization number, saponification number. These are the physical and chemical properties of lubricants and indicate – within certain limits – the fields of application of the lubricants.-> Specifications.

Lubricating Greases

Greases are consistent mixtures of thickeners and oils. The following grease types are distinguished:
- Metal soap base greases consisting of metal soaps as thickeners and lubricating oils,
- Non-soap greases comprising inorganic gelling agents or organic thickeners and oils,
- Synthetic greases consisting of organic or inorganic thickeners and synthetic oils. -> Table 27.

Lubricating Oils B

Dark, bituminous mineral oils with good adhesive properties: DIN 51513.

Lubricating Oils C, CL, CLP

Gear oils for circulation lubrication: DIN 51 517T1/T2/T3.

Glossary of Terms

Lubricating Oils CG
Slideway oils.

Lubricating Oils K
Refrigeration machine oils: DIN 51503.

Lubricating Oils N
Standard lubricating oils: DIN 51501.

Lubricating Oils T
Steam turbine lubricating and control oils: DIN 51 515T1.

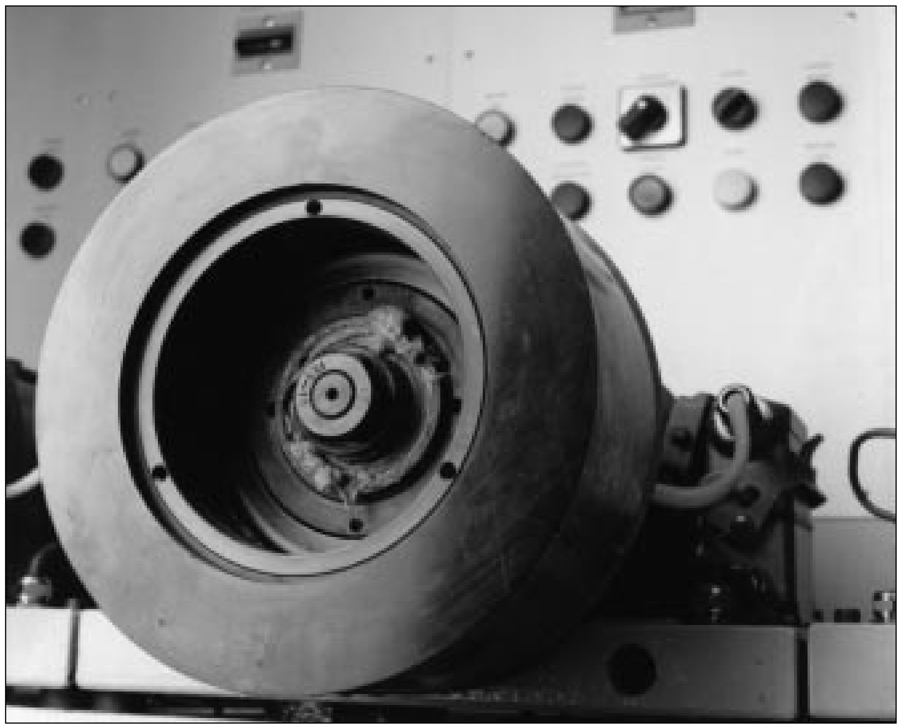
Lubricating Oils V
Air compressor oils: DIN 51506.

Lubricating Oils Z
Steam cylinder oils: DIN 51 510.

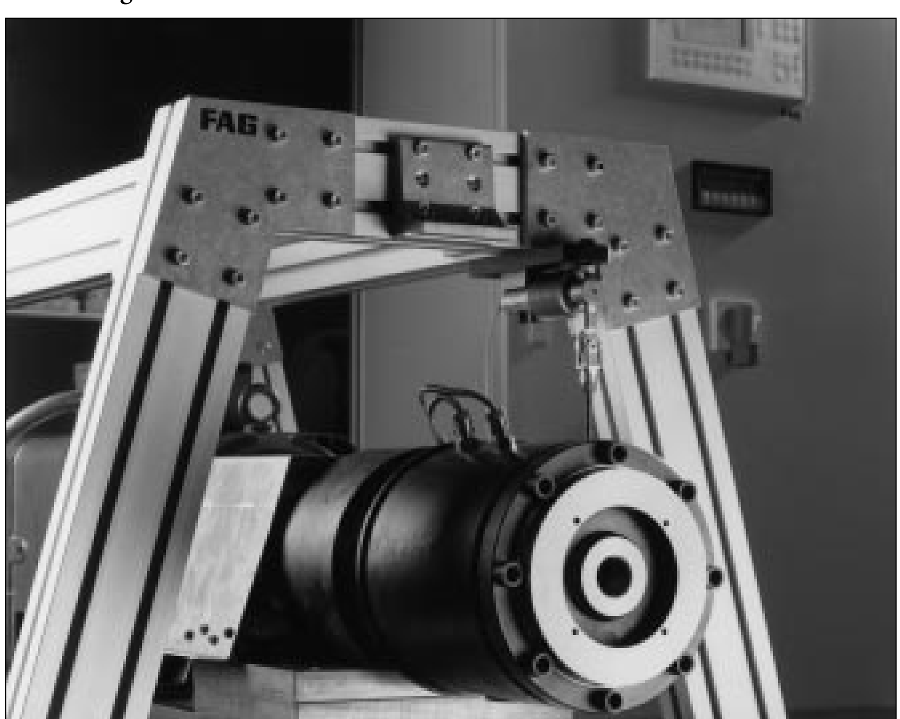
Lubrication Interval
The lubrication interval corresponds to the minimum grease service life F_{10} of standard greases in accordance with DIN 51 825. The lubrication interval is entered as a function of $k_f \cdot n \cdot d_m$, valid for 70 °C, see diagram "Lubricating intervals" in fig. 33. This value is assumed if the grease service life F_{10} of the grease used is not known. If the capacity of a grease is to be fully utilized, the grease service life F_{10}, determined in tests under field-like conditions, has to be assumed, or one orients oneself by experimental values. Influences which reduce the lubrication interval are taken into account by reduction factors.

Mechano-Dynamic Lubricant Testing
The rolling bearing greases are tested under field-like operating and environmental conditions. The lubricant is analysed by the behaviour of test specimen and lubricant during testing and their condition after the test. Test rigs using single bearing components as test specimens give results which can be applied to

FAG test rig FE9



FAG test rig FE8



complete rolling bearings only to a limited extent. Therefore, test rigs are preferred in which rolling bearings are used as test specimens.

The FAG rolling bearing grease test rig FE9, which is in accordance with DIN 51 821, is mentioned in the standard DIN 51 825 for testing rolling bearing greases. On this test rig, the grease service life is tested with rolling bearings as test specimens.

When using the FAG test system FE9, speeds, loads and mounting conditions can be freely selected. Also, the operating temperature can be varied by means of a heating system. Running times and power consumption are the criteria for evaluating the lubricity.

With the FAG test system FE8 (draft of DIN 51 819), the rolling bearing type and, to a limited extent, the bearing size can also be freely selected. Also, it is possible to measure the energy losses due to bearing friction and the bearing wear. The measured results must be backed by statistics because the measured values scatter widely.

MIL Specifications

Specifications of the US Armed Forces indicating the minimum mandatory requirements for the materials to be supplied. Some engine and machine builders apply the same minimum mandatory requirements to the lubricants. The MIL minimum mandatory requirements are taken as a quality standard.

Mineral Oils

Crude oils and/or their liquid derivates.

Miscibility of Greases

-> Page 38

Miscibility of Oils

Oils of different grades or from different manufacturers should not be mixed at random. The only exception are HD engine oils which can generally be mixed. If fresh oils are mixed with used oils, sludge can deposit. Whenever there is the risk of sludge formation, samples should be mixed in a beaker.

Multigrade Oils

Engine and gear oils with improved viscosity-temperature behaviour.

Neutralization Number NZ

The neutralization number NZ is a yardstick in assessing the deterioration of a mineral oil. It is expressed in milligrams of potassium hydroxide required to neutralize the free acids in one gram of oil. Due to the additives, the neutralization number of doped fresh oils is usually above zero. The neutralization number of a used oil should not differ from that of a new oil by more than 2.

NLGI Class

-> Penetration.

Nominal Viscosity

-> Viscosity.

Operating Viscosity

Kinematic viscosity of an oil at operating temperature. It is termed n. The operating viscosity can be determined by means of a viscosity-temperature diagram. The operating viscosity of mineral oils with average viscosity-temperature behaviour can be determined by means of diagram 5.

Oil Separation

Oil can separate from the greases if they are stored for an extended period of time or temperatures are high. Oil separation is determined according to DIN 51 817. For-life lubrication requires a small, steady oil separation rate which must, however, be large enough to lubricate all contact areas.

Oxidation

-> Deterioration.

Penetration

Penetration is a measure of the consistency of a lubricating grease. It is determined by allowing a standard cone to sink into a grease sample and measuring the depth of penetration in tenths of a millimetre (time of penetration 5 s).

Worked penetration is the penetration of a grease sample that has been worked a standard amount of strokes at 25 °C. The penetration classes range from 000 bis 6 (DIN 51 81 8).

Penetration of common rolling bearing greases

Consistency classification to NLGI (Penetration classes)	Worked penetration [0.1 mm]
1	310-340
2	265-295
3	220-250
4	175-205

Pour Point

The pour point of a mineral oil is the lowest temperature at which an oil sample can just about flow, if cooled under specified conditions.

Pressure Viscosity

-> Viscosity-pressure behaviour.

Radiation

In addition to the SI units, the old units rd and rem are still used occasionally.
The absorbed dose is expressed in:
1 J/kg = 1 Gy (gray)
1 Gy = 100 rd (rad)
The dose equivalent is expressed in:
1 J/kg = 1 Sv (sievert)
100 rem = 1 Sv
1 rd = 1 rem

Rated Viscosity

The rated viscosity is the kinematic viscosity attributed to a defined lubrication condition. It can be determined with diagram 6 by means of the mean bearing diameter and the bearing speed. By comparing the operating viscosity ν_1 with the operating viscosity ν the lubrication condition can be assessed.

Refined Oils

A satisfactory resistance to ageing of lubricating oils is obtained by refining the distillates in lubricating oil production. Unstable compounds which can incorporate sulphur, nitrogen, oxygen and metallic salts are removed. Several refining processes are used, the most important being the treatment with sulphuric acid (acid treatment) and the extraction of oil-insoluble unstable compounds with solvents (solvent refining).

Refrigerator Oils

These are used in refrigerators where they are exposed to the effects of the refrigerant. Refrigerator oils are classified according to the refrigerants used. The minimum requirements are specified in DIN 51 503.

Relubrication Interval

Period after which lubricant is replenished. The relubrication interval should be shorter than the lubricant renewal interval.

SAE Classification

In English speaking countries and in automotive engineering, the viscosity of lubricating oils is specified according to the SAE classification (Society of Automotive Engineers). Conversion of the SAE values for engine oils are indicated in DIN 51 511, and for automotive gear oils in DIN 51 512.

Saponification Number VZ

The condition of new and used mineral oils, including those with additives, can be assessed by means of the saponification number VZ. It is expressed in milligrams of potassium hydroxide which are required to neutralize the free and bonded acids in one gram of oil and to saponify the esters in the oil.

Saybolt Universal Viscosimeter

Viscosimeter used in the USA for determining the conventional viscosity in SSU (Second Saybolt Universal) or in SUS (Saybolt Universal Seconds).

Seals, Seal Compatibility

The reaction of sealing materials with mineral oils and greases differs widely. They can swell, shrink, embrittle or even dissolve, operating temperatures, lubricant composition and duration of exposure playing a major role. Seal and lubricant manufacturers should be consulted for seal compatibility.

Sediments

Sediments are mainly formed by lubricant residues, soot and dirt particles. They are caused by oil deterioration, mechanical wear under the influence of excessive heating and too long oil renewal intervals. They settle in the oil sump, in the bearings, in filters, and in lubricant feed lines. Sediments are hazardous to the operational reliability.

Semi-fluid Greases

These are lubricating greases of semi-fluid to pasty consistency. To improve their load carrying capacity, semi-fluid greases which are generally used for gear lubrication, can be doped with EP additives or solid lubricants.

Setting Point

The setting point of a lubricating oil is the temperature at which the oil ceases to flow if cooled under specific conditions. It is 2 to 5 K lower than the pour point. The low-temperature behaviour of the oil slightly above the setting point may be unsatisfactory and must therefore be determined by measuring the viscosity.

Silicone Oils

Synthetic oils which are used for special operating conditions. They have better physical data than mineral oils, but have poorer lubricating properties and a low load carrying capacity. See also table in fig. 30.

Sludging

Air and water can effect the formation of oxidation products and polymerizates in mineral oil products. They settle as sludge.

Sodium Soap Base Greases

Sodium soap base greases adhere well to the bearing surfaces and form a uniform and smooth lubricating film on the rolling and sliding surfaces of rolling bearings. They tend to emulsify with water, i.e. they are not water resistant. The grease is able to absorb minor quantities of water without problem; larger amounts of water liquefy the grease and make it run out of the bearing. Sodium soap base greases have poor low-temperature properties. They can be used at temperatures ranging from approx. –30 °C and +120 °C.

Solid Foreign Particles

All foreign contaminants insoluble in n-heptane and solvent compounds to DIN 51 813 are generally referred to as solid foreign particles. Solid foreign particles in lubricating oils are evaluated according to DIN 51 592 E, in greases according to DIN 51 813, in solvent compounds according to DIN 51 813.

Solvates

Mineral oils refined with solvents.

Specifications

Military and industrial standards for lubricants which stipulate physical and chemical properties as well as test methods.

Spindle oils

Low-viscosity lubricating oils with a viscosity of approximately 10 to 90 mm^2/s at 40 °C.

Standard Lubricating Oils

Lubricating oils L-AN in accordance with DIN 51 501. They are used where no particular demands are placed on the lubricant.

Steam Turbine Oils

Highly refined, non-ageing oils (lubricating oils T) which are used for the lubrication of steam turbine gears and bearings. The oils are available with additives (EP) and without additives: DIN 51515 P1.

Suspension

Colloidal suspension of solid particles dispersed in liquids, e.g. oil-insoluble additives in lubricants.

Swelling Properties

The swelling properties of natural rubber and elastomers under the effect of lubricants are tested according to DIN 53 521.

Synthetic Lubricants

Lubricants produced by chemical synthesis; their properties can be adapted to meet special requirements: very low setting point, good V-T behaviour, small evaporation losses, long life, high oxidation stability.

Thickener

Thickener and base oil are the constituents of lubricating greases. The most commonly used thickeners are metal soaps (lithium, calcium, sodium-12 hydroxystearates etc.) as well as polyurea, PTFE and magnesium aluminium silicate compounds.

Thixotropy

The property of a grease to become softer when mechanically stressed and to return to its original consistency when left to rest. Preserving oils with special additives are also thixotropic.

Unworked Static Penetration

Consistency of a grease sample, measured at 25 °C, which was not treated in a grease worker.

Viscosity

Viscosity is the most important physical property of a lubricating oil. It determines the load carrying capacity of the oil film under elastohydrodynamic lubricating conditions. Viscosity decreases with rising temperature and vice-versa (see V-T behaviour). Therefore, it is necessary to specify the temperature to which any given viscosity value applies. The nominal viscosity of an oil is its kinematic viscosity at 40 °C. See also "Viscosity Classification". Physically, the viscosity is the resistance which contiguous fluid strata oppose mutual displacement. Distinction is made between the dynamic viscosity η and the kinematic viscosity ν. The dynamic viscosity is the product of the kinematic viscosity and the density of a fluid: $\eta = \rho \cdot \nu$, ρ being the density. The SI Units (internationally agreed coherent system of units) for the dynamic viscosity are Pa s or mPa s. They have replaced the formerly used units Poise (P) and Centipoise (cP). Conversion: 1cP = 10^{-3} Pa s. The SI units for the kinematic viscosity are m^2/s und mm^2/s. The formerly used unit Centistoke (cSt) corresponds to the SI unit mm^2/s.

Viscosity Classification

The standards ISO 3448 and DIN 51 519 specify 18 viscosity classes ranging from 2 to 1500 mm^2/s at 40 °C for industrial liquid lubricants (see table).

ISO Viscosity Classification:

Viscosity class ISO	Viscosity at 40 °C mm^2/s	Limits of kinematic viscosity at 40 °C mm^2/s min.	max.
ISO VG 2	2.2	1.98	2.42
ISO VG 3	3.2	2.88	3.52
ISO VG 5	4.6	4.14	5.06
ISO VG 7	6.8	6.12	7.48
ISO VG 10	10	9.00	11.0
ISO VG 15	15	13.5	16.5
ISO VG 22	22	19.8	24.2
ISO VG 32	32	28.8	35.2
ISO VG 46	46	41.4	50.6
ISO VG 68	68	61.2	74.8
ISO VG 100	100	90.0	110
ISO VG 150	150	135	165
ISO VG 220	220	198	242
ISO VG 320	320	288	352
ISO VG 460	460	414	506
ISO VG 680	680	612	748
ISO VG 1000	1000	900	1100
ISO VG 1500	1500	1350	1650

Viscosity Index VI

The viscosity index VI of an oil gives a measure of its viscosity-temperature behaviour.

Viscosity Index Improvers

Additives dissolved in mineral oil which improve the viscosity-temperature behaviour. At high temperatures, they increase the viscosity, at low temperatures they improve the flow properties (fluidity).

Viscosity-Pressure Behaviour

Viscosity of a lubricating oil as a function of pressure. With a rise in pressure the viscosity of mineral oils increases (diagram, fig. 3).

V-T Behaviour

The term viscosity-temperature behaviour refers to the viscosity variations with temperatures. The V-T behaviour is good if the viscosity varies little with changing temperatures.
-> Viscosity Index (VI).

Water Content

If an oil contains water, the water droplets disrupt the lubricating film and reduce lubricity. Water in oil accelerates deterioration and leads to corrosion. The water content can be determined by distillation or by settling in a test tube; due to its higher specific gravity the water settles at the bottom. Samples of emulsifying oils must be heated. A small amount of water is identified by a crackling noise which is produced when the oil is heated in a test tube.

Water Resistance

The water resistance of lubricating greases is tested according to DIN 51 807 (static test); it is not indicative of the water resistance of the grease when used in the field. The test merely shows the effect which static, distilled water has on an unworked grease at different temperatures.

Water Separation Ability

Ability of an oil to separate water.
The test is carried out according to DIN 51 589.

Worked Penetration

Consistency of lubricating greases at 25 °C measured by the penetration depth of a standard cone, after treatment of the grease sample in a grease worker (DIN 51 804 T2 and DIN ISO 2137).

Rolling Bearing Lubrication

Every care has been taken to ensure the correctness of the information contained
in this publication but no liability can be accepted for any errors or omissions.
We reserve the right to make changes in the interest of technical progress.

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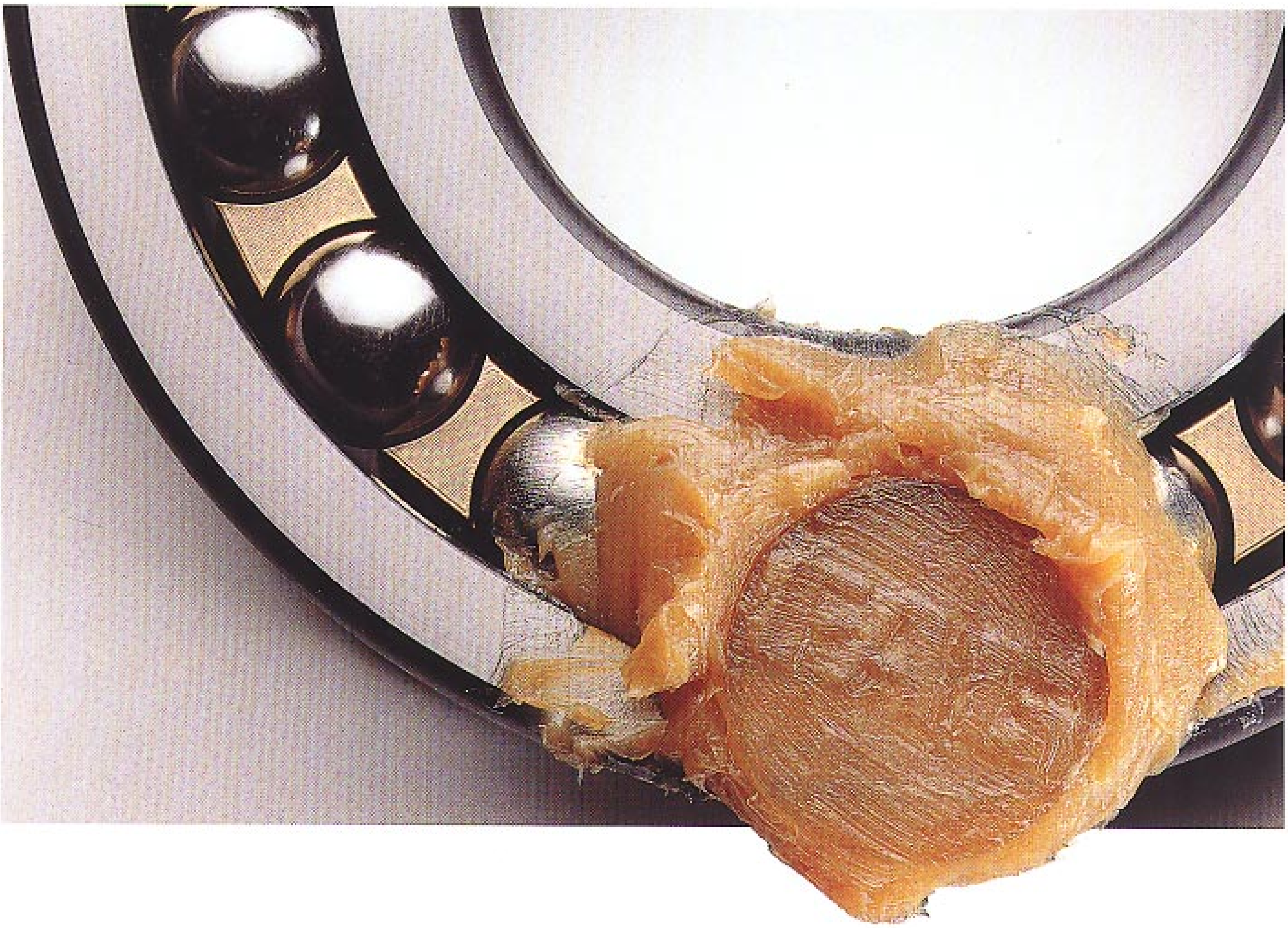
Arcanol
Rolling bearing-tested grease



arcanol

For a longer bearing life •
FAG rolling bearing grease

A grease has a long way to go until it may call itself Arcanol

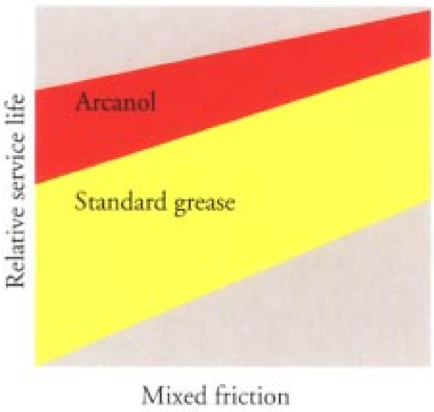
Special rolling bearing greases like Arcanol at first glance cost a little more than standard greases. But they are worth the price. For with Arcanol you buy some extra security as FAG selects only the best from a number of suitable greases in a series of tests, and gives quality assurance and specific lubricating recommendations for specific applications. Bearings which fail prematurely because they were lubricated with the wrong grease, with all the unpleasant and expensive consequences that go with it, increasingly belong to the past.

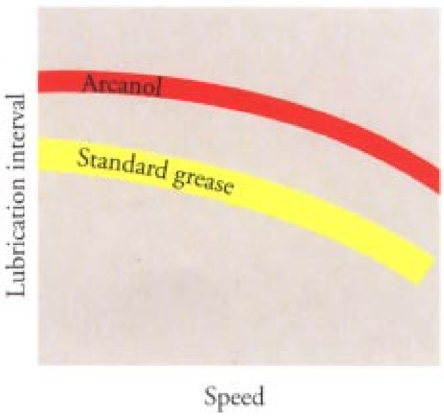
We long ago started to develop, in cooperation with renowned lubricant manufacturers, suitable rolling bearing lubricants. However, before any new grease is included in the Arcanol programme, it has to pass a series of tests in the FAG lubricant lab where all greases are put to the acid test. On our grease test rigs FE8 and FE9 the greases are tested in rolling bearings to find out how they improve service life and reduce friction and wear. Only the best greases are subjected to the following field tests in far more complicated rolling bearing test rigs. If the results meet the requirements of the stringent FAG specifications, the greases are included in the Arcanol programme.

In addition, we test every single batch to ensure the uniform quality of the product. Only after the grease has passed this final test it is allowed to be filled into tubes, cartridges, cans and buckets labelled Arcanol.

The programme consists of eight greases which cover nearly all fields of application optimally.

- **More than 80 % of all rolling bearings are grease-lubricated.**
- **More than 40 % of all cases of rolling bearing damage are caused by inadequate lubrication.**
- **Therefore users need lubricants and lubricating recommendations which they can rely on.**
- **Arcanol rolling bearing greases ensure that a bearing can be used to its full capacity**
  - long service life
  - good running behaviour
  - very safe operation





DIN 51 502

Thickener

Base oil viscosity at 40 °C (mm²/s)

Consistency (NLGI class)

Operating temperature range (°C)

Typical applications for Arcanol rolling bearing greases

Low temperatures

High temperatures

Low friction, high speed

High loads, low speeds

Vibrations

Sealing properties

Suitability for relubrication

	L78V	L71V	L135V	L186V	L223V	L74V	L12V	L79V
	K2K-30	K3N-30	KP2N-40	KP2K-20	KP2N-10	KE2K-40	K2P-30	KFK2U-30
	Lithium soap	Lithium soap	Lithium soap with EP additives	Lithium soap with EP additives	Lithium soap with EP additives	Special soap	Polyurea	Synthetic
	100	100	85	490	1 200	23	115	390
	2	3	2	2	2	2	2	2
	-30..+130	-30..+140	-40..+150	-20..+140	-10..+140	-40..+130	-30..+175	-30..+270
	Standard grease for smaller bearings ø D ≤ 62 mm in -small electric motors -agricultural and construction machinery -household appliances	Standard grease for larger bearings ø D > 62 mm in -large electric motors -wheel bearings for motor vehicles -ventilators	Special grease for bearings in -rolling mills -construction machinery -motor vehicles -rail vehicles -spinning and grinding spindles at -high speeds -high loads -high temperatures	Special grease for bearings in -mining machinery -construction machinery -machines with oscillating movements at -extremely high loads -medium speeds -medium temperatures	Special grease for bearings in -machines like those listed under L186V, particularly for impact loads and large bearings at -extremely high loads -low speeds	Special grease for bearings in -machine tools -spindle bearings -instruments at -high speeds -low temperatures	Special grease for bearings in -couplings -electric motors -generators at -high temperatures	Special grease for bearings in -track rollers in bakery machines -gudgeon pins in compressors -kiln trucks -chemical plants at -extremely high temperatures -chemically aggressive environment
	◒	◒	●	○	○	●	◒	◒
	◒	◒	●	◒	◒	◒	●	●
	◒	◒	●	○	○	●	◒	○
	◒	◒	●	●	●	○	◒	●
	◒	●	●	●	●	○	◒	○
	◒	●	◒	◒	◒	◒	◒	●
	●	◒	●	●	●	◒	◒	◒

Suitability of the greases for different requirements in operation. The grease is suitable for:

● very stringent requirements ◒ stringent requirements ○ moderate requirements

Quantities as they are needed in field work

arcanol	70 g Tube	250 g Tube	400 g Cartridge	1 kg Can	5 kg Bucket	10 kg Bucket	175/180 kg Barrel
L78V		✓	✓	✓	✓	✓	✓
L71V			✓	✓	✓	✓	✓
L135V			✓	✓	✓		✓
L186V			✓		✓	✓	✓
L223V					✓		✓
L74V		✓		✓			
L12V				✓	✓		✓
L79V	✓			✓			

FAG Kugelfischer Georg Schäfer AG

FAG

Rolling Bearings

For a longer bearing life •
FAG rolling bearing grease

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Rolling Bearing Damage

Recognition of damage and bearing inspection

FAG Rolling Bearings

FAG Bearings Corporation

Publ. No. WL 82 102/2 ED

Rolling Bearing Damage

Recognition of damage and bearing inspection

Publl. No. WL 82 102/2 ESi

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Preface

Rolling bearings are machine elements found in a wide field of applications. They are reliable even under the toughest conditions and premature failure is very rare.

The first sign of rolling bearing damage is primarily unusual operating behaviour of the bearings. The examination of damaged bearings reveals a wide and varied range of phenomena. Inspection of the bearings alone is normally not enough to pinpoint the cause of damage, but rather the inspection of the mating parts, lubrication, and sealing as well as the operating and environmental conditions. A set procedure for examination facilitates the determination of the cause of failure.

This brochure is essentially a workshop manual. It provides a survey of typical bearing damage, its cause and remedial measures. Along with the examples of damage patterns the possibility of recognising the bearing damage at an early stage are also presented at the start.

Bearings which are not classified as damaged are also inspected within the scope of preventive maintenance which is frequently carried out. This brochure therefore contains examples of bearings with the running features common to the life in question.

Cover page: What may at first appear to be a photo of sand dunes taken at a high altitude is in fact the wave-shaped deformation-wear-profile of a cylindrical roller thrust bearing. There is less than just 1 micron from peak to valley. At a slow speed mixed friction occurs in the areas stressed by sliding contact. Rippling results from the stick-slip effects.

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1 Unusual operating behaviour indicating damage

Gradual deterioration of the operating behaviour is normally the first sign of bearing damage. Spontaneous damage is rare, for example that caused by mounting errors or a lack of lubrication, which leads to immediate machine downtime. Depending on the operating conditions, a few minutes, or under some circumstances even a few months, may pass from the time damage begins to the moment the bearing actually fails. The case of application in question and the effects of bearing damage on the machine operation are taken as a basis when selecting the type of bearing monitoring to be provided.

1.1 Subjective damage recognition

In the vast majority of bearing applications it is sufficient when machine operators watch out for uneven running or unusual noise in the bearing system, see table 1.

1.2 Bearing monitoring with technical devices

Bearings which could be hazardous when damaged or which could lead to long production down-times require on the other hand accurate and constant monitoring. Two examples are jet engine turbines and paper-making machines. For monitoring to be reliable, its extent must be based on the type of damage which may be expected.

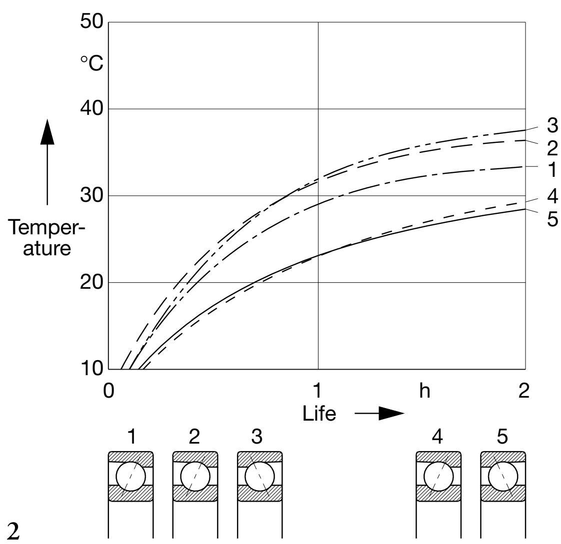
1.2.1 Wide-spread damage

A sufficient supply of clean lubricant is the main precondition for trouble-free operation. Undesirable changes can be detected by:

1: Recognition of damage by operating staff

Symptoms	Sources of trouble	Examples
Uneven running	Damaged rings or rolling elements Contamination Excessive bearing clearance	Motor vehicles: more and more wheel wobbling increased tilting clearance vibration of steering system Fans: growing vibration Saw mills: more knocks and blows in connecting rods
Reduced working accuracy	Wear due to contaminants or insufficient lubrication Damaged rings or rolling elements Change in adjustment (clearance or preload)	Lathe: gradual development of chatter marks on workpiece Grinders: wavy ground surface Cold rolling mill: Periodic surface defects on rolled material such as stretcher strains, ghost lines etc.
Unusual running noise: whining or squealing noise	Insufficient operating clearance	
rumbling or irregular noise	Excessive clearance Damaged contact areas Contamination Unsuitable lubricant	Electric motors Gears (the bearing noise is hard to identify since it is generally drowned by the noise of the gears)
gradual change in running noise	Change in operating clearance due to temperature Damaged running track (e.g. due to contamination or fatigue)	

2: March of temperature with intact main spindle bearings in a machine tool. Test condition: $n \cdot d_m = 750\,000\ min^{-1} \cdot mm$.
3: March of temperature with disturbed floating bearings. Test condition: $n \cdot d_m = 750\,000\ min^{-1} \cdot mm$.



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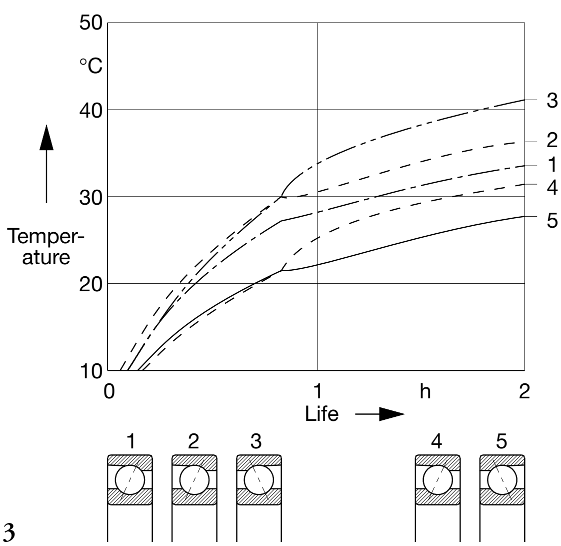


3

– Monitoring lubricant supply
  • oil level window
  • measuring oil pressure
  • measuring oil flow

– Measuring abraded matter in lubricant
  • at intervals
    magnetic plug
    spectral analysis of lubricant samples
    inspection of oil samples in the lab
  • continuously
    magnetic signal transmitter
    finding amount of particles flowing through with an online particle counter

– Measuring temperature
  • generally with thermocouples

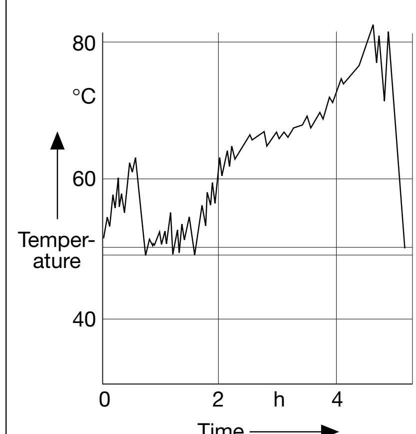
A very reliable and relatively easy way of recognising damage caused by inadequate lubrication is by measuring the temperature.

Normal temperature behaviour:
– reaching a steady state temperature in stationary operation, fig. 2.

Disturbed behaviour:
– sudden rise in temperature caused by lack of lubricant or by the occurrence of excessive radial or axial preload on the bearings, fig. 3.
– uneven march of temperature with maximum values tending to rise due to general deterioration of lubrication condition , e.g. with attained grease service life, fig. 4.

Measuring the temperature is not suitable, however, to register local damage at an early stage, e.g. fatigue.

4: March of temperature as a function of time with failing grease lubrication. Test condition: $n \cdot d_m = 200\,000\ min^{-1} \cdot mm$.



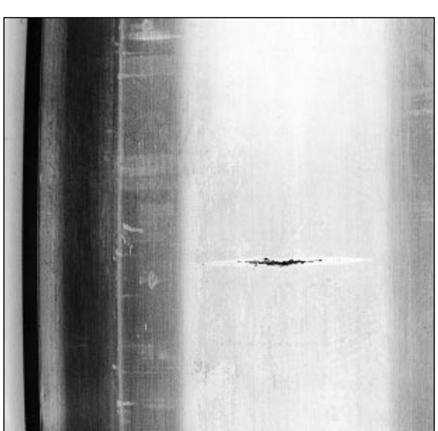
1.2.2 Damage in certain spots

Should bearing damage be restricted to specific locations such as indentations caused by rolling elements, standstill corrosion or fractures, it can be recognised at the earliest with vibration measurements. Shock waves which originate from the cycling of local indentations can be recorded by means of path, speed and acceleration pick-ups. These signals can be processed further at little or great expense depending on the operating conditions and the accuracy of the expected confidence factor. The most common are:

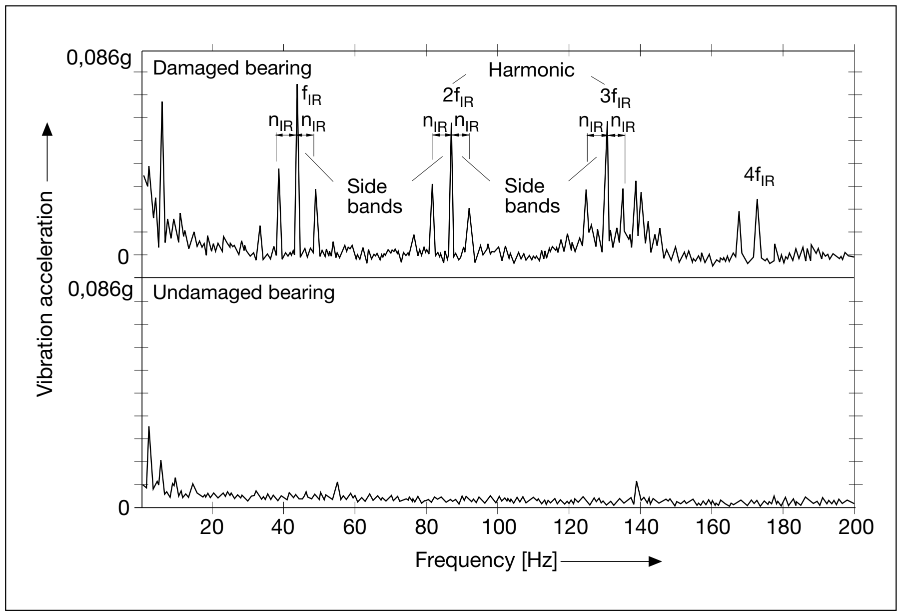
- measuring effective value
- measuring shock value
- signal analysis by envelope detection.

Experience has shown that the latter procedure is particularly reliable and practical in use. The damaged bearing components can even be pinpointed with a special type of signal processing, figs. 5 and 6. Please refer to our Publication WL 80 136 "Diagnosis of rolling bearings in machines and plants >FAG Rolling Bearing Analyser<" for more information.

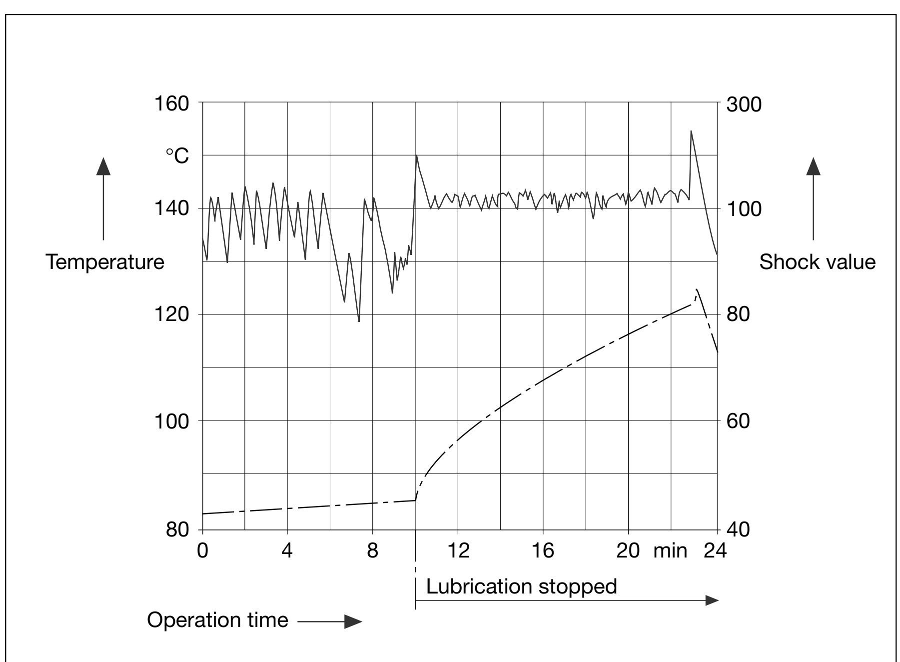
6: Inner ring damage to a spherical roller bearing in a paper making machine found by means of the envelope detection procedure.



5: Frequency spectrum of envelope signal between 0 and 200 Hz, below: undamaged bearing; above: damaged bearing
n_{IR} Inner ring speed [min^{-1}]
f_{IR} Frequency of inner ring signal (cycling frequency) [Hz]



7: March of temperature and shock value as a function of time stopping lubrication. Spindle bearing B7216E.TPA; P/C = 0.1; n = 9000 min^{-1}; Lubricating oil ISO VG100.



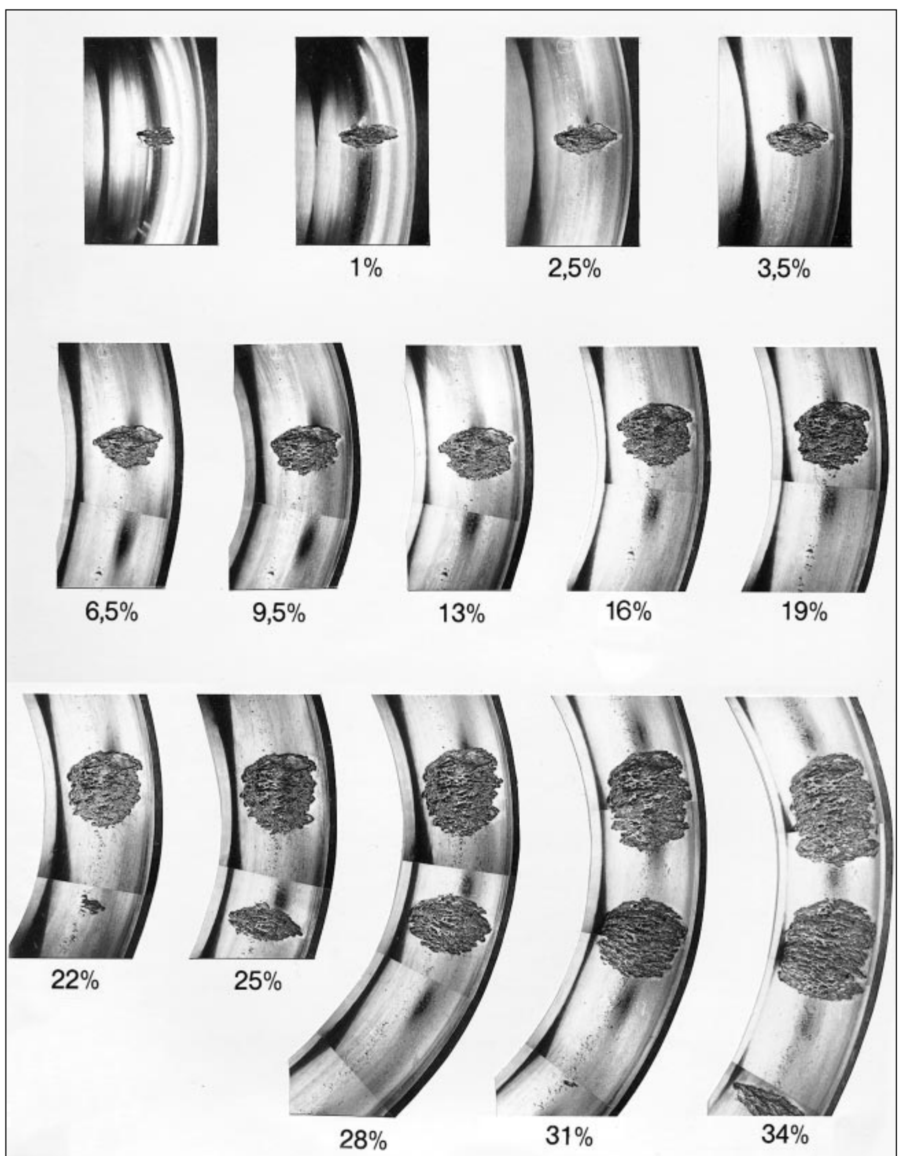
The vibration measuring procedures are very suitable for detecting fatigue damage. It is easiest with bearings with point contact (ball bearings) and with more sophisticated evaluation procedures such as envelope detection, for example, damage to roller bearings is found just as reliably. They are less suitable, however, for observing the lubrication condition. A fault in the lubricant supply can be reliably spotted by temperature measuring, as described above. This is particularly well illustrated in figure 7. The shock value is far less sensitive than the temperature sensor. Hence, in the case of expensive technical plants, temperature and vibration measurements complement one another ideally.

1.3 Urgency of bearing exchange – remaining life

Once bearing damage has been detected, the question arises as to whether the bearing must be exchanged immediately or whether it is possible to leave it in operation until the machine's next scheduled standstill. There are several conditions which must be given consideration before making any decision. If, for example, reduced working accuracy of a machine tool is reason to suspect bearing damage, the urgency of bearing exchange primarily depends on how long parts can continue to be produced without lacking in quality. Bearings which block suddenly at a high speed due to hot running caused by an interruption in lubricant supply going unrecognised, must be replaced immediately, of course.

In lots of cases a machine may remain in operation without the quality of the product suffering despite damage. How long it may do so depends on the bearing load, speed, lubrication, and lubricant cleanliness. Extensive examinations have been made on ball bearings on the progress of damage under various loads. The main results are as follows:

8: Development of fatigue damage on the inner ring raceway of an angular contact ball bearing. The periodic intervals between inspections from damage begin on, are given in percentage of the nominal life L_{10}.



Unusual operating behaviour indicating damage

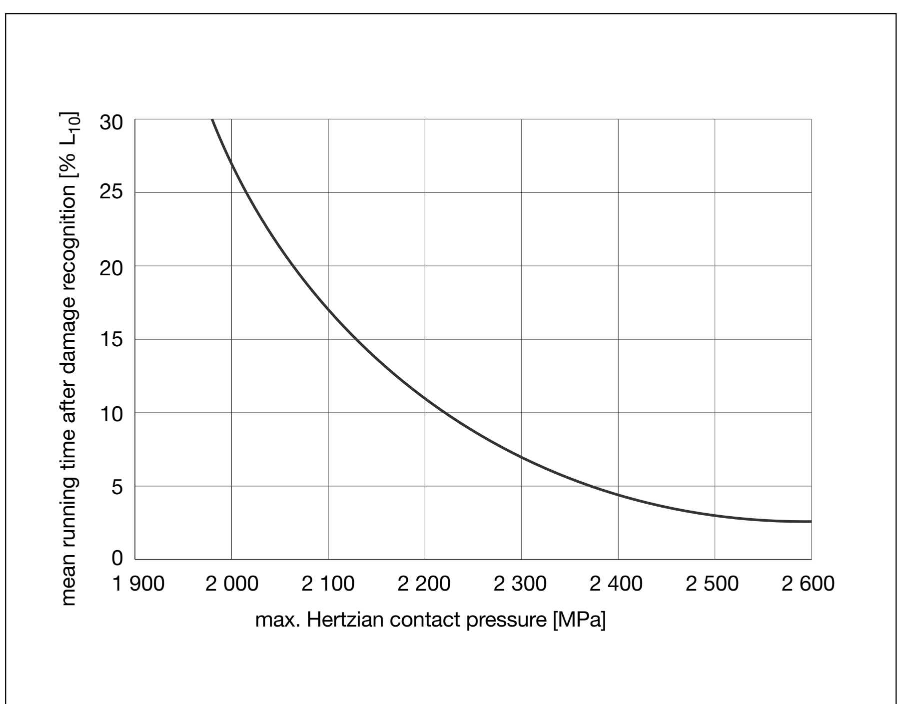
Urgency of bearing exchange

– With a moderate load, damage develops very slowly so that it is normally not necessary to replace the bearing prior to the next scheduled standstill.
– With an increasing load, damage grows far more quickly.
– The damage develops slowly first but as it becomes larger it spreads faster.

Figures 8 (page 7), 9 and 10 illustrate these findings.

9: Size of damage based on the running time after damage recognition (when approx. 0.1% of track circumference is flaked)

10: Mean remaining running time of angular contact ball bearings after recognition of fatigue damage based on stress condition until 1/10 of the track circumference is damaged. Operating condition prior to first signs of fatigue damage: Utmost cleanliness in EHD lubricating gap.



2 Securing damaged bearings

Should a bearing be removed from a machine due to damage the cause of the latter must be clarified as well as the means to avoid future failure. For the most reliable results possible it is practical to follow a systematic procedure when securing and inspecting the bearing. By the way, several of the points listed below should be given consideration when inspecting bearings dismounted during preventive maintenance.

Recommended sequence of measures:

- Determine operating data, evaluate records and charts from bearing monitoring devices
- Extract lubricant samples
- Check bearing environment for external influence and other damage
- Assessment of bearing in mounted condition
- Mark mounting position
- Dismount bearing
- Mark bearings and parts
- Check bearing seats
- Assessment of complete bearing
- Examination of individual bearing parts or dispatch to FAG

Important factors required for finding the cause of damage may be lost forever if the procedure selected is not suitable. Faults made when the damaged bearing is being secured can also disguise the damage pattern or at least make it extremely difficult to correctly explain the damage features.

2.1 Determination of operating data

Not only the bearing itself is examined when rolling bearing damage is being inspected but the environmental and application conditions are also checked in advance (with an assembly drawing if possible).

- Case of application:
  machine (device), bearing location, attained life, how many similar machines and how many failures in these machines
- Bearing construction:
  locating bearing, floating bearing
  floating bearing arrangement
  adjusted bearings (loose, rigid; with spacers, via fitting washers)
- Speed:
  constant, changing (inner ring and outer ring)
  acceleration, deceleration or retardation
- Load:
  axial, radial, combined, tilting moment
  constant, changing (collective)
  oscillating (acceleration, oscillation amplitude)
  centrifugal force
  point load, circumferential load (which ring is rotating?)
- Mating parts:
  shaft seat, housing seat (fits)
  fastening parts (e.g. type of locknut, elastic bolts etc.)
- Environmental conditions:
  external heat, cooling
  special media (e.g. oxygen, vacuum, radiation)
  vibrations in standstill
  dust, dirt, dampness,
  corrosive agents
  electric or magnetic fields
- Lubrication:
  lubricant, lubricant quantity
  lubricant supply
  relubrication interval
  date of last relubrication interval/last oil change
- Sealing
  contact, non-contact
- History of damaged bearing:
  first mounting or replacement bearing
  changes in bearing location/machine in the past
  failure frequency so far
  calculated L_{10} life
  life normally attainable
  particularities during operational period up to now
  repairs on other machine parts (construction measures, welding)
  machine trouble due to other machine elements (e.g. seal damage, loss of oil)
  distance and means of transport of the machine or bearings
  packaging
- Evaluate records and charts from bearing monitoring devices if available

2.2 Extraction and evaluation of lubricant samples

Lubricants can reveal diverse indications of damage causes in rolling bearings. Suitable test samples are a must (only with open bearings), please refer to DIN 51750, ASTM Standard D270-65 and 4057-81.

- Grease lubrication:
  - Documentation of grease distribution and colour in the bearing environment
  - Extraction of samples from different places in the bearing and bearing environment with corresponding marking
- Oil lubrication:
  - Remove samples from the oil flow near the bearing or from the middle of the supply container
  - Extract samples during machine operation or directly after in order to obtain a typical distribution of foreign matter
  - Do not remove samples from the bottom or from directly behind filters (wrong concentration of particles)

Securing damaged bearings

- Independent of the oil samples, filter residue should also be kept for inspection (indication of history prior to damage)

– General
- How often had the bearing been relubricated or had the oil been changed? When was either last carried out?
- Check oil or grease for any pieces broken off the bearing or other components
- Use clean vessels for the samples. They should be made of suitable material (glass, for example)
- There should be enough room left in the vessel for stirring the oil sample in the laboratory
- The analysis of the samples may take place at the customer's, in an external lubricant laboratory or at FAG. Points of interest are generally the degree of contamination and its type (sand, steel, soft little parts, water, cooling liquid) as well as an analysis of the lubricity (eg. ageing, consolidation, colour, coking, share of additives). If possible, a sample of fresh grease or oil should be handed on and ex amined as well (in the case of unknown lubricants, effects of heat)

2.3 Inspection of bearing environment

– Could surrounding parts have grazed against bearing parts anywhere?
– Are any other parts close to the bearing damaged (consequential or primary damage)?
– Cleanliness within and externally to seals (any foreign matter in the bearing space?)
– Loosening force of bearing fastening parts (was the bearing forced to deform? Are the bolts loose?)

2.4 Assessment of bearing in mounted condition

– Are there any ruptured or chipped areas?
– Are the seals damaged, particularly deformed or hardened?
– Is the bearing deformed at the visible areas?
– Can scratches by foreign matter be detected?
– Does the bearing run easily or tightly in mounted condition? (fit effect)

2.5 Dismounting damaged bearing

Great care should be given not to distort the damage pattern when dismounting a damaged bearing. If this is not possible damaged caused when dismounting should be marked and noted down. The following procedure should be observed if possible:
– Do not apply dismounting force via the rolling elements
– High dismounting force could be an indication of disturbed floating bearing function
– Do not open sealed bearings
– Do not destroy or damage heat-sensitive parts (lubricant, seal, cage) by heating too much
– Mark bearing (mounting location, mounting direction)

2.6 Seat check

– Shaft and housing dimensions (detrimental preload, seats too loose)
– Form tolerances of seats (oval deformation)
– Roughness of seats (excessive material loss)
– Fretting corrosion (varying degrees indicate uneven support, load direction)

2.7 Assessment of complete bearing

The bearings should always be handed over uncleaned, i.e. with lubricant remains, for assessment.

The following should be checked:
– General condition (cleanliness of bearing and condition of fitting surfaces, i.e. traces of mounting, fretting corrosion, ring fractures, dimensional accuracy, seizing marks, discolouration)
– Condition of seals and dust shields. Photograph or description of place and extent of any grease escape.
– Condition of cage
– Manual rotation test (indication of contamination, damage or preload)
– Measure bearing clearance (displaceability of rings in radial and axial direction), whereby bearings are loaded equally and rotated!

2.8 Dispatch to FAG or assessment of individual parts of bearing

The causes of failure basically possible can be detected very often by customers themselves or by an FAG employee on the site. Whether more specific examinations are required or not depends on the distinctness of each damage feature. The procedure for examining individual bearing parts is described in detail below.

If it is quite obvious that an examination is to be made at FAG the parts should be prepared for dispatch as follows:
– neither dismantle the bearing nor clean it. On no account should cold cleanser or gasoline be used for rinsing (otherwise lubrication hints disappear, corrodibility).

– Avoid contamination after dismounting. Pack the bearings separately in clean foil if possible, since paper and cloths remove oil from the grease.
– Select sufficiently strong and thick packaging to prevent damage arising during transport.

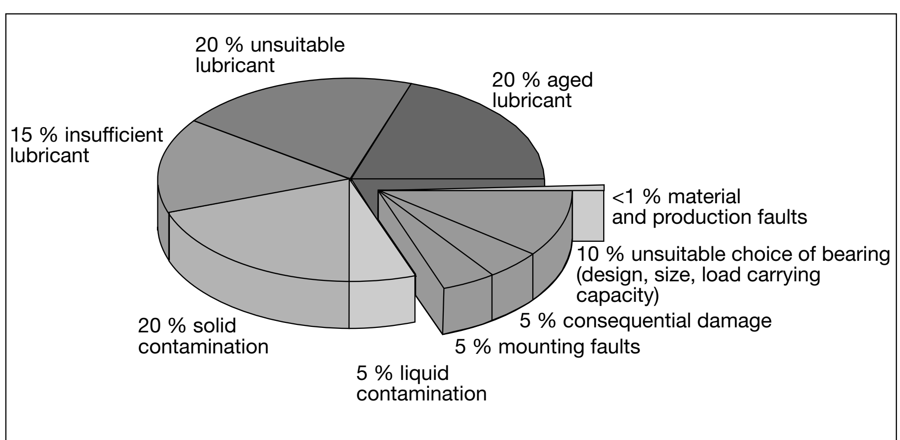
3 Evaluation of running features and damage to dismounted bearings

Bearing damage may not always imply a complete failure of a rolling bearing but also implies a reduction in the efficiency of the bearing arrangement. In this context it should be remembered that the earlier the particular bearing is dismounted the sooner the source of trouble can be detected.

A bearing arrangement can only function smoothly if the operating and environmental conditions and the components of the arrangement (bearings, mating parts, lubrication, sealing) are correctly coordinated. The cause of bearing damage does not always lie in the bearing alone. Damage which originates from bearing material and production faults is very rare. Prior to inspecting bearing damage by means of individual parts the possible damage sources should be studied based on the facts found according to Section 2. The operating conditions or external features of the bearing frequently provide an indication of the cause of damage. The table in fig. 12 illustrates the main damage features in rolling bearings with their typical causes.

This summary cannot take all types of damage into account but just provide a rough outline. It should also be kept in mind that a number of damage patterns are exclusively or almost only found with certain types of bearings or under special application conditions. In many cases one bearing may reveal several damage features concurrently. It is then frequently difficult to determine the primary cause of failure and a systematic clarification of diverse damage hypothesis is the only answer. The systematic procedure described below is recommended for such cases.

11: Causes of failure in rolling bearings (Source: antriebstechnik 18 (1979) No. 3, 71-74). Only about 0.35% of all rolling bearings do not reach expected life.



Evaluation of running features and damage to dismounted bearings

12: Rolling bearing damage symptoms and their causes

Symptom	Damaged area of bearing					Typical causes of rolling bearing damage					
						Mounting					
	Seats	Rolling contact areas	Lip and roller face areas	Cage	Sealing	Incorrect mounting procedure or tools	Dirt	Fit too tight, too much preload	Fit too loose, too little preload	Poor support of rings	Misalignment or shaft deflection
a) Unusual running behaviour											
Uneven running						■	■		■		
Unusual noise						■	■	■	■	■	■
Disturbed temperature behaviour								■			■
b) Appearance of dismounted bearing parts											
1 Foreign particle indentations		■					■				
2 Fatigue		■				■	■	■		■	■
3 Stationary vibration marks		■									
4 Molten dents and flutes		■									
5 Skidding		■							■		
6 Rolling element indentations, scuffing		■	■			■					
7 Seizing marks		■	■	■							
8 Wear		■	■	■	■		■				
9 Corrosion		■	■	■	■						
10 Overheating damage	■	■	■	■	■			■			
11 Fractures	■	■	■	■		■		■		■	
12 Fretting corrosion (false brinelling)	■								■	■	

Symptom	Typical causes of rolling bearing damage									
	Operational stress			**Environmental influence**				**Lubrication**		
	Load too high or too low	Vibra-tions	High speeds	Dust, dirt	Aggressive media, water	External heat	Current passage	Unsuitable lubricant	Insufficient lubricant	Excess lubricant
a) Unusual running behaviour										
Uneven running		■		■	■		■	■		
Unusual noise	■	■		■	■		■	■	■	
Disturbed temperature behaviour	■		■			■		■	■	■
b) Appearance of dis-mounted bearing parts										
1 Foreign particle indentations				■						
2 Fatigue	■			■		■		■	■	
3 Stationary vibration marks		■								
4 Molten dents and flutes							■			
5 Skidding	■								■	
6 Rolling element indentations, scuffing	■									
7 Seizing marks	■		■					■	■	
8 Wear				■				■	■	
9 Corrosion					■			■		
10 Overheating damage			■			■		■	■	■
11 Fractures										
12 Fretting corrosion (false brinelling)		■								

3.1 Measures to be taken

3.1.1 Marking separate parts

- When there are several bearings from the same type of bearing location number all bearing parts and keep a record of their arrangement in the location.
- Mark lateral arrangement of bearing parts to one another and in their mounting position.
- Mark radial mounting direction of the rings with regard to external forces.

3.1.2 Measurements taken with complete bearing

- Noise inspection
- Inspection of radial/axial clearance
- Inspection of radial/axial runout
- Inspection of frictional moment

3.1.3 Dismantling bearing into separate parts

- Determine grease quantity if grease has escaped from sealed bearings.
- Remove dust shields and seals carefully from sealed bearings avoiding deformations as much as possible.
- Assess grease distribution in the bearing.
- Take grease sample; take several samples if there is an irregular lubricant pattern.
- If dismounting cannot be non-destructive, those parts which are assumed to have had no influence on the cause of damage should be destroyed (e.g. cut or turn off the retaining lip at the small cone diameter of tapered roller bearing).

- Should damage be inevitable during the dismounting procedure it should be marked and taken note of.

3.1.4 Assessment of bearing parts

A good look at the main running and mounting features is taken first without using any devices.

A microscopic inspection of the bearing parts is recommended and often a must for the majority of bearings.
The following procedure for assessing bearing parts is usually suitable:

Assessment of:
- Seats (axial mating surfaces, inner ring bore, outer ring outside diameter)
- Raceways
- Lips
- Sealing seat surface/contact surface
- Rolling elements (outside diameter and face in the case of rollers)
- Cages
- Seals

Other inspections may also be required in order to clarify the cause of damage. These include lubricant analyses, measurements, electron micro-scopical tests, etc. In FAG's laboratories for product research and development you will find competent employees ready to assist (refer to section 4).

It must often be decided whether a bearing can be used again or whether it has to be replaced. There is no doubt about the procedure to be followed when the damage is quite obvious. Such damage, however, is seldom. The bearing assessment often provides an indication of the operating condition nevertheless. When unusual symptoms and their causes are detected extensive damage can frequently be avoided.

The following sections contain descriptions of symptoms, advice concerning their significance and cause and, where appropriate, preventive measures.

3.2 The condition of the seats

Diverse conclusions can be drawn from the condition of the seats about the supporting quality of the bearing rings on the shaft and in the housing. Ring movements against the seats cause noise which is often disturbing. They also lead to fretting corrosion and wear which in turn leads to lubricant contamination by corrosive and abrasive particles. In addition to this, the ring support continues to deteriorate and fretting corrosion can make dismounting difficult. A few examples are provided below.

3.2.1 Fretting corrosion

Symptoms:

Brownish-black spots on the seats, occassionally with brown abraded matter near bearing or in the lubricant as well. Wear at the fitting surfaces (bore, outside diameter), fatigue fracture possible in the case of rotating parts (usually the shaft), disturbance of floating bearing function possible in the case of stationary parts (usually the housing), fig. 13. With such fretting corrosion conclusions can frequently be made regarding the position and size of the load zone, fig. 14, and creeping of the rings.

Causes:
- Micromotion between fitted parts where fits are too loose in relation to the acting forces, but no creeping of rings
- Form disturbance of fitting surfaces
- Shaft deflection, housing deformation
- Floating bearing function at ring with circumferential load

Remedial measures:
- Provide floating bearing function at ring with point load
- Use bearing seats which are as tight as possible
- Make shaft (housing) more rigid to bending
- Coat bearing seats
- Use dimensionally stable rings for high operating temperatures (prevents fit loosening due to ring expansion as a result of changes in steel structure)
- Improve roundness of seats
- Check and improve, if required, the surface quality of the seats

13: Fretting corrosion in bore of a cylindrical roller bearing inner ring with seat too loose

14: Fretting corrosion reveals the size of the load zone at the stationary outer ring

3.2.2 Seizing marks or sliding wear

Symptoms:

Cold welding at the fitting surfaces (inner ring bore, outer ring outside diameter) and axial mating surfaces or also shiny contact areas where surface roughness is good, figs. 15, 16.

Wear of fitting surface and face, fig. 17, perhaps reduction in preload or clearance enlargement.

Causes:

- Rotary motion between ring and shaft/housing with loose fits under circumferential load; with static load and unbalance also
- Axial support of rings insufficient
- Sluggish movement of floating bearing

Remedial measures:

- Use bearing seats which are as tight as possible
- Extend axial mating surfaces
- Secure axial support
- Keep fitting surfaces dry
- Improve floating bearing function

16: Seizing marks in the inner ring bore as a result of inner ring creeping on the shaft

15: Seizing marks on the outside diameter as a result of outer ring creeping in the housing

17: Circumferential scoring and cold welding at the inner ring faces as a result of inner ring creeping on the shaft

3.2.3 Uneven support of bearing rings

Symptoms:

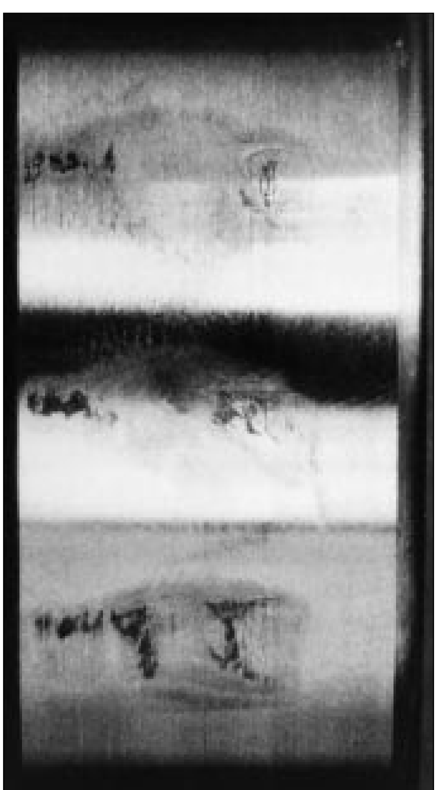
Seating marks not in the area of the expected load zone.

Machining structure of fitting surfaces worn in some areas and completely untouched in others, figs. 18, 19. Later fatigue damage and fractures due to uneven load distribution and bending of rings. Lip fractures result from too little support of tapered roller bearing cones, fig. 20, and plastic setting phenomenon from contact surfaces which are too small.

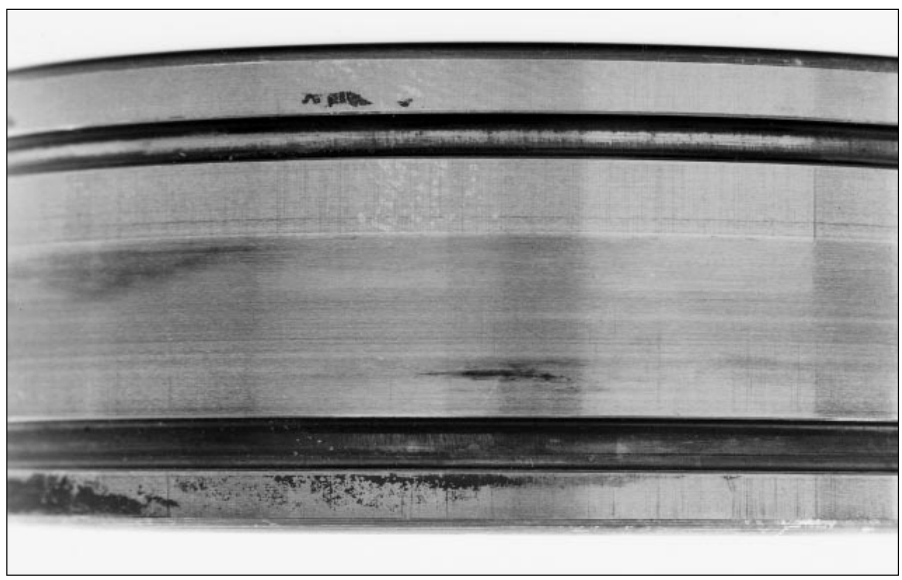
Causes:
– Unsuitable design
– Inaccurate machining

Remedial measures:
– Change mating parts constructively keeping uniform housing rigidity in mind; if necessary use other bearings
– Check production of mating parts

18: Outer ring outside diameter, fretting corrosion at "tough points" (e.g. ribs) in the housing



19: Outer ring outside diameter, only half its width supported



20: Lip fracture of a tapered roller bearing cone due to insufficient axial support of face

3.2.4 Lateral grazing tracks

Symptoms:

Circumferential scratch marks/wear on the faces of the bearing rings or seals, figs. 21, 22.

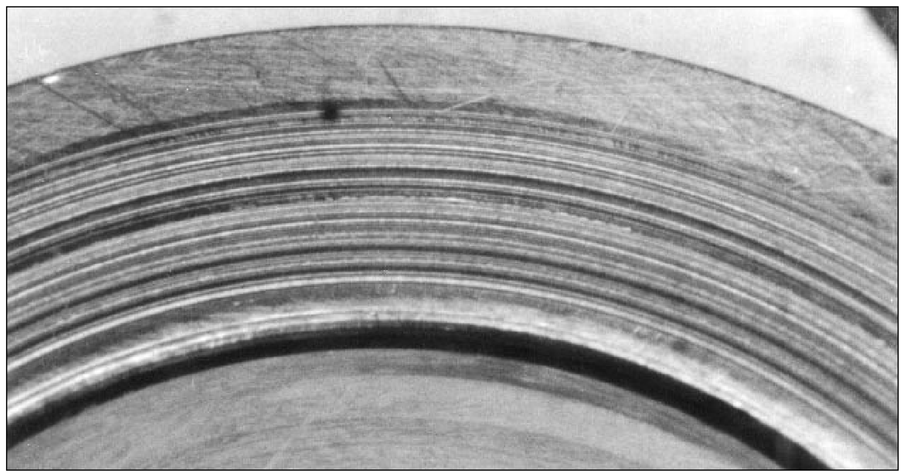
Causes:

– Insufficient fixation of the bearings in the housing or on the shaft
– Large amount of external contamination with narrow gap between bearing and mating part
– Loose mating parts
– Axial clearance too large

Remedial measures:

– Adjust parts correctly
– Ensure lubricant cleanliness
– Check axial clearance and make it closer perhaps

21: Circumferential scoring and cold welding at the faces due to grazing by a mating part



22: Seal damage due to lateral grazing

3.3 Pattern of rolling contact

3.3.1 Source and significance of tracks

Regardless of the occurence of damage, there are changes in the contact surfaces between rings and rolling elements called tracks to be found on every bearing which has been in operation. These tracks arise from the roughening or smoothening of the surface structure originally produced. They are also characterised by indentations made by cycled foreign particles which are often microscopically small. Conclusions can therefore be drawn from the tracks about the quality of lubrication, lubricant cleanliness and the direction of load as well as its distribution in the bearing.

3.3.1.1 Normal tracks

Under rotary motion and load the rolling elements leave tracks on the raceways which are bright in appearance when the lubricant film separates well. The individual pattern of the tracks is, however, largely dependent on the illumination of the surface but it should be possible to recognise almost all the machining structure particularly when working with a magnifying glass and microscope (compare with non-contact areas at the edge of the raceway!). Individual indentations of small foreign particles are inevitable. When lubrication is particularly good they are the only indication of the position of the load zones in the bearing, fig 23.

When temperatures are above approximately 80 °C discolouration of the raceways or rolling elements is a frequent feature. It originates from chemical reactions of the steel with the lubricant or its additives and has no negative effect on the service life of the bearing. Quite the contrary: These surface features frequently indicate effective wear protection of an additive.

Usually brown or blue colours result. However, no obvious conclusions can be drawn from the colour about the operating temperature which led to its origin. Very different shades of colour have at times been observed on the rolling elements of a bearing although the operating conditions are very similar.

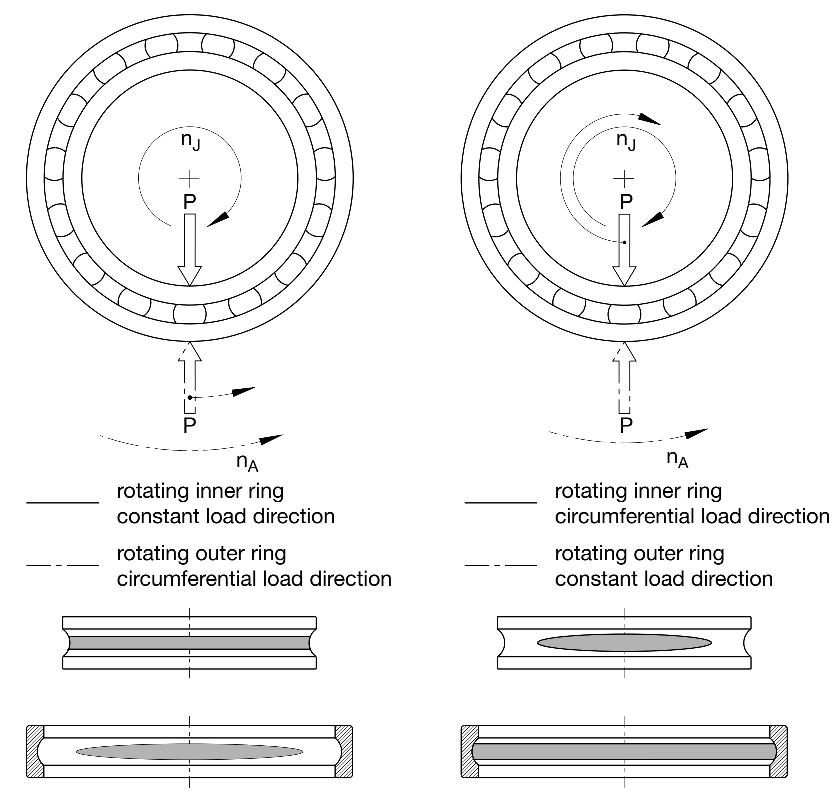
This oil discolouration should on no account be confused with the tempering colours which are found on faulty bearings in rare cases and which arise as a result of much higher temperatures, see section 3.3.5.

Tracks in the form of equatorial lines are sometimes found on balls as well. They appear on angular contact ball bearings when the balls always have the same rotary axis. Any significant reduction in life does not derive from them, fig. 24.

23: Normal track, surface structure still visible, just small indentations by foreign particles

24: Ball with equatorial circumferential lines

25: Radial load of a radial bearing, e.g. deep groove ball bearing. Under point load and with a sufficiently rigid housing, the track on the stationary ring is shorter than half the raceway circumference in so far as there is no radial preload. Under circumferential load, the track spreads over the entire raceway circumference.
a: Point load for the outer ring, circumferential load for the inner ring
b: Point load for the inner ring, circumferential load for the outer ring

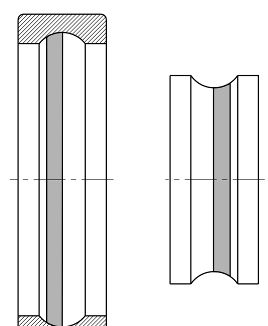


25a 25b

26: Axial load of a radial bearing, e.g. deep groove ball bearing. On the inner and outer rings the tracks spread off-centre over the entire raceway circumference.

27: Combined radial-axial load of a deep groove ball bearing. In the case of the inner ring (circumferential load) there is a constant wide track over the entire raceway circumference. The track on the outer ring (point load) is wider in the radial load zone than on the rest of the circumference.

The arrangement of the tracks is based on the direction of the external load and the cycling conditions (point load or circumferential load, axial load, combined load), figs. 25 to 27. A "target-actual" comparison would also reveal important information on unexpected load conditions, e.g. a disturbed floating bearing function. In the case of radial load exclusively, the origination of tracks in circumferential direction on the stationary ring depends mainly on the amount of load, the size of the bearing clearance, and the rigidity of the mating parts. The greater the load and smaller the clearance as well as the softer the housing, the longer the load zone is and thus the track also.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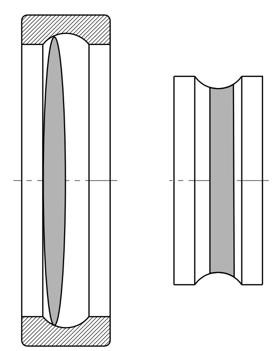
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3.3.1.2 Unusual tracks

Whether tracks are considered normal or unusual depends greatly on the case of application. Bearings could have perfectly normal tracks, for example, which are an indication of mainly radial load. If, however, the bearings should be operating under axial preload, the tracks would be an indication of incorrect bearing mounting. Therefore, in order to assess the tracks correctly the conditions of application should be known. Some fundamental symptoms can, however, always be assessed by means of the tracks.

- Tracks in the case of **inadequate lubrication**

Symptoms:

The visual pattern of the tracks and the surface as observed by microscope, that is, roughness, make it possible to draw conclusions about the quality of lubrication. Dull roughened tracks arise from a non-separating lubricant film under moderate load.

The thinner the lubricant film the greater the influence on the surface. We refer to poor surface separation in this case, fig. 28.

When the specific load is high in the contact areas, the tracks are bright, pressure-polished and frequently shiny and are a clear contrast to the uncycled part of the raceways, fig. 29.

Causes:
- Insufficient lubricant quantity available in the bearing
- The viscosity of the lubricant is insufficient for the operating temperature and speed (see catalgoue "FAG Rolling Bearings", adjusted rating life calculation)

Remedial measures:
- Improve lubricant supply
- Adapt lubricant viscosity to operating conditions
- Use lubricant with approved additives
- Use bearing parts with surface coating

28: Track with surface wear

29: Pressure-polished track

- Tracks in the case of **contamination in bearing or lubricant**

We must first differentiate between solid and liquid contamination.

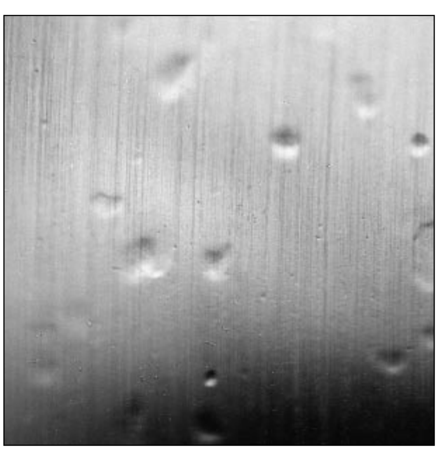
Symptoms with solid contamination:
Indentations are the result of foreign particles being cycled on the raceway. By means of the indentations, microscopic inspection of the tracks allows the differentiation between particles made of soft material, hardened steel and hard minerals, figs. 30, 31, 32. Foreign particles which are particularly large and hard are a hazard to the life. You can find more detail on this in the description of fatigue damage, please refer also to "Fatigue resulting from the cycling of foreign particles" in section 3.3.2.1.
A large amount of small hard foreign particles leads to roughening as in fig. 28 and accelerates abrasive wear.

Symptoms with liquid contamination:
Water is one of the main liquid contaminants. It can be taken up by the lubricant in some small amounts. It degrades the effect of lubrication, however, and often leads to tracks like those illustrated in fig. 29. When there are large amounts of moisture in the bearing dull tracks arise. Pressure-polished tracks with fatigue damage result also from corrosion or high load, please refer to "Fatigue as a result of poor lubrication" in section 3.3.2.1.

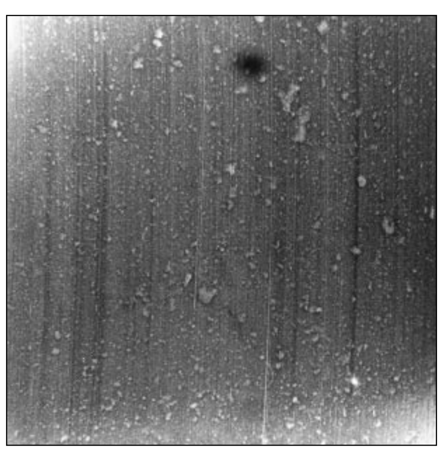
Causes:
- Inadequate sealing
- Mounting conditions not clean
- Production residues, e.g. foundry sand
- Temperature differences (condensation of water)
- Dirty oil

Remedial measures:
- Improve sealing constructively
- Clean mounting and well washed mating parts, coat if necessary
- Rinse out entire oil system before taking into operation (before first bearing rotation!)

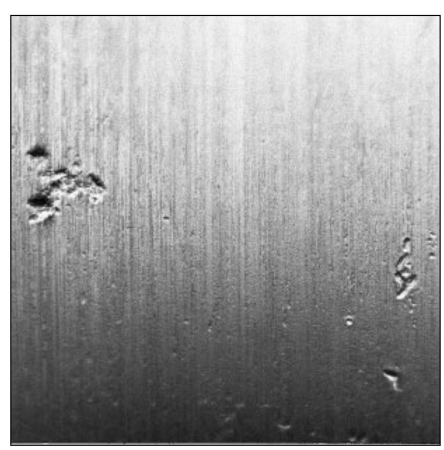
30: Indentations of soft foreign particles



31: Indentations of foreign particles made of hardened steel



32: Indentations of hard mineral foreign particles



• Tracks with **detrimental radial preload**

Symptoms:
Circumferential tracks appear on both rings in the case of detrimental radial preload, fig. 33. Hot run damage can arise in extreme cases, section 3.3.5.

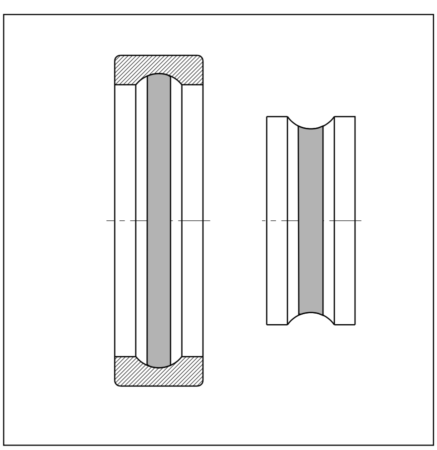
Causes:
– Fit interference at shaft/housing too large
– Temperature difference too great between inner and outer rings
– Bearing clearance too small

• Tracks with **oval deformation**

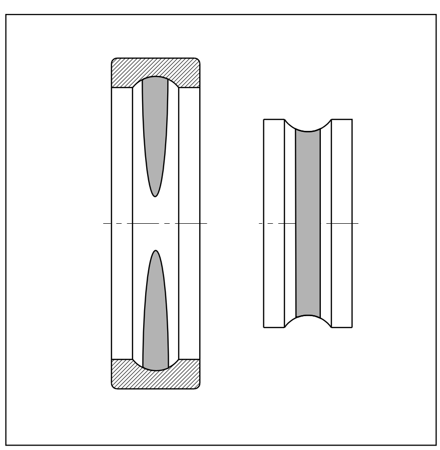
Symptoms:
Several separate track areas form on the circumference of the stationary ring, fig. 34.

Causes:
– Oval housing or shaft, e.g. due to diverse rigidness throughout the circumference during machining or due to tap holes near the bearing seats
– Different housing rigidness in circumferential direction with high interference of the outer ring
– Storing thin-walled bearings in vertical position

33: Deep groove ball bearing under detrimental radial preload. The tracks extend over the entire circumference, even on the point loaded ring.



34: Oval deformation of a deep groove ball bearing. Two opposed radial load zones formed in the raceway of the ovally deformed outer ring (point load).



Evaluation of running features and damage to dismounted bearings

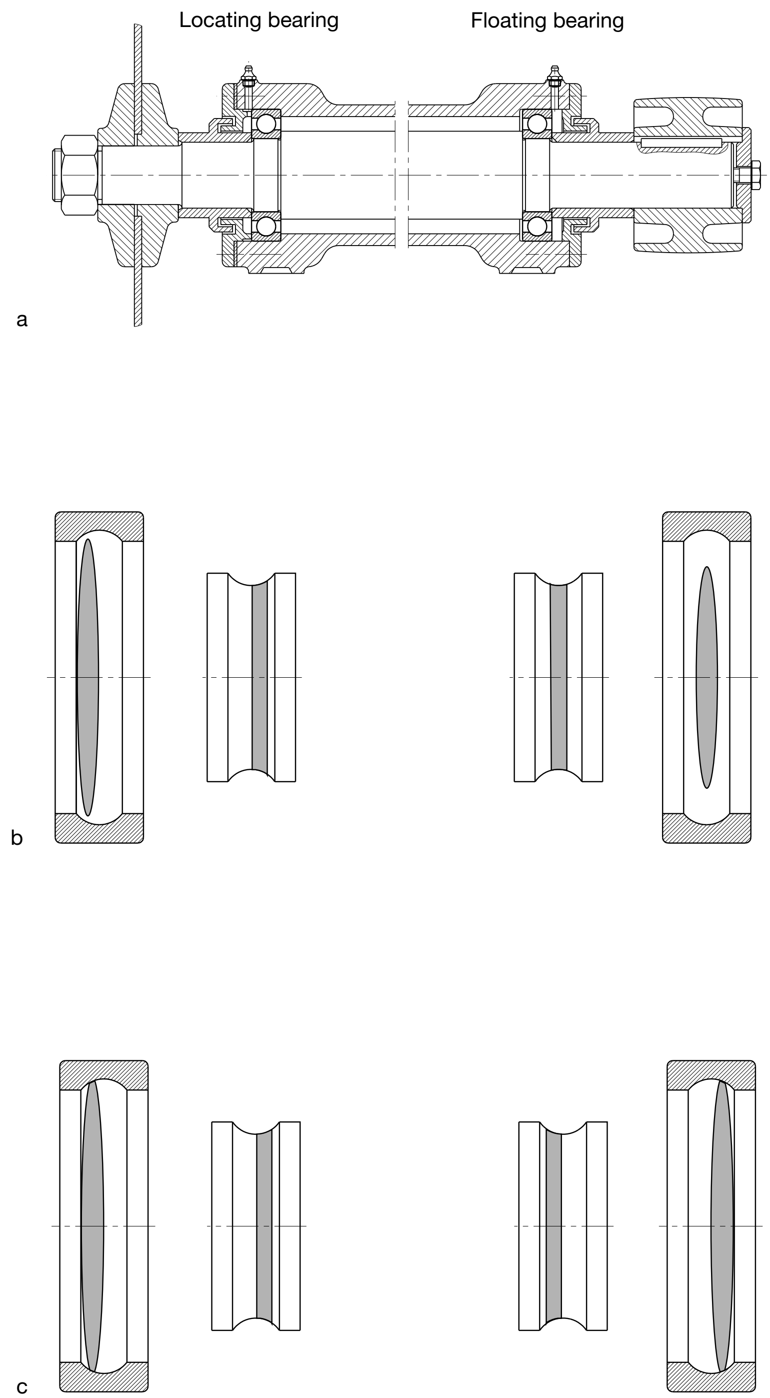
Pattern of rolling contact

• Tracks with **detrimental axial preload**

Symptoms:
Only the locating bearing of a locating-floating bearing arrangement may have distinctive tracks, as illustrated in fig. 35b, as they originate under axial load (fig. 26). At the most, a slight axial load share (preferably none at all) should be detected on the floating bearing.

Causes:
– Disturbed floating bearing function (wrong fit, radial-acting heat expansion, tilting, fretting corrosion)
– Unexpectedly high axial-acting heat expansion

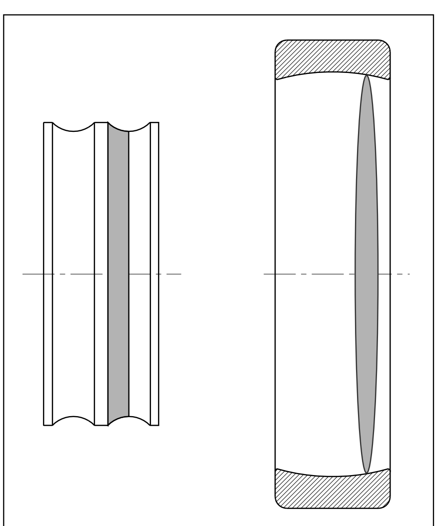
Remedial measures:
– Check fit and form accuracy of mating parts
– Change mounting and operating conditions
– Use bearing with axial displaceability: cylindrical roller bearing N, NU, NJ



35: Locating-floating bearing arrangement with two deep groove ball bearings.
a: The deep groove ball bearing on the work end is designed as the locating bearing, the bearing on the drive end as the floating bearing.
b: Tracks on bearings in working order. The locating bearing shows the characteristics of a bearing under combined load, the floating bearing those of a bearing under mainly/purely radial load.
c: Tracks on bearings under detrimental axial preload (outer ring of floating bearing does not move). Each bearing shows the characteristics of a combined load. The detrimental axial preload is clear from the symmetric tracks of both bearings.

36: Flaking in one of the tracks on the outer ring of a self-aligning ball bearing caused by detrimental axial preload

37: Development of tracks in the case of a self-aligning ball bearing with rotating inner ring under detrimental axial preload and radial load

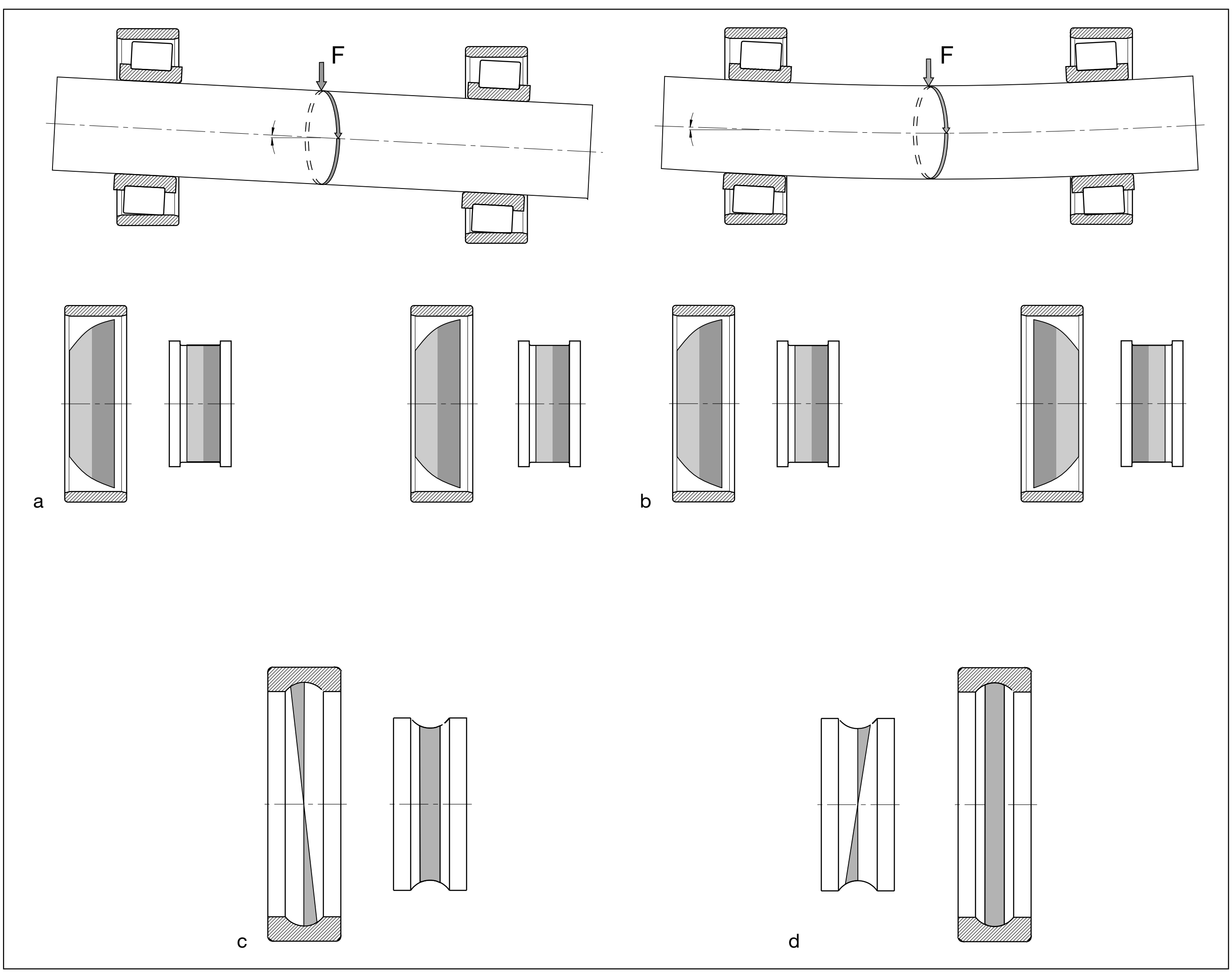


• Tracks with **misalignment**
Symptoms:
In the case of ball bearings the track of the stationary ring does not run vertically but diagonally to the axial direction, figs. 38 and 39. With roller bearings the track is more distinct on one edge of the raceway than on the other under tilting, fig. 40.

Causes:
- Shaft deflection
- Misaligned housing halves or plummer block housings
- Out-of-square abutment surfaces
- Dirt between abutment surfaces and bearing rings during mounting
- Too much bearing clearance in combination with moment load

Remedial measures:
- Observe mounting specifications regarding permissible tilting, see FAG Catalogue
- Ensure cleanliness during mounting
- Set suitable bearing clearance

38: Misaligned bearings
a: Tilting of the inner rings relative to the outer rings in the case of misaligned housing seats
b: Tilting of the inner rings relative to each other in the case of shaft deflection
c: Tracks of a misaligned deep groove ball bearing with rotating inner ring
d: Tracks of a misaligned deep groove ball bearing with rotating outer ring



39: Oblique track in inner ring of deep groove ball bearing

40: Tilted track on a tapered roller bearing

3.3.2 Indentations in raceways and rolling element surfaces

On damaged bearing parts indentations are often found in the contact areas which could have the most diverse causes. Since they generally occur evenly distributed in large numbers, the indentations originating from the cycling of foreign particles were taken into consideration when assessing tracks (section 3.3.1). In the subsequent paragraphs reference is made mainly to those which are locally restricted to the ring.

3.3.2.1 Fractures

During cycling, the material of the raceways and rolling elements is subject to a continuous pulsating stress. This leads to failure patterns like those resulting from the fatigue of mating parts under bending stress: fatigue fractures develop. In rolling bearings these fractured areas run largely parallel to the surface and lead to material flaking and are referred to as fatigue damage, flaking, pittings, spalling, grey stippiness, micro pittings, steel pittings etc.

• **Classical fatigue**

Even with very favourable operating conditions, i.e. hydrodynamic separating lubricating film, utmost cleanliness and moderate temperatures, fatigue damage can develop on rolling bearing parts depending on the stress. Endurance strength is assumed where the index of stress is

$f_{s*} = C_0/P_{0*} \geq 8$

(C_0 = static load rating, P_{0*} = equivalent load). When the stress is greater, which means the f_{s*} value is smaller, fatigue damage can be expected after a more or less long operating period.

Such damage due to classical fatigue with cracks starting below the surface seldom occurs. Fatigue damage starts far more often at the surface of the components in rolling contact as a result of inadequate lubrication or cleanliness. The causes are no longer detectable when damage has advanced.

Symptoms:

Subsurface cracks of raceway and rolling elements, material flaking (relatively deep pitting), undamaged areas of the raceway indicate good lubrication in the early stage of damage, (see fig. 23), while more or less a lot of indentations by cycled fractured parts (see fig. 31) can be detected depending on how far damage has progressed, figs. 41 to 43.

41: Classical fatigue can be recognized by pitting in the raceway of a deep groove ball bearing inner ring. Material flakes off the entire raceway when damage advances.

42: Advanced fatigue damage on deep groove ball bearing

43: Fatigue damage in the outer ring raceway of a tapered roller bearing

• Fatigue as a result of **foreign particle cycling**

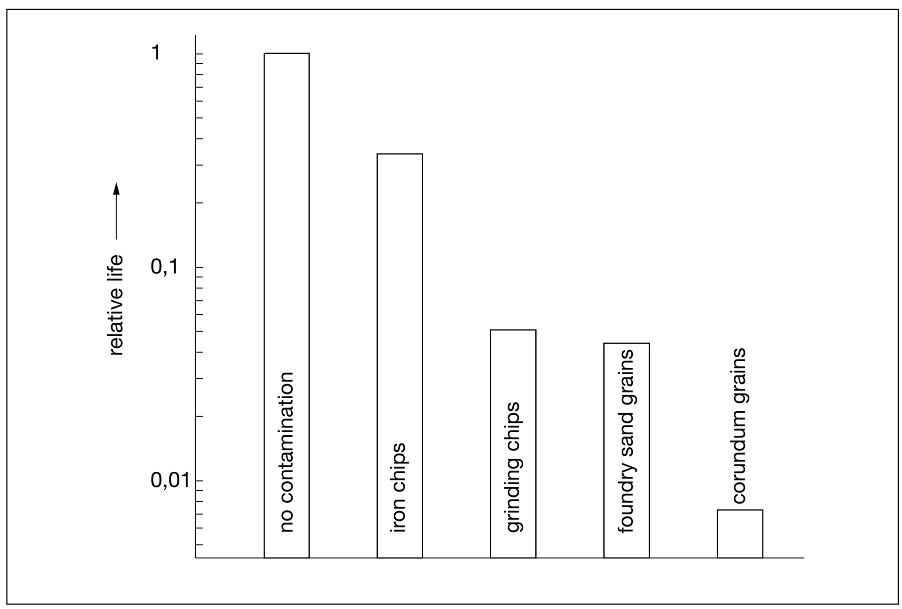
There is a great reduction in the fatigue life when rough contaminants are present in the bearing, fig. 44. The harmfulness of damage caused by foreign particles in actual cases of application depends on their hardness, size, and amount as well as the size of the bearing. With regard to fatigue ball bearings react more sensitively to contamination than roller bearings, and bearings with small rolling elements more sensitively than those with large ones. The rolled-up material plays a very important role where the indentation of foreign particles is concerned. It is particularly under stress during subsequent cycling and is responsible for the first incipient cracks, SEM fig. in section 4.

Symptoms:
Material flaking; V-shaped spreading behind the foreign particle indentation in cycling direction (V pitting), fig. 45.

Cause:
Damaged raceway, indentations by hard particles (foundry sand, grinding agent) are particularly dangerous.

Remedial measures:
– Wash housing parts thoroughly, and coat perhaps
– Cleanliness and caution required when mounting
– Improve sealing
– Use dirt-protected bearing construction
– Cleanliness of lubricant important
– Rinsing procedure with filtering prior to putting unit into operation

44: Reduction in life due to different contaminants



45: Fatigue damage caused by foreign particle indentation spreads itself in the cycling direction forming a V shape
a: Damage at the time of detection
b: Damage after about 1,000 operating hours
c: Damage after about 1,200 operating hours

• Fatigue as a result of **static overload**

Like foreign particle indentations, rolling element indentations develop due to the bearing's high static overload and their rolled-up edges lead to failure.

Symptoms:
At the early stage evenly edged indentations at rolling element spacing from which fractures arise, often only on part of the circumference.
Only on one ring sometimes. Usually asymmetric to centre of raceway.

Causes:
– Static overload, shock impact
– Mounting force applied via rolling element

Remedial measure:
– Mounting according to specification
– Avoid high impact forces, do not overload

• Fatigue as a result of **incorrect mounting**

Symptoms:
Fatigue near the small shoulder in the case of angular contact ball bearings, outside the contact angle area, fig. 46.

Causes:
– Insufficient adjustment
– Setting phenomenon of axial contact areas or in thread of clamping bolts
– Radial preload

Remedial measures:
– Rigid surrounding parts
– Correct mounting

46: Fatigue damage in groove bottom of an angular contact ball bearing's inner ring as a result of insufficient adjustment force

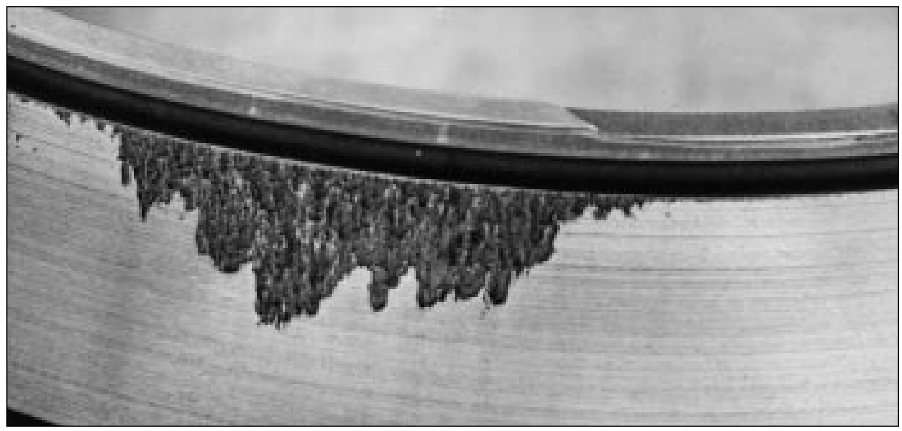
• Fatigue as a result of **misalignment**

Symptoms:
– Track asymmetric to bearing centre, fig. 40
– Fatigue on the edges of raceway/ rolling elements, fig. 47
– Circumferential notches on the entire or part of ball surface caused by plastic deformation and therefore having smooth edges. In extreme cases the bottoms of the notches may have cracks, fig. 48.

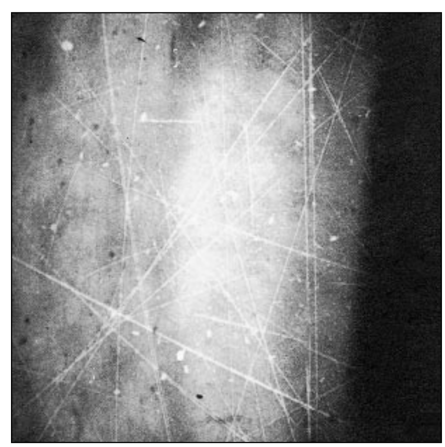
Causes:
Due to housing misalignment or shaft bending the inner ring tilts as opposed to the outer ring and high moment loads result. In ball bearings this leads to a constraining force in the cage pockets (section 3.5.4) and to more sliding in the raceways as well as the balls running on the shoulder edge. In the case of roller bearings, the raceway is asymmetrically loaded; when tilting of the rings is extreme, the edges of the raceways and rolling elements also carry the load causing excess stress in those positions, please refer to "Tracks with misalignment" in section 3.3.1.2.

Remedial measures:
– Use self-aligning bearings
– Correct misalignment
– Strengthen shaft

47: Fatigue may occur at the edge of the raceway of a misaligned tapered roller bearing due to local overload.



48: Fatigue at the raceway edge in the case of ball bearings, e.g. with high moment load (edge running); left raceway edge, right ball.

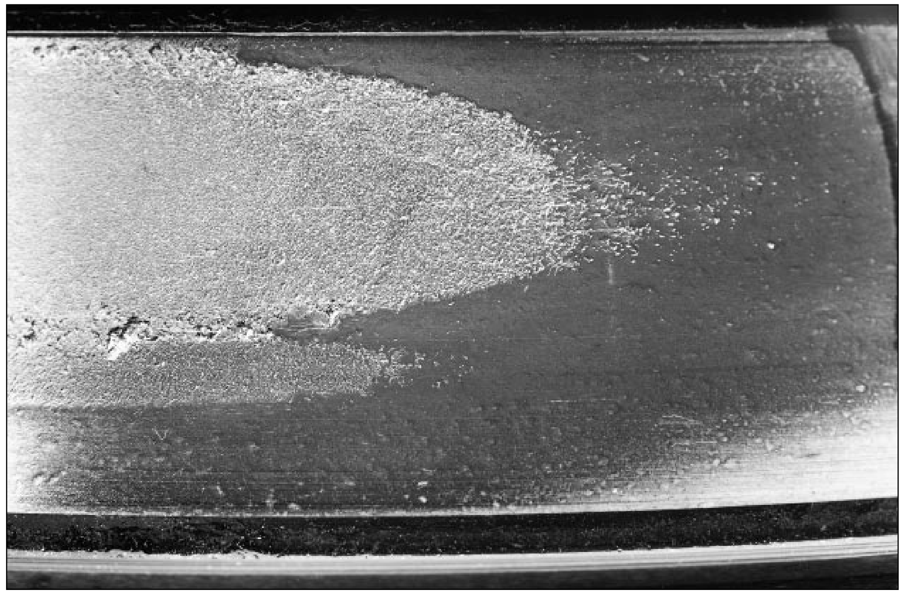


• Fatigue as a result of **poor lubrication**

Symptoms:
Depending on the load, diverse damage patterns arise in the case of poor lubrication. When load is low and slippage also occurs tiny superficial fractures develop. Since they grow in large numbers, they appear like spots on the raceway, fig. 49. We refer to the terms grey stippiness or micro pittings. When the load is very high and the lubricant has, for example, thinned down due to water penetration, mussel-shaped pittings develop when the raceways (fig. 29) are also pressure polished, fig. 50.
When loads are very high and lubrication is poor very distinct heating zones develop in the raceway where, in turn, incipient cracks arise when cycling continues.

Causes:
– Poor lubrication condition as a result of
– • insufficient lubricant supply
– • operating temperature too high
– • water penetrates
– causing more friction and material stress on the raceway surface
– Slippage at times

Remedial measures:
– Increase lubricant quantity
– Use lubricant with a higher viscosity, if possible with tested EP additives
– Cool lubricant/bearing position
– Use softer grease perhaps
– Prevent penetration of water



49: Micro pittings

50: Mussel-shaped fatigue

• Fatigue as a result of **wear**

Symptoms:
Local flaking, e.g. on the rolling elements of tapered roller bearing, figs. 51 and 52. Striped track, fig. 68.

Causes:
Change in geometry of components in rolling contact due to wear in the case of contaminated lubricant, for example due to the penetration of foreign particles when sealing is damaged. Local overload results, partly in connection also with insufficient adjustment of tapered roller bearings.

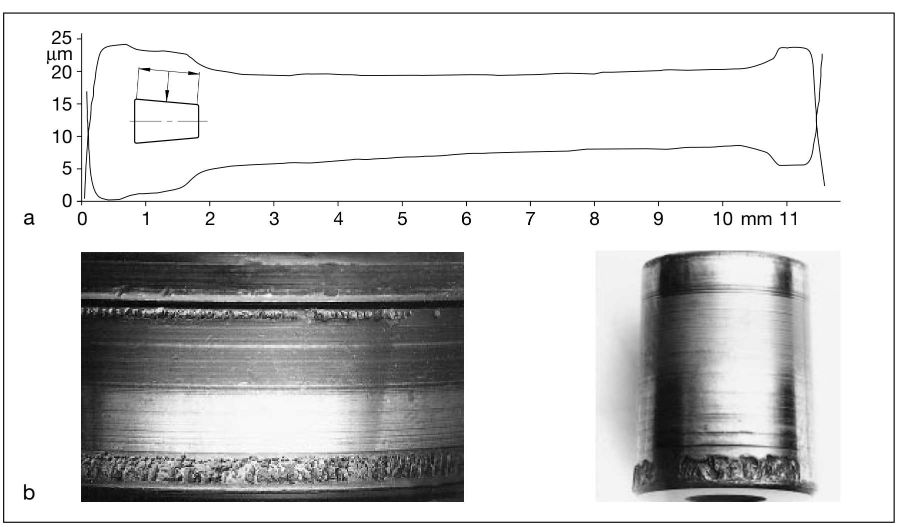
Remedial measures:
– Replace lubricant on time
– Filter lubricating oil
– Improve sealing
– Replace worn seals on time
– Special heat treatment for rings and rollers

• Fatigue due to **fracture in case layer**

Symptoms:
Raceway peeling in thick chunks in the case of case-hardened bearing parts.

Causes:
– Fracture or separation of case layer
– Load too high or case layer thickness too thin for given load, e.g. due to wrong design load

Remedial measures:
- Adjust thickness of case layer to suit load conditions
- Avoid overloading



51: Wear in diverse areas can change the geometry of the components in rolling contact to such an extent that local overload leads to fatigue
a: Cross profile of a roller;
b: Inner ring raceway and roller with fatigue damage.

52: Failure mechanism as in fig. 51 but with wear of the raceway edges, cross profile of the roller see fig. 69.

3.3.2.2 Corrosion damage

• Corrosion due to humidity (rust)

Symptoms:

Brownish discolouration of the complete bearing surface, usually unevenly distributed in the form of individual pits, fig. 53.

In many cases there are also spots of rust with pits at the rolling element pitch (standstill corrosion). Capillary effect causes humidity to concentrate on the contact areas when standstill is for a long period, fig. 54. This leads to wear at a later stage and premature fatigue originating at the rust pits.

Causes:
– Incorrect storage in warehouse (relative air humidity > 60%)
– Extreme temperature variations (condensation moisture)
– Sealing failure (accelerated by the abrasive action of dirt, fig. 87)
– Unsuitable lubricant

Remedial measures:
– Suitable storage according to the specifications of rolling bearing manufacturer
– Improvement in seals (additional shields perhaps)
– Use lubricant with corrosion inhibitors
– Relubricate frequently in the case of grease lubrication, particularly prior to standstill periods

53: Corrosion of the outer ring of a deep groove ball bearing, the corrosion protection of which was destroyed by humidity

54: Corrosion pits in the raceway at rolling element pitch

• Corrosion due to aggressive media

Symptoms:
Usually black etching pits, fig. 55.

Causes:
– Incorrect storage in warehouse (storage of aggressive chemicals in same area)
– Sealing failure
– Unsuitable lubricant

Remedial measures:
– Storage in accordance with rolling bearing manufacturer's specifications
– Improvement in seals
– Use lubricant with corrosion inhibitors

55: Surface damage due to attack of aggressive media. The etching pits are usually black.

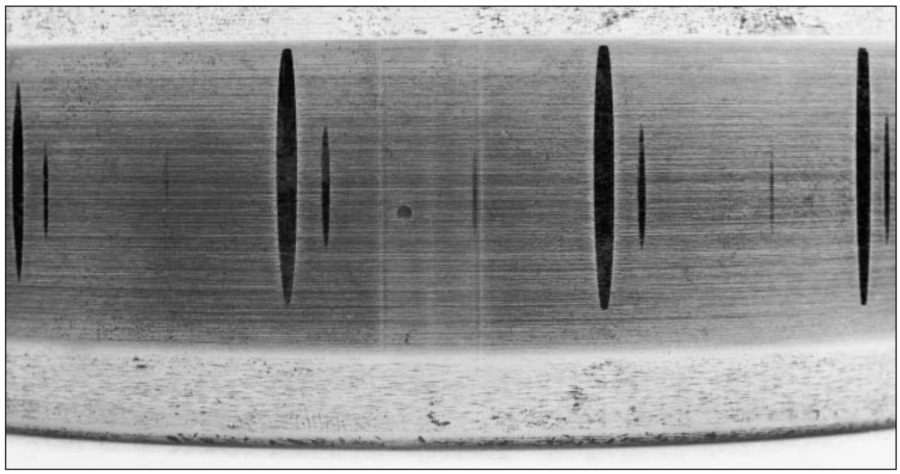
3.3.2.3 False brinelling

Symptoms:
Marks on the raceway surface at the rolling element pitch, figs. 56 and 57. No raised edges as opposed to marks due to incorrect mounting (see section 3.3.2.4 "Rolling element indentations"). Surfaces in the indentations frequently brown in colour (corrosion) and particularly with ball bearings badly roughened (machining structure missing). Scratches in the axial direction may also be detected with ball bearings. When the bearing rotates a little occasionally, several patches due to false brinelling arise.

Causes:
Vibrations in stationary machines which lead to micromotion in the contact areas of the components in rolling contact.

Remedial measures:
- Eliminate or absorb vibrations
- Avoid standstill of sensitive machines, leave running; use safety devices during transport which unload or preload the bearings.
- Use suitable lubricant (additives).
- Select larger radial clearance for rotating loads.

56: On the inner ring of a cylindrical roller bearing, marks due to false brinelling have developed on the raceway at rolling element pitch.



57: False brinelling on the ball bearing

3.3.2.4 Rolling element indentations

Symptoms:
Indentations at the rolling element pitch in the raceways of non-separable bearings, fig. 58. Fatigue sometines arising therefrom, see also "Fatigue as a result of static overload" in section 3.3.2.1.
The indentations may also have occured during dismounting: check cycling features (shiny edges), determine mounting direction.

Causes:
– Static overload/shock impacts
– Mounting or dismounting forces applied via rolling elements (incorrect mounting order, unsuitable accessories)

Remedial measures:
Mount the ring with the tight fit first. When both rings have a tight fit mount them together with a suitable disk.

58: Ball indentations in the shoulders of a deep groove ball bearing. The mounting tool was attached to the ring with a loose fit and the forces were therefore applied via the balls.

3.3.2.5 Craters and fluting due to passage of electric current

• Craters

Symptoms:
Craters in the raceway due to local melting at the contact area of the parts in rolling contact, sometimes several craters in a row or whole chains around the circumference. The surface in the craters is partly formed like welding beads, fig. 59.

Causes:
Sparking over current, for example during welding or due to earth contact failure

Remedial measures:
Do not direct current through the bearing during electro welding (earthing).

• Fluting

Symptoms:
Brownish marks parallel to the axis on a large part of the raceway or covering the entire raceway circumference, fig. 60.

Causes:
Constant passage of alternating or direct current, even low currents cause marks.

Remedial measures:
– Prevent currents from flowing through the bearing (earthing, insulation).
– Use current insulated bearings.

60: Fluting in the outer ring raceway of a deep groove ball bearing was caused by the constant passage of current.

59: Current sparkover led to the formation of craters in the raceway of a cylindrical roller bearing.

3.3.2.6 Rolling element edge running

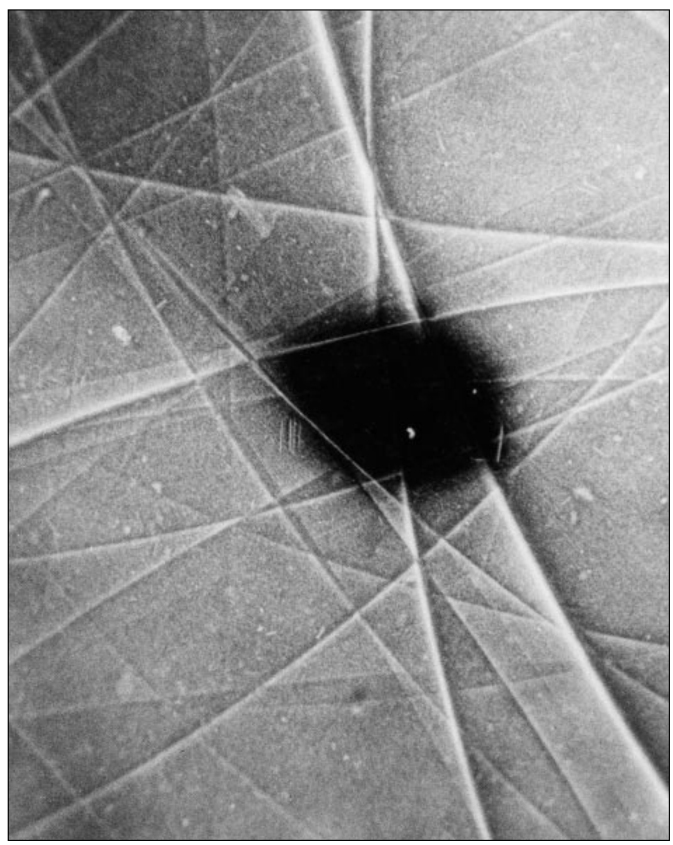
Symptoms:
In the case of balls, arch-shaped notches on the surface or what one could describe as "woolen balls" of notches, edges rounded since they are plastically deformed, figs. 61, 62. Circumferential notches near the faces in the case of rollers. Not to be confused with scratches by foreign particles, see section 3.3.4.2 "Scratches on rolling element outside diameters".

Causes:
- Excessive (axial) load
- Moment load too high
- Operating clearance too large
- Tilting

Remedial measures:
- Avoid overloading
- Use bearing with higher load carrying capacity
- Reduce operating clearance
- Avoid tilting

61: Ball with extreme edge tracks caused by long-term constant load

62: Ball with "woolen balls" of notches caused by long-term changing load



3.3.3 Ring fractures

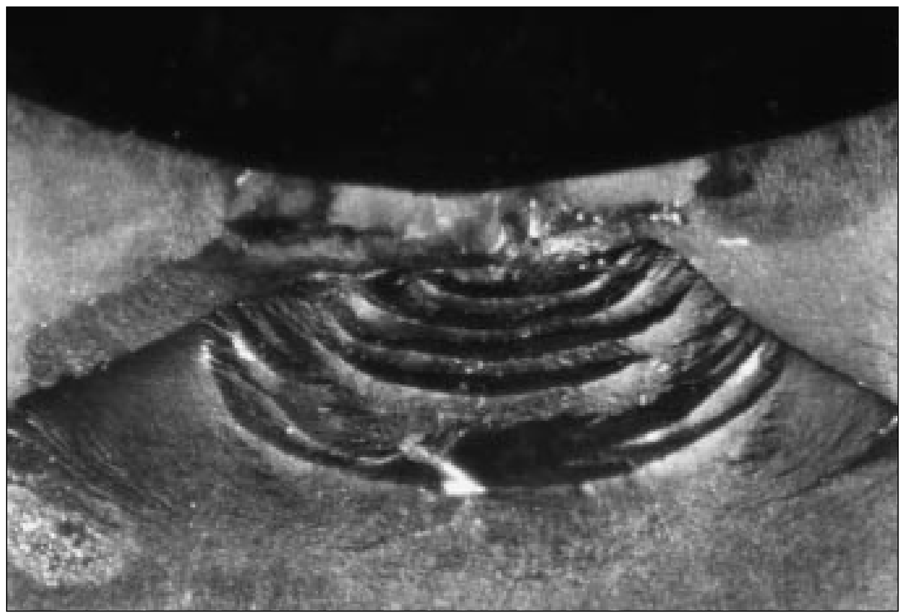
3.3.3.1 Fatigue fractures as a result of raceway fatigue

Symptoms:
Generally large-area fatigue damage in the raceway; frequently steps (lines of rest) in the fracture area, fig.63

Causes:
Well-advanced fatigue damage

Remedial measures:
See section 3.3.2.1 "Fractures"

63: Outer ring fracture of a deep groove ball bearing in the axial direction as a result of fatigue



3.3.3.2 Axial incipient cracks and through cracks of inner rings

Symptoms:
Ring partly or completely cracked in the axial direction. Fractured edges slightly rounded: indicates that the fracture originated during operation and was cycled. Sharp-edged crack flanks indicate that fracture occured during dismounting. In the case of long periods of operation with cracks, the latter's edges may be partly broken off, fig. 64.

Causes:
- Bearing slippage
- Fractures in the raceway
- Rotation of inner ring on the shaft
- Unsuitable lubrication
- Fit too tight on the shaft
- Shaft groove
- Out-of-roundness
- Grazing against surrounding parts

Remedial measures:
- Improve lubrication (additives, increase oil quantity)
- Find remedial measure for damage to raceway
- Select suitable fit
- Avoid grazing of surrounding parts
- Provide for better seating conditions
- Special heat treatment for rings

64: Axial through crack of a spherical roller bearing's inner ring

3.3.3.3 Outer ring fractures in circumferential direction

Symptoms:
Usually the crack spreads evenly in the circumferential direction. Several fractured pieces often originate. With axial load, these fractures occur as a rule a little beyond the middle of the raceway. Fatigue damage is often the cause. The outer ring outside surface normally shows an irregular load carrying pattern, fig. 65.

Causes:
Poor support of the rings in the housing

Remedial measures:
Constructive improvement in mounting required

65: Crack in outer ring in circumferential direction

3.3.4 Deep scratches and smear marks on the contact surfaces

In addition to local fractures, cracks, and other dents in the raceway or rolling element surfaces, large-area surface damage also frequently arises as a result of sliding in the bearing which leads to wear. In addition to the cycling conditions, the extent of this damage is essentially influenced by the intensity and cleanliness of the lubrication.

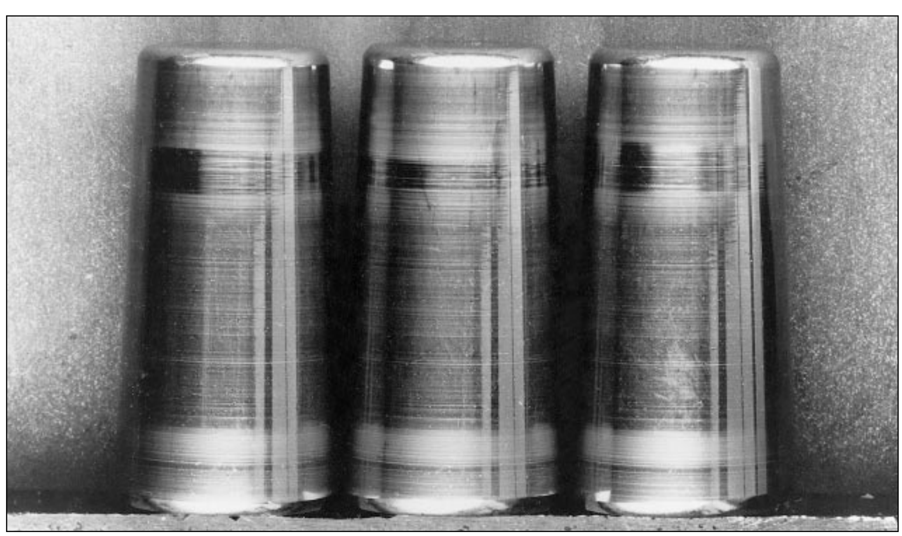
66: Worn, roughened raceway

3.3.4.1 Wear damage with poor lubrication

Symptoms:
The contact areas are dull and roughened, figs. 28 and 66. Abraded matter turns the lubricant dark in colour; also yellow in the case of brass cages. The grease is also solidified. In many cases, however, moisture leads to the lubricant consistency growing watery. Either preload is reduced or the bearing clearance is enlarged. If foreign particles are the cause of wear, the rolling element surfaces will be particularly badly scored, fig. 67. Under adverse conditions, roller bearing raceways may be unevenly worn throughout their circumference. The appearance of the raceways is then stripy, fig. 68 and 69. This type of wear leads to fatigue damage, please refer to "Fatigue as a result of wear" in section 3.3.2.1.

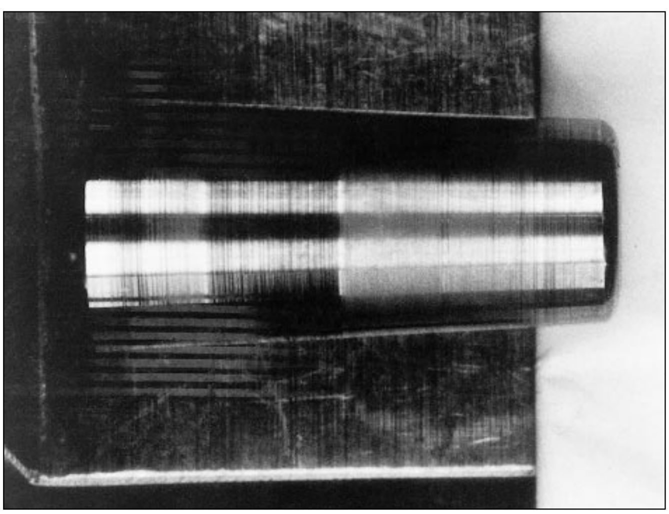
Causes:
- Non-load-carrying lubricant film
- Contaminants in lubricant (fine, hard particles, e.g. dust, or also water)
- Insufficient adjustment of bearings in the case of uneven wear of tapered roller bearings

67: Wear traces can usually first be detected on the surfaces of the rolling elements

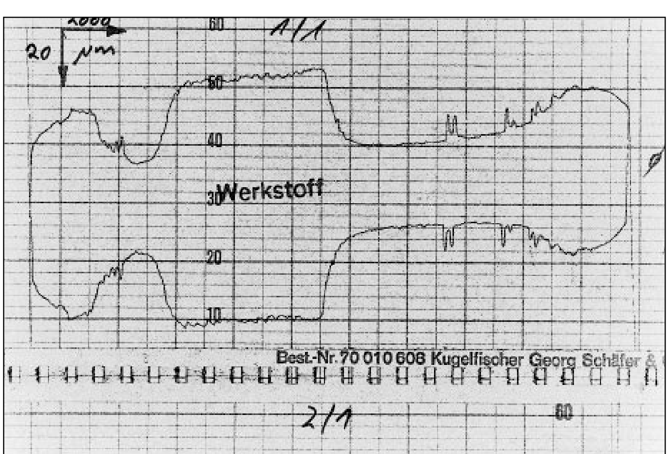


Remedial measures:
– Use lubricant with higher load carrying capacity, e.g. with more viscosity or EP additives
– Shorten lubricant change intervals
– Improve sealing
– Filter lubricant
– Ensure correct adjustment of bearings

68: Formation of stripes as a result of wear in certain areas.
a: Roller



b: Raceway



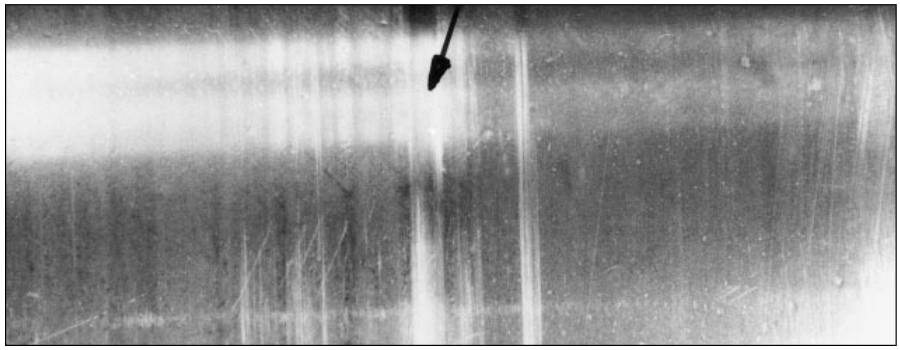
69: Chart for fig. 68a

3.3.4.2 Scratches on rolling element outside diameters

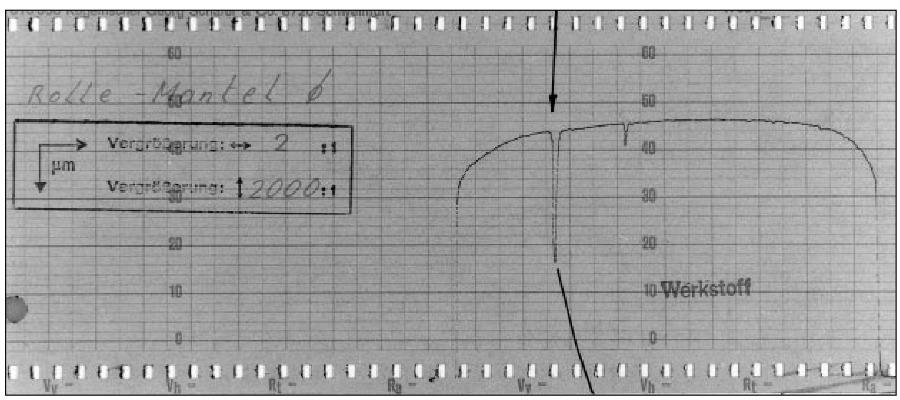
Symptoms:
Circumferential notches in the contact areas of rolling elements. Parallel rings in the case of rollers, figs. 70 and 71, and usually like "balls of wool" in the case of balls, fig. 72. Not to be confused with edge tracks (see section 3.3.2.6). Edge running forms tracks with smooth edges due to plastic deformation; scratches have sharp edges. Hard particles are frequently pressed into the cage pockets which cause the scratches, fig. 73.

Cause:
Contaminated lubricant; hard particles become fixed in the cage pockets and act like the grains in a grinding wheel.

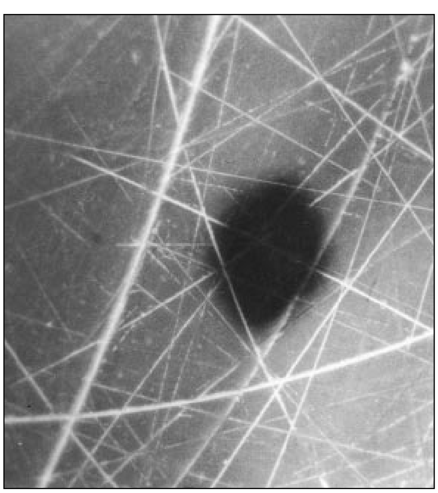
Remedial measures:
- Ensure clean mounting conditions
- Improve sealing
- Filter lubricant



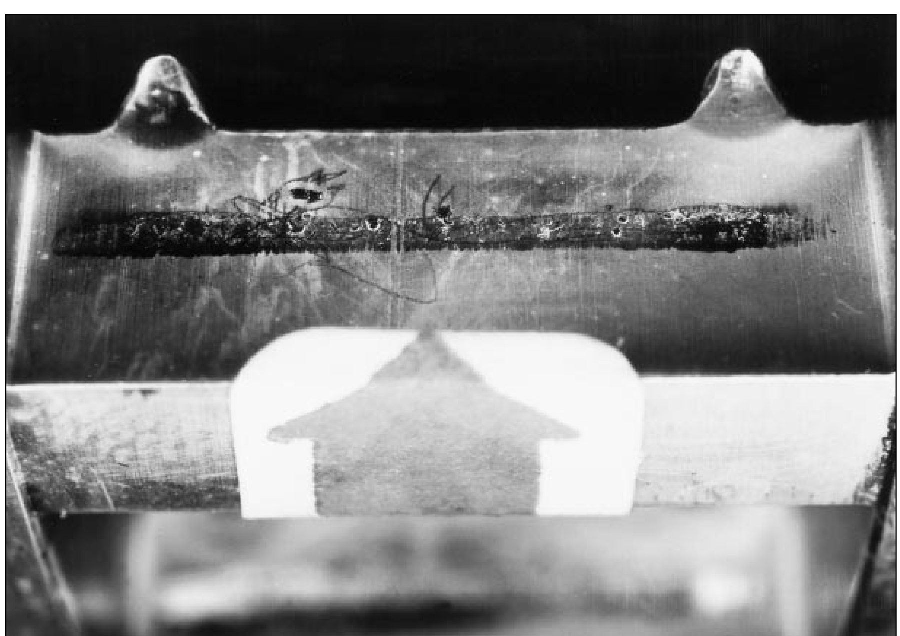
70: Deep scratches on rollers as a result of foreign particles in the cage



71: Chart for fig. 70.



72: Scratches on the ball surface resembling a ball of wool



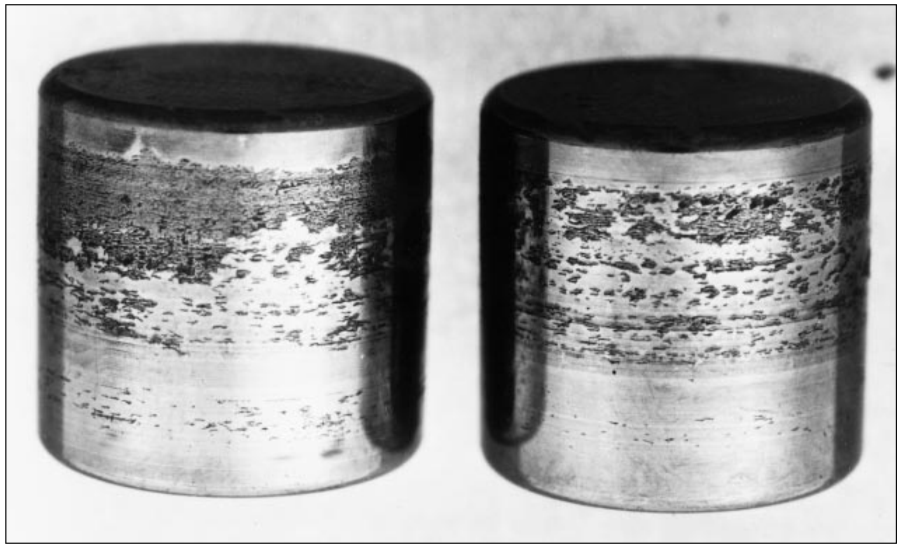
73: Embedding of foreign material in the cage crosspiece of a cylindrical roller bearing

3.3.4.3 Slippage tracks

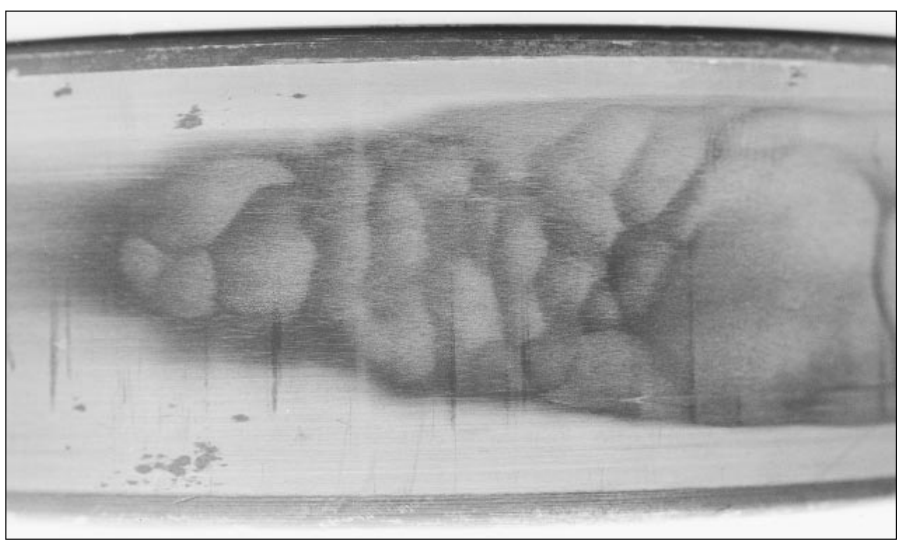
Symptoms:
Rolling element sliding, particularly in the case of large and heavy rollers e.g. in cageless bearings. Roughening of the raceways or rolling elements. Material often rolled up and with smear marks. Usually not evenly distributed on the surface but in spots, figs. 74 and 75. Found frequently in connection with micro pittings, see "Fatigue as a result of poor lubrication" in section 3.3.2.1.

Causes:
- The rolling elements slide on the raceways when load is low and lubrication is poor. Also due sometimes to load zones which are too short, where the rolling elements brake in the unloaded zone in the cage pockets and subsequently accelerate again when entering the load zone.
- Fast changes in speed.

Remedial measures:
- Use bearings with lower load carrying capacity
- Preload bearings, e.g. with springs
- Reduce bearing clearance
- Ensure sufficient load during the trial run also
- Improve lubrication



74: Slippage tracks on cylindrical rollers



75: Slippage damage on the inner ring of a cylindrical roller bearing

3.3.4.4 Score marks

Symptoms:
Material displacement at rolling element pitch parallel to the axis in raceways and rolling elements of separable cylindrical roller bearings or tapered roller bearings. Sometimes several sets of such marks displaced to one another by a few degress on the circumference. Frequently found on just about 1/3 of the circumference and not on the whole circumference, fig. 76.

Causes:
During mounting the single ring and the ring with the rolling element set are not concentric to one another or are misaligned and are shoved together forcefully. This can be particularly dangerous with large moving masses (large shaft is shoved with the bearing inner ring and rolling elements into the outer ring which has already been pressed into the housing).

Remedial measures:
– Use suitable mounting aids
– Avoid misalignment
– If possible assemble parts with a slow rotating movement

76: Score marks in the raceway of a cylindrical roller bearing inner ring caused by out-of-square insertion into the rolling element set

3.3.5 Damage due to overheating

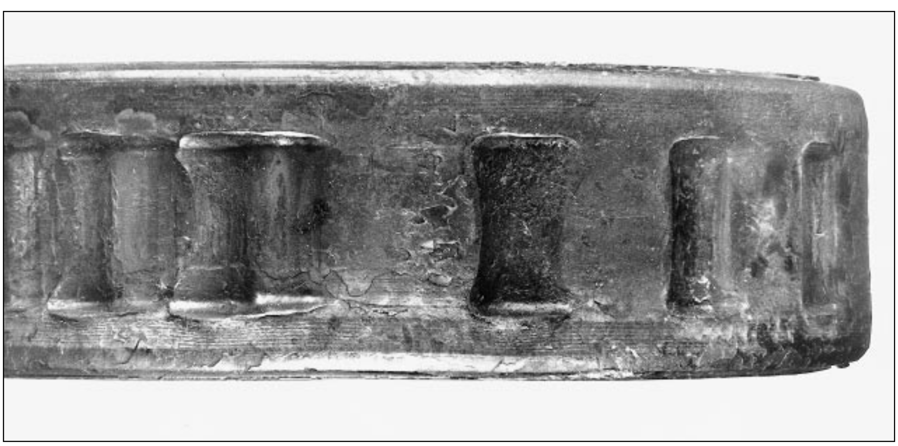
Symptoms:
Bearing parts badly discoloured*). Raceway/rolling elements plastically deformed to a large extent. Temperature surge. Bearing seizure frequent, fig. 77. Hardness well below 58 HRC.

Causes:
Usually no longer detectable from damage pattern resulting from overheated bearings. Possible causes:
- Bearing clearance in operating condition too low, particularly with high speed bearings
- Inadequate lubrication
- Radial preload due to external heating
- Overlubrication
- Impeded running due to cage fracture

Remedial measures:
- Increase bearing clearance
- In the case of external heating ensure sufficiently slow heating up and cooling down, that is, uniform heating of complete bearing
- Avoid lubricant pile-up
- Improve lubrication

*) Note on discolouration:
Tempering colours are related to overheating damage. Brown and blue shades develop depending on how high the temperature is and how long it takes effect. They resemble greatly the oil discolouration which appears far more frequently (see section 3.3.1.1). Therefore conclusions regarding an excess operating temperature may on no account be drawn from discolouration alone. The spreading of the discolouration may serve to differentiate between tempering colours and oil discolourating: while the latter is frequently found only on the rolling elements and directly in the track area the former usually covers a large part of the free bearing surfaces. However, the only answer to the occurence of extremely high operating temperatures is a hardness inspection.

77: The rollers left deep impressions in the raceway of a seized, overheated cylindrical roller bearing.



3.4 Assessment of lip contact

Fig. 78 illustrates a well run-in lip surface.

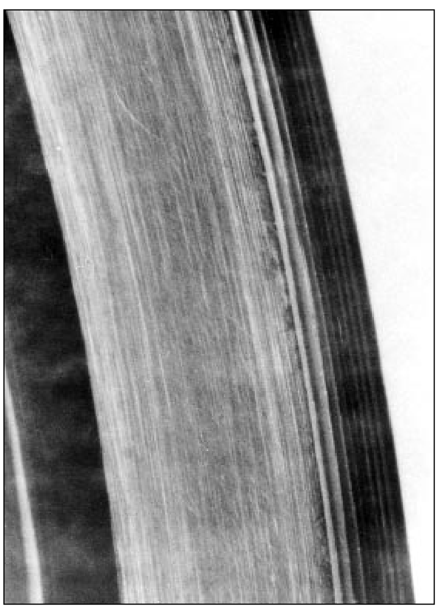
3.4.1 Damage to lip and roller faces in roller bearings

3.4.1.1 Scoring due to foreign particles

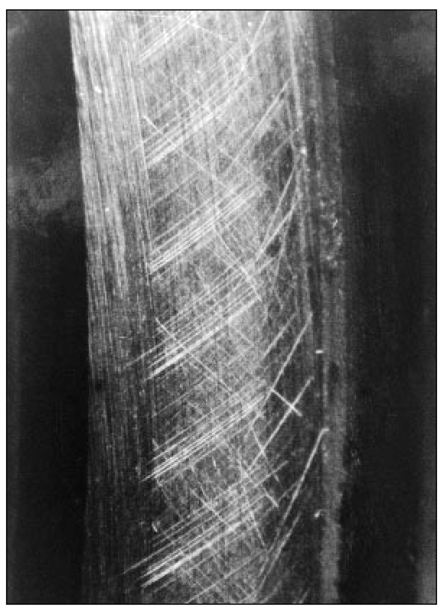
Symptoms:
Arc-shaped scratches in the lip surface or roller face (particularly frequent with tapered roller bearings), figs. 79 and 80. Their depth into the lip area depends on the rolling element radius the foreign particle became stuck in.

Causes:
Hard foreign particles in lubricant which are drawn into the area of contact between roller face and lip.

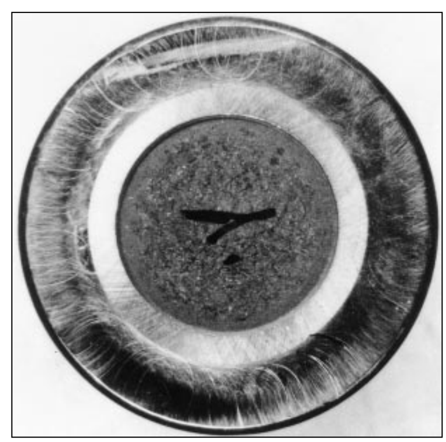
Remedial measures:
Improve lubricant cleanliness.



78: Normal run-in lip contact track in a tapered roller bearing



79: Lip area scoring due to foreign particles



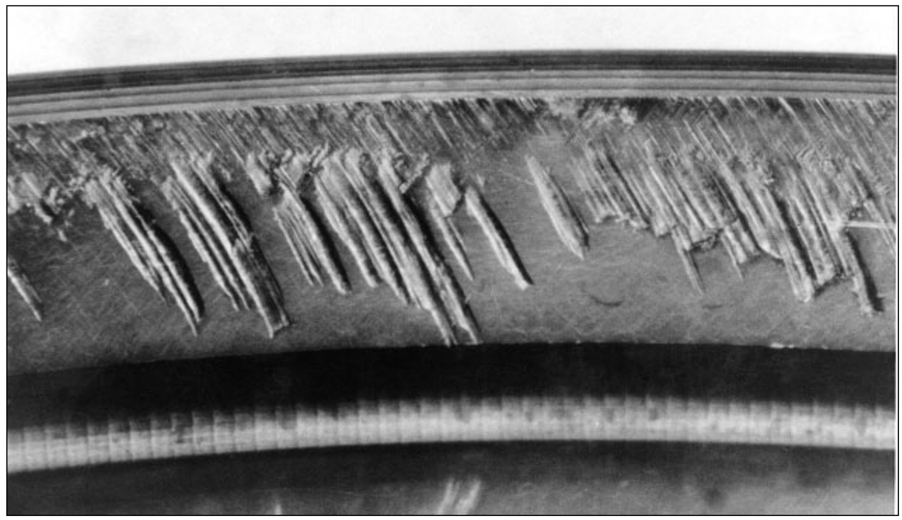
80: Scoring on the face of a tapered roller

3.4.1.2 Seizure in lip contact

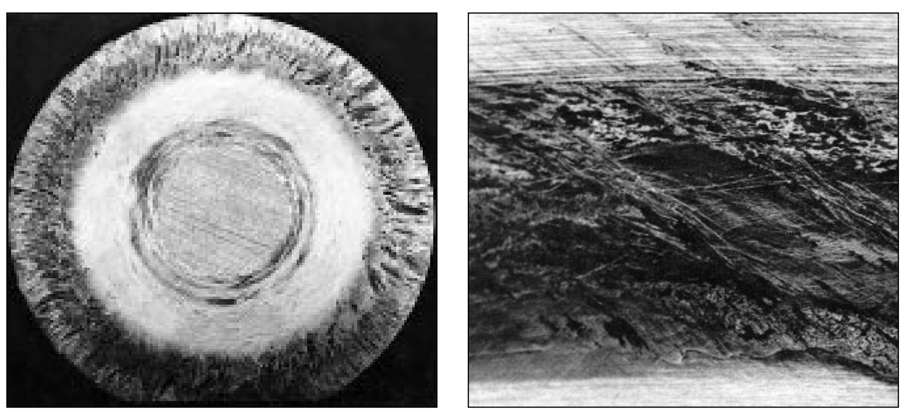
Symptoms:
Partial or large-area welding and deep scratches in the lip and roller face areas, figs. 81 and 82. Also lubricant coking in this area. Frequently related to very high loads.

Causes:
- Inadequate lubrication with high loads and high speeds (quantity or operating viscosity of lubricant too low)
- Inadequate lubrication with high loads and low speeds when there is no hydrodynamic lubricating film between roller face and lip
- Too high preload of tapered roller bearings
- Detrimental preload due to heat expansion
- Skewing of rollers for example in the case of raceway wear, ring tilting or insufficient adjustment, fig. 81
- Axial load too high on cylindrical roller bearings
- Axial preload of inner ring too high for out-of-square mating surfaces.

Remedial measures:
- Improve lubrication (increase viscosity, EP additives, increase lubricant quantity)
- Ensure correct adjustment of bearings



81: Skewing rollers caused seizure marks at the lip when in contact with its edges.

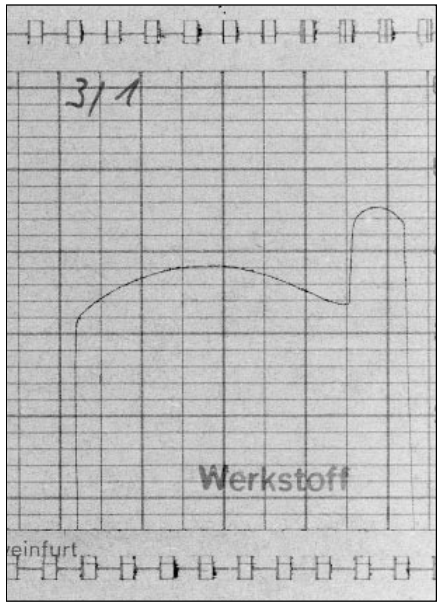


82: Seizure can arise at the roller face and lip when the lubricant supply is inadequate and loads are high.

3.4.1.3 Wear in the lip contact area

Symptoms:

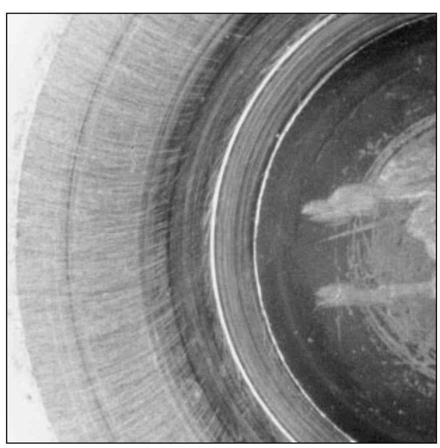
In the case of roller bearings poor lubrication conditions are first revealed by the sliding contact roller face/lip. In serious cases the previously mentioned seizure phenomena result. In all cases, however, the contact areas have wear characteristics. This can be clearly seen in the cross profile chart of the lip or roller faces, fig. 83. Rims frequently develop at the roller faces also. In the case of tapered roller bearings a reduction in preload or extended axial clearance results. This leads, for example in transmissions with load direction inversion, to increased running noise. The amount of wear in the lip contact area enters only about 1/3 of the axial clearance in the case of tapered roller bearings due to the geometric conditions. Lip wear is also an indication for wear in the raceway or roller outside diameter.



83: Cross profile chart of a worn tapered roller face

Causes:
- Inadequate lubrication (type, quantity)
- Contaminated lubricant

Remedial measures:
- Ensure utmost cleanliness
- Choose suitable lubricant (viscosity, EP additives) and ensure sufficient supply



84: Rim formation at the tapered roller

3.4.1.4 Lip fractures

Symptoms:
Supporting lips are completely or partly broken off or cracked, fig. 85.

Causes:
– Axial load unacceptably high
– Lip insufficiently supported, fig. 20
– Axial shock load
– Subsequent damage of cage and rolling element fracture
– Mounting damage

Remedial measures:
– Ensure good lip support design
– Keep load within the limits assumed for designing
– Observe mounting specifications

85: Lip broken off a barrel roller bearing. The inner ring was driven onto the shaft with a hammer.

3.4.2 Wear of cage guiding surfaces

Symptoms:
Wear may result when cages – particularly brass cages – are guided at the lips of bearing rings. The surface is usually badly roughened and seizure also results (cage material clings to lip). A shoulder develops at the lip when there is a lot of wear since the cage is not as a rule in contact with its entire width, fig. 86. Similar wear characteristics are also found at the side edges of the corresponding cage, see section 3.5.1. It is particularly hazardous for the inner ring lip contact of high-speed bearings.

Causes:
- Insufficient lubricant supply to contact areas, often inadequate drainage of the lubricant
- Contaminated lubricant
- Speed too high for the bearings applied
- Excess tilting during assembly
- Unexpectedly high operating temperature in the case of outer ring guided brass cages (different heat expansion steel/brass)

Remedial measures:
- Improve lubrication (greater flow, more cleanliness)
- Use bearings designed for operating conditions in question
- Coat cage

86: Bad contact marks on the cage guiding surface of an outer ring lip with smeared on material

3.4.3 Damage to seal running areas

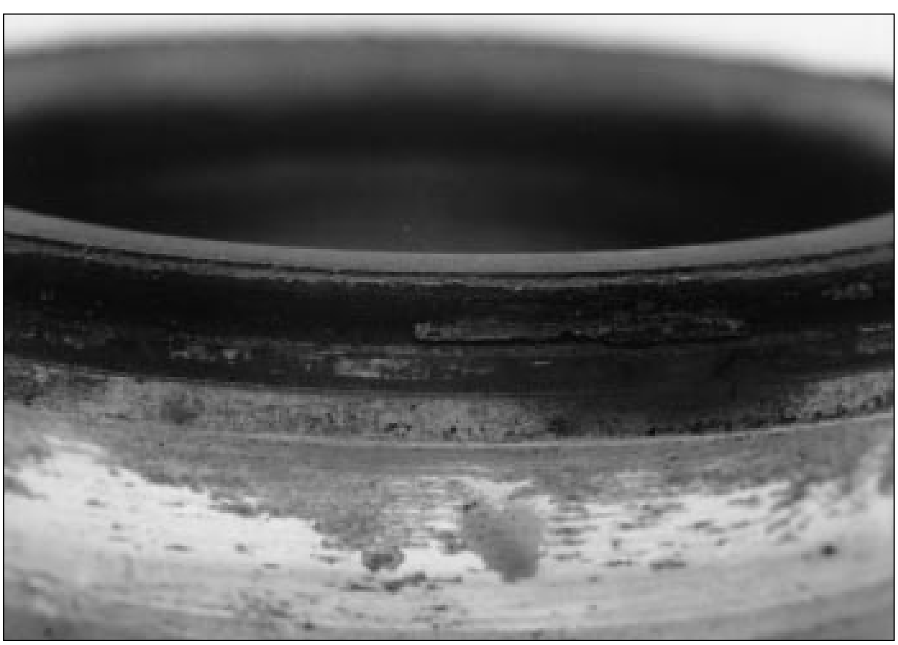
3.4.3.1 Worn sealing lip tracks

Symptoms:
At the area of the sealing lip contact a circumferential groove, usually shiny, develops in the lip. Also in conjunction frequently with worn sealing lips and damage to the bearing as a result of penetrating contaminants. Corrosion in the sealing area is found in several cases as well, fig. 87.

Causes:
– Extreme amount of external dirt, particularly in moist environment.
– Lip runs dry.

Remedial measures:
– Use preseals, e.g. flinger rings.
– Lubricate sealing lip.

87: Corrosion in the area of the sealing track at the lip of an angular contact ball bearing



3.4.3.2 Discolouration of sealing track

Symptoms:
Brown or blue colour in the area of sealing lip contact, particularly in the case of shaft seals. Excess heating leads to hardening and intense wear of the sealing, see section 3.6.1.

Causes:
– Intense heating of lip and shaft area due to overlapping or to a high press-on force of the sealing
– Sealing lip area of contact not sufficiently lubricated

Remedial measures:
– Lubricate sealing lip
– Reduce press-on force insofar as permissible for the sealing effect

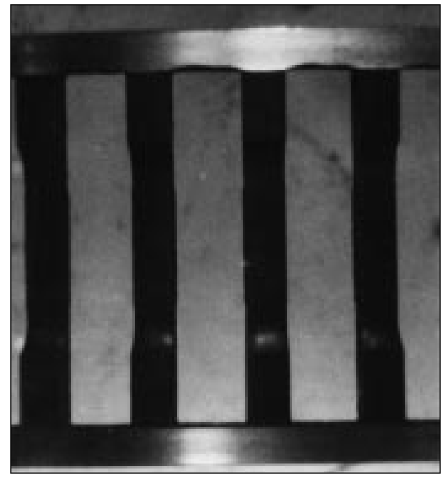
3.5 Cage damage

3.5.1 Wear due to starved lubrication and contamination

Symptoms:
In the case of cages with lip guidance wear in the side edges, for those guided by rolling elements wear in the pockets. Subsequent damage due to advanced wear could cause rolling element guidance to develop into lip guidance and abrade there also or vice versa. Wear is generally in the axial direction to a large extent symmetric in the pockets or in the case of cylindrical roller bearings at both side edges, fig. 88.

Causes:
– Lubricant contaminated with hard foreign particles
– Too little or unsuitable lubricant

Remedial measures:
– Ensure clean assembly conditions
– Filter lubricant
– Increase lubricant flow through and/or apply a different viscosity



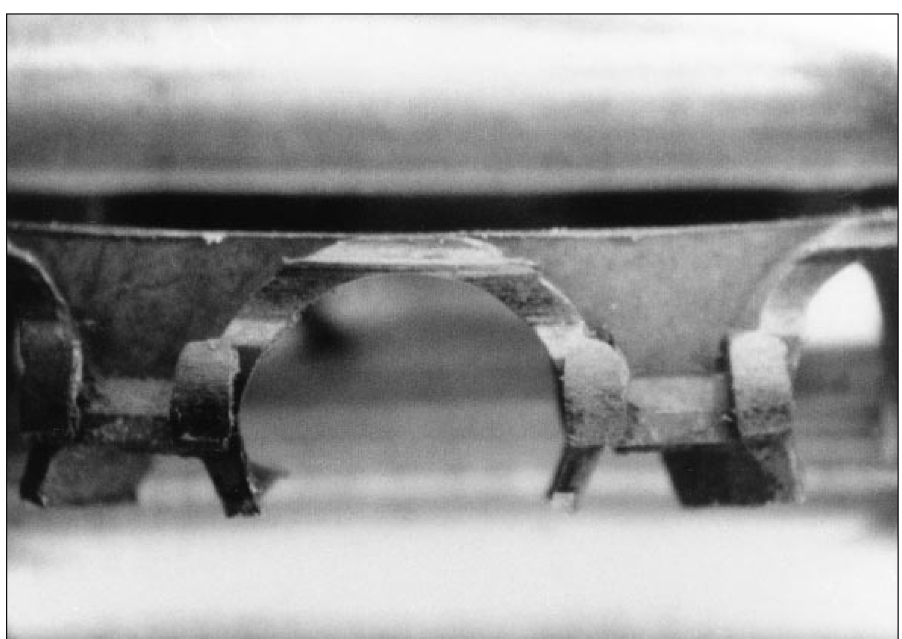
88: Wear of cage side edges

3.5.2 Wear due to excess speed

Symptoms:
Wear of cage outside diameter due to grazing at the bearing outer ring, fig. 89.

Causes:
– Excess speed
– Unsuitable cage construction selected

Remedial measures:
– Use different type of cage



89: Wear of cage outside diameter due to grazing at the bearing outer ring

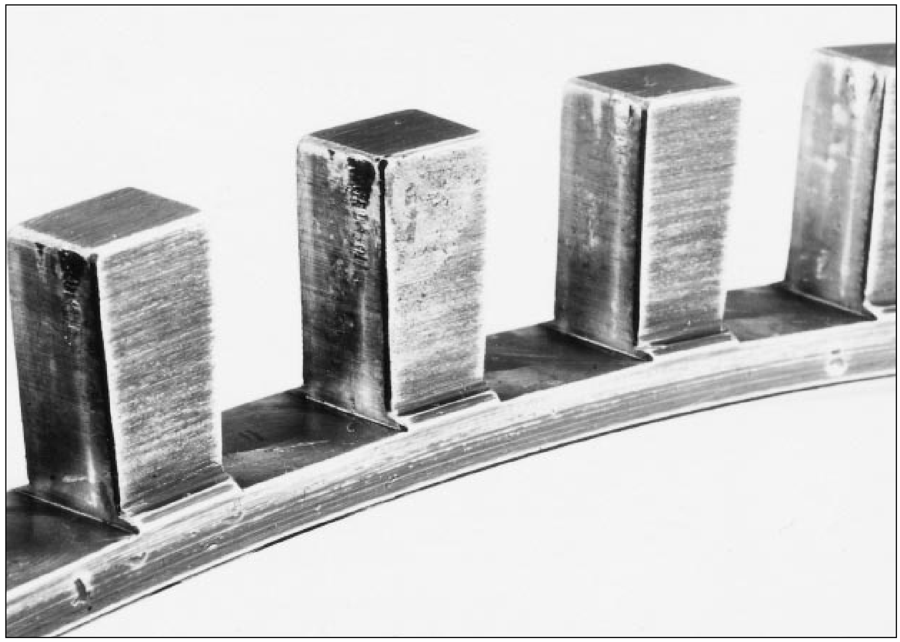
3.5.3 Wear due to roller skewing

Symptoms:
Roller skewing results when roller bearings carry low loads or badly tilt or when tapered roller bearings are not sufficiently adjusted. If the skewing forces cannot be accommodated by the lips, wear areas which are diagonally opposite one another develop due to the unpermissibly high load in the cage pockets. This can lead to fractures between cross-piece and side edge in the advanced stage of damage, fig. 90.

Causes:
– Unpermissible tilting of bearings, partly due to misalignment
– Faulty adjustment of clearance in the bearings

Remedial measures:
– Adjust bearings correctly
– Use self-aligning bearings, avoid misalignment

90: Diagonal wear in cage pockets of roller bearings



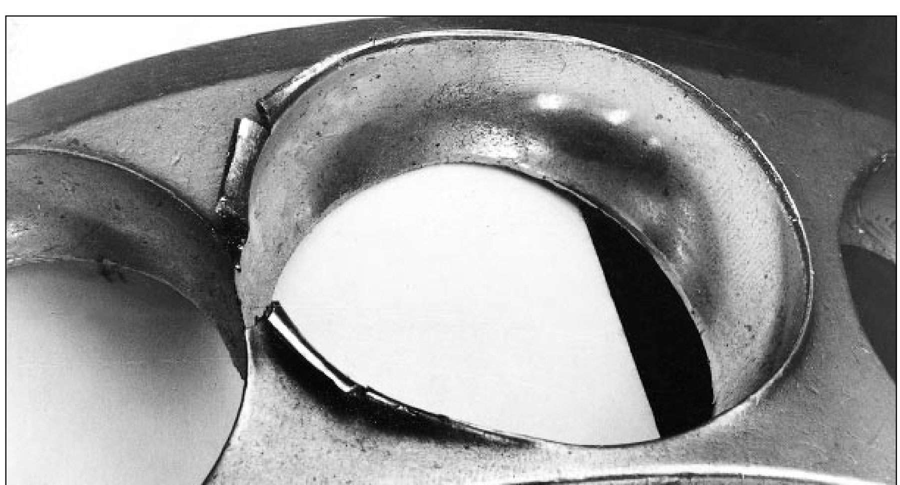
3.5.4 Wear in ball bearing cages due to tilting

Symptoms:
Intense wear at the webs between the cage pockets, deformation or fracture may occur, fig. 91 (tracks, compare with fig. 38).

Causes:
– Excess tilting of bearing rings to one another, e.g. ball bearings with combined load. Varying circumferential velocity of balls as a result.
– Stress in cage area high, particularly with poor lubrication

Remedial measures:
– Avoid tilting as much as possible
– Apply eventually self-aligning bearings or bearings with polyamide cages
– Special design: long hole pockets

91: Bearing rings tilting towards one another led to high constraining forces between balls and cage which, in turn, led to web fracture.



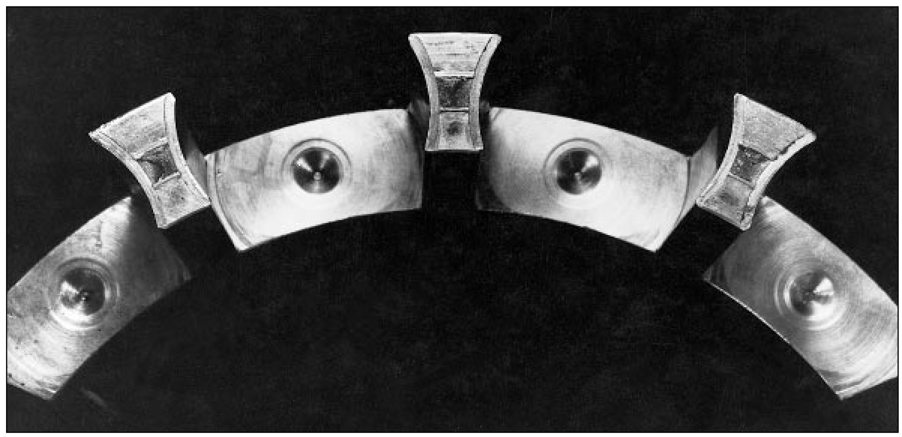
3.5.5 Fracture of cage connections

Symptoms:
- Loosening of riveted joints, rivet fracture (fig. 92)
- Breaking off of cage prongs

Causes:
- Vibrations or shocks which superimpose the normal cage stress, e.g. vibrating units or vehicles
- Tilting in the case of deep groove ball bearings

Remedial measures:
- Use of solid cage rather than pressed cage
- Use of window-type cage particularly when stress is great

92: Fractured cage-rivet connections may result from vibration stress.



3.5.6 Cage fracture

Symptoms:
Fracture of cage side edges (fig. 93), crosspiece fracture more seldom

Causes:
- Mounting damage
- Kinematically permissible speed exceeded
- As a result of wear and due to poor lubrication (see section 3.5.1)
- Moment load too high or tilting of ball bearings (see section 3.5.4)
- In the case of tapered roller bearing pairs which have a large clearance, also when axial loads reverse quickly

Remedial measures:
- Mount carefully
- Filter lubricant
- Increase lubricant flow through and/or use different viscosity
- Avoid tilting as much as possible
- Operate bearing pair preloaded if possible

93: Disruptive fracture at the side edge of a spherical roller bearing cage

3.5.7 Damage due to incorrect mounting

Symptoms:
Initial fusing in the case of plastic cages, grooves or warping in the case of metal cages, figs. 94 and 95.

Causes:
– Incorrect heating of the bearings for mounting
– Unsuitable mounting aids

Remedial measures:
Mount according to manufacturer's specifications (see for example FAG Publication WL 80 100 "Mounting and Dismounting of Rolling Bearings").

94: Melted fase of plastic cage in the case of incorrect bearing heating on a heating plate

95: Metal cage with dents

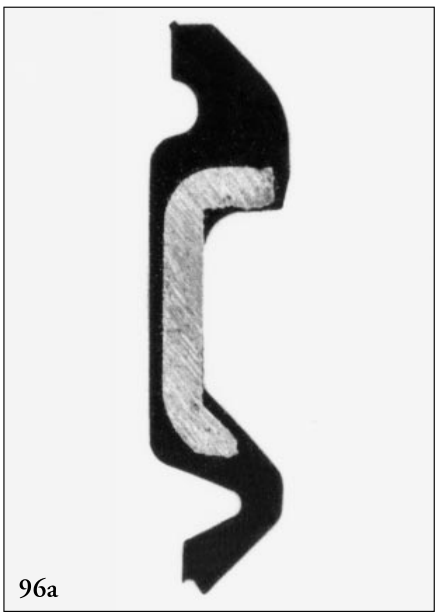
3.6 Sealing damage

3.6.1 Wear of sealing lips

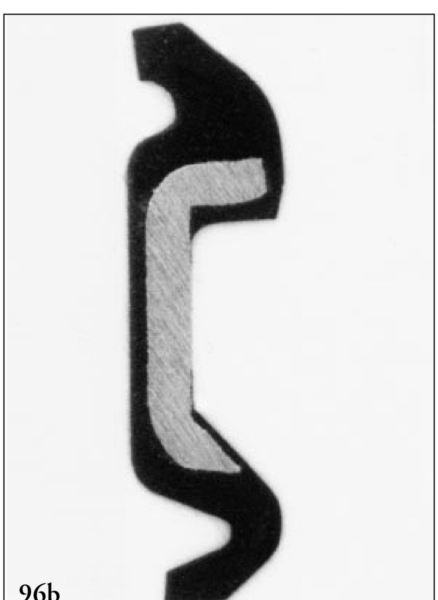
Symptoms:
Sealing lips no longer like edges but widened. Cracks in sealing material, sealing lip partly broken off, figs. 96, 97.

Causes:
- Operating temperatures too high for sealing material
- Extreme amount of dirt at the sealing lip
- Sealing interference too high
- Sealing lip not lubricated

Remedial measures:
- Adapt sealing material to suit operating temperatures.
- Use non-rubbing preseal
- Grease sealing lip.



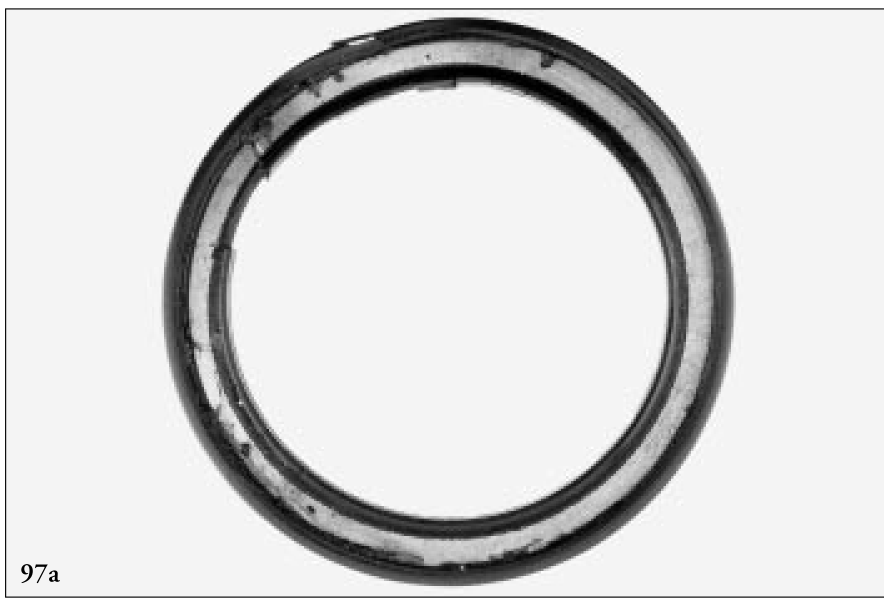
96a



96b

96: Cross section of a seal.
a: new sealing lip; b: worn sealing lip

97: a: Hardened sealing with wear and fractures
b: Part of worn lip close up



97a

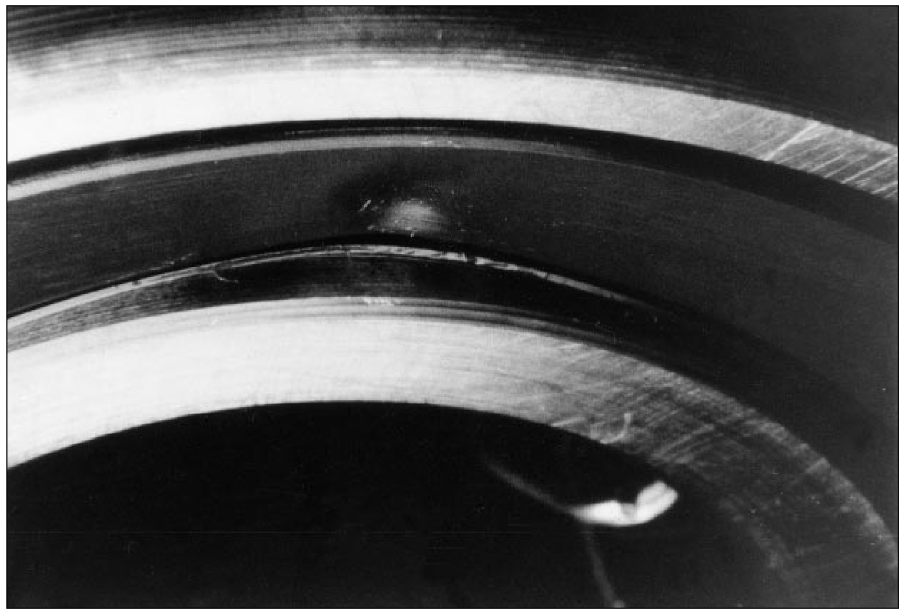
97b

3.6.2 Damage due to incorrect mounting

Symptoms:
Seal is too far inside, dented, discoloured, scratched. Sealing lips are turned up, figs. 98 and 99.

Causes:
– Incorrect mounting aids
– Bearing heated too much
– Sealing occasionally removed
– Bearing blown off with compressed air

Remedial measures:
– Ensure careful mounting with suitable mounting devices.
– Never open sealed bearings if they are to be subsequently used.



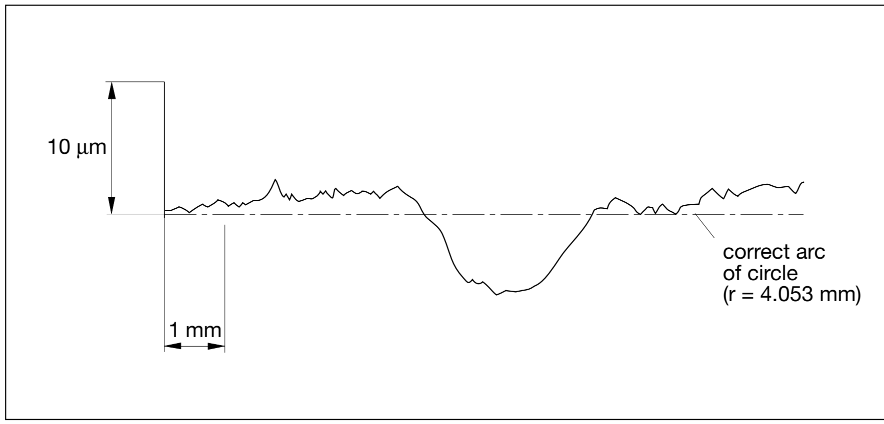
98: Dented seal with scorings

99: Turned-up sealing lips

4 Other means of inspection at FAG

Experience has revealed that in the majority of bearing damage cases, the cause of damage can be clarified by closely considering the damage symptoms together with the data on operating conditions. In a large amount of the remaining unclarified cases the cause of damage can be determined with the aid of a stereomicroscope. Only a very small amount of bearing damage cases require a profound examination of the damage symptoms and an intensive analysis of the application conditions. FAG's research and development capacities include the most diverse and highly developed technical inspection means with some very special features. A cost-benefit comparison of such inspections is recommended in advance as the latter may prove quite expensive.

The main inspection areas accompanied with some examples are presented in the following sections.



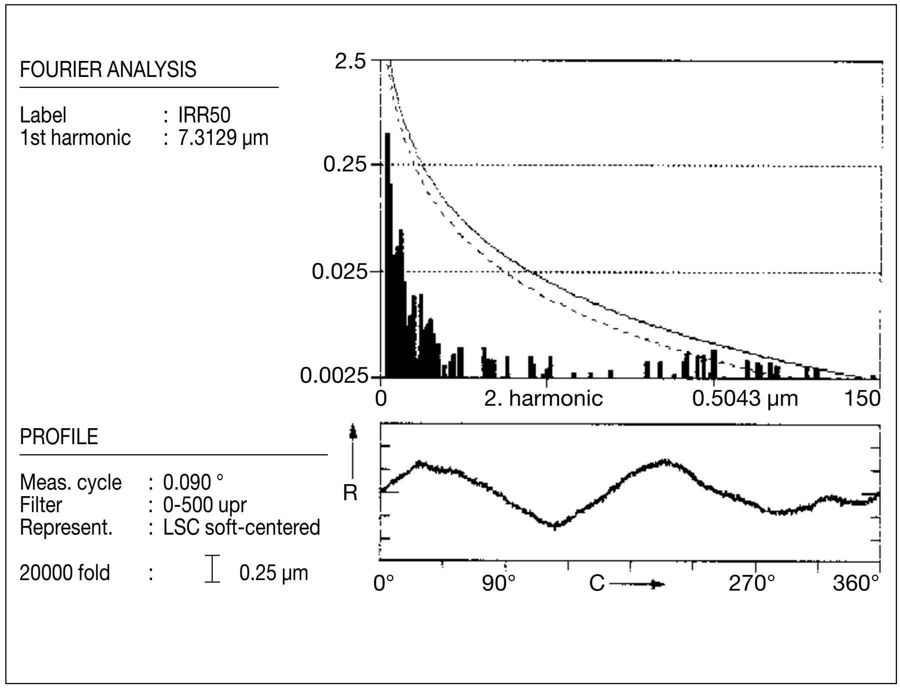
100: Profile of a deep groove ball bearing raceway with wear groove (raceway curve compensated for by measuring device)

101: Form Talysurf

4.1 Geometric measurings of bearings and bearing parts

FAG strives constantly to improve the production quality of rolling bearings. We therefore have the most sophisticated equipment with diverse measuring devices for dimensional and form inspection both on the spot in our quality assurance and in our own laboratory:
– Length and diameter measuring exactly to the micrometer
– Inspection of form and radius contours with a magnification of up to 100 000 fold, figs. 69, 100 and 101

– Deviation of roundness check with up to 100 000 fold magnitude including frequency analysis of waviness, figs. 102 and 103



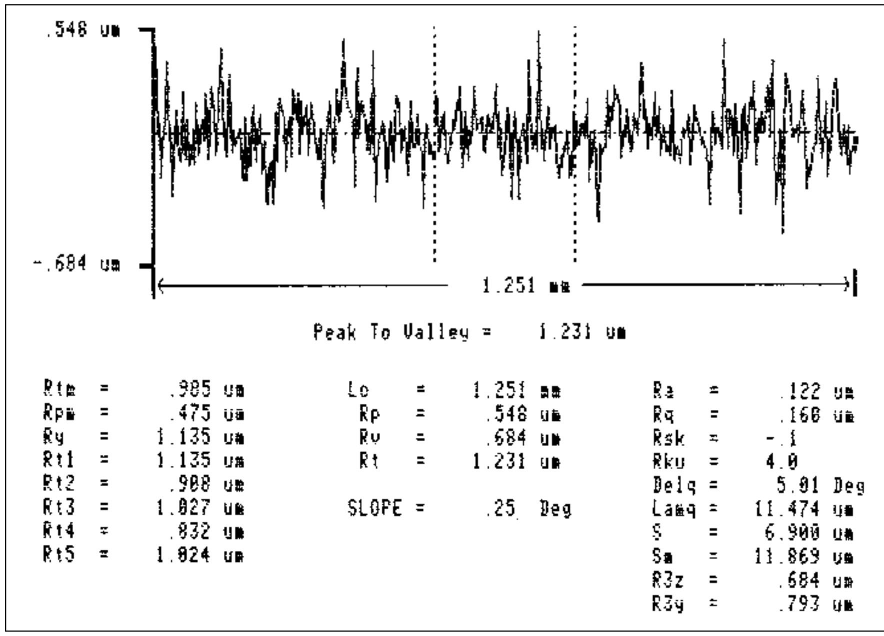
102: Form drawing with frequency analysis of waviness, inner ring 6207

103: Form measuring system

Other means of inspection at FAG

Geometric measuring

– Roughness measurements down to one hundredth of a micrometer, fig. 104
– Inspection of form and position tolerances on form measuring systems (FMS) and coordinate measuring machines, also for very irregularly formed construction parts such as cast steel housings, fig. 105
– Inspection of bearing clearances and radial runout of individual parts



104: Roughness measuring chart with characteristic values

105: Coordinate measuring machine

4.2 Lubricant analyses and lubricant inspections

FAG has laboratories and test floors for inspecting the quality and suitability of lubricants for rolling bearing applications.

Laboratory analyses of lubricants from failed bearings frequently supply the decisive information necessary to clarify the cause of failure. The main inspection means are:

- Amount and type of contamination present
  - solid, fig. 106a
  - liquid (humidity)
- Use of anti-oxidants
- Ageing, fig. 106b
- Change in viscosity
- Additive content (reduction/degradation)
- Oil-soap relation in greases
- Determination of type and class of lubricant, e.g. evidence of lubricant mixture during relubrication, fig. 106b

The extraction of a suitable lubricant sample is an essential prerequisite for reliable information based on the lubricant inspection (see section 2.2). The origin of contaminants can almost always be determined from the results of their analyses. A direct indication of possible measures to stop wear, for example, can therefore be obtained just as conclusions regarding suitable oil change intervals or a fresh grease supply can be drawn from information on the general condition of an oil or grease after a certain running period.

106 a: Inspection of contaminants, ICP-AES Analysis

Element	Lambda	Factor	Offset	low min	low max	high min	high max
Cobalt	228,616	1,673	268	962	415	179515	107157
Manganese	257,610	1,318	-76	-121	-34	67816	51496
Chromium	267,716	1,476	381	669	195	76696	51688
Copper	324,754	0,834	-471	80	660	2297	3316
Molybdenum	281,615	1,073	-17	89	99	47781	44543
Nickel	231,604	1,778	4	114	62	38487	21640
Vanadium	311,071	0,937	-37	5	45	64228	68560
Tungsten	400,875	0,742	-16	4	26	14129	19053
Silicon	251,611	2,173	310	509	92	2385	955

sample: solids in contaminated lubricant   method: steel 1   M(3)

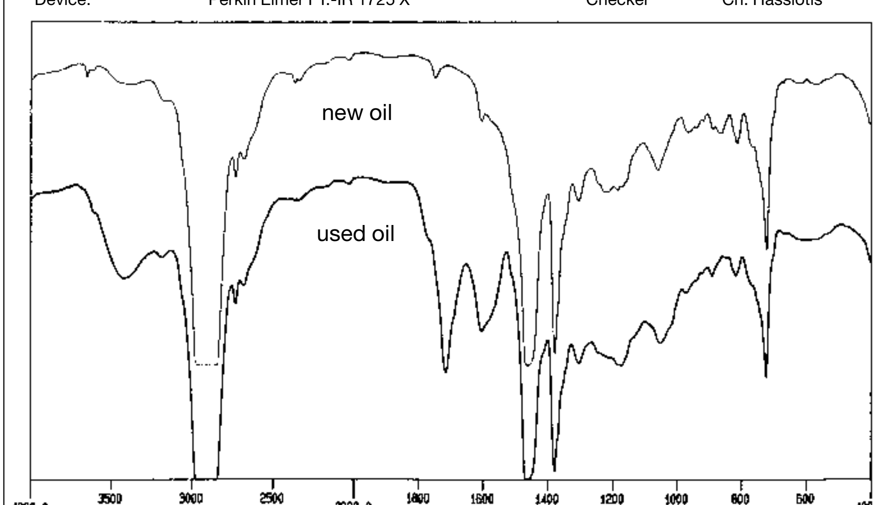
	Co	Mn	Cr	Cu	Mo	Ni	V	W	Si
x	.0107	0.636	1.412	0.185	0.797	0.271	.327	.002	0.359 %
s	.0004	.0002	.011	.0002	.0032	.0063	.0007	.0099	.0006
sr	4.11	0.67	0.03	1.18	0.40	2.31	0.22	57.44	0.06

106 b: FT-IR Analysis of lubricant

FAG OEM und Handel AG

Research and Development
OHT-L-1/Lubricating Greases
and Org. Analytic, W. Wolz

Product	preservative oil, new (above, green) preservative oil, used (below, red)
WE/Batch:	sample 26.04.1990/- / dito after Oxbomb
Date of receipt:	26.04.1990
Path length:	67.98 µm / 68.04 µm
Device:	Perkin Elmer FT.-IR 1725 X
Cont. IR nr.:	901495/901496
Date of check:	03.05.1990 31.05.1990
Nr. of scans	4
Resolution	2 cm–1
Checker	Ch. Hassiotis



Other means of inspection at FAG

Lubricant analyses and lubricant inspections

New lubricants, on which there are no findings concerning their suitability for lubricating rolling bearings, are also used in special cases of applications. FAG test rigs have been developed to check the properties of such greases and oils. They have also been standardized and adopted by the lubricant industry for testing new products, fig. 107.

107: Test rig for determining lubricant quality

4.3 Material inspection

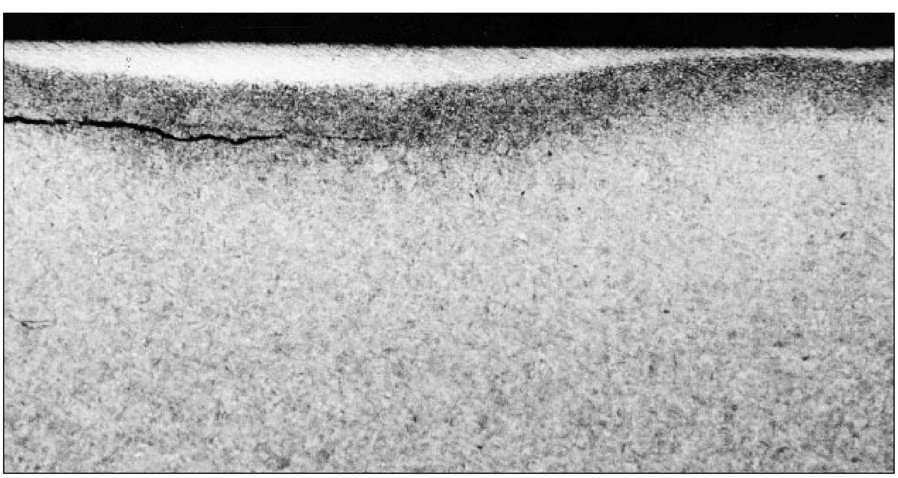
The condition of the material of all bearing parts is of decisive importance if the bearings are to be fully efficient. Indeed, bearing damage is very seldom due to material or production faults, fig. 11, but a material inspection can provide important information in cases of doubt. In a number of cases changes in the material condition are due to unexpected bearing application conditions.

The main inspections in this area are:

- Inspection of hardness and more seldom, tensile strength or notch impact bending strength
- Metalographic assessment of structure
- Making zones of unpermissible heating visible by etching the contact areas
- Crack inspection by means of ultrasound or eddy current
- Radioscopic measuring of retained austenite
- Inspection of material cleanliness
- Material analysis

In addition to determining material faults, these inspections can provide information for example on unpermissible slippage (sliding heat zones, fig. 108) or unexpectedly high operating temperatures (change in structural parts during operating and dimensional changes as a result).

108: Section of heat influence zone



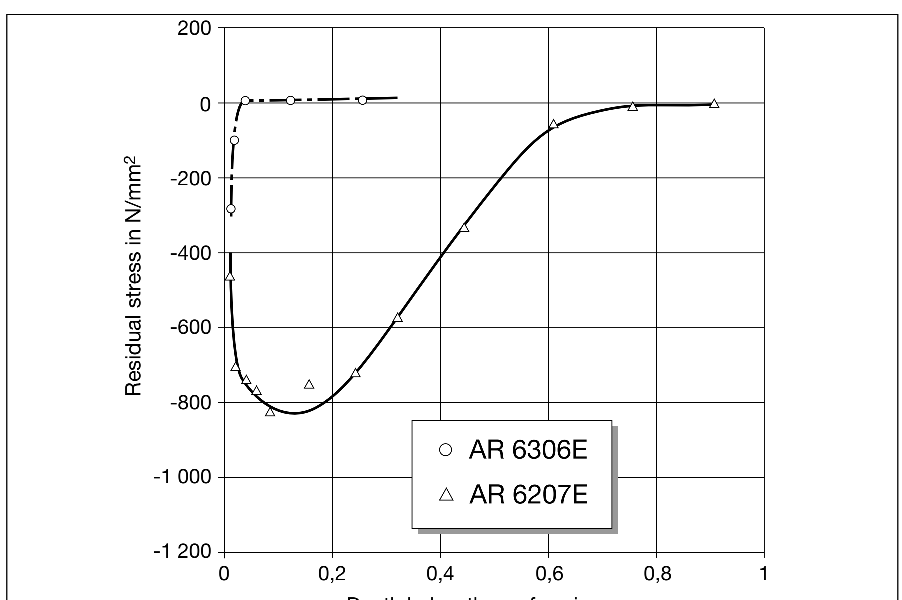
4.4 X-ray micro structure analysis

The radioscopic investigation of the lattice structure (cf. Measuring retained austenite in section 4.3) also allows one to draw very important conclusions on the residual stress "frozen" in the material and the stressing on which it is based. It is applied to determine with good approximation the actual load of bearings after operation. This may be particularly crucial in damage cases where the actual load situation cannot be attained by calculation. The specific raceway stress, however, must have reached a level of about 2,500 N/mm^2 for a longer period since it is only above this load that the plastic deformation of the material lattice occurs and only then can it be tested and quantified by means of X-ray diffraction, fig. 109. You could refer to the booklet "Schadenskunde in Maschinenbau", Expert Verlag 1990, for example, under "Schadensuntersuchung durch Röntgenfeinstructuranalyse" for a detailed report on determining residual stress and calculating stress. We have provided a brief summary for you below.

The residual stress present in small areas (size a few square millimeters surface, 1/100 millimeters in depth) can be calculated back from the lattice expansion measured by means of X-ray diffraction. Measuring is carried out layer by layer for the different depths below the raceway of a bearing ring by an electrochemical surface discharge. A pattern as in fig. 110 is then obtained. From the whole deformation depth and from the depth where stress is greatest, the maximum external load can be deduced on the one hand and, on the other hand, the share of possible sliding stress in the raceway. This is a vital contribution towards the search for damage causes, particularly if the values measured deviate greatly from those expected on the basis of calculations.

109: X-ray micro structure analysis equipment

110: Residual stress pattern as attained from an X-ray micro structure analysis; high tangential force portion in outer ring 6207E, no increased stress in reference bearing 6303E



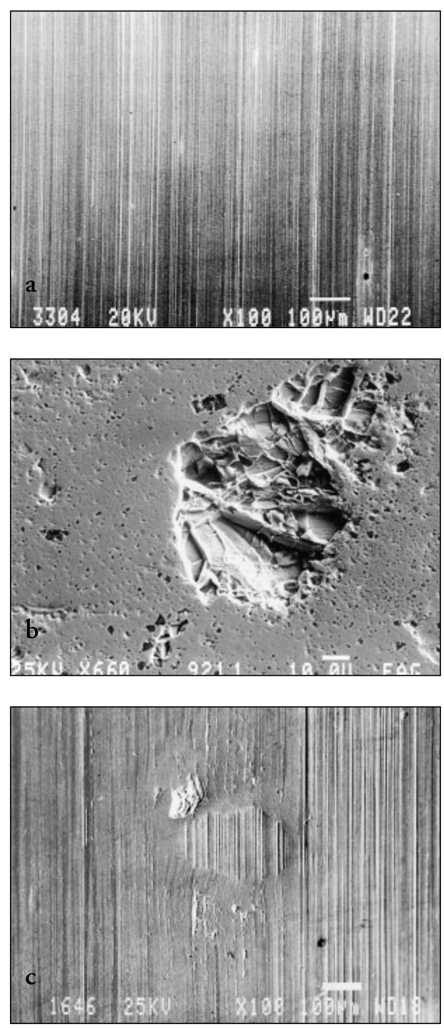
4.5. Scanning electron microscope investigations (SEM)

When investigating damage a stereomicroscope is usually applied in addition to the naked eye to detect the individual failure causes. However, the damage-related details are sometimes tiny. Due to the relatively large wave length of visible light, the definition of the image of light-optical projections is limited. With the usual surface uneveness of damaged rolling bearing raceways, photos can only be enlarged sharply defined up to 50 fold. This obstacle in light-optical inspection of surfaces can be bypassed with the very short-wave electron beam in a scanning electron microscope (SEM). It makes the detection of details several thousand times greater, fig. 111.

The scanning electron microscope is therefore a vital aid for the visual inspection of raceways damaged by wear or the passage of current, fractured areas, foreign particle indentations, and material inclusions, figs. 112a, b and c.

111: Scanning electron microscope

112: SEM photos of surface structure in various sizes.
a: raceway ok
b: hard foreign particle indentations
c: fatigue damage commencing

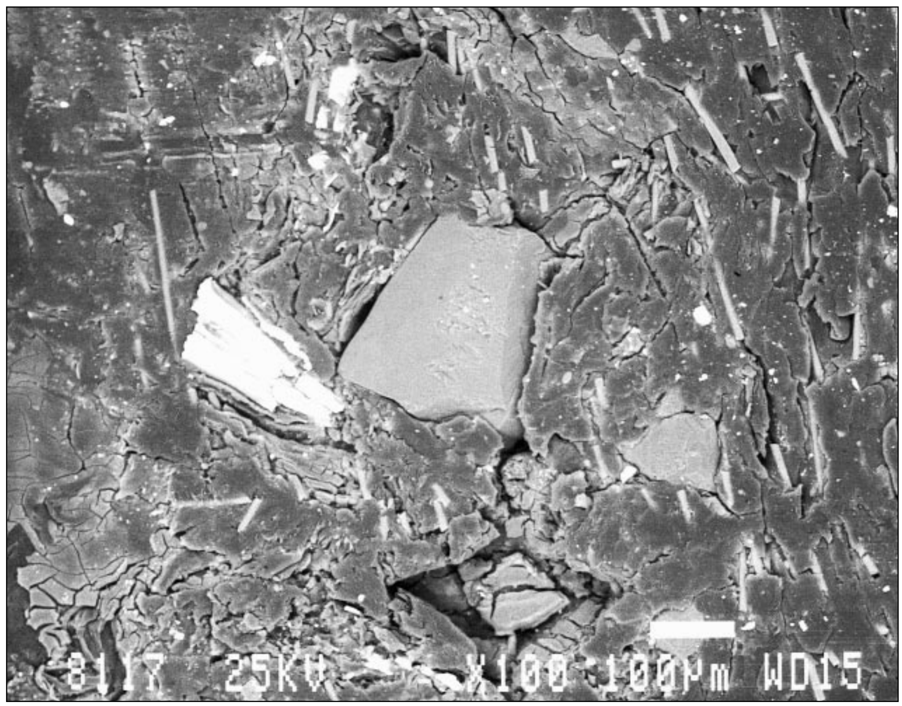


Other means of inspection at FAG

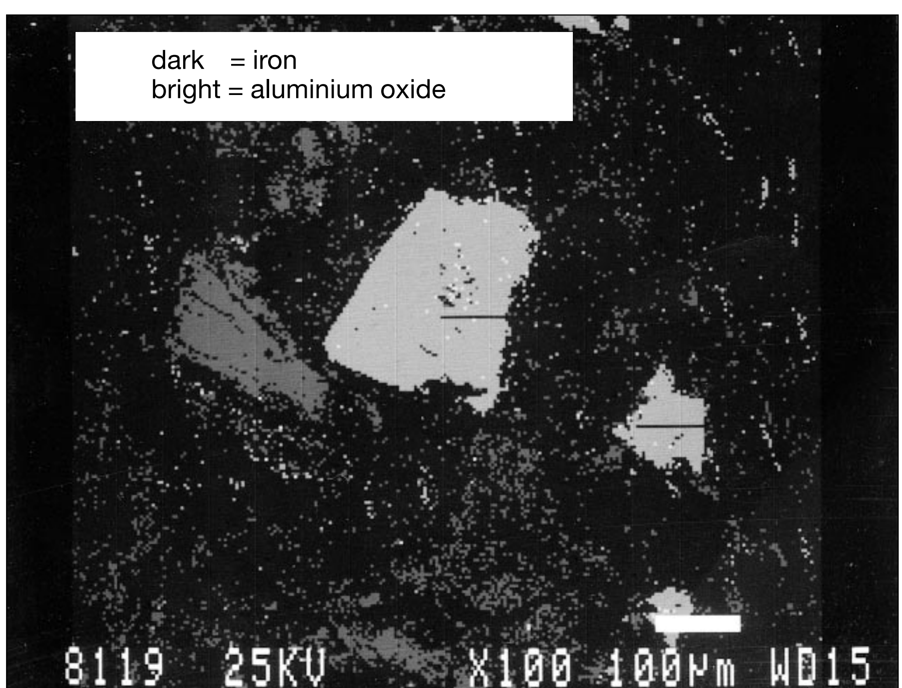
Scanning electron microscopic inspection

It is also possible to make the socalled electron beam micro analysis when using spectrometers together with the SEM. It inspects the material composition in the volume range of approx. 1 micron^3. This helps to determine the origin of foreign particles still stuck in the cage pockets of a bearing, figs. 113a and b. Other applications with it include the inspection of coatings or of reaction layers on the contact areas or the examination of material compositions in the micro area.

113: Micro analysis of foreign particles
a: Foreign particles in cage crosspiece



113 b: Material composition of foreign particles

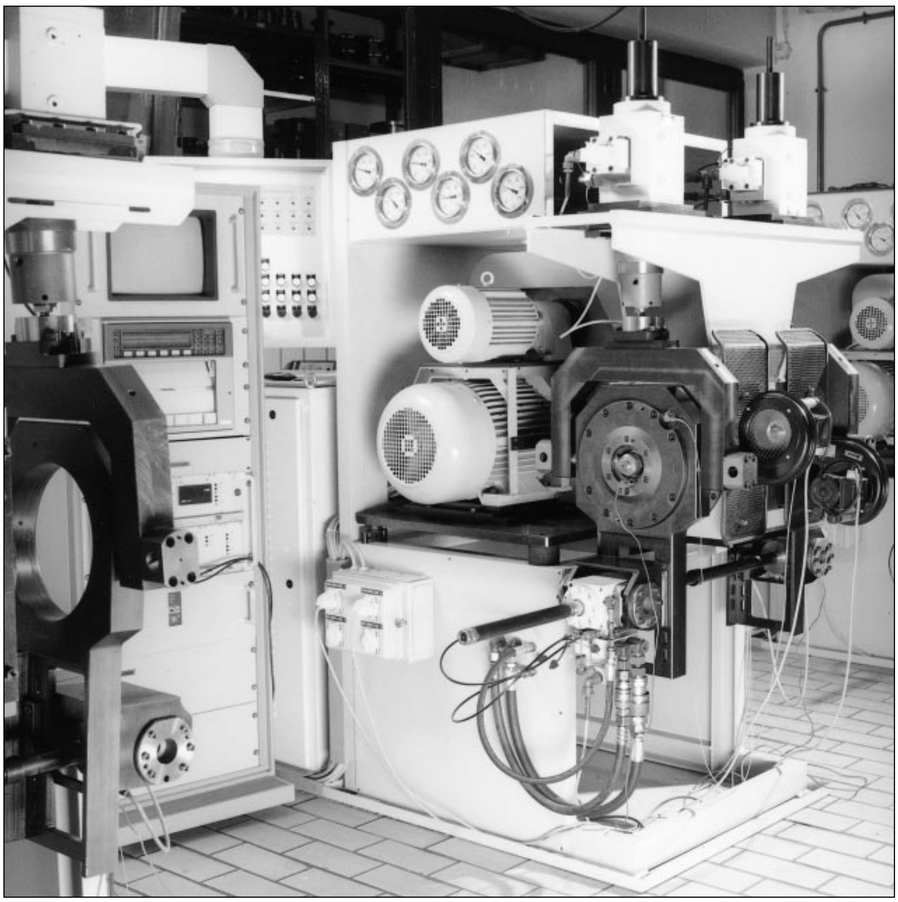


4.6 Component tests

There are numerous test rigs in FAG's development department for testing the efficiency of newly designed products. In some cases such tests can be used to clarify the cause of bearing damage. They include, on the one hand, direct tests on customer units for example deformation and vibration measuring on machines and, on the other hand, tightness inspections, measuring of frictional moment, and life tests on test rigs, figs. 114 and 115. The tests are performed under clearly defined conditions where the expected results are reliably foreseeable. Once the bearings have met the requirements in the experiment, the inspection of the damage case in question must then focus on the examination of actual operating conditions (unexpected extra load, also due to faulty mounting etc.). Should the bearings fail after an unexpectedly short running period, the technical monitoring facilities of the test rigs allow damage to be detected in its stage of origin. This is often a problem in the field but it is also frequently decisive for finding the cause of damage.

114: Test rig for inspecting the efficiency of rolling bearing seals

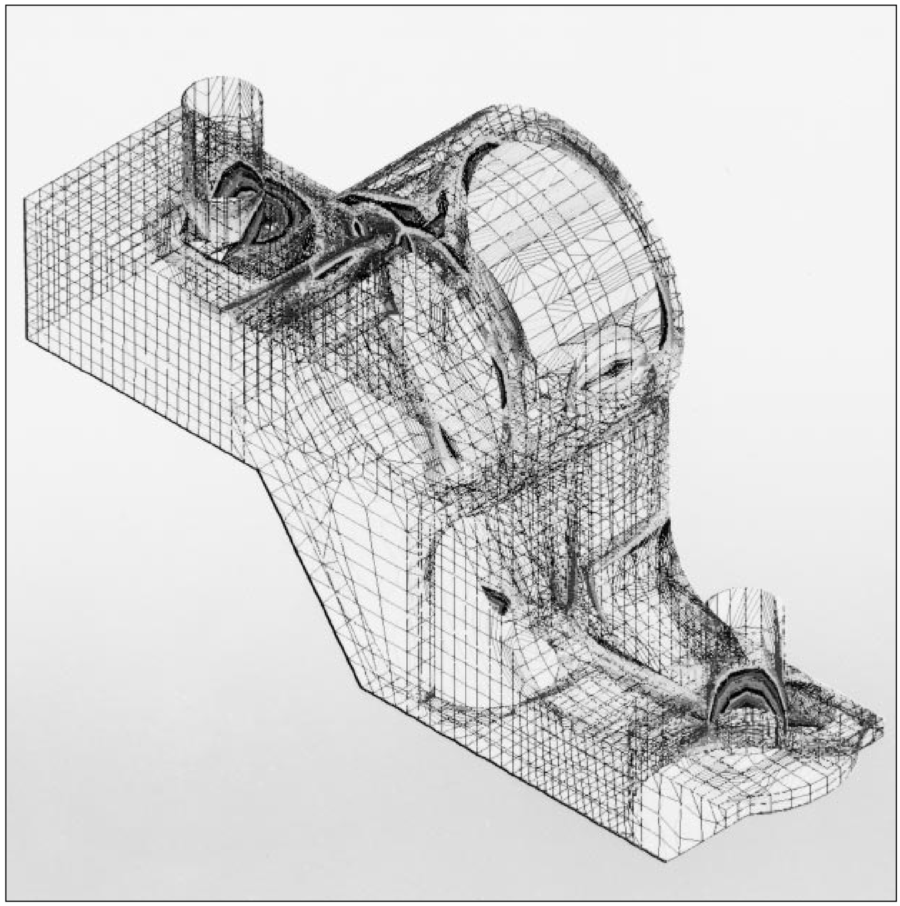
115: Test rig for simulating operating stress of car wheel bearings



4.7 Calculation of load conditions

In several cases bearings, whose load situation is not known completely, are selected for new constructions on the basis of experience with older, similar units. When bearing damage arises at a later stage, an accurate calculation of the mounting conditions frequently helps in the search for its cause. A comparison of the expected life calculation and the life actually attained is particularly important as well as the calculation of lubricating conditions. FAG has an extensive collection of calculation programs at its disposal. Even the most sophisticated bearing cases present no problem. The programs can calculate values for the external bearing load, tilting between mounted rings, internal stress, kinematic procedures within the bearing, deformation of mating parts, temperature marches and the like. The complexity of the programs ranges from simple evaluations of analytical formulae to the performance of various nummerical iterations with non-linear approximate solutions and even to extensive three-dimensional strength calculations for mating parts by means of the finite elements, fig. 116.

116: Calculation of stress on a journal roller bearing housing by means of the Finite Element Method (FEM)



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Recognition of damage and bearing inspection

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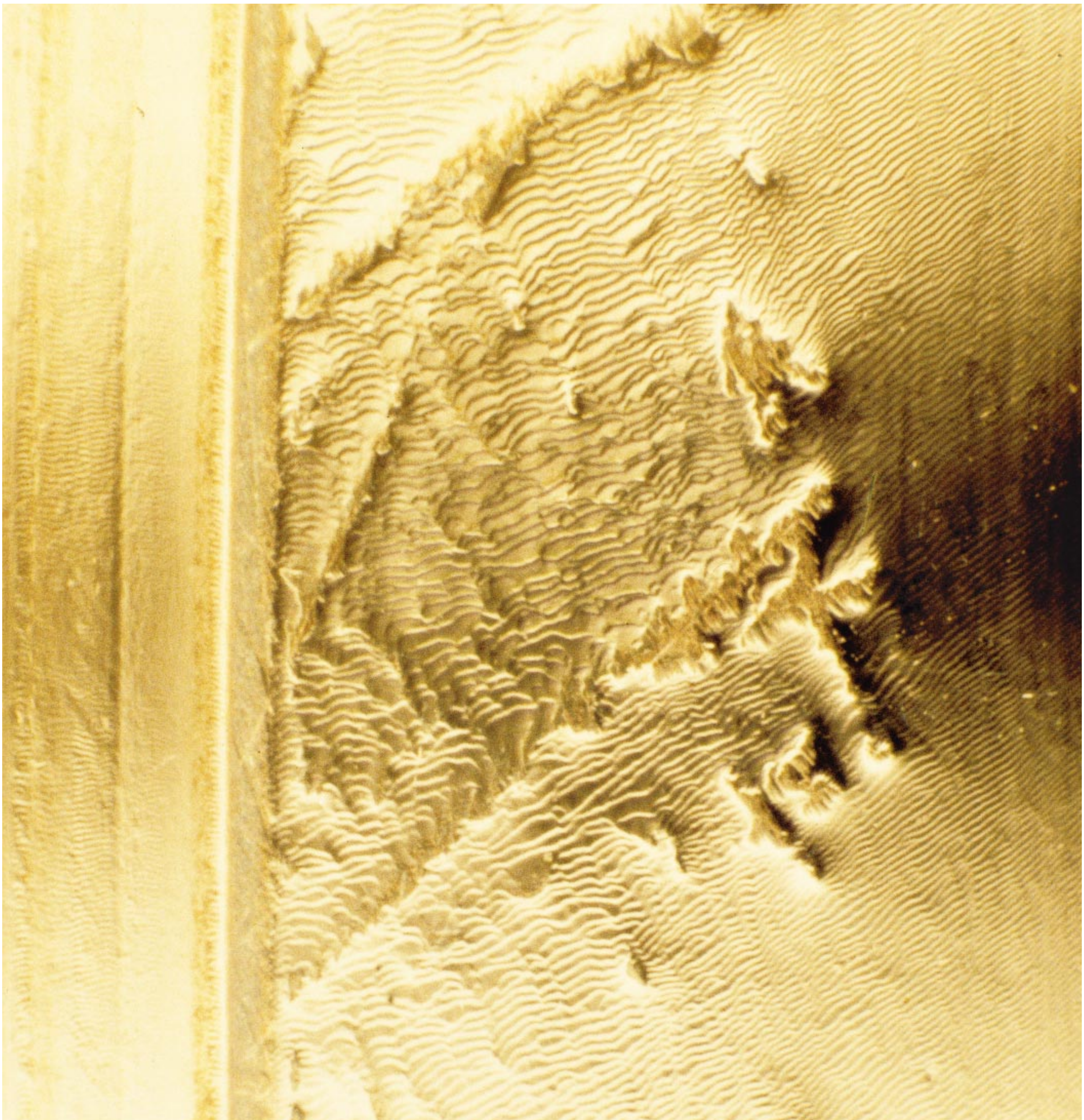

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FAG S-TYPE BEARINGS • FAG S-TYPE BEARING UNITS

Economical solutions for simple bearing arrangements

FAG OEM und Handel AG

PREFACE

The OEM und Handel company of the FAG Kugelfischer Georg Schäfer AG Group supplies rolling bearings, necessary accessories, and services to original equipment customers in machinery and plant construction as well as to customers in the distribution and spare parts business. Comprehensive rolling bearing know-how, competent consultation on applications, and extensive customer service for more operational reliability make FAG an indispensable partner to its customers. Research and development of our products is based on the requirements of operation in the field. An ideal outline of requirements is best achieved through cooperation of our application engineers and research team with the machine manufacturers and operators. It forms the basis for successful solutions both technically and economically speaking.

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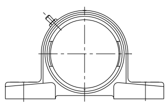
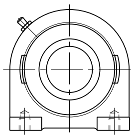
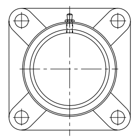
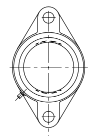
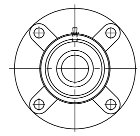
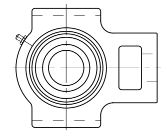
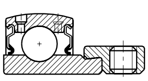
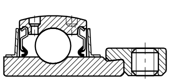
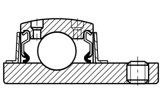
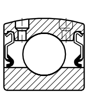
						
Series **162**	**S-type bearing units**					
	P162	**PA162**	**F162**	**FL162**	**FC162**	**T162**
d = 12...60 mm	d = 12...60 mm	d = 20...60 mm	d = 12...60 mm	d = 12...60 mm	d = 20...60 mm	d = 20...60 mm
d = $^{1}/_{2}$...2 $^{7}/_{16}$ in	Page 30	Page 36	Page 40	Page 46	Page 52	Page 58
	d = $^{1}/_{2}$...2 $^{7}/_{16}$ in	d = $^{3}/_{4}$...2 $^{7}/_{16}$ in	d = $^{1}/_{2}$...2 $^{7}/_{16}$ in	d = $^{1}/_{2}$...2 $^{7}/_{16}$ in	d = $^{3}/_{4}$...2 $^{7}/_{16}$ in	d = $^{3}/_{4}$...2 $^{7}/_{16}$ in
	Page 30	Page 36	Page 40	Page 46	Page 52	Page 58
Series **362**	**S-type bearing units**					
	P362	**PA362**	**F362**	**FL362**	**FC362**	**T362**
d = 20...90 mm	d = 20...90 mm	d = 20...60 mm	d = 20...90 mm	d = 20...75 mm	d = 20...90 mm	d = 20...90 mm
d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in	Page 30	Page 36	Page 40	Page 46	Page 52	Page 58
	d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in	d = $^{3}/_{4}$...2 $^{7}/_{16}$ in	d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in	d = $^{3}/_{4}$...3 in	d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in	d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in
	Page 30	Page 36	Page 40	Page 46	Page 52	Page 58
Series **562**	**S-type bearing units**					
	P562	**PA562**	**F562**	**FL562**	**FC562**	**T562**
d = 20...90 mm	d = 20...90 mm	d = 20...60 mm	d = 20...90 mm	d = 20...75 mm	d = 20...90 mm	d = 20...90 mm
d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in	Page 30	Page 36	Page 40	Page 46	Page 52	Page 58
	d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in	d = $^{3}/_{4}$...2 $^{7}/_{16}$ in	d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in	d = $^{3}/_{4}$...3 in	d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in	d = $^{3}/_{4}$... 3 $^{1}/_{2}$ in
	Page 30	Page 36	Page 40	Page 46	Page 52	Page 58
Series **762.2RSR**	**S-type bearing units**					
	P762.2RSR	**PA762.2RSR**	**F762.2RSR**	**FL762.2RSR**	**FC762.2RSR**	**T762.2RSR**
d = 17...60 mm	d = 17...60 mm	d = 20...60 mm	d = 17...60 mm	d = 17...60 mm	d = 20...60 mm	d = 20...60 mm
	Page 30	Page 36	Page 40	Page 46	Page 52	Page 58

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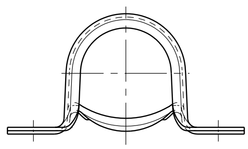
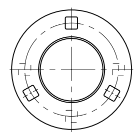
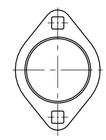
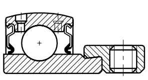
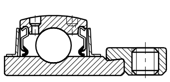
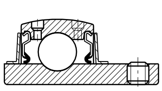
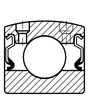
FAG PRESSED STEEL PLUMMER BLOCK HOUSINGS

for combination with S-type bearings

S-type bearings Page 24	Pressed steel plummer block housings Series SB2 	Pressed steel flanged housings Series FB2 	Pressed steel flanged housings Series FBB2 
Series **162** d = 12...50 mm d = $^{1}/_{2}...1^{15}/_{16}$ in 	for combination with S-type bearings of series 162 d = 12...35 mm Page 64 d = $^{1}/_{2}...1\,^{7}/_{16}$ in Page 64	d = 12...50 mm Page 66 d = $^{1}/_{2}...1^{15}/_{16}$ in Page 66	d = 12...35 mm Page 70 d = $^{1}/_{2}...1\,^{7}/_{16}$ in Page 70
Series **362** d = 20...50 mm d = $^{3}/_{4}...1^{15}/_{16}$ in 		for combination with S-type bearings of series 362 d = 20...50 mm Page 66 d = $^{3}/_{4}...1^{15}/_{16}$ in Page 66	d = 20...35 mm Page 70 d = $^{3}/_{4}...1\,^{7}/_{16}$ in Page 70
Series **562** d = 20...50 mm d = $^{3}/_{4}...1^{15}/_{16}$ in 		for combination with S-type bearings of series 562 d = 20...50 mm Page 66 d = $^{3}/_{4}...1^{15}/_{16}$ in Page 66	d = 20...35 mm Page 70 d = $^{3}/_{4}...1\,^{7}/_{16}$ in Page 70
Series **762.2RSR** d = 17...50 mm 	for combination with S-type bearings of series 762.2RSR d = 17...35 mm Page 64	d = 17...50 mm Page 66	d = 17...35 mm Page 70

FAG pressed steel S-type housings and FAG S-type bearings are not supplied as a unit and must, therefore, be ordered separately.

APPLICATION • ADVANTAGES

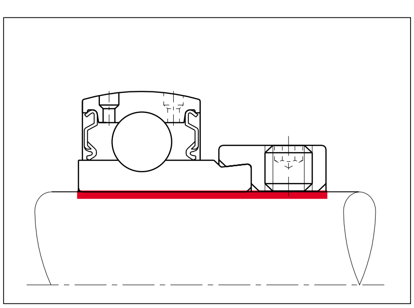
Application

FAG S-type bearings are preferably used for applications calling for simplicity of design and assembly. They are used, for instance, in agricultural machinery, conveyor systems and construction machinery.
The units consist of a deep groove ball bearing sealed on both sides, with a spherical outside diameter and a grey-cast iron (nodular cast iron also possible) or pressed steel housing.
FAG S-type bearings are used almost exclusively as locating bearings.
Therefore, they are particularly suitable for supporting short shafts and for applications where only minor thermal expansions are likely to occur. Minor expansions of the shaft are compensated for by the axial clearance of the bearings.

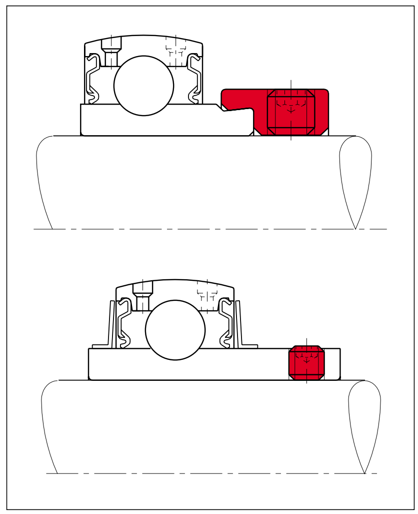
Advantages

- **Economical bearing arrangements for agricultural machinery, conveyor systems and construction machinery**

- **Simple mounting**
  The bore diameters of most FAG S-type bearings are selected such that loose shaft fits are obtained. This simplifies mounting.

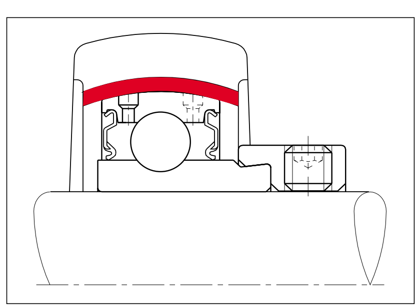


The bearings are fastened on the shaft either by means of eccentric self-locking collars or two threaded pins.

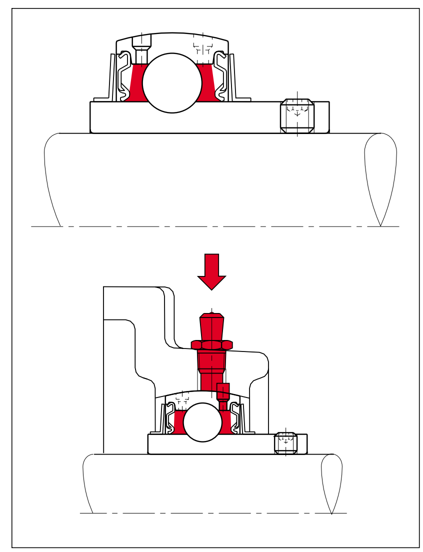


- **Standard shafts**
  The shafts for such bearing arrangements require no fine machining. Standard, drawn and peeled shafts that are machined to tolerance h9 will suffice.

- **Compensation of misalignments**
  FAG S-type bearing units can compensate for static misalignments. The spherical outer ring of the deep groove ball bearing can align as required in the accordingly designed housings.



- **No maintenance required**
  The deep groove ball bearings are sealed on both sides and contain a grease filling which will generally last for the whole bearing life. If cast housings are used, relubrication is possible, see drawing below.



- **Large selection of bearings, plummer block housings and flanged housings made of grey-cast iron or pressed steel**
  Deep groove ball bearings of series 162, 362, 562 and 762.2RSR are mounted into these housings. Synoptic tables of the FAG S-type Bearing Programme are shown on pages 4 and 5.
  Please inquire about the availability of other designs, e.g. deep groove ball bearings with the internal design of series 63 and bearings mounted onto an adapter sleeve.

DESIGN FEATURES OF S-TYPE BEARINGS

Dimensions • Codes • Materials • Clearance • Tolerances

Dimensions

The dimensions of FAG S-type bearings are largely in accordance with ISO 9628.
Bearings of series 762.2RSR have the same dimensions as deep groove ball bearings of series 62.2RSR. They differ only by their spherical outer ring. The other metric S-type bearings have the same nominal bore diameter and the same outside diameter as deep groove ball bearings of series 62.
Besides metric S-type bearings, we offer S-type bearings with inch size bores.

Codes

The code of a metric FAG S-type bearing is made up of the bearing series designation and the bore reference number.

Example:
S-type bearing FAG 16208
S-type bearing of series 162
Bore diameter 40 mm

For S-type bearings with inch size bores, three digits indicating the bore diameter are added to the metric-bearing code. The first digit indicates the whole inches, the last two digits indicate the fractions in $^{1}/_{16}$ in.

Example :
S-type bearing FAG 16208.109
S-type bearing of series 162
Bore diameter 1 $^{9}/_{16}$ in

Materials

Bearing rings and balls of FAG S-type bearings are made of through-hardening chromium steel (material no. 1.3505). The cage is made of pressed steel.

Bearing clearance

FAG S-type bearings have a radial clearance of C3 (series 762.2RSR bearings have CN clearance). The larger bearing clearance helps compensate for misalignments and shaft deflections.
The axial bearing clearance is eight to twelve times the radial clearance. Minor heat expansions of the shaft are, therefore, harmless.

Tolerances

Basically, FAG S-type bearings are machined to the normal tolerance class PN (in accordance with DIN 620) of radial bearings. An exception is the bore tolerance of series 162, 362 and 562 bearings. This tolerance provides a loose fit if the shaft is machined to one of the tolerance fields h. Standard, drawn or peeled shafts of tolerance h9 will suffice.

All dimensions of series 762.2RSR bearings have the normal tolerances of radial bearings. Therefore, the bearing seats on the shaft are machined, as usual, to j6 or k6, see also page 10.
Tolerance tables, see page 8.

Bore reference number		**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**
		Bearing clearance in µm									
Clearance group C3	min	11	13	13	13	15	15	18	18	23	23
	max	25	28	28	28	33	33	36	36	43	43
Clearance group CN	min	3	5	5	5	6	6	6	6	8	8
	max	18	20	20	20	20	20	23	23	28	28

Bore reference number		**13**	**14**	**15**	**16**	**17**	**18**
		Bearing clearance in µm					
Clearance group C3	min	23	25	25	25	30	30
	max	43	51	51	51	58	58

Radial clearance of FAG S-type bearings (clearance group C3 for series 162, 362, 562; clearance group CN for series 762.2RSR)

DESIGN FEATURES OF S-TYPE BEARINGS

Tolerances • Fastening of the inner rings

		Dimensions in mm				
Nominal bore diameter	over	**10**	**18**	**30**	**50**	**80**
	to	**18**	**30**	**50**	**80**	**120**
		Tolerances in µm				
Deviation Δ_{dmp} (series 162, 362, 562)		+18	+21	+25	+30	+35
		0	0	0	0	0
Deviation Δ_{dmp} (series 762.2RSR)		0	0	0	0	
		-8	-10	-12	-15	
Variation V_{dp} (series 162, 362, 562, 762.2RSR)		8	10	12	14	16
Radial runout K_{ia} (all series)		9	11	13	16	20

d_{mp} arithmetical mean of the largest and smallest single bore diameters in one radial plane
$\Delta_{dmp} = d_{mp} - d$ deviation of the mean bore diameter from nominal dimension
V_{dp} bore diameter variation; difference between the largest and smallest single bore diameters in one radial plane
K_{ia} radial runout of assembled bearing inner ring

Inner ring tolerances

		Dimensions in mm				
Nominal outside diameter	over	**30**	**50**	**80**	**120**	**150**
	to	**50**	**80**	**120**	**150**	**180**
Tolerance class PN (normal tolerance)						
		Tolerances in µm				
Deviation Δ_{Dmp}		0	0	0	0	0
		-11	-13	-15	-18	-25
Variation V_{Dp}		8	10	11	14	19
Radial runout K_{ea}		15	19	26	35	40

D_{mp} arithmetical mean of the largest and smallest single outside diameters in one radial plane
$\Delta_{Dmp} = D_{mp} - D$ deviation of the mean outside diameter from nominal dimension
V_{Dp} outside diameter variation; difference between the largest and smallest single outside diameter in one radial plane
K_{ea} radial runout of assembled bearing outer ring

Outer ring tolerances (series 162, 362, 562, 762.2RSR)

Fastening the inner rings

FAG S-type bearings of series 162 and 362 are fastened by means of eccentric self-locking collars. The inner eccentric of the self-locking collar is slipped over the outer eccentric of the bearing's extended inner ring. The self-locking collar is localized by means of its threaded pin. The dimensions of the eccentric self-locking collars are in accordance with ISO 9628.

Bearing with eccentric self-locking collar

FAG S-type bearings of series 562 are fastened by means of two threaded pins in the extended inner ring.

Bore reference number	**Tightening torque** Nm	**Wrench opening** mm
04	6	3
05	6	3
06	6	3
07	12	4
08	12	4
09	12	4
10	23	5
11	23	5
12	23	5
13	23	5
14	45	6
15	45	6
16	45	6
17	45	6
18	45	6

Tightening torque and wrench openings for the threaded pins of series 562 bearings

DESIGN FEATURES OF S-TYPE BEARINGS

Seals • Alignment • Operating temperature • Lubrication

Seals

FAG S-type bearings are fitted with rubbing seals. These seals consist of a sheet metal washer onto which a rubber lip is vulcanized. The seal lip contacts the inner ring lip under slight radial tension.
S-type bearings of series 362 and 562 can even be used for applications where they are exposed to heavy contamination. In addition to the rubbing seals, they have flinger shields on both sides that rotate with the inner ring.

Alignment

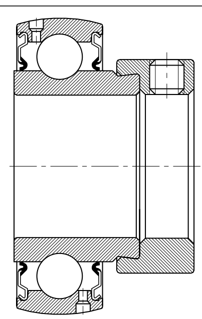
FAG S-type bearings with a spherical outside diameter can compensate for misalignments. They are mounted into grey-cast iron or pressed steel housings with a matching spherical inner surface.
Static misalignments of up to 5° out of the centre position are permissible. The angular misalignment of bearings which are relubricated must not exceed 2.5° as otherwise the lubricating hole in the outer ring will be covered and no longer accessible.

Operating temperature

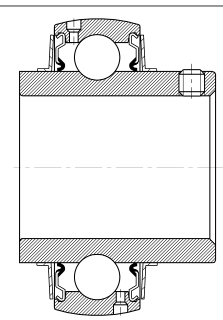
The maximum permissible operating temperature of FAG S-type bearings is 110 °C; the lower temperature limit is -30 °C.

Lubrication

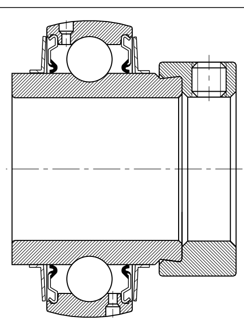
FAG S-type bearings are filled with a lithium soap base grease of penetration class 3. The standard grease filling will generally last for the whole bearing life. Where relubrication is planned, cast-iron housings are required. These housings have a lubricating nipple.
FAG S-type bearings have two lubricating holes in the outer ring at a distance of 180°.



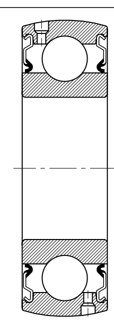
FAG S-type bearing of series 162



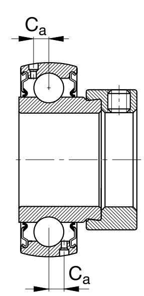
FAG S-type bearing of series 562



FAG S-type bearing of series 362



FAG S-type bearing of series 762.2RSR



Bore reference number	C_a ≈ mm
03	3.4
04	3.7
05	3.9
06	5
07	5.7
08	6.2
09	6.4
10	6.5
11	7
12	7.6
13	8.9
14	8.9
15	8.5
16	8.8
17	10
18	10

Position of the lubricating hole relative to the outer ring centre

Speed suitability

Speed suitability

The speeds attainable with an S-type bearing are determined primarily by the bearing seat on the shaft. The speeds reached with relatively rough shafts and loose fits are low. Higher speeds are reached with tighter fits and more accurately machined shafts. The following table lists the attainable speeds for various shaft tolerances.

Fits

With shafts machined to h9 a loose bearing fit is obtained. For tighter fits, such as required for higher speeds, the shafts are machined to k7 or m7.

The *interferences* or fit clearances obtained if the go-sides or the no-go-sides of bearing and shaft tolerances coincide are extreme values. Generally, the actual *interference* or fit clearance is somewhere between these two values.

The probable *interference* or fit clearance indicated is the value that is obtained if the actual dimensions are one third away from the go-side.

In the tables on pages 11 and 12 the tolerances of bearing bore and shaft as well as the fit clearance or *interference* are indicated. The meaning of the values is illustrated by examples above the tables.

Series 762.2RSR bearings are used where an increased running accuracy is required. These bearings have the permissible minimum dimensions usual for the inner ring bore of radial bearings (see page 7). The criteria for selecting the shaft tolerance if series 762.2RSR bearings are used are indicated in the table below.

Bore reference number	Shaft	Shaft tolerance				
		m7, k7	j7	h7	h8	h9
	mm	Speeds in min^{-1}				
03	17	12000	9500	6000	4300	1500
04	20	10000	8000	5000	3600	1200
05	25	9000	7200	4500	3100	1100
06	30	7500	6000	3800	2600	900
07	35	6300	5000	3200	2200	750
08	40	5600	4500	2800	1900	670
09	45	5300	4300	2600	1800	630
10	50	4800	3800	2400	1700	580
11	55	4300	3400	2200	1500	520
12	60	4000	3200	2000	1400	480
13	65	3600	2900	1800	1300	430
14	70	3400	2800	1700	1200	400
15	75	3200	2600	1600	1100	380
16	80	3000	2400	1500	1100	360
17	85	2800	2200	1400	1000	340
18	90	2600	2000	1300	900	320

Attainable speeds

Type of loading	Displaceability, load	Tolerance
Point load on the inner ring	Floating bearing with displaceable inner ring	g6 h6
Circumferential load on the inner ring or undefined load	normal load ($P/C \leq 0.15$)	j6
	high load ($P/C > 0.15$)	k6

Selection of shaft tolerances for series 762.2RSR bearings

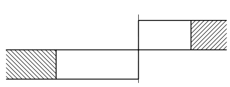
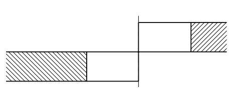
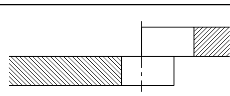
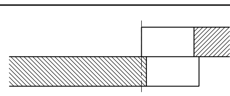
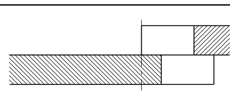
FITS

Example: Ø 40 j7

Go-side	+15	*15*	*Interference* or fit clearance if the go-sides coincide
		2	Probable *interference* or fit clearance
No-go-side	-10	35	*Interference* or fit clearance if the no-go-sides coincide

Numbers printed in *italics* = *Interference*
Figures in normal print = fit clearance

Dimensions in mm

Nominal shaft diameter	over to	 **18**		**18** **30**		**30** **50**		**50** **80**		**80** **120**	
Tolerance values in µm (normal tolerance)											
Bearing bore diameter Deviation Δ_{dmp}		+18 0		+21 0		+25 0		+30 0		+35 0	
Schematic fit drawing Shaft	Bearing	Shaft tolerance, *interference* or fit clearance in µm									
h9		0 -43	0 20 61	0 -52	0 24 73	0 -62	0 29 87	0 -74	0 35 104	0 -87	0 41 122
h8		0 -27	0 15 45	0 -33	0 18 54	0 -39	0 21 64	0 -46	0 25 76	0 -54	0 30 89
h7		0 -18	0 12 36	0 -21	0 14 42	0 -25	0 17 50	0 -30	0 20 60	0 -35	0 23 70
j7		+12 -6	*12* 0 24	+13 -8	*13* 1 29	+15 -10	*15* 2 35	+18 -12	*18* 2 42	+20 -15	*20* 4 50
k7		+19 +1	*19* *7* 17	+23 +2	*23* *9* 19	+27 +2	*27* *10* 23	+32 +2	*32* *12* 28	+38 +3	*38* *14* 32
m7		+25 +7	*25* *13* 11	+29 +8	*29* *15* 13	+34 +9	*34* *17* 16	+41 +11	*41* *21* 19	+48 +13	*48* *24* 22

$\Delta_{dmp} = d_{mp} - d$
Deviation of the mean bore diameter from nominal dimension

Shaft fits for series 162, 362 and 562 bearings

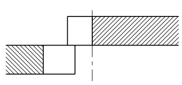
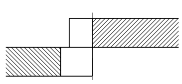
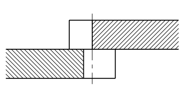
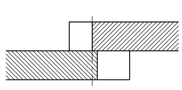
FITS

Example: Ø 40 j6

Go-side	+11	*23*	*Interference* or fit clearance if the go-sides coincide
		14	Probable *interference* or fit clearance
No-go-side	-5	5	*Interference* or fit clearance if the no-go-sides coincide

Numbers printed in *italics* = *Interference*
Figures in normal print = fit clearance

Dimensions in mm

Nominal shaft diameter	over to	**10** **18**		**18** **30**		**30** **50**		**50** **65**	
		Tolerance values in µm (normal tolerance)							
Bearing bore diameter Deviation Δ_{dmp}		-8 0		-10 0		-12 0		-15 0	
Schematic fit drawing Shaft	Bearing	Shaft tolerance, *interference* or fit clearance in µm							
g6		-6 -17	*2* 4 17	-7 -20	*3* 5 20	-9 -25	*3* 6 25	-10 -29	*5* 6 29
h6		0 -11	*8* *2* 11	0 -13	*10* *2* 13	0 -16	*12* *3* 16	0 -19	*15* *4* 19
j6		+8 -3	*16* *10* 3	+9 -4	*19* *11* 4	+11 -5	*23* *14* 5	+12 -7	*27* *16* 7
k6		+12 +1	*20* *14* *1*	+15 +2	*25* *17* *2*	+18 +2	*30* *21* *2*	+21 +2	*36* *25* *2*

$\Delta_{dmp} = d_{mp} - d$
Deviation of the mean bore diameter from nominal dimension

Shaft fits for series 762.2RSR bearings

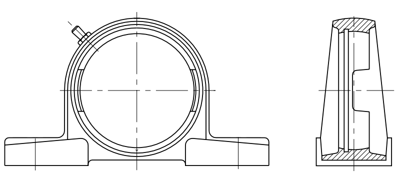
DESIGN FEATURES OF FAG S-TYPE HOUSINGS

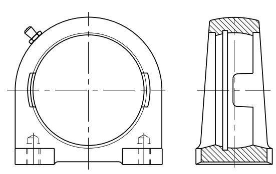
Designs

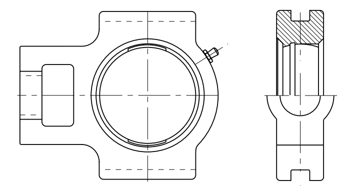
Designs

Cast FAG S-type housings are available as plummer block housings, as flanged housings and as take-up unit housings.

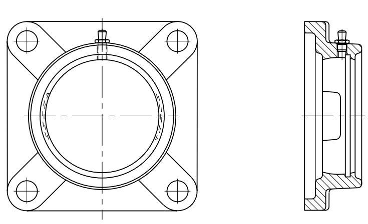
Pressed housings are available both as plummer block housings and as flanged housings.

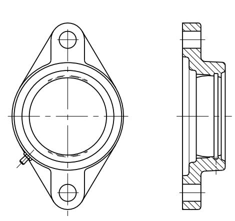

Series P2


Series PA2


Series T2

Plummer block housings (P2, PA2) and take-up unit housings (T2) made from grey-cast iron


Series F2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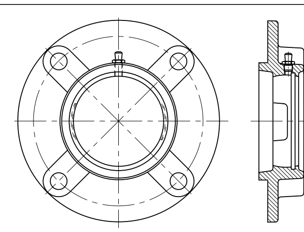
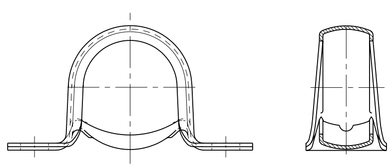
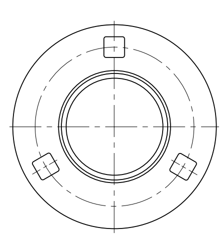
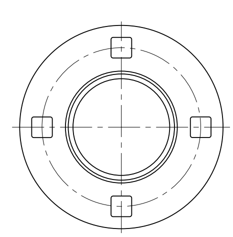
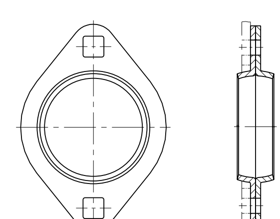

Series FC2

Flanged housings made from grey-cast iron (F2, FL2, FC2)


Series SB2


Series FB2
up to FB207


from FB208


Series FBB2

Plummer block housings made from pressed steel (SB2); flanged housings made from pressed steel (FB2, FBB2)

DESIGN FEATURES OF FAG S-TYPE HOUSINGS

Materials • Preservation • Dimensions • Tolerances • Relubrication • Load carrying capacity

Materials, preservation

Cast FAG S-type housings are made from GG-20 grey-cast iron (nodular cast iron also possible); they are one-piece housings. The non-machined outer surfaces of the cast housings have a bluish grey coat of paint. All machined surfaces are preserved.

Pressed FAG S-type housings are made of sheet steel. They consist of two parts. FAG pressed steel housings are zinc coated and chromized and in this way protected from corrosion.

Dimensions

The dimensions of cast iron S-type housings are largely in accordance with ISO 3228 and DIN 626-2.

The dimensions of pressed steel housings are specified in ISO 3228 and DIN 626-3.

The dimensions may vary from those of earlier housing designs.

Tolerances of the housing bores

The bearing seats in the cast housings are machined to J7. The bearing can align in the spherical seat if there is a shaft misalignment.
The bearing seats in the pressed steel housings are toleranced such that a tight fit is obtained for the outer ring when the housing halves are bolted together. For this reason the fastening bolts may only be tightened after the bearing has aligned during mounting.

Relubrication

As a rule, FAG S-type bearings require no relubrication. Relubrication is only recommended for applications where bearings are subjected to heavy contamination and considerable moisture as well as high loads, speeds and temperatures.

S-type bearings that are relubricated must be mounted into cast housings. These housings have a tapped hole M6 x 1 into which a lubricating nipple GU1 is screwed.

FAG lithium soap base grease Arcanol L71V is to be used for relubrication.

Load carrying capacity of FAG S-type housings

Where plummer block housings or flanged housings of cast iron are used, the strength of the housing does not have to be taken into account. It is in any case great enough that the load carrying capacity of the bearing can be fully utilized. Therefore, cast housings are used mainly where high loads have to be accommodated. If heavy shock loads have to be accommodated we recommend to use nodular cast iron housings which can be ordered as well.
The lower priced pressed housings on the other hand can be used only for low loads due to their limited strength. The permissible radial and axial loads are indicated in the table. With pressed steel flanged housings the axial load should not exceed 50% of the permissible radial load; with pressed steel plummer block housings the axial load should not exceed 30% of the permissible radial load.

Housing reference number	Series FB, FBB		SB	
	radial	axial	radial	axial
	permissible load ≈ kN			
03	2.4	1.2	1.2	0.4
04	3.2	1.6	1.6	0.5
05	3.65	1.8	1.8	0.55
06	4.8	2.4	2.6	0.8
07	6.3	3.15	3.45	1.05
08	7.1	3.55		
09	7.8	3.9		
10	9	4.5		

Permissible radial and axial loads on FAG pressed housings

DIMENSIONING

Load carrying capacity • Calculation of dynamically stressed bearings

Load carrying capacity of FAG S-type bearings

FAG S-type bearings have the same radial load carrying capacity as series 62 deep groove ball bearings (cp. p. 17). With smooth shafts, the axial load carrying capacity of FAG S-type bearings depends on the strength of the inner ring fixation on the shaft. The permissible axial loads are indicated in the table.

Bore reference number	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
permissible axial load ≈ kN	1.5	2	2.3	3	4	4.5	5	5.5	6.5	8	8.5	9.5	10	10.5	11	12

Permissible axial load on FAG S-type bearings

With higher axial loads, the inner ring is supported against a shaft shoulder. A greater axial load carrying capacity can also be achieved if the shafts feature holes into which the threaded pins are inserted.

Calculation of the FAG S-type bearings

A differentiation is made between dynamic and static stress in rolling bearing engineering. Dynamic stress implies that either the inner ring or the outer ring rotates. Static stress refers to bearings carrying a load when stationary. Depending on which type of stress is involved, either the dynamic load rating C or the static load rating C_0 is used for bearing calculation.

Calculation of dynamically stressed bearings

If a rotating bearing is subjected to a radial load and a thrust load at the same time, the bearing calculation is based on the equivalent dynamic load P.

$P = X \cdot F_r + Y \cdot F_a$ [kN]

P = equivalent dynamic load [kN]
F_r = radial load [kN]
F_a = axial load [kN]
X = radial factor
Y = thrust factor

The X and Y values for S-type bearings are determined by the F_a/F_r ratio and the $f_0 \cdot F_a / C_0$ ratio (f_0 values, see table on page 17).

Bearing clearance C3					
$\frac{f_0 \cdot F_a}{C_0}$	e	$\frac{F_a}{F_r} \le e$		$\frac{F_a}{F_r} > e$	
		X	Y	X	Y
0.3	0.32	1	0	0.46	1.7
0.5	0.35	1	0	0.46	1.56
0.9	0.39	1	0	0.46	1.41
1.6	0.43	1	0	0.46	1.27
3	0.48	1	0	0.46	1.14
6	0.54	1	0	0.46	1

X and Y factors for calculating the equivalent dynamic load

After selecting a suitable S-type bearing, its load carrying capacity must be checked. This is done by means of the f_L index.

$f_L = (C/P) \cdot f_n$
f_L = index of dynamic stressing
C = dynamic load rating [kN]
P = equivalent dynamic load [kN]
f_n = speed factor [kN]

The value of f_L that must be reached in this calculation is to be specified on the basis of a comparison with field-proven designs. The following table indicates which f_L values or which nominal life values are recommended for various applications.

Application	f_L value	Nominal life [h]
Seasonal operation with low-degree machine utilization	1.0 - 1.5	500 - 1 700
Seasonal operation with full machine utilization	1.5 - 2.0	1 700 - 4 000
Continuous operation with low-degree machine utilization	2.5 - 3.5	6 000 - 20 000
Continuous operation with full machine utilization	3.5 - 4.0	20 000 - 30 000

Recommended values for the f_L index and for the nominal life

DIMENSIONING

Calculation of dynamically stressed bearings

Speed factor f_n

$$f_n = \sqrt[3]{\frac{33\,^1/_3}{n}}$$

n min^{-1}	f_n	n min^{-1}	f_n	n min^{-1}	f_n	n min^{-1}	f_n	n min^{-1}	f_n
10	1.49	42	0.926	170	0.581	650	0.372	2800	0.228
11	1.45	44	0.912	180	0.57	700	0.362	3000	0.223
12	1.41	46	0.898	190	0.56	750	0.354	3200	0.218
13	1.37	48	0.886	200	0.55	800	0.347	3400	0.214
14	1.34	50	0.874	220	0.533	850	0.34	3600	0.21
15	1.3	55	0.846	240	0.518	900	0.333	3800	0.206
16	1.28	60	0.822	260	0.504	950	0.327	4000	0.203
17	1.25	65	0.8	280	0.492	1000	0.322	4200	0.199
18	1.23	70	0.781	300	0.481	1100	0.312	4400	0.196
19	1.21	75	0.763	320	0.471	1200	0.303	4600	0.194
20	1.19	80	0.747	340	0.461	1300	0.295	4800	0.191
22	1.15	85	0.732	360	0.452	1400	0.288	5000	0.188
24	1.12	90	0.718	380	0.444	1500	0.281	5500	0.182
26	1.09	95	0.705	400	0.437	1600	0.275	6000	0.177
28	1.06	100	0.693	420	0.43	1700	0.27	6500	0.172
30	1.04	110	0.672	440	0.423	1800	0.265	7000	0.168
32	1.01	120	0.652	460	0.417	1900	0.26	7500	0.164
34	0.993	130	0.635	480	0.411	2000	0.255	8000	0.161
36	0.975	140	0.62	500	0.405	2200	0.247	8500	0.158
38	0.957	150	0.606	550	0.393	2400	0.24	9000	0.155
40	0.941	160	0.593	600	0.382	2600	0.234	9500	0.152

f_L index and nominal life L_h

$$f_L = \sqrt[3]{\frac{L_h}{500}}$$

L_h h	f_L	L_h h	f_L	L_h h	f_L	L_h h	f_L	L_h h	f_L
100	0.585	380	0.913	1300	1.38	4400	2.06	16000	3.17
110	0.604	400	0.928	1400	1.41	4600	2.1	17000	3.24
120	0.621	420	0.944	1500	1.44	4800	2.13	18000	3.3
130	0.638	440	0.958	1600	1.47	5000	2.15	19000	3.36
140	0.654	460	0.973	1700	1.5	5500	2.22	20000	3.42
150	0.669	480	0.986	1800	1.53	6000	2.29	22000	3.53
160	0.684	500	1	1900	1.56	6500	2.35	24000	3.63
170	0.698	550	1.03	2000	1.59	7000	2.41	26000	3.73
180	0.711	600	1.06	2200	1.64	7500	2.47	28000	3.83
190	0.724	650	1.09	2400	1.69	8000	2.52	30000	3.91
200	0.737	700	1.12	2600	1.73	8500	2.57	32000	4
220	0.761	750	1.14	2800	1.78	9000	2.62	34000	4.08
240	0.783	800	1.17	3000	1.82	9500	2.67	36000	4.16
260	0.804	850	1.19	3200	1.86	10000	2.71	38000	4.24
280	0.824	900	1.22	3400	1.89	11000	2.8	40000	4.31
300	0.843	950	1.24	3600	1.93	12000	2.88	42000	4.38
320	0.862	1000	1.26	3800	1.97	13000	2.96	44000	4.45
340	0.879	1100	1.3	4000	2	14000	3.04	46000	4.51
360	0.896	1200	1.34	4200	2.03	15000	3.11	48000	4.58

DIMENSIONING

Calculation of dynamically stressed bearings • Calculation of statically stressed bearings

Modified life calculation

For normal applications, dimensioning bearings to reach a nominal life in accordance with DIN ISO 281 usually yields very failsafe bearings. In some cases, however, the capacity of a bearing has to be determined more accurately and utilized more fully. Calculating the attainable life in accordance with the FAG method allows designers to take operating influences and ambient influences (loads, lubrication, cleanliness in the lubricating gap) into account more specifically. For details see catalogue WL 41 520 “FAG Rolling Bearings”.

Other influences on the bearing life

When estimating the life of a bearing not only the fatigue life must be taken into account. If contaminants penetrate into the bearing, if there is corrosion or starved lubrication, a bearing can become unserviceable as a result of wear.

Calculation of statically stressed bearings

If a statically stressed bearing is simultaneously subjected to a radial load and a thrust load, the bearing calculation is based on the equivalent static load.

$P_0 = F_r$ [kN] for $\frac{F_a}{F_r} \leq 0.8$

$P_0 = 0.6 \cdot F_r + 0.5 \cdot F_a$ [kN] for $\frac{F_a}{F_r} > 0.8$

P_0 = equivalent static load [kN]
F_r = radial load [kN]
F_a = thrust load [kN]

After selecting a suitable S-type bearing, its static load carrying capacity must be checked. This is done by means of the f_s index.

$$f_s = \frac{C_0}{P_0}$$

f_s = index of static stressing
C_0 = static load rating [kN]
P_0 = equivalent static load [kN]

The f_s index is a safety factor against permanent deformations of the contact areas of raceway and balls. A high fs value is required for bearings which must run smoothly. Smaller values suffice when a moderate degree of running smoothness is required.

f_s = 1.5 to 2.5 for a high degree
f_s = 1.0 to 1.5 for a normal degree
f_s = 0.7 to 1.0 for a moderate degree

Bore reference number	**Load rating · Factor Series 162, 362, 562, 762.2RSR** C dyn. kN	C_0 stat.	f_0
03	9.5	4.75	13.1
04	12.7	6.55	13.1
05	14.3	7.8	13.8
06	19.3	11.2	13.8
07	25.5	15.3	13.8
08	29	18	14
09	31	20.4	14.3
10	36.5	24	14.3
11	43	29	14.3
12	52	36	14.3
13	60	41.5	14.3
14	62	44	14.4
15	65.5	49	14.7
16	72	53	14.6
17	83	64	14.7
18	96.5	72	14.5

If pressed housings are used, the permissible loads on the housings must be observed (page 14).

Dynamic and static load ratings, f_0 values

MOUNTING OF FAG S-TYPE BEARINGS

Mounting

FAG S-type bearings are used almost exclusively as locating bearings. Therefore, they are particularly suitable for supporting short shafts and for applications where only minor thermal expansions are likely to occur. S-type bearings are also used as locating bearings for applications where a shaft is supported by more than two bearings.

Minor expansions of the shaft are compensated for by the axial clearance of the bearings. If in the case of a shaft supported by two bearings the inner rings of the bearings are pushed towards each other during mounting, a length compensation by twice the axial clearance is possible. In constructions where S-type bearings are mounted into sheet metal walls or sectional steel frames the elasticity of the surrounding structure prevents detrimental preloading of the bearings.

Floating bearings are obtained if the inner ring is provided with a loose fit. For applications where shafts toleranced to h9 are used, a floating bearing should only be mounted at locations subjected to slight stressing or if the inner ring accommodates a point load. It is better to machine the bearing seat to h7 or j7.

Fastening on the shaft

Eccentric self-locking collars are tightened in the main direction of shaft rotation, in the case of rotating housings against the direction of housing rotation.

As the inner ring of the bearing cannot be held in place the eccentric self-locking collar is tightened with a slight jerk first. The eccentric self-locking collar is then securely localized by means of hammer and metal drift. The eccentric self-locking collar has a radial hole where the metal drift can be applied. Finally, the collar is localized by means of a threaded pin.

Bearings with an extended inner ring (series 562) are fastened on the shaft by means of two threaded pins. The threaded pins must be tightened so that the cutting edges are pressed into the shaft. If increased axial loads or impacts have to be accommodated the inner ring is supported against a shaft shoulder. A greater axial load carrying capacity is achieved if the shafts have holes into which the threaded pins are inserted. The tightening torques required for the threaded pins are listed on page 8.

MOUNTING OF FAG S-TYPE BEARINGS

Grey-cast iron plummer block housings

Mounting S-type bearings with grey-cast iron plummer block housings (series FAG P2 and PA2)

a: Insert S-type bearing into the two recesses; remove eccentric self-locking collar first.

b: Swing bearing into the right position using a pin or a section of pipe; for this purpose the housing is best clamped in a vice.

c: Push bearing unit onto the shaft together with the eccentric self-locking collar.

d: Fasten the housing with bolts.

e: Manually tighten eccentric self-locking collar with a slight jerk in the direction of shaft rotation.

f: Localize eccentric self-locking collar by means of metal drift and hammer.

g: Tighten threaded pin.

h: Series 562: tighten both threaded pins.

Note:
Proceed accordingly when mounting S-type bearings with take-up unit housings (series T2).

MOUNTING OF FAG S-TYPE BEARINGS

Grey-cast iron flanged housings

Mounting S-type bearings with grey-cast iron flanged housings (series FAG F2, FL2 and FC2)

a: Insert S-type bearing into the two recesses; remove eccentric self-locking collar first.

b: Swing bearing into the right position using a pin or a section of pipe; for this purpose the housing is best clamped in a vice.

c: Push bearing unit onto the shaft together with the eccentric self-locking collar.

d: Fasten the housing with bolts.

e: Manually tighten eccentric self-locking collar with a slight jerk in the direction of shaft rotation.

f: Localize eccentric self-locking collar by means of metal drift and hammer.

g: Tighten threaded pin.

h: Series 562: tighten both threaded pins.

MOUNTING OF FAG S-TYPE BEARINGS

Pressed steel plummer block housings

Mounting S-type bearings with pressed steel plummer block housings (series FAG SB2)

a: Assemble housing and bearing and push them onto the shaft.

b: Slightly tighten bolts. Assemble housing and bearing at the other shaft end in the same manner. Securely tighten bolts.

c: Manually tighten eccentric self-locking collar in the direction of shaft rotation.

d: Localize eccentric self-locking collar by means of metal drift and hammer.

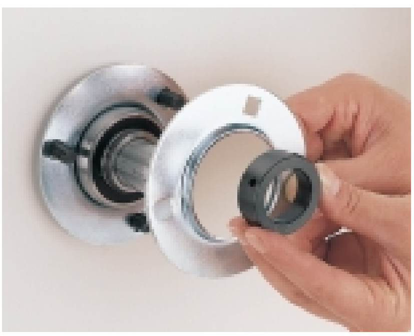
e: Tighten threaded pin.

MOUNTING OF FAG S-TYPE BEARINGS

Pressed steel flanged housings

Mounting S-type bearings with pressed steel flanged housings (series FAG FB2 and FBB2)

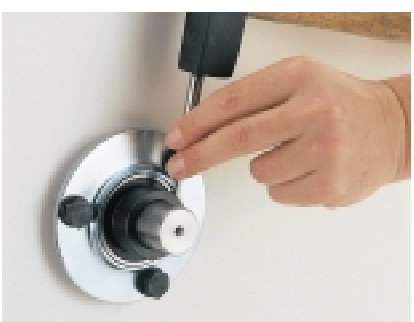
a: Assemble housing and bearing and push them onto the shaft.



b: Slightly tighten bolts. Assemble housing and bearing at the other shaft end in the same manner. Securely tighten bolts.

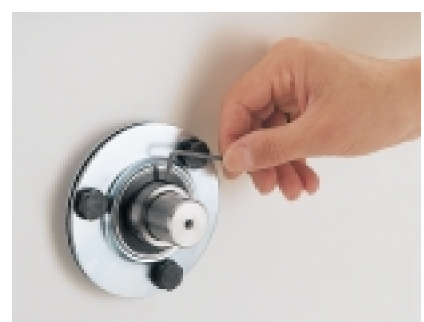
c: Manually tighten eccentric self-locking collar in the direction of shaft rotation.

d: Localize eccentric self-locking collar by means of metal drift and hammer.



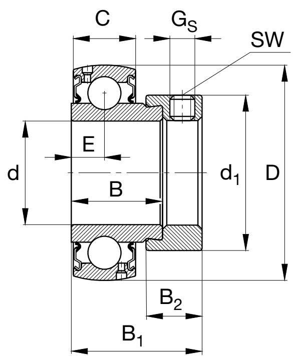
e: Tighten threaded pin.

f: series 562: tighten both threaded pins.

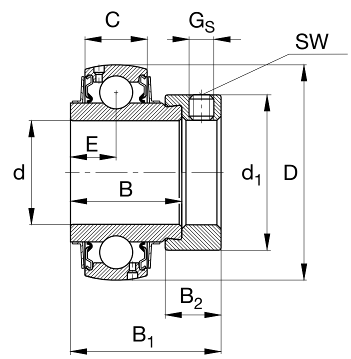


FAG S-TYPE BEARINGS FOR METRIC AND INCH SHAFT SIZES

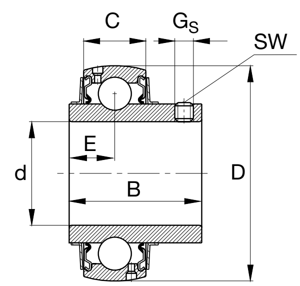
Series 162, 362, 562, 762..2RSR



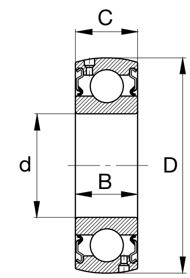
162



362



562



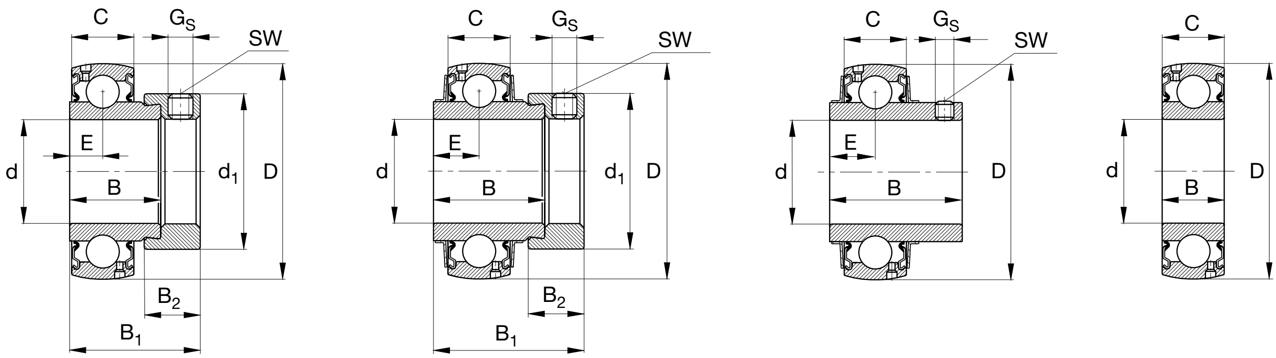
762...2RSR

Shaft	**Dimensions**										**Load rating**		**Code**	**Mass**
	d	D	C	B	B_1	d_1 max	B_2	E	G_S	SW	dyn. C	stat. C_0	Bearing with locking device	≈
mm in	mm								mm *in*		kN		**FAG**	kg
12	12	40	12	19.1	28.6	28.6	13.5	6.5	M6x0.75	3	9.5	4.75	16203/12	0.13
1/2	12.7	40	12	19.1	28.6	28.6	13.5	6.5	*1/4 - 28UNF*	*1/8*	9.5	4.75	16203.008	0.128
9/16	14.288	40	12	19.1	28.6	28.6	13.5	6.5	*1/4 - 28UNF*	*1/8*	9.5	4.75	16203.009	0.123
15	15	40	12	19.1	28.6	28.6	13.5	6.5	M6x0.75	3	9.5	4.75	16203/15	0.12
5/8	15.875	40	12	19.1	28.6	28.6	13.5	6.5	*1/4 - 28UNF*	*1/8*	9.5	4.75	16203.010	0.117
17	17	40	12	19.1	28.6	28.6	13.5	6.5	M6x0.75	3	9.5	4.75	**16203**	0.1
	17	40	12	12							9.5	4.75	76203.2RSR	0.064
11/16	17.463	40	12	19.1	28.6	28.6	13.5	6.5	*1/4 - 28UNF*	*1/8*	9.5	4.75	16203.011	0.091
3/4	19.05	47	14	21.5	31	33.3	13.5	7.5	*1/4 - 28UNF*	*1/8*	12.7	6.55	16204.012	0.154
	19.05	47	17	34.2	43.7	33.3	13.5	17.1	*1/4 - 28UNF*	*1/8*	12.7	6.55	36204.012	0.208
	19.05	47	17	31				12.7	*1/4 - 28UNF*	*1/8*	12.7	6.55	56204.012	0.162
20	20	47	14	21.5	31	33.3	13.5	7.5	M6x0.75	3	12.7	6.55	**16204**	0.15
	20	47	17	34.2	43.7	33.3	13.5	17.1	M6x0.75	3	12.7	6.55	**36204**	0.2
	20	47	17	31				12.7	M6x0.75	3	12.7	6.55	**56204**	0.14
	20	47	14	14							12.7	6.55	**76204.2RSR**	0.106
13/16	20.638	52	15	21.5	31	38.1	13.5	7.5	*1/4 - 28UNF*	*1/8*	14	7.8	16205.013	0.246
	20.638	52	17	34.9	44.4	38.1	13.5	17.5	*1/4 - 28UNF*	*1/8*	14	7.8	36205.013	0.313
	20.638	52	17	34.1				14.3	*1/4 - 28UNF*	*1/8*	14	7.8	56205.013	0.238
7/8	22.225	52	15	21.5	31	38.1	13.5	7.5	*1/4 - 28UNF*	*1/8*	14	7.8	16205.014	0.237
	22.225	52	17	34.9	44.4	38.1	13.5	17.5	*1/4 - 28UNF*	*1/8*	14	7.8	36205.014	0.298
	22.225	52	17	34.1				14.3	*1/4 - 28UNF*	*1/8*	14	7.8	56205.014	0.223
15/16	23.813	52	15	21.5	31	38.1	13.5	7.5	*1/4 - 28UNF*	*1/8*	14	7.8	16205.015	0.228
	23.813	52	17	34.9	44.4	38.1	13.5	17.5	*1/4 - 28UNF*	*1/8*	14	7.8	36205.015	0.282
	23.813	52	17	34.1				14.3	*1/4 - 28UNF*	*1/8*	14	7.8	56205.015	0.208
25	25	52	15	21.5	31	38.1	13.5	7.5	M6x0.75	3	14	7.8	**16205**	0.22
	25	52	17	34.9	44.4	38.1	13.5	17.5	M6x0.75	3	14	7.8	**36205**	0.27
	25	52	17	34.1				14.5	M6x0.75	3	14	7.8	**56205**	0.19
	25	52	15	15							14	7.8	**76205.2RSR**	0.128

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.

FAG S-TYPE BEARINGS FOR METRIC AND INCH SHAFT SIZES

Series 162, 362, 562, 762..2RSR



162 **362** **562** **762...2RSR**

Shaft	Dimensions										Load rating		Code	Mass
	d	D	C	B	B_1	d_1 max	B_2	E	G_S	SW	dyn. C	stat. C_0	Bearing with locking device	≈
mm in	mm								mm *in*		kN		**FAG**	kg
1	25.4	52	15	21.5	31	38.1	13.5	7.5	*$^1/_4$-28UNF*	*$^1/_8$*	14	7.8	16205.100	0.217
	25.4	52	17	34.9	44.4	38.1	13.5	17.5	*$^1/_4$-28UNF*	*$^1/_8$*	14	7.8	36205.100	0.265
	25.4	52	17	34.1				14.3	*$^1/_4$-28UNF*	*$^1/_8$*	14	7.8	56205.100	0.188
1 $^1/_{16}$	26.988	62	16	23.8	35.7	44.5	15.9	9	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	19.3	11.2	16206.101	0.325
	26.988	62	19	36.5	48.4	44.5	15.9	18.3	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	19.3	11.2	36206.101	0.459
	26.988	62	19	38.1				15.9	*$^1/_4$-28UNF*	*$^1/_8$*	19.3	11.2	56206.101	0.352
1 $^1/_8$	28.575	62	16	23.8	35.7	44.5	15.9	9	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	19.3	11.2	16206.102	0.312
	28.575	62	19	36.5	48.4	44.5	15.9	18.3	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	19.3	11.2	36206.102	0.439
	28.575	62	19	38.1				15.9	*$^1/_4$-28UNF*	*$^1/_8$*	19.3	11.2	56206.102	0.331
30	30	62	16	23.8	35.7	44.5	15.9	9	M8x1	4	19.3	11.2	**16206**	0.3
	30	62	19	36.5	48.4	44.5	15.9	18.3	M8x1	4	19.3	11.2	**36206**	0.42
	30	62	19	38.1				15.9	M6x0.75	3	19.3	11.2	**56206**	0.31
	30	62	16	16							19.3	11.2	**76206.2RSR**	0.193
1 $^3/_{16}$	30.163	62	16	23.8	35.7	44.5	15.9	9	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	19.3	11.2	16206.103	0.299
	30.163	62	19	36.5	48.4	44.5	15.9	18.3	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	19.3	11.2	36206.103	0.418
	30.163	62	19	38.1				15.9	*$^1/_4$-28UNF*	*$^1/_8$*	19.3	11.2	56206.103	0.308
1 $^1/_4$	31.75	62	16	23.8	35.7	44.5	15.9	9	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	19.3	11.2	16206.104	0.284
	31.75	62	19	36.5	48.4	44.5	15.9	18.3	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	19.3	11.2	36206.104	0.396
	31.75	62	19	38.1				15.9	*$^1/_4$-28UNF*	*$^1/_8$*	19.3	11.2	56206.104	0.284
	31.75	72	17	25.4	38.9	55.6	17.5	9.5	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	25.5	15.3	16207.104	0.534
	31.75	72	20	37.6	51.1	55.6	17.5	18.8	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	25.5	15.3	36207.104	0.69
	31.75	72	20	42.9				17.5	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	25.5	15.3	56207.104	0.539
1 $^5/_{16}$	33.338	72	17	25.4	38.9	55.6	17.5	9.5	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	25.5	15.3	16207.105	0.518
	33.338	72	20	37.6	51.1	55.6	17.5	18.8	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	25.5	15.3	36207.105	0.666
	33.338	72	20	42.9				17.5	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	25.5	15.3	56207.105	0.512
1 $^3/_8$	34.925	72	17	25.4	38.9	55.6	17.5	9.5	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	25.5	15.3	16207.106	0.501
	34.925	72	20	37.6	51.1	55.6	17.5	18.8	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	25.5	15.3	36207.106	0.641
	34.925	72	20	42.9				17.5	*$^5/_{16}$-24UNF*	*$^5/_{32}$*	25.5	15.3	56207.106	0.483
35	35	72	17	25.4	38.9	55.6	17.5	9.5	M8x1	4	25.5	15.3	**16207**	0.5
	35	72	20	37.6	51.1	55.6	17.5	18.8	M8x1	4	25.5	15.3	**36207**	0.64
	35	72	20	42.9				17.5	M8x1	4	25.5	15.3	**56207**	0.47
	35	72	17	17							25.5	15.3	**76207.2RSR**	0.288

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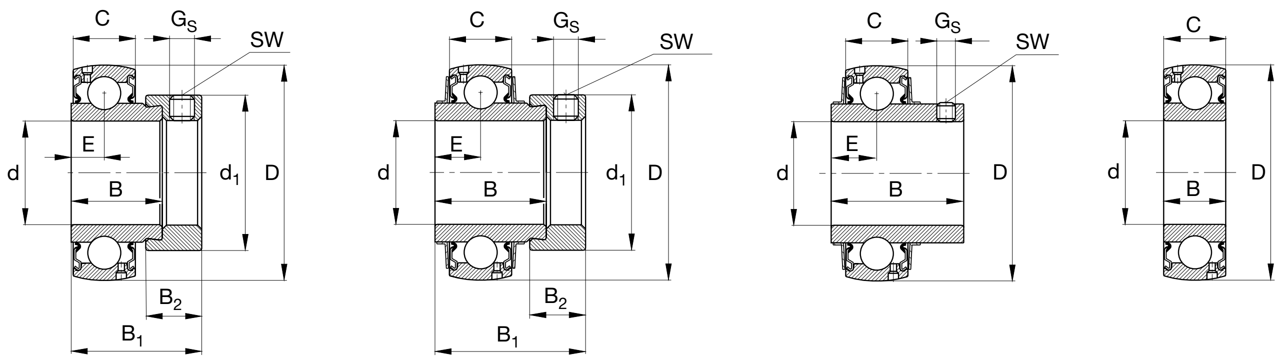
FAG S-TYPE BEARINGS FOR METRIC AND INCH SHAFT SIZES

Series 162, 362, 562, 762..2RSR



162 **362** **562** **762...2RSR**

Shaft mm / in	Dimensions d mm	D	C	B	B_1	d_1 max	B_2	E	G_S mm / *in*	SW	Load rating dyn. C kN	stat. C_0	Code Bearing with locking device **FAG**	Mass ≈ kg
1 7/16	36.513	72	17	25.4	38.9	55.6	17.5	9.5	*5/16-24UNF*	5/32	25.5	15.3	16207.107	0.483
	36.513	72	20	37.6	51.1	55.6	17.5	18.8	*5/16-24UNF*	5/32	25.5	15.3	36207.107	0.615
	36.513	72	20	42.9				17.5	*5/16-24UNF*	5/32	25.5	15.3	56207.107	0.453
1 1/2	38.1	80	18	30.2	43.7	60.3	18.3	11	*5/16-24UNF*	5/32	29	18	16208.108	0.656
	38.1	80	21	42.8	56.3	60.3	18.3	21.4	*5/16-24UNF*	5/32	29	18	36208.108	0.879
	38.1	80	21	49.2				19	*5/16-24UNF*	5/32	29	18	56208.108	0.637
1 9/16	39.688	80	18	30.2	43.7	60.3	18.3	11	*5/16-24UNF*	5/32	29	18	16208.109	0.634
	39.688	80	21	42.8	56.3	60.3	18.3	21.4	*5/16-24UNF*	5/32	29	18	36208.109	0.846
	39.688	80	21	49.2				19	*5/16-24UNF*	5/32	29	18	56208.109	0.612
40	40	80	18	30.2	43.7	60.3	18.3	11	M10x1.25	5	29	18	**16208**	0.63
	40	80	21	42.8	56.3	60.3	18.3	21.4	M10x1.25	5	29	18	**36208**	0.84
	40	80	21	49.2				19	M8x1	4	29	18	**56208**	0.61
	40	80	18	18							29	18	**76208.2RSR**	0.366
1 5/8	41.275	85	19	30.2	43.7	63.5	18.3	11	*5/16-24UNF*	5/32	31	20.4	16209.110	0.74
	41.275	85	22	42.8	56.3	63.5	18.3	21.4	*5/16-24UNF*	5/32	31	20.4	36209.110	0.965
	41.275	85	22	49.2				19	*5/16-24UNF*	5/32	31	20.4	56209.110	0.84
1 11/16	42.863	85	19	30.2	43.7	63.5	18.3	11	*5/16-24UNF*	5/32	31	20.4	16209.111	0.715
	42.863	85	22	42.8	56.3	63.5	18.3	21.4	*5/16-24UNF*	5/32	31	20.4	36209.111	0.93
	42.863	85	22	49.2				19	*5/16-24UNF*	5/32	31	20.4	56209.111	0.8
1 3/4	44.45	85	19	30.2	43.7	63.5	18.3	11	*5/16-24UNF*	5/32	31	20.4	16209.112	0.689
	44.45	85	22	42.8	56.3	63.5	18.3	21.4	*5/16-24UNF*	5/32	31	20.4	36209.112	0.893
	44.45	85	22	49.2				19	*5/16-24UNF*	5/32	31	20.4	56209.112	0.766
45	45	85	19	30.2	43.7	63.5	18.3	11	M10x1.25	5	31	20.4	**16209**	0.68
	45	85	22	42.8	56.3	63.5	18.3	21.4	M10x1.25	5	31	20.4	**36209**	0.88
	45	85	22	49.2				19	M8x1	4	31	20.4	**56209**	0.76
	45	85	19	19							31	20.4	**76209.2RSR**	0.407
1 13/16	46.038	90	20	30.2	43.7	69.9	18.3	11	*5/16-24UNF*	5/32	36.5	24	16210.113	0.841
	46.038	90	24	49.2	62.7	69.9	18.3	24.6	*5/16-24UNF*	5/32	36.5	24	36210.113	1.13
	46.038	90	24	51.6				19	*3/8-24UNF*	3/16	36.5	24	56210.113	0.908
1 7/8	47.625	90	20	30.2	43.7	69.9	18.3	11	*5/16-24UNF*	5/32	36.5	24	16210.114	0.813
	47.625	90	24	49.2	62.7	69.9	18.3	24.6	*5/16-24UNF*	5/32	36.5	24	36210.114	1.08
	47.625	90	24	51.6				19	*3/8-24UNF*	3/16	36.5	24	56210.114	0.861

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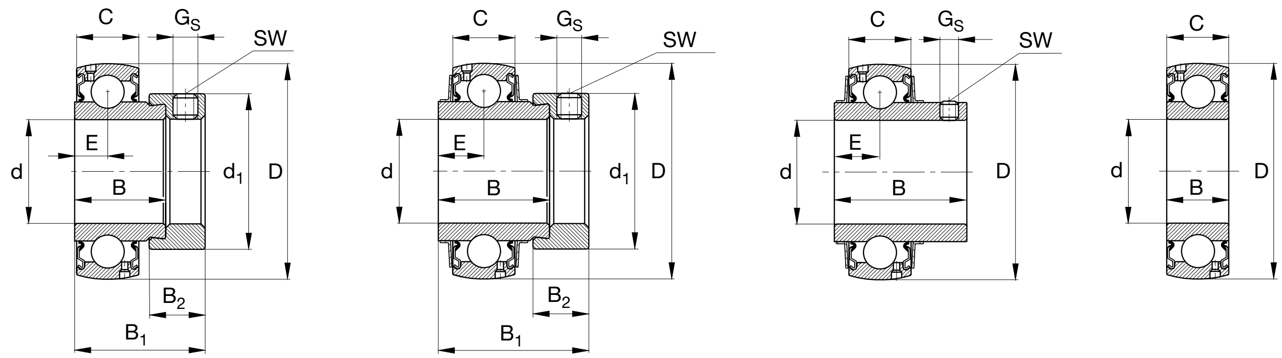
FAG S-TYPE BEARINGS FOR METRIC AND INCH SHAFT SIZES

Series 162, 362, 562, 762..2RSR



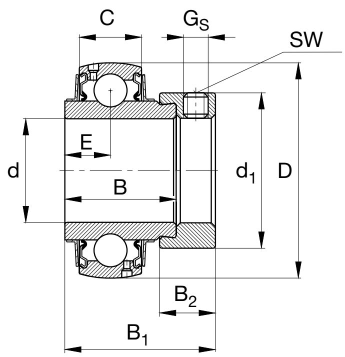
162 **362** **562** **762...2RSR**

Shaft mm in	Dimensions d mm	D	C	B	B_1	d_1 max	B_2	E	G_S mm *in*	SW	Load rating dyn. C kN	stat. C_0	Code Bearing with locking device **FAG**	Mass ≈ kg
1 15/16	49.213	90	20	30.2	43.7	69.9	18.3	11	*5/16 - 24UNF*	*5/32*	36.5	24	16210.115	0.785
	49.213	90	24	49.2	62.7	69.9	18.3	24.6	*5/16 - 24UNF*	*5/32*	36.5	24	36210.115	1.03
	49.213	90	24	51.6				19	*3/8 - 24UNF*	*3/16*	36.5	24	56210.115	0.812
50	50	90	20	30.2	43.7	69.9	18.3	11	M10x1.25	5	36.5	24	**16210**	0.77
	50	90	24	49.2	62.7	69.9	18.3	24.6	M10x1.25	5	36.5	24	**36210**	1.01
	50	90	24	51.6				19	M10x1.25	5	36.5	24	**56210**	0.77
	50	90	20	20							36.5	24	**76210.2RSR**	0.463
2	50.8	100	21	32.5	48.4	76.2	20.7	12	*3/8 - 24UNF*	*3/16*	43	29	16211.200	0.96
	50.8	100	25	55.5	71.4	76.2	20.7	27.8	*3/8 - 24UNF*	*3/16*	43	29	36211.200	1.5
	50.8	100	25	55.6				22.2	*3/8 - 24UNF*	*3/16*	43	29	56211.200	1.26
2 1/8	53.975	100	21	32.5	48.4	76.2	20.7	12	*3/8 - 24UNF*	*3/16*	43	29	16211.202	0.87
	53.975	100	25	55.5	71.4	76.2	20.7	27.8	*3/8 - 24UNF*	*3/16*	43	29	36211.202	1.45
	53.975	100	25	55.6				22.2	*3/8 - 24UNF*	*3/16*	43	29	56211.202	1.21
55	55	100	21	32.5	48.4	76.2	20.7	12	M10x1.25	5	43	29	**16211**	0.83
	55	100	25	55.5	71.4	76.2	20.7	27.8	M10x1.25	5	43	29	**36211**	1.43
	55	100	25	55.6				22.2	M10x1.25	5	43	29	**56211**	1.19
	55	100	21	21							43	29	76211.2RSR	0.667
2 3/16	55.563	100	21	32.5	48.4	76.2	20.7	12	*3/8 - 24UNF*	*3/16*	43	29	16211.203	0.81
	55.563	100	25	55.5	71.4	76.2	20.7	27.8	*3/8 - 24UNF*	*3/16*	43	29	36211.203	0.951
	55.563	100	25	55.6				22.2	*3/8 - 24UNF*	*3/16*	43	29	56211.203	1.16
2 1/4	57.15	110	22	37.1	53.1	84.2	22.3	13.5	*3/8 - 24UNF*	*3/16*	52	36	16212.204	1.3
	57.15	110	27	61.9	77.8	84.2	22.3	31	*3/8 - 24UNF*	*3/16*	52	36	36212.204	2
	57.15	110	27	65.1				25.4	*3/8 - 24UNF*	*3/16*	52	36	56212.204	1.59
60	60	110	22	37.1	53.1	84.2	22.3	13.5	M10x1.25	5	52	36	**16212**	1.17
	60	110	27	61.9	77.8	84.2	22.3	31	M10x1.25	5	52	36	**36212**	1.9
	60	110	27	65.1				25.4	M10x1.25	5	52	36	**56212**	1.52
	60	110	22	22							52	36	76212.2RSR	0.6
2 3/8	60.325	110	22	37.1	53.1	84.2	22.3	13.5	*3/8 - 24UNF*	*3/16*	52	36	16212.206	1.16
	60.325	110	27	61.9	77.8	84.2	22.3	31	*3/8 - 24UNF*	*3/16*	52	36	36212.206	1.8
	60.325	110	27	65.1				25.4	*3/8 - 24UNF*	*3/16*	52	36	56212.206	1.39
2 7/16	61.913	110	22	37.1	53.1	84.2	22.3	13.5	*3/8 - 24UNF*	*3/16*	52	36	16212.207	1.08
	61.913	110	27	61.9	77.8	84.2	22.3	31	*3/8 - 24UNF*	*3/16*	52	36	36212.207	1.78
	61.913	110	27	65.1				25.4	*3/8 - 24UNF*	*3/16*	52	36	56212.207	1.31

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.

FAG S-TYPE BEARINGS FOR METRIC AND INCH SHAFT SIZES

Series 362, 562



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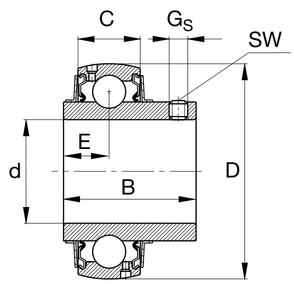


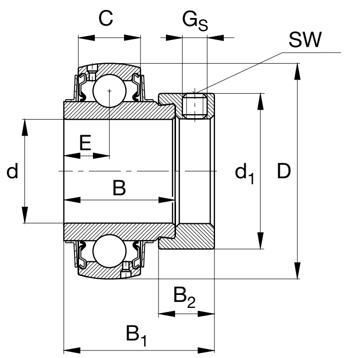
562

Shaft	**Dimensions**										**Load rating**		**Code**	**Mass**
	d	D	C	B	B_1	d_1 max	B_2	E	G_S	SW	dyn. C	stat. C_0	Bearing with locking device	≈
mm in	mm								mm *in*		kN		**FAG**	kg
2 1/2	63.5	120	28	48.5	66.1	97	23.9	21.5	*3/8 - 24UNF*	*3/16*	60	41.5	36213.208	2.81
	63.5	120	30	65.1				25.4	*3/8 - 24UNF*	*3/16*	60	41.5	56213.208	1.71
65	65	120	28	48.5	66.1	97	23.9	21.5	M12x1.5	6	60	41.5	36213	2.71
	65	120	30	65.1				25.4	M10x1.25	5	60	41.5	**56213**	1.63
2 9/16	65.087	120	28	48.5	66.1	97	23.9	21.5	*3/8 - 24UNF*	*3/16*	60	41.5	36213.209	2.66
	65.087	120	30	65.1				25.4	*3/8 - 24UNF*	*3/16*	60	41.5	56213.209	1.56
2 5/8	66.675	125	28	48.5	66.1	97	23.9	21.5	*3/8 - 24UNF*	*3/16*	62	44	36214.210	2.56
	66.675	125	30	74.6				30.2	*7/16 - 20UNF*	*7/32*	62	44	56214.210	2.13
2 11/16	68.262	125	28	48.5	66.1	97	23.9	21.5	*3/8 - 24UNF*	*3/16*	62	44	36214.211	2.55
	68.262	125	30	74.6				30.2	*7/16 - 20UNF*	*7/32*	62	44	56214.211	2.03
2 3/4	69.85	125	28	48.5	66.1	97	23.9	21.5	*3/8 - 24UNF*	*3/16*	62	44	36214.212	2.46
	69.85	125	30	74.6				30.2	*7/16 - 20UNF*	*7/32*	62	44	56214.212	2.02
70	70	125	28	48.5	66.1	97	23.9	21.5	M12x1.5	6	62	44	36214	2.45
	70	125	30	74.6				30.2	M12x1.5	6	62	44	**56214**	1.92
2 13/16	71.437	130	28	49.5	67.1	101	23.9	21.5	*3/8 - 24UNF*	*3/16*	65.5	49	36215.213	2.87
	71.437	130	32	77.8				33.3	*7/16 - 20UNF*	*7/32*	65.5	49	56215.213	2.38
2 7/8	73.025	130	28	49.5	67.1	101	23.9	21.5	*3/8 - 24UNF*	*3/16*	65.5	49	36215.214	2.77
	73.025	130	32	77.8				33.3	*7/16 - 20UNF*	*7/32*	65.5	49	56215.214	2.27
2 15/16	74.612	130	28	49.5	67.1	101	23.9	21.5	*3/8 - 24UNF*	*3/16*	65.5	49	36215.215	2.68
	74.612	130	32	77.8				33.3	*7/16 - 20UNF*	*7/32*	65.5	49	56215.215	2.16
75	75	130	28	49.5	67.1	101	23.9	21.5	M12x1.5	6	65.5	49	36215	2.65
	75	130	32	77.8				33.3	M12x1.5	6	65.5	49	**56215**	2.13
3	76.2	130	28	49.5	67.1	101	23.9	21.5	*3/8 - 24UNF*	*3/16*	65.5	49	36215.300	2.58
	76.2	130	32	77.8				33.3	*7/16 - 20UNF*	*7/32*	65.5	49	56215.300	2.04
3 1/8	79.375	140	30	53.2	71	109	23.9	23.4	*7/16 - 20UNF*	*7/32*	72	53	36216.302	3
	79.375	140	33	82.6				33.3	*7/16 - 20UNF*	*7/32*	72	53	56216.302	2.95
80	80	140	30	53.2	71	109	23.9	23.4	M12x1.5	6	72	53	36216	2.95
	80	140	33	82.6				33.3	M12x1.5	6	72	53	**56216**	2.9

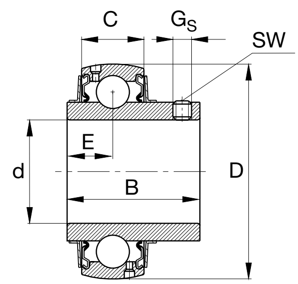
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.

FAG S-TYPE BEARINGS FOR METRIC AND INCH SHAFT SIZES

Series 362, 562



362



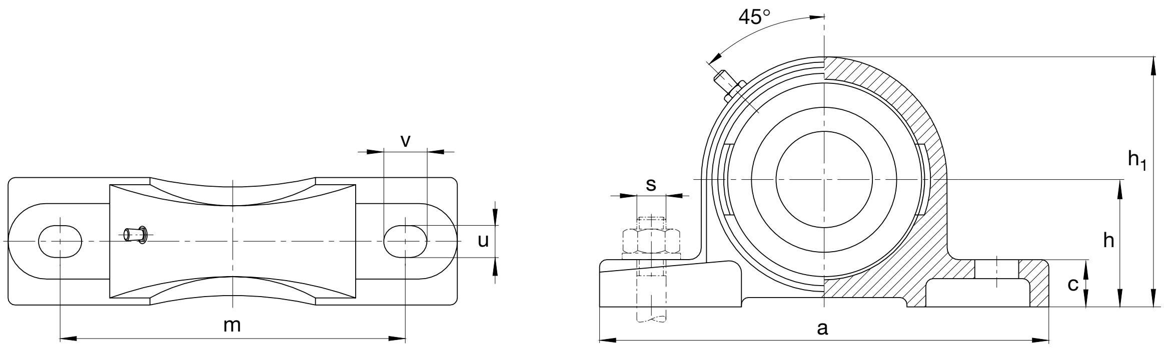
562

Shaft	**Dimensions**										**Load rating**		**Code**	**Mass**
	d	D	C	B	B_1	d_1 max	B_2	E	G_S	SW	dyn. C	stat. C_0	Bearing with locking device	≈
mm in	mm								mm *in*		kN		**FAG**	kg
$3\,^1/_4$	82.55	150	34	53.2	71	113	23.9	23.4	*$^7/_{16}$ - 20UNF*	*$^7/_{32}$*	83	64	36217.304	3.9
	82.55	150	35	85.7				34.1	*$^7/_{16}$ - 20UNF*	*$^7/_{32}$*	83	64	56217.304	3.64
85	85	150	34	53.2	71	113	23.9	23.4	M12x1.5	6	83	64	36217	3.72
	85	150	35	85.7				34.1	M12x1.5	6	83	64	56217	3.46
$3\,^1/_2$	88.9	160	36	52	69.5	119	23.9	23	*$^7/_{16}$ - 20UNF*	*$^7/_{32}$*	96.5	72	36218.308	4.75
	88.9	160	37	96				39.7	*$^1/_2$ - 20UNF*	*$^1/_4$*	96.5	72	56218.308	4.65
90	90	160	36	52	69.5	119	23.9	23	M12x1.5	6	96.5	72	36218	4.65
	90	160	37	96				39.7	M12x1.5	6	96.5	72	**56218**	4.53

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.

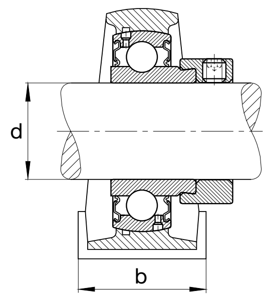
FAG S-TYPE BEARING UNITS

Series P162, P362, P562, P762..2RSR
Plummer block housings of grey-cast iron

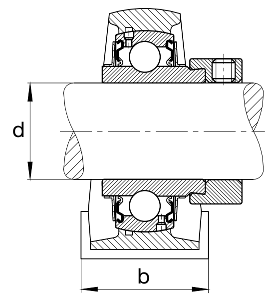


Shaft mm / in	mm	Code: Plummer block unit FAG	S-type bearing with locking device FAG	Housing FAG	Dimensions a mm	b	c	h	h_1	m	u	v	Fastening bolt s mm	in	Mass ≈ S-type bearing unit kg
12	12	P16203/12	16203/12	**P203**	125	32	13	30.2	57	96	11.5	16	M10	$^3/_8$	0.58
$^1/_2$	12.7	P16203.008	16203.008	**P203**	125	32	13	30.2	57	96	11.5	16	M10	$^3/_8$	0.578
$^9/_{16}$	14.288	P16203.009	16203.009	**P203**	125	32	13	30.2	57	96	11.5	16	M10	$^3/_8$	0.573
15	15	P16203/15	16203/15	**P203**	125	32	13	30.2	57	96	11.5	16	M10	$^3/_8$	0.57
$^5/_8$	15.875	P16203.010	16203.010	**P203**	125	32	13	30.2	57	96	11.5	16	M10	$^3/_8$	0.567
17	17	**P16203**	**16203**	**P203**	125	32	13	30.2	57	96	11.5	16	M10	$^3/_8$	0.55
	17	P76203.2RSR	76203.2RSR	**P203**	125	32	13	30.2	57	96	11.5	16	M10	$^3/_8$	0.514
$^{11}/_{16}$	17.463	P16203.011	16203.011	**P203**	125	32	13	30.2	57	96	11.5	16	M10	$^3/_8$	0.541
$^3/_4$	19.05	P16204.012	16204.012	**P204**	127	38	14	33.3	65	95	11.5	16	M10	$^3/_8$	0.704
	19.05	P36204.012	36204.012	**P204**	127	38	14	33.3	65	95	11.5	16	M10	$^3/_8$	0.758
	19.05	P56204.012	56204.012	**P204**	127	38	14	33.3	65	95	11.5	16	M10	$^3/_8$	0.712
20	20	**P16204**	**16204**	**P204**	127	38	14	33.3	65	95	11.5	16	M10	$^3/_8$	0.7
	20	**P36204**	**36204**	**P204**	127	38	14	33.3	65	95	11.5	16	M10	$^3/_8$	0.75
	20	**P56204**	**56204**	**P204**	127	38	14	33.3	65	95	11.5	16	M10	$^3/_8$	0.69
	20	**P76204.2RSR**	**76204.2RSR**	**P204**	127	38	14	33.3	65	95	11.5	16	M10	$^3/_8$	0.656
$^{13}/_{16}$	20.638	P16205.013	16205.013	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.946
	20.638	P36205.013	36205.013	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	1.13
	20.638	P56205.013	56205.013	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.938
$^7/_8$	22.225	P16205.014	16205.014	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.937
	22.225	P36205.014	36205.014	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.998
	22.225	P56205.014	56205.014	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.923
$^{15}/_{16}$	23.813	P16205.015	16205.015	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.928
	23.813	P36205.015	36205.015	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.982
	23.813	P56205.015	56205.015	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.908
25	25	**P16205**	**16205**	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.92
	25	**P36205**	**36205**	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.97
	25	**P56205**	**56205**	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.89
	25	**P76205.2RSR**	**76205.2RSR**	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.828

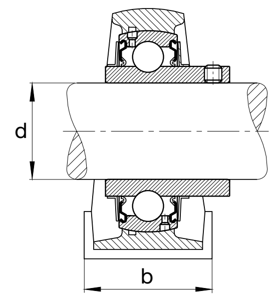
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



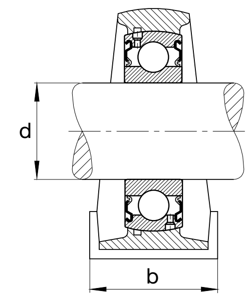
P162



P362



P562



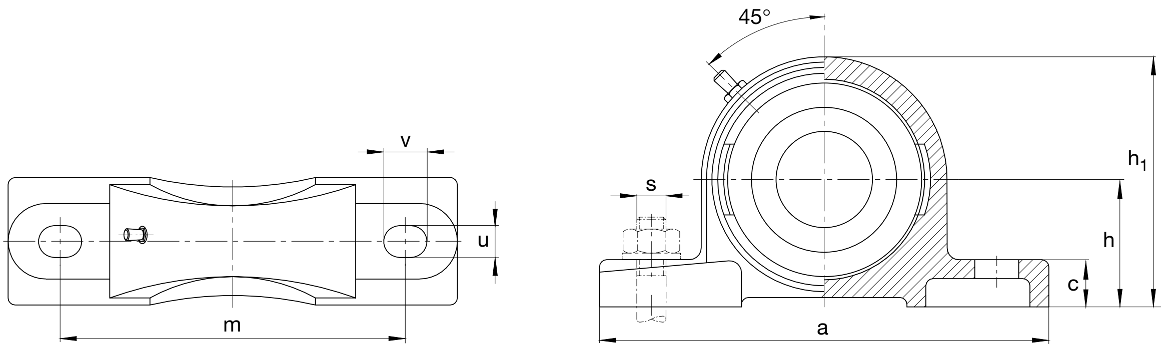
P762...2RSR

Shaft			**Code**			**Dimensions**								**Fastening bolt**		**Mass** ≈
			Plummer block unit	S-type bearing with locking device	Housing	a	b	c	h	h_1	m	u	v	s		S-type bearing unit
mm	in	mm	**FAG**	**FAG**	**FAG**	mm								mm	in	kg
	1	25.4	P16205.100	16205.100	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.917
		25.4	P36205.100	36205.100	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.965
		25.4	P56205.100	56205.100	**P205**	140	38	15	36.5	71	105	11.5	16	M10	$^3/_8$	0.888
	1 $^1/_{16}$	26.988	P16206.101	16206.101	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.33
		26.988	P36206.101	36206.101	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.46
		26.988	P56206.101	56206.101	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.35
	1 $^1/_8$	28.575	P16206.102	16206.102	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.31
		28.575	P36206.102	36206.102	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.44
		28.575	P56206.102	56206.102	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.33
30		30	**P16206**	**16206**	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.3
		30	**P36206**	**36206**	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.42
		30	**P56206**	**56206**	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.31
		30	**P76206.2RSR**	**76206.2RSR**	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.19
	1 $^3/_{16}$	30.163	P16206.103	16206.103	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.3
		30.163	P36206.103	36206.103	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.42
		30.163	P56206.103	56206.103	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.31
	1 $^1/_4$	31.75	P16206.104	16206.104	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.28
		31.75	P36206.104	36206.104	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.4
		31.75	P56206.104	56206.104	**P206**	165	48	17	42.9	83	121	14	19	M12	$^1/_2$	1.28
		31.75	P16207.104	16207.104	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.78
		31.75	P36207.104	36207.104	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.94
		31.75	P56207.104	56207.104	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.79
	1 $^5/_{16}$	33.338	P16207.105	16207.105	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.77
		33.338	P36207.105	36207.105	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.92
		33.338	P56207.105	56207.105	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.76
	1 $^3/_8$	34.925	P16207.106	16207.106	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.75
		34.925	P36207.106	36207.106	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.89
		34.925	P56207.106	56207.106	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.73
35		35	**P16207**	**16207**	P207	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.75
		35	**P36207**	**36207**	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.89
		35	**P56207**	**56207**	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.72
		35	**P76207.2RSR**	**76207.2RSR**	**P207**	167	48	18	47.6	93	126	14	19	M12	$^1/_2$	1.54

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

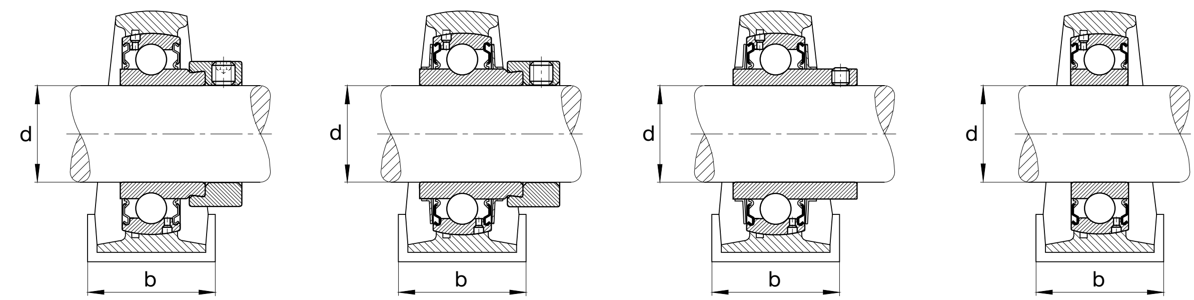
FAG S-TYPE BEARING UNITS

Series P162, P362, P562, P762..2RSR
Plummer block housings of grey-cast iron



Shaft mm	Shaft in	Shaft mm	Code: Plummer block unit FAG	Code: S-type bearing with locking device FAG	Code: Housing FAG	Dimensions mm: a	b	c	h	h_1	m	u	v	Fastening bolt s mm	Fastening bolt s in	Mass ≈ S-type bearing unit kg
	1 7/16	36.513	P16207.107	16207.107	**P207**	167	48	18	47.6	93	126	14	19	M12	1/2	1.73
		36.513	P36207.107	36207.107	**P207**	167	48	18	47.6	93	126	14	19	M12	1/2	1.87
		36.513	P56207.107	56207.107	**P207**	167	48	18	47.6	93	126	14	19	M12	1/2	1.7
	1 1/2	38.1	P16208.108	16208.108	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	2.26
		38.1	P36208.108	36208.108	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	2.48
		38.1	P56208.108	56208.108	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	2.24
	1 9/16	39.688	P16208.109	16208.109	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	2.23
		39.688	P36208.109	36208.109	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	2.45
		39.688	P56208.109	56208.109	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	2.21
40		40	**P16208**	**16208**	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	2.23
		40	**P36208**	**36208**	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	2.44
		40	**P56208**	**56208**	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	2.21
		40	**P76208.2RSR**	**76208.2RSR**	**P208**	184	54	18	49.2	98	136	14	19	M12	1/2	1.97
	1 5/8	41.275	P16209.110	16209.110	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.59
		41.275	P36209.110	36209.110	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.82
		41.275	P56209.110	56209.110	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.69
	1 11/16	42.863	P16209.111	16209.111	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.57
		42.863	P36209.111	36209.111	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.78
		42.863	P56209.111	56209.111	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.65
	1 3/4	44.45	P16209.112	16209.112	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.54
		44.45	P36209.112	36209.112	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.74
		44.45	P56209.112	56209.112	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.62
45		45	**P16209**	**16209**	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.53
		45	**P36209**	**36209**	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.73
		45	**P56209**	**56209**	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.61
		45	**P76209.2RSR**	**76209.2RSR**	**P209**	190	54	20	54	106	146	14	19	M12	1/2	2.26
	1 13/16	46.038	P16210.113	16210.113	**P210**	206	60	21	57.2	114	159	18	20.5	M16	5/8	3.24
		46.038	P36210.113	36210.113	**P210**	206	60	21	57.2	114	159	18	20.5	M16	5/8	3.53
		46.038	P56210.113	56210.113	**P210**	206	60	21	57.2	114	159	18	20.5	M16	5/8	3.31
	1 7/8	47.625	P16210.114	16210.114	**P210**	206	60	21	57.2	114	159	18	20.5	M16	5/8	3.21
		47.625	P36210.114	36210.114	**P210**	206	60	21	57.2	114	159	18	20.5	M16	5/8	3.41
		47.625	P56210.114	56210.114	**P210**	206	60	21	57.2	114	159	18	20.5	M16	5/8	3.26

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



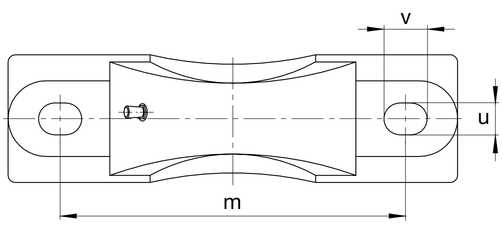
P162 **P362** **P562** **P762...2RSR**

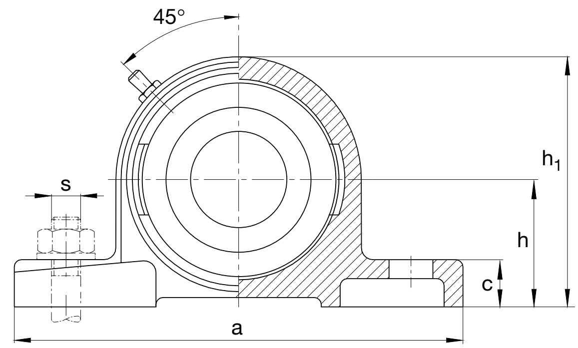
Shaft		**Code**			**Dimensions**								**Fastening bolt**		**Mass** ≈
		Plummer block unit	S-type bearing with locking device	Housing	a	b	c	h	h_1	m	u	v	s		S-type bearing unit
mm in	mm	**FAG**	**FAG**	**FAG**	mm								mm	in	kg
1 $^{15}/_{16}$	49.213	P16210.115	16210.115	**P210**	206	60	21	57.2	114	159	18	20.5	M16	$^5/_8$	3.19
	49.213	P36210.115	36210.115	**P210**	206	60	21	57.2	114	159	18	20.5	M16	$^5/_8$	3.43
	49.213	P56210.115	56210.115	**P210**	206	60	21	57.2	114	159	18	20.5	M16	$^5/_8$	3.21
50	50	**P16210**	**16210**	**P210**	206	60	21	57.2	114	159	18	20.5	M16	$^5/_8$	3.17
	50	**P36210**	**36210**	**P210**	206	60	21	57.2	114	159	18	20.5	M16	$^5/_8$	3.41
	50	**P56210**	**56210**	**P210**	206	60	21	57.2	114	159	18	20.5	M16	$^5/_8$	3.17
	50	**P76210.2RSR**	**76210.2RSR**	**P210**	206	60	21	57.2	114	159	18	20.5	M16	$^5/_8$	2.86
2	50.8	P16211.200	16211.200	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	4.01
	50.8	P36211.200	36211.200	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	4.61
	50.8	P56211.200	56211.200	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	4.31
2 $^1/_8$	53.975	P16211.202	16211.202	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	3.92
	53.975	P36211.202	36211.202	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	4.5
	53.975	P56211.202	56211.202	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	4.26
55	55	**P16211**	**16211**	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	3.88
	55	**P36211**	**36211**	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	4.48
	55	**P56211**	**56211**	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	4.24
	55	P76211.2RSR	76211.2RSR	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	3.72
2 $^3/_{16}$	55.563	P16211.203	16211.203	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	3.86
	55.563	P36211.203	36211.203	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	4
	55.563	P56211.203	56211.203	**P211**	219	60	23	63.5	126	171	18	20.5	M16	$^5/_8$	4.19
2 $^1/_4$	57.15	P16212.204	16212.204	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	4.9
	57.15	P36212.204	36212.204	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	5.6
	57.15	P56212.204	56212.204	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	5.19
60	60	**P16212**	**16212**	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	4.77
	60	**P36212**	**36212**	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	5.5
	60	**P56212**	**56212**	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	5.12
	60	P76212.2RSR	76212.2RSR	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	4.2
2 $^3/_8$	60.325	P16212.206	16212.206	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	4.76
	60.325	P36212.206	36212.206	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	5.4
	60.325	P56212.206	56212.206	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	4.99
2 $^7/_{16}$	61.913	P16212.207	16212.207	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	4.68
	61.913	P36212.207	36212.207	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	5.35
	61.913	P56212.207	56212.207	**P212**	241	70	25	69.9	138	184	18	22	M16	$^5/_8$	4.91

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

FAG S-TYPE BEARING UNITS

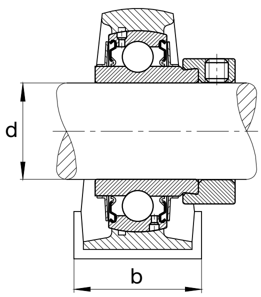
Series P362, P562
Plummer block housings of grey-cast iron



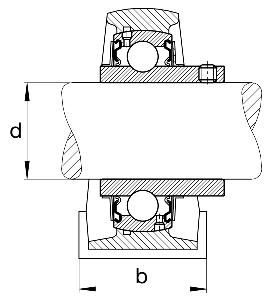


Shaft mm / in	mm	Code Plummer block unit FAG	S-type bearing with locking device FAG	Housing FAG	Dimensions a mm	b	c	h	h_1	m	u	v	Fastening bolt s mm	in	Mass ≈ S-type bearing unit kg
2 $^{1}/_{2}$	63.5	P36213.208	36213.208	**P213**	265	70	27	76.2	151	203	25	28	M20	$^{3}/_{4}$	7.5
	63.5	P56213.208	56213.208	**P213**	265	70	27	76.2	151	203	25	28	M20	$^{3}/_{4}$	6.4
65	65	P36213	36213	**P213**	265	70	27	76.2	151	203	25	28	M20	$^{3}/_{4}$	7.4
	65	**P56213**	**56213**	**P213**	265	70	27	76.2	151	203	25	28	M20	$^{3}/_{4}$	6.3
2 $^{9}/_{16}$	65.087	P36213.209	36213.209	**P213**	265	70	27	76.2	151	203	25	28	M20	$^{3}/_{4}$	7.4
	65.087	P56213.209	56213.209	**P213**	265	70	27	76.2	151	203	25	28	M20	$^{3}/_{4}$	6.3
2 $^{5}/_{8}$	66.675	P36214.210	36214.210	**P214**	266	72	27	79.4	157	210	25	28	M20	$^{3}/_{4}$	7.4
	66.675	P56214.210	56214.210	**P214**	266	72	27	79.4	157	210	25	28	M20	$^{3}/_{4}$	7
2 $^{11}/_{16}$	68.262	P36214.211	36214.211	**P214**	266	72	27	79.4	157	210	25	28	M20	$^{3}/_{4}$	7.4
	68.262	P56214.211	56214.211	**P214**	266	72	27	79.4	157	210	25	28	M20	$^{3}/_{4}$	6.9
2 $^{3}/_{4}$	69.85	P36214.212	36214.212	**P214**	266	72	27	79.4	157	210	25	28	M20	$^{3}/_{4}$	7.3
	69.85	P56214.212	56214.212	**P214**	266	72	27	79.4	157	210	25	28	M20	$^{3}/_{4}$	6.9
70	70	P36214	36214	**P214**	266	72	27	79.4	157	210	25	28	M20	$^{3}/_{4}$	7.3
	70	**P56214**	**56214**	**P214**	266	72	27	79.4	157	210	25	28	M20	$^{3}/_{4}$	6.8
2 $^{13}/_{16}$	71.437	P36215.213	36215.213	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	8.4
	71.437	P56215.213	56215.213	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	7.9
2 $^{7}/_{8}$	73.025	P36215.214	36215.214	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	8.3
	73.025	P56215.214	56215.214	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	7.8
2 $^{15}/_{16}$	74.612	P36215.215	36215.215	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	8.2
	74.612	P56215.215	56215.215	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	7.7
75	75	P36215	36215	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	8.2
	75	**P56215**	**56215**	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	7.7
3	76.2	P36215.300	36215.300	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	8
	76.2	P56215.300	56215.300	**P215**	275	74	28	82.6	163	217	25	28	M20	$^{3}/_{4}$	7.6
3 $^{1}/_{8}$	79.375	P36216.302	36216.302	**P216**	292	78	30	88.9	175	232	25	28	M20	$^{3}/_{4}$	9.1
	79.375	P56216.302	56216.302	**P216**	292	78	30	88.9	175	232	25	28	M20	$^{3}/_{4}$	9
80	80	P36216	36216	**P216**	292	78	30	88.9	175	232	25	28	M20	$^{3}/_{4}$	9.2
	80	**P56216**	**56216**	**P216**	292	78	30	88.9	175	232	25	28	M20	$^{3}/_{4}$	9.1

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



P362



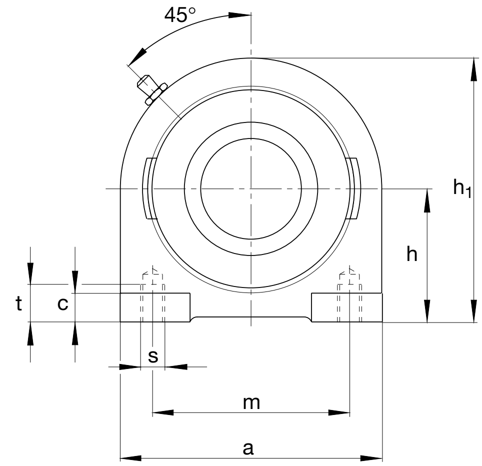
P562

Shaft		**Code**			**Dimensions**								**Fastening bolt**		**Mass** ≈
		Plummer block unit	S-type bearing with locking device	Housing	a	b	c	h	h_1	m	u	v	s		S-type bearing unit
mm in	mm	**FAG**	**FAG**	**FAG**	mm								mm	in	kg
$3\,{}^{1}/_{4}$	82.55	P36217.304	36217.304	P217	310	83	32	95.2	187	247	25	28	M20	${}^{3}/_{4}$	12
	82.55	P56217.304	56217.304	P217	310	83	32	95.2	187	247	25	28	M20	${}^{3}/_{4}$	11.6
85	85	P36217	36217	P217	310	83	32	95.2	187	247	25	28	M20	${}^{3}/_{4}$	11.8
	85	P56217	56217	P217	310	83	32	95.2	187	247	25	28	M20	${}^{3}/_{4}$	11.5
$3\,{}^{1}/_{2}$	88.9	P36218.308	36218.308	**P218**	327	88	33	101.6	200	262	27	34	M24	1	13.8
	88.9	P56218.308	56218.308	**P218**	327	88	33	101.6	200	262	27	34	M24	1	13.7
90	90	P36218	36218	**P218**	327	88	33	101.6	200	262	27	34	M24	1	13.7
	90	**P56218**	**56218**	**P218**	327	88	33	101.6	200	262	27	34	M24	1	13.5

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

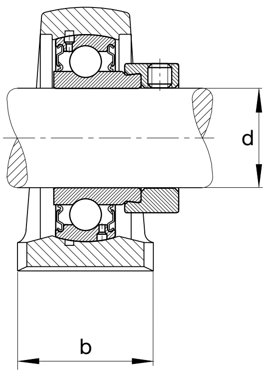
FAG S-TYPE BEARING UNITS

Series PA162, PA362, PA562, PA762..2RSR
Plummer block housings of grey-cast iron

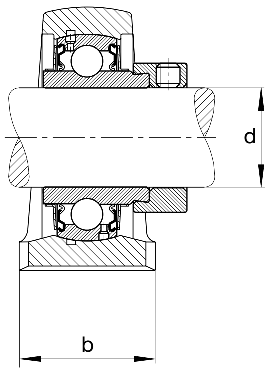


Shaft			Code			Dimensions							Fastening bolt	Mass ≈
			Plummer block unit	S-type bearing with locking device	Housing	a	b	c	h	h_1	m	t	s	S-type bearing unit
mm	in	mm	FAG	FAG	FAG	mm							mm	kg
	$^{3}/_{4}$	19.05	PA16204.012	16204.012	PA204	76	38	8	33.3	62	52	13	M10	0.704
		19.05	PA36204.012	36204.012	PA204	76	38	8	33.3	62	52	13	M10	0.758
		19.05	PA56204.012	56204.012	PA204	76	38	8	33.3	62	52	13	M10	0.712
20		20	PA16204	**16204**	PA204	76	38	8	33.3	62	52	13	M10	0.7
		20	PA36204	**36204**	PA204	76	38	8	33.3	62	52	13	M10	0.75
		20	PA56204	**56204**	PA204	76	38	8	33.3	62	52	13	M10	0.69
		20	PA76204.2RSR	**76204.2RSR**	PA204	76	38	8	33.3	62	52	13	M10	0.66
	$^{13}/_{16}$	20.638	PA16205.013	16205.013	PA205	84	38	10	36.5	72	56	15	M10	1.05
		20.638	PA36205.013	36205.013	PA205	84	38	10	36.5	72	56	15	M10	1.11
		20.638	PA56205.013	56205.013	PA205	84	38	10	36.5	72	56	15	M10	1.04
	$^{7}/_{8}$	22.225	PA16205.014	16205.014	PA205	84	38	10	36.5	72	56	15	M10	1.04
		22.225	PA36205.014	36205.014	PA205	84	38	10	36.5	72	56	15	M10	1.01
		22.225	PA56205.014	56205.014	PA205	84	38	10	36.5	72	56	15	M10	1.02
	$^{15}/_{16}$	23.813	PA16205.015	16205.015	PA205	84	38	10	36.5	72	56	15	M10	1.03
		23.813	PA36205.015	36205.015	PA205	84	38	10	36.5	72	56	15	M10	1.08
		23.813	PA56205.015	56205.015	PA205	84	38	10	36.5	72	56	15	M10	1
25		25	PA16205	**16205**	PA205	84	38	10	36.5	72	56	15	M10	1.02
		25	PA36205	**36205**	PA205	84	38	10	36.5	72	56	15	M10	1.01
		25	PA56205	**56205**	PA205	84	38	10	36.5	72	56	15	M10	1
		25	PA76205.2RSR	**76205.2RSR**	PA205	84	38	10	36.5	72	56	15	M10	0.93
	1	25.4	PA16205.100	16205.100	PA205	84	38	10	36.5	72	56	15	M10	1.02
		25.4	PA36205.100	36205.100	PA205	84	38	10	36.5	72	56	15	M10	1.07
		25.4	PA56205.100	56205.100	PA205	84	38	10	36.5	72	56	15	M10	0.99
	1 $^{1}/_{16}$	26.988	PA16206.101	16206.101	PA206	94	48	10	42.9	84	66	18	M14	1.43
		26.988	PA36206.101	36206.101	PA206	94	48	10	42.9	84	66	18	M14	1.56
		26.988	PA56206.101	56206.101	PA206	94	48	10	42.9	84	66	18	M14	1.45
	1 $^{1}/_{8}$	28.575	PA16206.102	16206.102	PA206	94	48	10	42.9	84	66	18	M14	1.41
		28.575	PA36206.102	36206.102	PA206	94	48	10	42.9	84	66	18	M14	1.54
		28.575	PA56206.102	56206.102	PA206	94	48	10	42.9	84	66	18	M14	1.43
30		30	PA16206	**16206**	PA206	94	48	10	42.9	84	66	18	M14	1.4
		30	PA36206	**36206**	PA206	94	48	10	42.9	84	66	18	M14	1.52
		30	PA56206	**56206**	PA206	94	48	10	42.9	84	66	18	M14	1.41
		30	PA76206.2RSR	**76206.2RSR**	PA206	94	48	10	42.9	84	66	18	M14	1.29

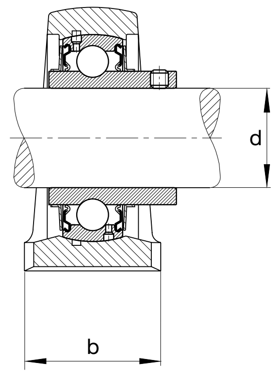
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



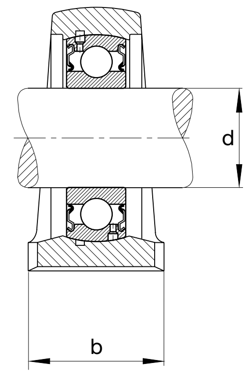
PA162



PA362



PA562



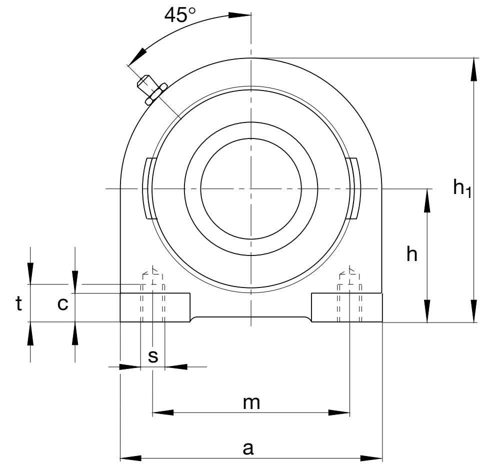
PA762...2RSR

Shaft		**Code**			**Dimensions**							**Fastening bolt**	**Mass** ≈
mm		Plummer block unit	S-type bearing with locking device	Housing	a	b	c	h	h_1	m	t	s	S-type bearing unit
in	mm	**FAG**	**FAG**	**FAG**	mm							mm	kg
$1\,^3/_{16}$	30.163	PA16206.103	16206.103	PA206	94	48	10	42.9	84	66	18	M14	1.4
	30.163	PA36206.103	36206.103	PA206	94	48	10	42.9	84	66	18	M14	1.52
	30.163	PA56206.103	56206.103	PA206	94	48	10	42.9	84	66	18	M14	1.41
$1\,^1/_4$	31.75	PA16206.104	16206.104	PA206	94	48	10	42.9	84	66	18	M14	1.38
	31.75	PA36206.104	36206.104	PA206	94	48	10	42.9	84	66	18	M14	1.5
	31.75	PA56206.104	56206.104	PA206	94	48	10	42.9	84	66	18	M14	1.38
	31.75	PA16207.104	16207.104	PA207	110	48	12	47.6	95	80	20	M14	1.96
	31.75	PA36207.104	36207.104	PA207	110	48	12	47.6	95	80	20	M14	2.12
	31.75	PA56207.104	56207.104	PA207	110	48	12	47.6	95	80	20	M14	1.97
$1\,^5/_{16}$	33.338	PA16207.105	16207.105	PA207	110	48	12	47.6	95	80	20	M14	1.95
	33.338	PA36207.105	36207.105	PA207	110	48	12	47.6	95	80	20	M14	2.1
	33.338	PA56207.105	56207.105	PA207	110	48	12	47.6	95	80	20	M14	1.94
$1\,^3/_8$	34.925	PA16207.106	16207.106	PA207	110	48	12	47.6	95	80	20	M14	1.93
	34.925	PA36207.106	36207.106	PA207	110	48	12	47.6	95	80	20	M14	2.07
	34.925	PA56207.106	56207.106	PA207	110	48	12	47.6	95	80	20	M14	1.91
35	35	PA16207	**16207**	PA207	110	48	12	47.6	95	80	20	M14	1.93
	35	PA36207	**36207**	PA207	110	48	12	47.6	95	80	20	M14	2.07
	35	PA56207	**56207**	PA207	110	48	12	47.6	95	80	20	M14	1.9
	35	PA76207.2RSR	**76207.2RSR**	PA207	110	48	12	47.6	95	80	20	M14	1.72
$1\,^7/_{16}$	36.513	PA16207.107	16207.107	PA207	110	48	12	47.6	95	80	20	M14	1.91
	36.513	PA36207.107	36207.107	PA207	110	48	12	47.6	95	80	20	M14	2.05
	36.513	PA56207.107	56207.107	PA207	110	48	12	47.6	95	80	20	M14	1.88
$1\,^1/_2$	38.1	PA16208.108	16208.108	PA208	116	54	12	49.2	100	84	20	M14	2.41
	38.1	PA36208.108	36208.108	PA208	116	54	12	49.2	100	84	20	M14	2.63
	38.1	PA56208.108	56208.108	PA208	116	54	12	49.2	100	84	20	M14	2.39
$1\,^9/_{16}$	39.688	PA16208.109	16208.109	PA208	116	54	12	49.2	100	84	20	M14	2.34
	39.688	PA36208.109	36208.109	PA208	116	54	12	49.2	100	84	20	M14	2.56
	39.688	PA56208.109	56208.109	PA208	116	54	12	49.2	100	84	20	M14	2.36
40	40	PA16208	**16208**	PA208	116	54	12	49.2	100	84	20	M14	2.38
	40	PA36208	**36208**	PA208	116	54	12	49.2	100	84	20	M14	2.59
	40	PA56208	**56208**	PA208	116	54	12	49.2	100	84	20	M14	2.36
	40	PA76208.2RSR	**76208.2RSR**	PA208	116	54	12	49.2	100	84	20	M14	2.12

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

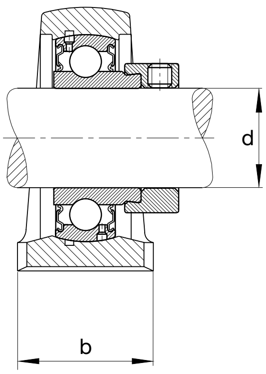
FAG S-TYPE BEARING UNITS

Series PA162, PA362, PA562, PA762..2RSR
Plummer block housings of grey-cast iron

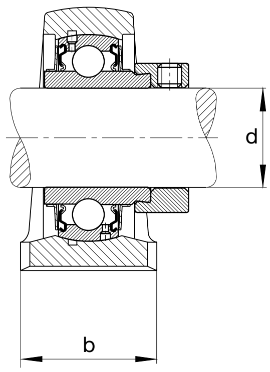


Shaft mm / in	mm	Code: Plummer block unit FAG	S-type bearing with locking device FAG	Housing FAG	Dimensions a mm	b	c	h	h_1	m	t	Fastening bolt s mm	Mass ≈ S-type bearing unit kg
$1\,^{5}/_{8}$	41.275	PA16209.110	16209.110	PA209	120	54	12	54	108	90	25	M14	2.54
	41.275	PA36209.110	36209.110	PA209	120	54	12	54	108	90	25	M14	2.76
	41.275	PA56209.110	56209.110	PA209	120	54	12	54	108	90	25	M14	2.64
$1\,^{11}/_{16}$	42.863	PA16209.111	16209.111	PA209	120	54	12	54	108	90	25	M14	2.52
	42.863	PA36209.111	36209.111	PA209	120	54	12	54	108	90	25	M14	2.73
	42.863	PA56209.111	56209.111	PA209	120	54	12	54	108	90	25	M14	2.6
$1\,^{3}/_{4}$	44.45	PA16209.112	16209.112	PA209	120	54	12	54	108	90	25	M14	2.49
	44.45	PA36209.112	36209.112	PA209	120	54	12	54	108	90	25	M14	2.69
	44.45	PA56209.112	56209.112	PA209	120	54	12	54	108	90	25	M14	2.57
45	45	PA16209	**16209**	PA209	120	54	12	54	108	90	25	M14	2.48
	45	PA36209	**36209**	PA209	120	54	12	54	108	90	25	M14	2.68
	45	PA56209	**56209**	PA209	120	54	12	54	108	90	25	M14	2.56
	45	PA76209.2RSR	**76209.2RSR**	PA209	120	54	12	54	108	90	25	M14	2.21
$1\,^{13}/_{16}$	46.038	PA16210.113	16210.113	PA210	130	60	14	57.2	116	94	25	M16	3.24
	46.038	PA36210.113	36210.113	PA210	130	60	14	57.2	116	94	25	M16	3.53
	46.038	PA56210.113	56210.113	PA210	130	60	14	57.2	116	94	25	M16	3.31
$1\,^{7}/_{8}$	47.625	PA16210.114	16210.114	PA210	130	60	14	57.2	116	94	25	M16	3.21
	47.625	PA36210.114	36210.114	PA210	130	60	14	57.2	116	94	25	M16	3.48
	47.625	PA56210.114	56210.114	PA210	130	60	14	57.2	116	94	25	M16	3.26
$1\,^{15}/_{16}$	49.213	PA16210.115	16210.115	PA210	130	60	14	57.2	116	94	25	M16	3.18
	49.213	PA36210.115	36210.115	PA210	130	60	14	57.2	116	94	25	M16	3.43
	49.213	PA56210.115	56210.115	PA210	130	60	14	57.2	116	94	25	M16	3.21
50	50	PA16210	**16210**	PA210	130	60	14	57.2	116	94	25	M16	3.17
	50	PA36210	**36210**	PA210	130	60	14	57.2	116	94	25	M16	3.41
	50	PA56210	**56210**	PA210	130	60	14	57.2	116	94	25	M16	3.17
	50	PA76210.2RSR	**76210.2RSR**	PA210	130	60	14	57.2	116	94	25	M16	2.86
2	50.8	PA16211.200	16211.200	PA211	140	66	14	63.5	125	104	25	M16	3.76
	50.8	PA36211.200	36211.200	PA211	140	66	14	63.5	125	104	25	M16	4.3
	50.8	PA56211.200	56211.200	PA211	140	66	14	63.5	125	104	25	M16	4.06
$2\,^{1}/_{8}$	53.975	PA16211.202	16211.202	PA211	140	66	14	63.5	125	104	25	M16	3.76
	53.975	PA36211.202	36211.202	PA211	140	66	14	63.5	125	104	25	M16	4.25
	53.975	PA56211.202	56211.202	PA211	140	66	14	63.5	125	104	25	M16	4.01

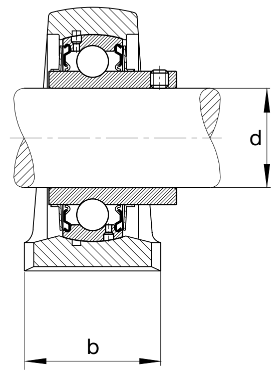
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



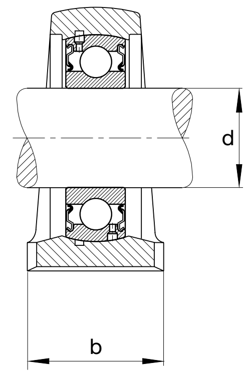
PA162



PA362



PA562



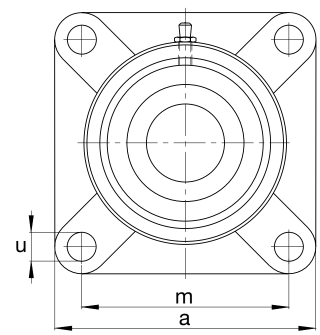
PA762...2RSR

Shaft mm	in	mm	**Code** Plummer block unit **FAG**	S-type bearing with locking device **FAG**	Housing **FAG**	**Dimensions** a mm	b	c	h	h_1	m	t	**Fastening bolt** s mm	**Mass** ≈ S-type bearing unit kg
55		55	PA16211	**16211**	PA211	140	66	14	63.5	125	104	25	M16	3.63
		55	PA36211	**36211**	PA211	140	66	14	63.5	125	104	25	M16	4.23
		55	PA56211	**56211**	PA211	140	66	14	63.5	125	104	25	M16	3.99
		55	PA76211.2RSR	76211.2RSR	PA211	140	66	14	63.5	125	104	25	M16	3.47
	2 3/16	55.563	PA16211.203	16211.203	PA211	140	66	14	63.5	125	104	25	M16	3.61
		55.563	PA36211.203	36211.203	PA211	140	66	14	63.5	125	104	25	M16	3.75
		55.563	PA56211.203	56211.203	PA211	140	66	14	63.5	125	104	25	M16	3.96
	2 1/4	57.15	PA16212.204	16212.204	PA212	150	68	15	69.9	138	114	25	M16	4.9
		57.15	PA36212.204	36212.204	PA212	150	68	15	69.9	138	114	25	M16	5.6
		57.15	PA56212.204	56212.204	PA212	150	68	15	69.9	138	114	25	M16	5.19
60		60	PA16212	**16212**	PA212	150	68	15	69.9	138	114	25	M16	4.7
		60	PA36212	**36212**	PA212	150	68	15	69.9	138	114	25	M16	5.5
		60	PA56212	**56212**	PA212	150	68	15	69.9	138	114	25	M16	5.12
		60	PA76212.2RSR	76212.2RSR	PA212	150	68	15	69.9	138	114	25	M16	4.2
	2 3/8	60.325	PA16212.206	16212.206	PA212	150	68	15	69.9	138	114	25	M16	4.76
		60.325	PA36212.206	36212.206	PA212	150	68	15	69.9	138	114	25	M16	5.4
		60.325	PA56212.206	56212.206	PA212	150	68	15	69.9	138	114	25	M16	4.99
	2 7/16	61.913	PA16212.207	16212.207	PA212	150	68	15	69.9	138	114	25	M16	4.68
		61.913	PA36212.207	36212.207	PA212	150	68	15	69.9	138	114	25	M16	5.38
		61.913	PA56212.207	56212.207	PA212	150	68	15	69.9	138	114	25	M16	4.91

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

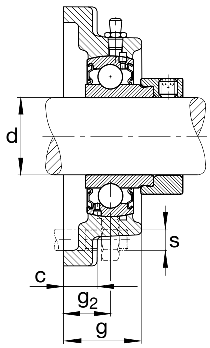
FAG S-TYPE BEARING UNITS

Series F162, F362, F562, F762..2RSR
Flanged housings of grey-cast iron

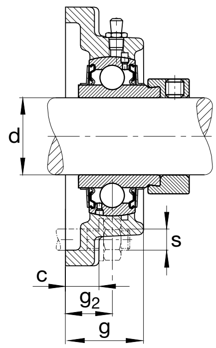


Shaft			**Code**			**Dimensions**							**Fastening bolt**		**Mass ≈**
			Flanged bearing unit	S-type bearing with locking device	Housing	a	c	g	g_2	m	u min	max	s		S-type bearing unit
mm	in	mm	**FAG**	**FAG**	**FAG**	mm							mm	in	kg
12		12	F16203/12	16203/12	**F203**	76	12	27	17	54	11	12.5	M10	$^{3}/_{8}$	0.73
	$^{1}/_{2}$	12.7	F16203.008	16203.008	**F203**	76	12	27	17	54	11	12.5	M10	$^{3}/_{8}$	0.728
	$^{9}/_{16}$	14.288	F16203.009	16203.009	**F203**	76	12	27	17	54	11	12.5	M10	$^{3}/_{8}$	0.723
15		15	F16203/15	16203/15	**F203**	76	12	27	17	54	11	12.5	M10	$^{3}/_{8}$	0.72
	$^{5}/_{8}$	15.875	F16203.010	16203.010	**F203**	76	12	27	17	54	11	12.5	M10	$^{3}/_{8}$	0.717
17		17	**F16203**	**16203**	**F203**	76	12	27	17	54	11	12.5	M10	$^{3}/_{8}$	0.7
		17	F76203.2RSR	76203.2RSR	**F203**	76	12	27	17	54	11	12.5	M10	$^{3}/_{8}$	0.664
	$^{11}/_{16}$	17.463	F16203.011	16203.011	**F203**	76	12	27	17	54	11	12.5	M10	$^{3}/_{8}$	0.691
	$^{3}/_{4}$	19.05	F16204.012	16204.012	**F204**	86	13	29.5	19	63.5	11	12.5	M10	$^{3}/_{8}$	0.754
		19.05	F36204.012	36204.012	**F204**	86	13	29.5	19	63.5	11	12.5	M10	$^{3}/_{8}$	0.808
		19.05	F56204.012	56204.012	**F204**	86	13	29.5	19	63.5	11	12.5	M10	$^{3}/_{8}$	0.762
20		20	**F16204**	**16204**	**F204**	86	13	29.5	19	63.5	11	12.5	M10	$^{3}/_{8}$	0.75
		20	**F36204**	**36204**	**F204**	86	13	29.5	19	63.5	11	12.5	M10	$^{3}/_{8}$	0.8
		20	**F56204**	**56204**	**F204**	86	13	29.5	19	63.5	11	12.5	M10	$^{3}/_{8}$	0.74
		20	**F76204.2RSR**	**76204.2RSR**	**F204**	86	13	29.5	19	63.5	11	12.5	M10	$^{3}/_{8}$	0.706
	$^{13}/_{16}$	20.638	F16205.013	16205.013	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.05
		20.638	F36205.013	36205.013	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.11
		20.638	F56205.013	56205.013	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.04
	$^{7}/_{8}$	22.225	F16205.014	16205.014	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.04
		22.225	F36205.014	36205.014	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.1
		22.225	F56205.014	56205.014	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.02
	$^{15}/_{16}$	23.813	F16205.015	16205.015	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.03
		23.813	F36205.015	36205.015	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.08
		23.813	F56205.015	56205.015	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.01
25		25	**F16205**	**16205**	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.02
		25	**F36205**	**36205**	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	1.07
		25	**F56205**	**56205**	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	0.99
		25	**F76205.2RSR**	**76205.2RSR**	**F205**	93	13	30	19	70	11.5	12.5	M10	$^{7}/_{16}$	0.928

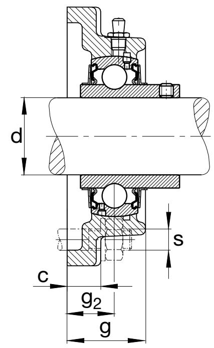
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



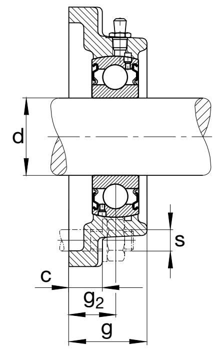
F162



F362



F562



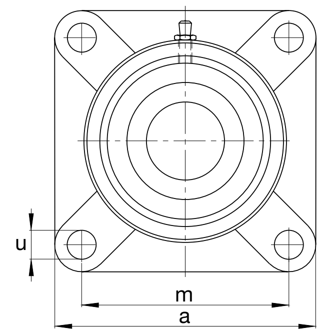
F762...2RSR

Shaft			**Code**			**Dimensions**							**Fastening bolt**		**Mass** ≈
			Flanged bearing unit	S-type bearing with locking device	Housing	a	c	g	g_2	m	u min	max	s		S-type bearing unit
mm	in	mm	FAG	FAG	FAG	mm							mm	in	kg
	1	25.4	F16205.100	16205.100	**F205**	93	13	30	19	70	11.5	12.5	M10	7/16	1.02
		25.4	F36205.100	36205.100	**F205**	93	13	30	19	70	11.5	12.5	M10	7/16	1.07
		25.4	F56205.100	56205.100	**F205**	93	13	30	19	70	11.5	12.5	M10	7/16	0.988
	1 1/16	26.988	F16206.101	16206.101	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.33
		26.988	F36206.101	36206.101	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.46
		26.988	F56206.101	56206.101	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.35
	1 1/8	28.575	F16206.102	16206.102	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.31
		28.575	F36206.102	36206.102	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.44
		28.575	F56206.102	56206.102	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.33
30		30	**F16206**	**16206**	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.3
		30	**F36206**	**36206**	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.42
		30	**F56206**	**56206**	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.31
		30	**F76206.2RSR**	**76206.2RSR**	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.19
	1 3/16	30.163	F16206.103	16206.103	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.3
		30.163	F36206.103	36206.103	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.42
		30.163	F56206.103	56206.103	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.31
	1 1/4	31.75	F16206.104	16206.104	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.28
		31.75	F36206.104	36206.104	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.4
		31.75	F56206.104	56206.104	**F206**	106	14	32.5	20	82.5	11.5	12.5	M10	7/16	1.28
		31.75	F16207.104	16207.104	**F207**	116	15	35	21	92	13	15	M12	1/2	1.83
		31.75	F36207.104	36207.104	**F207**	116	15	35	21	92	13	15	M12	1/2	1.99
		31.75	F56207.104	56207.104	**F207**	116	15	35	21	92	13	15	M12	1/2	1.84
	1 5/16	33.338	F16207.105	16207.105	**F207**	116	15	35	21	92	13	15	M12	1/2	1.82
		33.338	F36207.105	36207.105	**F207**	116	15	35	21	92	13	15	M12	1/2	1.97
		33.338	F56207.105	56207.105	**F207**	116	15	35	21	92	13	15	M12	1/2	1.81
	1 3/8	34.925	F16207.106	16207.106	**F207**	116	15	35	21	92	13	15	M12	1/2	1.8
		34.925	F36207.106	36207.106	**F207**	116	15	35	21	92	13	15	M12	1/2	1.94
		34.925	F56207.106	56207.106	**F207**	116	15	35	21	92	13	15	M12	1/2	1.78
35		35	**F16207**	**16207**	**F207**	116	15	35	21	92	13	15	M12	1/2	1.8
		35	**F36207**	**36207**	**F207**	116	15	35	21	92	13	15	M12	1/2	1.94
		35	**F56207**	**56207**	**F207**	116	15	35	21	92	13	15	M12	1/2	1.77
		35	**F76207.2RSR**	**76207.2RSR**	**F207**	116	15	35	21	92	13	15	M12	1/2	1.59

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

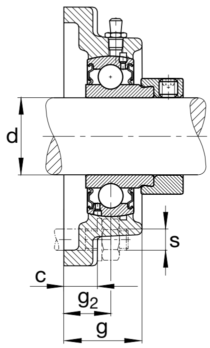
FAG S-TYPE BEARING UNITS

Series F162, F362, F562, F762..2RSR
Flanged housings of grey-cast iron

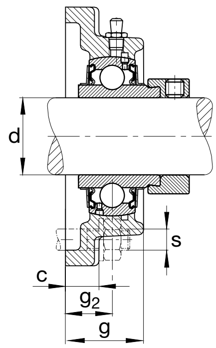


Shaft		Code			Dimensions							Fastening bolt		Mass ≈
mm		Flanged bearing unit	S-type bearing with locking device	Housing	a	c	g	g_2	m	u min	max	s		S-type bearing unit
in	mm	**FAG**	**FAG**	**FAG**	mm							mm	in	kg
1 7/16	36.513	F16207.107	16207.107	**F207**	116	15	35	21	92	13	15	M12	1/2	1.78
	36.513	F36207.107	36207.107	**F207**	116	15	35	21	92	13	15	M12	1/2	1.92
	36.513	F56207.107	56207.107	**F207**	116	15	35	21	92	13	15	M12	1/2	1.75
1 1/2	38.1	F16208.108	16208.108	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.31
	38.1	F36208.108	36208.108	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.53
	38.1	F56208.108	56208.108	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.29
1 9/16	39.688	F16208.109	16208.109	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.28
	39.688	F36208.109	36208.109	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.5
	39.688	F56208.109	56208.109	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.26
40	40	**F16208**	**16208**	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.28
	40	**F36208**	**36208**	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.49
	40	**F56208**	**56208**	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.26
	40	**F76208.2RSR**	**76208.2RSR**	**F208**	129	15	39	24	101.5	13	15	M12	1/2	2.02
1 5/8	41.275	F16209.110	16209.110	**F209**	135	16	40	24	105	15	17	M14	9/16	2.74
	41.275	F36209.110	36209.110	**F209**	135	16	40	24	105	15	17	M14	9/16	2.97
	41.275	F56209.110	56209.110	**F209**	135	16	40	24	105	15	17	M14	9/16	2.84
1 11/16	42.863	F16209.111	16209.111	**F209**	135	16	40	24	105	15	17	M14	9/16	2.72
	42.863	F36209.111	36209.111	**F209**	135	16	40	24	105	15	17	M14	9/16	2.93
	42.863	F56209.111	56209.111	**F209**	135	16	40	24	105	15	17	M14	9/16	2.8
1 3/4	44.45	F16209.112	16209.112	**F209**	135	16	40	24	105	15	17	M14	9/16	2.69
	44.45	F36209.112	36209.112	**F209**	135	16	40	24	105	15	17	M14	9/16	2.89
	44.45	F56209.112	56209.112	**F209**	135	16	40	24	105	15	17	M14	9/16	2.77
45	45	**F16209**	**16209**	**F209**	135	16	40	24	105	15	17	M14	9/16	2.68
	45	**F36209**	**36209**	**F209**	135	16	40	24	105	15	17	M14	9/16	2.88
	45	**F56209**	**56209**	**F209**	135	16	40	24	105	15	17	M14	9/16	2.76
	45	**F76209.2RSR**	**76209.2RSR**	**F209**	135	16	40	24	105	15	17	M14	9/16	2.41
1 13/16	46.038	F16210.113	16210.113	**F210**	143	17	45	28	111	17	19	M16	5/8	3.04
	46.038	F36210.113	36210.113	**F210**	143	17	45	28	111	17	19	M16	5/8	3.33
	46.038	F56210.113	56210.113	**F210**	143	17	45	28	111	17	19	M16	5/8	3.11
1 7/8	47.625	F16210.114	16210.114	**F210**	143	17	45	28	111	17	19	M16	5/8	3.01
	47.625	F36210.114	36210.114	**F210**	143	17	45	28	111	17	19	M16	5/8	3.28
	47.625	F56210.114	56210.114	**F210**	143	17	45	28	111	17	19	M16	5/8	3.06

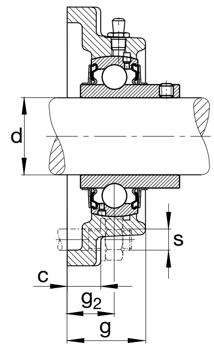
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



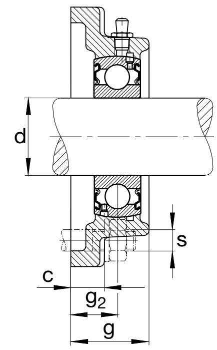
F162



F362



F562



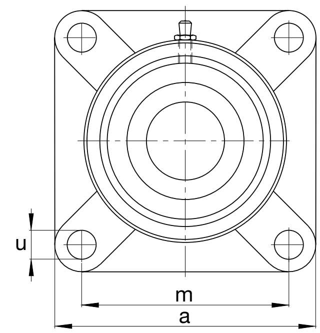
F762...2RSR

Shaft		**Code**			**Dimensions**							**Fastening bolt**		**Mass** ≈
		Flanged bearing unit	S-type bearing with locking device	Housing	a	c	g	g_2	m	u min	max	s		S-type bearing unit
mm in	mm	**FAG**	**FAG**	**FAG**	mm							mm	in	kg
1 $^{15}/_{16}$	49.213	F16210.115	16210.115	**F210**	143	17	45	28	111	17	19	M16	$^5/_8$	2.99
	49.213	F36210.115	36210.115	**F210**	143	17	45	28	111	17	19	M16	$^5/_8$	3.23
	49.213	F56210.115	56210.115	**F210**	143	17	45	28	111	17	19	M16	$^5/_8$	3.01
50	50	**F16210**	**16210**	**F210**	143	17	45	28	111	17	19	M16	$^5/_8$	2.97
	50	**F36210**	**36210**	**F210**	143	17	45	28	111	17	19	M16	$^5/_8$	3.21
	50	**F56210**	**56210**	**F210**	143	17	45	28	111	17	19	M16	$^5/_8$	2.97
	50	**F76210.2RSR**	**76210.2RSR**	**F210**	143	17	45	28	111	17	19	M16	$^5/_8$	2.66
2	50.8	F16211.200	16211.200	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	3.91
	50.8	F36211.200	36211.200	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	4.45
	50.8	F56211.200	56211.200	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	4.21
2 $^1/_8$	53.975	F16211.202	16211.202	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	3.82
	53.975	F36211.202	36211.202	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	4.4
	53.975	F56211.202	56211.202	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	4.16
55	55	**F16211**	**16211**	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	3.78
	55	**F36211**	**36211**	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	4.38
	55	**F56211**	**56211**	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	4.14
	55	F76211.2RSR	76211.2RSR	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	3.62
2 $^3/_{16}$	55.563	F16211.203	16211.203	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	3.76
	55.563	F36211.203	36211.203	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	3.9
	55.563	F56211.203	56211.203	**F211**	162	18	49	31	130	17	19	M16	$^5/_8$	4.09
2 $^1/_4$	57.15	F16212.204	16212.204	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	4.55
	57.15	F36212.204	36212.204	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	5.25
	57.15	F56212.204	56212.204	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	4.84
60	60	**F16212**	**16212**	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	4.42
	60	**F36212**	**36212**	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	5.15
	60	**F56212**	**56212**	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	4.77
	60	F76212.2RSR	76212.2RSR	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	3.85
2 $^3/_8$	60.325	F16212.206	16212.206	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	4.41
	60.325	F36212.206	36212.206	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	5.05
	60.325	F56212.206	56212.206	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	4.64
2 $^7/_{16}$	61.913	F16212.207	16212.207	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	4.33
	61.913	F36212.207	36212.207	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	5.03
	61.913	F56212.207	56212.207	**F212**	175	18	53.5	34	143	17	19	M16	$^5/_8$	4.56

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

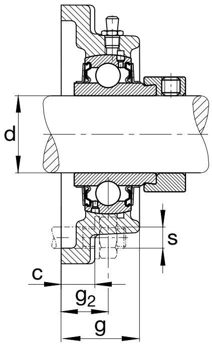
FAG S-TYPE BEARING UNITS

Series F362, F562
Flanged housings of grey-cast iron

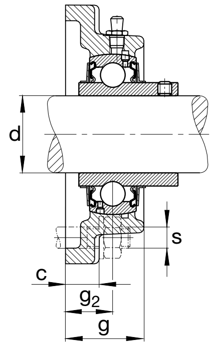


Shaft mm	Shaft in	mm	Code: Flanged bearing unit FAG	Code: S-type bearing with locking device FAG	Code: Housing FAG	Dimensions a mm	c	g	g_2	m	u min	u max	Fastening bolt s mm	Fastening bolt s in	Mass ≈ S-type bearing unit kg
	$2\,{}^{1}/_{2}$	63.5	F36213.208	36213.208	**F213**	187	22	50	34	149.5	17	19	M16	$^{5}/_{8}$	7
		63.5	F56213.208	56213.208	**F213**	187	22	50	34	149.5	17	19	M16	$^{5}/_{8}$	5.9
65		65	F36213	36213	**F213**	187	22	50	34	149.5	17	19	M16	$^{5}/_{8}$	6.9
		65	**F56213**	**56213**	**F213**	187	22	50	34	149.5	17	19	M16	$^{5}/_{8}$	5.8
	$2\,{}^{9}/_{16}$	65.087	F36213.209	36213.209	**F213**	187	22	50	34	149.5	17	19	M16	$^{5}/_{8}$	6.9
		65.087	F56213.209	56213.209	**F213**	187	22	50	34	149.5	17	19	M16	$^{5}/_{8}$	5.8
	$2\,{}^{5}/_{8}$	66.675	F36214.210	36214.210	**F214**	193	22	54	35	153	17	19.9	M16	$^{5}/_{8}$	7.5
		66.675	F56214.210	56214.210	**F214**	193	22	54	35	153	17	19.9	M16	$^{5}/_{8}$	7
	$2\,{}^{11}/_{16}$	68.262	F36214.211	36214.211	**F214**	193	22	54	35	153	17	19.9	M16	$^{5}/_{8}$	7.5
		68.262	F56214.211	56214.211	**F214**	193	22	54	35	153	17	19.9	M16	$^{5}/_{8}$	6.9
	$2\,{}^{3}/_{4}$	69.85	F36214.212	36214.212	**F214**	193	22	54	35	153	17	19.9	M16	$^{5}/_{8}$	7.4
		69.85	F56214.212	56214.212	**F214**	193	22	54	35	153	17	19.9	M16	$^{5}/_{8}$	6.9
70		70	F36214	36214	**F214**	193	22	54	35	153	17	19.9	M16	$^{5}/_{8}$	7.4
		70	**F56214**	**56214**	**F214**	193	22	54	35	153	17	19.9	M16	$^{5}/_{8}$	6.8
	$2\,{}^{13}/_{16}$	71.437	F36215.213	36215.213	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	7.8
		71.437	F56215.213	56215.213	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	7.3
	$2\,{}^{7}/_{8}$	73.025	F36215.214	36215.214	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	7.7
		73.025	F56215.214	56215.214	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	7.2
	$2\,{}^{15}/_{16}$	74.612	F36215.215	36215.215	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	7.6
		74.612	F56215.215	56215.215	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	7.1
75		75	F36215	36215	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	7.6
		75	**F56215**	**56215**	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	7
	3	76.2	F36215.300	36215.300	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	7.5
		76.2	F56215.300	56215.300	**F215**	200	22	56	35	159	17	24.5	M16	$^{5}/_{8}$	6.9
	$3\,{}^{1}/_{8}$	79.375	F36216.302	36216.302	**F216**	208	22	58	35	165	21	24.5	M20	$^{3}/_{4}$	8.6
		79.375	F56216.302	56216.302	**F216**	208	22	58	35	165	21	24.5	M20	$^{3}/_{4}$	8.6
80		80	F36216	36216	**F216**	208	22	58	35	165	21	24.5	M20	$^{3}/_{4}$	8.6
		80	**F56216**	**56216**	**F216**	208	22	58	35	165	21	24.5	M20	$^{3}/_{4}$	8.5

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



F362



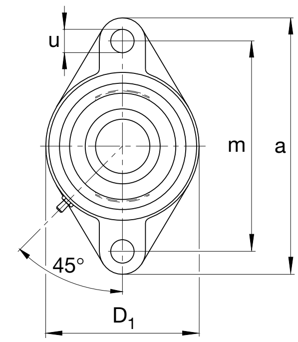
F562

Shaft		**Code**			**Dimensions**							**Fastening bolt**		**Mass** ≈
		Flanged bearing unit	S-type bearing with locking device	Housing	a	c	g	g_2	m	u min	max	s		S-type bearing unit
mm in	mm	**FAG**	**FAG**	**FAG**	mm							mm	in	kg
$3\,^{1}/_{4}$	82.55	F36217.304	36217.304	F217	220	24	63	36	175	21	24.5	M20	$^{3}/_{4}$	11
	82.55	F56217.304	56217.304	F217	220	24	63	36	175	21	24.5	M20	$^{3}/_{4}$	10.8
85	85	F36217	36217	F217	220	24	63	36	175	21	24.5	M20	$^{3}/_{4}$	10.8
	85	F56217	56217	F217	220	24	63	36	175	21	24.5	M20	$^{3}/_{4}$	10.6
$3\,^{1}/_{2}$	88.9	F36218.308	36218.308	**F218**	235	24	68	42	187	21	24.5	M20	$^{3}/_{4}$	13
	88.9	F56218.308	56218.308	**F218**	235	24	68	42	187	21	24.5	M20	$^{3}/_{4}$	12.9
90	90	F36218	36218	**F218**	235	24	68	42	187	21	24.5	M20	$^{3}/_{4}$	12.9
	90	**F56218**	**56218**	**F218**	235	24	68	42	187	21	24.5	M20	$^{3}/_{4}$	12.8

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

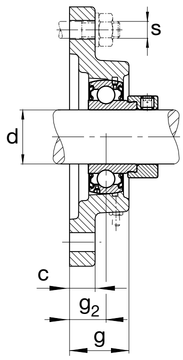
FAG S-TYPE BEARING UNITS

Series FL162, FL362, FL562, FL762..2RSR
Flanged housings of grey-cast iron

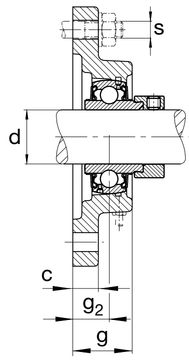


Shaft			Code			Dimensions								Fastening bolt		Mass ≈
			Flanged bearing unit	S-type bearing with locking device	Housing	a	c	D_1	g	g_2	m	u		s		S-type bearing unit
mm												min	max			
	in	mm	FAG	FAG	FAG	mm								mm	in	kg
12		12	FL16203/12	16203/12	FL203	98	12	60	27	17	76.5	11	12.5	M10	$^{3}/_{8}$	0.48
	$^{1}/_{2}$	12.7	FL16203.008	16203.008	FL203	98	12	60	27	17	76.5	11	12.5	M10	$^{3}/_{8}$	0.478
	$^{9}/_{16}$	14.288	FL16203.009	16203.009	FL203	98	12	60	27	17	76.5	11	12.5	M10	$^{3}/_{8}$	0.473
15		15	FL16203/15	16203/15	FL203	98	12	60	27	17	76.5	11	12.5	M10	$^{3}/_{8}$	0.47
	$^{5}/_{8}$	15.875	FL16203.010	16203.010	FL203	98	12	60	27	17	76.5	11	12.5	M10	$^{3}/_{8}$	0.467
17		17	FL16203	**16203**	FL203	98	12	60	27	17	76.5	11	12.5	M10	$^{3}/_{8}$	0.45
		17	FL76203.2RSR	76203.2RSR	FL203	98	12	60	27	17	76.5	11	12.5	M10	$^{3}/_{8}$	0.414
	$^{11}/_{16}$	17.463	FL16203.011	16203.011	FL203	98	12	60	27	17	76.5	11	12.5	M10	$^{3}/_{8}$	0.441
	$^{3}/_{4}$	19.05	FL16204.012	16204.012	**FL204**	113	13	61	29.5	19	90	11	12.5	M10	$^{3}/_{8}$	0.554
		19.05	FL36204.012	36204.012	**FL204**	113	13	61	29.5	19	90	11	12.5	M10	$^{3}/_{8}$	0.608
		19.05	FL56204.012	56204.012	**FL204**	113	13	61	29.5	19	90	11	12.5	M10	$^{3}/_{8}$	0.562
20		20	**FL16204**	**16204**	**FL204**	113	13	61	29.5	19	90	11	12.5	M10	$^{3}/_{8}$	0.55
		20	**FL36204**	**36204**	**FL204**	113	13	61	29.5	19	90	11	12.5	M10	$^{3}/_{8}$	0.6
		20	**FL56204**	**56204**	**FL204**	113	13	61	29.5	19	90	11	12.5	M10	$^{3}/_{8}$	0.54
		20	**FL76204.2RSR**	**76204.2RSR**	**FL204**	113	13	61	29.5	19	90	11	12.5	M10	$^{3}/_{8}$	0.506
	$^{13}/_{16}$	20.638	FL16205.013	16205.013	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.846
		20.638	FL36205.013	36205.013	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.913
		20.638	FL56205.013	56205.013	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.838
	$^{7}/_{8}$	22.225	FL16205.014	16205.014	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.837
		22.225	FL36205.014	36205.014	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.898
		22.225	FL56205.014	56205.014	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.823
	$^{15}/_{16}$	23.813	FL16205.015	16205.015	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.828
		23.813	FL36205.015	36205.015	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.882
		23.813	FL56205.015	56205.015	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.808
25		25	**FL16205**	**16205**	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.82
		25	**FL36205**	**36205**	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.87
		25	**FL56205**	**56205**	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.79
		25	**FL76205.2RSR**	**76205.2RSR**	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^{7}/_{16}$	0.728

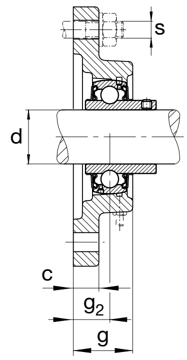
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



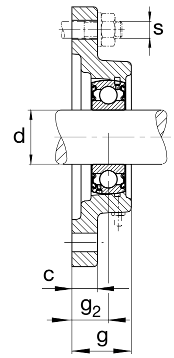
FL162



FL362



FL562



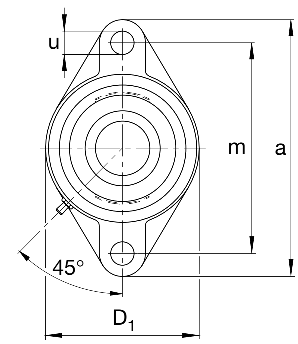
FL762...2RSR

Shaft		**Code**			**Dimensions**								**Fastening bolt**		**Mass** ≈
mm in	mm	Flanged bearing unit **FAG**	S-type bearing with locking device **FAG**	Housing **FAG**	a mm	c	D_1	g	g_2	m	u min	max	s mm	in	S-type bearing unit kg
1	25.4	FL16205.100	16205.100	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^7/_{16}$	0.817
	25.4	FL36205.100	36205.100	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^7/_{16}$	0.865
	25.4	FL56205.100	56205.100	**FL205**	123	13	70	30	19	99	11.5	12.5	M10	$^7/_{16}$	0.788
1 $^1/_{16}$	26.988	FL16206.101	16206.101	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.08
	26.988	FL36206.101	36206.101	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.21
	26.988	FL56206.101	56206.101	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.1
1 $^1/_8$	28.575	FL16206.102	16206.102	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.06
	28.575	FL36206.102	36206.102	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.19
	28.575	FL56206.102	56206.102	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.08
30	30	**FL16206**	**16206**	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.05
	30	**FL36206**	**36206**	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.17
	30	**FL56206**	**56206**	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.06
	30	**FL76206.2RSR**	**76206.2RSR**	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	0.943
1 $^3/_{16}$	30.163	FL16206.103	16206.103	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.05
	30.163	FL36206.103	36206.103	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.17
	30.163	FL56206.103	56206.103	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.06
1 $^1/_4$	31.75	FL16206.104	16206.104	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.03
	31.75	FL36206.104	36206.104	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.15
	31.75	FL56206.104	56206.104	**FL206**	142	14	82	32.5	20	116.5	11.5	12.5	M10	$^7/_{16}$	1.03
	31.75	FL16207.104	16207.104	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.43
	31.75	FL36207.104	36207.104	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.59
	31.75	FL56207.104	56207.104	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.44
1 $^5/_{16}$	33.338	FL16207.105	16207.105	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.42
	33.338	FL36207.105	36207.105	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.57
	33.338	FL56207.105	56207.105	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.41
1 $^3/_8$	34.925	FL16207.106	16207.106	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.4
	34.925	FL36207.106	36207.106	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.54
	34.925	FL56207.106	56207.106	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.38
35	35	**FL16207**	**16207**	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.4
	35	**FL36207**	**36207**	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.54
	35	**FL56207**	**56207**	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.37
	35	**FL76207.2RSR**	**76207.2RSR**	**FL207**	156	15	94	35	21	130	13	15	M12	$^1/_2$	1.19

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

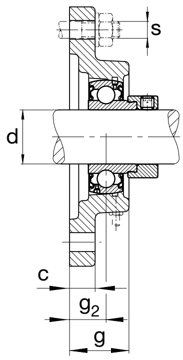
FAG S-TYPE BEARING UNITS

Series FL162, FL362, FL562, FL762..2RSR
Flanged housings of grey-cast iron

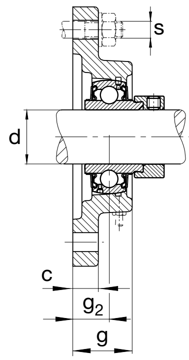


Shaft			**Code**			**Dimensions**								**Fastening bolt**		**Mass** ≈
			Flanged bearing unit	S-type bearing with locking device	Housing	a	c	D_1	g	g_2	m	u min	max	s		S-type bearing unit
mm	in	mm	**FAG**	**FAG**	**FAG**	mm								mm	in	kg
	1 7/16	36.513	FL16207.107	16207.107	**FL207**	156	15	94	35	21	130	13	15	M12	1/2	1.38
		36.513	FL36207.107	36207.107	**FL207**	156	15	94	35	21	130	13	15	M12	1/2	1.52
		36.513	FL56207.107	56207.107	**FL207**	156	15	94	35	21	130	13	15	M12	1/2	1.35
	1 1/2	38.1	FL16208.108	16208.108	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	1.91
		38.1	FL36208.108	36208.108	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	2.13
		38.1	FL56208.108	56208.108	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	1.89
	1 9/16	39.688	FL16208.109	16208.109	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	1.88
		39.688	FL36208.109	36208.109	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	2.1
		39.688	FL56208.109	56208.109	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	1.86
40		40	**FL16208**	**16208**	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	1.88
		40	**FL36208**	**36208**	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	2.09
		40	**FL56208**	**56208**	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	1.86
		40	**FL76208.2RSR**	**76208.2RSR**	**FL208**	172	15	103	39	24	143.5	13	15	M12	1/2	1.62
	1 5/8	41.275	FL16209.110	16209.110	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.09
		41.275	FL36209.110	36209.110	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.32
		41.275	FL56209.110	56209.110	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.19
	1 11/16	42.863	FL16209.111	16209.111	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.07
		42.863	FL36209.111	36209.111	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.28
		42.863	FL56209.111	56209.111	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.15
	1 3/4	44.45	FL16209.112	16209.112	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.04
		44.45	FL36209.112	36209.112	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.24
		44.45	FL56209.112	56209.112	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.12
45		45	**FL16209**	**16209**	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.03
		45	**FL36209**	**36209**	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.23
		45	**FL56209**	**56209**	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	2.11
		45	**FL76209.2RSR**	**76209.2RSR**	**FL209**	180	16	108	40	24	148.5	15	17	M14	9/16	1.76
	1 13/16	46.038	FL16210.113	16210.113	**FL210**	190	17	114	45	28	157	17	19	M16	5/8	2.49
		46.038	FL36210.113	36210.113	**FL210**	190	17	114	45	28	157	17	19	M16	5/8	2.78
		46.038	FL56210.113	56210.113	**FL210**	190	17	114	45	28	157	17	19	M16	5/8	2.56
	1 7/8	47.625	FL16210.114	16210.114	**FL210**	190	17	114	45	28	157	17	19	M16	5/8	2.46
		47.625	FL36210.114	36210.114	**FL210**	190	17	114	45	28	157	17	19	M16	5/8	2.73
		47.625	FL56210.114	56210.114	**FL210**	190	17	114	45	28	157	17	19	M16	5/8	2.51

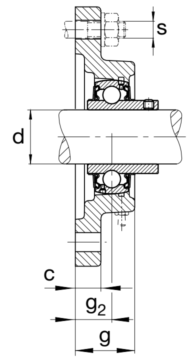
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



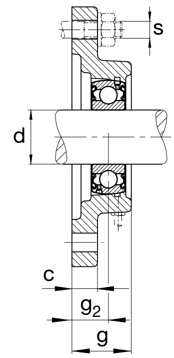
FL162



FL362



FL562



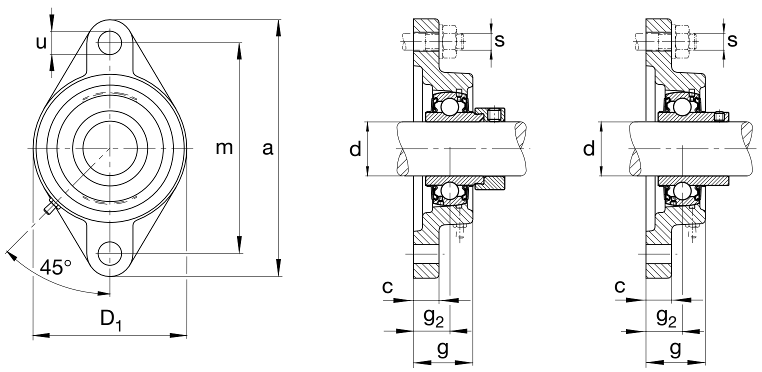
FL762...2RSR

Shaft		**Code**			**Dimensions**								**Fastening bolt**		**Mass** ≈
mm		Flanged bearing unit	S-type bearing with locking device	Housing	a	c	D_1	g	g_2	m	u min	max	s		S-type bearing unit
in	mm	**FAG**	**FAG**	**FAG**	mm								mm	in	kg
$1\frac{15}{16}$	49.213	FL16210.115	16210.115	**FL210**	190	17	114	45	28	157	17	19	M16	$^5/_8$	2.44
	49.213	FL36210.115	36210.115	**FL210**	190	17	114	45	28	157	17	19	M16	$^5/_8$	2.68
	49.213	FL56210.115	56210.115	**FL210**	190	17	114	45	28	157	17	19	M16	$^5/_8$	2.46
50	50	**FL16210**	**16210**	**FL210**	190	17	114	45	28	157	17	19	M16	$^5/_8$	2.42
	50	**FL36210**	**36210**	**FL210**	190	17	114	45	28	157	17	19	M16	$^5/_8$	2.66
	50	**FL56210**	**56210**	**FL210**	190	17	114	45	28	157	17	19	M16	$^5/_8$	2.42
	50	**FL76210.2RSR**	**76210.2RSR**	**FL210**	190	17	114	45	28	157	17	19	M16	$^5/_8$	2.11
2	50.8	FL16211.200	16211.200	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.16
	50.8	FL36211.200	36211.200	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.76
	50.8	FL56211.200	56211.200	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.46
$2\frac{1}{8}$	53.975	FL16211.202	16211.202	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.07
	53.975	FL36211.202	36211.202	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.65
	53.975	FL56211.202	56211.202	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.41
55	55	**FL16211**	**16211**	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.03
	55	FL36211	**36211**	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.63
	55	FL56211	**56211**	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.39
	55	FL76211.2RSR	76211.2RSR	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	2.87
$2\frac{3}{16}$	55.563	FL16211.203	16211.203	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.01
	55.563	FL36211.203	36211.203	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.15
	55.563	FL56211.203	56211.203	FL211	217	18	128	49	31	184	17	19	M16	$^5/_8$	3.34
$2\frac{1}{4}$	57.15	FL16212.204	16212.204	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	3.95
	57.15	FL36212.204	36212.204	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	4.65
	57.15	FL56212.204	56212.204	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	4.24
60	60	**FL16212**	**16212**	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	3.82
	60	FL36212	**36212**	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	4.55
	60	FL56212	**56212**	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	4.17
	60	FL76212.2RSR	76212.2RSR	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	3.25
$2\frac{3}{8}$	60.325	FL16212.206	16212.206	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	3.81
	60.325	FL36212.206	36212.206	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	4.45
	60.325	FL56212.206	56212.206	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	4.04
$2\frac{7}{16}$	61.913	FL16212.207	16212.207	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	3.73
	61.913	FL36212.207	36212.207	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	4.43
	61.913	FL56212.207	56212.207	FL212	237	18	138	53.5	34	202	17	19	M16	$^5/_8$	3.96

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

FAG S-TYPE BEARING UNITS

Series FL362, FL562
Flanged housings of grey-cast iron



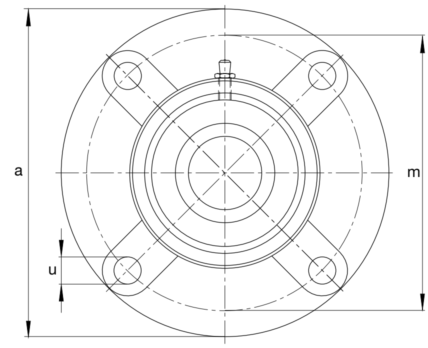
FL362 **FL562**

Shaft		Code			Dimensions								Fastening bolt		Mass ≈
		Flanged bearing unit	S-type bearing with locking device	Housing	a	c	D_1	g	g_2	m	u min	max	s		S-type bearing unit
mm in	mm	FAG	FAG	FAG	mm								mm	in	kg
2 1/2	63.5	FL36213.208	36213.208	FL213	258	22	155	50	35	210	17	19	M16	5/8	6.1
	63.5	FL56213.208	56213.208	FL213	258	22	155	50	35	210	17	19	M16	5/8	5
65	65	FL36213	36213	FL213	258	22	155	50	35	210	17	19	M16	5/8	6
	65	FL56213	**56213**	FL213	258	22	155	50	35	210	17	19	M16	5/8	5
2 9/16	65.087	FL36213.209	36213.209	FL213	258	22	155	50	35	210	17	19	M16	5/8	6
	65.087	FL56213.209	56213.209	FL213	258	22	155	50	35	210	17	19	M16	5/8	4.9
2 5/8	66.675	FL36214.210	36214.210	FL214	265	22	160	54	35	216	17	19.9	M16	5/8	6.4
	66.675	FL56214.210	56214.210	FL214	265	22	160	54	35	216	17	19.9	M16	5/8	5.9
2 11/16	68.262	FL36214.211	36214.211	FL214	265	22	160	54	35	216	17	19.9	M16	5/8	6.4
	68.262	FL56214.211	56214.211	FL214	265	22	160	54	35	216	17	19.9	M16	5/8	5.8
2 3/4	69.85	FL36214.212	36214.212	FL214	265	22	160	54	35	216	17	19.9	M16	5/8	6.3
	69.85	FL56214.212	56214.212	FL214	265	22	160	54	35	216	17	19.9	M16	5/8	5.8
70	70	FL36214	36214	FL214	265	22	160	54	35	216	17	19.9	M16	5/8	6.3
	70	FL56214	**56214**	FL214	265	22	160	54	35	216	17	19.9	M16	5/8	5.3
2 13/16	71.437	FL36215.213	36215.213	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6.9
	71.437	FL56215.213	56215.213	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6.4
2 7/8	73.025	FL36215.214	36215.214	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6.8
	73.025	FL56215.214	56215.214	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6.3
2 15/16	74.612	FL36215.215	36215.215	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6.7
	74.612	FL56215.215	56215.215	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6.2
75	75	FL36215	36215	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6.7
	75	FL56215	**56215**	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6.2
3	76.2	FL36215.300	36215.300	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6.6
	76.2	FL56215.300	56215.300	FL215	275	22	165	56	35	225	17	24.5	M16	5/8	6

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.
When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

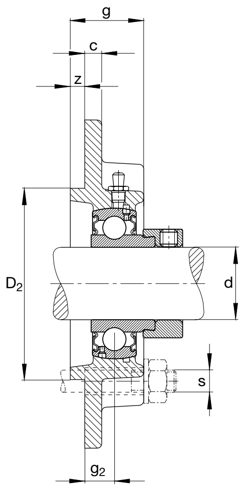
FAG S-TYPE BEARING UNITS

Series FC162, FC362, FC562, FC762..2RSR
Flanged housings of grey-cast iron

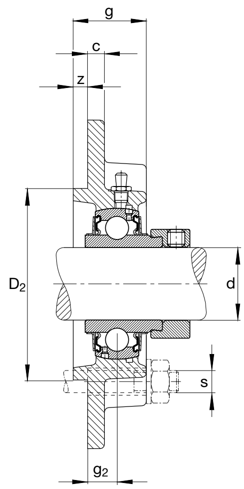


Shaft mm in	 mm	Code Flanged bearing unit FAG	 S-type bearing with locking device FAG	 Housing FAG	Dimensions a mm	 c	 D_2	 g	 g_2	 m	 u	 z	Fastening bolt s mm	 in	Mass ≈ S-type bearing unit kg
$^3/_4$	19.05	FC16204.012	16204.012	FC204	100	7	62	25.5	10	78	12	5	M10	$^3/_8$	0.954
	19.05	FC36204.012	36204.012	FC204	100	7	62	25.5	10	78	12	5	M10	$^3/_8$	1.01
	19.05	FC56204.012	56204.012	FC204	100	7	62	25.5	10	78	12	5	M10	$^3/_8$	0.962
20	20	FC16204	**16204**	FC204	100	7	62	25.5	10	78	12	5	M10	$^3/_8$	0.95
	20	FC36204	**36204**	FC204	100	7	62	25.5	10	78	12	5	M10	$^3/_8$	1
	20	FC56204	**56204**	FC204	100	7	62	25.5	10	78	12	5	M10	$^3/_8$	0.94
	20	FC76204.2RSR	**76204.2RSR**	FC204	100	7	62	25.5	10	78	12	5	M10	$^3/_8$	0.91
$^{13}/_{16}$	20.638	FC16205.013	16205.013	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.3
	20.638	FC36205.013	36205.013	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.36
	20.638	FC56205.013	56205.013	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.23
$^7/_8$	22.225	FC16205.014	16205.014	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.29
	22.225	FC36205.014	36205.014	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.35
	22.225	FC56205.014	56205.014	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.27
$^{15}/_{16}$	23.813	FC16205.015	16205.015	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.28
	23.813	FC36205.015	36205.015	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.33
	23.813	FC56205.015	56205.015	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.26
25	25	FC16205	**16205**	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.27
	25	FC36205	**36205**	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.32
	25	FC56205	**56205**	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.24
	25	FC76205.2RSR	**76205.2RSR**	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.18
1	25.4	FC16205.100	16205.100	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.27
	25.4	FC36205.100	36205.100	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.32
	25.4	FC56205.100	56205.100	FC205	115	7	70	27	10	90	12	6	M10	$^3/_8$	1.24
1 $^1/_{16}$	26.988	FC16206.101	16206.101	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.68
	26.988	FC36206.101	36206.101	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.81
	26.988	FC56206.101	56206.101	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.7
1 $^1/_8$	28.575	FC16206.102	16206.102	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.66
	28.575	FC36206.102	36206.102	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.79
	28.575	FC56206.102	56206.102	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.68
30	30	FC16206	**16206**	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.65
	30	FC36206	**36206**	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.77
	30	FC56206	**56206**	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.66
	30	FC76206.2RSR	**76206.2RSR**	FC206	125	8	80	31	10	100	12	8	M10	$^3/_8$	1.54

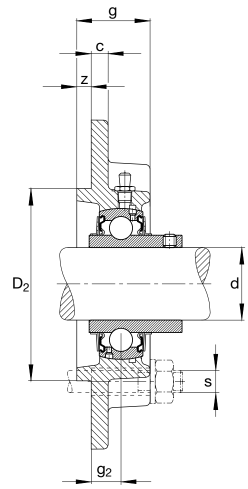
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



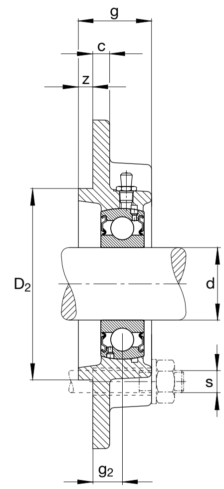
FC162



FC362



FC562



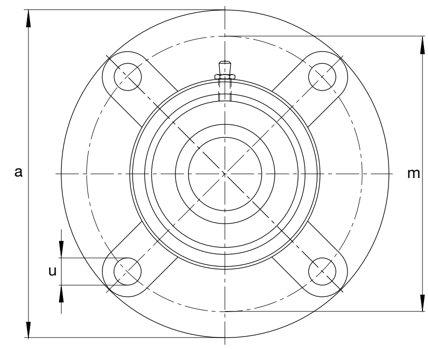
FC762...2RSR

Shaft		**Code**			**Dimensions**								**Fastening bolt**		**Mass** ≈
		Flanged bearing unit	S-type bearing with locking device	Housing	a	c	D_2	g	g_2	m	u	z	s		S-type bearing unit
mm in	mm	**FAG**	**FAG**	**FAG**	mm								mm	in	kg
1 3/16	30.163	FC16206.103	16206.103	FC206	125	8	80	31	10	100	12	8	M10	3/8	1.65
	30.163	FC36206.103	36206.103	FC206	125	8	80	31	10	100	12	8	M10	3/8	1.77
	30.163	FC56206.103	56206.103	FC206	125	8	80	31	10	100	12	8	M10	3/8	1.66
1 1/4	31.75	FC16206.104	16206.104	FC206	125	8	80	31	11	100	12	8	M10	3/8	1.63
	31.75	FC36206.104	36206.104	FC206	125	8	80	31	11	100	12	8	M10	3/8	1.75
	31.75	FC56206.104	56206.104	FC206	125	8	80	31	11	100	12	8	M10	3/8	1.63
	31.75	FC16207.104	16207.104	FC207	135	9	90	34	11	110	14	8	M12	1/2	1.93
	31.75	FC36207.104	36207.104	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.05
	31.75	FC56207.104	56207.104	FC207	135	9	90	34	11	110	14	8	M12	1/2	1.93
1 5/16	33.338	FC16207.105	16207.105	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.18
	33.338	FC36207.105	36207.105	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.34
	33.338	FC56207.105	56207.105	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.19
1 3/8	34.925	FC16207.106	16207.106	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.17
	34.925	FC36207.106	36207.106	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.32
	34.925	FC56207.106	56207.106	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.16
35	35	FC16207	**16207**	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.15
	35	FC36207	**36207**	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.29
	35	FC56207	**56207**	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.12
	35	FC76207.2RSR	**76207.2RSR**	FC207	135	9	90	34	11	110	14	8	M12	1/2	1.94
1 7/16	36.513	FC16207.107	16207.107	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.13
	36.513	FC36207.107	36207.107	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.27
	36.513	FC56207.107	56207.107	FC207	135	9	90	34	11	110	14	8	M12	1/2	2.1
1 1/2	38.1	FC16208.108	16208.108	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.51
	38.1	FC36208.108	36208.108	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.73
	38.1	FC56208.108	56208.108	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.5
1 9/16	39.688	FC16208.109	16208.109	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.48
	39.688	FC36208.109	36208.109	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.7
	39.688	FC56208.109	56208.109	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.46
40	40	FC16208	**16208**	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.48
	40	FC36208	**36208**	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.69
	40	FC56208	**56208**	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.46
	40	FC76208.2RSR	**76208.2RSR**	FC208	145	9	100	36	11	120	14	10	M12	1/2	2.22

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

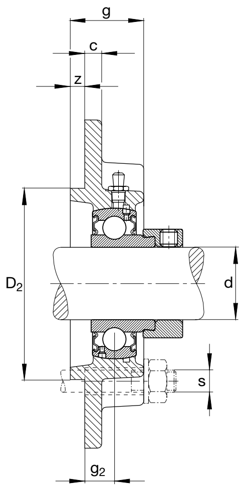
FAG S-TYPE BEARING UNITS

Series FC162, FC362, FC562, FC762..2RSR
Flanged housings of grey-cast iron

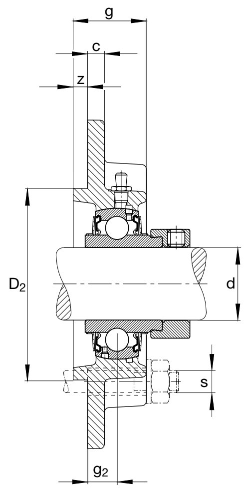


Shaft mm	in	mm	Code Flanged bearing unit FAG	S-type bearing with locking device FAG	Housing FAG	Dimensions a mm	c	D_2	g	g_2	m	u	z	Fastening bolt s mm	in	Mass ≈ S-type bearing unit kg
	1 5/8	41.275	FC16209.110	16209.110	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.39
		41.275	FC36209.110	36209.110	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.62
		41.275	FC56209.110	56209.110	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.49
	1 11/16	42.863	FC16209.111	16209.111	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.37
		42.863	FC36209.111	36209.111	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.58
		42.863	FC56209.111	56209.111	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.45
	1 3/4	44.45	FC16209.112	16209.112	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.34
		44.45	FC36209.112	36209.112	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.54
		44.45	FC56209.112	56209.112	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.42
45		45	FC16209	**16209**	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.33
		45	FC36209	**36209**	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.53
		45	FC56209	**56209**	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.41
		45	FC76209.2RSR	**76209.2RSR**	FC209	160	14	105	38	10	132	16	12	M14	9/16	3.06
	1 13/16	46.038	FC16210.113	16210.113	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.64
		46.038	FC36210.113	36210.113	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.93
		46.038	FC56210.113	56210.113	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.71
	1 7/8	47.625	FC16210.114	16210.114	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.61
		47.625	FC36210.114	36210.114	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.88
		47.625	FC56210.114	56210.114	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.66
	1 15/16	49.213	FC16210.115	16210.115	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.59
		49.213	FC36210.115	36210.115	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.83
		49.213	FC56210.115	56210.115	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.61
50		50	FC16210	**16210**	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.57
		50	FC36210	**36210**	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.81
		50	FC56210	**56210**	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.57
		50	FC76210.2RSR	**76210.2RSR**	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.27
	2	50.8	FC16211.200	16211.200	FC210	165	14	110	40	10	138	16	12	M14	9/16	3.76
		50.8	FC36211.200	36211.200	FC210	165	14	110	40	10	138	16	12	M14	9/16	4.3
		50.8	FC56211.200	56211.200	FC210	165	14	110	40	10	138	16	12	M14	9/16	4.06
	2 1/8	53.975	FC16211.202	16211.202	FC211	185	15	125	43	13	150	19	12	M16	5/8	4.87
		53.975	FC36211.202	36211.202	FC211	185	15	125	43	13	150	19	12	M16	5/8	5.45
		53.975	FC56211.202	56211.202	FC211	185	15	125	43	13	150	19	12	M16	5/8	5.21

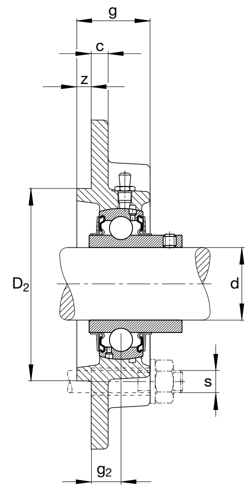
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



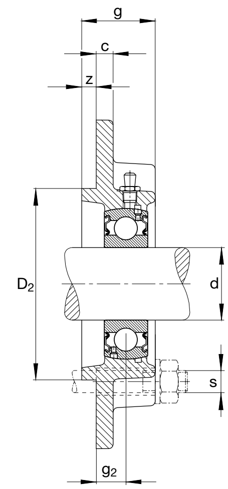
FC162



FC362



FC562



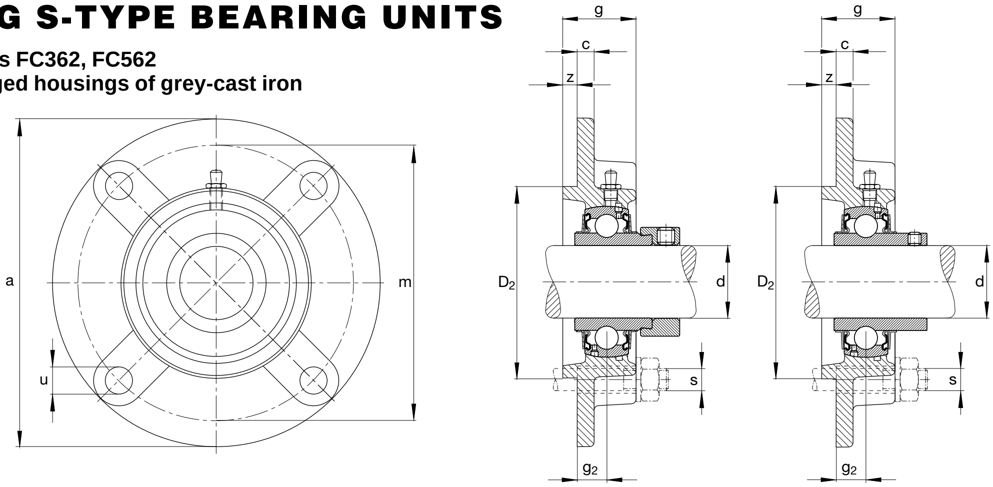
FC762...2RSR

Shaft		**Code**			**Dimensions**								**Fastening bolt**		**Mass** ≈
		Flanged bearing unit	S-type bearing with locking device	Housing	a	c	D_2	g	g_2	m	u	z	s		S-type bearing unit
mm in	mm	**FAG**	**FAG**	**FAG**	mm								mm	in	kg
55	55	FC16211	**16211**	FC211	185	15	125	43	13	150	19	12	M16	$^{5}/_{8}$	4.83
	55	FC36211	**36211**	FC211	185	15	125	43	13	150	19	12	M16	$^{5}/_{8}$	5.43
	55	FC56211	**56211**	FC211	185	15	125	43	13	150	19	12	M16	$^{5}/_{8}$	5.19
	55	FC76211.2RSR	76211.2RSR	FC211	185	15	125	43	13	150	19	12	M16	$^{5}/_{8}$	4.67
$2\,^{3}/_{16}$	55.563	FC16211.203	16211.203	FC211	185	15	125	43	13	150	19	12	M16	$^{5}/_{8}$	4.81
	55.563	FC36211.203	36211.203	FC211	185	15	125	43	13	150	19	12	M16	$^{5}/_{8}$	4.95
	55.563	FC56211.203	56211.203	FC211	185	15	125	43	13	150	19	12	M16	$^{5}/_{8}$	5.16
$2\,^{1}/_{4}$	57.15	FC16212.204	16212.204	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	5.75
	57.15	FC36212.204	36212.204	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	6.45
	57.15	FC56212.204	56212.204	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	6.04
60	60	FC16212	**16212**	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	5.62
	60	FC36212	**36212**	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	6.35
	60	FC56212	**56212**	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	5.97
	60	FC76212.2RSR	76212.2RSR	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	5.05
$2\,^{3}/_{8}$	60.325	FC16212.206	16212.206	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	5.61
	60.325	FC36212.206	36212.206	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	6.25
	60.325	FC56212.206	56212.206	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	5.84
$2\,^{7}/_{16}$	61.913	FC16212.207	16212.207	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	5.53
	61.913	FC36212.207	36212.207	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	6.23
	61.913	FC56212.207	56212.207	FC212	195	15	135	48	17	160	19	12	M16	$^{5}/_{8}$	5.76
$2\,^{1}/_{2}$	63.5	FC36213.208	36213.208	FC213	205	15	145	50	16	170	19	14	M16	$^{5}/_{8}$	7.51
	63.5	FC56213.208	56213.208	FC213	205	15	145	50	16	170	19	14	M16	$^{5}/_{8}$	6.41
65	65	FC36213	36213	FC213	205	15	145	50	16	170	19	14	M16	$^{5}/_{8}$	7.41
	65	FC56213	**56213**	FC213	205	15	145	50	16	170	19	14	M16	$^{5}/_{8}$	6.33
$2\,^{9}/_{16}$	65.087	FC36213.209	36213.209	FC213	205	15	145	50	16	170	19	14	M16	$^{5}/_{8}$	7.36
	65.087	FC56213.209	56213.209	FC213	205	15	145	50	16	170	19	14	M16	$^{5}/_{8}$	6.26
$2\,^{5}/_{8}$	66.675	FC36214.210	36214.210	FC214	215	18	150	54	17	177	19	14	M16	$^{5}/_{8}$	8.36
	66.675	FC56214.210	56214.210	FC214	215	18	150	54	17	177	19	14	M16	$^{5}/_{8}$	7.93
$2\,^{11}/_{16}$	68.262	FC36214.211	36214.211	FC214	215	18	150	54	17	177	19	14	M16	$^{5}/_{8}$	8.35
	68.262	FC56214.211	56214.211	FC214	215	18	150	54	17	177	19	14	M16	$^{5}/_{8}$	7.83
$2\,^{3}/_{4}$	69.85	FC36214.212	36214.212	FC214	215	18	150	54	17	177	19	14	M16	$^{5}/_{8}$	8.26
	69.85	FC56214.212	56214.212	FC214	215	18	150	54	17	177	19	14	M16	$^{5}/_{8}$	7.82

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

FAG S-TYPE BEARING UNITS

Series FC362, FC562
Flanged housings of grey-cast iron



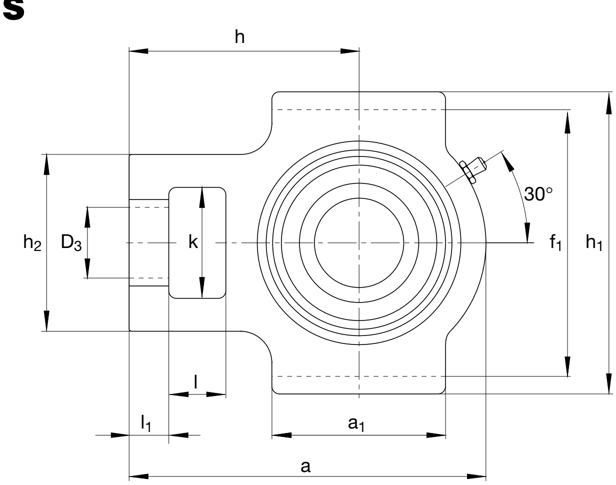
FC362 **FC562**

Shaft mm / in	mm	**Code** Flanged bearing unit FAG	S-type bearing with locking device FAG	Housing FAG	**Dimensions** a mm	c	D_2	g	g_2	m	u	z	**Fastening bolt** s mm	in	**Mass** ≈ S-type bearing unit kg
70	70	FC36214	36214	FC214	215	18	150	54	17	177	19	14	M16	$^5/_8$	8.25
	70	FC56214	**56214**	FC214	215	18	150	54	17	177	19	14	M16	$^5/_8$	7.72
$2\,^{13}/_{16}$	71.437	FC36215.213	36215.213	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	9.27
	71.437	FC56215.213	56215.213	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	8.78
$2\,^{7}/_{8}$	73.025	FC36215.214	36215.214	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	9.17
	73.025	FC56215.214	56215.214	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	8.67
$2\,^{15}/_{16}$	74.612	FC36215.215	36215.215	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	9.08
	74.612	FC56215.215	56215.215	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	8.56
75	75	FC36215	36215	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	9.05
	75	FC56215	**56215**	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	8.53
3	76.2	FC36215.300	36215.300	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	8.98
	76.2	FC56215.300	56215.300	FC215	220	18	160	56	18	184	19	16	M16	$^5/_8$	8.44
$3\,^{1}/_{8}$	79.375	FC36216.302	36216.302	FC216	240	18	170	58	18	200	23	16	M20	$^3/_4$	10.7
	79.375	FC56216.302	56216.302	FC216	240	18	170	58	18	200	23	16	M20	$^3/_4$	10.7
80	80	FC36216	36216	FC216	240	18	170	58	18	200	23	16	M20	$^3/_4$	10.7
	80	FC56216	**56216**	FC216	240	18	170	58	18	200	23	16	M20	$^3/_4$	10.6
$3\,^{1}/_{4}$	82.55	FC36217.304	36217.304	FC217	250	20	180	63	18	208	23	18	M20	$^3/_4$	12.9
	82.55	FC56217.304	56217.304	FC217	250	20	180	63	18	208	23	18	M20	$^3/_4$	11.3
85	85	FC36217	36217	FC217	250	20	180	63	18	208	23	18	M20	$^3/_4$	12.7
	85	FC56217	56217	FC217	250	20	180	63	18	208	23	18	M20	$^3/_4$	12.5
$3\,^{1}/_{2}$	88.9	FC36218.308	36218.308	FC218	265	20	190	68	22	220	23	18	M20	$^3/_4$	15.1
	88.9	FC56218.308	56218.308	FC218	265	20	190	68	22	220	23	18	M20	$^3/_4$	15
90	90	FC36218	36218	FC218	265	20	190	68	22	220	23	18	M20	$^3/_4$	15
	90	FC56218	**56218**	FC218	265	20	190	68	22	220	23	18	M20	$^3/_4$	14.8

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.
When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

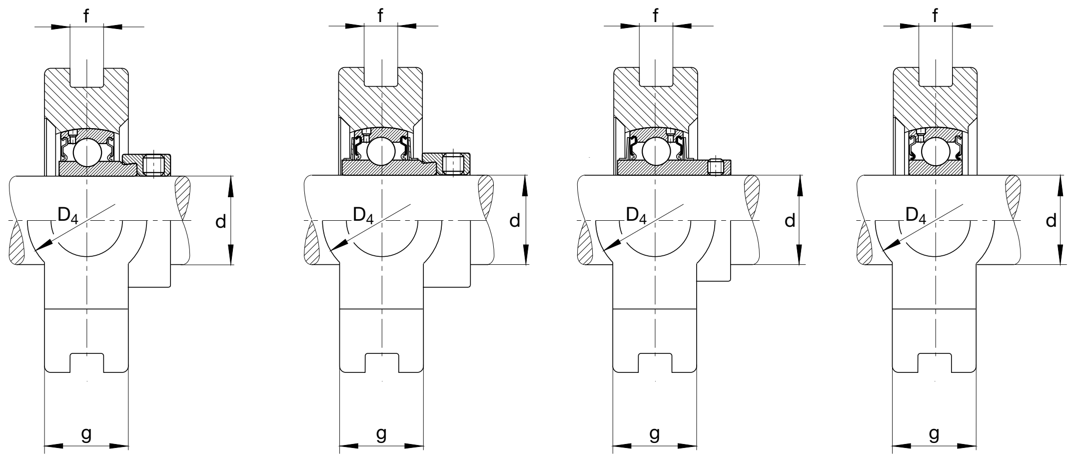
FAG S-TYPE BEARING UNITS

Series T162, T362, T562, T762..2RSR
Take-up unit housings of grey-cast iron



Shaft		Code			Dimensions													Mass
mm		Take-up bearing unit	S-type bearing with locking device	Housing	a	a_1	D_3	D_4	f	f_1	g	h	h_1	h_2	k	l	l_1	≈ S-type bearing unit
in	mm	FAG	FAG	FAG	mm													kg
$^{3}/_{4}$	19.05	T16204.012	16204.012	T204	94	51	19	32	12	76	21	61	89	51	32	16	10	0.884
	19.05	T36204.012	36204.012	T204	94	51	19	32	12	76	21	61	89	51	32	16	10	0.938
	19.05	T56204.012	56204.012	T204	94	51	19	32	12	76	21	61	89	51	32	16	10	0.892
20	20	T16204	**16204**	T204	94	51	19	32	12	76	21	61	89	51	32	16	10	0.88
	20	T36204	**36204**	T204	94	51	19	32	12	76	21	61	89	51	32	16	10	0.93
	20	T56204	**56204**	T204	94	51	19	32	12	76	21	61	89	51	32	16	10	0.87
	20	T76204.2RSR	**76204.2RSR**	T204	94	51	19	32	12	76	21	61	89	51	32	16	10	0.84
$^{13}/_{16}$	20.638	T16205.013	16205.013	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.05
	20.638	T36205.013	36205.013	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.11
	20.638	T56205.013	56205.013	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.04
$^{7}/_{8}$	22.225	T16205.014	16205.014	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.04
	22.225	T36205.014	36205.014	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.1
	22.225	T56205.014	56205.014	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.02
$^{15}/_{16}$	23.813	T16205.015	16205.015	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.03
	23.813	T36205.015	36205.015	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.08
	23.813	T56205.015	56205.015	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.01
25	25	T16205	**16205**	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.02
	25	T36205	**36205**	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.07
	25	T56205	**56205**	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	0.99
	25	T76205.2RSR	**76205.2RSR**	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	0.93
1	25.4	T16205.100	16205.100	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.02
	25.4	T36205.100	36205.100	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	1.07
	25.4	T56205.100	56205.100	T205	97	51	19	32	12	76	24	62	89	51	32	16	10	0.99
1 $^{1}/_{16}$	26.988	T16206.101	16206.101	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.48
	26.988	T36206.101	36206.101	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.61
	26.988	T56206.101	56206.101	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.5
1 $^{1}/_{8}$	28.575	T16206.102	16206.102	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.46
	28.575	T36206.102	36206.102	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.59
	28.575	T56206.102	56206.102	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.48
30	30	T16206	**16206**	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.45
	30	T36206	**36206**	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.57
	30	T56206	**56206**	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.46
	30	T76206.2RSR	**76206.2RSR**	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.34

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



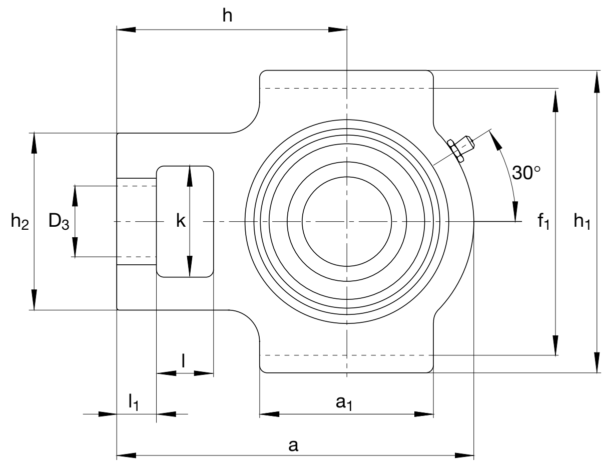
T162 **T362** **T562** **T762...2RSR**

Shaft		Code			Dimensions													Mass
		Take-up bearing unit	S-type bearing with locking device	Housing	a	a_1	D_3	D_4	f	f_1	g	h	h_1	h_2	k	l	l_1	≈ S-type bearing unit
mm in	mm	**FAG**	**FAG**	**FAG**	mm													kg
1 $^3/_{16}$	30.163	T16206.103	16206.103	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.45
	30.163	T36206.103	36206.103	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.57
	30.163	T56206.103	56206.103	T206	113	57	22	37	12	89	28	70	102	56	37	16	10	1.46
1 $^1/_4$	31.75	T16206.104	16206.104	T206	113	57	22	37	12	89	28	70	102	56	37	16	13	1.43
	31.75	T36206.104	36206.104	T206	113	57	22	37	12	89	28	70	102	56	37	16	13	1.55
	31.75	T56206.104	56206.104	T206	113	57	22	37	12	89	28	70	102	56	37	16	13	1.43
	31.75	T16207.104	16207.104	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.88
	31.75	T36207.104	36207.104	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	2.04
	31.75	T56207.104	56207.104	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.89
1 $^5/_{16}$	33.338	T16207.105	16207.105	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.87
	33.338	T36207.105	36207.105	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	2.02
	33.338	T56207.105	56207.105	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.86
1 $^3/_8$	34.925	T16207.106	16207.106	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.85
	34.925	T36207.106	36207.106	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.99
	34.925	T56207.106	56207.106	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.83
35	35	T16207	**16207**	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.85
	35	T36207	**36207**	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.99
	35	T56207	**56207**	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.82
	35	T76207.2RSR	**76207.2RSR**	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.64
1 $^7/_{16}$	36.513	T16207.107	16207.107	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.83
	36.513	T36207.107	36207.107	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.96
	36.513	T56207.107	56207.107	T207	129	64	22	37	12	89	30	78	102	64	37	16	13	1.8
1 $^1/_2$	38.1	T16208.108	16208.108	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.71
	38.1	T36208.108	36208.108	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.93
	38.1	T56208.108	56208.108	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.69
1 $^9/_{16}$	39.688	T16208.109	16208.109	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.68
	39.688	T36208.109	36208.109	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.9
	39.688	T56208.109	56208.109	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.66
40	40	T16208	**16208**	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.68
	40	T36208	**36208**	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.89
	40	T56208	**56208**	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.66
	40	T76208.2RSR	**76208.2RSR**	T208	144	83	29	49	16	102	33	88	114	83	49	19	16	2.42

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

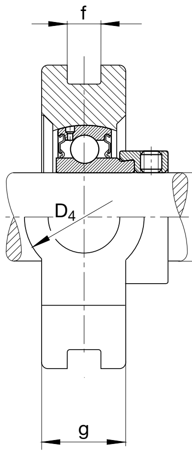
FAG S-TYPE BEARING UNITS

Series T162, T362, T562, T762..2RSR
Take-up unit housings of grey-cast iron

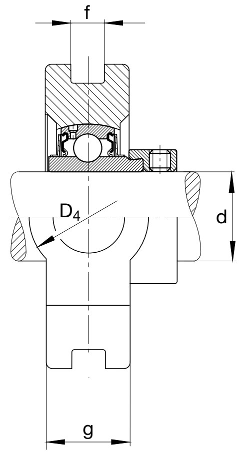


Shaft		Code			Dimensions													Mass
mm		Take-up bearing unit	S-type bearing with locking device	Housing	a	a_1	D_3	D_4	f	f_1	g	h	h_1	h_2	k	l	l_1	≈ S-type bearing unit
in	mm	FAG	FAG	FAG	mm													kg
1 5/8	41.275	T16209.110	16209.110	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.84
	41.275	T36209.110	36209.110	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	3.07
	41.275	T56209.110	56209.110	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.94
1 11/16	42.863	T16209.111	16209.111	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.82
	42.863	T36209.111	36209.111	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	3.03
	42.863	T56209.111	56209.111	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.9
1 3/4	44.45	T16209.112	16209.112	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.79
	44.45	T36209.112	36209.112	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.99
	44.45	T56209.112	56209.112	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.87
45	45	T16209	**16209**	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.78
	45	T36209	**36209**	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.98
	45	T56209	**56209**	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.86
	45	T76209.2RSR	**76209.2RSR**	T209	144	83	29	49	16	102	35	87	117	83	49	19	16	2.51
1 13/16	46.038	T16210.113	16210.113	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	3.04
	46.038	T36210.113	36210.113	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	3.33
	46.038	T56210.113	56210.113	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	3.12
1 7/8	47.625	T16210.114	16210.114	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	3.01
	47.625	T36210.114	36210.114	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	3.28
	47.625	T56210.114	56210.114	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	3.06
1 15/16	49.213	T16210.115	16210.115	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	2.99
	49.213	T36210.115	36210.115	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	3.23
	49.213	T56210.115	56210.115	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	3.01
50	50	T16210	**16210**	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	2.97
	50	T36210	**36210**	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	3.21
	50	T56210	**56210**	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	2.97
	50	T76210.2RSR	**76210.2RSR**	T210	149	86	29	49	16	102	37	90	117	83	49	19	16	2.66
2	50.8	T16211.200	16211.200	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.41
	50.8	T36211.200	36211.200	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.95
	50.8	T56211.200	56211.200	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.71
2 1/8	53.975	T16211.202	16211.202	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.32
	53.975	T36211.202	36211.202	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.9
	53.975	T56211.202	56211.202	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.66

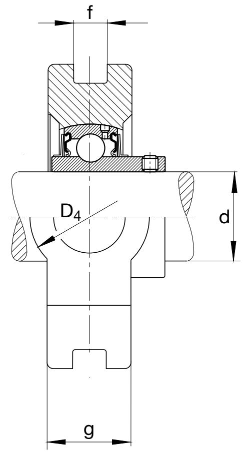
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.



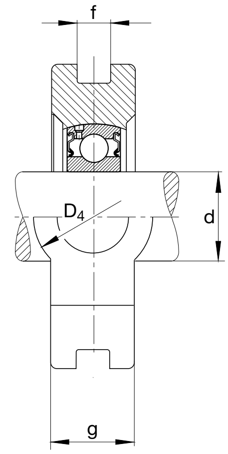
T162



T362



T562



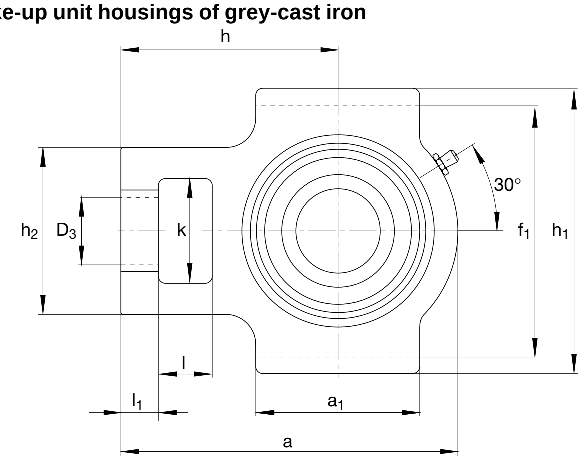
T762...2RSR

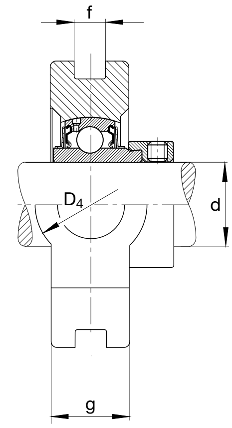
Shaft		**Code**			**Dimensions**													**Mass** ≈
mm in	mm	Take-up bearing unit **FAG**	S-type bearing with locking device **FAG**	Housing **FAG**	a mm	a_1	D_3	D_4	f	f_1	g	h	h_1	h_2	k	l	l_1	S-type bearing unit kg
55	55	T16211	**16211**	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.28
	55	T36211	**36211**	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.88
	55	T56211	**56211**	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.64
	55	T76211.2RSR	76211.2RSR	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.12
2 $^{3}/_{16}$	55.563	T16211.203	16211.203	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.26
	55.563	T36211.203	36211.203	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.4
	55.563	T56211.203	56211.203	T211	171	95	35	64	22	130	38	106	146	102	64	25	19	4.61
2 $^{1}/_{4}$	57.15	T16212.204	16212.204	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.35
	57.15	T36212.204	36212.204	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	6.05
	57.15	T56212.204	56212.204	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.64
60	60	T16212	**16212**	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.22
	60	T36212	**36212**	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.95
	60	T56212	**56212**	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.57
	60	T76212.2RSR	76212.2RSR	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	4.65
2 $^{3}/_{8}$	60.325	T16212.206	16212.206	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.21
	60.325	T36212.206	36212.206	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.85
	60.325	T56212.206	56212.206	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.44
2 $^{7}/_{16}$	61.913	T16212.207	16212.207	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.13
	61.913	T36212.207	36212.207	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.83
	61.913	T56212.207	56212.207	T212	194	102	35	64	22	130	42	119	146	102	64	32	19	5.36
2 $^{1}/_{2}$	63.5	T36213.208	36213.208	T213	224	121	41	70	26	151	44	137	167	111	70	32	21	8.61
	63.5	T56213.208	56213.208	T213	224	121	41	70	26	151	44	137	167	111	70	32	21	7.51
65	65	T36213	36213	T213	224	121	41	70	26	151	44	137	167	111	70	32	21	8.51
	65	T56213	**56213**	T213	224	121	41	70	26	151	44	137	167	111	70	32	21	7.43
2 $^{9}/_{16}$	65.087	T36213.209	36213.209	T213	224	121	41	70	26	151	44	137	167	111	70	32	21	8.46
	65.087	T56213.209	56213.209	T213	224	121	41	70	26	151	44	137	167	111	70	32	21	7.36
2 $^{5}/_{8}$	66.675	T36214.210	36214.210	T214	224	121	41	70	26	151	46	137	167	111	70	32	21	8.16
	66.675	T56214.210	56214.210	T214	224	121	41	70	26	151	46	137	167	111	70	32	21	7.73
2 $^{11}/_{16}$	68.262	T36214.211	36214.211	T214	224	121	41	70	26	151	46	137	167	111	70	32	21	8.15
	68.262	T56214.211	56214.211	T214	224	121	41	70	26	151	46	137	167	111	70	32	21	7.63
2 $^{3}/_{4}$	69.85	T36214.212	36214.212	T214	224	121	41	70	26	151	46	137	167	111	70	32	21	8.06
	69.85	T56214.212	56214.212	T214	224	121	41	70	26	151	46	137	167	111	70	32	21	7.62

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

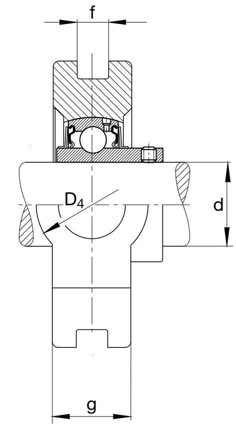
FAG S-TYPE BEARING UNITS

Series T362, T562
Take-up unit housings of grey-cast iron





T362



T562

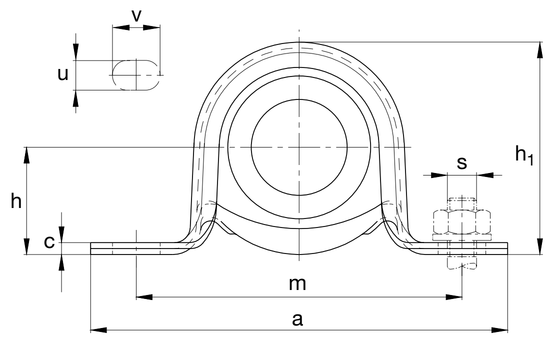
Shaft mm / in	mm	Code: Take-up bearing unit FAG	S-type bearing with locking device FAG	Housing FAG	Dimensions (mm) a	a_1	D_3	D_4	f	f_1	g	h	h_1	h_2	k	l	l_1	Mass ≈ S-type bearing unit kg
70	70	T36214	36214	T214	224	121	41	70	26	151	46	137	167	111	70	32	21	8.05
	70	T56214	**56214**	T214	224	121	41	70	26	151	46	137	167	111	70	32	21	7.52
2 $^{13}/_{16}$	71.437	T36215.213	36215.213	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.97
	71.437	T56215.213	56215.213	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.48
2 $^{7}/_{8}$	73.025	T36215.214	36215.214	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.87
	73.025	T56215.214	56215.214	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.37
2 $^{15}/_{16}$	74.612	T36215.215	36215.215	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.78
	74.612	T56215.215	56215.215	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.26
75	75	T36215	36215	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.75
	75	T56215	**56215**	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.23
3	76.2	T36215.300	36215.300	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.68
	76.2	T56215.300	56215.300	T215	232	121	41	70	26	151	48	140	167	111	70	32	21	8.14
3 $^{1}/_{8}$	79.375	T36216.302	36216.302	T216	235	121	41	70	26	165	51	140	184	111	70	32	21	9.5
	79.375	T56216.302	56216.302	T216	235	121	41	70	26	165	51	140	184	111	70	32	21	11.1
80	80	T36216	36216	T216	235	121	41	70	26	165	51	140	184	111	70	32	21	9.45
	80	T56216	**56216**	T216	235	121	41	70	26	165	51	140	184	111	70	32	21	9.4
3 $^{1}/_{4}$	82.55	T36217.304	36217.304	T217	260	157	48	73	30	173	54	162	198	124	73	38	29	12.4
	82.55	T56217.304	56217.304	T217	260	157	48	73	30	173	54	162	198	124	73	38	29	12.1
85	85	T36217	36217	T217	260	157	48	73	30	173	54	162	198	124	73	38	29	12.2
	85	T56217	56217	T217	260	157	48	73	30	173	54	162	198	124	73	38	29	12
3 $^{1}/_{2}$	88.9	T36218.308	36218.308	T218	275	140	47	80	28	190	55	170	215	130	80	40	30	16.4
	88.9	T56218.308	56218.308	T218	275	140	47	80	28	190	55	170	215	130	80	40	30	16.3
90	90	T36218	36218	T218	275	140	47	80	28	190	55	170	215	130	80	40	30	16.3
	90	T56218	**56218**	T218	275	140	47	80	28	190	55	170	215	130	80	40	30	16.1

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.
When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

FAG PRESSED STEEL S-TYPE HOUSINGS

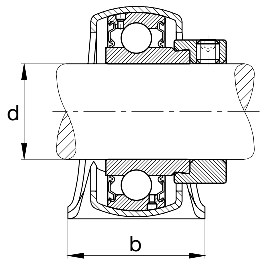
Plummer block housings of series SB2
for combination with S-type bearings of series 162 and 762..2RSR

Permissible loads, page 14

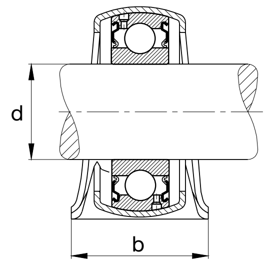


Shaft mm / in	mm	Code Housing FAG	S-type bearing with locking device FAG	Dimensions a max mm	b max	c max	h	h_1	m ±0,4	u	v	Fastening bolt s mm	in	Mass ≈ S-type bearing and housing kg
12	12	**SB203**	16203/12	87	26	4	22.2	43.8	68	8.7	12.7	M8	5/16	0.185
1/2	12.7	**SB203**	16203.008	87	26	4	22.2	43.8	68	8.7	12.7	M8	5/16	0.183
9/16	14.288	**SB203**	16203.009	87	26	4	22.2	43.8	68	8.7	12.7	M8	5/16	0.178
15	15	**SB203**	16203/15	87	26	4	22.2	43.8	68	8.7	12.7	M8	5/16	0.175
5/8	15.875	**SB203**	16203.010	87	26	4	22.2	43.8	68	8.7	12.7	M8	5/16	0.172
17	17	**SB203**	**16203**	87	26	4	22.2	43.8	68	8.7	12.7	M8	5/16	0.155
	17	**SB203**	76203.2RSR	87	26	4	22.2	43.8	68	8.7	12.7	M8	5/16	0.119
11/16	17.463	**SB203**	16203.011	87	26	4	22.2	43.8	68	8.7	12.7	M8	5/16	0.146
3/4	19.05	**SB204**	16204.012	99	33	4	25.4	50.5	76	10.3	12.7	M8	3/8	0.229
20	20	**SB204**	**16204**	99	33	4	25.4	50.5	76	10.3	12.7	M8	3/8	0.225
	20	**SB204**	**76204.2RSR**	99	33	4	25.4	50.5	76	10.3	12.7	M8	3/8	0.181
13/16	20.638	**SB205**	16205.013	109	33	4.5	28.6	56.6	86	10.3	14.3	M8	3/8	0.356
7/8	22.225	**SB205**	16205.014	109	33	4.5	28.6	56.6	86	10.3	14.3	M8	3/8	0.347
15/16	23.813	**SB205**	16205.015	109	33	4.5	28.6	56.6	86	10.3	14.3	M8	3/8	0.338
25	25	**SB205**	**16205**	109	33	4.5	28.6	56.6	86	10.3	14.3	M8	3/8	0.33
	25	**SB205**	**76205.2RSR**	109	33	4.5	28.6	56.6	86	10.3	14.3	M8	3/8	0.238
1	25.4	**SB205**	16205.100	109	33	4.5	28.6	56.6	86	10.3	14.3	M8	3/8	0.327
1 1/16	26.988	**SB206**	16206.101	119	39	4.5	33.3	66.3	95	10.3	14.3	M8	3/8	0.495
1 1/8	28.575	**SB206**	16206.102	119	39	4.5	33.3	66.3	95	10.3	14.3	M8	3/8	0.482
30	30	**SB206**	**16206**	119	39	4.5	33.3	66.3	95	10.3	14.3	M8	3/8	0.47
	30	**SB206**	**76206.2RSR**	119	39	4.5	33.3	66.3	95	10.3	14.3	M8	3/8	0.363
1 3/16	30.163	**SB206**	16206.103	119	39	4.5	33.3	66.3	95	10.3	14.3	M8	3/8	0.469
1 1/4	31.75	**SB206**	16206.104	119	39	4.5	33.3	66.3	95	10.3	14.3	M8	3/8	0.454
	31.75	**SB207**	16207.104	130	43	5	39.7	78	106	13.5	19	M10	1/2	0.814

The **designs** in boldface are most readily available. Information on other designs will be supplied on request.
FAG S-type housings of pressed steel and FAG S-type bearings are not supplied as a unit und must, therefore, be ordered separately.



SB2
combined with 162



SB2
combined with 762..2RSR

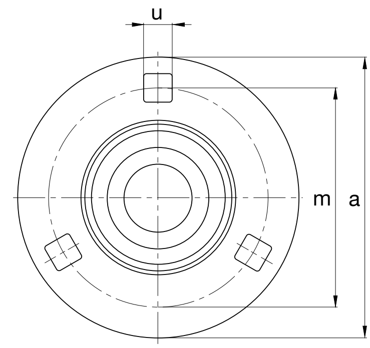
Shaft		**Code**		**Dimensions**								**Fastening bolt**		**Mass** ≈
		Housing	S-type bearing with locking device	a max	b max	c max	h	h_1	m ±0,4	u	v	s		S-type bearing and housing
mm in	mm	**FAG**	**FAG**	mm								mm	in	kg
$1\,^{5}/_{16}$	33.338	**SB207**	16207.105	130	43	5	39.7	78	106	13.5	19	M12	$^{1}/_{2}$	0.798
$1\,^{3}/_{8}$	34.925	**SB207**	16207.106	130	43	5	39.7	78	106	13.5	19	M12	$^{1}/_{2}$	0.781
35	35	**SB207**	**16207**	130	43	5	39.7	78	106	13.5	19	M12	$^{1}/_{2}$	0.78
	35	**SB207**	**76207.2RSR**	130	43	5	39.7	78	106	13.5	19	M12	$^{1}/_{2}$	0.568
$1\,^{7}/_{16}$	36.513	**SB207**	16207.107	130	43	5	39.7	78	106	13.5	19	M12	$^{1}/_{2}$	0.763

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

FAG PRESSED STEEL S-TYPE HOUSINGS

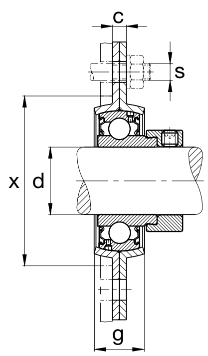
Flanged housings of series FB2
for combination with S-type bearings of series 162, 362, 562 and 762..2RSR

Permissible loads, page 14

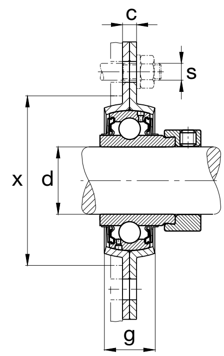


Shaft			Code		Dimensions						Fastening bolt		Mass ≈
			Housing	S-type bearing with locking device	a max	c max	g max	m ±0,4	u ±0,6	x min	s		S-type bearing and housing
mm	in	mm	FAG	FAG	mm						mm	in	kg
12		12	**FB203**	16203/12	82	4.5	15	63.5	7.1	50	M6	$^1/_4$	0.26
	$^1/_2$	12.7	**FB203**	16203.008	82	4.5	15	63.5	7.1	50	M6	$^1/_4$	0.258
	$^9/_{16}$	14.388	**FB203**	16203.009	82	4.5	15	63.5	7.1	50	M6	$^1/_4$	0.253
15		15	**FB203**	16203/15	82	4.5	15	63.5	7.1	50	M6	$^1/_4$	0.383
	$^5/_8$	15.875	**FB203**	16203.010	82	4.5	15	63.5	7.1	50	M6	$^1/_4$	0.247
17		17	**FB203**	**16203**	82	4.5	15	63.5	7.1	50	M6	$^1/_4$	0.23
		17	**FB203**	76203.2RSR	82	4.5	15	63.5	7.1	50	M6	$^1/_4$	0.194
	$^{11}/_{16}$	17.463	**FB203**	16203.011	82	4.5	15	63.5	7.1	50	M6	$^1/_4$	0.221
	$^3/_4$	19.05	**FB204**	16204.012	91	4.5	17	71.5	9	57	M8	$^5/_{16}$	0.319
		19.05	**FB204**	36204.012	91	4.5	17	71.5	9	57	M8	$^5/_{16}$	0.373
		19.05	**FB204**	56204.012	91	4.5	17	71.5	9	57	M8	$^5/_{16}$	0.327
20		20	**FB204**	**16204**	91	4.5	17	71.5	9	57	M8	$^5/_{16}$	0.315
		20	**FB204**	**36204**	91	4.5	17	71.5	9	57	M8	$^5/_{16}$	0.365
		20	**FB204**	**56204**	91	4.5	17	71.5	9	57	M8	$^5/_{16}$	0.305
		20	**FB204**	**76204.2RSR**	91	4.5	17	71.5	9	57	M8	$^5/_{16}$	0.271
	$^{13}/_{16}$	20.638	**FB205**	16205.013	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.426
		20.638	**FB205**	36205.013	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.493
		20.638	**FB205**	56205.013	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.418
	$^7/_8$	22.225	**FB205**	16205.014	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.417
		22.225	**FB205**	36205.014	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.478
		22.225	**FB205**	56205.014	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.403
	$^{15}/_{16}$	23.813	**FB205**	16205.015	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.408
		23.813	**FB205**	36205.015	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.462
		23.813	**FB205**	56205.015	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.388
25		25	**FB205**	**16205**	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.4
		25	**FB205**	**36205**	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.45
		25	**FB205**	**56205**	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.37
		25	**FB205**	**76205.2RSR**	96	4.5	19	76	9	62	M8	$^5/_{16}$	0.308

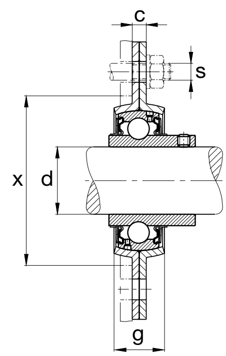
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.
FAG S-type housings of pressed steel and FAG S-type bearings are not supplied as a unit und must, therefore, be ordered separately.



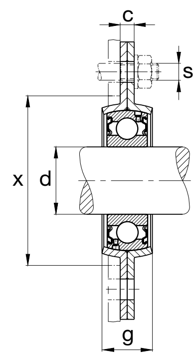
FB2
combined with 162



FB2
combined with 362



FB2
combined with 562



FB2
combined with 762..2RSR

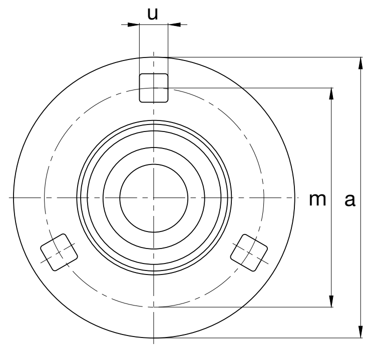
Shaft mm	in	mm	**Code** Housing **FAG**	S-type bearing with locking device **FAG**	**Dimensions** a max mm	c max	g max	m ±0,4	u ±0,6	x min	**Fastening bolt** s mm	in	**Mass** ≈ S-type bearing and housing kg
	1	25.4	**FB205**	16205.100	96	4.5	19	76	9	62	M8	$^{5}/_{16}$	0.397
		25.4	**FB205**	36205.100	96	4.5	19	76	9	62	M8	$^{5}/_{16}$	0.445
		25.4	**FB205**	56205.100	96	4.5	19	76	9	62	M8	$^{5}/_{16}$	0.368
	1 $^{1}/_{16}$	26.988	**FB206**	16206.101	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.625
		26.988	**FB206**	36206.101	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.759
		26.988	**FB206**	56206.101	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.652
	1 $^{1}/_{8}$	28.575	**FB206**	16206.102	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.612
		28.575	**FB206**	36206.102	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.739
		28.575	**FB206**	56206.102	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.631
30		30	**FB206**	**16206**	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.6
		30	**FB206**	**36206**	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.72
		30	**FB206**	**56206**	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.61
		30	**FB206**	**76206.2RSR**	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.493
	1 $^{3}/_{16}$	30.163	**FB206**	16206.103	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.599
		30.163	**FB206**	36206.103	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.718
		30.163	**FB206**	56206.103	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.608
	1 $^{1}/_{4}$	31.75	**FB206**	16206.104	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.584
		31.75	**FB206**	36206.104	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.696
		31.75	**FB206**	56206.104	114	5.5	20	90.5	11	73	M8	$^{3}/_{8}$	0.584
		31.75	**FB207**	16207.104	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.871
		31.75	**FB207**	36207.104	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	1.03
		31.75	**FB207**	56207.104	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.876
	1 $^{5}/_{16}$	33.338	**FB207**	16207.105	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.855
		33.338	**FB207**	36207.105	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	1
		33.338	**FB207**	56207.105	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.849
	1 $^{3}/_{8}$	34.925	**FB207**	16207.106	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.838
		34.925	**FB207**	36207.106	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.978
		34.925	**FB207**	56207.106	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.82
35		35	**FB207**	**16207**	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.837
		35	**FB207**	**36207**	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.977
		35	**FB207**	**56207**	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.807
		35	**FB207**	**76207.2RSR**	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.625

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

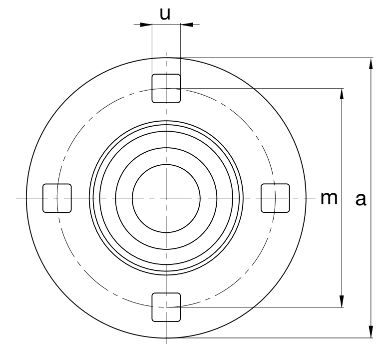
FAG PRESSED STEEL S-TYPE HOUSINGS

Flanged housings of series FB2
for combination with S-type bearings of series
162, 362, 562 and 762..2RSR

Permissible loads, page 14



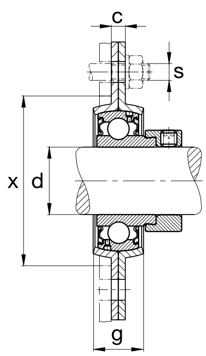
up to FB207



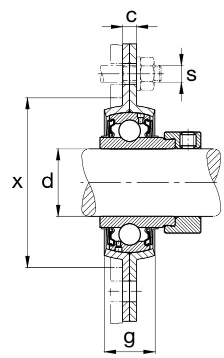
from FB208

Shaft mm / in	mm	**Code** Housing **FAG**	S-type bearing with locking device **FAG**	**Dimensions** a max mm	c max	g max	m ±0,4	u ±0,6	x min	**Fastening bolt** s mm	in	**Mass** ≈ S-type bearing and housing kg
1 $^{7}/_{16}$	36.513	**FB207**	16207.107	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.82
	36.513	**FB207**	36207.107	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.952
	36.513	**FB207**	56207.107	127	5.5	23	100	11	83	M8	$^{3}/_{8}$	0.79
1 $^{1}/_{2}$	38.1	**FB208**	16208.108	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	1.07
	38.1	**FB208**	36208.108	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	1.29
	38.1	**FB208**	56208.108	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	1.05
1 $^{9}/_{16}$	39.688	**FB208**	16208.109	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	1.04
	39.688	**FB208**	36208.109	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	1.26
	39.688	**FB208**	56208.109	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	1.02
40	40	**FB208**	**16208**	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	1.04
	40	**FB208**	**36208**	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	1.25
	40	**FB208**	**56208**	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	1.02
	40	**FB208**	**76208.2RSR**	149	7	23	119	13.5	93	M12	$^{1}/_{2}$	0.776
1 $^{5}/_{8}$	41.275	**FB209**	16209.110	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.42
	41.275	**FB209**	36209.110	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.65
	41.275	**FB209**	56209.110	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.52
1 $^{11}/_{16}$	42.863	**FB209**	16209.111	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.4
	42.863	**FB209**	36209.111	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.61
	42.863	**FB209**	56209.111	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.48
1 $^{3}/_{4}$	44.45	**FB209**	16209.112	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.37
	44.45	**FB209**	36209.112	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.57
	44.45	**FB209**	56209.112	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.45
45	45	**FB209**	**16209**	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.36
	45	**FB209**	**36209**	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.56
	45	**FB209**	**56209**	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.44
	45	**FB209**	**76209.2RSR**	150	7	23	120.5	13.5	100	M12	$^{1}/_{2}$	1.09
1 $^{13}/_{16}$	46.038	FB210	16210.113	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.65
	46.038	FB210	36210.113	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.94
	46.038	FB210	56210.113	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.72
1 $^{7}/_{8}$	47.625	FB210	16210.114	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.62
	47.625	FB210	36210.114	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.89
	47.625	FB210	56210.114	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.67

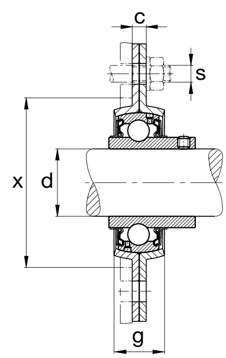
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.
FAG S-type housings of pressed steel and FAG S-type bearings are not supplied as a unit und must, therefore, be ordered separately.



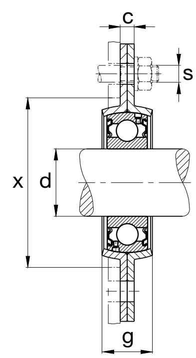
FB2
combined with 162



FB2
combined with 362



FB2
combined with 562



FB2
combined with 762..2RSR

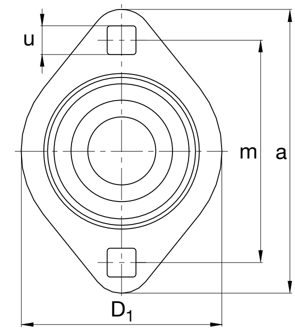
Shaft		**Code**		**Dimensions**						**Fastening bolt**		**Mass** ≈
		Housing	S-type bearing with locking device	a max	c max	g max	m ±0,4	u ±0,6	x min	s		S-type bearing and housing
mm in	mm	**FAG**	**FAG**	mm						mm	in	kg
$1\,^{15}/_{16}$	49.213	FB210	16210.115	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.6
	49.213	FB210	36210.115	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.84
	49.213	FB210	56210.115	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.62
50	50	FB210	**16210**	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.58
	50	FB210	**36210**	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.82
	50	FB210	**56210**	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.58
	50	FB210	**76210.2RSR**	157	8	25	127	13.5	105	M12	$^{1}/_{2}$	1.27

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

FAG PRESSED STEEL S-TYPE HOUSINGS

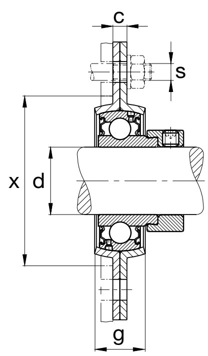
Flanged housings of series FBB2
for combination with S-type bearings of series 162, 362, 562 and 762..2RSR

Permissible loads, page 14

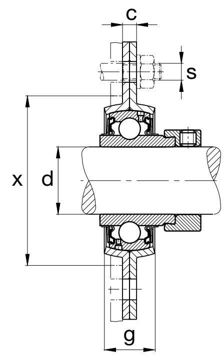


Shaft mm	Shaft in	mm	Code Housing FAG	S-type bearing with locking device FAG	Dimensions a max mm	c max	D_1 max	g max	m ±0,4	u ±0,6	x min	Fastening bolt s mm	s in	Mass ≈ S-type bearing and housing kg
12		12	FBB203	16203/12	82	4.5	60	15	63.5	7.1	50	M6	$^{1}/_{4}$	0.2
	$^{1}/_{2}$	12.7	FBB203	16203.008	82	4.5	60	15	63.5	7.1	50	M6	$^{1}/_{4}$	0.198
	$^{9}/_{16}$	14.288	FBB203	16203.009	82	4.5	60	15	63.5	7.1	50	M6	$^{1}/_{4}$	0.193
15		15	FBB203	16203/15	82	4.5	60	15	63.5	7.1	50	M6	$^{1}/_{4}$	0.19
	$^{5}/_{8}$	15.875	FBB203	16203.010	82	4.5	60	15	63.5	7.1	50	M6	$^{1}/_{4}$	0.187
17		17	FBB203	**16203**	82	4.5	60	15	63.5	7.1	50	M6	$^{1}/_{4}$	0.17
		17	FBB203	76203.2RSR	82	4.5	60	15	63.5	7.1	50	M6	$^{1}/_{4}$	0.134
	$^{11}/_{16}$	17.463	FBB203	16203.011	82	4.5	60	15	63.5	7.1	50	M6	$^{1}/_{4}$	0.161
	$^{3}/_{4}$	19.05	FBB204	16204.012	91	4.5	68	17	71.5	9	57	M8	$^{5}/_{16}$	0.244
		19.05	FBB204	36204.012	91	4.5	68	17	71.5	9	57	M8	$^{5}/_{16}$	0.298
		19.05	FBB204	56204.012	91	4.5	68	17	71.5	9	57	M8	$^{5}/_{16}$	0.252
20		20	FBB204	**16204**	91	4.5	68	17	71.5	9	57	M8	$^{5}/_{16}$	0.24
		20	FBB204	**36204**	91	4.5	68	17	71.5	9	57	M8	$^{5}/_{16}$	0.29
		20	FBB204	**56204**	91	4.5	68	17	71.5	9	57	M8	$^{5}/_{16}$	0.23
		20	FBB204	**76204.2RSR**	91	4.5	68	17	71.5	9	57	M8	$^{5}/_{16}$	0.196
	$^{13}/_{16}$	20.638	FBB205	16205.013	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.346
		20.638	FBB205	36205.013	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.413
		20.638	FBB205	56205.013	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.338
	$^{7}/_{8}$	22.225	FBB205	16205.014	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.337
		22.225	FBB205	36205.014	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.398
		22.225	FBB205	56205.014	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.323
	$^{15}/_{16}$	23.813	FBB205	16205.015	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.328
		23.813	FBB205	36205.015	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.382
		23.813	FBB205	56205.015	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.308
25		25	FBB205	**16205**	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.32
		25	FBB205	**36205**	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.37
		25	FBB205	**56205**	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.29
		25	FBB205	**76205.2RSR**	96	4.5	72	19	76	9	62	M8	$^{5}/_{16}$	0.228

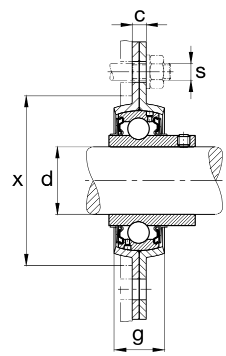
The **designs** in boldface are most readily available. Information on other designs will be supplied on request.
FAG S-type housings of pressed steel and FAG S-type bearings are not supplied as a unit und must, therefore, be ordered separately.



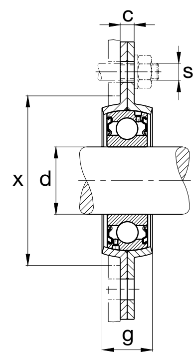
FBB2
combined with 162



FBB2
combined with 362



FBB2
combined with 562



FBB2
combined with 762..2RSR

Shaft			**Code**		**Dimensions**							**Fastening bolt**		**Mass**
			Housing	S-type bearing with locking device	a	c	D_1	g	m	u	x	s		≈ S-type bearing and housing
mm	in	mm	**FAG**	**FAG**	max mm	max	max	max	±0,4	±0,6	min	mm	in	kg
	1	25.4	FBB205	16205.100	96	4.5	72	19	76	9	62	M8	$^5/_{16}$	0.317
		25.4	FBB205	36205.100	96	4.5	72	19	76	9	62	M8	$^5/_{16}$	0.365
		25.4	FBB205	56205.100	96	4.5	72	19	76	9	62	M8	$^5/_{16}$	0.288
	$1\ ^1/_{16}$	26.988	FBB206	16206.101	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.485
		26.988	FBB206	36206.101	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.619
		26.988	FBB206	56206.101	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.512
	$1\ ^1/_8$	28.575	FBB206	16206.102	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.472
		28.575	FBB206	36206.102	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.599
		28.575	FBB206	56206.102	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.491
30		30	FBB206	**16206**	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.46
		30	FBB206	**36206**	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.58
		30	FBB206	**56206**	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.47
		30	FBB206	**76206.2RSR**	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.353
	$1\ ^3/_{16}$	30.163	FBB206	16206.103	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.459
		30.163	FBB206	36206.103	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.578
		30.163	FBB206	56206.103	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.468
	$1\ ^1/_4$	31.75	FBB206	16206.104	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.444
		31.75	FBB206	36206.104	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.556
		31.75	FBB206	56206.104	114	5.5	85	20	90.5	11	73	M8	$^3/_8$	0.444
		31.75	FBB207	16207.104	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.734
		31.75	FBB207	36207.104	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.89
		31.75	FBB207	56207.104	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.739
	$1\ ^5/_{16}$	33.338	FBB207	16207.105	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.718
		33.338	FBB207	36207.105	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.866
		33.338	FBB207	56207.105	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.712
	$1\ ^3/_8$	34.925	FBB207	16207.106	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.701
		34.925	FBB207	36207.106	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.841
		34.925	FBB207	56207.106	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.683
35		35	FBB207	**16207**	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.7
		35	FBB207	**36207**	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.84
		35	FBB207	**56207**	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.67
		35	FBB207	**76207.2RSR**	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.488
	$1\ ^7/_{16}$	36.513	FBB207	16207.107	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.683
		36.513	FBB207	36207.107	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.815
		36.513	FBB207	56207.107	127	5.5	95	23	100	11	83	M8	$^3/_8$	0.653

When replacing housings of earlier design the possibility of minor dimensional differences must be taken into account.

NOTES

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FAG Split Plummer Block Housings of Series SNV

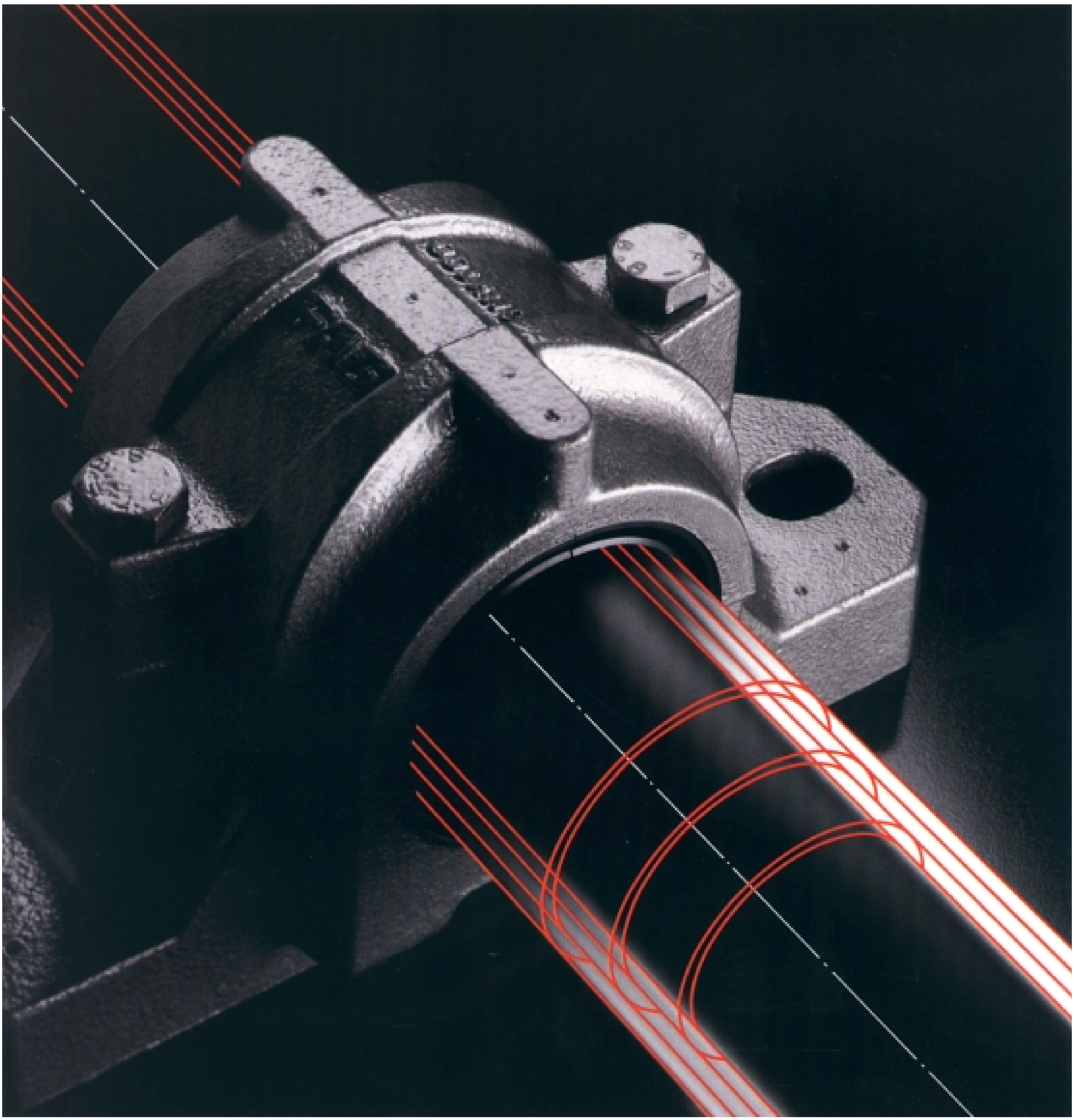
for shaft diameters of 20 to 160 mm and $^{3}/_{4}$ to $5^{1}/_{2}$ inches

FAG

Rolling Bearings

FAG OEM und Handel AG

Publ. No. WL 90 118/3 EA



FAG Split Plummer Block Housings of Series SNV
for shaft diameters of 20 to 160 mm and $^3/_4$ to $5^1/_2$ inches

Publ. No. WL 90118/3 EA

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Preface

The OEM und Handel company of the FAG Kugelfischer Georg Schäfer AG Group supplies rolling bearings, necessary accessories, and services to original equipment customers in machinery and plant construction as well as to customers in the distribution and spare parts business. Comprehensive rolling bearing know-how, competent consultation on applications, and extensive customer service for more operational reliability make FAG an indispensible partner to its customers. Development and further development of our products is based on the requirements of operation in the field. An ideal outline of requirements is best achieved through cooperation of our application engineers with the manufacturers and operators of machinery. It forms the basis for successful solutions both technically and economically speaking.

Production locations are found in Germany, Italy, Portugal, the USA and India. Sales are conducted by subsidiaries and distribution partners in almost every country in the world.

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Split plummer block housings of series SNV

The FAG split plummer block housings of series SNV, fig. 1, were designed according to the modular system and developed on the basis of the SN/SNE housings. Rolling bearings of diverse diameter and width series can be mounted in any SNV housing if they have an outside diameter suitable for the housing, fig.2.

Suitable bearing types are, for example, self-aligning ball bearings, barrel roller bearings, split and unsplit spherical roller bearings and deep groove ball bearings.

The bearings are either directly seated on the shaft or fixed with adapter sleeves. This results in different shaft diameters for the same bearing size. Corresponding seals compensate for the gaps between the shaft and the housing passage.

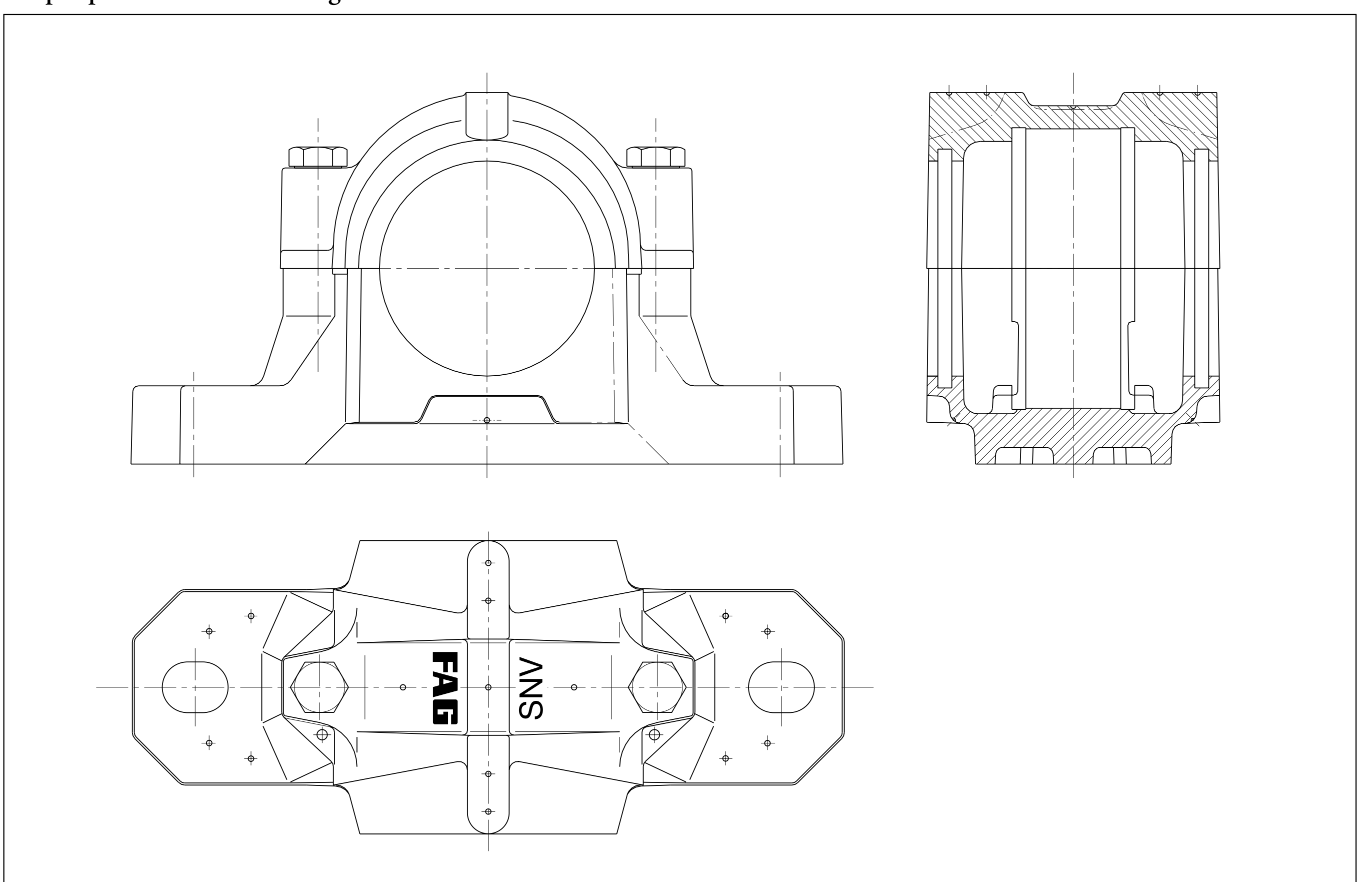
FAG supplies split plummer block housings of series SNV for shafts with diameters from 20 to 160 mm and for $^3/_4$ to $5^1/_2$ inches.

The numbers in the housing codes indicate the housing bore and therefore the outside diameter of the suitable bearing e.g. 100 mm in the case of SNV100.

The main advantages of the SNV housing are:

- Easier stock-keeping due to the modular design. One housing size is suitable for different shaft diameters.
- High loadability.
- Depending on operating conditions two-lip seals, labyrinth seals, felt seals or combined seals can be used. Special seals are available upon request.
- Centered locating bearings by means of two locating rings of identical width.
- Plane faces at housing base allow the housing to be secured with stops if high forces do not act vertically on the housing support surface.
- Holes can be drilled at spots marked on the housing for: lubricating and monitoring systems, fastening bolts, straight or tapered pins.
- Universal coating of all outer surfaces of the housing which are not machined (colour RAL 7031, blue-grey). The paint can be coated with all synthetic resin, polyurethane, acrylic, epoxy resin, chlorine rubber, cellulose, and acid-hardening hammer dimple enamels.

1: Split plummer block housing of series SNV



Dimensions · Material · Bearing seat · Bearing mounting · Seals and covers

Dimensions, material

The dimensions of the FAG housings of series SNV correspond to ISO 113 and DIN 736 to DIN 739.

The SNV housings are interchangeable with the former SN/SNE housings.

The SNV housings are made of cast iron, material no. 0.6027. Their loadability is considerably higher than that of the SN/SNE housings (see “Loadability“ section).

For particularly high stresses nodular cast iron, material no. 0.7040, may also be used (please inquire about availability).

Bearing seat and bearing mounting

The bearing seat in the SNV housing is machined to H7 (applies to condition on supply, i.e. prior to loosening the connecting bolts of upper and lower part). The bearings can be displaced thus acting as floating bearings. Locating bearings are obtained by inserting two FRM locating rings, one on each bearing side. The bearing is then in the centre of the housing.

Rolling bearings which are seated directly on a stepped shaft or with an adapter sleeve on a straight shaft can be fitted into SNV housings, fig. 2.

A diameter tolerance of the shaft according to h8 (h9) is permissible when fastening with adapter sleeve.

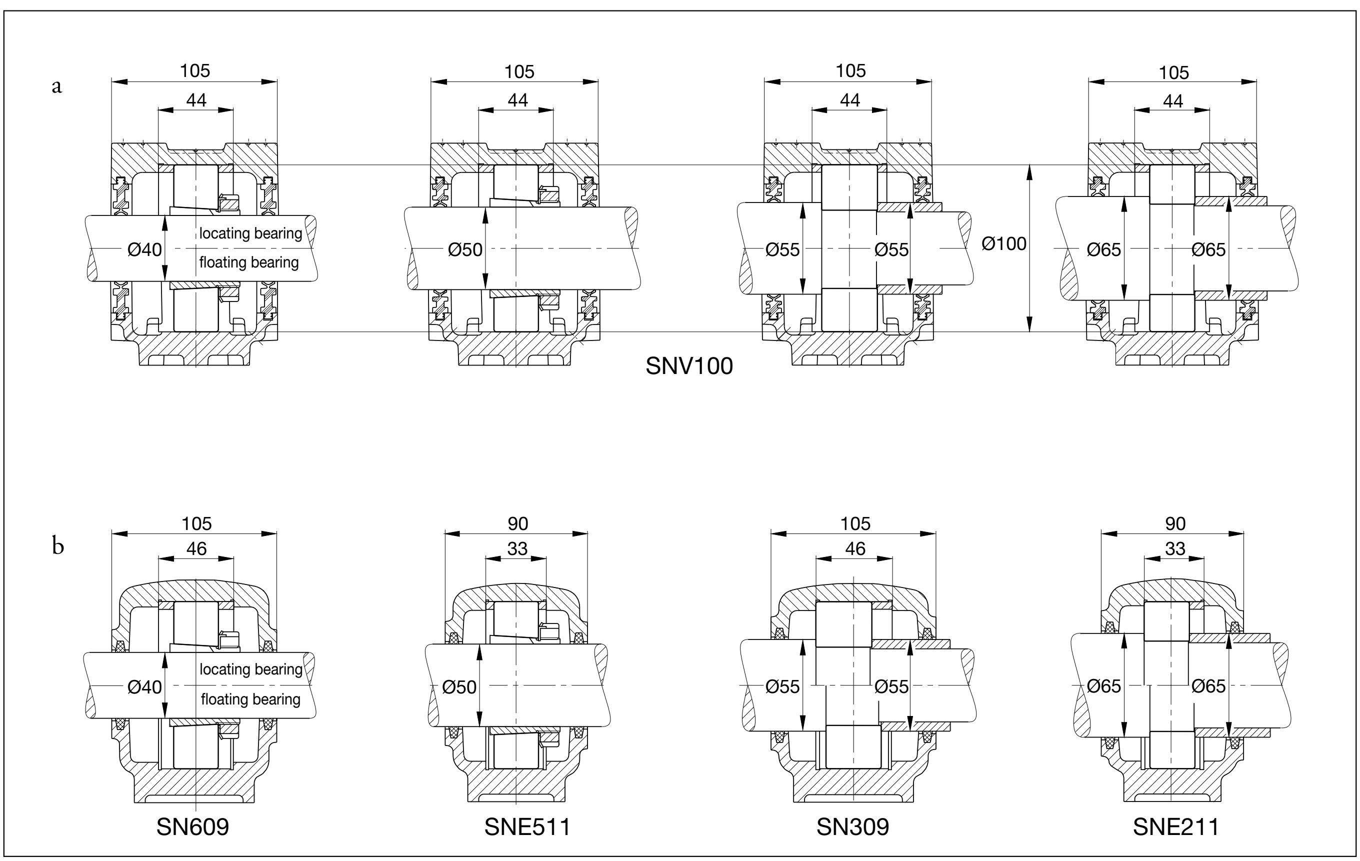
Seals and covers

Seals and covers fit into the annular grooves, with rectangular profile, on both sides of the SNV housings.

The DH two-lip seal is usually used. FAG also supplies upon request TSV labyrinth seals, FSV felt seals, TCV combined seals and special seals. The seals must be specified in the order. They are especially suitable for grease lubrication, see “Lubrication“ section.

The FAG two-lip seal DH made of acrylonitrile-butadiene rubber (NBR), fig. 3a, is suitable for circumferential velocities of up to 13 m/s. The two-piece seal can be easily inserted into the annular groove of the housing (observe the position of separating joint).

2: The SNV housings are suitable for bearings with diverse diameter and width series which have the same outside diameter, e.g. 100 mm in the case of SNV100 (2a). Formerly four housing sizes were required for the shaft diameters indicated (2b).



The sealing lips slide on the rotating shaft. The outer sealing lip prevents the penetration of dirt into the bearing. This is also supported by the grease filled between the two lips during mounting. The inner lip prevents the escape of grease from the housing. The two-lip seal permits shaft inclinations of up to 0.5° in both directions. It is suitable for temperatures between –40 °C and +100 °C. At the contact area of the sealing lips the roughness of the shaft should correspond to class N8 (DIN ISO 1302).

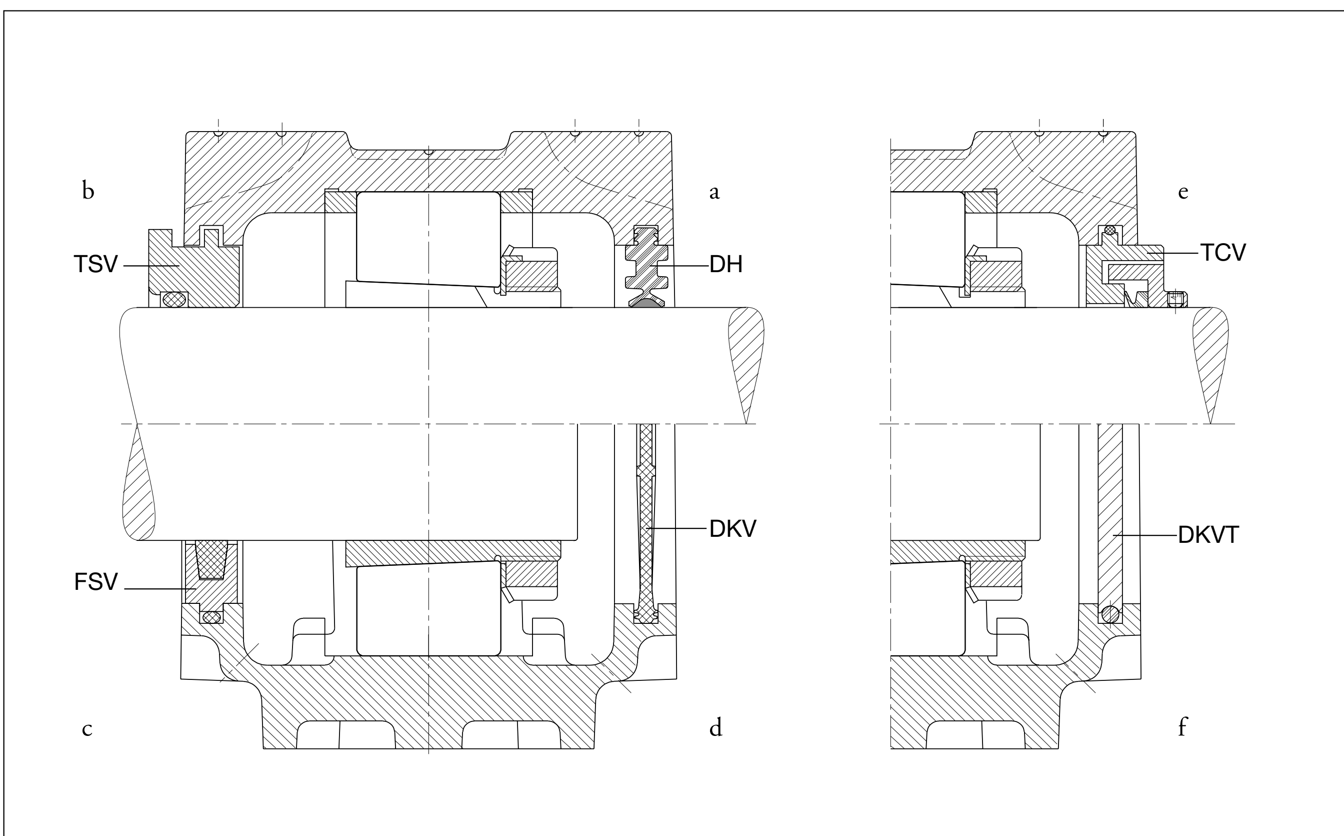
FAG labyrinth rings of the series TSV, fig. 3b, are also suitable for higher circumferential velocities since they are non-rubbing. The O ring which is pressed in between the shaft and labyrinth ring ensures that the labyrinth ring does not slip despite its loose fit. The O ring, which is made of fluoro-caoutchouc (Viton®), is suitable for temperatures up to 200 °C. The labyrinth seal accepts shaft inclinations of up to 0.5° in both directions. The labyrinth can be relubricated at position 1 and 5, fig. 4, if required.

FAG FSV felt seals, fig. 3c, are suitable for grease lubrication and temperatures up to 100 °C (aramide packages for higher temperatures available upon request). The adapter with the felt strip, which is previously soaked in oil, is secured in the housing groove and is prevented from rotating by an O-ring. Felt seals are suitable for circumferential velocities of up to 5 m/s and, after the running-in phase, up to 15 m/s. The permissible shaft inclination is 0.5° in both directions.

Seals made up of a combination of labyrinth seat and V ring (TCV), fig. 3e, are available upon request.

If the SNV housings are to be closed on one side, the DKV covers have to be ordered separately. The synthetic covers are suitable for long-term operation at temperatures up to 120 °C. DKVT covers for higher temperatures, fig. 3f, are available upon request.

3: Seals and covers for SNV housings



Lubrication

Grease lubrication

In many cases, the bearings can be greased for-life, i.e. the initial grease fill (see fig. 5 for initial grease fill amounts) will last for the entire bearing life if using rubbing seals (e.g. DH, FSV). The bearings are packed to capacity with grease and 60% of the housing cavities is filled.

The FAG rolling bearing grease Arcanol L135V, a lithium soap base grease of the NLGI class 2 with particularly effective EP additives is especially suitable (see FAG Publ. No. WL 81 116 also) for bearing operating temperatures < 100 °C, bearing loads P/C < 0.3 and a bearing-related speed index $k_a \cdot n \cdot d_m <$ 700 000 $min^{-1} \cdot mm$ ($k_a = 1$ for self-aligning ball bearings and deep groove ball bearings, $k_a = 2$ for spherical roller bearings).

In the case of a speed index $n \cdot d_m <$ 50 000 $min^{-1} \cdot mm$ and non-rubbing sealing (e.g. TSV), where the grease also has to function as a seal, the housing and sealing cavities may be packed to capacity.

Grease change

A change of grease for new grease should be undertaken if the attainable fatigue life of the bearing is considerably longer than the grease service life (to be found in FAG Publ. No. WL 81 115 "Rolling Bearing Lubrication").

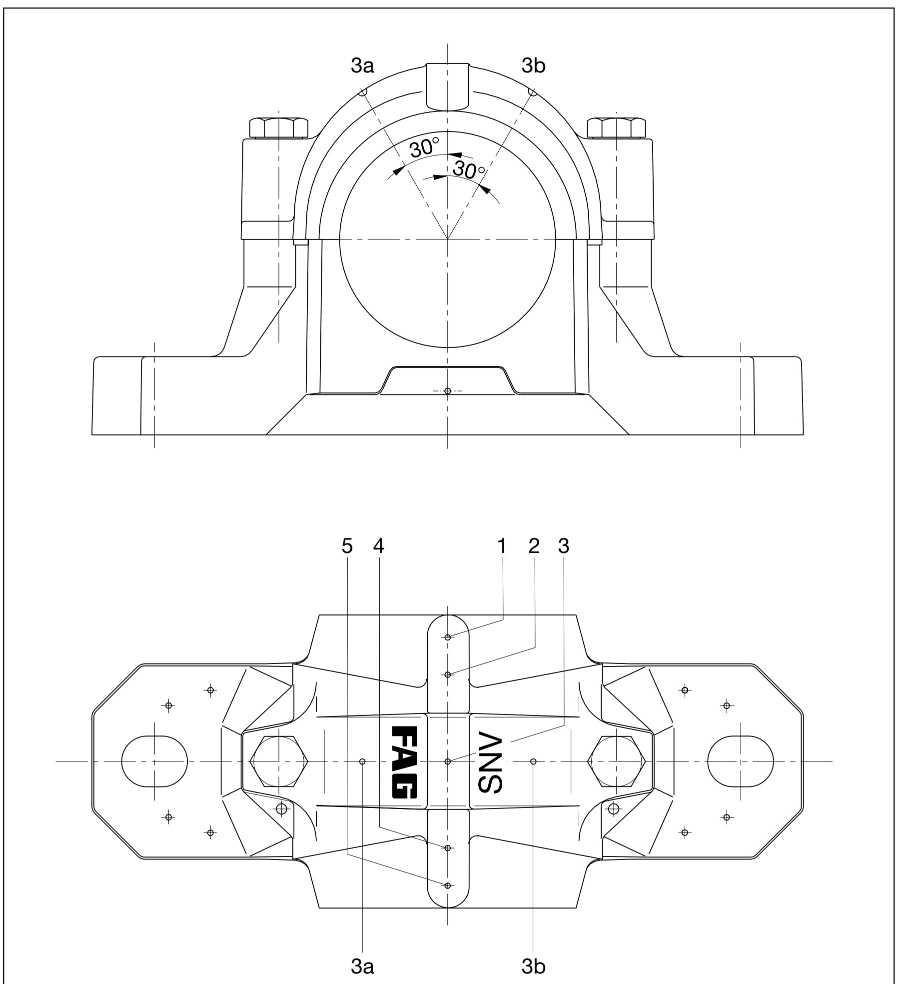
Grease relubrication
Grease outlet hole

If, in isolated cases, the grease exchange intervals are too short, relubrication is recommended. The lubricant can be supplied to the housing laterally or where bearings with lubricating groove and holes are used also centrally. In the case of lateral lubrication the housing cavities on the side of the grease nipple must be filled to about 100% so that the replenished grease reaches the bearing immediately. Depending on the seal type selected and on the application in question, the housing top can be provided with grease nipples for lubricant supply at positions 2 or 4, fig. 4, and on the opposite side of the housing base the grease outlet hole can be provided (an absolute must for DH seals).

The grease nipple and outlet hole are specified in the order by adding the suffix G944A* to the housing code. Please refer to fig. 6 for the location and dimensions of the holes and the grease nipple.

The far right column of fig. 5 indicates the minimum relubrication quantities. It is not possible to overgrease the bearings if there is a grease outlet hole or non rubbing sealing. The temperature may rise due to the working of the replenished grease. It will drop to its original level after a few running hours when the surplus grease has been expelled. In the interest of the environment it is recommended to dose the lubricant.

4: Markings at the housing top for grease nipple connecting holes



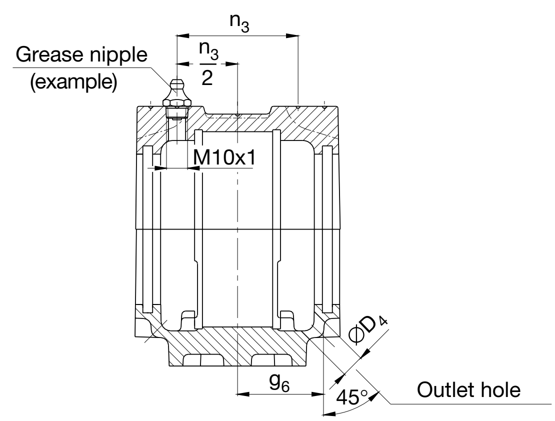
Due to their good flow behaviour, greases of consistency class 2, e.g. Arcanol L135V and L78V, are more suitable for replenishment than greases of higher consistency classes.

5: Recommended grease quantities for the initial grease fill (housing cavities 60%, bearings packed to capacity) and the relubrication of SNV housings

Housing FAG	Grease quantity ≈ Initial fill g	Re-lubrication
SNV052	30	5
SNV062	45	5
SNV072	65	10
SNV080	80	10
SNV085	105	10
SNV090	130	10
SNV100	180	15
SNV110	210	15
SNV120	270	20
SNV125	290	20
SNV130	330	20
SNV140	440	25
SNV150	500	30
SNV160	650	40
SNV170	700	45
SNV180	900	55
SNV190	950	60
SNV200	1200	70
SNV215	1400	80
SNV230	1600	85
SNV240	1700	90
SNV250	2000	100
SNV260	2000	120
SNV270	2500	130
SNV280	2600	140
SNV290	3000	150
SNV300	3100	160
SNV320	3700	200
SNV340	4500	240

6: Dimensions recommended for grease nipple connecting holes and grease outlet holes

SNV housings for grease replenishment (suffix G944A*, supply on request) are equipped with a grease nipple and an outlet hole of the sizes shown in the table.
Example: Design G944AA with conical grease nipple NIP.DIN71412-AM10x1.



Housing FAG	Connection for grease nipple $\frac{n_3}{2}$ mm	Grease outlet hole D_4 mm	g_6
SNV052	19	10	27.5
SNV062	21	10	30
SNV072	23	10	33
SNV080	26	10	36
SNV085	23.5	10	34.5
SNV090	29	10	41.5
SNV100	31	15	44
SNV110	33.5	15	46
SNV120	35.5	15	49
SNV125	28.5	10	41
SNV130	38	15	51.5
SNV140	40.5	15	57.5
SNV150	42.5	15	60
SNV160	45	15	62.5
SNV170	46.5	20	64
SNV180	49.5	20	69
SNV190	49.5	20	68.5
SNV200	55.5	20	77.5
SNV215	58.5	20	80
SNV230	61	20	83
SNV240	60	20	81.5
SNV250	65.5	20	89
SNV260	62.5	20	84
SNV270	71.5	20	96.5
SNV280	68	20	92.5
SNV290	76	20	102.5
SNV300	73	20	99.5
SNV320	77	20	104.5
SNV340	81	20	109.5

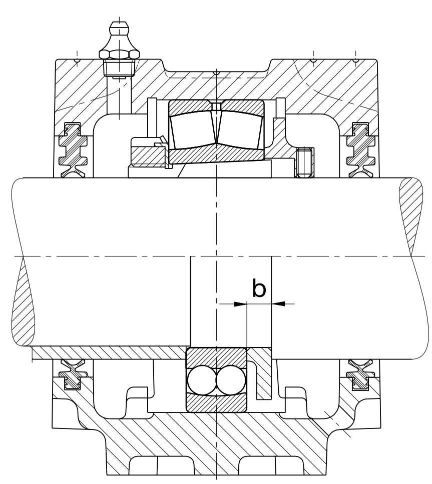
Lubrication

Grease valves

For high-speed operation, e.g. with fan bearing arrangements, FAG supply RSV grease valves upon request, fig. 7.

Grease valves for SNV housings of design G944A* must be listed separately in the order. RSV5 or RSV6 grease valves are used for bearings with adapter sleeves while RSV2 or RSV3 valves are used for bearings with cylindrical bore.

7: RSV grease valve



Grease valve FAG	Width b mm	Grease valves FAG	Width b mm
RSV205 to 211	8	RSV305 to 308	8
RSV212 to 218	10	RSV309 to 313	10
RSV219 to 222	13	RSV314 to 316	13
RSV224 to 232	15	RSV317 to 322	15
		RSV324 to 332	16

Oil lubrication

The SNV housings are designed for both oil sump and circulation oil lubrication. The housings are spacious with oil collecting pockets in the base, oil inlet and outlet holes, holes for connecting oil level gauges and temperature sensors. Connection dimensions fig. 8.

In the case of oil sump lubrication a minimum oil level must be maintained (h_3 dimension in fig. 8). If FAG two-lip seals are used, a certain leakage must be taken into account. Leakage is inevitable with split seals and with seals which are not spring-preloaded. To keep the leakage rate down, the seal contact surface on the shaft should have the following quality:

hardness at least 55 HRC,

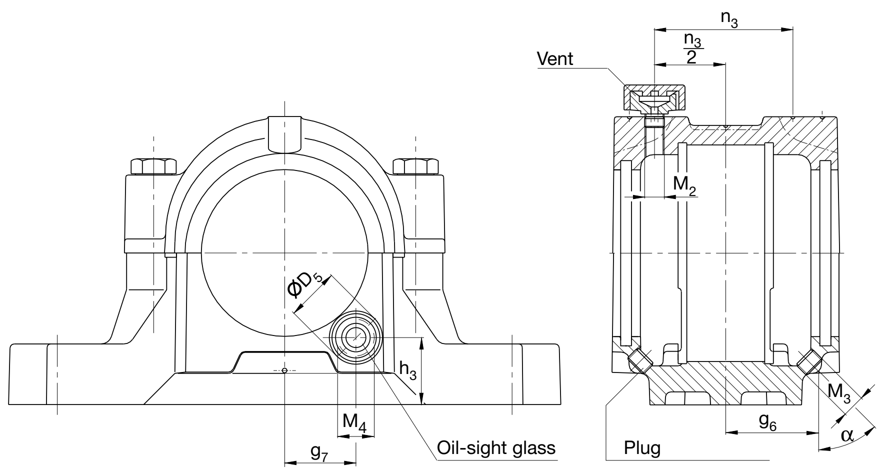
ground twist-free with R_a = 0.2 µm to max. 0.5 µm.

The joint between housing top and base must be sealed with a thin layer of a commercial sealing compound (permanent elasticity). In the case of housings closed at one end, the groove bottom must also be filled with the sealing compound.

Technically-speaking, an oil-proof design is only possible with a spring-preloaded, unsplit radial shaft seal. Please note: the housing must be ventilated in the case of oil sump lubrication (e.g. closing the inlet hole with a ventilation plug). Please contact the FAG advisory service about design and availability.

**8: Dimensions recommended for the connecting holes of oil inlet, oil outlet and oil-sight glass for oil sump lubrication.
For oil circulation lubrication the bore M_4 can be used as the oil outlet.**

SNV housings for oil sump lubrication (suffix G944BA) contain
1 Oil-sight glass OSGL.MOD24OMR-R../..,
1 Vent VENT.MOD556E-R../..,
2 Plugs VSB.DIN906-M10x1-ST.
FAG supply the G944BA design upon request.



Housing	Connection for oil inlet		Connection for oil outlet			Connection for oil-sight glass			
	M_2	$\frac{n_3}{2}$	M_3	α	g_6	M_4	g_7	h_3	D_5
		mm		°	mm		mm		
SNV100	$G^1/_4$	31	M10x1	50	44	$G^3/_8$	33	31	25
SNV110	$G^1/_4$	33.5	M10x1	50	46	$G^3/_8$	35	28	25
SNV120	$G^1/_4$	35.5	M10x1	50	49	$G^3/_8$	38	35	25
SNV125	$G^1/_4$	28.5	M10x1	50	49	$G^3/_8$	44	24	25
SNV130	$G^1/_4$	38	M10x1	50	51.5	$G^1/_2$	43	28.5	30
SNV140	$G^1/_4$	40.5	M10x1	60	57.5	$G^1/_2$	45	40	30
SNV150	$G^1/_4$	42.5	M10x1	60	60	$G^1/_2$	47	38	30
SNV160	$G^1/_4$	45	M10x1	60	62.5	$G^1/_2$	50	39	30
SNV170	$G^1/_4$	46.5	M10x1	60	64	$G^3/_4$	55	46	38
SNV180	$G^1/_4$	49.5	M10x1	60	69	$G^3/_4$	57	43	38
SNV190	$G^1/_4$	49.5	M10x1	60	68.5	$G^3/_4$	48	45	38
SNV200	$G^1/_4$	55.5	M10x1	60	77.5	$G^3/_4$	62	50	38
SNV215	$G^1/_4$	58.5	M10x1	60	80	$G^3/_4$	67	58	38
SNV230	$G^1/_4$	61	M10x1	60	83	$G^3/_4$	70	60	38
SNV240	$G^1/_4$	60	M10x1	60	81.5	$G^3/_4$	61	60	38
SNV250	$G^1/_4$	65.5	M10x1	60	89	$G^3/_4$	75	55	38
SNV260	$G^1/_4$	62.5	M10x1	60	84	$G^3/_4$	65	65	38
SNV270	$G^1/_4$	71.5	M10x1	60	96.5	$G^3/_4$	81	55	38
SNV280	$G^1/_4$	68	M10x1	60	92.5	$G^3/_4$	70	60	38
SNV290	$G^1/_4$	76	M10x1	60	102.5	$G^3/_4$	87	58	38
SNV300	$G^1/_4$	73	M10x1	60	99.5	$G^3/_4$	75	70	38
SNV320	$G^1/_4$	77	M10x1	60	104.5	$G^3/_4$	80	73	38
SNV340	$G^1/_4$	81	M10x1	60	109.5	$G^3/_4$	95	75	38

Mounting

Mounting instructions

Correct mounting has a decisive influence on the attainable life of the bearing.

Careful attention should therefore be paid to the following mounting instructions. Further information can be found in the FAG Publ. No. WL 80 100 "Mounting and Dismounting of Rolling Bearings".

The bearings which fit into the SNV housings can be fastened onto the shaft with adapter sleeves or seated directly on the shaft with a cylindrical bore. The required machining tolerances of the shaft can be taken from the catalogue WL 41 520 "FAG Rolling Bearings". When using adapter sleeves, the tight fit is obtained by pushing the inner ring axially onto the shaft and from the resulting radial expansion of the inner ring. The axial displacement or reduction in radial clearance of the bearing is the dimension (see table 9 for recommended values). Pressing on is facilitated by using an FAG hydraulic nut.

In the case of spherical roller bearings the reduction in radial clearance is determined by measuring the remaining clearance with feeler gauges. Self-aligning ball bearings are pressed so far onto the sleeve until a slight resistance can be felt when the outer ring is swivelled out. However, the outer ring must be easy to rotate in circumferential direction.

Housing tops and bases are not interchangeable.

The support surface must first be cleaned and checked for flatness prior to mounting the SNV plummer block housings.

See section "Loadability", page 14, for flatness tolerances (DIN ISO 1101).

The housing base, which has been cleaned, is then fixed to the support surface with the fastening bolts. The bolts should not be fully tightened so that the housing can be adjusted at a later stage.

Mounting the bearings on the shaft

Bearings with a cylindrical bore are pressed onto the shaft or, even better, pushed on in heated condition. The bearing inner ring must abut the shaft shoulder accurately. If necessary, press again after cooling.

When mounting bearings with tapered bores and adapter sleeves it must be insured that the bearing is seated in the centre of the housing before fixing. This is achieved by inserting the shaft with the bearing in the housing base and adjusting it. Axial displacement of the bearing on the sleeve must also be taken into consideration.

Mounting split spherical roller bearings

Split FAG spherical roller bearings are mounted similarly. Particularities for mounting split bearings are enclosed with the bearings upon delivery.

9: Reduction in radial clearance for FAG spherical roller bearings with tapered bore

Nominal bore		**Radial clearance prior to mounting** Clearance group						**Reduction in radial clearance**[1]		**Axial displacement on the taper 1:12**[1]				**Control value for the radial clearance after mounting**		
d		CN (normal)		C3		C4				Shaft		Sleeve		CN	C3	C4
over	to	min	max	min	max	min	max	min	max	min	max	min	max	min	min	min
mm		mm						mm		mm				mm		
24	**30**	0.03	0.04	0.04	0.055	0.055	0.075	0.015	0.02	0.3	0.35	0.3	0.4	0.015	0.02	0.035
30	**40**	0.035	0.05	0.05	0.065	0.065	0.085	0.02	0.025	0.35	0.4	0.35	0.45	0.015	0.025	0.04
40	**50**	0.045	0.06	0.06	0.08	0.08	0.1	0.025	0.03	0.4	0.45	0.45	0.5	0.02	0.03	0.05
50	**65**	0.055	0.075	0.075	0.095	0.095	0.12	0.03	0.04	0.45	0.6	0.5	0.7	0.025	0.035	0.055
65	**80**	0.07	0.095	0.095	0.12	0.12	0.15	0.04	0.05	0.6	0.75	0.7	0.85	0.025	0.04	0.07
80	**100**	0.08	0.11	0.11	0.14	0.14	0.18	0.045	0.06	0.7	0.9	0.75	1	0.035	0.05	0.08
100	**120**	0.1	0.135	0.135	0.17	0.17	0.22	0.05	0.07	0.7	1.1	0.8	1.2	0.05	0.065	0.1
120	**140**	0.12	0.16	0.16	0.2	0.2	0.26	0.065	0.09	1.1	1.4	1.2	1.5	0.055	0.08	0.11
140	**160**	0.13	0.18	0.18	0.23	0.23	0.3	0.075	0.1	1.2	1.6	1.3	1.7	0.055	0.09	0.13

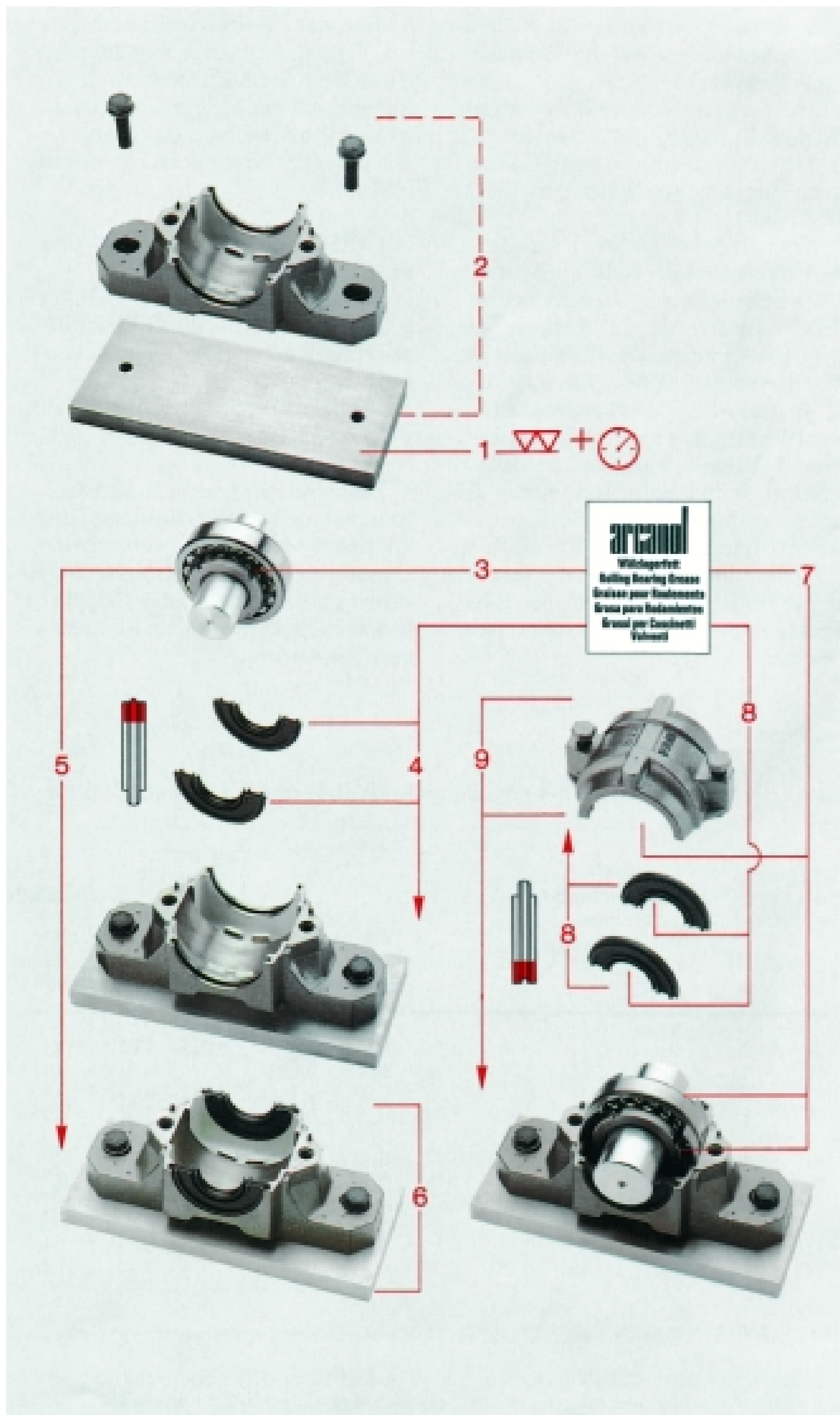
[1]) Only applicable to solid shafts made of steel and to hollow shafts with a bore not larger than half the shaft diameter.

The following applies: Bearings, whose radial clearance lies in the upper half of the tolerance range prior to mounting, are mounted with the higher value of the radial clearance reduction or axial displacement, bearings in the lower half of the tolerance range with the lower value of the radial clearance reduction or axial displacement.

Mounting sequence for SNV housings with the two-lip seal DH (fig. 10)

1. Clean and check support surface.
2. Lock housing base into position.
3. Mount bearing on shaft and fill its cavities with some of the grease quantity according to table 5.
4. Fill space between the sealing lips with grease. Place each of the sealing halves in the grooves of the housing base.
5. Insert shaft with bearing in housing base. Insert both locating rings for locating bearing. The floating bearing should be positioned in the housing centre. In the case of housings closed at one end insert only one seal and, at the opposite side, the cover DKV into the housing grooves.
6. Align housing base and tighten fastening bolts in housing foot with recommended tightening torque, table 13.
7. Distribute equally the remaining bearing grease (point 3) between housing top and base.
8. Insert greased seal halves into the grooves of housing top.
9. Mount housing top and tighten fastening bolts with recommended tightening torque, table 13.

10: Mounting of SNV housings with two-lip seals DH

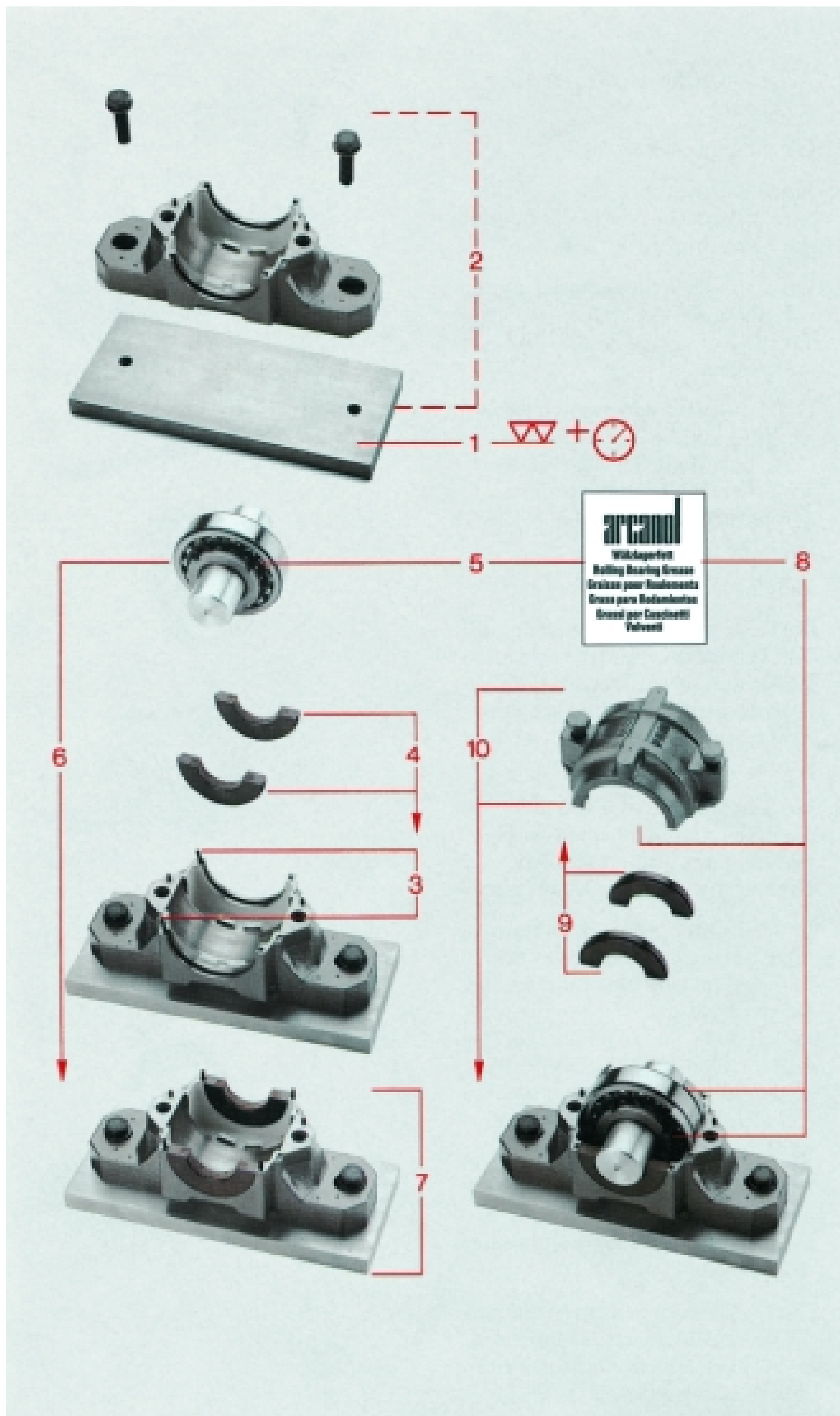


Mounting

Mounting sequence for SNV housings with the felt seal FSV (fig. 11)

1. Clean and check support surface.
2. Lock housing base into position.
3. Insert O rings into the grooves of housing base.
4. Place each half of the adapter with oil-soaked felt strip on the O ring in the grooves of housing base.
5. Mount bearing on shaft and fill its cavities with some of the grease quantity according to table 5.
6. Insert shaft with mounted bearing in housing base. Insert both locating rings for locating bearing. The floating bearing should be positioned in the housing centre. In the case of housings closed at one end insert only one adapter with felt strip and, at the opposite side, the cover DKV into the housing grooves.
7. Align housing base and tighten fastening bolts in housing foot with the recommended tightening torque, table 13.
8. Distribute equally the remaining bearing grease (point 5) between the housing top and base.
9. Insert O ring and adapter with oil-soaked felt strip into the grooves of housing top.
10. Mount housing top and tighten fastening bolts with the recommended tightening torque, table 13.

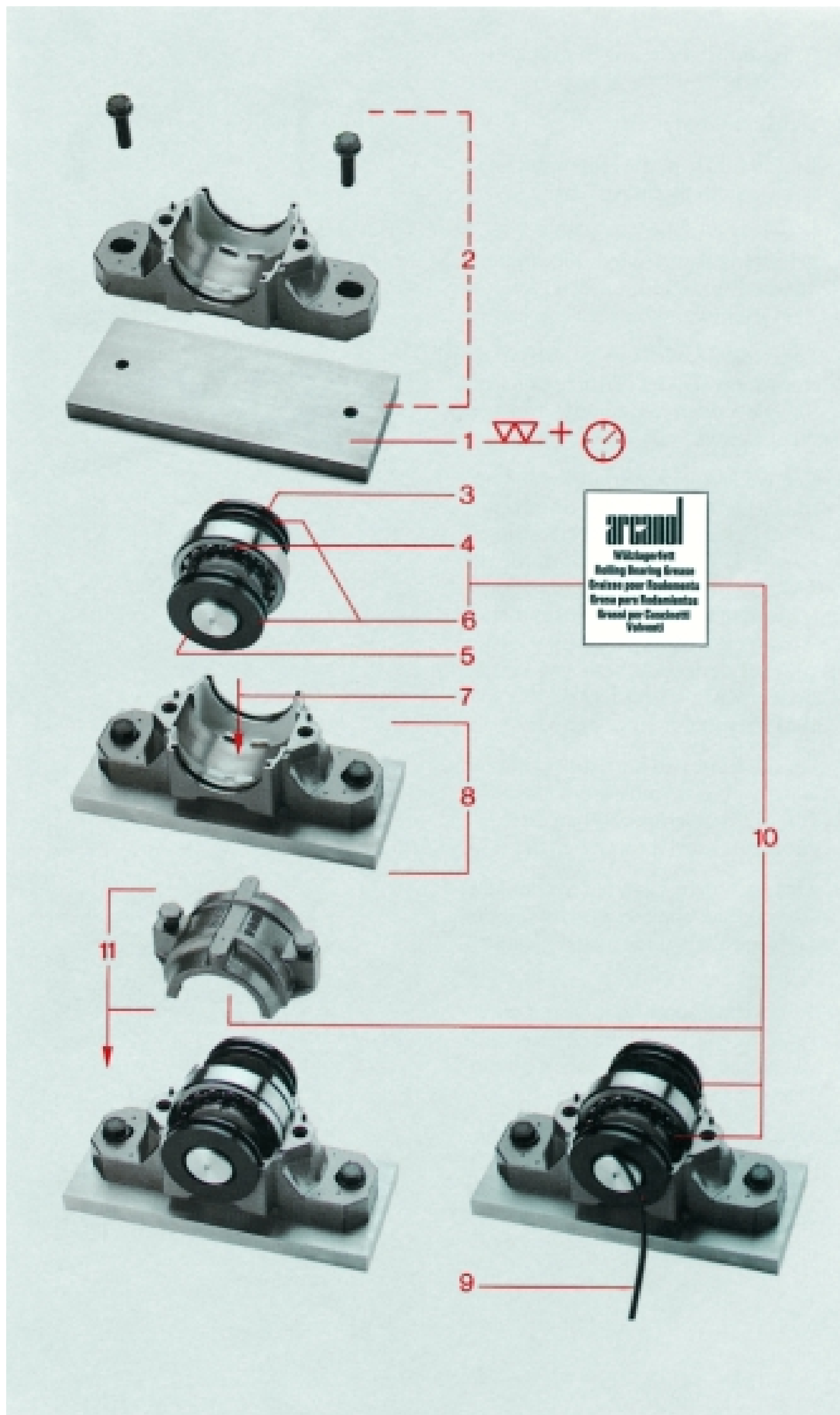
11: Mounting of SNV housings with felt seals FSV

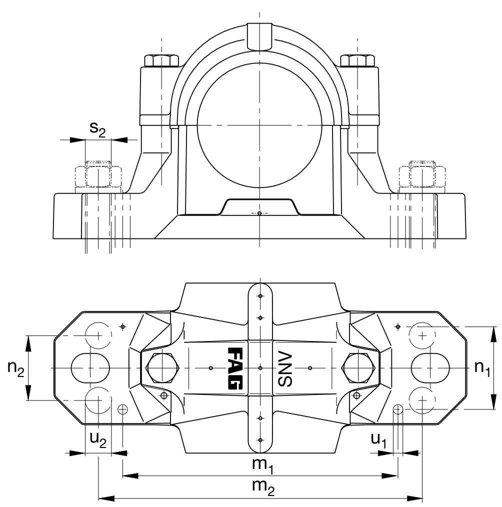


Mounting sequence for SNV housings with the labyrinth seal TSV (fig. 12)

1. Clean and check support surface.
2. Lock housing base into position.
3. Push one labyrinth ring onto shaft. The groove in the bore of the ring must be on the outside.
4. Mount bearing on shaft and fill its cavities with some of the grease quantity according to table 5.
5. If necessary, push the second labyrinth ring onto shaft (note position). For bearings closed at one end place the cover DKV into the housing groove.
6. Grease labyrinth.
7. Insert shaft with mounted bearing and labyrinth rings in housing base. Insert both locating rings for locating bearing. The floating bearing should be positioned in the housing centre.
8. Align housing base and tighten fastening bolts in housing foot with the recommended tightening torque, table 13.
9. The bores of the labyrinth rings have an annular groove. An O ring is forced into the groove by simultaneously turning the shaft with a screwdriver. Then adjust the distance between the labyrinth rings and the housing grooves so that equal axial gaps are obtained.
10. Distribute equally the remaining bearing grease (point 4) between the housing top and base.
11. Mount housing top and tighten fastening bolts with the recommended tightening torque, table 13.

12: Mounting of SNV housings with labyrinth seals TSV





Housing	Dimensions for pins			Dimensions for bolts				
Code	m_1	n_1	u_1	m_2	n_2	u_2	s_2	
FAG	mm			mm				inch
SNV052	95	32	4	115	25			
SNV062	115	36	4	130	25			
SNV072	115	37	4	135	25			
SNV080	135	43	4	160	34	11	M10	$^3/_8$
SNV085	135	40	4	160	34	11	M10	$^3/_8$
SNV090	135	44	6	160	34	11	M10	$^3/_8$
SNV100	170	51	6	200	40	14	M12	$^1/_2$
SNV110	170	52	6	200	40	14	M12	$^1/_2$
SNV120	190	58	6	220	48	14	M12	$^1/_2$
SNV125	190	52	4	220	48	14	M12	$^1/_2$
SNV130	190	60	8	220	48	14	M12	$^1/_2$
SNV140	210	65	8	252	52	18	M16	$^5/_8$
SNV150	210	66	8	252	52	18	M16	$^5/_8$
SNV160	240	72	8	280	58	18	M16	$^5/_8$
SNV170	240	74	8	280	58	18	M16	$^5/_8$
SNV180	261	80	8	300	66	18	M16	$^5/_8$
SNV190	271	81	8	300	66	18	M16	$^5/_8$
SNV200	291	88	8	320	74	18	M16	$^5/_8$
SNV215	297	91	8	330	74	18	M16	$^5/_8$
SNV230	325	97	10	370	80	22	M20	$^3/_4$
SNV240	328	96	10	370	80	22	M20	$^3/_4$
SNV250	342	109	12	400	92	26	M24	$^7/_8$
SNV260	372	113	12	430	100	26	M24	$^7/_8$
SNV270	372	116	12	430	100	26	M24	$^7/_8$
SNV280	392	114	12	450	100	26	M24	$^7/_8$
SNV290	392	120	12	450	100	26	M24	$^7/_8$
SNV300	442	123	12	500	100	26	M24	$^7/_8$
SNV320	482	130	12	540	100	26	M24	$^7/_8$
SNV340	489	138	14	570	100	33	M30	$1^1/_4$

Additional holes for fastening bolts and pins

SNV housings are normally fastened with two bolts. The housing base has two slots which allow the housings to be aligned during mounting (dimensions m, u, v from page 18 on).

Four bolts are required for fastening on T section supports. Spots (dimensions m_2 and n_2) are marked where additional holes (diameter u_2) can be drilled for fastening bolts (s_2). FAG supply upon request housings from size SNV080 on with these four additional holes for fastening bolts. The order should then be, for example: FAG plummer block housing SNV080.G944DA.

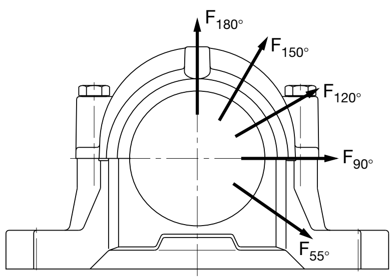
Holes (diameter u_1) can be drilled at the marked spots (dimensions m_1, n_1) for pins to secure the bearing positions.

Loadability

The breaking loads of the SNV housings based on the load direction are indicated in table 13, page 15.

These values apply if the support surfaces of the mating parts are finished with a flatness tolerance of IT8 according to DIN ISO 1101 (related to distance a). An overall and rigid support of the housing base is a precondition for the accommodation of the loads. The common safety factors which apply in general in mechanical engineering must be taken into consideration when determining the values for the permissible load (see page 16).

13: Standard values for the breaking load of SNV housings and the maximum loadability of connecting bolts



For compensation of the housing breaking load value a safety factor of 6 is recommended.

Housing Code	Housing breaking load in load direction					Connecting bolts Designation according to DIN 931	Maximum loadability of both bolts with contact of joint surfaces in load direction			Tightening torque**)	Holding-down bolts*) Designation according to DIN 931	Tightening torque**)
	55°	90°	120°	150°	180°	Material 8.8	120°	150°	180°	Mat. 8.8	Mat. 8.8	Mat. 8.8
FAG	kN						kN			N m		N m
SNV052	160	95	70	60	80	M10x40	60	35	30	50	M12	85
SNV062	170	100	80	65	85	M10x50	60	35	30	50	M12	85
SNV072	190	110	85	80	95	M10x50	60	35	30	50	M12	85
SNV080	210	130	95	85	105	M10x50	60	35	30	50	M12	85
SNV085	225	140	100	90	120	M10x50	60	35	30	50	M12	85
SNV090	265	160	120	105	130	M10x50	60	35	30	50	M12	85
SNV100	280	170	125	120	140	M12x60	80	45	40	85	M16	210
SNV110	300	180	130	125	150	M12x60	80	45	40	85	M16	210
SNV120	335	200	150	130	170	M12x70	80	45	40	85	M16	210
SNV125	335	200	150	130	170	M12x70	80	45	40	85	M16	210
SNV130	400	250	180	150	200	M12x70	80	45	40	85	M16	210
SNV140	425	265	190	170	210	M12x70	80	45	40	85	M20	410
SNV150	475	280	200	180	235	M12x80	80	45	40	85	M20	410
SNV160	530	335	250	210	265	M16x90	180	100	90	210	M20	410
SNV170	560	355	265	225	280	M16x90	180	100	90	210	M20	410
SNV180	630	375	280	250	300	M20x110	260	150	130	410	M24	710
SNV190	630	375	280	250	300	M20x110	260	150	130	410	M24	710
SNV200	670	400	315	280	335	M20x110	260	150	130	410	M24	710
SNV215	800	450	355	315	400	M20x110	260	150	130	410	M24	710
SNV230	900	530	400	355	450	M24x130	360	210	180	710	M24	710
SNV240	1000	600	450	400	500	M24x130	360	210	180	710	M24	710
SNV250	1060	630	475	425	530	M24x130	360	210	180	710	M30	1450
SNV260	1180	710	530	475	600	M24x130	360	210	180	710	M30	1450
SNV270	1180	710	530	475	600	M24x130	360	210	180	710	M30	1450
SNV280	1320	750	600	530	630	M24x140	360	210	180	710	M30	1450
SNV290	1400	850	630	560	710	M24x140	360	210	180	710	M30	1450
SNV300	1500	900	670	600	750	M24x140	360	210	180	710	M30	1450
SNV320	1700	1000	750	670	850	M24x150	360	210	180	710	M30	1450
SNV340	1900	1120	850	750	950	M30x160	640	370	320	1450	M36	2600

*) Holding-down bolts are not supplied by FAG.
**) The tightening torques are maximum values at a 90% utilization of the yield strength of the bolt material and a coefficient of friction of 0.14. We recommend tightening the bolts to 70% of these values.

Loadability · Codes · How to Order

The safety factors are:
– 6 for the breaking load of the housing
– 3 for the maximum loadability of connecting bolts and holding-down bolts.

The maximum axial housing load is assumed to be two thirds of the breaking load value $F_{180°}$. In this case the permissible axial loadability of the bearings used and the axial holding force of bearings on sleeves without positive contact must be considered (see FAG TI No. WL 80-14). For load directions between 55° and 120° or for axial load the housing must be secured at the foot with stops in the load direction if the force acting parallel to the clamping surface exceeds $0.05 \cdot F_{180°}$.

The maximum permissible load on eyebolts in the housing top is the weight of the housing together with the bearing.

Codes

The housing code is made up of the designation of the housing series SNV and the bearing outside diameter in mm, e.g. SNV100.

Bearings and adapter sleeves, locating rings, seals and covers must be ordered separately (see following examples of how to order). The accessories required for the housing based on the bearing provided are indicated in the dimension tables.

Examples of how to order

EXAMPLE 1

Plummer block housing, closed on one side, self-aligning ball bearing 2210K.TV.C3 as a locating bearing, adapter sleeve, two-lip seal.

Order:

1 plummer block housing	FAG SNV090
1 self-aligning ball bearing	FAG 2210K.TV.C3
1 adapter sleeve	FAG H310
2 locating rings	FAG FRM90/9
1 cover	FAG DKV090
1 two-lip seal	FAG DH510

EXAMPLE 2

Plummer block housing for through shaft, spherical roller bearing 22212EK as a floating bearing, adapter sleeve, two-lip seals.

Order:

1 plummer block housing	FAG SNV110
1 spherical roller bearing	FAG 22212EK
1 adapter sleeve	FAG H312
2 two-lip seals	FAG DH512

EXAMPLE 3

Plummer block housing for through shaft, split spherical roller bearing 222SM70T as a locating bearing, two-lip seal.

Order:

1 plummer block housing	FAG SNV140
1 split spherical roller bearing	FAG 222SM70T
2 locating rings	FAG FRM140/12,5
2 two-lip seals	FAG DH516

EXAMPLE 4

Plummer block housing with labyrinth seal, one end closed, spherical roller bearing 22216EK as a floating bearing, adapter sleeve.

Order:

1 plummer block housing	FAG SNV140
1 spherical roller bearing	FAG 22216EK
1 adapter sleeve	FAG H316
1 labyrinth ring	FAG TSV516
1 cover	FAG DKV140

EXAMPLE 5

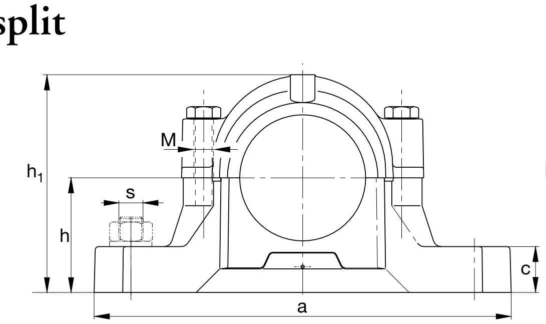
Plummer block housing, one end closed, spherical roller bearing 23218ES.TVPB as a floating bearing, felt seal.

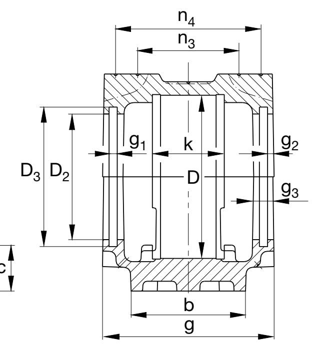
Order:

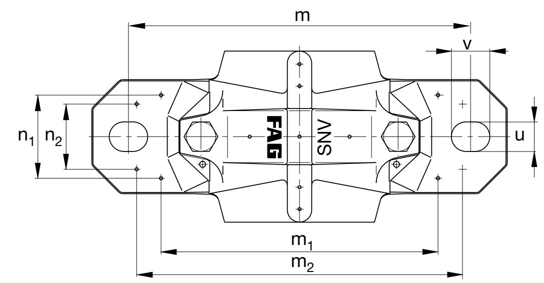
1 plummer block housing	FAG SNV160
1 spherical roller bearing	FAG 23218ES.TVPB
1 shaft nut	FAG KM18
1 lock washer	FAG MB18A
1 cover	FAG DKV160
1 felt seal	FAG FSV218

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve

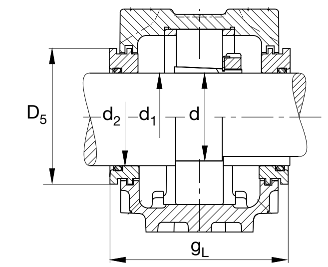


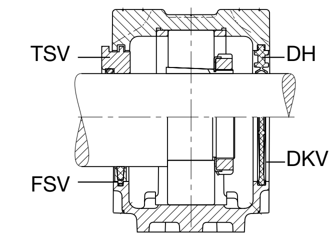




Bearing with tapered bore and adapter sleeve

Bearing with cylindrical bore





SNV052

Dimensions

D (mm)	a	b	c	g	h	m	s (mm)	s (inch)	u (mm)	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈ kg
52	165	46	19	70	40	130	M12	1/2	15	20	75	36.5	44.5	42.7	5	3	10.5	83[1]	27	95	32	115	25	38	56	M10	–	1.3

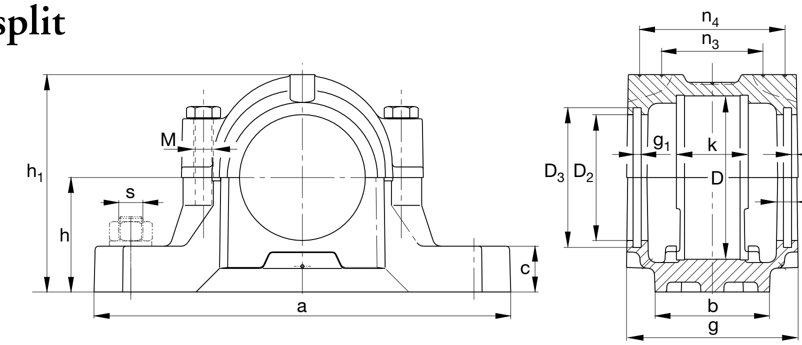
Shaft d_1 / d (mm)	Shaft (inch)	d_2 (mm)	Bearings which fit the housing: Unsplit bearings – Codes according to DIN*						Split spherical roller bearing FAG	Required accessories: Adapter sleeve FAG	Locknut FAG	Lock washer FAG	Locating ring 2 pieces FAG	Two-lip seal FAG	Labyrinth ring with O ring FAG	Felt seal FAG	Cover FAG
19.05	3/4			1205K	20205K					H205.012			FRM52/6	DH505.012	TSV505.012	FSV505.012	DKV052
							2205K	22205K		H305.012			FRM52/4,5	DH505.012	TSV505.012	FSV505.012	DKV052
20				1205K	20205K					H205			FRM52/6	DH505	TSV505	FSV505	DKV052
							2205K	22205K		H305			FRM52/4,5	DH505	TSV505	FSV505	DKV052
		25	6304	1304	20304	21304					KM4	MB4A	FRM52/6	DH304	TSV304	FSV304	DKV052
		25					2304				KM4	MB4A	FRM52/3	DH304	TSV304	FSV304	DKV052
20.638	13/16			1205K	20205K					H205.013			FRM52/6	DH505	TSV505.013	FSV505	DKV052
							2205K	22205K		H305.013			FRM52/4,5	DH505	TSV505.013	FSV505	DKV052
25		30	6205	1205	20205						KM5	MB5A	FRM52/6	DH205	TSV205		DKV052
		30					2205	22205			KM5	MB5A	FRM52/4,5	DH205	TSV205		DKV052

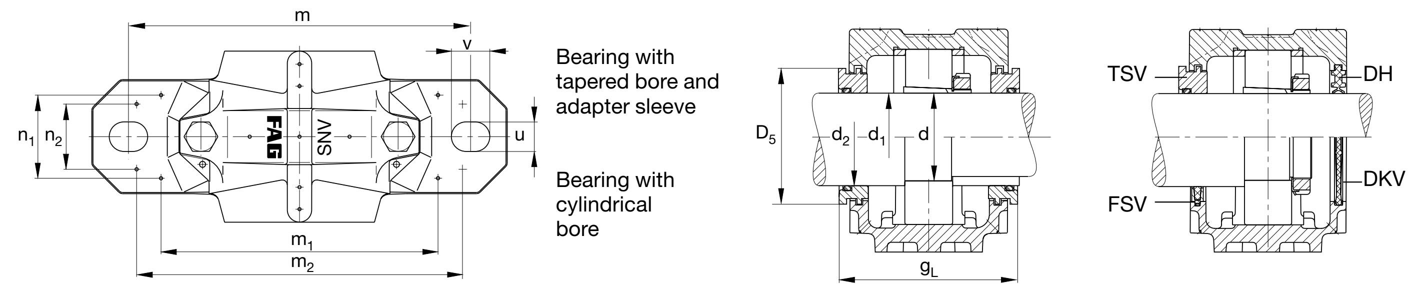
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

[1]) 95 mm at TSV205 and TSV304

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV062

Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
62	185	52	22	75	50	150	M12	$^{1}/_{2}$	15	20	91	41.5	49.5	47.7	5	3	10.5	88[1])	30	115	36	130	25	42	61	M10	–	1.9

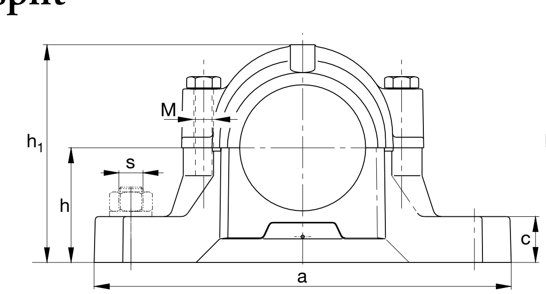
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings						Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
19.05	$^{3}/_{4}$			1305K	20305K					H305.012			FRM62/6,5	DH605.012	TSV605.012	FSV605.012	DKV062
							2305K			H2305.012			FRM62/3	DH605.012	TSV605.012	FSV605.012	DKV062
20				1305K	20305K					H305			FRM62/6,5	DH605	TSV605	FSV605	DKV062
							2305K			H2305			FRM62/3	DH605	TSV605	FSV605	DKV062
22.225	$^{7}/_{8}$			1206K	20206K					H206.014			FRM62/7	DH506.014	TSV506.014	FSV506.014	DKV062
							2206K	22206K		H306.014			FRM62/5	DH506.014	TSV506.014	FSV506.014	DKV062
23.813	$^{15}/_{16}$			1206K	20206K					H206.015			FRM62/7	DH506.014	TSV506.015	FSV506.015	DKV062
							2206K	22206K		H306.015			FRM62/5	DH506.014	TSV506.015	FSV506.015	DKV062
25				1206K	20206K					H206			FRM62/7	DH506	TSV506	FSV506	DKV062
							2206K	22206K		H306			FRM62/5	DH506	TSV506	FSV506	DKV062
		30	6305	1305	20305	21305					KM5	MB5A	FRM62/6,5	DH305	TSV305	FSV305	DKV062
		30					2305				KM5	MB5A	FRM62/3	DH305	TSV305	FSV305	DKV062
25.4	1			1206K	20206K					H206.100			FRM62/7	DH506	TSV506.100	FSV506	DKV062
							2206K	22206K		H306.100			FRM62/5	DH506	TSV506.100	FSV506	DKV062
30		35	6206	1206	20206						KM6	MB6A	FRM62/7	DH206	TSV206		DKV062
		35					2206	22206			KM6	MB6A	FRM62/5	DH206	TSV206		DKV062

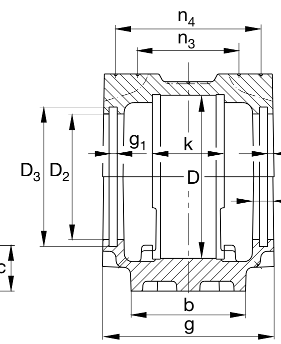
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

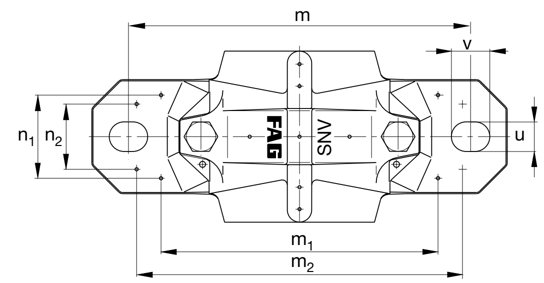
[1]) 100 mm at TSV206 and TSV305

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve

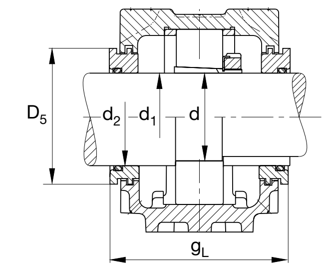


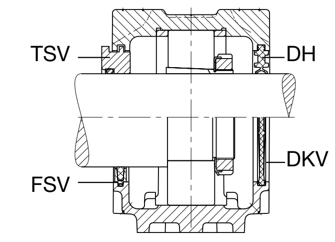




Bearing with tapered bore and adapter sleeve

Bearing with cylindrical bore





SNV072

Dimensions

D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	**Mass** ≈
mm							mm	inch	mm																			kg
72	185	52	22	80	50	150	M12	$^1/_2$	15	20	97	51.5	59.5	57.7	5	3	10.5	93[1]	33	115	37	135	25	46	66	M10	–	2

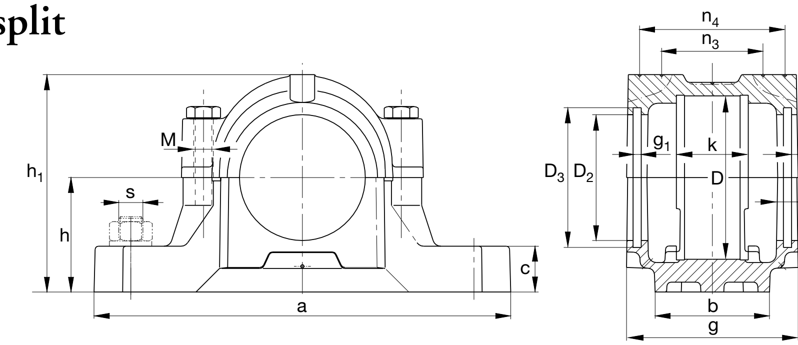
Shaft d_1 / d		d_2	**Bearings which fit the housing** Unsplit bearings						Split spherical roller bearing	**Required accessories** Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
22.225	$^7/_8$			1306K	20306K					H306.014			FRM72/7	DH606.014	TSV606.014	FSV606.014	DKV072
							2306K			H2306.014			FRM72/3	DH606.014	TSV606.014	FSV606.014	DKV072
23.813	$^{15}/_{16}$			1306K	20306K					H306.015			FRM72/7	DH606.014	TSV606.015	FSV606.015	DKV072
							2306K			H2306.015			FRM72/3	DH606.014	TSV606.015	FSV606.015	DKV072
25				1306K	20306K					H306			FRM72/7	DH606	TSV606	FSV606	DKV072
							2306K			H2306			FRM72/3	DH606	TSV606	FSV606	DKV072
25.4	1			1306K	20306K					H306.100			FRM72/7	DH606	TSV606.100	FSV606	DKV072
							2306K			H2306.100			FRM72/3	DH606	TSV606.100	FSV606	DKV072
28.575	$1^1/_8$			1207K	20207K					H207.102			FRM72/8	DH507.102	TSV507.102	FSV507.102	DKV072
							2207K	22207K		H2307.102			FRM72/5	DH507.102	TSV507.102	FSV507.102	DKV072
30				1207K	20207K					H207			FRM72/8	DH507	TSV507	FSV507	DKV072
							2207K	22207K		H307			FRM72/5	DH507	TSV507	FSV507	DKV072
		35	6306	1306	20306	21306					KM6	MB6A	FRM72/7	DH306	TSV306	FSV306	DKV072
		35					2306				KM6	MB6A	FRM72/3	DH306	TSV306	FSV306	DKV072
30.163	$1^3/_{16}$			1207K	20207K					H207.103			FRM72/8	DH507	TSV507	FSV507	DKV072
							2207K	22207K		H307.103			FRM72/5	DH507	TSV507	FSV507	DKV072
35		45	6207	1207	20207						KM7	MB7A	FRM72/8	DH207	TSV207		DKV072
		45					2207	22207			KM7	MB7A	FRM72/5	DH207	TSV207		DKV072

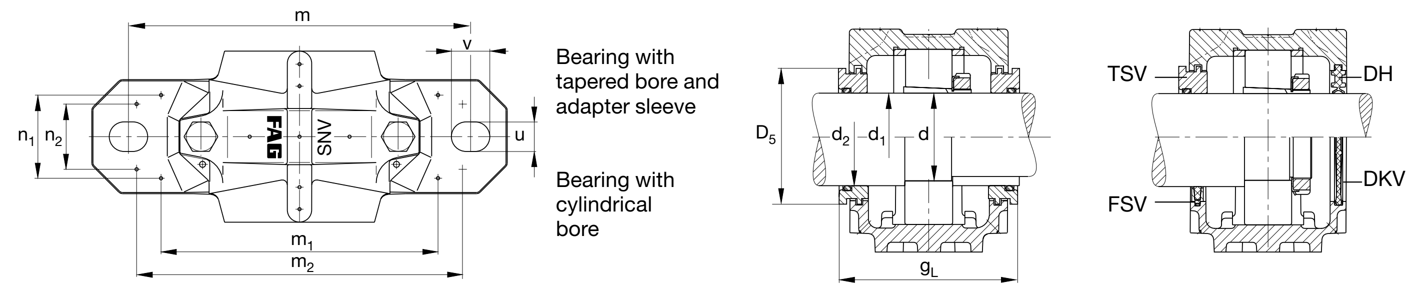
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

[1]) 105 mm at TSV207

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV080

Dimensions

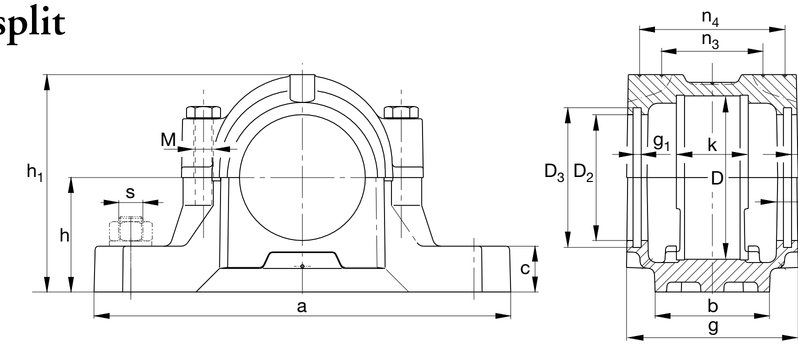
D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
80	205	60	25	85	60	170	M12	$^1/_2$	15	20	112	62	70.5	68.7	5	3	10.5	98	39	135	43	160	34	52	71	M10	–	2.9

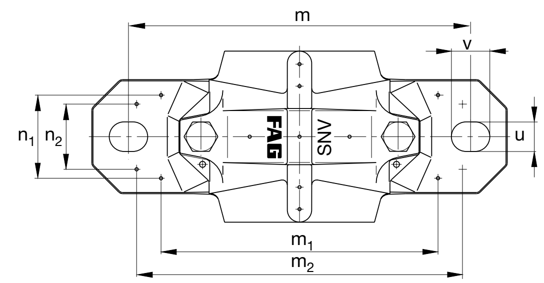
Shaft d_1 d	Shaft	d_2	Bearings which fit the housing: Unsplit bearings						Split spherical roller bearing	Required accessories: Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
28.575	$1^1/_8$			1307K	20307K	21307K				H307.102			FRM80/9	DH607.102	TSV607.102	FSV607.102	DKV080
							2307K			H2307.102			FRM80/4	DH607.102	TSV607.102	FSV607.102	DKV080
30				1307K	20307K	21307K				H307			FRM80/9	DH607	TSV607	FSV607	DKV080
							2307K			H2307			FRM80/4	DH607	TSV607	FSV607	DKV080
30.163	$1^3/_{16}$			1307K	20307K	21307K				H307.103			FRM80/9	DH607	TSV607	FSV607	DKV080
							2307K			H2307.103			FRM80/4	DH607	TSV607	FSV607	DKV080
31.75	$1^1/_4$			1208K	20208K					H208.104			FRM80/10,5	DH508.104	TSV508.104	FSV508.104	DKV080
							2208K	22208K		H308.104			FRM80/8	DH508.104	TSV508.104	FSV508.104	DKV080
33.338	$1^5/_{16}$			1208K	20208K					H208.105			FRM80/10,5	DH508.104	TSV508.105	FSV508.105	DKV080
							2208K	22208K		H308.105			FRM80/8	DH508.104	TSV508.105	FSV508.105	DKV080
34.925	$1^3/_8$			1208K	20208K					H208.106			FRM80/10,5	DH508	TSV508	FSV508	DKV080
							2208K	22208K		H308.106			FRM80/8	DH508	TSV508	FSV508	DKV080
35				1208K	20208K					H208			FRM80/10,5	DH508	TSV508	FSV508	DKV080
							2208K	22208K		H308			FRM80/8	DH508	TSV508	FSV508	DKV080
		45	6307	1307	20307	21307					KM7	MB7A	FRM80/9	DH307	TSV307	FSV307	DKV080
		45					2307				KM7	MB7A	FRM80/4	DH307	TSV307	FSV307	DKV080
40		50	6208	1208	20208						KM8	MB8A	FRM80/10,5	DH208	TSV208	FSV208	DKV080
		50					2208	22208			KM8	MB8A	FRM80/8	DH208	TSV208	FSV208	DKV080

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

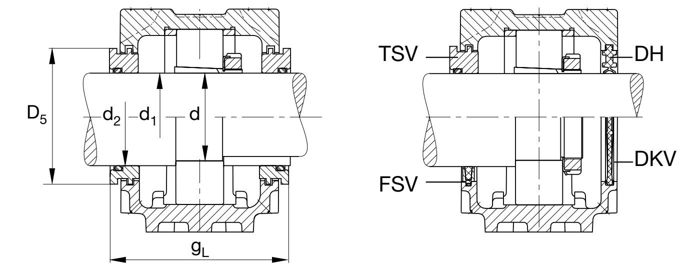
for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





Bearing with tapered bore and adapter sleeve

Bearing with cylindrical bore



SNV085

Dimensions

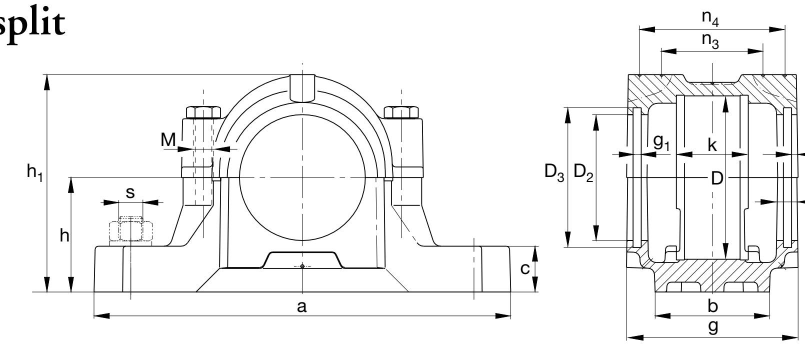
D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
85	205	60	25	87	60	170	M12	$^1/_2$	15	20	114	67	75.5	73.7	5	4	12.5	101	31	135	40	160	34	47	71	M10	–	2.8

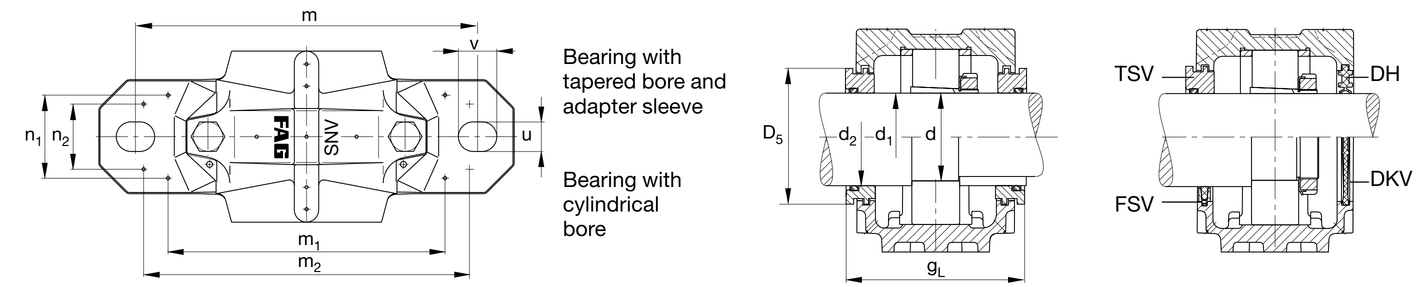
Shaft d_1 d	inch	d_2	Bearings which fit the housing – Unsplit bearings					Split spherical roller bearing	Required accessories – Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*					FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
36.513	$1^7/_{16}$			1209K	20209K				H209.107			FRM85/6	DH509.107	TSV509.107	FSV509.107	DKV085
						2209K	22209K		H309.107			FRM85/4	DH509.107	TSV509.107	FSV509.107	DKV085
38.1	$1^1/_2$			1209K	20209K				H209.108			FRM85/6	DH509.107	TSV509.108	FSV509.108	DKV085
						2209K	22209K		H309.108			FRM85/4	DH509.107	TSV509.108	FSV509.108	DKV085
40				1209K	20209K				H209			FRM85/6	DH509	TSV509	FSV509	DKV085
						2209K	22209K		H309			FRM85/4	DH509	TSV509	FSV509	DKV085
45		55	6209	1209	20209					KM9	MB9A	FRM85/6	DH209	TSV209	FSV209	DKV085
		55				2209	22209			KM9	MB9A	FRM85/4	DH209	TSV209	FSV209	DKV085

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV090

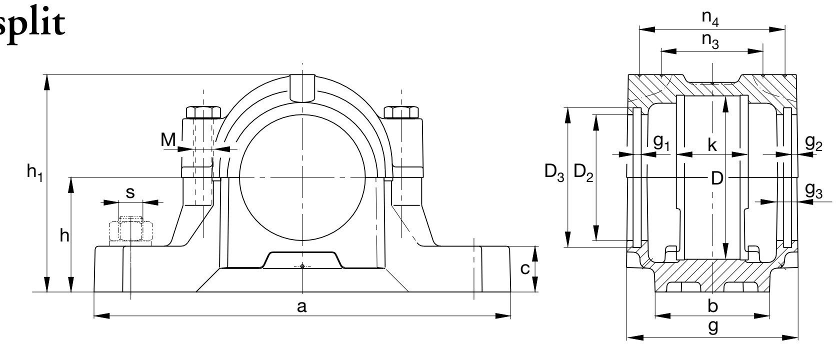
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
90	205	60	25	100	60	170	M12	$^1/_2$	15	20	117	72	80.5	78.2	5	4	12.5	114	41	135	44	160	34	58	84	M10	–	3.1

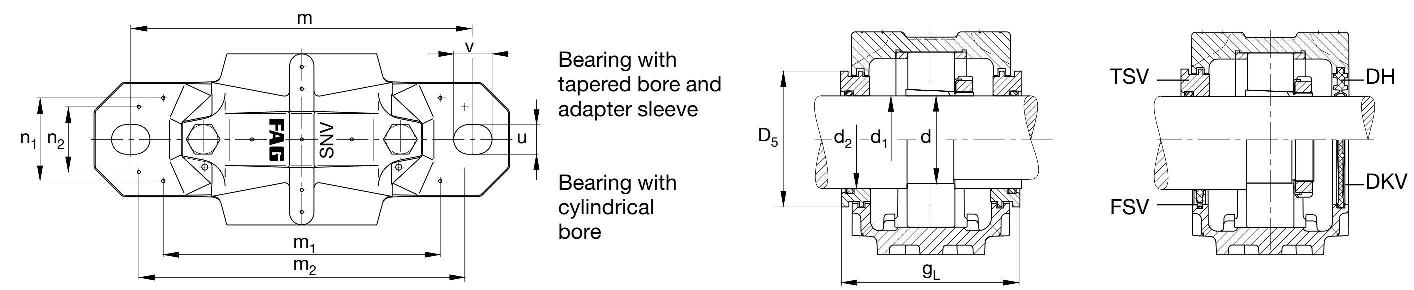
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings						Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
31.75	$1^1/_4$			1308K	20308K	21308K				H308.104			FRM90/9	DH608.104	TSV608.104	FSV608.104	DKV090
							2308K	22208K		H2308.104			FRM90/4	DH608.104	TSV608.104	FSV608.104	DKV090
33.338	$1^5/_{16}$			1308K	20308K	21308K				H308.105			FRM90/9	DH608.104	TSV608.105	FSV608.105	DKV090
							2308K	22308K		H2308.105			FRM90/4	DH608.104	TSV608.105	FSV608.105	DKV090
34.925	$1^3/_8$			1308K	20308K	21308K				H308.106			FRM90/9	DH608	TSV608	FSV608	DKV090
							2308K	22308K		H2308.106			FRM90/4	DH608	TSV608	FSV608	DKV090
35				1308K	20308K	21308K				H308			FRM90/9	DH608	TSV608	FSV608	DKV090
							2308K	22308K		H2308			FRM90/4	DH608	TSV608	FSV608	DKV090
40		50	6308	1308	20308	21308					KM8	MB8A	FRM90/9	DH308	TSV308	FSV308	DKV090
		50					2308	22308			KM8	MB8A	FRM90/4	DH308	TSV308	FSV308	DKV090
41.275	$1^5/_8$			1210K	20210K					H210.110			FRM90/10,5	DH510.110	TSV510.110	FSV510.110	DKV090
							2210K	22210K		H310.110			FRM90/9	DH510.110	TSV510.110	FSV510.110	DKV090
42.863	$1^{11}/_{16}$			1210K	20210K					H210.111			FRM90/10,5	DH510.110	TSV510.111	FSV510.111	DKV090
							2210K	22210K		H310.111			FRM90/9	DH510.110	TSV510.111	FSV510.111	DKV090
44.45	$1^3/_4$			1210K	20210K					H210.112			FRM90/10,5	DH510	TSV510.112	FSV510	DKV090
							2210K	22210K		H310.112			FRM90/9	DH510	TSV510.112	FSV510	DKV090
45				1210K	20210K					H210			FRM90/10,5	DH510	TSV510	FSV510	DKV090
							2210K	22210K		H310			FRM90/9	DH510	TSV510	FSV510	DKV090
50		60	6210	1210	20210						KM10	MB10A	FRM90/10,5	DH210	TSV210	FSV210	DKV090
		60					2210	22210			KM10	MB10A	FRM90/9	DH210	TSV210	FSV210	DKV090

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV100

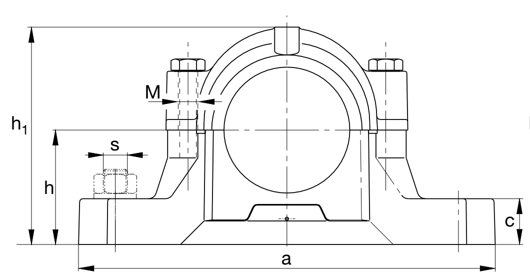
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	**Mass** ≈
mm							mm	inch	mm																			kg
100	255	70	28	105	70	210	M16	$^5/_8$	18	23	133	77	85.5	83.2	5	4	12.5	119	44	170	51	200	40	62	89	M12	–	4.3

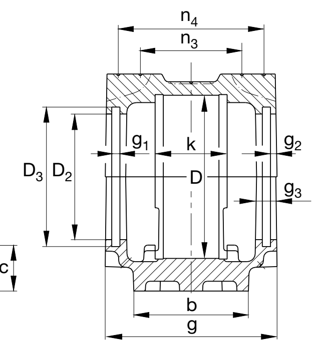
Shaft d_1 d		d_2	**Bearings which fit the housing** Unsplit bearings						Split spherical roller bearing	**Required accessories** Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
36.513	$1^7/_{16}$			1309K	20309K	21309K				H309.107			FRM100/9,5	DH609.107	TSV609.107	FSV609.107	DKV100
							2309K	22309K		H2309.107			FRM100/4	DH609.107	TSV609.107	FSV609.107	DKV100
38.1	$1^1/_2$			1309K	20309K	21309K				H309.108			FRM100/9,5	DH609.107	TSV609.108	FSV609.108	DKV100
							2309K	22309K		H2309.108			FRM100/4	DH609.107	TSV609.108	FSV609.108	DKV100
39.688	$1^9/_{16}$			1309K	20309K	21309K				H309.109			FRM100/9,5	DH609	TSV609	FSV609	DKV100
							2309K	22309K		H2309.109			FRM100/4	DH609	TSV609	FSV609	DKV100
40				1309K	20309K	21309K				H309			FRM100/9,5	DH609	TSV609	FSV609	DKV100
							2309K	22309K		H2309			FRM100/4	DH609	TSV609	FSV609	DKV100
45		55	6309	1309	20309	21309					KM9	MB9A	FRM100/9,5	DH309	TSV309	FSV309	DKV100
		55					2309	22309			KM9	MB9A	FRM100/4	DH309	TSV309	FSV309	DKV100
47.625	$1^7/_8$			1211K	20211K					H211.114			FRM100/11,5	DH511.114	TSV511.114	FSV511.114	DKV100
							2211K	22211K		H311.114			FRM100/9,5	DH511.114	TSV511.114	FSV511.114	DKV100
49.213	$1^{15}/_{16}$			1211K	20211K					H211.115			FRM100/11,5	DH511	TSV511.115	FSV511.115	DKV100
							2211 K	22211K		H311.115			FRM100/9,5	DH511	TSV511.115	FSV511.115	DKV100
50				1211K	20211K					H211			FRM100/11,5	DH511	TSV511	FSV511	DKV100
							2211 K	22211K		H311			FRM100/9,5	DH511	TSV511	FSV511	DKV100
50.8	2			1211K	20211K					H211.200			FRM100/11,5	DH511	TSV511.200	FSV511	DKV100
							2211K	22211K		H311.200			FRM100/9,5	DH511	TSV511.200	FSV511	DKV100
55		65	6211	1211	20211						KM11	MB11A	FRM100/11,5	DH211	TSV211	FSV211	DKV100
		65					2211	22211			KM11	MB11A	FRM100/9,5	DH211	TSV211	FSV211	DKV100

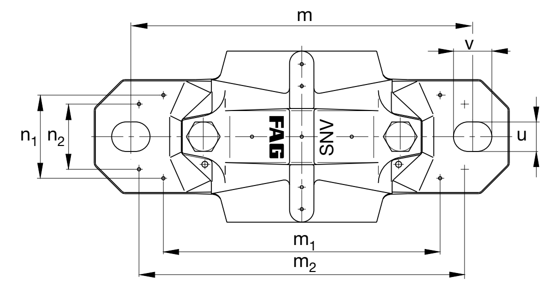
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve

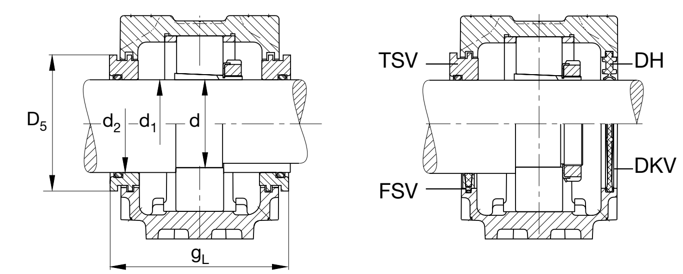






Bearing with tapered bore and adapter sleeve

Bearing with cylindrical bore



SNV110

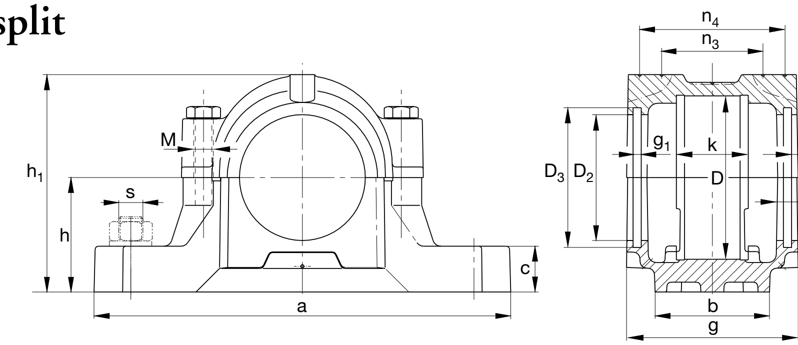
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
110	255	70	30	110	70	210	M16	5/8	18	23	139	82	90.5	88.2	5	4	12.5	124	48	170	52	200	40	67	94	M12	–	4.9

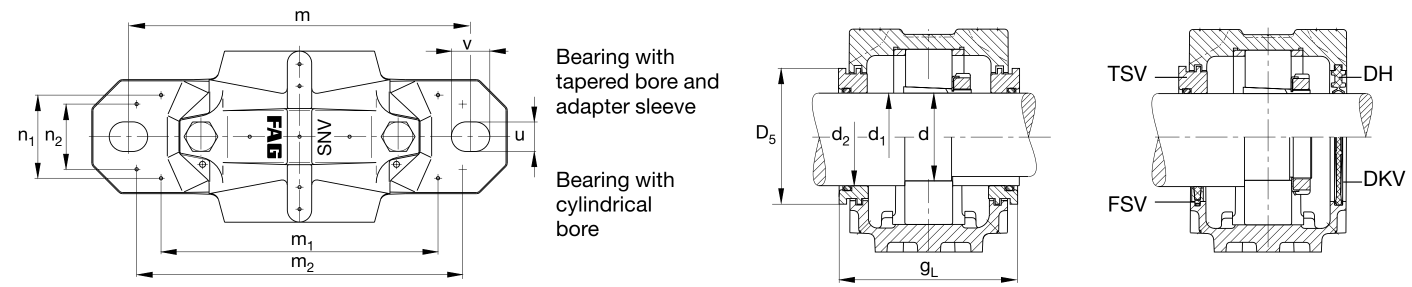
Shaft d_1 d		d_2	Bearings which fit the housing: Unsplit bearings						Split spherical roller bearing	Required accessories: Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
41.275	1 5/8			1310K	20310K	21310K				H310.110			FRM110/10,5	DH610.110	TSV610.110	FSV610.110	DKV110
							2310K	22310K		H2310.110			FRM110/4	DH610.110	TSV610.110	FSV610.110	DKV110
42.863	1 11/16			1310K	20310K	21310K				H310.111			FRM110/10,5	DH610.110	TSV610.111	FSV610.111	DKV110
							2310K	22310K		H2310.111			FRM110/4	DH610.110	TSV610.111	FSV610.111	DKV110
44.45	1 3/4			1310K	20310K	21310K				H310.112			FRM110/10,5	DH610	TSV610.112	FSV610	DKV110
							2310K	22310K		H2310.112			FRM110/4	DH610	TSV610.112	FSV610	DKV110
45				1310K	20310K	21310K				H310			FRM110/10,5	DH610	TSV610	FSV610	DKV110
							2310K	22310K		H2310			FRM110/4	DH610	TSV610	FSV610	DKV110
50		60	6310	1310	20310	21310					KM10	MB10A	FRM110/10,5	DH310	TSV310	FSV310	DKV110
		60					2310	22310			KM10	MB10A	FRM110/4	DH310	TSV310	FSV310	DKV110
53.975	2 1/8			1212K	20212K					H212.202			FRM110/13	DH512	TSV512.202	FSV512.202	DKV110
							2212K	22212K		H312.202			FRM110/10	DH512	TSV512.202	FSV512.202	DKV110
55				1212K	20212K					H212			FRM110/13	DH512	TSV512	FSV512	DKV110
							2212K	22212K		H312			FRM110/10	DH512	TSV512	FSV512	DKV110
									222SM55T				FRM110/10	DH512	TSV512	FSV512	DKV110
60		70	6212	1212	20212						KM12	MB12A	FRM110/13	DH212	TSV212	FSV212	DKV110
		70					2212	22212			KM12	MB12A	FRM110/10	DH212	TSV212	FSV212	DKV110

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV120

Dimensions

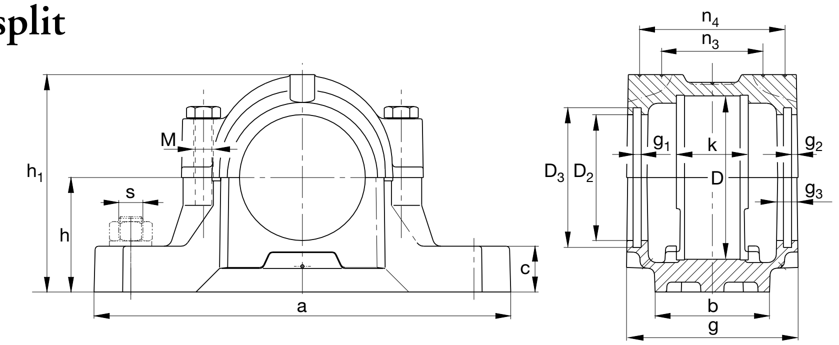
D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	**Mass** ≈
mm							mm	inch	mm																			kg
120	275	80	30	115	80	230	M16	$^5/_8$	18	23	155	87	95.5	93.2	5	4	12.5	129	51	190	58	220	48	71	99	M12	–	6.1

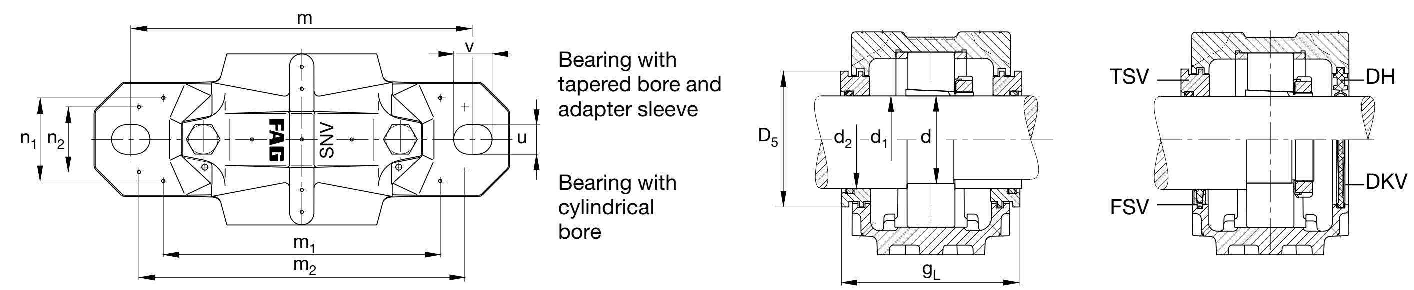
Shaft d_1 d		d_2	**Bearings which fit the housing** Unsplit bearings						Split spherical roller bearing	**Required accessories** Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
47.625	$1^7/_8$			1311K	20311K	21311K	2311K	22311K		H311.114 H2311.114			FRM120/11 FRM120/4	DH611.114 DH611.114	TSV611.114 TSV611.114	FSV611.114 FSV611.114	DKV120 DKV120
49.213	$1^{15}/_{16}$			1311K	20311K	21311K	2311K	22311K		H311.115 H2311.115			FRM120/11 FRM120/4	DH611 DH611	TSV611.115 TSV611.115	FSV611.115 FSV611.115	DKV120 DKV120
50				1311K	20311K	21311K	2311K	22311K		H311 H2311			FRM120/11 FRM120/4	DH611 DH611	TSV611 TSV611	FSV611 FSV611	DKV120 DKV120
50.8	2			1311K	20311K	21311K	2311K	22311K		H311.200 H2311.200			FRM120/11 FRM120/4	DH611 DH611	TSV611.200 TSV611.200	FSV611 FSV611	DKV120 DKV120
55		65 65	6311	1311	20311	21311	2311	22311			KM11 KM11	MB11A MB11A	FRM120/11 FRM120/4	DH311 DH311	TSV311 TSV311	FSV311 FSV311	DKV120 DKV120
55.563	$2^3/_{16}$			1213K	20213K		2213K	22213K	222S.203	H213.203 H313.203			FRM120/14 FRM120/10 FRM120/10	DH513.203 DH513.203 DH513.203	TSV513.203 TSV513.203 TSV513.203	FSV513.203 FSV513.203 FSV513.203	DKV120 DKV120 DKV120
57.15	$2^1/_4$			1213K	20213K		2213K	22213K	222S.204	H213.204 H313.204			FRM120/14 FRM120/10 FRM120/10	DH513.203 DH513.203 DH513.203	TSV513.204 TSV513.204 TSV513.204	FSV513.204 FSV513.204 FSV513.204	DKV120 DKV120 DKV120
60				1213K	20213K		2213K	22213K		H213 H313			FRM120/14 FRM120/10	DH513 DH513	TSV513 TSV513	FSV513 FSV513	DKV120 DKV120
60.325	$2^3/_8$			1213K	20213K		2213K	22213K		H213.206 H313.206			FRM120/14 FRM120/10	DH513 DH513	TSV513 TSV513	FSV513 FSV513	DKV120 DKV120
65		75 75	6213	1213	20213		2213	22213			KM13 KM13	MB13A MB13A	FRM120/14 FRM120/10	DH213 DH213	TSV213 TSV213	FSV213 FSV213	DKV120 DKV120

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV125

Dimensions

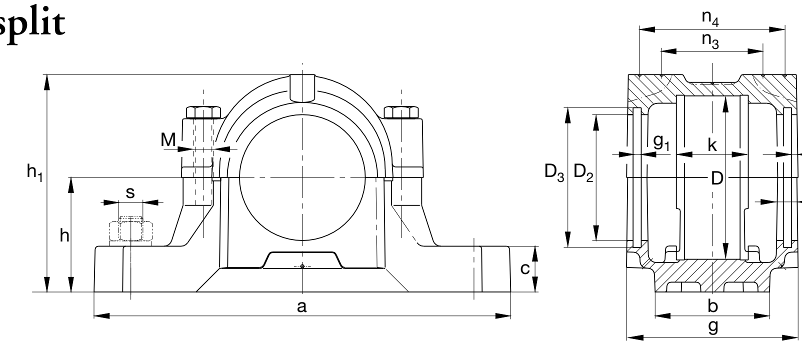
D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	**Mass** ≈
mm							mm	inch	mm																			kg
125	275	80	30	105	80	230	M16	$^5/_8$	18	23	158	112	120.5	118.2	5	5.25	15	120.3	39	190	52	220	48	57	86	M12	–	6.5

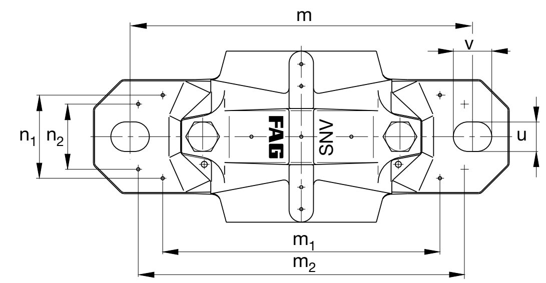
Shaft d_1 d		d_2	**Bearings which fit the housing** Unsplit bearings					Split spherical roller bearing	**Required accessories** Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*					**FAG**	**FAG**	**FAG**	**FAG**	**FAG**	**FAG**	**FAG**	**FAG**	**FAG**
70		80	6214	1214	20214					KM14	MB14A	FRM125/7,5	DH214	TSV214	FSV214	DKV150
		80				2214	22214			KM14	MB14A	FRM125/4	DH214	TSV214	FSV214	DKV150

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Plummer Block Housings, split

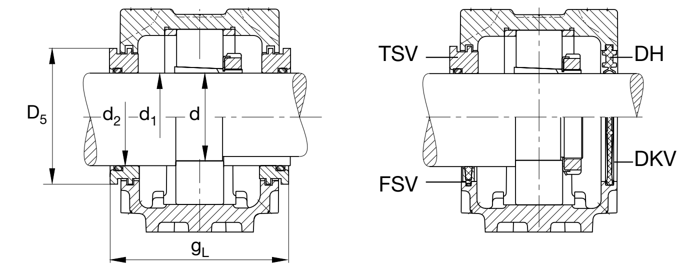
for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





Bearing with tapered bore and adapter sleeve

Bearing with cylindrical bore



SNV130

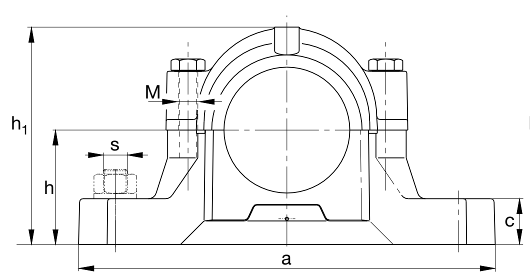
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
130	280	80	30	120	80	230	M16	$^5/_8$	18	23	161	102.5	111	108.7	5	4	12.5	134	56	190	60	220	48	76	104	M12	–	6.8

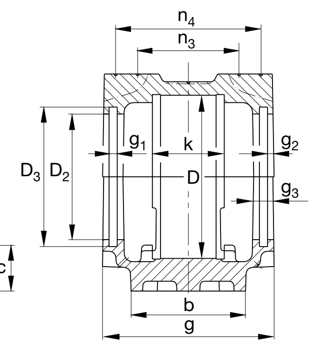
Shaft d_1 d		d_2	Bearings which fit the housing: Unsplit bearings						Split spherical roller bearing	Required accessories: Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
53.975	$2^1/_8$			1312K	20312K	21312K				H312.202			FRM130/12,5	DH612	TSV612.202	FSV612.202	DKV130
							2312K	22312K		H2312.202			FRM130/5	DH612	TSV612.202	FSV612.202	DKV130
55				1312K	20312K	21312K				H312			FRM130/12,5	DH612	TSV612	FSV612	DKV130
							2312K	22312K		H2312			FRM130/5	DH612	TSV612	FSV612	DKV130
60		70	6312	1312	20312	21312					KM12	MB12A	FRM130/12,5	DH312	TSV312	FSV312	DKV130
		70					2312	22312			KM12	MB12A	FRM130/5	DH312	TSV312	FSV312	DKV130
61.913	$2^7/_{16}$			1215K	20215K					H215.207			FRM130/15,5	DH515.207	TSV515.207	FSV515.207	DKV130
							2215K	22215K		H315.207			FRM130/12,5	DH515.207	TSV515.207	FSV515.207	DKV130
									222S.207				FRM130/12,5	DH515.207	TSV515.207	FSV515.207	DKV130
63.5	$2^1/_2$			1215K	20215K					H215.208			FRM130/15,5	DH515.207	TSV515.208	FSV515.208	DKV130
							2215K	22215K		H315.208			FRM130/12,5	DH515.207	TSV515.208	FSV515.208	DKV130
									222S.208				FRM130/12,5	DH515.207	TSV515.208	FSV515.208	DKV130
65				1215K	20215K					H215			FRM130/15,5	DH515	TSV515	FSV515	DKV130
							2215K	22215K		H315			FRM130/12,5	DH515	TSV515	FSV515	DKV130
									222SM65T				FRM130/12,5	DH515	TSV515	FSV515	DKV130
66.675	$2^5/_8$			1215K	20215K					H215.210			FRM130/15,5	DH515	TSV515.210	FSV515.210	DKV130
							2215K	22215K		H315.210			FRM130/12,5	DH515	TSV515.210	FSV515.210	DKV130
75		85	6215	1215	20215						KM15	MB15A	FRM130/15,5	DH215	TSV215	FSV215	DKV130
		85					2215	22215			KM15	MB15A	FRM130/12,5	DH215	TSV215	FSV215	DKV130

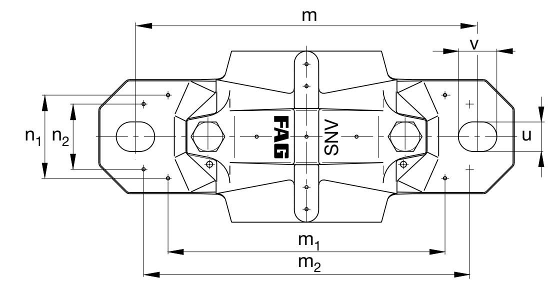
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

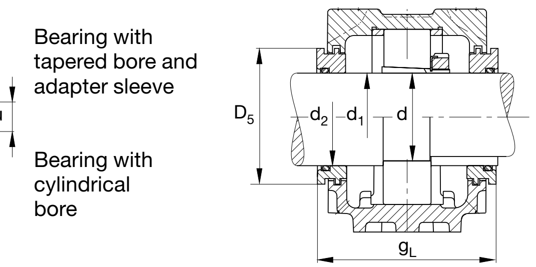
FAG Plummer Block Housings, split

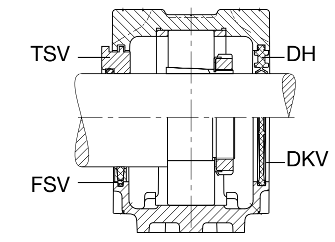
for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve











SNV140

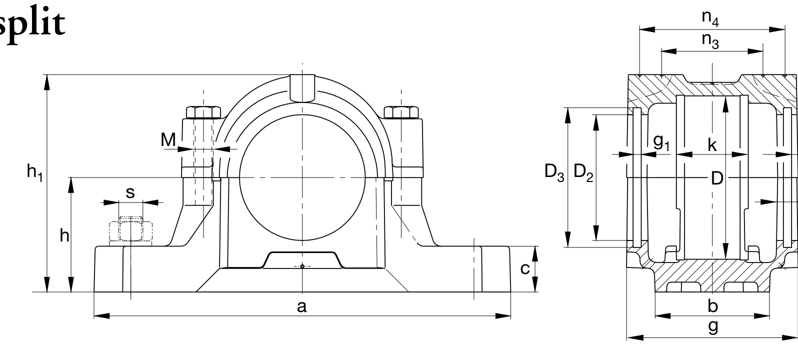
Dimensions D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
140	315	90	32	135	95	260	M20	$^{3}/_{4}$	22	27	183	108	116.5	114.2	5	5.25	15	150.3	58	210	65	252	52	81	117	M12	–	9.3

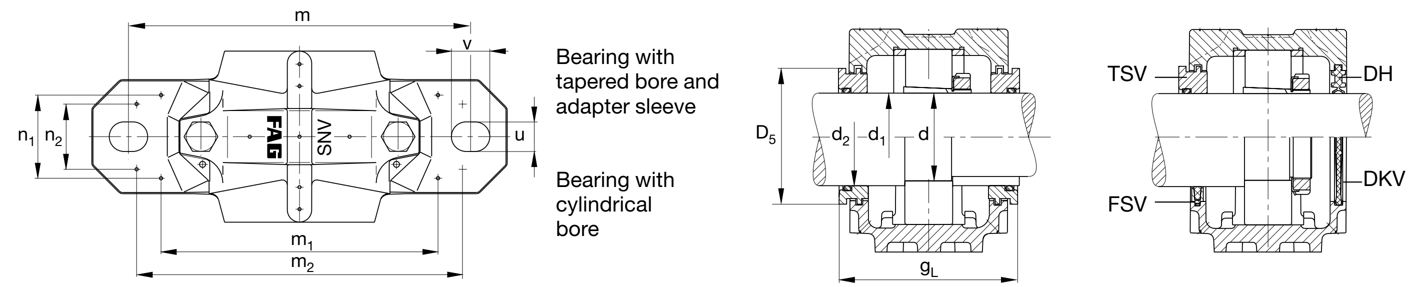
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings						Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
55.563	$2^{3}/_{16}$			1313K	20313K	21313K				H313.203			FRM140/12,5	DH613.203	TSV613.203	FSV613.203	DKV140
							2313K	22313K		H2313.203			FRM140/5	DH613.203	TSV613.203	FSV613.203	DKV140
57.15	$2^{1}/_{4}$			1313K	20313K	21313K				H313.204			FRM140/12,5	DH613.203	TSV613.204	FSV613.204	DKV140
							2313K	22313K		H2313.204			FRM140/5	DH613.203	TSV613.204	FSV613.204	DKV140
60				1313K	20313K	21313K				H313			FRM140/12,5	DH613	TSV613	FSV613	DKV140
							2313K	22313K		H2313			FRM140/5	DH613	TSV613	FSV613	DKV140
60.325	$2^{3}/_{8}$			1313K	20313K	21313K				H313.206			FRM140/12,5	DH613	TSV613	FSV613	DKV140
							2313K	22313K		H2313.206			FRM140/5	DH613	TSV613	FSV613	DKV140
65		75	6313	1313	20313	21313					KM13	MB13A	FRM140/12,5	DH313	TSV313	FSV313	DKV140
		75					2313	22313			KM13	MB13A	FRM140/5	DH313	TSV313	FSV313	DKV140
68.263	$2^{11}/_{16}$			1216K	20216K					H216.211			FRM140/16	DH516.211	TSV516.211	FSV516.211	DKV140
							2216K	22216K		H316.211			FRM140/12,5	DH516.211	TSV516.211	FSV516.211	DKV140
									222S.211				FRM140/12,5	DH516.211	TSV516.211	FSV516.211	DKV140
69.85	$2^{3}/_{4}$			1216K	20216K					H216.212			FRM140/16	DH516	TSV516	FSV516	DKV140
							2216K	22216K		H316.212			FRM140/12,5	DH516	TSV516	FSV516	DKV140
70				1216K	20216K					H216			FRM140/16	DH516	TSV516	FSV516	DKV140
							2216K	22216K		H316			FRM140/12,5	DH516	TSV516	FSV516	DKV140
									222SM70T				FRM140/12,5	DH516	TSV516	FSV516	DKV140
73.025	$2^{7}/_{8}$			1216K	20216K					H216.214			FRM140/16	DH516.214	TSV516.214	FSV516.214	DKV140
							2216K	22216K		H316.214			FRM140/12,5	DH516.214	TSV516.214	FSV516.214	DKV140
80		90	6216	1216	20216						KM16	MB16A	FRM140/16	DH216	TSV216	FSV216	DKV140
		90					2216	22216			KM16	MB16A	FRM140/12,5	DH216	TSV216	FSV216	DKV140

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV150

Dimensions

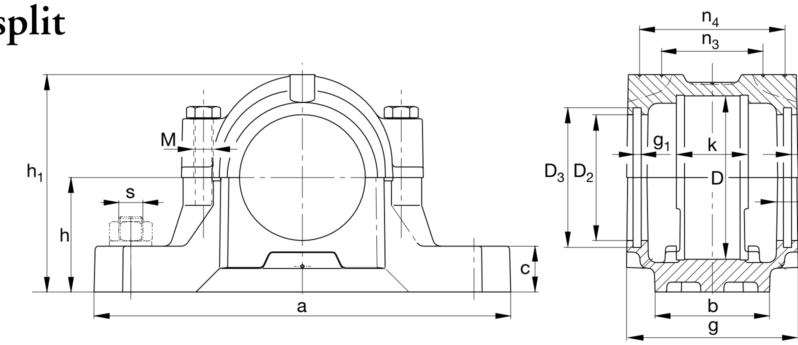
D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	**Mass** ≈
mm							mm	inch	mm																			kg
150	320	90	32	140	95	260	M20	$^3/_4$	22	27	189	112	120.5	118.2	5	5.25	15	155.3	61	210	66	252	52	85	122	M12	–	9.9

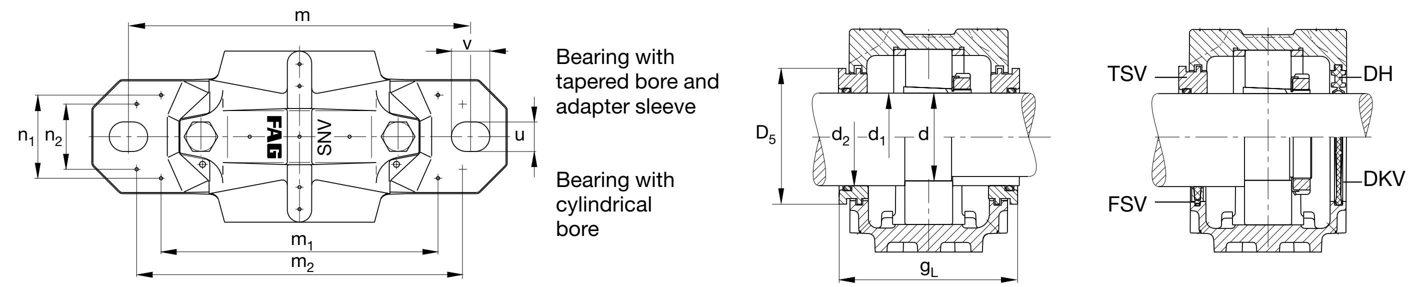
Shaft d_1 d		d_2	**Bearings which fit the housing** Unsplit bearings						Split spherical roller bearing	**Required accessories** Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
70		80	6314	1314	20314	21314					KM14	MB14A	FRM150/13	DH214	TSV214	FSV214	DKV150
		80					2314	22314			KM14	MB14A	FRM150/5	DH214	TSV214	FSV214	DKV150
74.613	$2^{15}/_{16}$			1217K	20217K					H217.215			FRM150/16,5	DH517	TSV517	FSV517	DKV150
							2217K	22217K		H317.215			FRM150/12,5	DH517	TSV517	FSV517	DKV150
									222S.215				FRM150/12,5	DH517	TSV517	FSV517	DKV150
75				1217K	20217K					H217			FRM150/16,5	DH517	TSV517	FSV517	DKV150
							2217K	22217K		H317			FRM150/12,5	DH517	TSV517	FSV517	DKV150
									222SM75T				FRM150/12,5	DH517	TSV517	FSV517	DKV150
76.2	3			1217K	20217K					H217.300			FRM150/16,5	DH517	TSV517.300	FSV517.300	DKV150
							2217K	22217K		H317.300			FRM150/12,5	DH517	TSV517.300	FSV517.300	DKV150
									222S.300				FRM150/12,5	DH517	TSV517.300	FSV517.300	DKV150
85		95	6217	1217	20217						KM17	MB17A	FRM150/16,5	DH217	TSV217	FSV217	DKV150
		95					2217	22217			KM17	MB17A	FRM150/12,5	DH217	TSV217	FSV217	DKV150

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV160

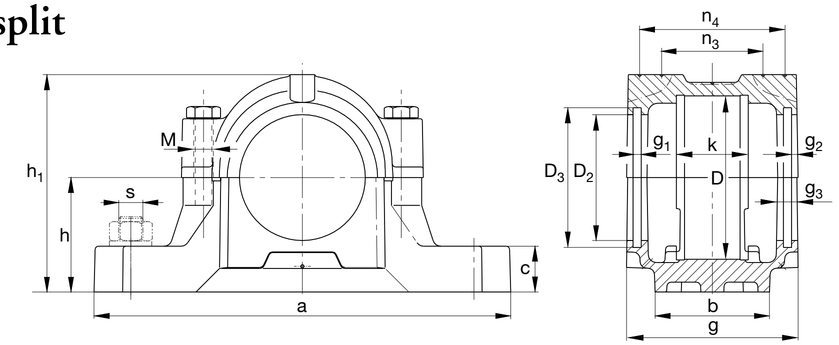
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
160	345	100	35	145	100	290	M20	$^3/_4$	22	27	201	120	128.5	125.7	5	5.25	15	160.3	65	240	72	280	58	90	127	M16	–	12.8

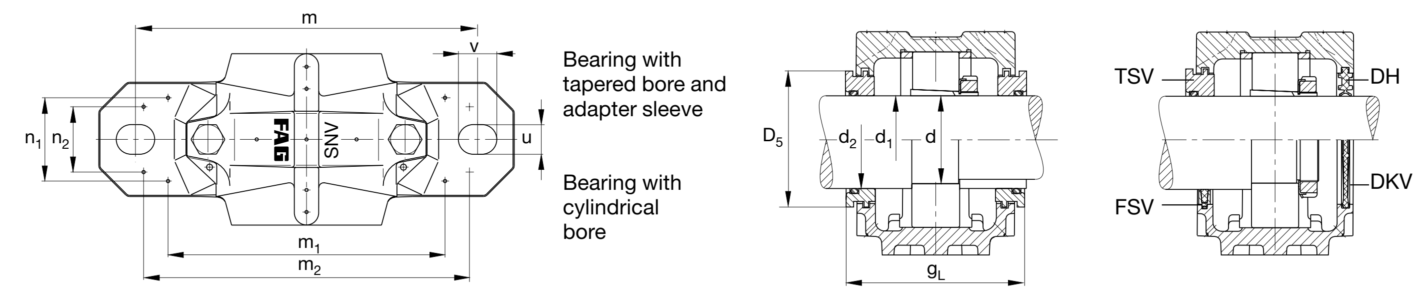
Shaft d_1 d		d_2	Bearings which fit the housing: Unsplit bearings							Split spherical roller bearing	Required accessories: Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*							FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
61.913	$2^7/_{16}$			1315K	20315K	21315K					H315.207			FRM160/14	DH615.207	TSV615.207	FSV615.207	DKV160
							2315K	22315K			H2315.207			FRM160/5	DH615.207	TSV615.207	FSV615.207	DKV160
63.5	$2^1/_2$			1315K	20315K	21315K					H315.208			FRM160/14	DH615.207	TSV615.208	FSV615.208	DKV160
							2315K	22315K			H2315.208			FRM160/5	DH615.207	TSV615.208	FSV615.208	DKV160
65				1315K	20315K	21315K					H315			FRM160/14	DH615	TSV615	FSV615	DKV160
							2315K	22315K			H2315			FRM160/5	DH615	TSV615	FSV615	DKV160
66.675	$2^5/_8$			1315K	20315K	21315K					H315.210			FRM160/14	DH615	TSV615.210	FSV615.210	DKV160
							2315K	22315K			H2315.210			FRM160/5	DH615	TSV615.210	FSV615.210	DKV160
75		85	6315	1315	20315	21315						KM15	MB15A	FRM160/14	DH315	TSV315	FSV315	DKV160
		85					2315	22315				KM15	MB15A	FRM160/5	DH315	TSV315	FSV315	DKV160
79.375	$3^1/_8$			1218K	20218K						H218.302			FRM160/17,5	DH518	TSV518.302	FSV518	DKV160
							2218K	22218K			H318.302			FRM160/12,5	DH518	TSV518.302	FSV518	DKV160
									23218K		H2318.302			FRM160/6,3	DH518	TSV518.302	FSV518	DKV160
80				1218K	20218K						H218			FRM160/17,5	DH518	TSV518	FSV518	DKV160
							2218K	22218K			H318			FRM160/12,5	DH518	TSV518	FSV518	DKV160
										222SM80T				FRM160/12,5	DH518	TSV518	FSV518	DKV160
									23218K		H2318			FRM160/6,3	DH518	TSV518	FSV518	DKV160
80.963	$3^3/_{16}$			1218K	20218K						H218.303			FRM160/17,5	DH518	TSV518.303	FSV518.303	DKV160
							2218K	22218K			H318.303			FRM160/12,5	DH518	TSV518.303	FSV518.303	DKV160
										222S.303				FRM160/12,5	DH518	TSV518.303	FSV518.303	DKV160
									23218K		H2318.303			FRM160/6,3	DH518	TSV518.303	FSV518.303	DKV160
82.55	$3^1/_4$			1218K	20218K						H218.304			FRM160/17,5	DH518.304	TSV518.304	FSV518.304	DKV160
							2218K	22218K			H318.304			FRM160/12,5	DH518.304	TSV518.304	FSV518.304	DKV160
										222S.304				FRM160/12,5	DH518.304	TSV518.304	FSV518.304	DKV160
									23218K		H2318.304			FRM160/6,3	DH518.304	TSV518.304	FSV518.304	DKV160
90		100	6218	1218	20218							KM18	MB18A	FRM160/17,5	DH218	TSV218	FSV218	DKV160
		100					2218	22218				KM18	MB18A	FRM160/12,5	DH218	TSV218	FSV218	DKV160
		100							23218			KM18	MB18A	FRM160/6,3	DH218	TSV218	FSV218	DKV160

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV170

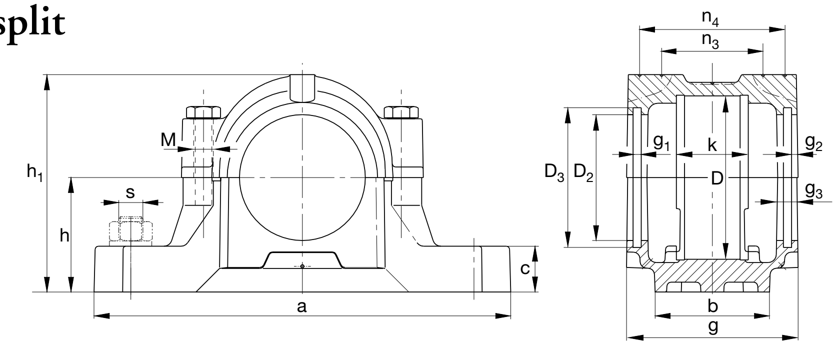
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
170	345	100	35	150	112	290	M20	$^3/_4$	22	27	219	131	141	138.2	6	5.25	16	167.3	68	240	74	280	58	93	132	M16	–	14.4

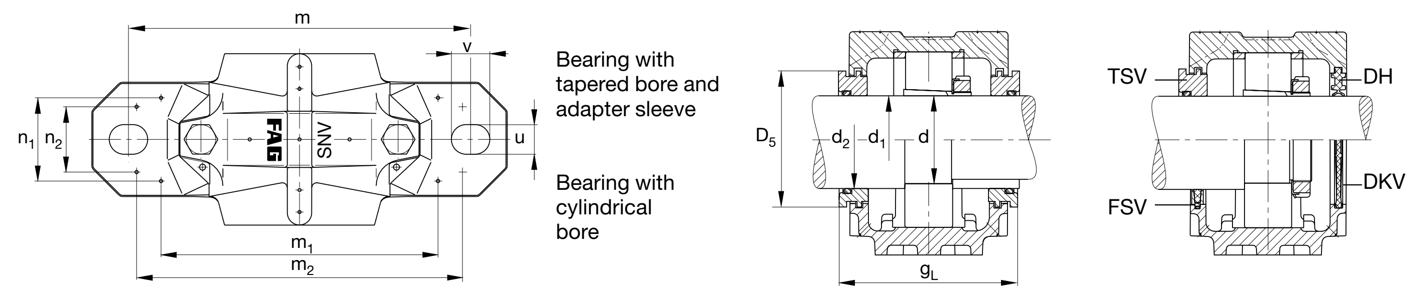
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings						Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*						FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
68.263	$2^{11}/_{16}$			1316K	20316K	21316K				H316.211			FRM170/14,5	DH616.211	TSV616.211	FSV616.211	DKV170
							2316K	22316K		H2316.211			FRM170/5	DH616.211	TSV616.211	FSV616.211	DKV170
69.85	$2^3/_4$			1316K	20316K	21316K				H316.212			FRM170/14,5	DH616	TSV616	FSV616	DKV170
							2316K	22316K		H2316.212			FRM170/5	DH616	TSV616	FSV616	DKV170
70				1316K	20316K	21316K				H316			FRM170/14,5	DH616	TSV616	FSV616	DKV170
							2316K	22316K		H2316			FRM170/5	DH616	TSV616	FSV616	DKV170
73.025	$2^7/_8$			1316K	20316K	21316K				H316.214			FRM170/14,5	DH616.214	TSV616.214	FSV616.214	DKV170
							2316K	22316K		H2316.214			FRM170/5	DH616.214	TSV616.214	FSV616.214	DKV170
80		90	6316	1316	20316	21316					KM16	MB16A	FRM170/14,5	DH316	TSV316	FSV316	DKV170
		90					2316	22316			KM16	MB16A	FRM170/5	DH316	TSV316	FSV316	DKV170
85				1219K	20219K					H219			FRM170/18	DH519	TSV519	FSV519	DKV170
							2219K	22219K		H319			FRM170/12,5	DH519	TSV519	FSV519	DKV170
									222SM85T				FRM170/12,5	DH519	TSV519	FSV519	DKV170
85.725	$3^3/_8$			1219K	20219K					H219.306			FRM170/18	DH519	TSV519.306	FSV519	DKV170
							2219K	22219K		H319.306			FRM170/12,5	DH519	TSV519.306	FSV519	DKV170
95		110	6219	1219	20219						KM19	MB19A	FRM170/18	DH219	TSV219	FSV219	DKV170
		110					2219	22219			KM19	MB19A	FRM170/12,5	DH219	TSV219	FSV219	DKV170

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV180

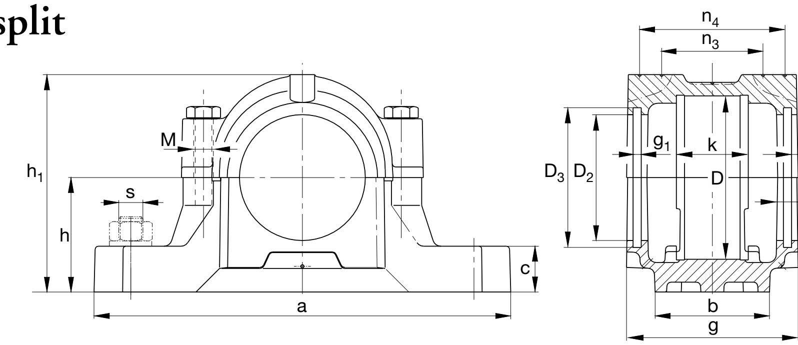
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
180	380	110	40	160	112	320	M24	$^7/_8$	26	32	223	137.5	147.5	144.7	6	5.25	16	177.3	70	261	80	300	66	99	142	M20	–	17

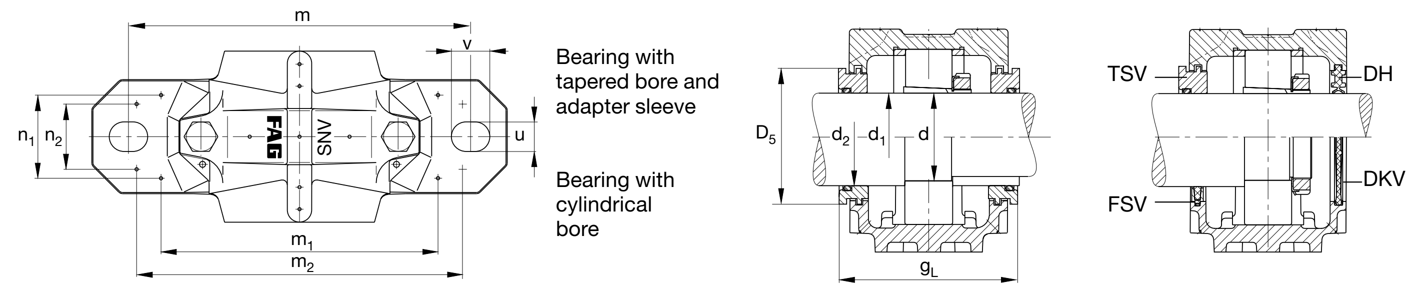
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings							Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*							FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
74.613	$2^{15}/_{16}$			1317K	20317K	21317K					H317.215			FRM180/14,5	DH617	TSV617	FSV617	DKV180
							2317K	22317K			H2317.215			FRM180/5	DH617	TSV617	FSV617	DKV180
75				1317K	20317K	21317K					H317			FRM180/14,5	DH617	TSV617	FSV617	DKV180
							2317K	22317K			H2317			FRM180/5	DH617	TSV617	FSV617	DKV180
76.2	3			1317K	20317K	21317K					H317.300			FRM180/14,5	DH617	TSV617.300	FSV617.300	DKV180
							2317K	22317K			H2317.300			FRM180/5	DH617	TSV617.300	FSV617.300	DKV180
85		95	6317	1317	20317	21317						KM17	MB17A	FRM180/14,5	DH317	TSV317	FSV317	DKV180
		95					2317	22317				KM17	MB17A	FRM180/5	DH317	TSV317	FSV317	DKV180
87.313	$3^7/_{16}$			1220K	20220K						H220.307			FRM180/18	DH520.307	TSV520.307	FSV520.307	DKV180
							2220K	22220K			H320.307			FRM180/12	DH520.307	TSV520.307	FSV520.307	DKV180
										222S.307				FRM180/12	DH520.307	TSV520.307	FSV520.307	DKV180
									23220K		H2320.307			FRM180/4,85	DH520.307	TSV520.307	FSV520.307	DKV180
88.9	$3^1/_2$			1220K	20220K						H220.308			FRM180/18	DH520	TSV520.308	FSV520.308	DKV180
							2220K	22220K			H320.308			FRM180/12	DH520	TSV520.308	FSV520.308	DKV180
										222S.308				FRM180/12	DH520	TSV520.308	FSV520.308	DKV180
									23220K		H2320.308			FRM180/4,85	DH520	TSV520.308	FSV520.308	DKV180
90				1220K	20220K						H220			FRM180/18	DH520	TSV520	FSV520	DKV180
							2220K	22220K			H320			FRM180/12	DH520	TSV520	FSV520	DKV180
										222SM90T				FRM180/12	DH520	TSV520	FSV520	DKV180
									23220K		H2320			FRM180/4,85	DH520	TSV520	FSV520	DKV180
92.075	$3^5/_8$			1220K	20220K						H220.310			FRM180/18	DH520.310	TSV520.310	FSV520.310	DKV180
							2220K	22220K			H320.310			FRM180/12	DH520.310	TSV520.310	FSV520.310	DKV180
									23220K		H2320.310			FRM180/4,85	DH520.310	TSV520.310	FSV520.310	DKV180
93.663	$3^{11}/_{16}$			1220K	20220K						H220.311			FRM 180/18	DH520.310	TSV520.311	FSV520.311	DKV180
							2220K	22220K			H320.311			FRM180/12	DH520.310	TSV520.311	FSV520.311	DKV180
									23220K		H2320.311			FRM180/4,85	DH520.310	TSV520.311	FSV520.311	DKV180
100		115	6220	1220	20220							KM20	MB20A	FRM180/18	DH220	TSV220	FSV220	DKV180
		115					2220	22220				KM20	MB20A	FRM180/12	DH220	TSV220	FSV220	DKV180
		115							23220			KM20	MB20A	FRM180/4,85	DH220	TSV220	FSV220	DKV180

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV190

Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3
mm							mm	inch	mm				
190	380	110	40	155	112	320	M24	$^7/_8$	26	32	229	120	128.5

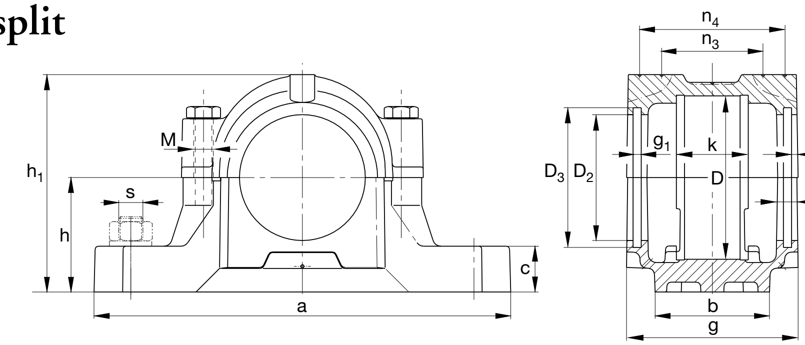
D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈ kg
125.7	5	5.25	15	170.3	74	271	81	300	66	99	137	M20	–	22

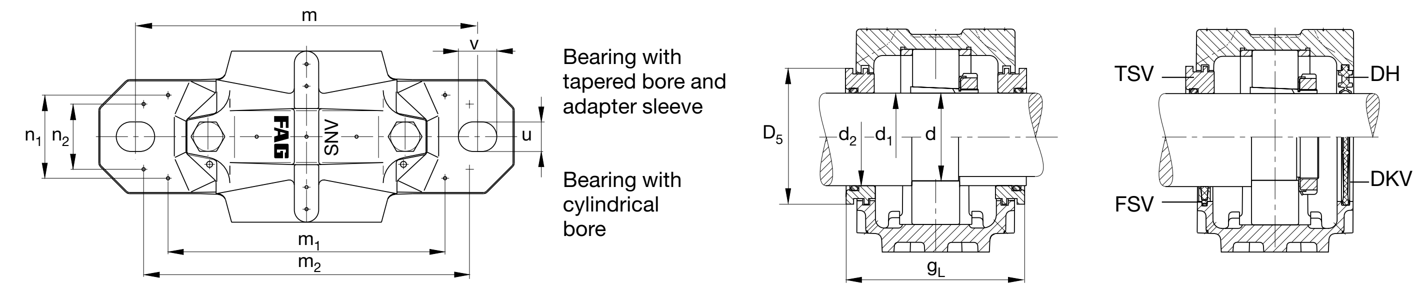
Shaft d_1 / d mm	inch	d_2 mm	Bearings which fit the housing: Unsplit bearings — Codes according to DIN*						Split spherical roller bearing FAG	Required accessories: Adapter sleeve FAG	Locknut FAG	Lock washer FAG	Locating ring 2 pieces FAG	Two-lip seal FAG	Labyrinth ring with O ring FAG	Felt seal FAG	Cover FAG
79.375	**$3^1/_8$**			1318K	20318K	21318K				H318.302			FRM190/15,5	DH518	TSV518.302	FSV518	DKV160
							2318K	22318K		H2318.302			FRM190/5	DH518	TSV518.302	FSV518	DKV160
80				1318K	20318K	21318K				H318			FRM190/15,5	DH518	TSV518	FSV518	DKV160
							2318K	22318K		H2318			FRM190/5	DH518	TSV518	FSV518	DKV160
80.963	**$3^3/_{16}$**			1318K	20318K	21318K				H318.303			FRM190/15,5	DH518	TSV518.303	FSV518.303	DKV160
							2318K	22318K		H2318.303			FRM190/5	DH518	TSV518.303	FSV518.303	DKV160
82.55	**$3^1/_4$**			1318K	20318K	21318K				H318.304			FRM190/15,5	DH518.304	TSV518.304	FSV518.304	DKV160
							2318K	22318K		H2318.304			FRM190/5	DH518.304	TSV518.304	FSV518.304	DKV160
90		105	6318	1318	20318	21318					KM18	MB18A	FRM190/15,5	DH318	TSV318	FSV318	DKV160
		105					2318	22318			KM18	MB18A	FRM190/5	DH318	TSV318	FSV318	DKV160

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV200

Dimensions

D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	**Mass** ≈
mm							mm	inch	mm																			kg
200	410	120	45	175	125	350	M24	$^7/_8$	26	32	248	147.5	157.5	154.7	6	5.25	16	192.3[1])	80	291	88	320	74	111	157	M20	–	21

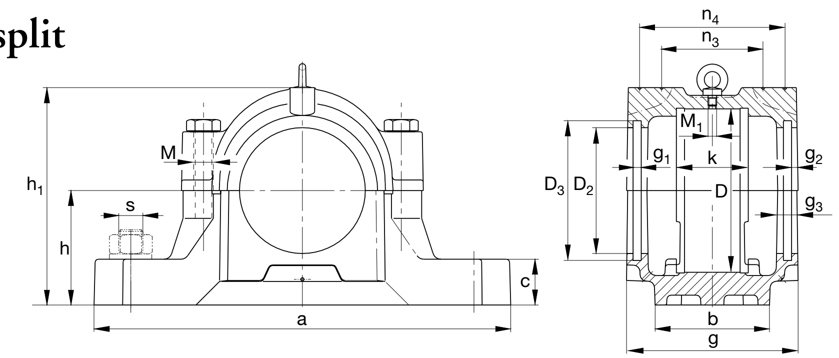
Shaft d_1 d		d_2	**Bearings which fit the housing** Unsplit bearings							Split spherical roller bearing	**Required accessories** Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*							FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
85				1319K	20319K	21319K					H319			FRM200/17,5	DH619	TSV619	FSV619	DKV200
							2319K	22319K			H2319			FRM200/6,5	DH619	TSV619	FSV619	DKV200
85.725	$3^3/_8$			1319K	20319K	21319K					H319.306			FRM200/17,5	DH619	TSV619.306	FSV619	DKV200
							2319K	22319K			H2319.306			FRM200/6,5	DH619	TSV619.306	FSV619	DKV200
95		110	6319	1319	20319	21319						KM19	MB19A	FRM200/17,5	DH319	TSV319	FSV319	DKV200
		110					2319	22319				KM19	MB19A	FRM200/6,5	DH319	TSV319	FSV319	DKV200
95.25	$3^3/_4$			1222K	20222K						H222.312			FRM200/21	DH522.312	TSV522.312	FSV522.312	DKV200
								22222K			H322.312			FRM200/13,5	DH522.312	TSV522.312	FSV522.312	DKV200
									23222K		H2322.312			FRM200/5,1	DH522.312	TSV522.312	FSV522.312	DKV200
98.425	$3^7/_8$			1222K	20222K						H222.314			FRM200/21	DH522.314	TSV522.314	FSV522.314	DKV200
								22222K			H322.314			FRM200/13,5	DH522.314	TSV522.314	FSV522.314	DKV200
									23222K		H2322.314			FRM200/5,1	DH522.314	TSV522.314	FSV522.314	DKV200
100				1222K	20222K						H222			FRM200/21	DH522	TSV522	FSV522	DKV200
								22222K			H322			FRM200/13,5	DH522	TSV522	FSV522	DKV200
										222SM100T				FRM200/13,5	DH522	TSV522	FSV522	DKV200
									23222K		H2322			FRM200/5,1	DH522	TSV522	FSV522	DKV200
100.013	$3^{15}/_{16}$			1222K	20222K						H222.315			FRM200/21	DH522	TSV522	FSV522	DKV200
								22222K			H322.315			FRM200/13,5	DH522	TSV522	FSV522	DKV200
									23222K		H2322.315			FRM200/5,1	DH522	TSV522	FSV522	DKV200
101.6	4			1222K	20222K						H222.400			FRM200/21	DH522	TSV522.400	FSV522.400	DKV200
								22222K			H322.400			FRM200/13,5	DH522	TSV522.400	FSV522.400	DKV200
										222S.400				FRM200/13,5	DH522	TSV522.400	FSV522.400	DKV200
									23222K		H2322.400			FRM200/5,1	DH522	TSV522.400	FSV522.400	DKV200
110		125	6222	1222	20222							KM22	MB22	FRM200/21	DH222	TSV222	FSV222	DKV200
		125						22222				KM22	MB22	FRM200/13,5	DH222	TSV222	FSV222	DKV200
		125							23222			KM22	MB22	FRM200/5,1	DH222	TSV222	FSV222	DKV200

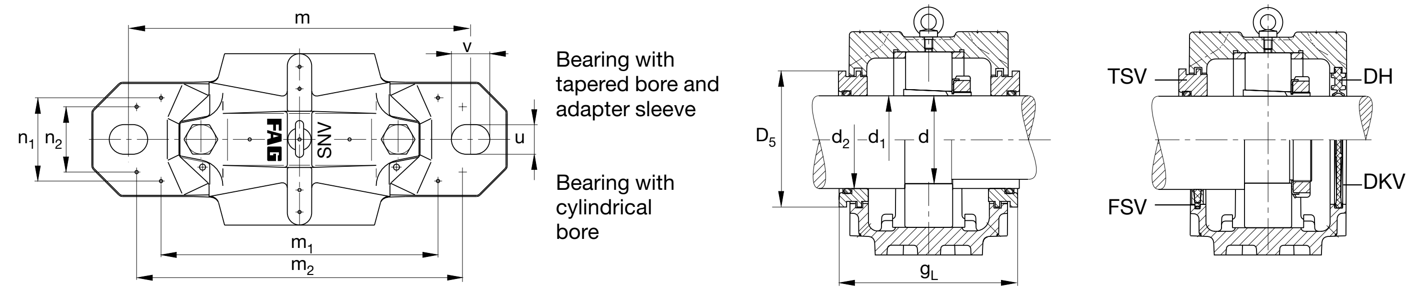
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

[1]) g_L = 195.3 mm at TSV522.312, TSV522.314, TSV522, TSV522.400 and TSV222

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV215

Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
215	410	120	45	180	140	350	M24	$^{7}/_{8}$	26	32	271	157.5	167.5	164.7	6	5.25	16	197.3[1])	86	297	91	330	74	117	162	M20	M10	24.5

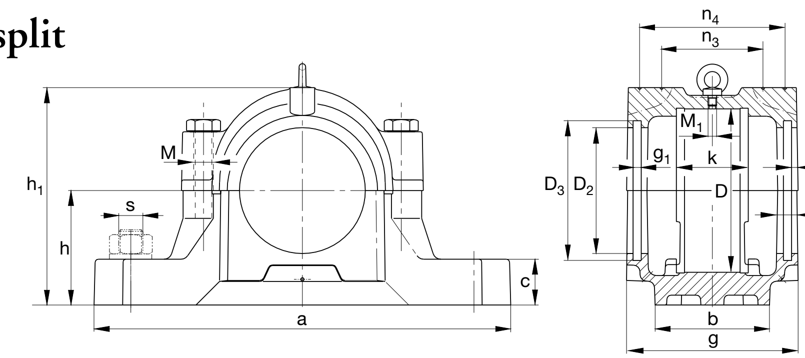
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings							Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*							FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
87.313	$3^{7}/_{16}$			1320K	20320K	21320K					H320.307			FRM215/19,5	DH620.307	TSV620.307	FSV620.307	DKV215
							2320K	22320K			H2320.307			FRM215/6,5	DH620.307	TSV620.307	FSV620.307	DKV215
88.9	$3^{1}/_{2}$			1320K	20320K	21320K					H320.308			FRM215/19,5	DH620	TSV620.308	FSV620.308	DKV215
							2320K	22320K			H2320.308			FRM215/6,5	DH620	TSV620.308	FSV620.308	DKV215
90				1320K	20320K	21320K					H320			FRM215/19,5	DH620	TSV620	FSV620	DKV215
							2320K	22320K			H2320			FRM215/6,5	DH620	TSV620	FSV620	DKV215
92.075	$3^{5}/_{8}$			1320K	20320K	21320K					H320.310			FRM215/19,5	DH620.310	TSV620.310	FSV620.310	DKV215
							2320K	22320K			H2320.310			FRM215/6,5	DH620.310	TSV620.310	FSV620.310	DKV215
93.663	$3^{11}/_{16}$			1320K	20320K	21320K					H320.311			FRM215/19,5	DH620.310	TSV620.311	FSV620.311	DKV215
							2320K	22320K			H2320.311			FRM215/6,5	DH620.310	TSV620.311	FSV620.311	DKV215
100		115	6320	1320	20320	21320						KM20	MB20A	FRM215/19,5	DH320	TSV320	FSV320	DKV215
		115					2320	22320				KM20	MB20A	FRM215/6,5	DH320	TSV320	FSV320	DKV215
106.363	$4^{3}/_{16}$				20224K						H3024.403			FRM215/23	DH524.403	TSV524.403	FSV524.403	DKV215
								22224K			H3124.403			FRM215/14	DH524.403	TSV524.403	FSV524.403	DKV215
										222S.403				FRM215/14	DH524.403	TSV524.403	FSV524.403	DKV215
									23224K		H2324.403			FRM215/5	DH524.403	TSV524.403	FSV524.403	DKV215
107.95	$4^{1}/_{4}$				20224K						H3024.404			FRM215/23	DH524.403	TSV524.404	FSV524.404	DKV215
								22224K			H3124.404			FRM215/14	DH524.403	TSV524.404	FSV524.404	DKV215
									23224K		H2324.404			FRM215/5	DH524.403	TSV524.404	FSV524.404	DKV215
110					20224K						H3024			FRM215/23	DH524	TSV524	FSV524	DKV215
								22224K			H3124			FRM215/14	DH524	TSV524	FSV524	DKV215
										222SM110T				FRM215/14	DH524	TSV524	FSV524	DKV215
									23224K		H2324			FRM215/5	DH524	TSV524	FSV524	DKV215
120		135	6224		20224							KM24	MB24	FRM215/23	DH224	TSV224	FSV224	DKV215
		135						22224				KM24	MB24	FRM215/14	DH224	TSV224	FSV224	DKV215
		135							23224			KM24	MB24	FRM215/5	DH224	TSV224	FSV224	DKV215

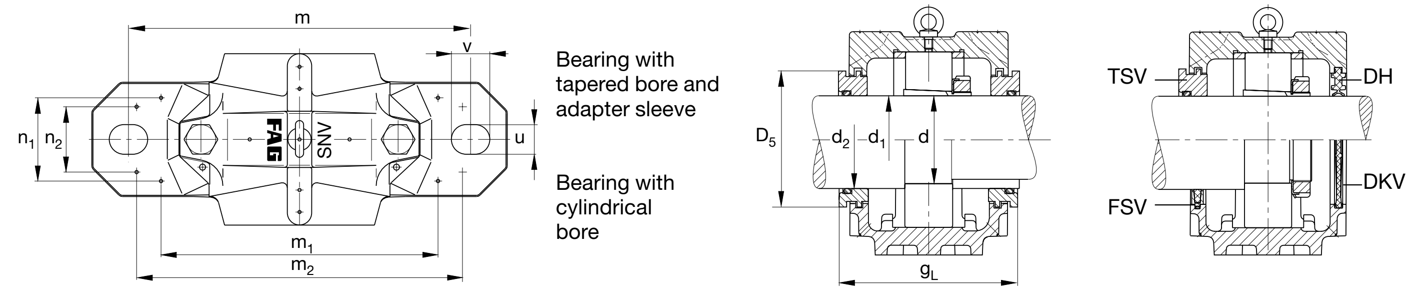
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

[1]) g_L = 200.3 mm at TSV524.403, TSV524.404, TSV524 and TSV224

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV230

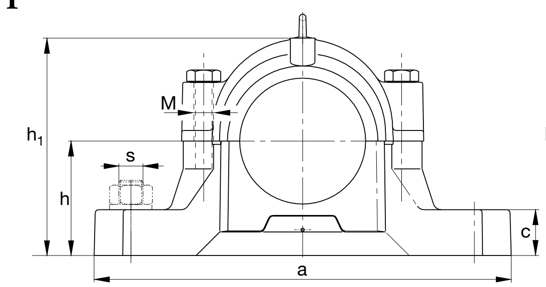
Dimensions D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
230	445	130	50	190	150	380	M24	1	28	35	291	167.5	177.5	174.7	6	6.25	18	208.3	90	325	97	370	80	122	170	M24	M10	30

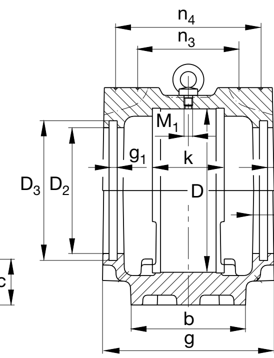
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings				Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*				FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
112.713	4 7/16			20226K				H3026.407			FRM230/25	DH526.407	TSV526.407	FSV526.407	DKV230
					22226K			H3126.407			FRM230/13	DH526.407	TSV526.407	FSV526.407	DKV230
							222S.407				FRM230/13	DH526.407	TSV526.407	FSV526.407	DKV230
						23226K		H2326.407			FRM230/5	DH526.407	TSV526.407	FSV526.407	DKV230
114.3	4 1/2			20226K				H3026.408			FRM230/25	DH526	TSV526.408	FSV526	DKV230
					22226K			H3126.408			FRM230/13	DH526	TSV526.408	FSV526	DKV230
							222S.408				FRM230/13	DH526	TSV526.408	FSV526	DKV230
						23226K		H2326.408			FRM230/5	DH526	TSV526.408	FSV526	DKV230
115				20226K				H3026			FRM230/25	DH526	TSV526	FSV526	DKV230
					22226K			H3126			FRM230/13	DH526	TSV526	FSV526	DKV230
							222SM115T				FRM230/13	DH526	TSV526	FSV526	DKV230
						23226K		H2326			FRM230/5	DH526	TSV526	FSV526	DKV230
120.65	4 3/4			20226K				H3026.412			FRM230/25	DH526.412	TSV526.412	FSV526.412	DKV230
					22226K			H3126.412			FRM230/13	DH526.412	TSV526.412	FSV526.412	DKV230
						23226K		H2326.412			FRM230/5	DH526.412	TSV526.412	FSV526.412	DKV230
130		145	6226	20226					KM26	MB26	FRM230/25	DH226	TSV226	FSV226	DKV230
		145			22226				KM26	MB26	FRM230/13	DH226	TSV226	FSV226	DKV230
		145				23226			KM26	MB26	FRM230/5	DH226	TSV226	FSV226	DKV230

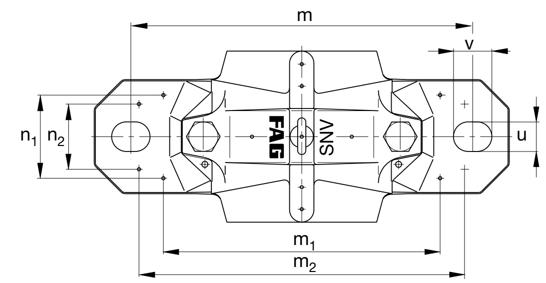
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

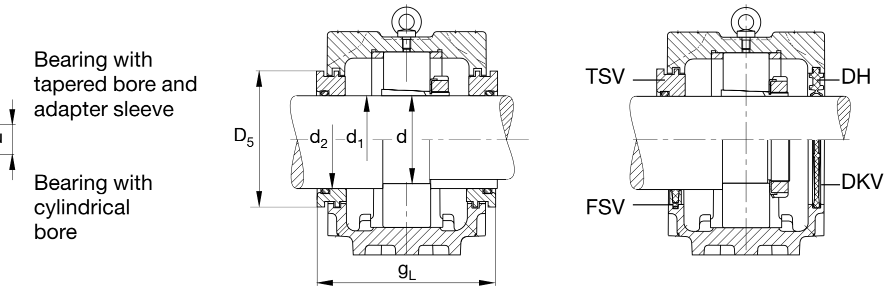
FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve









SNV240

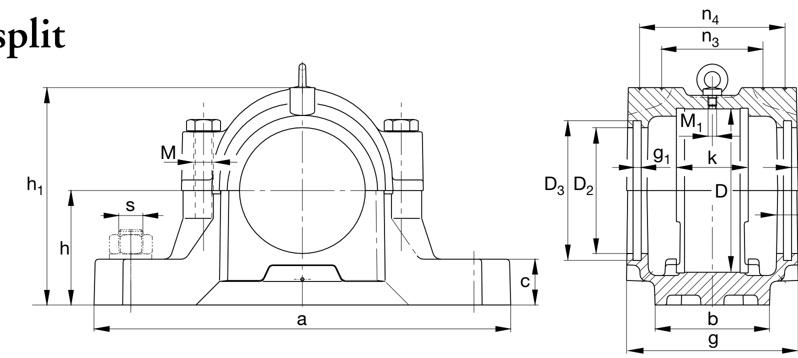
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
240	450	130	50	185	150	390	M24	1	28	35	298	147.5	157.5	154.7	6	6.25	18	203.3	90	328	96	370	80	120	165	M24	M10	32

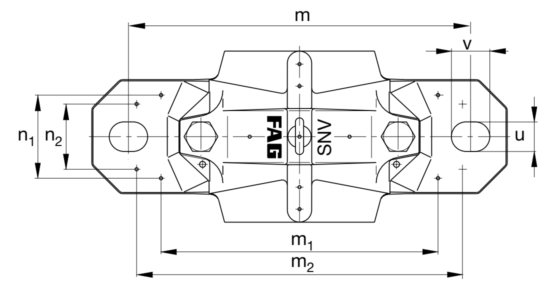
Shaft d_1 d		d_2	Bearings which fit the housing: Unsplit bearings				Split spherical roller bearing	Required accessories: Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*				FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
95.25	$3^3/_4$			20322K	21322K			H322.312			FRM240/20	DH522.312	TSV522.312	FSV522.312	DKV200
						22322K		H2322.312			FRM240/5	DH522.312	TSV522.312	FSV522.312	DKV200
98.425	$3^7/_8$			20322K	21322K			H322.314			FRM240/20	DH522.314	TSV522.314	FSV522.314	DKV200
						22322K		H2322.314			FRM240/5	DH522.314	TSV522.314	FSV522.314	DKV200
100				20322K	21322K			H322			FRM240/20	DH522	TSV522	FSV522	DKV200
						22322K		H2322			FRM240/5	DH522	TSV522	FSV522	DKV200
100.013	$3^{15}/_{16}$			20322K	21322K			H322.315			FRM240/20	DH522	TSV522	FSV522	DKV200
						22322K		H2322.315			FRM240/5	DH522	TSV522	FSV522	DKV200
101.6	4			20322K	21322K			H322.400			FRM240/20	DH522	TSV522.400	FSV522.400	DKV200
						22322K		H2322.400			FRM240/5	DH522	TSV522.400	FSV522.400	DKV200
110		125	6322	20322	21322				KM22	MB22	FRM240/20	DH222	TSV222	FSV222	DKV200
		125				22322			KM22	MB22	FRM240/5	DH222	TSV222	FSV222	DKV200

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Plummer Block Housings, split

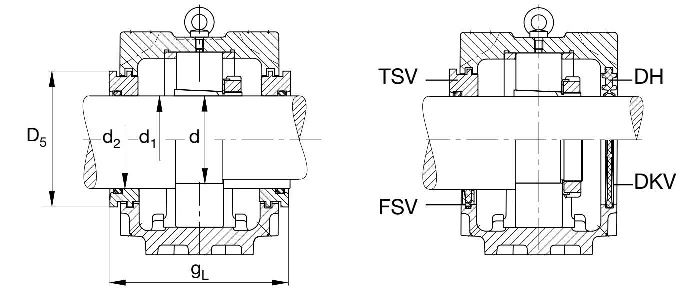
for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





Bearing with tapered bore and adapter sleeve

Bearing with cylindrical bore



SNV250

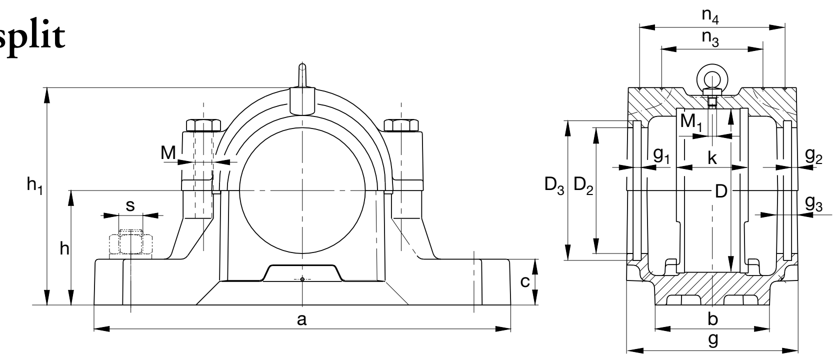
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	**Mass** ≈
mm							mm	inch	mm																			kg
250	500	150	50	200	150	420	M30	$1^1/_4$	35	42	304	177.5	187.5	184.2	6	6.25	18	218.3	98	342	109	400	92	131	180	M24	M10	38

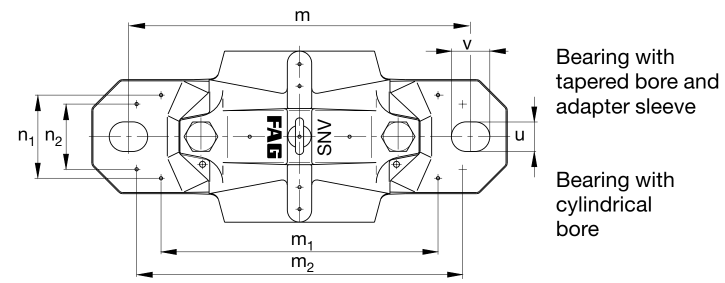
Shaft d_1 d		d_2	**Bearings which fit the housing** Unsplit bearings				Split spherical roller bearing	**Required accessories** Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*				FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
125				20228K				H3028			FRM250/28	DH528	TSV528	FSV528	DKV250
					22228K			H3128			FRM250/15	DH528	TSV528	FSV528	DKV250
							222SM125T				FRM250/15	DH528	TSV528	FSV528	DKV250
						23228K		H2328			FRM250/5	DH528	TSV528	FSV528	DKV250
125.413	$4^{15}/_{16}$			20228K				H3028.415			FRM250/28	DH528	TSV528.415	FSV528	DKV250
					22228K			H3128.415			FRM250/15	DH528	TSV528.415	FSV528	DKV250
						23228K		H2328.415			FRM250/5	DH528	TSV528.415	FSV528	DKV250
127	5			20228K				H3028.500			FRM250/28	DH528	TSV528.500	FSV528.500	DKV250
					22228K			H3128.500			FRM250/15	DH528	TSV528.500	FSV528.500	DKV250
							222S.500				FRM250/15	DH528	TSV528.500	FSV528.500	DKV250
						23228K		H2328.500			FRM250/5	DH528	TSV528.500	FSV528.500	DKV250
140		155	6228	20228					KM28	MB28	FRM250/28	DH228	TSV228	FSV228	DKV250
		155			22228				KM28	MB28	FRM250/15	DH228	TSV228	FSV228	DKV250
		155				23228			KM28	MB28	FRM250/5	DH228	TSV228	FSV228	DKV250

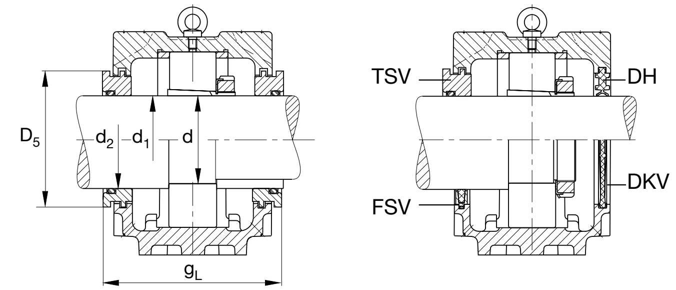
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve







SNV260

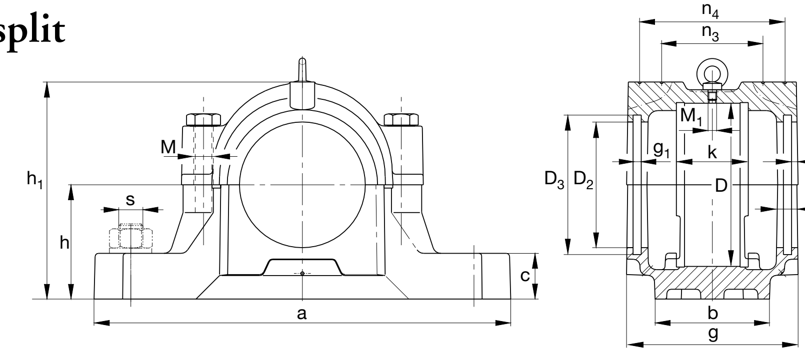
Dimensions D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
260	530	160	60	190	160	450	M30	$1^1/_4$	35	42	321	157.5	167.5	164.7	6	6.25	18	208.3	96	372	113	430	100	125	170	M24	M10	48

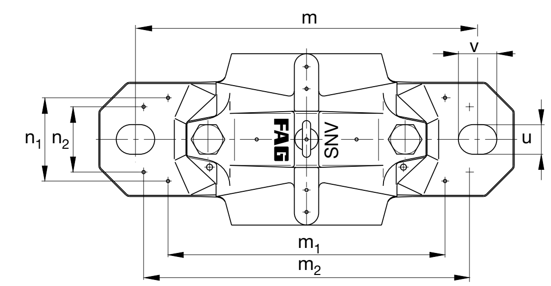
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings			Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*			FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
106.363	$4^3/_{16}$			20324K			H3124.403			FRM260/20,5	DH524.403	TSV524.403	FSV524.403	DKV215
					22324K		H2324.403			FRM260/5	DH524.403	TSV524.403	FSV524.403	DKV215
107.95	$4^1/_4$			20324K			H3124.404			FRM260/20,5	DH524.403	TSV524.404	FSV524.404	DKV215
					22324K		H2324.404			FRM260/5	DH524.403	TSV524.404	FSV524.404	DKV215
110				20324K			H3124			FRM260/20,5	DH524	TSV524	FSV524	DKV215
					22324K		H2324			FRM260/5	DH524	TSV524	FSV524	DKV215
120		135	6324	20324				KM24	MB24	FRM260/20,5	DH224	TSV224	FSV224	DKV215
		135			22324			KM24	MB24	FRM260/5	DH224	TSV224	FSV224	DKV215

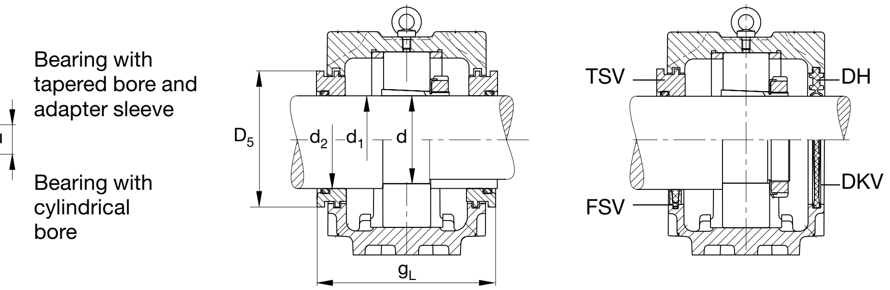
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve







SNV270

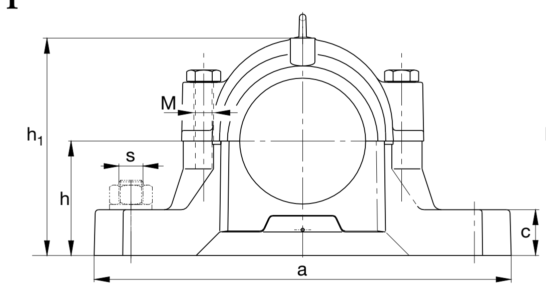
Dimensions D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
270	530	160	60	215	160	450	M30	$1^1/_4$	35	42	328	192.5	202.5	199.2	6	6.25	18	233.3	106	372	116	430	100	143	195	M24	M10	45.5

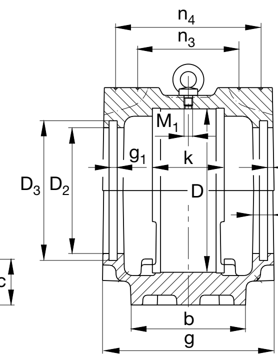
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings				Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*				FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
131.763	$5^3/_{16}$			20230K				H3030.503			FRM270/30,5	DH530.503	TSV530.503	FSV530.503	DKV270
					22230K			H3130.503			FRM270/16,5	DH530.503	TSV530.503	FSV530.503	DKV270
							222S.503				FRM270/16,5	DH530.503	TSV530.503	FSV530.503	DKV270
						23230K		H2330.503			FRM270/5	DH530.503	TSV530.503	FSV530.503	DKV270
133.35	$5^1/_4$			20230K				H3030.504			FRM270/30,5	DH530.504	TSV530.504	FSV530.504	DKV270
					22230K			H3130.504			FRM270/16,5	DH530.504	TSV530.504	FSV530.504	DKV270
						23230K		H2330.504			FRM270/5	DH530.504	TSV530.504	FSV530.504	DKV270
135				20230K				H3030			FRM270/30,5	DH530	TSV530	FSV530	DKV270
					22230K			H3130			FRM270/16,5	DH530	TSV530	FSV530	DKV270
							222SM135T				FRM270/16,5	DH530	TSV530	FSV530	DKV270
						23230K		H2330			FRM270/5	DH530	TSV530	FSV530	DKV270
150		165	6230	20230					KM30	MB30	FRM270/30,5	DH230	TSV230	FSV230	DKV270
		165			22230				KM30	MB30	FRM270/16,5	DH230	TSV230	FSV230	DKV270
		165				23230			KM30	MB30	FRM270/5	DH230	TSV230	FSV230	DKV270

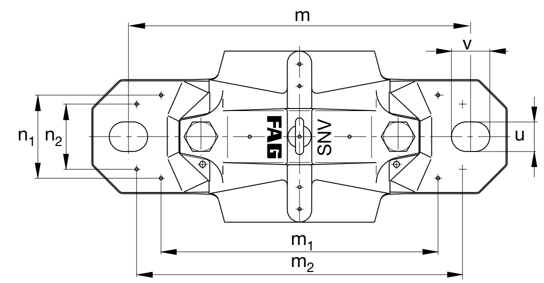
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve

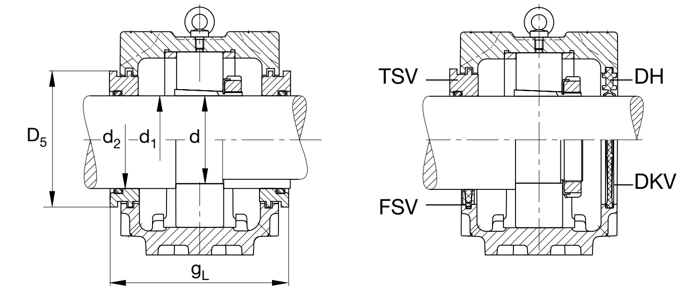






Bearing with
tapered bore and
adapter sleeve

Bearing with
cylindrical
bore



SNV280

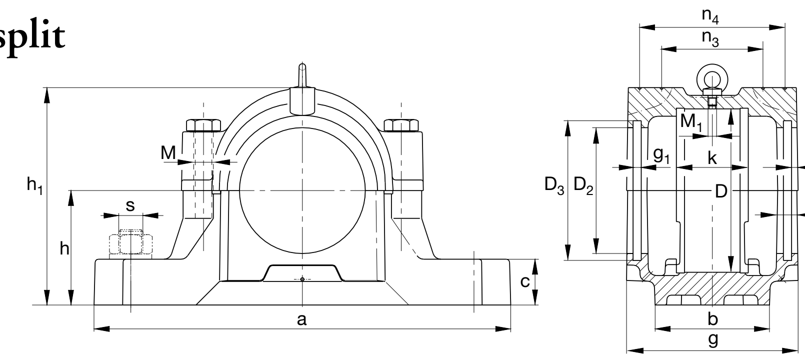
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
280	550	160	60	205	170	470	M30	$1^1/_4$	35	42	344	167.5	177.5	174.7	6	6.25	18	223.3	103	392	114	450	100	136	185	M24	M10	55

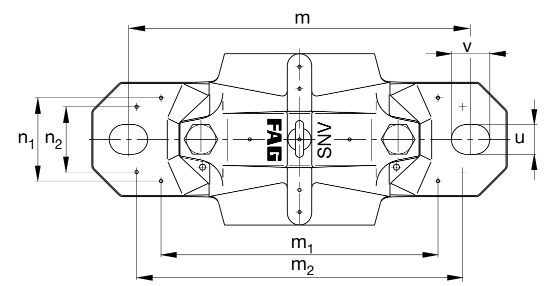
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings			Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*			FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
112.713	$4^7/_{16}$			20326K			H3126.407			FRM280/22,5	DH526.407	TSV526.407	FSV526.407	DKV230
					22326K		H2326.407			FRM280/5	DH526.407	TSV526.407	FSV526.407	DKV230
114.3	$4^1/_2$			20326K			H3126.408			FRM280/22,5	DH526	TSV526.408	FSV526	DKV230
					22326K		H2326.408			FRM280/5	DH526	TSV526.408	FSV526	DKV230
115				20326K			H3126			FRM280/22,5	DH526	TSV526	FSV526	DKV230
					22326K		H2326			FRM280/5	DH526	TSV526	FSV526	DKV230
120.65	$4^3/_4$			20326K			H3126.412			FRM280/22,5	DH526.412	TSV526.412	FSV526.412	DKV230
					22326K		H2326.412			FRM280/5	DH526.412	TSV526.412	FSV526.412	DKV230
130		150	6326	20326				KM26	MB26	FRM280/22,5	DH326	TSV326	FSV326	DKV230
		150			22326			KM26	MB26	FRM280/5	DH326	TSV326	FSV326	DKV230

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Plummer Block Housings, split

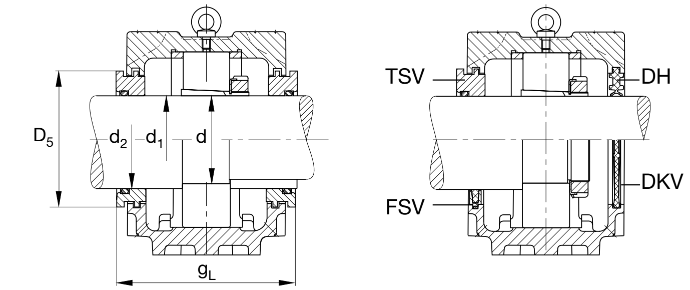
for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





Bearing with tapered bore and adapter sleeve

Bearing with cylindrical bore



SNV290

Dimensions

D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3
mm							mm	inch	mm				
290	550	160	60	225	170	470	M30	$1^1/_4$	35	42	351	202.5	212.5

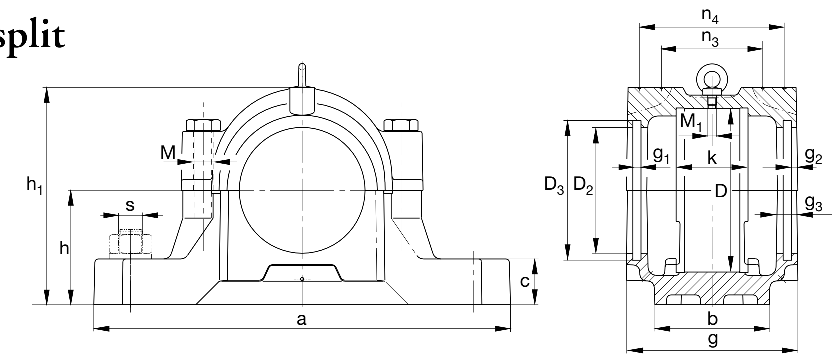
D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm														kg
209.2	6	6.25	18	243.3	114	392	120	450	100	152	205	M24	M10	53.8

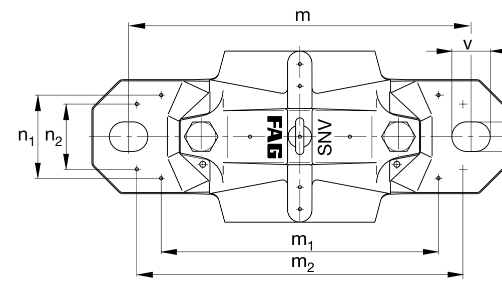
Shaft d_1 d		d_2	Bearings which fit the housing: Unsplit bearings				Split spherical roller bearing	Required accessories: Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*				FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
138.113	$5^7/_{16}$			20232K				H3032.507			FRM290/33	DH532.507	TSV532.507	FSV532.507	DKV290
					22232K			H3132.507			FRM290/17	DH532.507	TSV532.507	FSV532.507	DKV290
							222S.507				FRM290/17	DH532.507	TSV532.507	FSV532.507	DKV290
						23232K		H2332.507			FRM290/5	DH532.507	TSV532.507	FSV532.507	DKV290
139.7	$5^1/_2$			20232K				H3032.508			FRM290/33	DH532	TSV532	FSV532	DKV290
					22232K			H3132.508			FRM290/17	DH532	TSV532	FSV532	DKV290
						23232K		H2332.508			FRM290/5	DH532	TSV532	FSV532	DKV290
140				20232K				H3032			FRM290/33	DH532	TSV532	FSV532	DKV290
					22232K			H3132			FRM290/17	DH532	TSV532	FSV532	DKV290
							222SM140T				FRM290/17	DH532	TSV532	FSV532	DKV290
						23232K		H2332			FRM290/5	DH532	TSV532	FSV532	DKV290
160		175	6232	20232					KM32	MB32	FRM290/33	DH232	TSV232	FSV232	DKV290
		175			22232				KM32	MB32	FRM290/17	DH232	TSV232	FSV232	DKV290
		175				23232			KM32	MB32	FRM290/5	DH232	TSV232	FSV232	DKV290

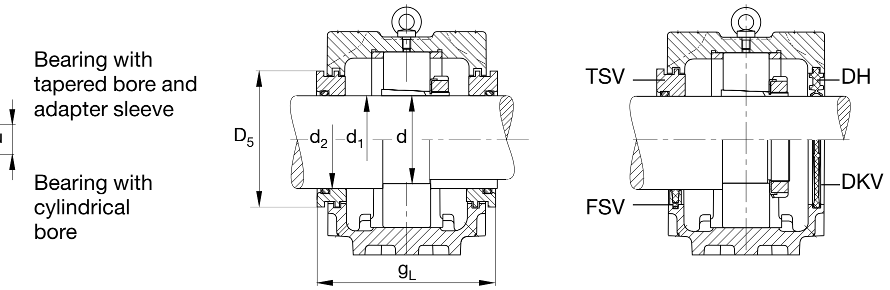
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve







SNV300

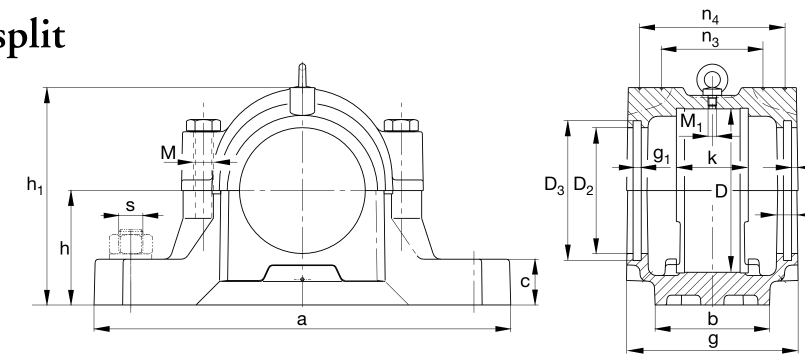
Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	Mass ≈
mm							mm	inch	mm																			kg
300	620	170	65	215	180	520	M30	$1^1/_4$	35	42	366	177.5	187.5	184.2	6	6.25	18	233.3	112	442	123	500	100	146	195	M24	M10	70

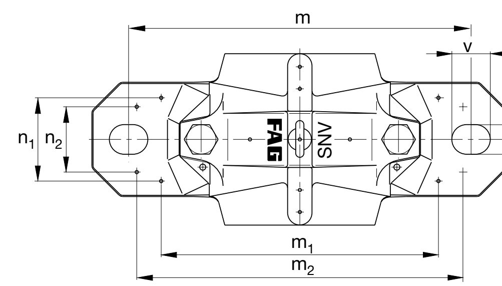
Shaft d_1 d		d_2	Bearings which fit the housing Unsplit bearings			Split spherical roller bearing	Required accessories Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*			FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG	FAG
125				20328K			H3128			FRM300/25	DH528	TSV528	FSV528	DKV250
					22328K		H2328			FRM300/5	DH528	TSV528	FSV528	DKV250
125.413	$4^{15}/_{16}$			20328K			H3128.415			FRM300/25	DH528	TSV528.415	FSV528	DKV250
					22328K		H2328.415			FRM300/5	DH528	TSV528.415	FSV528	DKV250
127	5			20328K			H3128.500			FRM300/25	DH528	TSV528.500	FSV528.500	DKV250
					22328K		H2328.500			FRM300/5	DH528	TSV528.500	FSV528.500	DKV250
140		160	6328	20328				KM28	MB28	FRM300/25	DH328	TSV328	FSV328	DKV250
		160			22328			KM28	MB28	FRM300/5	DH328	TSV328	FSV328	DKV250

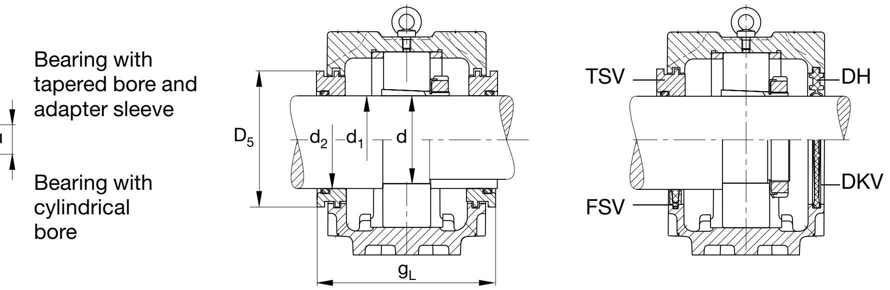
* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA “FAG Rolling Bearings”

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve







SNV320

Dimensions

D	a	b	c	g	h	m	s	s	u	v	h_1	D_2	D_3
mm							mm	inch	mm				
320	650	180	65	225	190	560	M30	$1^1/_4$	35	42	386	192.5	202.5

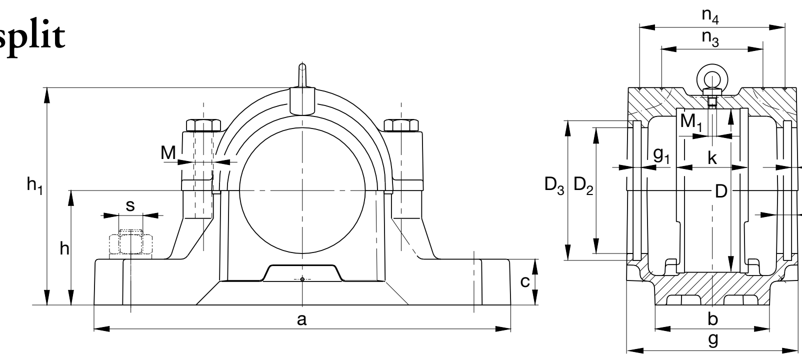
D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	**Mass** ≈
														kg
199.2	6	6.25	18	243.3	118	482	130	540	100	154	205	M24	M10	95

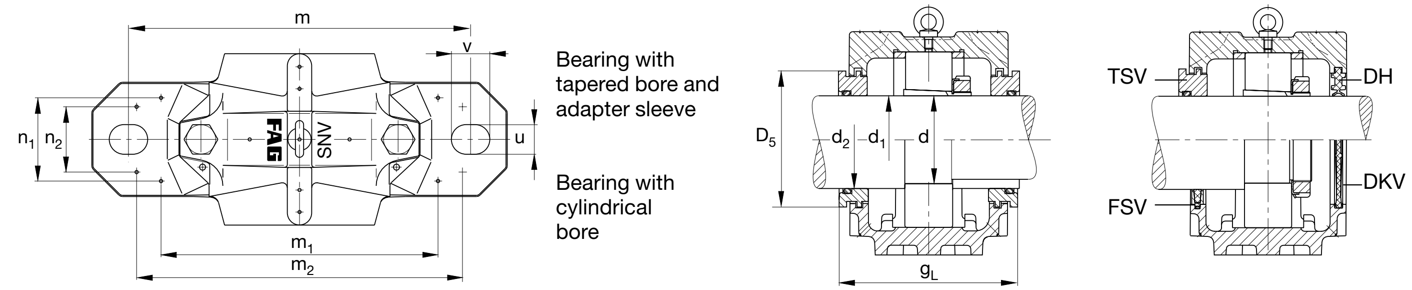
Shaft d_1 d mm	inch	d_2 mm	**Bearings which fit the housing** Unsplit bearings Codes according to DIN*			Split spherical roller bearing FAG	**Required accessories** Adapter sleeve FAG	Locknut FAG	Lock washer FAG	Locating ring 2 pieces FAG	Two-lip seal FAG	Labyrinth ring with O ring FAG	Felt seal FAG	Cover FAG
131.763	$5^3/_{16}$			20330K			H3130.503			FRM320/26,5	DH530.503	TSV530.503	FSV530.503	DKV270
					22330K		H2330.503			FRM320/5	DH530.503	TSV530.503	FSV530.503	DKV270
133.35	$5^1/_4$			20330K			H3130.504			FRM320/26,5	DH530.504	TSV530.504	FSV530.504	DKV270
					22330K		H2330.504			FRM320/5	DH530.504	TSV530.504	FSV530.504	DKV270
135				20330K			H3130			FRM320/26,5	DH530	TSV530	FSV530	DKV270
					22330K		H2330			FRM320/5	DH530	TSV530	FSV530	DKV270
150		170	6330	20330				KM30	MB30	FRM320/26,5	DH330	TSV330	FSV330	DKV270
		170			22330			KM30	MB30	FRM320/5	DH330	TSV330	FSV330	DKV270

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Plummer Block Housings, split

for bearings with cylindrical bore and
for bearings with tapered bore and adapter sleeve





SNV340

Dimensions D	a	b	c	g	h	m	s		u	v	h_1	D_2	D_3	D_5	g_1	g_2	g_3	g_L	k	m_1	n_1	m_2	n_2	n_3	n_4	M DIN 931	M_1 DIN 580	**Mass** ≈
mm							mm	inch	mm																			kg
340	680	190	70	235	200	580	M36	$1^1/_2$	42	50	406	202.5	212.5	209.2	6	6.25	18	253.3	124	489	138	570	100	162	215	M30	M10	115

Shaft d_1 d		d_2	**Bearings which fit the housing** Unsplit bearings			Split spherical roller bearing	**Required accessories** Adapter sleeve	Locknut	Lock washer	Locating ring 2 pieces	Two-lip seal	Labyrinth ring with O ring	Felt seal	Cover
mm	inch	mm	Codes according to DIN*			**FAG**	**FAG**	**FAG**	**FAG**	**FAG**	**FAG**	**FAG**	**FAG**	**FAG**
138.113	$5^7/_{16}$			20332K			H3132.507			FRM340/28	DH532.507	TSV532.507	FSV532.507	DKV290
					22332K		H2332.507			FRM340/5	DH532.507	TSV532.507	FSV532.507	DKV290
139.7	$5^1/_2$			20332K			H3132.508			FRM340/28	DH532	TSV532	FSV532	DKV290
					22332K		H2332.508			FRM340/5	DH532	TSV532	FSV532	DKV290
140				20332K			H3132			FRM340/28	DH532	TSV532	FSV532	DKV290
					22332K		H2332			FRM340/5	DH532	TSV532	FSV532	DKV290
160		180	6332	20332				KM32	MB32	FRM340/28	DH332	TSV332	FSV332	DKV290
		180			22332			KM32	MB32	FRM340/5	DH332	TSV332	FSV332	DKV290

* The order designation in the code according to DIN can be taken from the catalogue WL 41520EA "FAG Rolling Bearings"

FAG Split Plummer Block Housings of Series SNV
for shaft diameters of 20 to 160 mm and $^{3}/_{4}$ to $5^{1}/_{2}$ inches

Publl. No. WL 90118/3 EC

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FAG Split Plummer Block Housings of Series SNV

for shaft diameters of 20 to 160 mm and $^3/_4$ to $5^1/_2$ inches

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FAG

FAG S-TYPE BEARING UNITS

For simple, robust and economical bearing arrangements

FAG Sales Europe GmbH

For simple, robust and economical bearing arrangements

FAG S-type bearing units consist of a deep groove ball bearing with seals on both sides and a grey-cast iron housing (nodular cast iron housing on request) or a pressed-steel housing. The bearings' and housings' spherical fitting surfaces facilitate the compensation of misalignments.

AD+VANTAGES

+ Particularly cost-effective
+ Varied range of bearings in metric and inch dimensions for specific applications
+ High degree of availability from stock
+ Many possible combinations of housings and bearings

plus
- units are ready to mount
- easy mounting
- self-aligning
- maintenance-free after mounting
- insensitive to dirt, dust, moisture

The main fields of application of S-type bearing units are

- agricultural machines
- conveyor plants
- construction machines
- textile machines
- packing machines

Due to their good sealing – in some cases double sealing – they are particularly suitable for reliable, safe and long-term operation in dirty, dusty or moist environments. They can accommodate impacts and misalignments without problems.

S-type bearing units *)	S-type bearing Series 162	Series 362	Series 562	Series 762.2RSR
Plummer block housing of grey-cast iron Series P2	P162 d = 12 - 60 mm	P362 d = 20 - 90 mm	P562 d = 20 - 90 mm	P762.2RSR d = 17 - 60 mm
Flanged housing of grey-cast iron Series F2	F162 d = 12 - 60 mm	F362 d = 20 - 90 mm	F562 d = 20 - 90 mm	F762.2RSR d = 17 - 60 mm
Flanged housing of grey-cast iron Series FL2	FL162 d = 12 - 60 mm	FL362 d = 20 - 75 mm	FL562 d = 20 - 75 mm	FL762.2RSR d = 17 - 60 mm
Plummer block housing of grey-cast iron Series PA2	PA162 d = 20 - 60 mm	PA362 d = 20 - 60 mm	PA562 d = 20 - 60 mm	PA762..2RSR d = 20 - 60 mm
Flanged housing of grey-cast iron Series FC2	FC162 d = 20 - 60 mm	FC362 d = 20 - 90 mm	FC562 d = 20 - 90 mm	FC762..2RSR d = 20 - 60 mm
Take-up unit housing of grey-cast iron Series T2	T162 d = 20 - 60 mm	T362 d = 20 - 90 mm	T562 d = 20 - 90 mm	T762..2RSR d = 20 - 60 mm
Plummer block housing of pressed steel Series SB2	*) d = 12 - 35 mm			*) d = 17 - 35 mm
Flanged housing of pressed steel Series FB2	*) d = 12 - 50 mm	*) d = 20 - 50 mm	*) d = 20 - 50 mm	*) d = 17 - 50 mm
Flanged housing of pressed steel Series FBB2	*) d = 12 - 35 mm	*) d = 20 - 35 mm	*) d = 20 - 35 mm	*) d = 17 - 35 mm

*) Pressed-steel housings and S-type bearings are not available as units and must be ordered separately

S-type bearing units at the FAG Internet Shop
Just a mouse click away
www.fag.com/saleseurope

or ask for our technical publication WL 90115/3
"FAG S-Type Bearings · FAG S-Type Bearing Units".

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