SKF @ptitude Exchange

Bearings for Fans

Bearing arrangements for fans

Summary
The large variety of fans can be classified in different ways. Generally, there are two categories that are based on the fan's directions of airflow or gas moved: centrifugal fans and axial flow fans. This article, a reprint from the 1982 SKF "S-Range" handbook, covers the following areas as they relate to fans: bearing arrangements and lubrication. Guidelines for fan load calculations are adapted from the later SKF PI 113 E publication, 1987. The bearing designs and housings are subjected to change. Recommended bearing arrangements with spherical and CARB bearings are not included; see also SKF 4417 publication, "Self-Aligning Bearing Systems", 2000.

SKF @ptitude Exchange
SKF Reliability Systems
5271 Viewridge Court
San Diego, CA 92123
United States
tel. +1 858 496 3400
fax +1 858 496 3511
email: info@aptitudexchange.com
Internet: www.aptitudexchange.com

SKF_3213_E
SKF
13 Pages
Published 1982
Revised November, 2012

1. Fans – general

The large variety of fans at present available can be classified in different ways.

Based on the direction of the air flow or of the gas to be moved there are chiefly two types, namely centrifugal fans and axial flow fans. In more recent times tangential flow fans have also gained some importance; here the medium to be moved is introduced radially, transported over a certain range of the circumference by the blades of the impeller and then expelled radially.

The range of applications for fans is very wide and the demands placed on the bearings are equally varied, especially with regard to running noise and maintenance.

The impeller of a small fan is generally mounted on the extended shaft of an electric motor, whereas medium and large fans are fitted with separate bearing arrangements and are driven via couplings or V-belts. One field of application for medium fans is the ventilation of large rooms or workshops often in conjunction with air-conditioning plants. Large industrial fans are often classified according to their use, such as fresh air and hot gas fans for heating/power stations, cooling tower fans, converter fans, mine fans, tunnel fans etc.

The load acting on fan bearings is generally not too heavy. When selecting the bearings, however, the expected axial loads have to be considered for the majority of fans. It is also important to consider the extension of the shaft and temperature differences between the bearing inner and outer rings when designing the bearing arrangement.

It is recommended that bearings with C3 radial internal clearance are used when speeds exceed more than about 75 % of the limiting speed values given in the SKF General Catalogue; the same is true, at all speeds, for hot gas fans.

Generally the bearings can be used at operating temperatures up to +125 °C. Bearings with moulded cages of glass fibre reinforced polyamide can be used in the range -40 to +120 °C; higher temperatures, e.g. +130 or +140 °C, can be tolerated provided they act only for short periods and that the intervening periods at lower temperatures are relatively long.

As the requisite basic rating life values for the bearings vary according to the desired duration of service and operational safety, the guideline values shown in the table below may be taken.

Type of operation	L_{10h} operating hours
Intermittent	≦ 20 000
12 to 16 hours per day	40 000
24 hours per day with high operational reliability	≧ 60 000

Speed r/min	Unbalance % of impeller mass
1 000	30
2 000	60
3 000	90
4 000	125
5 000	150

Type of operation	Requisite basic rating life L_{10h} operating hours
Intermittent	≦ 20 000
12 to 16 h/day	40 000
24 h/day with high operational reliability	≧ 60 000

Selection of unit size

Normally, the instructions given in the SKF General Catalogue in the section entitled "Selection of bearing size" should be followed. A simple calculation method for the type of arrangement used for fans is presented in the following, this being the most common application for two-bearing units.

1. The load acting on each bearing produced by the masses of the shaft, impeller and pulley or coupling should be calculated.

2a. If a belt drive is used, the tension force should be calculated. First, the tangential force F_t is obtained using the equation

$$F_t = 19{,}1 \times 10^6 \times \frac{P}{n\, d_p}$$

where
F_t = tangential force, N
P = rating, kW
n = rotational speed, r/min
d_p = pitch diameter of pulley, mm

The tangential force F_t is then multiplied by a factor:
= 2 to 2,5 for V-belts
= 4 for flat belts
to obtain the tension force.

2b. The radial force F_r produced when a semi-flexible coupling is used can be obtained from

$$F_r = 5\,600 \sqrt{\frac{P}{n}}$$

where
F_r = radial force, N
P = rating, kW
n = rotational speed, r/min

3. The unbalance of the impeller is determined. Guideline values expressed as percentages of the impeller mass are given in the table above.

4. The axial load acting on the locating bearing, F_a, is calculated.

The axial load can be obtained from

$$F_a = \frac{\pi\, D_s^2\, H}{4 \times 10^6}$$

where
F_a = axial load, N
D_s = inlet diameter, mm
H = pressure differential, Pa

When calculating vertical shafts, the weight of the rotating parts must be added to or subtracted from the axial force exerted by the impeller, depending on the force direction.

5. The mean load F_m of the radial loads which have constant direction and the radial unbalance force is calculated using the method described in the SKF General Catalogue. The equivalent dynamic bearing load P can then be determined for each bearing. The larger of the values obtained should be used in the life equation.

6. Guideline values for the requisite basic rating life L_{10h} (in hours) are given in the table above.

Note: Adapted from SKF Product Information -113 E: "Two-Bearing Units", 1987, p.7

2. S-range of bearings for fans

The selection of bearings for a particular application is generally governed by the prevailing operating conditions, but may also be determined by various standards relating to that application. These factors, plus the wide experience gained by SKF over many years, have all been taken into account when selecting this S-Range. The complete S-Range of bearings for fans is shown, in matrix form, on pages I3 to 19. A wide range of housings is available for the various bearing types, see pages 30 to 33.

2.1. Bearing types

Deep groove ball bearings

Deep groove ball bearings are very suitable for high speed applications; compared with self-aligning ball bearings they can also take relatively heavy axial loads. Unlike Y-bearings and self-aligning ball bearings, however, deep groove ball bearings have a limited ability to accommodate errors of alignment, and this must be taken into consideration when designing the bearing housing.

Self-aligning ball bearings

These bearings are included in this S-Range mainly because of their ability to accommodate misalignment. They are used for light and medium duty fans where high speeds predominate. A gradual changeover to cages of glass fibre reinforced polyamide (designation suffix TN9) is being carried out. Bearings with this cage which are already in production are shown in the matrix, see page 14.

Self-aligning ball bearings are usually mounted in SNA plummer block housings. Where the relubrication interval is short the housing may be fitted with a grease nipple during mounting. Excessive grease must be allowed to escape and SKF can supply a special design of SNA housing with grease escape valve, type TAV, see SKF General Catalogue. If housing type TC or TG is preferred, a grease escape hole should be cut or drilled in the housing.

Angular contact ball bearings

Angular contact ball bearings are suitable where moderate axial loads are involved. A pair of these bearings, mounted back-to-back, can be incorporated as locating bearings into two-bearing housings instead of deep groove ball bearings.

Cylindrical roller bearings

These bearings perform favourably under high speeds and loads. They are normally used as non-locating bearings in two-bearing housings where paired angular contact ball bearings or deep groove ball bearings are used as locating bearings.

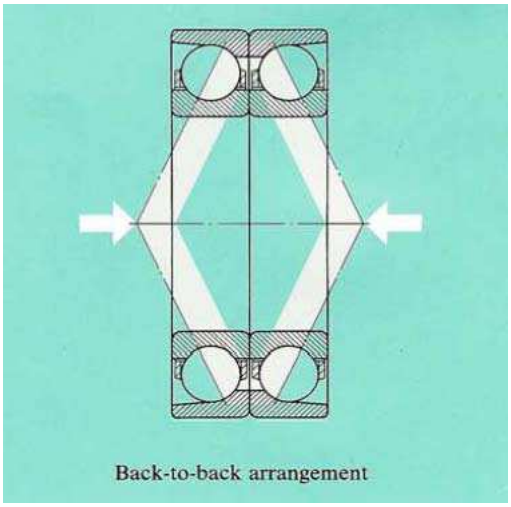
SKF has recently introduced a new standard design of cylindrical roller bearing which has increased radial and axial load carrying capacities and a cage of glass fibre reinforced polyamide (ECP design).

Spherical roller bearings

Spherical roller bearings are used for larger fans where a high carrying capacity and misalignment accommodation are required.

The CC type spherical roller bearings included in this S-Range have a high speed capability and give low running temperatures even under moderate axial loads.

SNA plummer blocks, often in connection with a grease escape valve, type TAV, are usually recommended. For shaft diameters over 140 mm at moderate speeds, SD 31 housings which incorporate labyrinth seals (designation suffix TS) are available. Where speeds are moderate to high, SOFN housings are recommended.



Back-to-back arrangement

Spherical roller thrust bearings

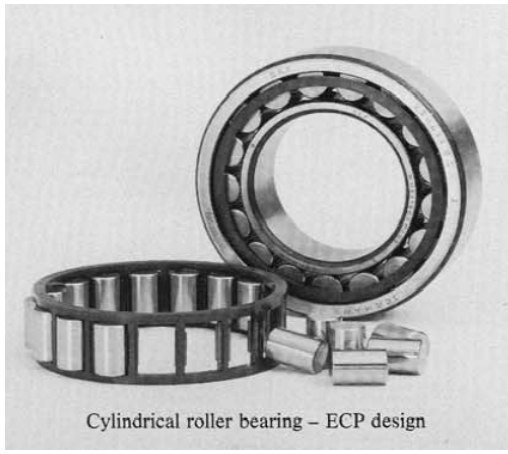
Spherical roller thrust bearings are used in horizontal and vertical fans where heavy axial loads have to be carried. The new E-type bearing has a higher load carrying capacity and also lower friction than the earlier designs. Generally spherical roller thrust bearings are utilized to take axial loads only, whilst the radial loads are taken by deep groove ball bearings, cylindrical roller bearings or spherical roller bearings.

Y-bearings

SKF Y-bearings are basically deep groove ball bearings which are fitted with very effective seals and are supplied already charged with the correct amount of grease. The permissible operating temperature range is -30 to +110 °C.

These bearings can accommodate a certain degree of initial misalignment by virtue of the sphered outside diameter and the corresponding sphered seating in the housing.

The limiting speeds for Y—bearings are governed by the method used to locate them on the shaft, see the SKF catalogue "Y-bearing units".



Cylindrical roller bearing – ECP design

2.2. Bearing data

Data on the bearings included in this S-Range with the exception of Y-bearings will be found in the SKF General Catalogue. For data on Y-bearings reference should be made to the SKF catalogue "Y-bearing units".

3. Bearing arrangement design

Bearing arrangements for fans may be designed in a variety of ways depending upon the size, operating conditions etc. and a wide range of rolling bearings would be required to cover every type of application.

Some typical bearing arrangements, which include S-Range bearings and appropriate housings, are included in this leaflet.

Particulars of suitable bearing seating tolerances are given in the application notes but it should be remembered that the selection of tolerances relates, in these instances, to the sizes of bearings applied. Consequently, for similar applications using bearings of other sizes. it may be necessary to select different tolerances for the shaft seatings. Recommendations regarding tolerance selection are to be found in the SKF General Catalogue. However, it is advisable to consult SKF about tolerances for fans for special operating conditions. e.g. hot gas fans.

A guide to the lubrication of the bearings in the various fans is also given in the notes, but SKF should be consulted whenever further information is desired concerning lubrication.

3.1. Bearing arrangements using Y-bearing units

Bearing selection

SKF Y-bearings are recommended for light duty fans with shaft diameters up to and including 50 mm, see matrix on page 19. These bearings have a zinc coated bore and an extended inner ring with eccentric locking collar.

Bearing arrangement

In the arrangement shown in fig 1 the fly-wheel of the fan is supported by Y-bearings mounted in cast iron housings. As both Y-bearings are located the sheet steel walls of the fan must accommodate possible thermal elongation of the shaft.

Tolerances

As the bearing bore tolerances are to plus limits to permit mounting on drawn steel shafts (say tolerance h9/IT5) a clearance fit is obtained. This leads to a slightly eccentric operation with resulting vibration, therefore the use of Y-bearings should be confined to low or medium speed operation.

Lubrication

Relubrication is not normally required as the bearings are supplied lubricated for life. However, Y-bearings fitted in cast iron housings can be relubricated. Please see the SKF catalogue "Y-bearing units".

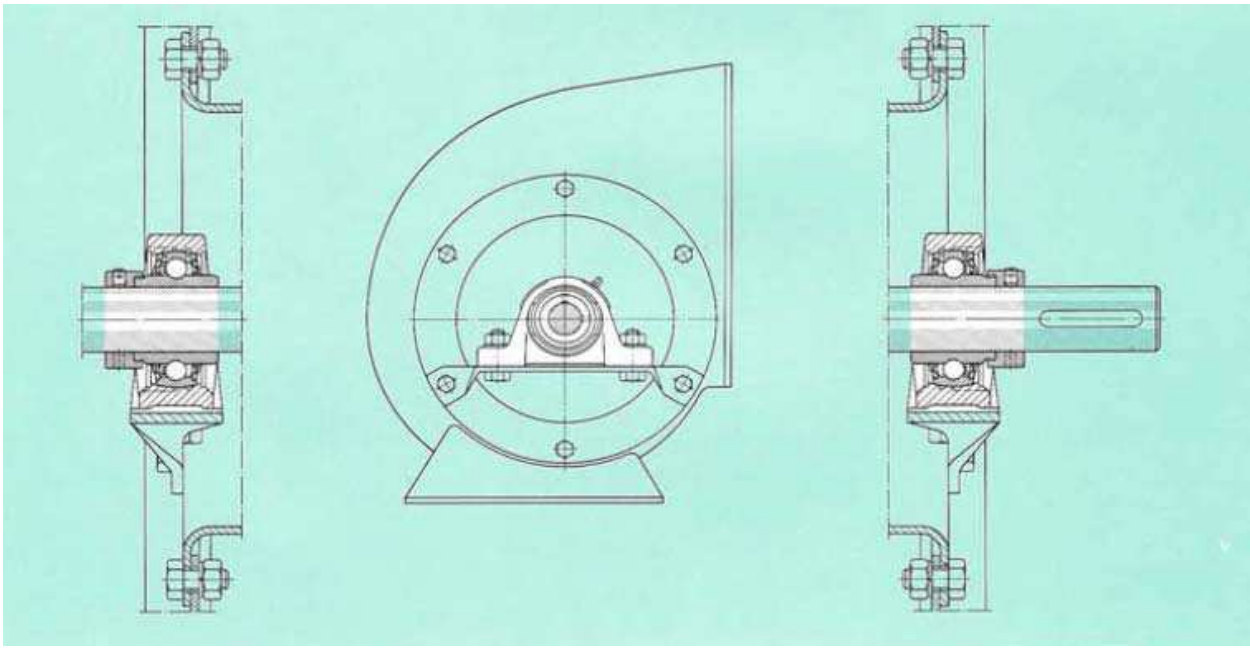


Figure 1

3.2. Bearing arrangements using SNA and SD plummer block housings

Bearing selection

Where silent running is stipulated with relatively high speeds, self-aligning ball bearings mounted on adapter sleeves are recommended for light and medium duty fans with shaft diameters up to and including 110 mm. For heavy-duty fans spherical roller bearings mounted on adapter sleeves are recommended.

Bearing arrangement

Normally the bearing is mounted in an SNA plummer block housing. The various types of seal are shown in the SKF General Catalogue. Relubrication can be arranged if there is a suitable grease escape arrangement for use with the various types of seal. Fig 2 shows an arrangement using a self-aligning ball bearing mounted in an SNA plummer block housing with grease escape valve, type TAV. The efficiency of relubrication has been much improved by mounting an extra V-ring inboard of the V-ring seal washer at the side where grease is supplied, so that grease can only leave the housing at the opposite side after passing through the bearing. It should be noted that grease is usually supplied to these housings on the side away from the lock nut.

Tolerances

Shaft		h9/IT5
Housing	Standard plummer block	H8
	Plummer block with grease escape valve	H7

Lubrication

A high quality lithium base grease, such as SKF LGMT2 or LGMT3, is normally recommended.

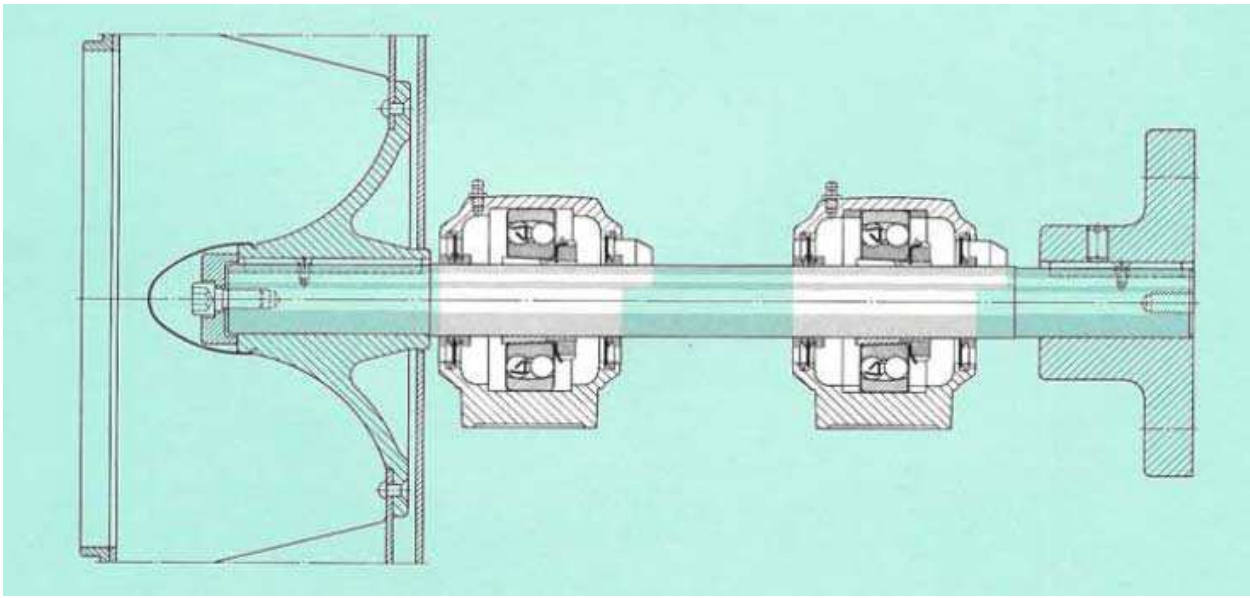


Figure 2

3.3. Bearing arrangements using two-bearing housings

Bearing selection

Deep groove ball bearings, paired angular contact ball bearings and cylindrical roller bearings, in different combinations, are all recommended for use in two—bearing housings with shaft diameters up to and including 120 mm for light to heavy duty fans. Appropriate housings are listed on pages 32 and 33. It should be noted that SKF can also deliver complete units including shafts; please check availability with SKF before ordering.

Bearing arrangement

Fig 3 and 4 show arrangements which incorporate single row deep groove ball bearings. The bearings are mounted with axial clearance in the housings and up to and including sizes 6218 and 6316 they can be lightly preloaded by using springs in order to reduce noise. V-rings have been used at both sides in the illustrations, but the end covers for housings of series PDN 3 and PDR 3 are also provided with grooves so that felt rings can be used alternatively or additionally. The hot gas fan shown in fig 4 is protected on the outside by a heat—resistant wall; the shaft on the rotor side is drilled and filled with a similar heat—resistant material. A cooling ring, usually made of aluminum, has also been included

between the impeller and bearing housing. For heavy radial or axial loads, two bearing housings can be fitted with paired angular contact ball bearings of series 72 as locating bearings and cylindrical roller bearings of series NU 22 or NU 22 ECP as non-locating bearings. Fig 5 shows such a unit, series PDPF 22.

For heavier radial loads, the arrangement PDRJ 3, shown in fig 6, is more favorable. Here, cylindrical roller bearings of series NU 3 or NU 3 ECP are used as radial bearings, whilst a deep groove ball bearing of series 63 serves as the locating bearing.

Tolerances

Shaft	k6
Housing	G6

Lubrication

A high quality lithium base grease, such as SKF LGMT2 or LGMT3, is normally recommended.

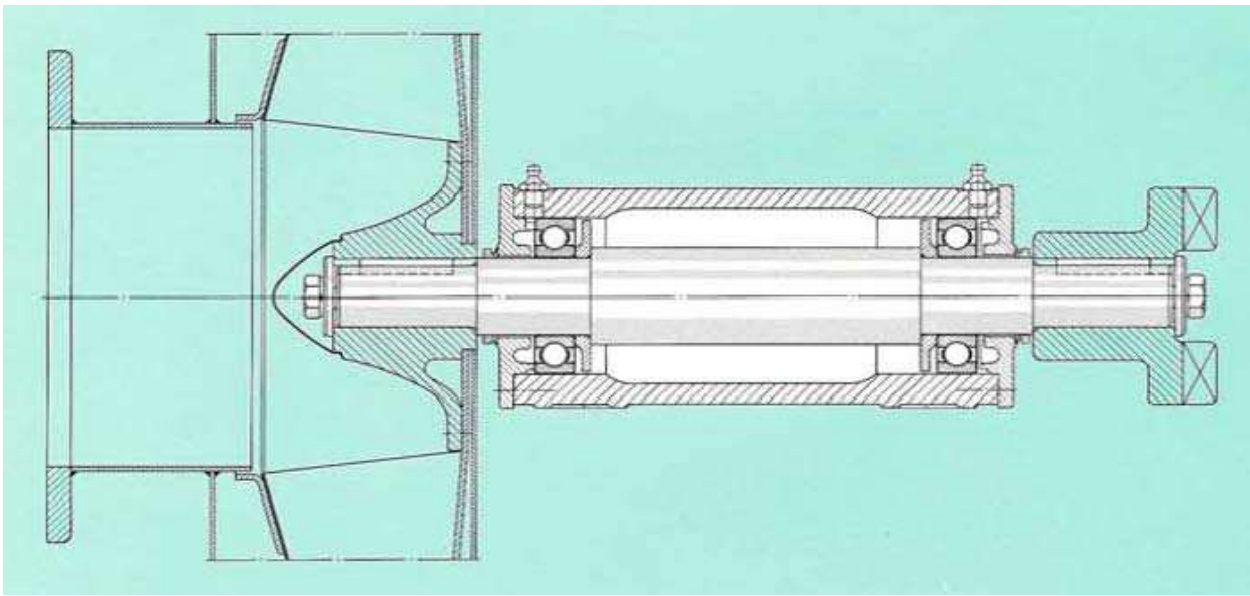


Figure 3

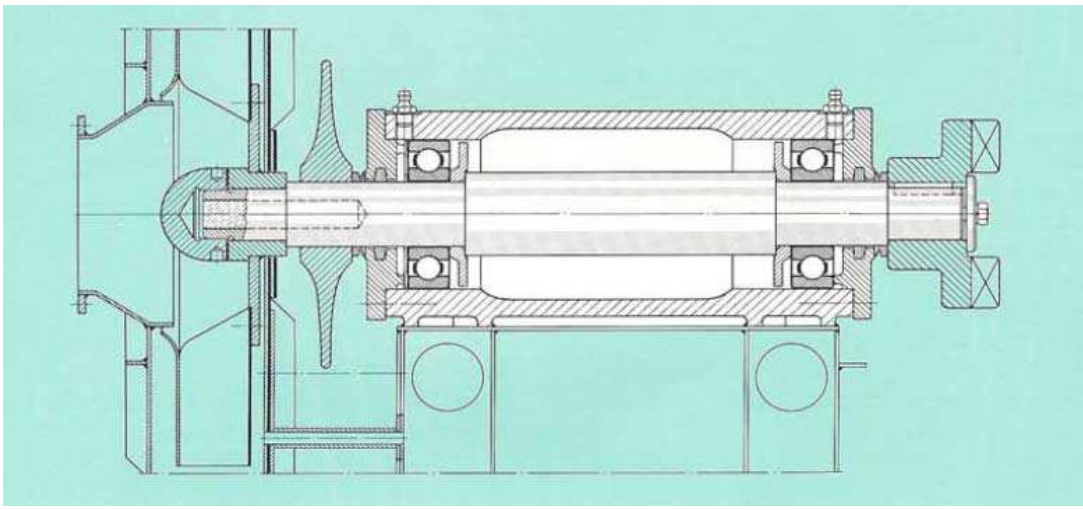


Figure 4

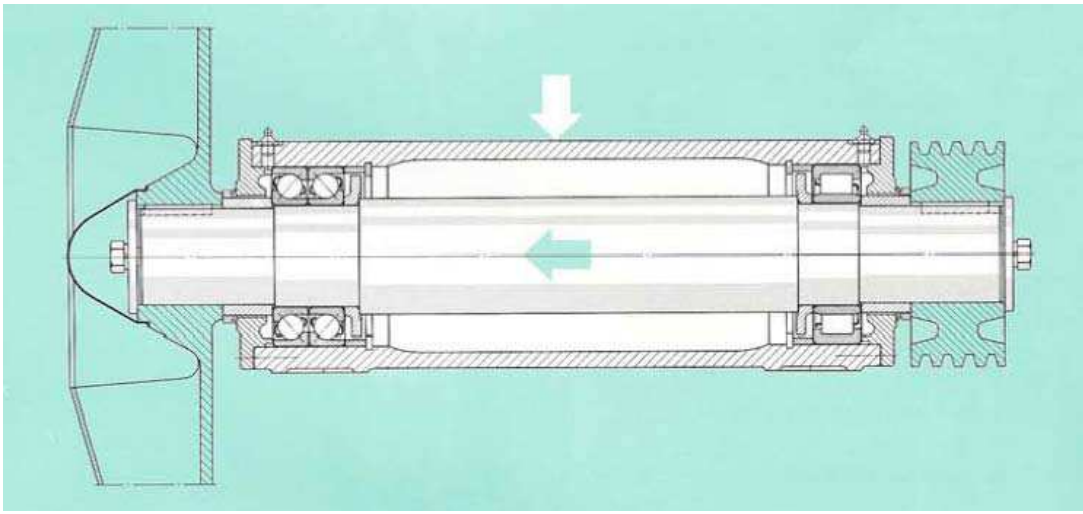


Figure 5

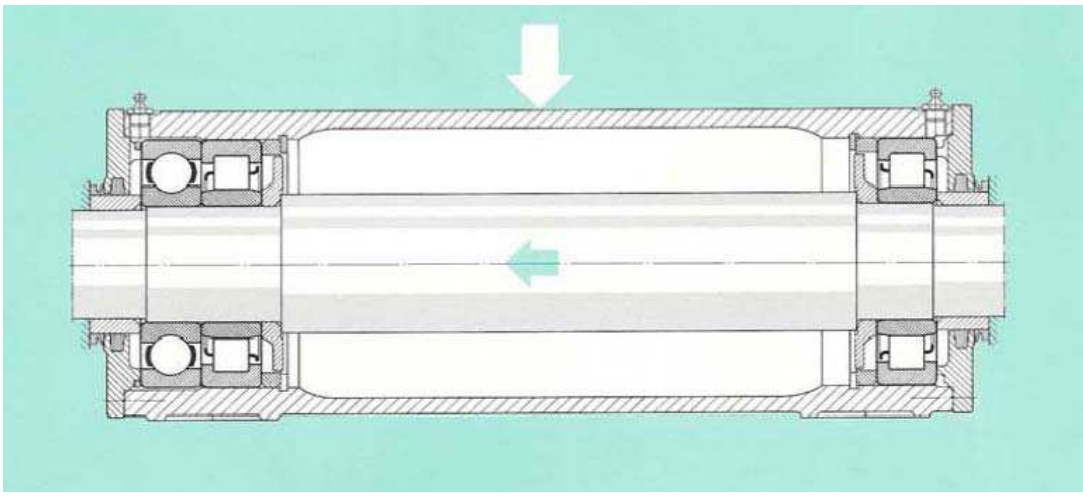


Figure 6

3.4. Bearing arrangements using SOFN plummer block housings

Bearing selection

Spherical roller bearings with cylindrical bore and also with tapered bore plus the relevant adapter sleeve, are recommended for the larger heavy-duty fans.

Bearing arrangement

Where long relubrication intervals are desirable oil lubrication is recommended and SOFN plummer block housings can be used. These have an adequate space for an oil reservoir and have been developed mainly for high speed fans. They are equipped with effective labyrinth seals to eliminate oil losses.

For applications where low vibration and silent operation are required, preference is given to the use of spherical roller bearings with cylindrical bore mounted in series SOFN 2 and SOFN 3 housings, see fig 7. Spherical roller bearings with tapered bore mounted on adapter sleeves are frequently used where easy mounting is required. In this case series SOFN 5 housings should be chosen.

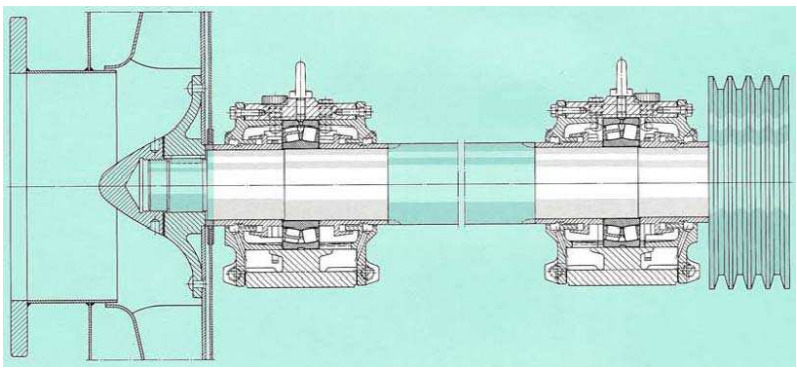


Figure 7

Each SOFN housing size is available in three slightly different designs:

Shaft end, non-locating bearing - suffix AL
Through shaft, non-locating bearing - suffix BL
Through shaft, locating bearing - suffix BF

Tolerances

Shaft	Cylindrical seatings – direct mounting	m6
	Cylindrical seatings – mounting on sleeves	h9/IT5
Housing		F6

Lubrication

Oil lubrication is used. To keep the bearing temperature as low as possible with the minimum amount of oil in the bearing, the oil is lifted from the reservoir to a collecting trough, as the shaft rotates, by a pick-up ring which hangs loosely on a sleeve on the shaft and dips into the oil in the lower half of the housing. The oil then passes through the bearing on its way back to the reservoir.

3.5. Bearing arrangements incorporating spherical roller thrust bearings

Bearing arrangement

When high axial forces have to be accommodated, it is sometimes necessary to use a thrust bearing for the support. Fig 8 and 9 show respectively a horizontal and a vertical fan, each fitted with a spherical roller thrust bearing. In each case, the spherical roller thrust bearing is radially free and therefore only axially loaded; the housing washer is loaded by using several springs, equally spaced around the periphery, to prevent the bearing from separating when the fan is started or the thrust load reversed.

Tolerances

Shaft	Deep groove ball bearings	
	d ≤ 100 mm	k5
	d > 100 mm	k6
	Cylindrical roller bearings	
	d ≤ 140 mm	m5
	d > 140 mm	n6
	Spherical roller bearings	
	d ≤ 140 mm	m6
	d > 140 mm	n6
	Spherical roller thrust bearings	
	All diameters	j6
Housing	Deep groove ball bearings (with O-ring to prevent creeping)	H7
	Cylindrical roller bearings	M7
	Spherical roller bearings (with O-ring to prevent creeping)	H7
	Spherical roller thrust bearings	clearance

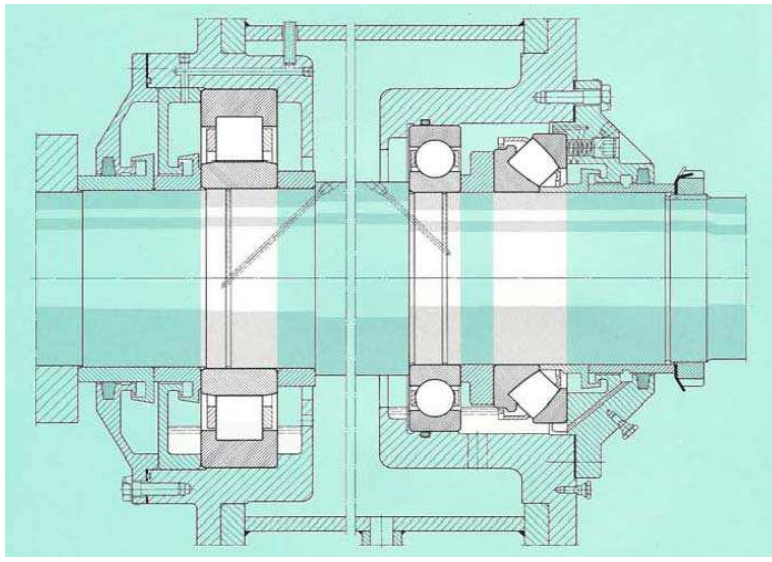


Figure 8

Lubrication

Circulating oil lubrication is used for the bearings in the horizontal fan. Oil bath lubrication is preferred for the bearings in the vertical fun. The pumping action of the spherical roller thrust bearing is utilized to ensure lubrication of both bearings in this arrangement.