SKF

The CARB™ bearing – a better solution for the front side of drying cylinders



Made by SKF® stands for excellence. It symbolises our consistent endeavour to achieve total quality in everything we do. For those who use our products, “Made by SKF” implies three main benefits.

Reliability – thanks to modern, efficient products, based on our worldwide application know-how, optimised materials, forward-looking designs and the most advanced production techniques.

Cost effectiveness – resulting from the favourable ratio between our product quality plus service facilities, and the purchase price of the product.

Market lead – which you can achieve by taking advantage of our products and services. Increased operating time and reduced down-time, as well as improved output and product quality are the key to a successful partnership.



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CARB is a trademark of AB SKF

Why CARB™ bearings?

“Why is the CARB bearing a better non-locating bearing solution for drying and Yankee cylinders in papermaking machines?”

“Because CARB can handle cylinder elongation, shaft and housing mis-alignment, increased loads, increased speeds, high journal temperatures etc. better than any other solution.”

“So CARB gives better bearing function and longer service life?”

“Yes, and for you this means: lower bearing consumption, fewer planned and unplanned stops, the possibility to increase the loads or select a smaller bearing and the poss-ibility to increase the speed with an equal or improved vibration level.”



Demanding environment

Drying cylinder

Drying cylinders are heated by steam. The steam temperature can vary between 130 and 200 °C, depending on paper grade. A dryer section may contain 35 to 100 drying cylinders.

The bearing housing on the drive side is in most cases an integral part of the machine frame where the circulating oil drains into the gear casing. On the drive side the drying cylinder is supported by a spherical roller bearing.

The design of the bearing arrangement for the front side of the machine depends mainly upon the machine width. Often fixed housing arrangements can be found, but for machines with wire widths above 4 500 mm, a bearing housing mounted on so-called rockers is frequently used.

The front side bearing arrangement has to be axially free in order to accommodate the expansion of the cylinder due to the high operating temperature. The steam heating through the shaft also produces high thermal stresses in the bearing inner ring. Furthermore, the bearings are often subjected to misalignment caused by deflection, low accuracy of housing alignment and settling of foundations.

Summary of operating conditions:

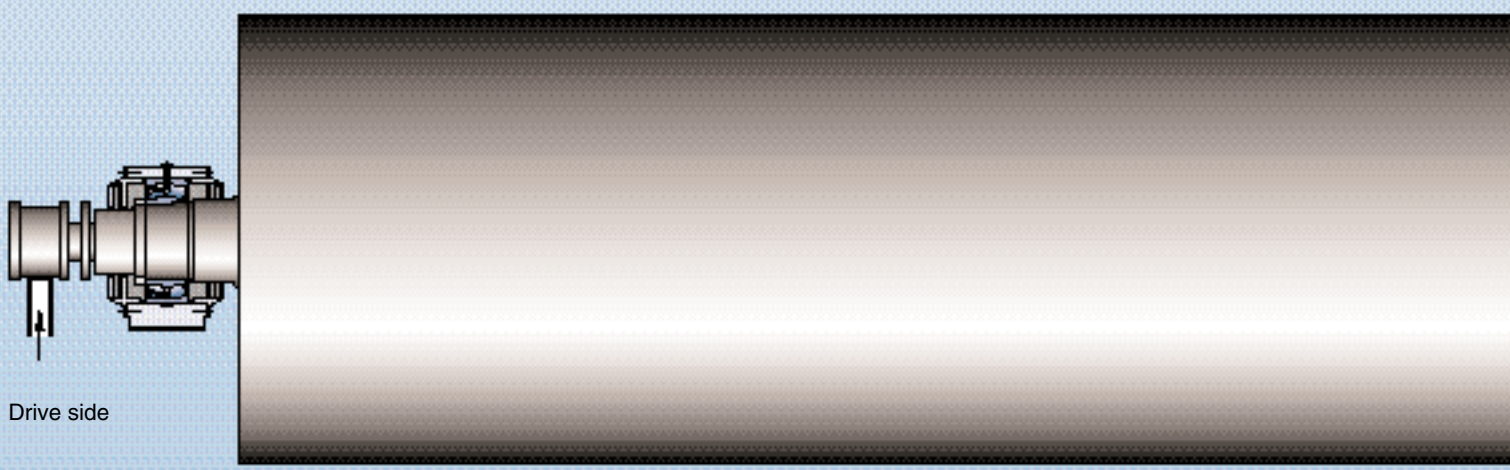
- Large axial displacement due to thermal expansion of the shaft – up to some 10 mm.
- High thermal inner ring stresses due to temperature differences.
- Separate housings, sometimes more than 10 metres apart, necessitate bearings which can accommodate substantial misalignment.

Yankee cylinder

Most of the information in this brochure regarding drying cylinders is also valid for Yankee cylinders. Bearings in Yankee cylinders have approximately the same operating conditions as those in drying cylinders, including operating temperature and expansion of the cylinder. In relation to bearing size, also speeds and loads are in the same order of magnitude.

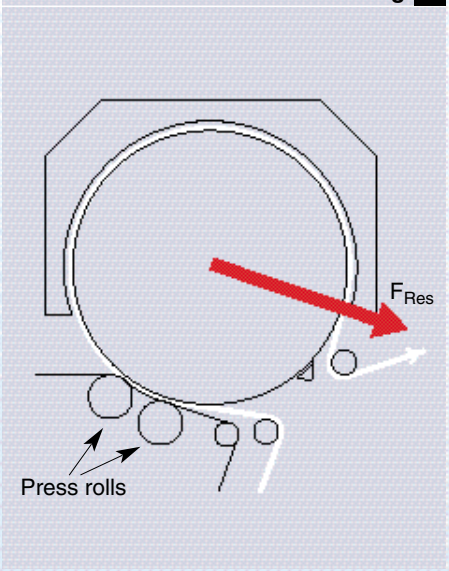
The design of the bearing arrangement for Yankee cylinders is similar to that of drying cylinders. The major difference is that the Yankee press rolls cause a resultant bearing load (➔ **fig** 1), which might even be directed upwards. For rocker housings this is taken care of by means of “hooks” in combination with additional rockers or linear bearings. Still, the press loads are a source of problems.

For more detailed information concerning Yankee cylinder bearing arrangements, please contact SKF.



Drive side

Fig 1

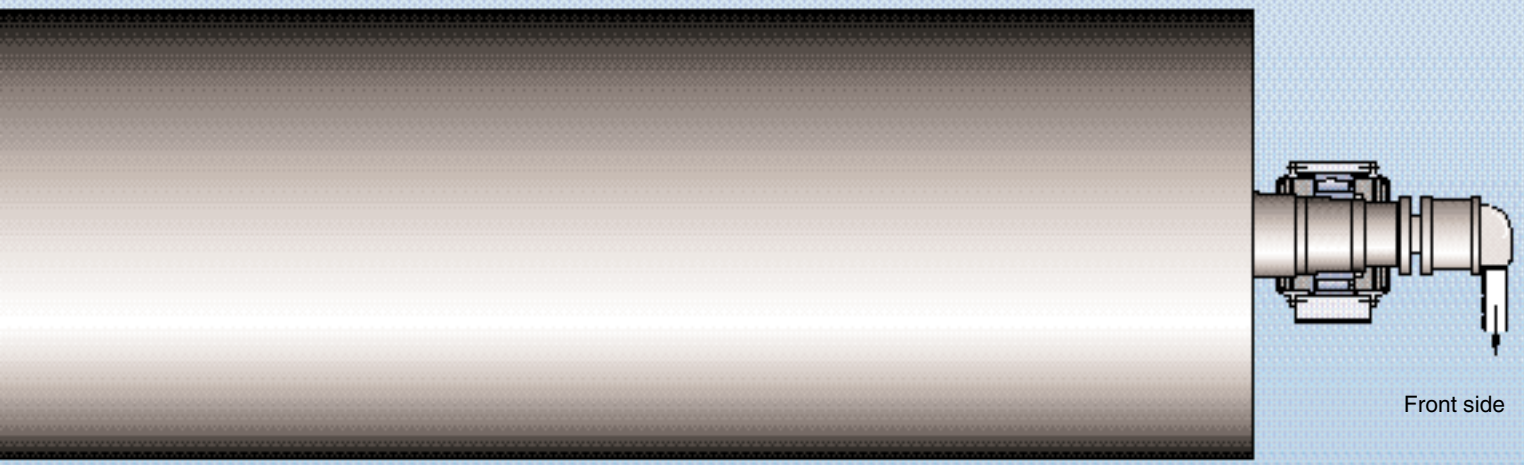


Yankee cylinder.
The major difference for the bearings in Yankee cylinders compared to those in drying cylinders, is the resultant bearing load, F_{Res} , caused by the Yankee press rolls

Table 1

	Drying cylinder	Yankee cylinder
Shaft diameter	180 – 320 mm	340 – 670 mm
Cylinder diameter	1 500 – 2 200 mm	3 000 – 6 500 mm
Cylinder length	2 500 –10 500 mm	2 000 – 7 000 mm
Cylinder mass	5 – 30 tonnes	50 – 170 tonnes
Paper speed	up to 1 800 m/min	up to 2 100 m/min (tissue) up to 700 m/min (board)
Steam temperature	130 – 200 °C	140 – 190 °C

Drying cylinders can be up to 10 metres wide and have a diameter of up to 2,2 metres



Front side

Solutions – up to now ...

Spherical roller bearing with axially free outer ring

With an arrangement according to **fig** 2 the axial displacement is accommodated between outer ring and housing. There is a risk that the axial friction forces in this contact can become excessive due, for example, to fretting corrosion, unsuitable fit or ovality of the housings.

In unfavourable cases the friction between outer ring and housing may cause axial forces which are roughly 10–20 % of the radial bearing load, perhaps even more. This results in a considerable reduction of bearing life. Furthermore, at least for wide machines, the frame is mainly designed for radial loads. The general guideline is thus not to use this bearing arrangement for wire widths above 4 500 mm.

Example: 15 % axial load on bearing 23052 reduces calculated bearing life by 70 %.

Cylindrical roller bearing

Cylindrical roller bearings accommodate axial displacement within the bearing (➔ **fig** 3). The load carrying capacity is substantially lower than for spherical roller bearings. However, the major disadvantage with this arrangement is that misalignment causes edge stresses on rollers and raceways. To align the housings as accurately as is required for cylindrical roller bearings is time consuming. Still misalignment may occur again at any time due, for example, to settling of the foundation. Accordingly cylindrical roller bearings are not recommended for drying cylinders, see also **diagram** 1, **page 9**.

Example: 0,15° misalignment on a cylindrical roller bearing with logarithmic profile reduces calculated bearing life by 90 %.

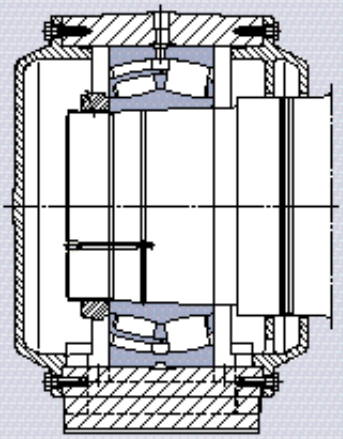
Self-aligning double row cylindrical roller bearing

With this special cylindrical roller bearing design, the axial displacement is accommodated between outer and inner ring and the misalignment by the sphered mating surfaces of the two outer ring parts (➔ **fig** 4). The reason why this solution is so uncommon is that the bearing design is complicated and gives a reduced load carrying capacity, resulting in short bearing life.

There is also a risk of fretting corrosion between the two outer ring parts. Fretting corrosion in this contact eliminates the ability of the bearing to cope with misalignment. The result is edge

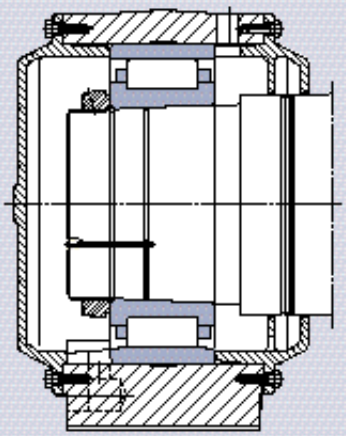
Friction between bearing outer ring and housing results in axial loads on bearing and machine frame

Fig 2



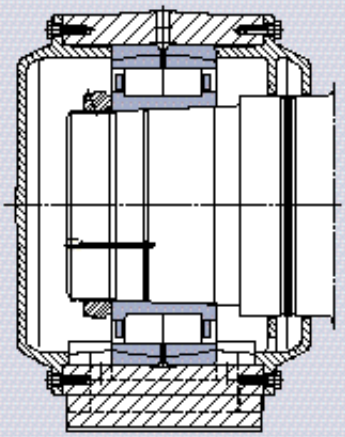
Misalignment causes edge stresses on rollers and raceways

Fig 3



The outer ring design gives low load carrying capacity

Fig 4



stresses and further reduction of bearing life.

Example: 30 % lower load carrying capacity reduces calculated bearing life by about 70 %.

Spherical roller bearing in a housing mounted on rockers

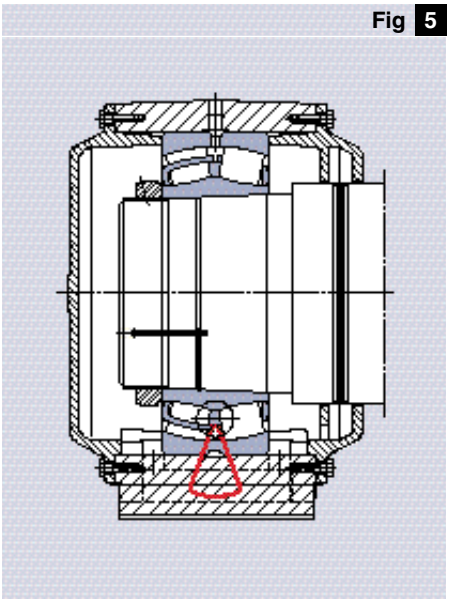
When the housing is mounted on rockers, the axial displacement is accommodated by a slight tilting of the rockers (➔ **fig** 5). Due to the shape of the rockers this gives a pure axial displacement with no displacement in the vertical direction.

This has previously been the best solution and accordingly recommended by SKF for machines with a wire width above 4 500 mm. However, this housing arrangement is rather unstable and does not damp vibrations as well as solid housings; this may be a problem when upgrading to higher speeds. This arrangement is also sensitive to tilting forces, from for example rope sheaves and steam joints fastened on the housing.

Maintenance costs due to wear of the rocker arrangement may also be high as malfunctioning rockers produce axial loads.

Vibrations and tilting forces may cause problems

Fig 5



To sum up: with this solution there is a risk of axial forces and increased maintenance costs caused by malfunctioning rockers as well as restrictions in the speed capability of the machine.

There has to be a better solution ...

The CARB bearing – the better solution

SKF has introduced a new bearing – the CARB bearing. It is a major breakthrough in bearing technology – the greatest in over 50 years (SKF introduced the spherical roller thrust bearing in 1939).

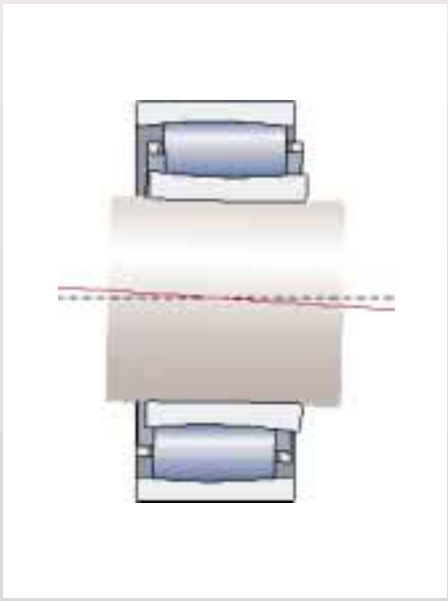
This new bearing is in accordance with the increasing demand for high load carrying capacity, robustness and low friction. Like a spherical roller bearing the CARB bearing can accommodate misalignment and heavy radial loads, but it is also able to take axial displacement like a cylindrical roller bearing. Similar to the needle roller bearing the CARB bearing has the potential of a compact design.

CARB provides a unique combination of accommodating misalignment and axial displacement. This was the main reason why the front side of drying cylinders was one of the main applications considered when developing the CARB bearing.

Tests, made at a number of paper mills, have proved the CARB bearing mounted in a fixed housing to be the ideal bearing arrangement for this application.

The CARB bearing gives the potential of using interference fits for both inner and outer rings and to make a design with low sectional height. These features are mainly intended for other applications than drying cylinders.





The design

The rollers are long and barrel-shaped with a profile radius much larger than that of rollers in single or double row spherical roller bearings.

This means that the centre of curvature of the outer ring raceway is not located on the bearing axis as is the case for spherical roller bearings (➔ **fig** 6).

Raceway profile radii are optimised to achieve favourable load distribution and minimum friction. Roller self-guidance is obtained by well-matched roller and ring raceway geometries, long rollers and zero contact angle.

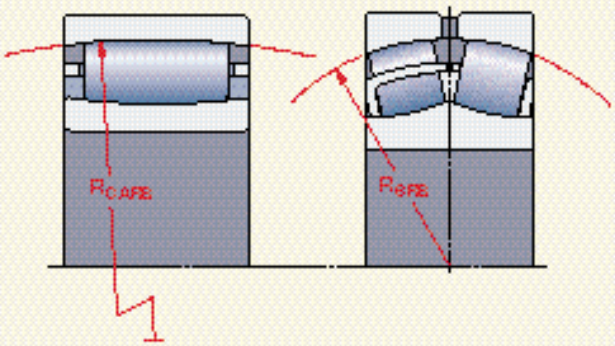
Load carrying capacity

The radial load carrying capacity of CARB is high due to the long rollers. This can be achieved within a low sectional height. The dynamic load rating C given in catalogues is usually used as a basis for the selection of type and size of bearing. However, the ability of most bearing types to carry load and still reach expected life can be reduced if there is misalignment involved. Misalignment can occur in two ways (➔ **fig** 7). When mounting the bearing housing it should be well aligned around the vertical axis. This can easily be achieved by measuring with a feeler gauge between shaft and housing cover. CARB accepts 0,5° misalignment in this direction but in most cases the misalignment is only about 0,1° and is not likely to change over time. It is therefore neglected in the following text.

The other misalignment direction, around the horizontal axis, is often substantial as the bearings are mounted in separate housings, sometimes more than 10 metres apart. Due to deflection and settling of the foundation this misalignment may increase over time and accordingly up to 0,3° misalignment is common for drying cylinder bearings.

Diagram 1 shows a comparison between the CARB bearing, spherical roller bearings and cylindrical roller bearings.

Fig 6

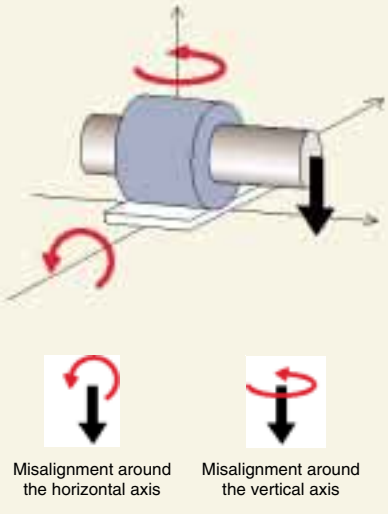


The raceway profile radius of CARB is much larger than that of a spherical roller bearing. $R_{CARB}>>R_{SRB}$

The high load carrying capacity, the misalignment ability and the ability to accommodate axial displacement without causing axial loads are characteristic of the CARB design. These properties can either be used for downsizing, that is selection of a smaller bearing size, or for increased reliability depending on which is considered more valuable.

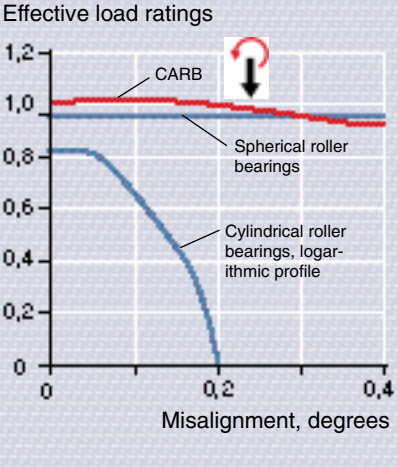
Misalignment can occur in two directions – around a vertical axis or around a horizontal axis

Fig 7



The CARB bearing has the same high load carrying capacity and is practically as insensitive to misalignment around a horizontal axis as spherical roller bearings

Diagram 1



Friction

The CARB bearing has about the same friction as cylindrical roller bearings and double row spherical roller bearings. The friction depends on the misalignment as the rollers adjust their axial position to avoid edge load.

The CARB bearing can be misaligned up to 1,0° around a horizontal axis. For this type of misalignment up to 0,5° the increase in bearing friction is negligible. As mentioned before, misalignments up to 0,3° are common for drying cylinder bearings.

Measurements in cases where a CARB in a fixed housing has replaced a spherical roller bearing in a housing on rockers have shown that the temperature has dropped.

Axial displacement

The relation between radial clearance and axial displacement from a central position is shown in **diagram** 2. The bearing may be even further displaced without life reduction, into the dark blue area. In this area friction increases by up to 50 %.

Axial displacement and radial clearance are given in relation to bearing width (B). This makes the diagram valid for all CARB bearings.

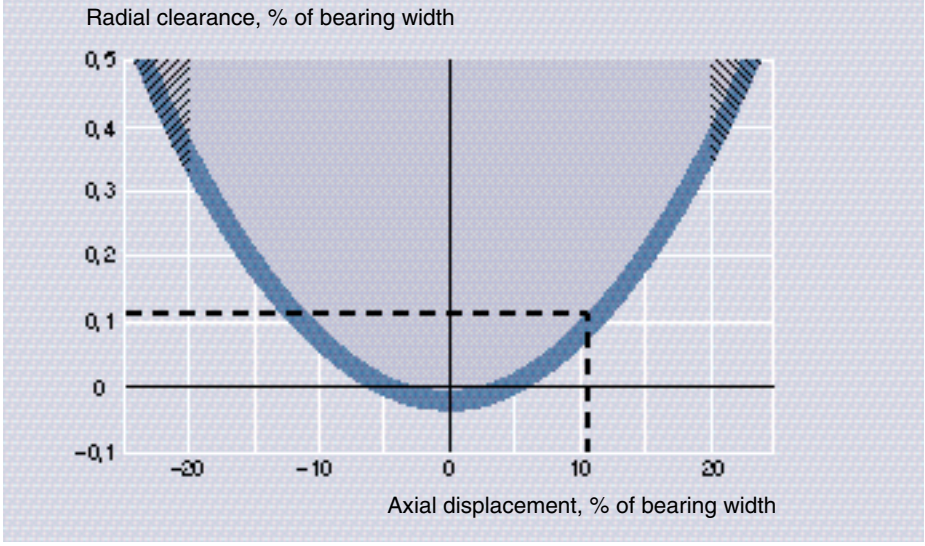
Example: Bearing C 3044/HA3C4 with bearing width B = 90 mm (from table on page 20).

Assume that the operational radial clearance during start-up is 0,1 mm. That is 0,11 % of the bearing width.

The diagram then shows (dotted line) that the bearing can be axially displaced up to 11 % of bearing width, which is 0,11 × 90 = 9,9 mm from the centre.

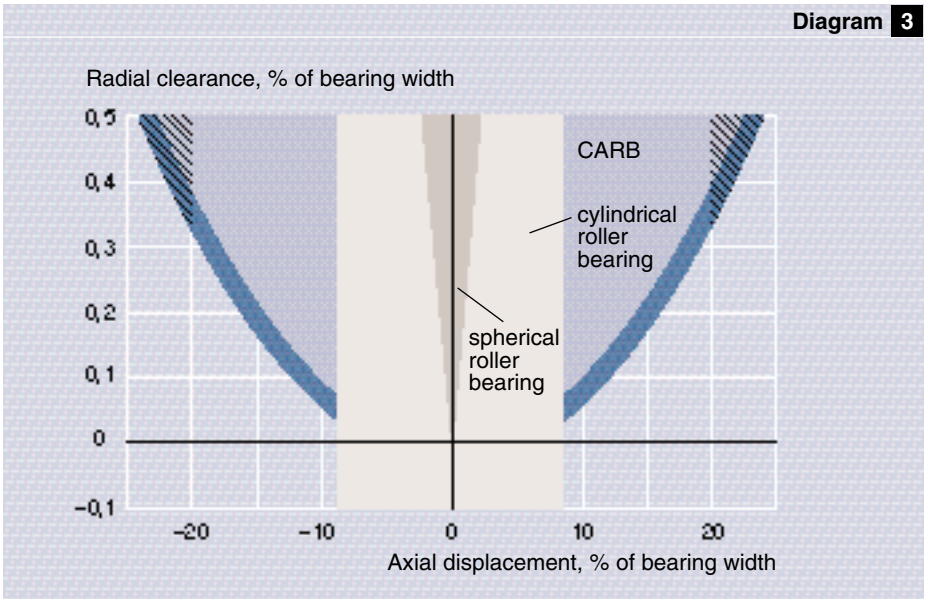
During start-up a typical operational clearance at moderate steam temperature and without journal insulation can be 0,1 % of the bearing width. This corresponds to a possible axial displacement from the centre of 10 % of the bearing width.

Diagram 2



Available axial displacement depends on radial clearance. Rollers may protrude from the ring raceway at axial displacements above 20 % of the bearing width

Diagram 3

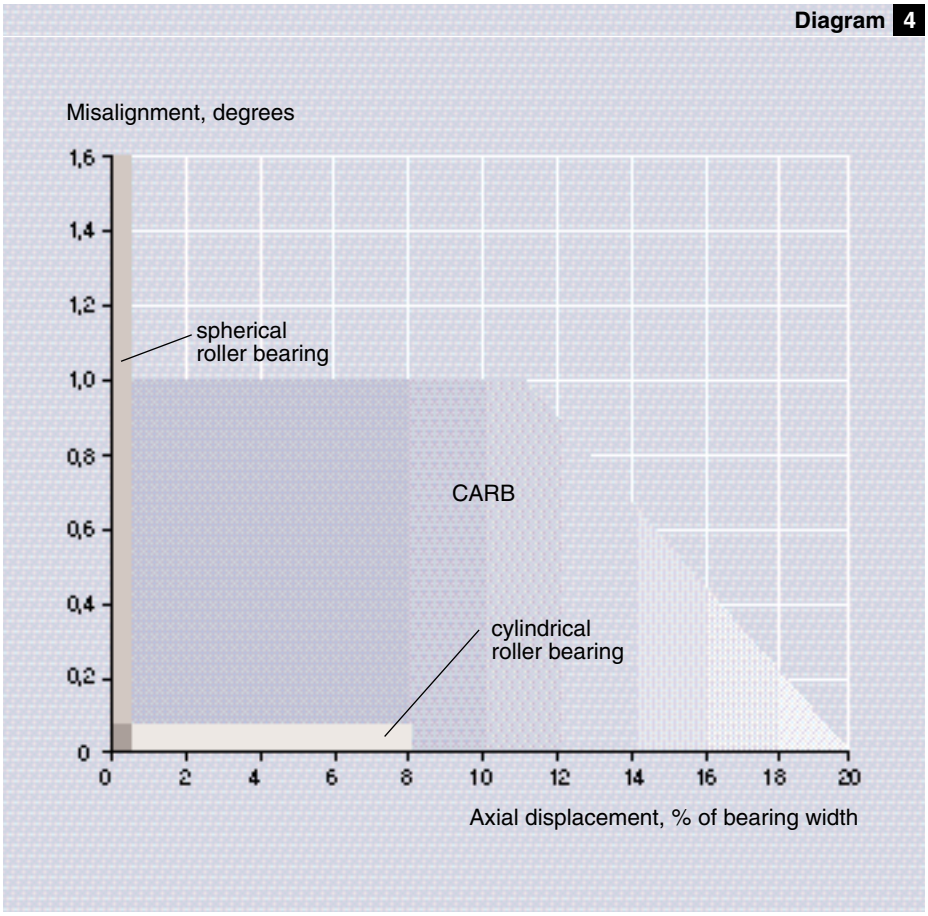


Available axial displacement of CARB, cylindrical roller bearings and spherical roller bearings

In **diagram** 3 the available axial displacement of CARB is compared with corresponding displacement of cylindrical and spherical roller bearings. Just like for CARB the available axial displacement of spherical roller bearings depends on the radial clearance. For cylindrical roller bearings the available axial displacement is independent of the radial clearance but is limited by the width of the raceways.

Because of the ability to take both misalignment and axial displacement, the CARB bearing has a much greater "working area" than spherical roller bearings or cylindrical roller bearings **diagram** 4. Within the dark blue area (axial displacement up to 8 % of bearing width) for CARB in the diagram the risk of radial preload occurring is less than or equal to that for spherical roller bearings with C4 clearance. To what extent the light blue area (above 8 % of bearing width) for CARB is available depends on the operating clearance.

Diagram 4



The CARB bearing has a much greater "working area" than spherical roller bearings or cylindrical roller bearings. The diagram is valid for misalignments around a horizontal axis (→ fig 7)

Comparison and summary

Improved reliability.
Improved service life.

Higher output.
Machines can be speeded up.
Improved paper quality.
Optimised new bearing arrangements.

Each unplanned stop in a papermaking machine costs 10 000–15 000 $ per hour. A safer, more reliable bearing arrangement will save you a lot of money!

Table 2

This bearing arrangement can handle	Cylindrical roller bearing	Self-aligning double row cylindrical roller bearing	Spherical roller bearing with axially free outer ring	Spherical roller bearing in rocker housing	CARB
Axial displacement	yes	yes	sometimes	yes	**yes**
Misalignment	no	sometimes	yes	yes	**yes**
Vibrations	yes	yes	yes	no	**yes**
High radial load	sometimes	no	yes	yes	**yes**
Fretting corrosion	yes	no	no	yes	**yes**
Tilting forces	yes	yes	yes	sometimes	**yes**

Application

Bearing life and reliability

A typical bearing arrangement for CARB is shown in **fig** 8. The requirements for journal and housing tolerances as well as the requirements on the calculated bearing lives L_{10h} and L_{10ah} are the same as for other bearing types, see SKF publication 4200 “Bearings in papermaking machines – Application handbook”.

As the load carrying capacity for CARB is somewhat higher than for spherical roller bearings and substantially higher than for other bearing types used in this application (➔ **figs** 3 and 4, **page 6**), the calculated bearing lives will be up to three times higher for CARB.

Compared to solutions with spherical roller bearings (➔ **figs** 2 and 5, **pages 6** and **7**), the major increase in calculated bearing lives is due to the elimination of axial loads from the steam joint, malfunctioning housing rockers, and, in the case of a fixed housing, friction between outer ring and housing.

Operating conditions may change over time, for example increased misalignment due to settling of the foundation. This means that the increase in real service life for CARB compared to other solutions may be higher than the calculated one.

Even more important than a long bearing service life is to avoid unplanned stops. For this reason the CARB inner ring is case-hardened (HA3 execution), as standard for maximum resistance to ring cracking.

Nuts

To secure the bearing in the right position a good locking device is needed.

SKF has designed a wide selection of nuts which can be used in papermaking machines.

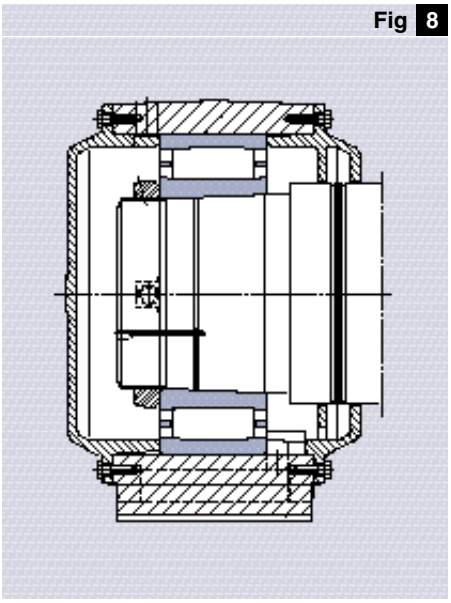
The KMT lock nuts are high precision components, the nut being locked by means of three radial brass locking pins arranged at the same angle as the thread flanks (➔ **fig** 9). This removes the need for a locking washer or keyway. The nut can be accurately located at right angles to the shaft by means of the radial locking pins.

The KML and HM nuts are used in conjunction with an MBL or MS locking washer. This gives a simple, stable, and reliable fastening element. The nuts have four or eight equally spaced slots around the outside diameter to take hook or impact spanners.

For more information and product range see SKF publication 3766/I “Bearing accessories”.

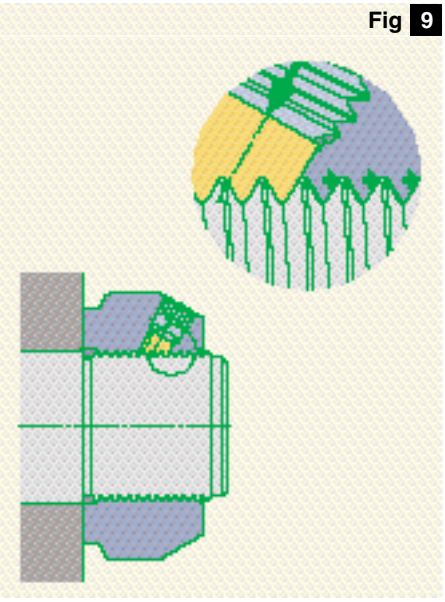
Bearing arrangement for CARB

Fig 8



The KMT lock nut locking principle. A high precision component without any need for locking washer or keyway

Fig 9



Housings

Historically all papermaking machines have been equipped with specially designed bearing housings. The manufacturer has designed a special housing for more or less every individual machine which has involved a lot of cost of pattern equipment and design time. Specially made housings have also been very difficult to find when a replacement has been required at the paper mill.

SKF stepped into the lead position in the early nineties by introducing a standard range of bearing housings for the felt rolls in the dryer section, drying cylinders and Yankee cylinders.

These housings have a compact optimal design for the pulp and paper industry that gives advantages for both the manufacturers and the paper mills.

Today paper mills worldwide wish to increase production, for example by speeding up the papermaking machine. That requires in many cases an increased oil flow to maintain good lubrication. The SKF range of housings is designed for high flow circulating oil lubrication.

The new CARB bearing eliminates the need for the rocker housing, as the bearing itself will take up the thermal expansion of the cylinder. Instead the bearing can be mounted in a more robust and rigid, fixed housing (➔ **fig** 10). This gives a more stable arrangement and reduced vibration level which is especially important at increased speeds. Lower vibration level also means less risk of component wear.

There are two designs available for the housings, the standard one and design A (➔ **page 21**). The standard design, which is most common, has a wider distance between the fastening bolts than the base of design A. Base design A should be used when a narrower attachment is needed.

The product range for the standard design CARB housings covers bearing sizes shown in the table on **page 21**. The range will be enlarged in accordance with market demand.

Steam joint on front side

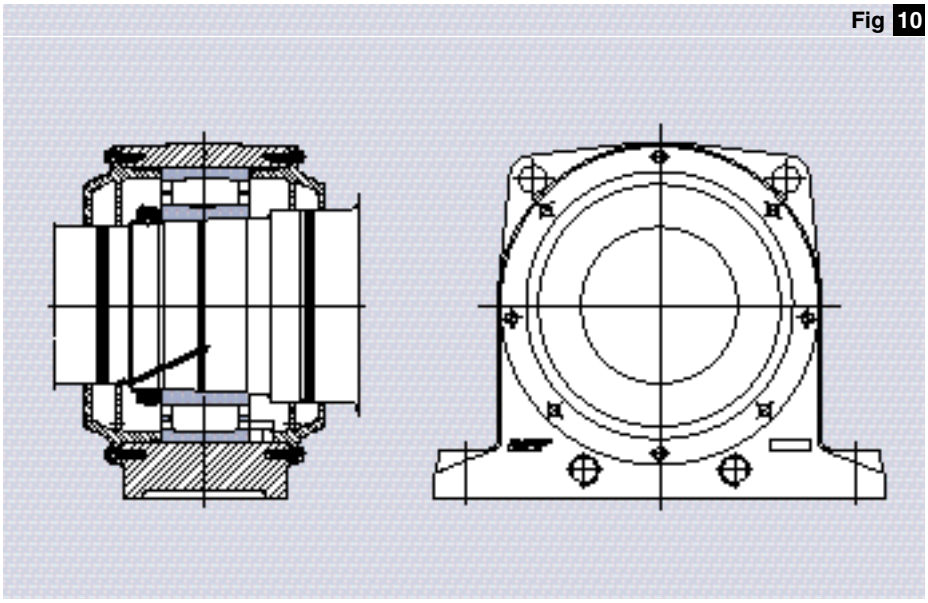
Sometimes drying cylinders are equipped with a steam joint for condensate outlet on the front side. Steam joints are used on both rocker housings and plummer block housings (fixed).

As CARB is mounted in a fixed housing, the axial expansion of the cylinder will be taken up within the bearing. This means that if the steam joint is mounted directly on the cover of the housing, it has to be designed to take up all the axial cylinder expansion inside the joint. This is no problem if the expansion sleeve can accommodate this displacement with regard to space and spring preload (➔ **fig** 11). Otherwise some rework and new springs might be required. The joint is usually equipped with some sort of spherical wear washer. This wear washer is designed to prevent steam leakage and to minimise bending forces. It is normally changed at regular maintenance periods. The total distance the sleeve moves axially due to wear of the washer is roughly 5 mm. To accept both expansion and washer wear, the sleeve may have to be extended.

Different manufacturers of steam joints have of course their own solution or design. As the CARB bearing arrangement is more rigid and stable than a rocker housing arrangement it is much easier to adjust the siphon in a correct position. When a CARB bearing arrangement is used it is necessary to check that the siphon has sufficient space in the axial direction inside the cylinder as the cylinder expands.

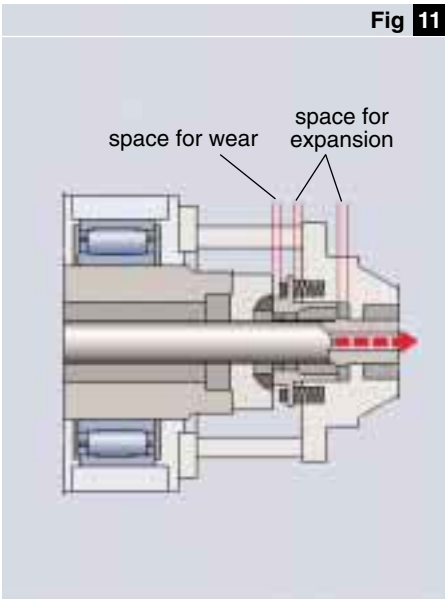
The CARB bearing can be mounted in a one-piece, fixed housing which eliminates the need for rocker housings

Fig 10



Basic layout of a front side steam joint. Make sure that there is room for axial cylinder expansion inside the steam joint

Fig 11



Condition monitoring

Condition monitoring can be used to increase machine uptime and paper quality.

The technique developed for this by SKF is called Multi-Parameter Monitoring. Multi-Parameter Monitoring is based on measurements of several parameters, including traditional vibration, enveloping techniques and SKF SEE (Spectral Emitted Energy) measurements.

Some of the main areas of condition monitoring in papermaking machines are:

- Bearing condition to find possible problems at a very early stage.
- General machine condition to find defects which may cause bearing problems later on. Some typical problems are imbalance, misalignment, resonance, mechanical looseness and electrical problems.
- Felt monitoring for improved paper quality and increased felt life.

Defect frequencies for CARB bearings are shown in **table** 3.

When rebuilding from a rocker housing arrangement to a CARB arrangement with fixed housing, the vibration level will most probably be reduced. Condition monitoring measurements have shown that the axial vibrations can be reduced by up to 85 % (→ **diagram** 5).

SKF provides a complete condition monitoring programme. The product range includes everything from handheld vibration pens to advanced online systems for continuous monitoring, all prepared for multi-parameter monitoring.

The instruments are supported by a full range software platform (Windows and DOS) for administration and analysis of measurement data. Training and support can be given by SKF local representatives.

CARB arrangements for the dryer section can be supplied to special order already prepared for multi-parameter monitoring. The measurement points can be provided with everything from a quick-connector to a complete sensor arrangement fitted to the housing. Different solutions are available depending on the position in the dryer section.

Several SKF condition monitoring systems are already operating with CARB arrangements in the dryer section of papermaking machines, with very good results.

Please contact SKF for references and for more information.

Table 3

Frequencies when inner ring rotational frequency = 1Hz = 60 r/min

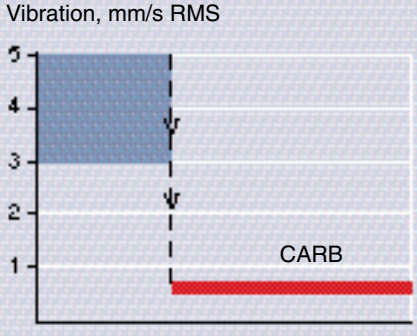
Bearing size	Frequencies BPFI	BPFO	BSF	FTF
–	Hz			
C 3036	13,80	11,20	4,75	0,45
C 3038	14,82	12,18	5,07	0,45
C 3040	13,29	10,71	4,59	0,45
C 3044	13,29	10,71	4,60	0,45
C 3048	13,76	11,24	4,91	0,45
C 3052	13,80	11,20	4,75	0,45
C 3140	11,84	9,16	3,86	0,44
C 3144	11,81	9,19	3,95	0,44
C 3152	11,30	8,70	3,78	0,44
C 3156	12,35	9,65	4,03	0,44
C 3160	11,81	9,19	3,95	0,44

BPFI = Inner ring defect frequency
BPFO = Outer ring defect frequency
BSF = Roller rotational frequency
FTF = Cage rotational frequency

Defect frequencies for CARB bearings

Measured axial vibrations before and after rebuild from rocker housing arrangement to CARB with fixed housing

Diagram 5



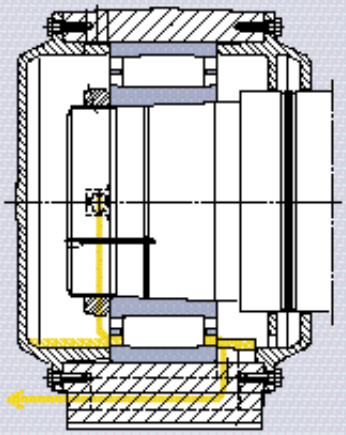
Lubrication

Concerning lubrication of CARB for drying cylinders, the same guidelines can be used as for spherical roller bearings, see SKF publication 4201, “Bearings in papermaking machines – Lubrication handbook”. As the CARB has only one roller row it is lubricated from the side (➔ **fig** 12).

In most cases when cylindrical roller bearings are used for drying cylinders the oil inlet is on the inner side (towards the cylinder) of the bearing (➔ **fig** 3, **page 6**). If the shaft diameter on this side of the bearing is very large, this may result in a lower maximum oil flow compared to a design according to **fig** 12. However, the pressed steel cage used in CARB allows higher oil flows than the brass cage usually used in cylindrical roller bearings.

A CARB bearing lubricated from the side

Fig 12



Mounting

When mounting CARB in drying cylinders the use of the new SKF axial drive-up method is strongly recommended. This is a more precise and less subjective method than measuring clearance reduction with a feeler gauge. Accordingly we recommend this method also for spherical roller bearings.

A step-by-step mounting instruction for CARB as a front side drying cylinder bearing is given below.

Please note that the drive-up values in **table** 4 correspond to a clearance reduction between the minimum and mean values according to the General Catalogue. This is the general SKF recommendation for drying cylinders as the shaft expands due to the hot steam.

Step-by-step mounting procedure for CARB on tapered journal

1 Lightly oil the mating surfaces with a thin oil (for example SKF LHMF 300)

2 Carefully position the bearing in the housing and on the shaft

3a For housing bolted to a frame: check that all rollers are unloaded, i.e. the shaft must be centred in the housing during the drive-up

3b For housing disconnected from frame: lift the shaft with bearing and housing about 5 mm and check that the housing is free to move axially

4 Drive the inner ring up to the starting position (➔ **fig** 13) by applying the HMV nut pressure listed in the drive-up table opposite. Do not use the oil injection method in this case

5 Drive the inner ring up the taper the required distance s_s ±5 % (wait a few minutes before releasing the hydraulic nut)

6 If the housing has been disconnected, bolt it to the frame again

7 Check the housing alignment

8 Check that the axial displacement of the inner ring (relative to outer ring) is within specified values

9 If necessary, adjust the position of the housing

Suitable tools are shown in **fig** 14

Table 4

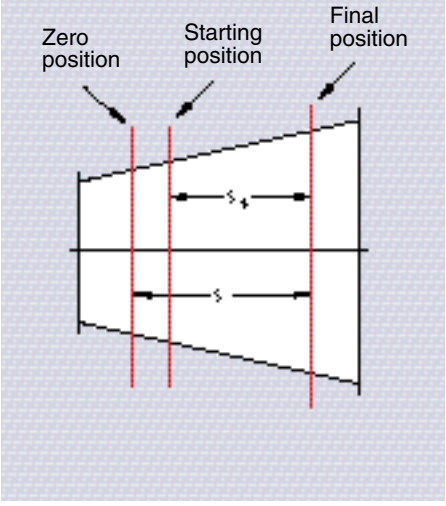
Drive-up table for CARB bearings

Bearing designation	Total radial clearance reduction	SKF HMV E nut pressure at start	Shaft bore	Axial drive-up s_s from starting position		
				Cast steel shaft[1]	Nodular iron shaft[2]	Cast iron shaft[3]
–	µm	MPa	mm	mm		
C 2238 K/HA3C4	90 – 110	1,75	80	1,25	1,30	1,40
			100	1,30	1,35	1,45
			120	1,35	1,45	1,55
C 2244 K/HA3C4	100 – 120	1,95	90	1,35	1,40	1,50
			110	1,40	1,45	1,55
			130	1,45	1,50	1,65
C 3036 K/HA3C4	80 – 95	1,45	70	1,10	1,10	1,20
			90	1,10	1,15	1,25
			110	1,15	1,20	1,30
C 3038 K/HA3C4	90 – 110	1,60	80	1,30	1,35	1,40
			100	1,35	1,40	1,50
			120	1,40	1,45	1,60
C 3040 K/HA3C4	90 – 110	1,60	80	1,25	1,25	1,35
			100	1,25	1,30	1,40
			120	1,35	1,40	1,50
C 3044 K/HA3C4	100 – 120	1,60	90	1,35	1,40	1,45
			110	1,35	1,40	1,50
			130	1,40	1,50	1,60
C 3048 K/HA3C4	110 – 130	1,35	100	1,45	1,50	1,60
			120	1,50	1,55	1,65
			140	1,55	1,60	1,70
C 3052 K/HA3C4	120 – 145	1,70	110	1,10	1,70	1,80
			130	1,10	1,75	1,85
			150	1,15	1,80	1,95
C 3130 K/HA3C4	75 – 88	2,40	60	1,65	1,10	1,20
			75	1,70	1,15	1,25
			90	1,75	1,25	1,35
C 3140 K/HA3C4	90 – 110	2,70	80	1,25	1,30	1,40
			100	1,30	1,35	1,45
			120	1,35	1,45	1,60
C 3144 K/HA3C4	100 – 120	2,75	90	1,40	1,45	1,55
			110	1,45	1,50	1,60
			130	1,50	1,60	1,75
C 3152 K/HA3C4	120 – 145	2,75	110	1,70	1,75	1,85
			130	1,75	1,80	1,95
			150	1,80	1,85	2,05
C 3156 K/HA3C4	120 – 145	2,65	110	1,65	1,70	1,80
			140	1,70	1,75	1,90
			170	1,80	1,85	2,05
C 3160 K/HA3C4	130 – 160	2,80	120	1,85	1,90	2,00
			150	1,90	1,95	2,10
			180	2,00	2,05	2,25

[1] E = 210 000 MPa
[2] E = 170 000 MPa
[3] E = 120 000 MPa

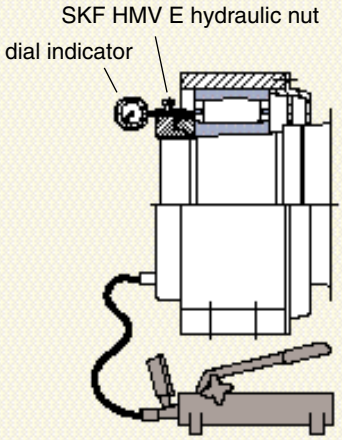
Zero/starting/final positions

Fig 13



Mounting tools. Please contact SKF for more information

Fig 14



SKF 729124 SRB (for nuts ≤ HMV 54 E)
SKF TMJL 100 SRB (for nuts ≤ HMV 92 E)
SKF TMJL 50 SRB (for nuts ≤ HMV 200 E)

Axial mounting position

In **diagram** 2, **page 10**, the axial clearance was shown in relation to the radial clearance. However, the operating radial clearance depends on the temperature distribution in the bearing arrangement, which in turn depends on the design and the operating conditions.

Diagram 6 shows the axial to radial clearance relation estimated for bearing C 3052 K/HA3C4 and 150–160 °C steam temperature without journal insulation.

The dotted lines in **diagram** 6 show what happens to the available clearance during start-up with or without initial displacement. Remember that available clearance has its minimum at start-up. It increases when all parts are warmed up, shown in the diagram as “running”.

A Without initial displacement position A is reached at start-up. In this position the axial clearance is 3 mm outwards (from the cylinder) and 17 mm inwards.

B With 10 mm initial displacement position B is reached at start-up. In this position the axial clearance is 13 mm outwards (from the cylinder) and 7 mm inwards.

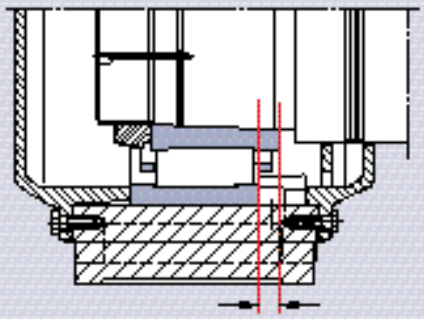
SKF experience shows that the cylinder thermal elongation is about one millimetre per metre cylinder length at a steam temperature of 150 °C. To compensate for this elongation it is possible to displace the housing outwards from the cylinder (➔ **fig** 15).

To achieve an equal or higher safety margin against preload as for spherical roller bearings with C4 clearance, the axial mounting positions shown in **table** 5 are recommended (valid for cold machine).

In many cases, especially for insulated journals with negligible risk of steam leakage, these values for initial axial displacement of the housing may be reduced. In such cases please consult SKF.

Initial displacement can be used to increase the available axial clearance for cylinder expansion

Fig 15

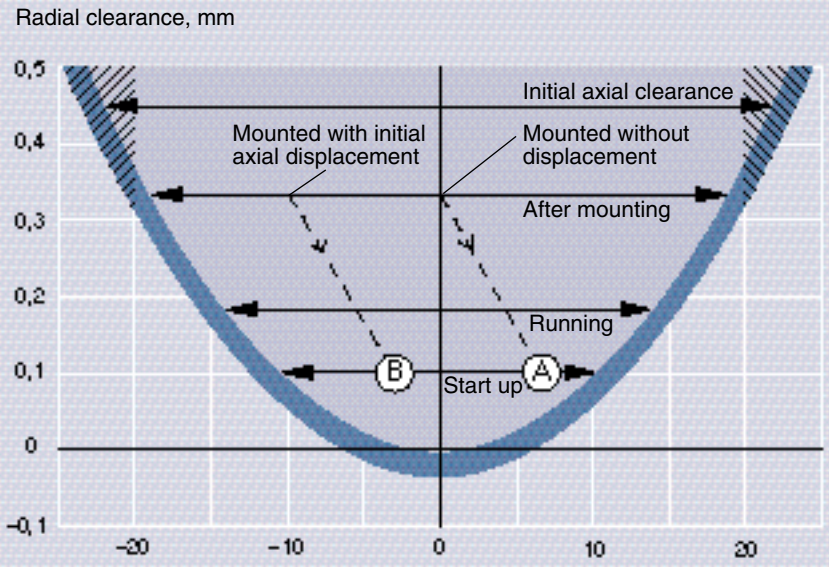


Axial housing mounting positions for cold machine, see also diagram 2, page 10. For further information please contact SKF

Table 5

Cylinder length over	incl.	Steam temperature	Initial axial displacement
m		°C	mm
0	4	<160	0±1
0	4	160 – 200	2 – 4
4	7	<160	2 – 4
4	7	160 – 200	4 – 6
7	11	<160	4 – 6
7	11	160 – 200	6 – 8

Diagram 6



Example: C 3052 K/HA3C4 with radial clearances estimated for 150–160 °C steam temperature and no journal insulation. Cylinder thermal expansion 7 mm

Dismounting

Usually drying cylinder bearings are mounted in non-split housings.

The best way to release the inner ring from a tapered shaft is to use the oil injection method. When the inner ring is released the distance between inner ring side face and nut must be about twice the drive-up distance. This is valid also for other bearing types. If the distance is too long there is a risk of damage to the raceways.

It is often difficult to dismount the bearing from the housing without damaging the raceways. The reason is that it is difficult to apply an axial dismounting force by hand.

Further, a spherical roller bearing sometimes tends to stick in the housing, especially if fretting corrosion has occurred. There are even paper mills which make threaded holes in the cage of spherical roller bearings to be able to dismount with a puller.

As the dismounting force is to be applied on the outer ring, the use of the SKF TMMC puller shown in **fig** 16 is recommended for dismounting a CARB from a drying cylinder housing.

The use of a puller is possible due to the design of CARB with more space between rollers, cage and outer ring compared with a spherical roller bearing. For more information about dismounting tools, please contact SKF.

Rebuild to CARB bearing arrangement!

To obtain all the benefits a CARB bearing arrangement can give, SKF recommends the use of SKF CARB housings when rebuilding existing machines. The SKF range of CARB housings is shown on **page 21**. Reworking existing housings may cause additional machine stoppages and this can be as expensive as a new housing.

After many years in operation the bearing seatings of drying cylinder housings may have extensive fretting corrosion and be worn or oval. When converting from a rocker housing, a reworked housing will not be as stable as a new one.

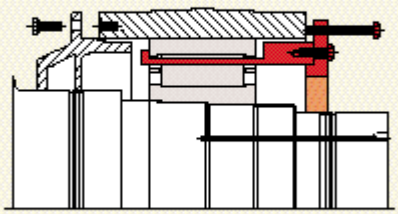
As CARB follows the ISO standard for bearing dimensions, bearing C 3152 has the same boundary dimensions as spherical roller bearing 23152 or cylindrical roller bearing N 3152. If the existing housings are inspected with good result they may in many cases, perhaps somewhat modified, be used for CARB when converting from other bearing types. If modifications are required, the total cost for a rebuild is often as high as an investment in new housings.

- When a rocker housing is modified to a fixed housing, it must be locked in all directions. This can be achieved by modifying the housing according to **fig** 17, depending on the design of the original housing.
- When rebuilding from spherical roller bearings with an axially free outer ring, distance sleeves have to be used in order to axially locate the CARB outer ring.
- When the existing bearing is lubricated from the side (➔ **fig** 3, **page 6**), it can be replaced by CARB without any changes related to the lubrication, although the oil flow can be somewhat increased due to the open design of CARB.
- If the existing bearing is lubricated through the outer ring (➔ **figs** 2, 4 and 5, **pages 6** and **7**), the housing lubrication design must be changed when converting to CARB. One way is to displace the oil inlet to the outer side of the bearing as for the SKF standard CARB housings. However, this requires modifications in order to ensure that no oil drains without passing through the bearing. In some existing housings the diameter of the oil channels connecting the two sides of the bearing is small and should be enlarged to make a high oil flow possible. The other alternative is to displace the oil inlet to the inner side of the bearing and plug the oil channels connecting the two sides. Note that this modification may influence the drainage capacity of the housing.

When rebuilding to CARB, please contact SKF in order to optimise the bearing arrangement regarding bearing function and total cost.

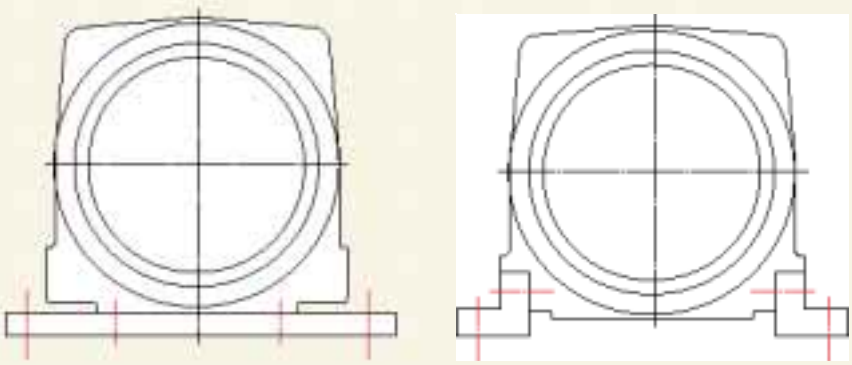
The SKF TMMC puller for easy dismounting of CARB

Fig 16



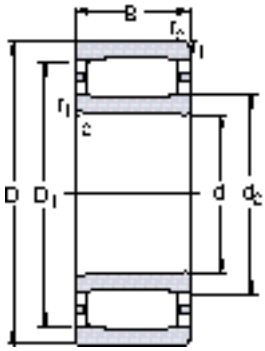
Rebuild from rocker housings

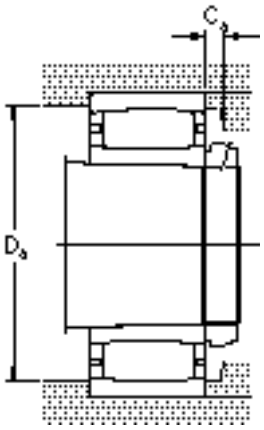
Fig 17



Product range

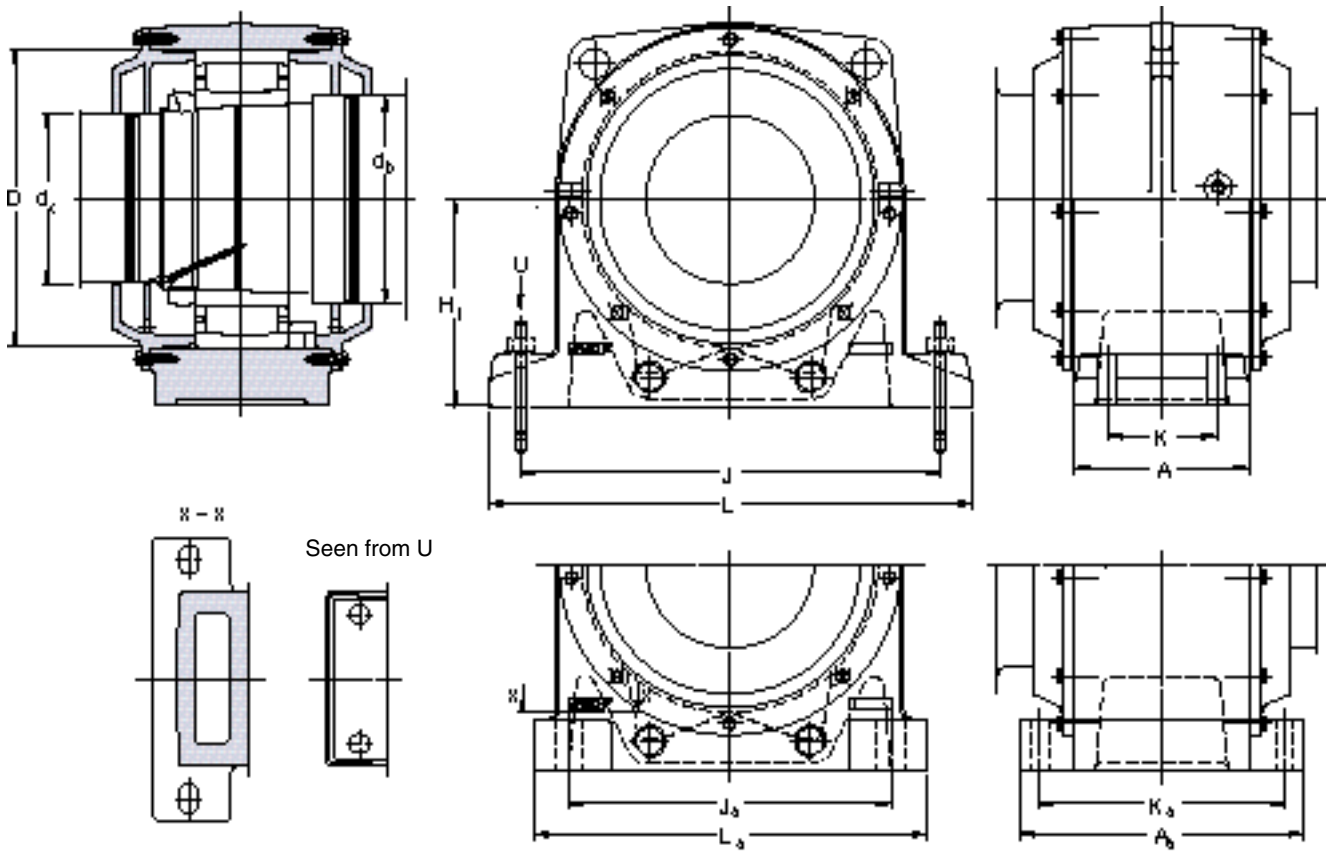
The product range for CARB has been initially chosen to meet the demand for drying cylinders in papermaking machines and so far comprises 14 sizes. It will be progressively enlarged in accordance with market demands. For sizes not shown, please contact SKF.





Dimensions						Abutment and fillet dimensions		Basic load ratings dynamic	static	Radial internal clearance	Designation
d	D	B	d_2	D_1	$r_{1,2}$ min	D_a max	C_a	C	C_0		
mm						mm		kN		µm	–
150	250	80	182	225	2,1	239	7,5	771	1 290	265–340	**C 3130 K/HA3C4**
180	280	74	209	251	2,1	269	8,2	771	1 340	300–385	**C 3036 K/HA3C4**
190	290	75	225	266	2,1	279	8,7	799	1 460	330–420	**C 3038 K/HA3C4**
	340	92	224	296	4	324	12	1 200	1 730	330–420	**C 2238 K/HA3C4**
200	310	82	235	285	2,1	299	8,3	978	1 730	330–420	**C 3040 K/HA3C4**
	340	112	245	305	3	327	14	1 380	2 320	330–420	**C 3140 K/HA3C4**
220	340	90	257	310	3	327	9	1 150	2 040	365–465	**C 3044 K/HA3C4**
	370	120	268	333	4	354	12	1 640	2 900	365–465	**C 3144 K/HA3C4**
	400	108	260	350	4	384	11	1 730	2 500	365–465	**C 2244 K/HA3C4**
240	360	92	276	329	3	347	10	1 200	2 240	400–510	**C 3048 K/HA3C4**
260	400	104	306	367	4	384	10	1 540	2 850	440–555	**C 3052 K/HA3C4**
	440	144	314	394	4	424	14	2 300	4 050	440–555	**C 3152 K/HA3C4**
280	460	146	336	416	5	440	15	2 480	4 500	440–555	**C 3156 K/HA3C4**
300	500	160	362	448	5	480	16	2 880	5 200	485–610	**C 3160 K/HA3C4**

Standard base design



Base design A

Shaft diameter	Designations Housing	Lock nut	Lock nut alternative	Dimensions Shaft		Housing		Standard base design				Base design A			
				d_b	d_c	D	H_1	A	J	K	L	A_a	J_a	K_a	L_a
mm	–			mm											
150	SBP 3130 RA	KMT 30	KML 30 + MBL 30	170	130	250	195	160	390	80	470	330	270	270	350
180	SBP 3036 RA	KMT 36	–	200	160	280	220	170	440	90	520	340	320	280	400
190	SBP 3038 RA	KMT 38	KML 38 + MBL 38	220	170	290	220	170	440	90	520	340	320	280	400
	SBP 2238 RA	KMT 38	KML 38 + MBL 38	220	170	340	240	200	485	115	570	370	350	310	440
200	SBP 3040 RA	KMT 40	KML 40 + MBL 40	230	180	310	240	200	485	115	570	370	350	310	440
	SBP 3140 RA	KMT 40	KML 40 + MBL 40	230	180	340	240	200	485	115	570	370	350	310	440
220	SBP 3044 RA	KMT 44	HM 3044 + MS 3044	250	200	340	240	200	485	115	570	370	350	310	440
	SBP 3144 RA	KMT 44	HM 3044 + MS 3044	250	200	370	265	235	550	135	640	400	380	340	490
	SBP 2244RA	KMT 44	HM 3044 + MS 3044	250	200	400	285	250	580	150	680	410	425	350	530
240	SBP 3048 RA	KMT 48	–	275	220	360	265	235	550	135	640	400	380	340	490
260	SBP 3052 RA	KMT 52	HM 3052 + MS 3052-48	300	240	400	285	250	580	150	680	410	425	350	530
	SBP 3152 RA	KMT 52	HM 3052 + MS 3052-48	300	240	440	310	265	620	160	720	435	470	375	580
280	SBP 3156 RA	KMT 56	HM 3056 + MS 3056	320	260	460	320	270	650	170	750	440	500	380	610
300	SBP 3160 RA	KMT 60	HM 3160 + MS 3160	340	280	500	335	300	720	180	820	470	560	410	670

The SKF Group – a worldwide corporation

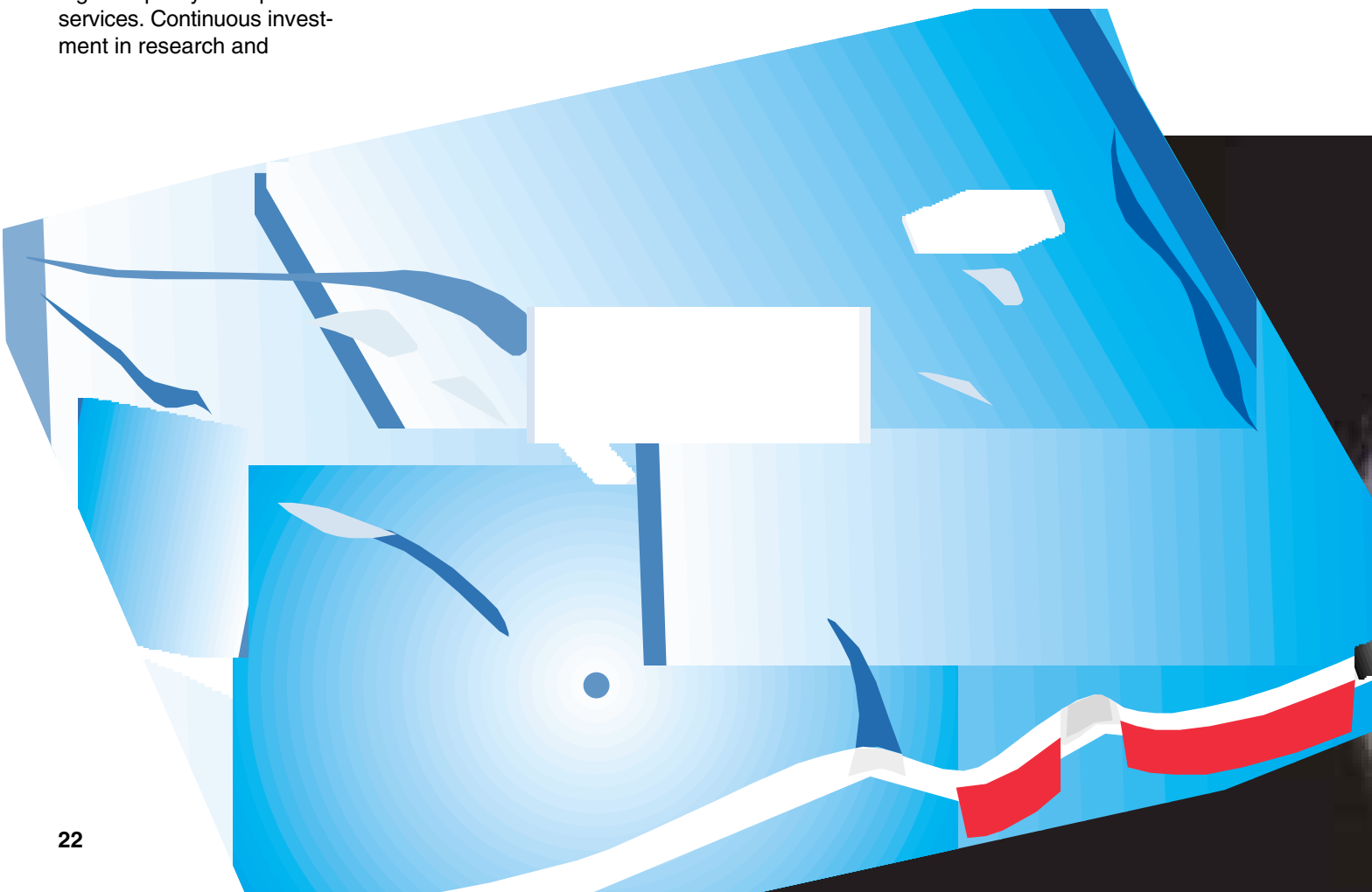
SKF is an international industrial Group operating in some 130 countries and is world leader in bearings.

The company was founded in 1907 following the invention of the self-aligning ball bearing by Sven Wingquist and, after only a few years, SKF began to expand all over the world.

Today, SKF has some 43 000 employees and more than 80 manufacturing facilities spread throughout the world. An international sales network includes a large number of sales companies and some 20 000 distributors and retailers. Worldwide availability of SKF products is supported by a comprehensive technical advisory service.

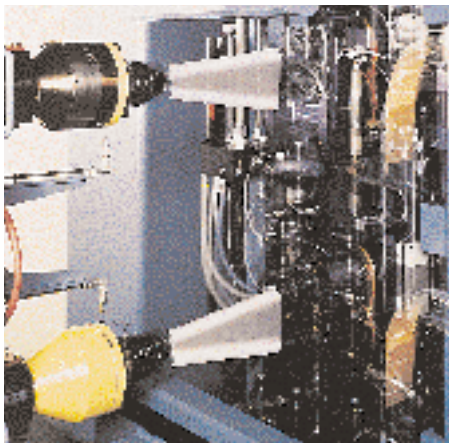
The key to success has been a consistent emphasis on maintaining the highest quality of its products and services. Continuous investment in research and development has also played a vital role, resulting in many examples of epoch-making innovations.

The business of the Group consists of bearings, seals, special steel and a comprehensive range of other high-tech industrial components. The experience gained in these various fields provides SKF with the essential knowledge and expertise required in order to provide the customers with the most advanced engineering products and efficient service.





The SKF house colours are blue and red, but the thinking is green. The latest example is the new factory in Malaysia, where the bearing component cleaning process conforms to the strictest ecological standards. Instead of trichloroethylene, a water-based cleaning fluid is used in a closed system. The cleaning fluid is recycled in the factory's own treatment plant.



The SKF Engineering & Research Centre is situated just outside Utrecht in The Netherlands. In an area of 17 000 square metres (185 000 sq.ft) some 150 scientists, engineers and support staff are engaged in the further improvement of bearing performance. They are developing technologies aimed at achieving better materials, better designs, better lubricants and better seals – together leading to an even better understanding of the operation of a bearing in its application. This is also where the SKF New Life Theory was evolved, enabling the design of bearings which are even more compact and offer even longer operational life.



SKF has developed the Channel concept in factories all over the world. This drastically reduces the lead time from raw material to end product as well as work in progress and finished goods in stock. The concept enables faster and smoother information flow, eliminates bottlenecks and bypasses unnecessary steps in production. The Channel team members have the knowledge and commitment needed to share the responsibility for fulfilling objectives in areas such as quality, delivery time, production flow etc.



SKF manufactures ball bearings, roller bearings and plain bearings. The smallest are just a few millimetres (a fraction of an inch) in diameter, the largest several metres. In order to protect the bearings effectively against the ingress of contamination and the escape of lubricant, SKF also manufactures oil and bearing seals. SKF's subsidiaries CR Industries and RFT S.p.A. are among the world's largest producers of seals.

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