SKF

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

# Contents

The SKF brand now stands for more than ever before, and means more to you as a valued customer.

While SKF maintains its leadership as the hallmark of quality bearings throughout the world, new dimensions in technical advances, product support and services have evolved SKF into a truly solutions-oriented supplier, creating greater value for customers.

These solutions encompass ways to bring greater productivity to customers, not only with breakthrough application-specific products, but also through leading-edge design simulation tools and consultancy services, plant asset efficiency maintenance programs, and the industry's most advanced supply management techniques.

The SKF brand still stands for the very best in rolling bearings, but it now stands for much more.

**SKF – The knowledge engineering company**

# 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 misalignment, 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 possibility 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(270 - 390 °F), 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

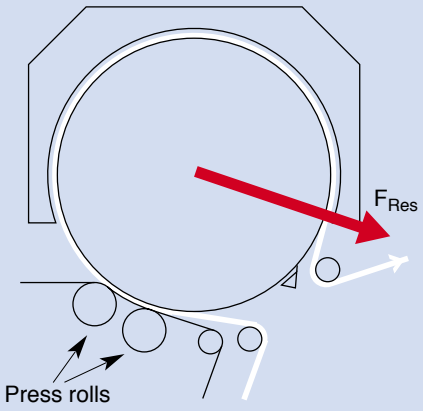
Most of the information in this brochure regarding drying cylinders is also valid for Yankee cylinders. Bearings in Yankee cylinders have approximately the same operating conditions as those in drying cylinders, including operating temperature and expansion of the cylinder. In relation to bearing size, 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 – 710 mm |
| **Cylinder diameter** | 1 500 – 2 200 mm | 3 000 – 6 500 mm |
| **Cylinder length** | 2 500 –12 000 mm | 2 000 – 7 000 mm |
| **Cylinder mass** | 5 – 30 tonnes | 50 – 170 tonnes |
| **Paper speed** | up to 1 900 m/min | up to 2 200 m/min (tissue)<br>up to 700 m/min (board) |
| **Steam temperature** | 130 – 200 °C<br>270 – 390 °F | 140 – 190 °C<br>285 – 375 °F |

Drying cylinders can be up to 12 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 %.

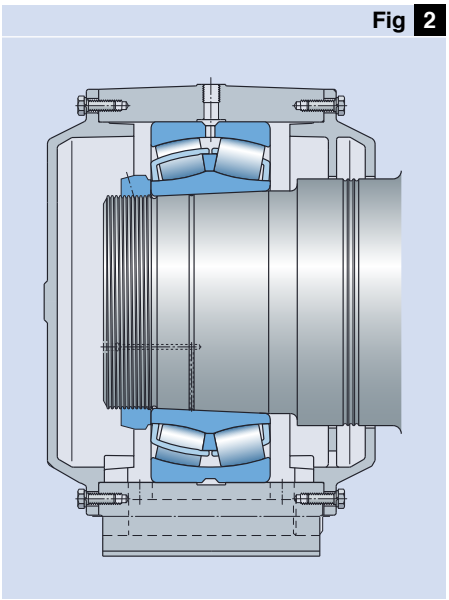
## Self-aligning double row cylindrical roller bearing

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

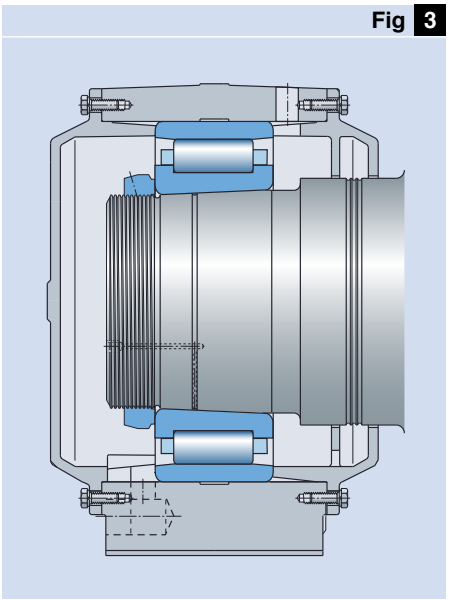
Friction between bearing outer ring and housing results in axial loads on bearing and machine frame

**Fig 2**



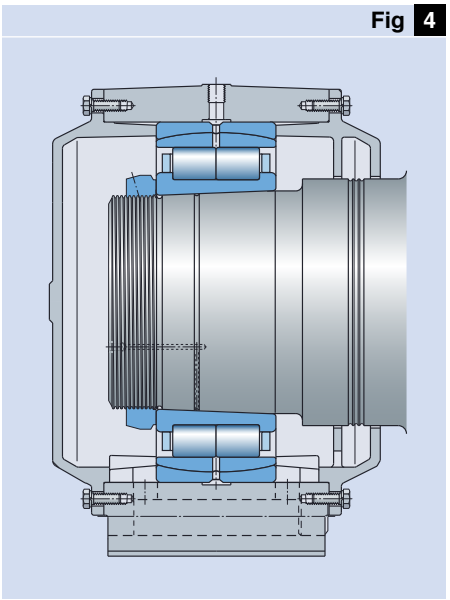
Misalignment causes edge stresses on rollers and raceways

**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.

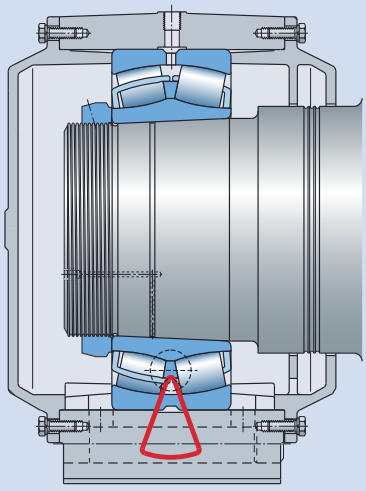
This has previously been the best solution and accordingly recommended by SKF for machines with a wire width above 4 500 mm. However, this housing arrangement is rather unstable and does not damp vibrations as well as solid housings; this may be a problem when upgrading to higher speeds. This arrangement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

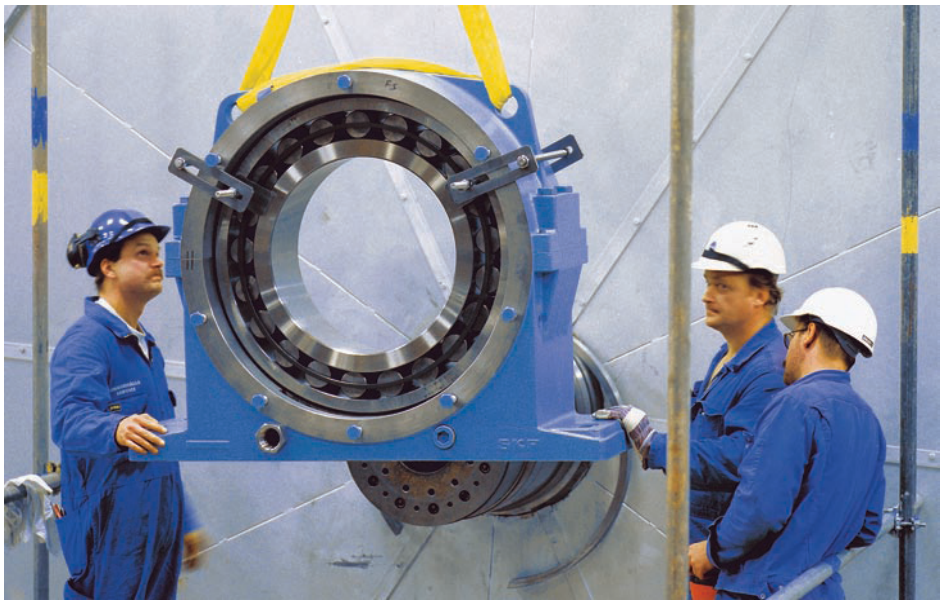
To sum up: with this solution there is a risk of axial forces and increased maintenance costs caused by malfunctioning rockers as well as restrictions in the speed capability of the machine.

Vibrations and tilting forces may cause problems

**Fig 5**



There has to be a better solution...



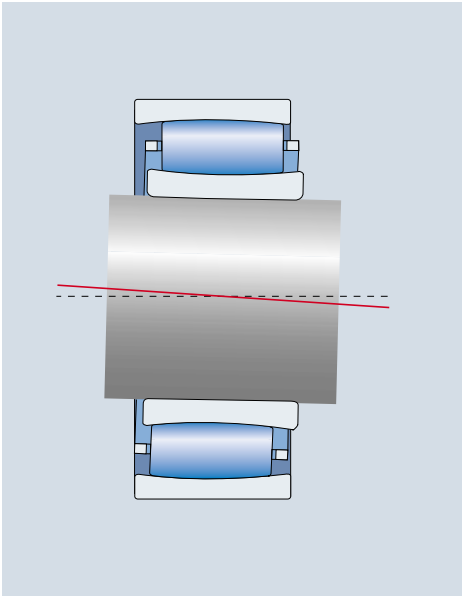
# A better solution with CARB toroidal roller bearings

In 1995 SKF introduced a new bearing – the CARB bearing. It was 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, CARB toroidal roller bearings 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, a CARB bearing has the potential of a compact design.

CARB bearing 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 CARB toroidal roller bearing. Tests made at a number of paper mills have proved that CARB bearing mounted in a fixed housing is the ideal bearing arrangement for this application.



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 optimized 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 bearing 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 bearing 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 CARB toroidal roller bearing, spherical roller bearings and cylindrical roller bearings.

The high load carrying capacity, the mis-alignment ability and the ability to accommodate axial displacement without causing axial loads are characteristic of CARB bearing 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.

## Friction

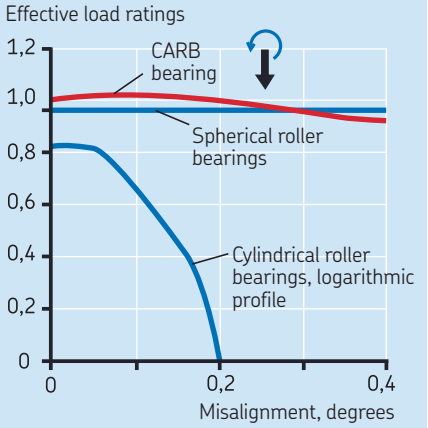
CARB bearing has about the same friction as cylindrical roller bearings and double row spherical roller bearings. The friction depends on the misalignment as the rollers adjust their axial position to avoid edge load.

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

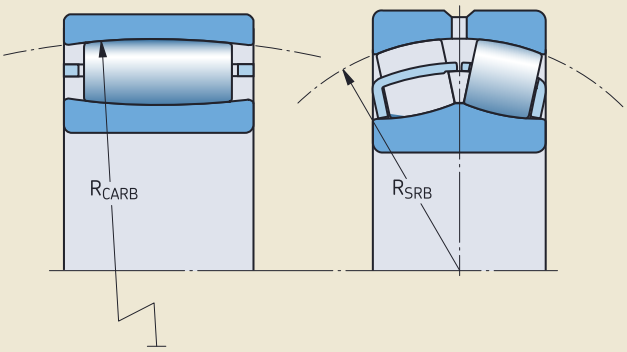
**Diagram 1**

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



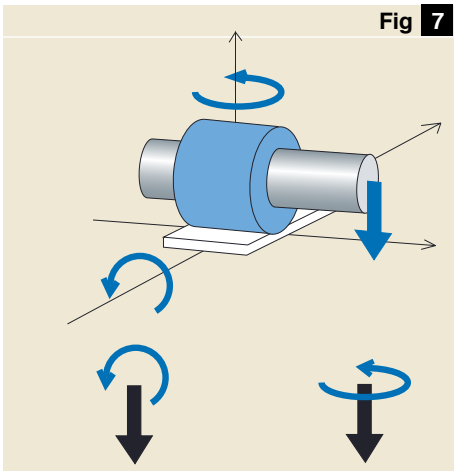

The raceway profile radius of CARB bearing is much larger than that of a spherical roller bearing $R_{CARB} >> R_{SRB}$

**Fig 6**




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

**Fig 7**



# 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

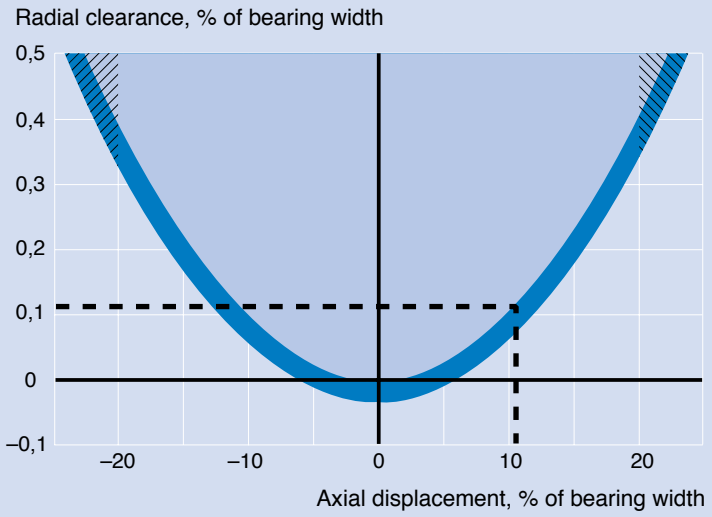
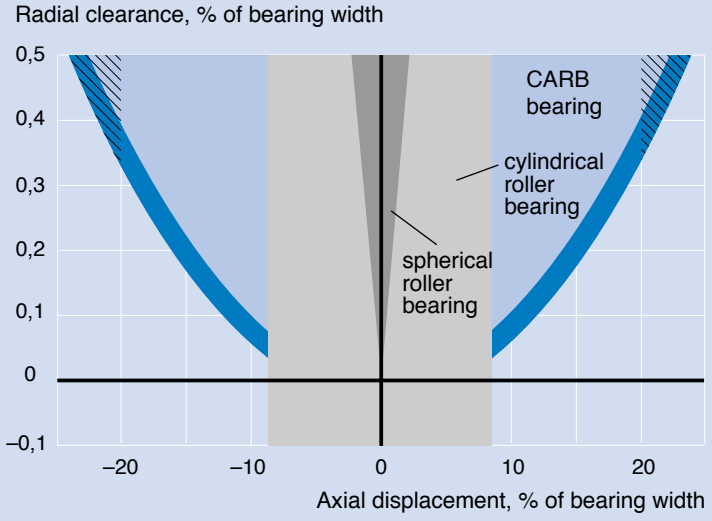



**Diagram 3**

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

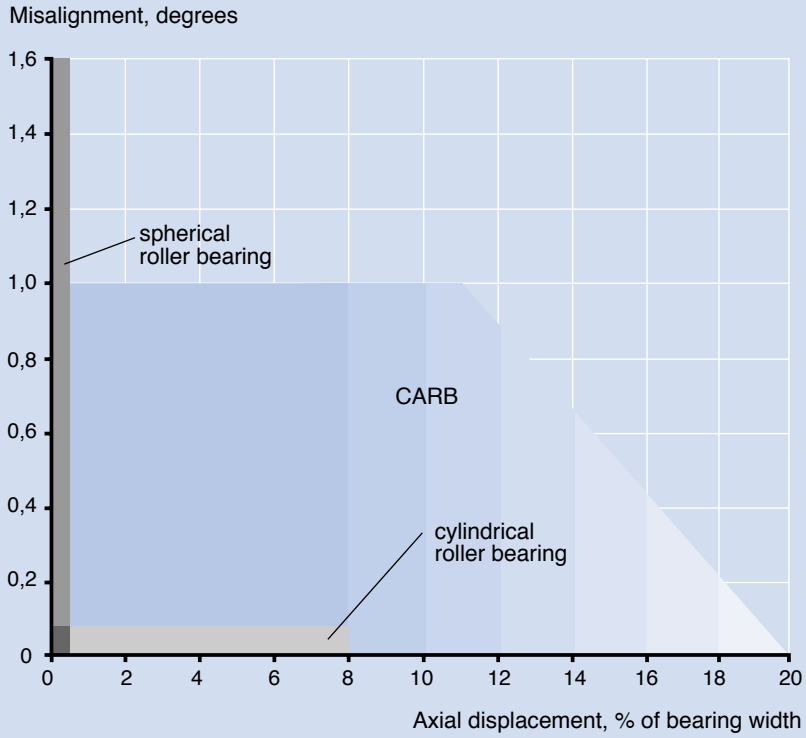


In **diagram** 3 the available axial displacement of a CARB bearing is compared with corresponding displacement of cylindrical and spherical roller bearings. Just like for a CARB bearing the available axial displacement of spherical roller bearings depends on the radial clearance. For cylindrical roller 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 a CARB bearing 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 a CARB bearing is available depends on the operating clearance.

**Diagram 4**

CARB bearings have 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, page 9**)



# Comparison and summary

- Improved reliability.
- Improved service life.
- Higher output.
- Machines can be speeded up.
- Improved paper quality.
- Optimized new bearing arrangements.
- Each unplanned stop in a papermaking machine costs 7 000 - 13 000 $ per hour.

A safer, more reliable bearing arrangement will save you a lot of money!

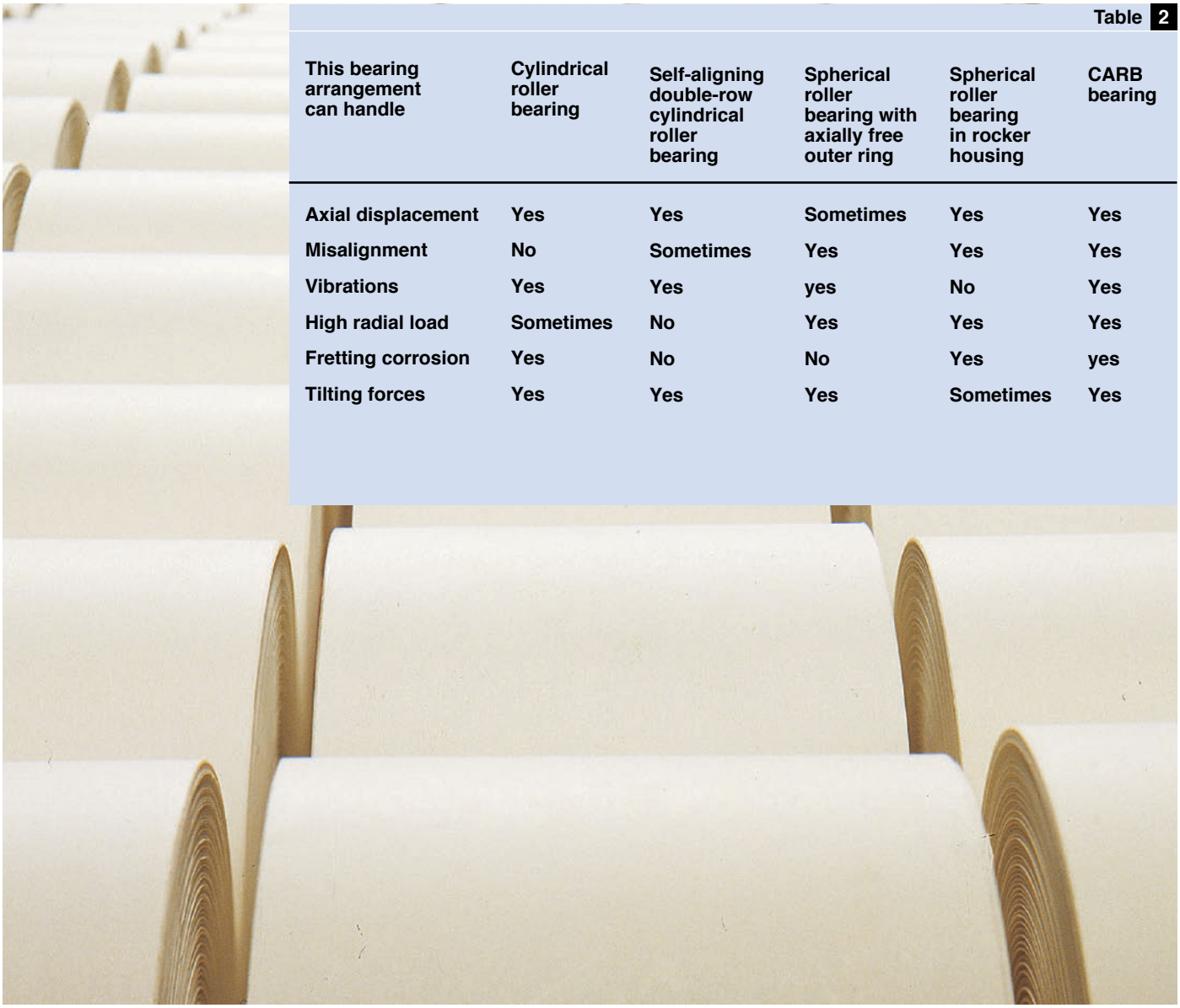


Table 2

| 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 bearing |
|---|---|---|---|---|---|
| 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 incorporating a CARB bearing 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 $L_{10mh}$ are the same as for other bearing types (➔ SKF publication 4690 “Rolling bearings in paper machines”).

As the load carrying capacity for a CARB bearing 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 a CARB bearing .

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 a CARB bearing 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 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 reference should be made to the SKF catalogue ”Bearing accessories”.

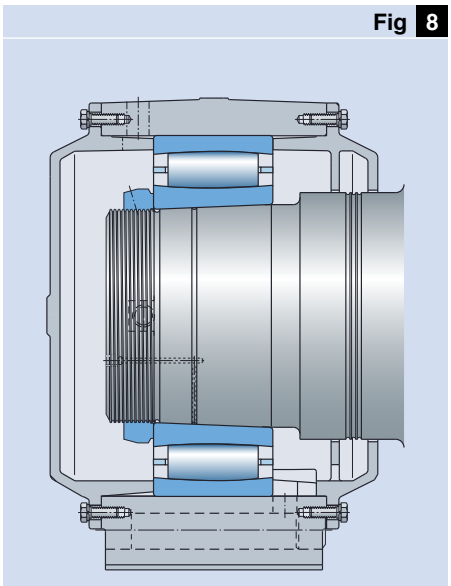
## Housings

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.

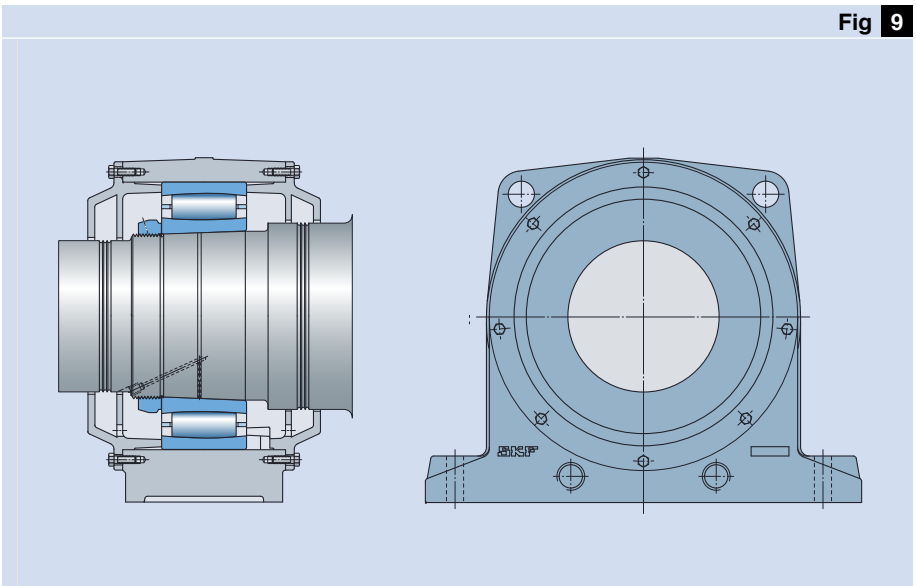
Bearing arrangement for CARB

**Fig 8**



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

**Fig 9**



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** 9, **page 13**). 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.

## Steam joint on front side

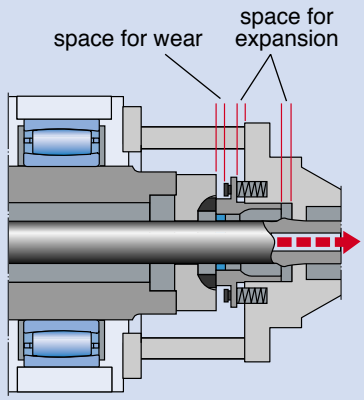
Sometimes drying cylinders are equipped with a steam joint for condensate outlet on the front side. Steam joints are used on both rocker housings and plummer block housings (fixed).

As the CARB bearing 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** 10). 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 minimize 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.

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

**Fig 10**




## 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. Multiparameter monitoring is based on measurements of several parameters, including traditional vibration, enveloping techniques and 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 bearing 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 for administration and analysis of measurement data. Training and support can be given by SKF local representatives.

CARB bearing 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 bearing arrangements in the dryer section of papermaking machines, with very good results.

Please contact SKF for references and for more information.

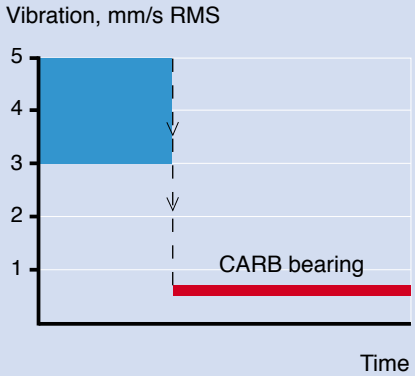
## Lubrication

Concerning lubrication of CARB bearings for drying cylinders, the same guidelines can be used as for spherical roller bearings (➔ SKF publication 4690 “Rolling bearings in paper machines”). As CARB bearing has only one roller row it is lubricated from the side (➔ **fig 11**).

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 11**. However, the pressed steel cage used in CARB bearing allows higher oil flows than the brass cage usually used in cylindrical roller bearings.

**Diagram 5**

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




A CARB bearing lubricated from the side

**Fig 11**

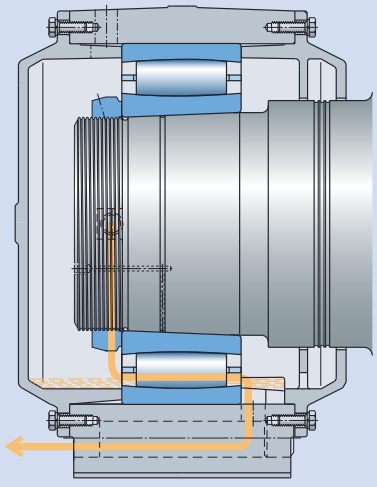


**Table 3**

**Defect frequencies for CARB bearings when inner ring rotational frequency = 1Hz = 60 r/min**

| Bearing size | Frequencies BPFI | BPFO | BSF | FTF |
|---|---|---|---|---|
| – | Hz | | | |
| **C 2234** | 10,33 | 7,67 | 3,30 | 0,43 |
| **C 3036** | 13,80 | 11,20 | 4,75 | 0,45 |
| **C 3136** | 11,35 | 8,65 | 3,63 | 0,43 |
| **C 3038** | 14,82 | 12,18 | 5,07 | 0,45 |
| **C 2238** | 9,82 | 7,18 | 3,14 | 0,42 |
| **C 3040** | 13,29 | 10,71 | 4,59 | 0,45 |
| **C 3140** | 11,84 | 9,16 | 3,86 | 0,44 |
| **C 3044** | 13,29 | 10,71 | 4,60 | 0,45 |
| **C 3144** | 11,81 | 9,19 | 3,95 | 0,44 |
| **C 2244** | 9,31 | 6,69 | 2,98 | 0,42 |
| **C 3048** | 13,76 | 11,24 | 4,91 | 0,45 |
| **C 3148** | 11,35 | 8,65 | 3,62 | 0,43 |
| **C 3052** | 13,80 | 11,20 | 4,75 | 0,45 |
| **C 3152** | 11,30 | 8,70 | 3,78 | 0,44 |
| **C 3056** | 14,82 | 12,18 | 5,07 | 0,45 |
| **C 3156** | 12,35 | 9,66 | 4,03 | 0,44 |
| **C 3160** | 11,81 | 9,19 | 3,95 | 0,44 |
| **C 3164** | 10,84 | 8,16 | 3,46 | 0,43 |
| **C 3168** | 10,84 | 8,16 | 3,46 | 0,43 |
| **C 3172** | 11,35 | 8,65 | 3,63 | 0,43 |
| **C 3084** | 14,35 | 11,65 | 4,75 | 0,45 |
| **C 3184** | 12,27 | 9,73 | 4,27 | 0,44 |
| **C 3092** | 15,76 | 13,24 | 5,71 | 0,46 |
| **C 3192** | 12,83 | 10,17 | 4,27 | 0,44 |
| **C 3096** | 16,27 | 13,73 | 5,87 | 0,46 |
| **C 30/500** | 17,32 | 14,68 | 6,04 | 0,46 |
| **C 31/500** | 12,32 | 9,68 | 4,11 | 0,44 |
| **C 30/530** | 14,74 | 12,26 | 5,39 | 0,45 |
| **C 31/530** | 11,76 | 9,24 | 4,10 | 0,44 |
| **C 30/560** | 16,81 | 14,19 | 5,87 | 0,46 |
| **C 30/600** | 15,76 | 13,24 | 5,71 | 0,46 |
| **C 30/630** | 15,29 | 12,71 | 5,40 | 0,45 |
| **C 30/670** | 15,80 | 13,21 | 5,55 | 0,46 |
| **C 30/710** | 15,83 | 13,17 | 5,39 | 0,45 |

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

# Mounting

When mounting CARB bearings in drying cylinders the use of the SKF drive-up method is strongly recommended. This is a more precise and less subjective method than measuring clearance reduction with a feeler gauge.

This method is preferable for mounting larger bearings for example on drying cylinders, suction rolls and press rolls. This method is preferable for smaller bearings as well.

SKF can supply suitable tools (➔ **fig** 12) and mounting instructions for general applications as well as specific applications like drying and Yankee cylinders. SKF can also supply the software program “SKF Drive-up” making it possible to make your own calculations. Note that the drive-up values obtained are only valid for SKF bearings.

The most precise, reliable and also the simplest way to mount larger bearings is the SensorMount® method. SensorMount uses electronics to control the inner ring drive-up.

The system comprises a bearing with a sensor and a hand-held indicator (➔ **fig** 13). The indicator reads the actual radial expansion and therefore no calculations or drive-up tables are needed to achieve the proper drive-up distance.

For detailed information about SKF drive-up method and SensorMount please contact your local SKF sales unit.
Additional information can be found

- in the handbook “Rolling bearings in paper machines”, Publ. No. 4690,
- in the handbook “SKF Drive-up Method” on CD-ROM,
- in the “SKF Interactive Engineering Catalogue” online at www.skf.com, or
- online at www.skf.com/mount.

# 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”.

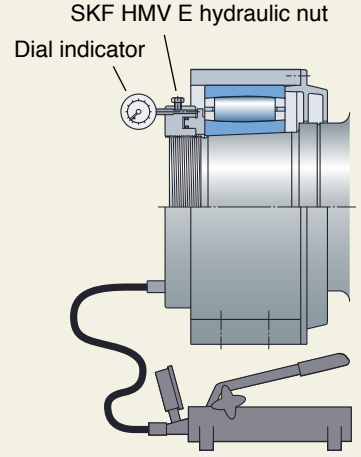
A Without initial displacement position A is reached at start-up. In this position the axial clearance is 3 mm outwards (from the cylinder) and 17 mm inwards.
B With 10 mm initial displacement position B is reached at start-up. In this position the axial clearance is 13 mm outwards (from the cylinder) 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** 14).

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** 4 are recommended (valid for cold machine).

Mounting tools used with SKF drive-up method

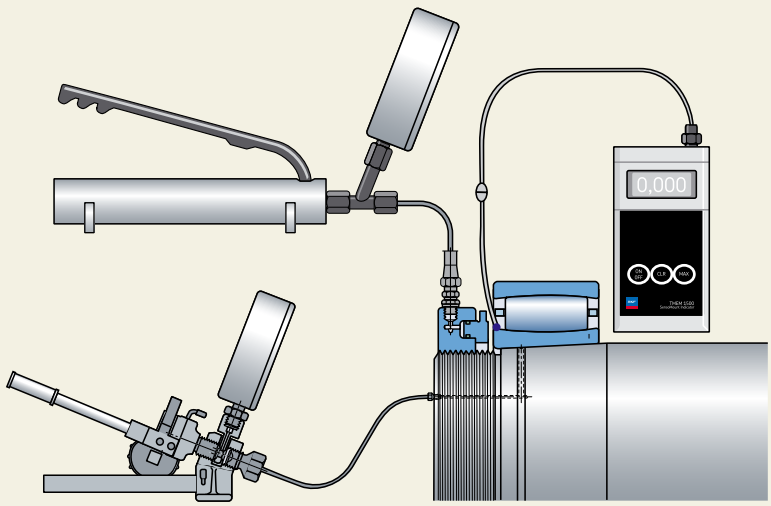
**Fig 12**




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)

Mounting tools used for SensorMount®

**Fig 13**



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.

## 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.

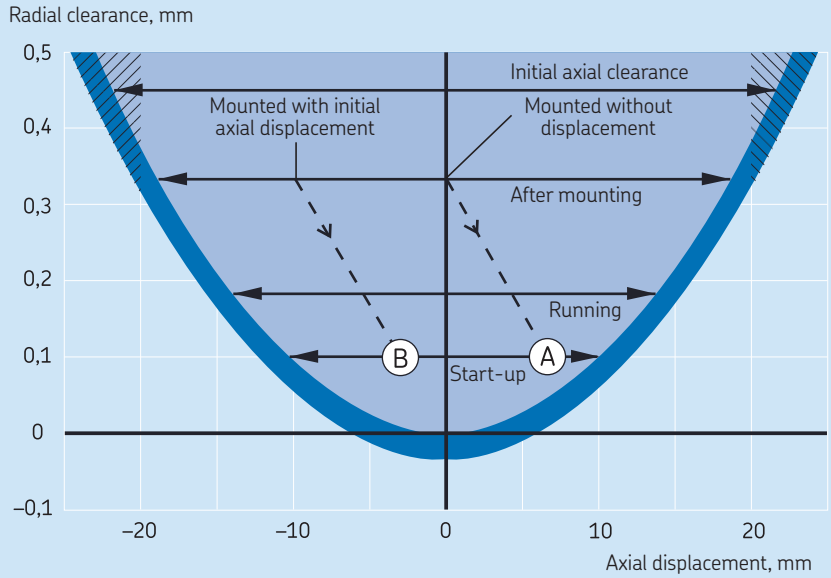
It is often difficult to dismount the bearing from the housing without damaging the raceways. The reason is that it is difficult to apply an axial dismounting force by hand.

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.

Various larger CARB toroidal roller bearings which have a loose or a transition fit in the housing can be removed using a tool with hooks that pass between the rollers and grip the outer ring from behind (→ **fig 15**), so that the withdrawal forces are applied directly to the outer ring and the rollers do not become jammed between the rings.

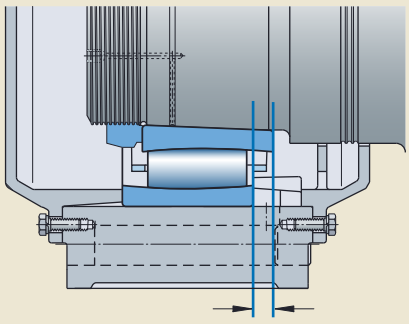
**Diagram 6**

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




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

**Fig 14**



*Schematic sketch of tool for removal of CARB bearings from a non-split housing*

**Fig 15**

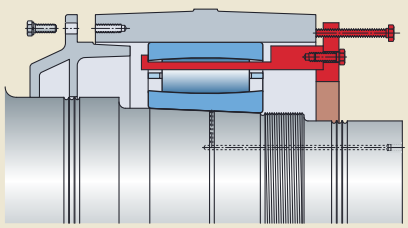


**Table 4**

**Axial housing mounting positions for cold machine (→ diagram 2, page 10). For further information please contact SKF**

| 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 |

# 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. Reworking existing housings may cause additional machine stoppages and this can be as expensive as a new housing.

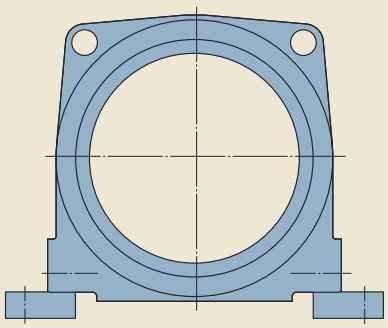
After many years in operation the bearing seatings of drying cylinder housings may have extensive fretting corrosion and be worn or oval. When converting from a rocker housing, a reworked housing will not be as stable as a new one.

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** 16, 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 outer ring of the CARB bearing.
- 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 the CARB bearing.
- 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 bearings. 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.

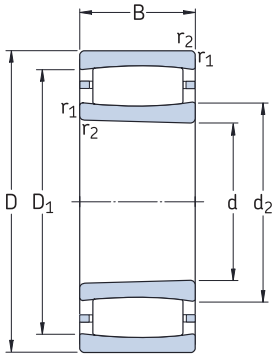
*Rebuild from rocker housing*

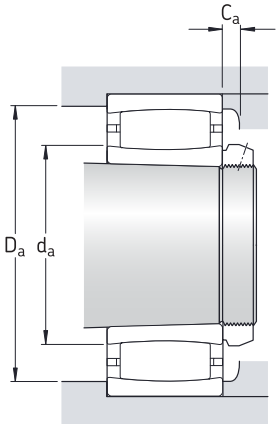
**Fig 16**



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

# Product range




| Dimensions | | | | | | Abutment and fillet dimensions | | | Basic load ratings dynamic | static | Designation[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| d | D | B | $d_2$ | $D_1$ | $r_{1,2}$ min | $d_a$ max | $D_a$ min | $C_a$[1] min | C | $C_0$ | |
| mm | | | | | | mm | | | kN | | – |
| **170** | 310 | 86 | 209 | 274 | 4 | 230 | 255 | 3 | 1 270 | 1 630 | **C 2234 K/HA3C4** |
| **180** | 280 | 74 | 209 | 251 | 2,1 | 220 | 240 | 2 | 880 | 1 340 | **C 3036 K/HA3C4** |
| | 300 | 96 | 210 | 266 | 3 | 230 | 255 | 2,2 | 1 250 | 1 730 | **C 3136 K/HA3C4** |
| **190** | 290 | 75 | 225 | 266 | 2,1 | 235 | 255 | 1,9 | 930 | 1 460 | **C 3038 K/HA3C4** |
| | 340 | 92 | 224 | 296 | 4 | 250 | 275 | 1,6 | 1 370 | 1 730 | **C 2238 K/HA3C4** |
| **200** | 310 | 82 | 235 | 285 | 2,1 | 250 | 275 | 2,9 | 1 120 | 1 730 | **C 3040 K/HA3C4** |
| | 340 | 112 | 245 | 305 | 3 | 260 | 307 | – | 1 600 | 2 320 | **C 3140 K/HA3C4** |
| **220** | 340 | 90 | 257 | 310 | 3 | 270 | 295 | 3,1 | 1 320 | 2 040 | **C 3044 K/HA3C4** |
| | 370 | 120 | 268 | 333 | 4 | 290 | 315 | 3,5 | 1 900 | 2 900 | **C 3144 K/HA3C4** |
| | 400 | 108 | 259 | 350 | 4 | 295 | 320 | 1,7 | 2 000 | 2 500 | **C 2244 K/HA3C4** |
| **240** | 360 | 92 | 276 | 329 | 3 | 290 | 315 | 1,3 | 1 340 | 2 160 | **C 3048 K/HA3C4** |
| | 400 | 128 | 281 | 357 | 4 | 305 | 335 | 3,7 | 2 320 | 3 450 | **C 3148 K/HA3C4** |
| **260** | 400 | 104 | 305 | 367 | 4 | 325 | 350 | 3,4 | 1 760 | 2 850 | **C 3052 K/HA3C4** |
| | 440 | 144 | 314 | 394 | 4 | 340 | 375 | 4,1 | 2 650 | 4 050 | **C 3152 K/HA3C4** |
| **280** | 420 | 106 | 328 | 389 | 4 | 350 | 375 | 1,8 | 1 860 | 3 100 | **C 3056 K/HA3C4** |
| | 460 | 146 | 336 | 416 | 5 | 360 | 395 | 4,1 | 2 850 | 4 500 | **C 3156 K/HA3C4** |
| **300** | 500 | 160 | 362 | 448 | 5 | 390 | 425 | 4,9 | 3 250 | 5 200 | **C 3160 K/HA3C4** |
| **320** | 540 | 176 | 372 | 476 | 5 | 410 | 455 | 3,9 | 4 150 | 6 300 | **C 3164 KM/HA3C4** |

[1] Minimum width of free space for bearings with cage in normal position; for a displaced bearing, half the displacement should be added to the table value
[2] For sizes not shown, please contact SKF

| Dimensions | | | | | | Abutment and fillet dimensions | | | Basic load ratings dynamic | static | Designation[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| d | D | B | $d_2$ | $D_1$ | $r_{1,2}$ min | $d_a$ max | $D_a$ min | $C_a$[1] min | C | $C_0$ | |
| mm | | | | | | mm | | | kN | | – |
| **340** | 580 | 190 | 405 | 517 | 5 | 445 | 490 | 4,2 | 4 900 | 7 500 | **C 3168 KM/HA3C4** |
| **360** | 600 | 192 | 423 | 537 | 5 | 460 | 510 | 3,9 | 5 000 | 8 000 | **C 3172 KM/HA3C4** |
| **420** | 620 | 150 | 475 | 570 | 5 | 510 | 550 | 2,2 | 3 800 | 6 400 | **C 3084 KM/HA3C4** |
| | 700 | 224 | 508 | 618 | 6 | 540 | 595 | 3,8 | 6 000 | 10 400 | **C 3184 KM/HA3C4** |
| **460** | 680 | 163 | 539 | 624 | 6 | 565 | 605 | 2,3 | 4 000 | 7 500 | **C 3092 KM/HA3C4** |
| | 760 | 240 | 559 | 679 | 7,5 | 570 | 655 | 4,2 | 6 800 | 12 000 | **C 3192 KM/HA3C4** |
| **480** | 700 | 165 | 555 | 640 | 6 | 580 | 625 | 2,3 | 4 050 | 7 800 | **C 3096 KM/HA3C4** |
| **500** | 720 | 167 | 572 | 656 | 6 | 600 | 640 | 2,3 | 4 250 | 8 300 | **C 30/500 KM/HA3C4** |
| | 830 | 264 | 605 | 738 | 7,5 | 655 | 705 | – | 7 500 | 12 700 | **C 31/500 KM/HA3C4** |
| **530** | 780 | 185 | 601 | 704 | 6 | 635 | 685 | 2,5 | 5 100 | 9 500 | **C 30/530 KM/HA3C4** |
| | 870 | 272 | 635 | 781 | 7,5 | 680 | 745 | 4,8 | 8 800 | 15 600 | **C 31/530 KM/HA3C4** |
| **560** | 820 | 195 | 660 | 761 | 6 | 695 | 740 | 2,7 | 5 600 | 11 000 | **C 30/560 KM/HA3C4** |
| **600** | 870 | 200 | 692 | 805 | 6 | 725 | 775 | 2,7 | 6 300 | 12 200 | **C 30/600 KM/HA3C4** |
| **630** | 920 | 212 | 717 | 840 | 7,5 | 755 | 810 | 2,9 | 6 800 | 12 900 | **C 30/630 KM/HA3C4** |
| **670** | 980 | 230 | 775 | 904 | 7,5 | 820 | 875 | 2,9 | 8 150 | 16 300 | **C 30/670 KM/HA3C4** |
| **710** | 1 030 | 236 | 807 | 945 | 7,5 | 850 | 910 | 3,2 | 8 800 | 17 300 | **C 30/710 KM/HA3C4** |

[1] Minimum width of free space for bearings with cage in normal position; for a displaced bearing, half the displacement should be added to the table value
[2] For sizes not shown, please contact SKF

# SKF – the knowledge engineering company

From the company that invented the self-aligning ball bearing 100 years ago, SKF has evolved into a knowledge engineering company that is able to draw on five platforms to create unique solutions for its customers. These platforms include bearings, bearing units and seals, of course, but extend to other areas including: lubricants and lubrication systems, critical for long bearing life in many applications; mechatronics that combine mechanical and electronics knowledge into systems for more effective linear motion and sensorized solutions; and a full range of services, from design and logistics support to conditioning monitoring and reliability systems.

Though the scope has broadened, SKF continues to maintain the world's leadership in the design, manufacture and marketing of rolling bearings, as well as complementary products such as radial seals. SKF also holds an increasingly important position in the market for linear motion products, high-precision aerospace bearings, machine tool spindles and plant maintenance services.

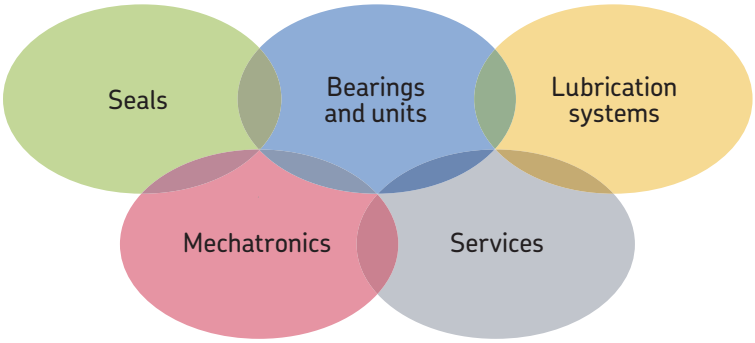
The SKF Group is globally certified to ISO 14001, the international standard for environmental management, as well as OHSAS 18001, the health and safety management standard. Individual divisions have been approved for quality certification in accordance with either ISO 9000 or QS 9000.

With some 100 manufacturing sites worldwide and sales companies in 70 countries, SKF is a truly international corporation. In addition, our distributors and dealers in some 15 000 locations around the world, an e-business marketplace and a global distribution system put SKF close to customers for the supply of both products and services. In essence, SKF solutions are available wherever and whenever customers need them. Overall, the SKF brand and the corporation are stronger than ever. As the knowledge engineering company, we stand ready to serve you with world-class product competencies, intellectual resources, and the vision to help you succeed.




***Evolving by-wire technology***
*SKF has a unique expertise in fast-growing by-wire technology, from fly-by-wire, to drive-by-wire, to work-by-wire. SKF pioneered practical fly-by-wire technology and is a close working partner with all aerospace industry leaders. As an example, virtually all aircraft of the Airbus design use SKF by-wire systems for cockpit flight control.*

*SKF is also a leader in automotive by-wire technology, and has partnered with automotive engineers to develop two concept cars, which employ SKF mechatronics for steering and braking. Further by-wire development has led SKF to produce an all-electric forklift truck, which uses mechatronics rather than hydraulics for all controls.*




***Harnessing wind power***
*The growing industry of wind-generated electric power provides a source of clean, green electricity. SKF is working closely with global industry leaders to develop efficient and trouble-free turbines, providing a wide range of large, highly specialized bearings and condition monitoring systems to extend equipment life of wind farms located in even the most remote and inhospitable environments.*

***Working in extreme environments***
*In frigid winters, especially in northern countries, extreme sub-zero temperatures can cause bearings in railway axleboxes to seize due to lubrication starvation. SKF created a new family of synthetic lubricants formulated to retain their lubrication viscosity even at these extreme temperatures. SKF knowledge enables manufacturers and end user customers to overcome the performance issues resulting from extreme temperatures, whether hot or cold. For example, SKF products are at work in diverse environments such as baking ovens and instant freezing in food processing plants.*

***Developing a cleaner cleaner***
*The electric motor and its bearings are the heart of many household appliances. SKF works closely with appliance manufacturers to improve their products' performance, cut costs, reduce weight, and reduce energy consumption. A recent example of this cooperation is a new generation of vacuum cleaners with substantially more suction. SKF knowledge in the area of small bearing technology is also applied to manufacturers of power tools and office equipment.*


***Maintaining a 350 km/h R&D lab***
*In addition to SKF's renowned research and development facilities in Europe and the United States, Formula One car racing provides a unique environment for SKF to push the limits of bearing technology. For over 50 years, SKF products, engineering and knowledge have helped make Scuderia Ferrari a formidable force in F1 racing. (The average racing Ferrari utilizes more than 150 SKF components.) Lessons learned here are applied to the products we provide to automakers and the aftermarket worldwide.*

***Delivering Asset Efficiency Optimization***
*Through SKF Reliability Systems, SKF provides a comprehensive range of asset efficiency products and services, from condition monitoring hardware and software to maintenance strategies, engineering assistance and machine reliability programs. To optimize efficiency and boost productivity, some industrial facilities opt for an Integrated Maintenance Solution, in which SKF delivers all services under one fixed-fee, performance-based contract.*

***Planning for sustainable growth***
*By their very nature, bearings make a positive contribution to the natural environment, enabling machinery to operate more efficiently, consume less power, and require less lubrication. By raising the performance bar for our own products, SKF is enabling a new generation of high-efficiency products and equipment. With an eye to the future and the world we will leave to our children, the SKF Group policy on environment, health and safety, as well as the manufacturing techniques, are planned and implemented to help protect and preserve the earth's limited natural resources. We remain committed to sustainable, environmentally responsible growth.*

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