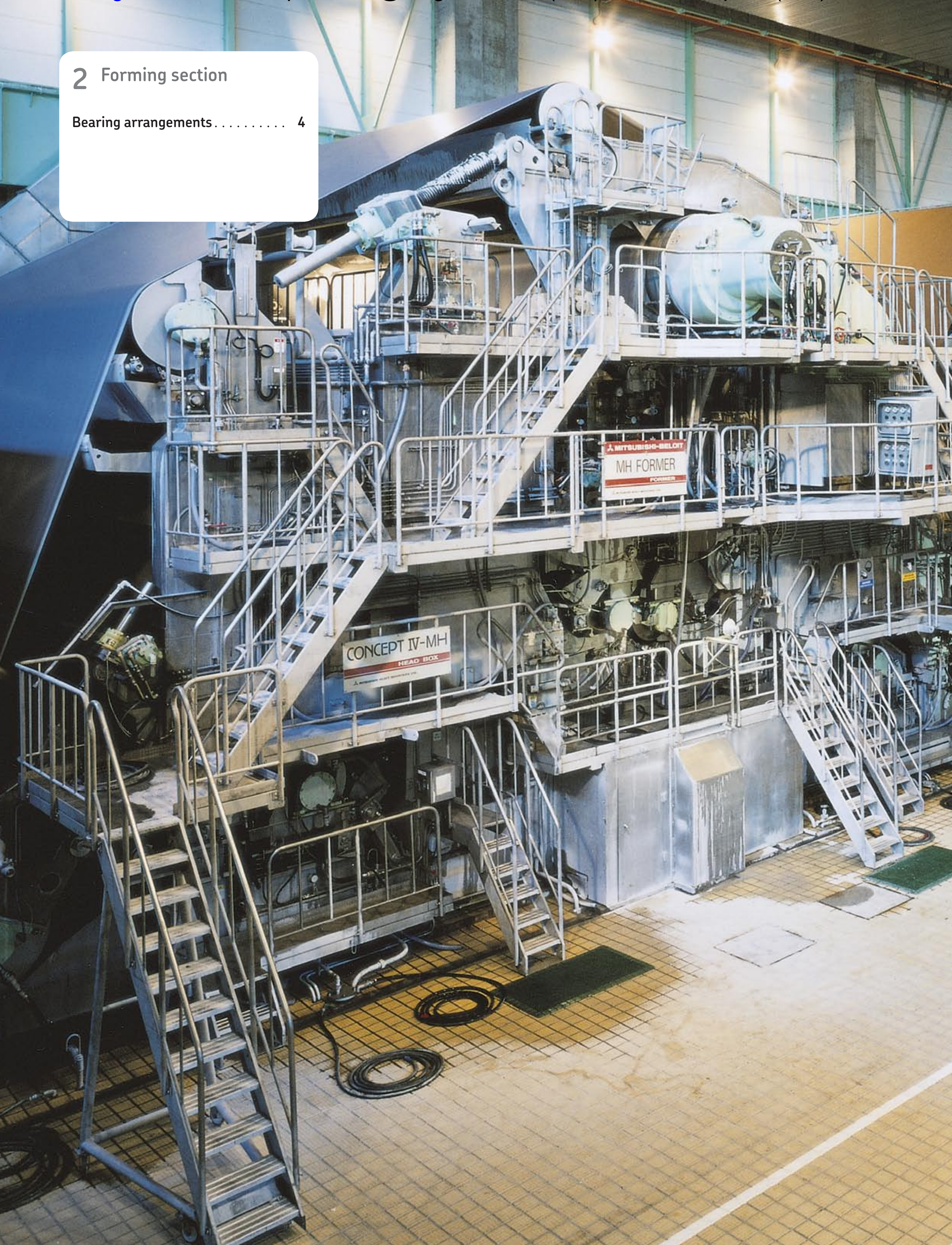
2 Forming section



Forming section

The forming section is the first part of the paper machine. The stock contains around 99% water at this stage. By the end of the forming section, the water content has to be about 80% to make the paper web self-supporting as it moves on to the press section. Depending on the design of the forming section, modern paper machines can be grouped under the headings Fourdrinier machines or twin wire machines.

Fourdrinier machine

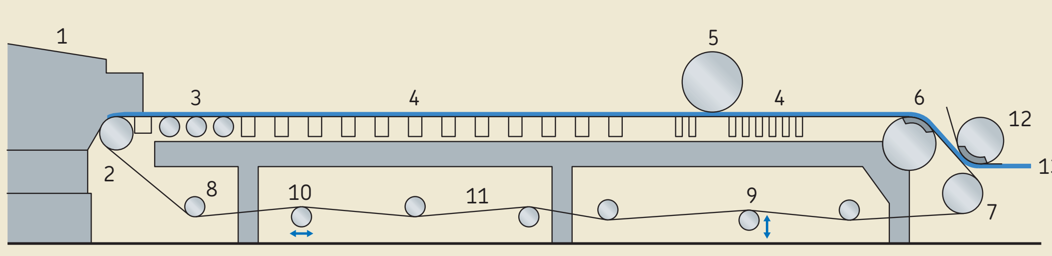
The Fourdrinier machine is the original, and still most widely used, formation unit. It can be used for virtually all types of paper and for machine speeds up to 900 m/min. **Fig. 1** shows the wire part of such a machine.

Some wire parts are equipped with a dandy roll to flatten the top surface of the sheet, giving it a smoother and closer finish, and to make watermarks in fine papers.

At the end of the wire part, there is a suction couch roll that finally reduces the water content to 80% to make the web self-supporting. The suction couch roll is equipped with a drive system and drives the whole wire part.

Large machines and machines operating at high speeds are usually equipped with an additional drive roll, called the forward drive roll.

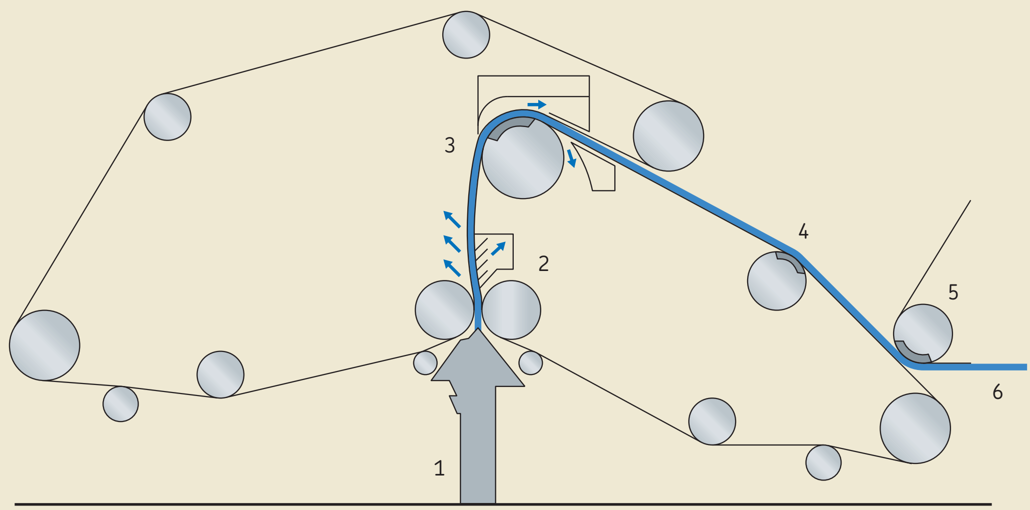
Fig. 1



Wire part of Fourdrinier machine
1 Headbox
2 Breast roll
3 Table roll
4 Suction box
5 Dandy roll
6 Suction couch roll
7 Forward drive roll
8 Wire roll
9 Wire stretch roll
10 Wire guide roll
11 Wire
12 Suction pickup roll
13 Paper web

Blade former, Beloit Bel Baie III
1 Headbox
2 Forming shoe and blades
3 Primary suction roll
4 Secondary suction roll
5 Suction pickup roll
6 Paper web

Fig. 2



Twin wire machine

It is becoming increasingly common to dewater stock between two wires. This process was developed in the early 1970s to make dewatering and forming possible at high speeds. It is possible to distinguish between three different types of twin wire machines: blade formers, roll formers and top wire formers.

Blade former

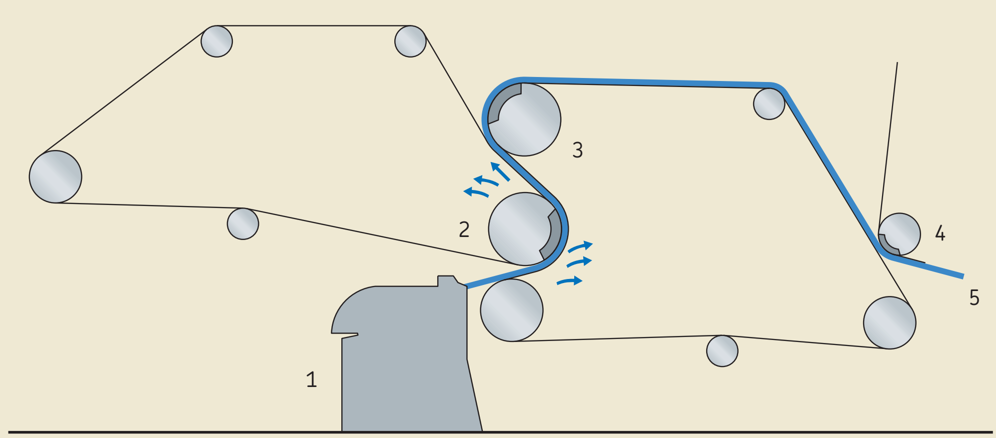
In a blade former, the dewatering zone can be curved (→ **fig. 2**). The curved dewatering zone is followed by suction rolls.

Roll former

In a roll former, dewatering is accomplished between two wires which run around part of a relatively large forming roll. In most cases, a suction roll is used as the forming roll (→ **fig. 3**).

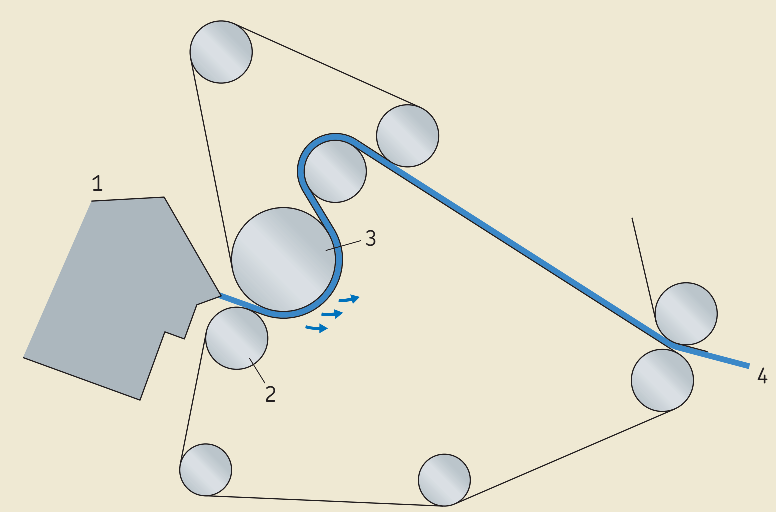
In the case of tissue machines with web speeds up to 2 500 m/min, the centrifugal force is utilized in the dewatering process. The forming roll is plain and dewatering occurs outwards only (→ **fig. 4**).

Fig. 3



Roll former, Voith Paper DuoFormer
1 Headbox
2 Forming (suction) roll
3 Suction couch roll
4 Suction pickup roll
5 Paper web

Fig. 4



Roll former, Metso PeriFormer
1 *Headbox*
2 *Breast roll*
3 *Forming roll (plain)*
4 *Paper web*

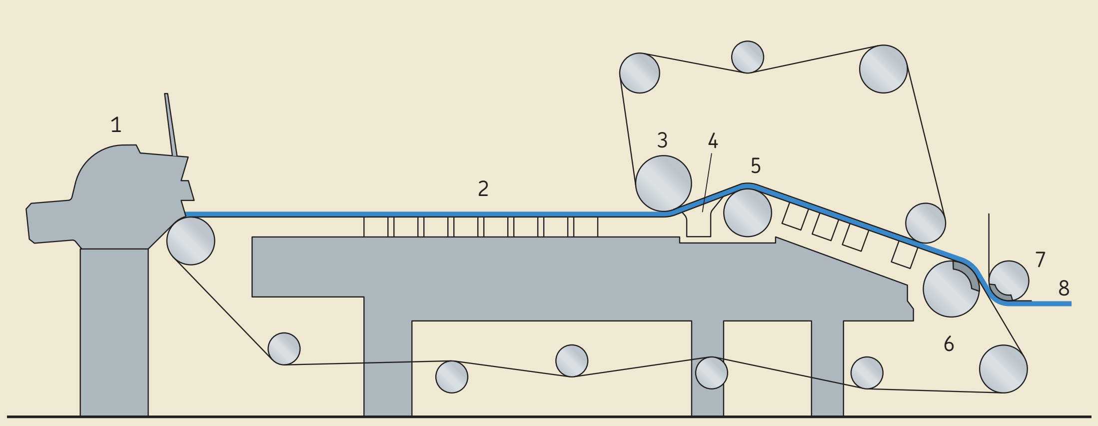
2

Top wire former

In a top wire former, the dewatering and forming process starts on a Fourdrinier wire. Then the paper web passes through a nip between the Fourdrinier wire and a top wire where most of the dewatering in the wire part is carried out (→ **fig. 5**).

Existing Fourdrinier machines (→ **fig. 1**, **page 1**) can easily be upgraded by the addition of a top wire to increase capacity.

Fig. 5



Top wire former, Metso SymFormer
1 *Headbox*
2 *Suction box*
3 *Forming roll (grooved)*
4 *Forming shoe*
5 *Forming roll (plain)*
6 *Suction couch roll*
7 *Suction pickup roll*
8 *Paper web*

Bearing arrangements

Breast and forward drive rolls

Different bearing arrangements may be used for breast and forward drive rolls. In **fig. 6**, the bearing housing is of the plummer (pillow) block type. The housing has its end cover designed to provide support for the extended journal during lifting.

In **fig. 7**, the bearing housing is sphered externally and stabilized by the use of an extra support bearing mounted on the end of the journal. The housing is carried in a sphered bracket connected to the frame. During wire changing, the roll is suspended by the bearing housing end covers in line with the support bearing. A spherical or a cylindrical roller bearing may be used as the support bearing.

In some old machines, the main bearing was positioned on the load direction line. This load was created by the contact housing/frame and, in some cases, the support bearing could become unloaded. As such, to avoid failures due to an unloaded bearing running at high speed, the main bearing is now often axially displaced a few millimetres inwards to load the support bearings. If needed, space can be provided in one of the housings to allow for axial movement of the non-locating bearing.

Journal and housing tolerances for breast and drive rolls

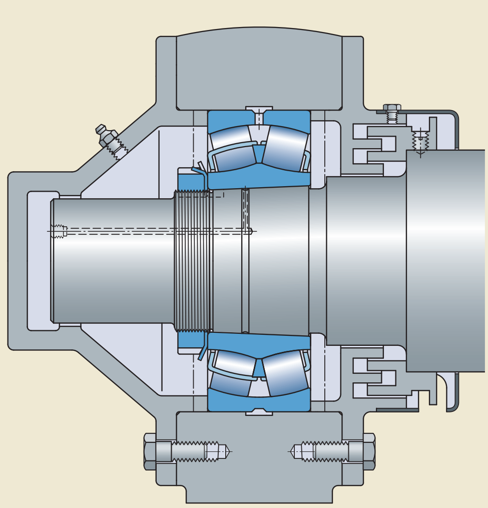
Journal	Mounting on a sleeve		h9 (IT5/2)
	Mounting on a tapered journal, see tolerances in *chapter 1*, **pages 14-16**		
	Support bearing seating		
	Cylindrical roller bearing	Spherical roller bearing	
	(65) to 140 mm	(65) to 100 mm	m6
	(140) to 200 mm	(100) to 140 mm	n6
		(140) to 200 mm	p6
Housing			G7

See also *chapter 1*, *General requirements and recommendations*, *Tolerances*, **pages 14–16**

These bearing arrangements work under very wet conditions. The housings should therefore incorporate efficient seals irrespective of whether grease or oil lubrication is employed. For CARB toroidal roller bearings, the lubricant must be supplied from the side. For spherical roller bearings, the lubricant can be supplied either from the side or via the groove and the holes in the outer ring. An annular groove turned in the housing, so as to coincide with the holes, improves the entry of lubricant. In designs incorporating a support bearing, a separate arrangement must be made for its lubrication.

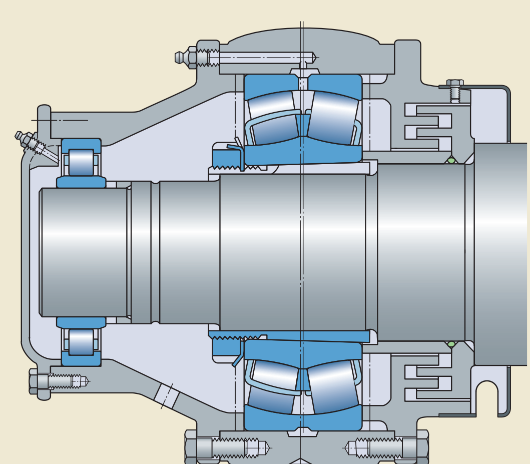
Breast and forward drive roll bearing arrangement

Fig. 6



Breast and forward drive roll bearing arrangement

Fig. 7



Bearing types

Breast and forward drive rolls are carried by spherical roller bearings, series 232 and 223 and CARB toroidal roller bearings series C 32 and C 23, mounted on adapter or withdrawal sleeves or direct on tapered journals.

A spherical or a cylindrical roller bearing may be used as the support bearing.

The main bearings, as well as the support bearings, are usually selected with Normal radial internal clearance. Sealed spherical roller bearings can improve service life by adding extra protection against contamination.

Selection of bearing size

Bearing selections should be based on life calculations according to the recommendations on **pages 3–4**, *chapter 1*, *General requirements and recommendations*. The recommended L_{10h} and L_{10ah} lives are 120 000 hours. The wire tension of 3–7 N/mm of roll length and the mass of the roll are to be taken into consideration when calculating the bearing loads. When the housings are mounted on shake rails, the axial accelerations must be taken into account.

Lubrication

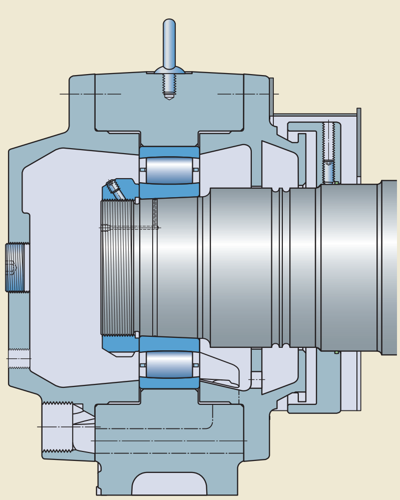
The two most important factors for effective lubrication are the viscosity, achieving a satisfactory oil film, and the lubricant cleanliness with respect to water and solid particles. Protection against corrosion has top priority for these bearing positions. Therefore, the lubricant must have good rust-inhibiting properties.

Sometimes, oil rather than grease lubrication is selected for these bearings. There are several reasons for this. One is the increased operating temperatures in high-speed machines requiring excessive grease quantities when relubricating. Another reason is that there are other oil-lubricated bearings nearby. When oil lubrication is selected, the seals must be modified to suit oil lubrication. An example of such a seal arrangement is shown in → **fig. 8**.

For further information, see *chapter 7*, *Lubrication*, **pages 8–16** and *examples 1* and *2* in *chapter 8*, *Lubrication examples*, **pages 2–5**.

Wire and felt roll bearing arrangement

Fig. 8



Wire rolls

Wire roll bearings in existing machines with moderate speeds are mainly grease lubricated and mounted on sleeves but, with increasing paper speeds, the use of oil lubrication and of bearings mounted direct on the journal is preferred.

Fig. 8, **page 5** shows an oil lubricated bearing arrangement for the wire rolls. The housing is the plummer (pillow) block type. The CARB toroidal roller bearing is mounted directly on the shaft, but mounting on a withdrawal sleeve is also used. The bearing arrangement is similar to that for press rolls.

Fig. 9 shows a bearing arrangement, with two bearings in the same housing, for guide and stretch rolls. The housing is sphered externally. The bearing arrangement is designed so that one of the bearings takes up the main load. The function of the support bearing is to keep the housing and journal axes in line during wire tension adjustment and wire guidance.

The design of the bearing arrangement for guide and stretch rolls depends on the design of the associated components. The support bearing may be a spherical or a cylindrical roller bearing and must be mounted at a certain distance from the load carrying bearing. The arrangement shown in **fig. 9** uses a spherical roller bearing as the support bearing. Note that the support bearings in both housings must be able to accommodate axial displacement.

Journal and housing tolerances for wire rolls

Journal	Mounting on a sleeve		h9 (IT5/2)
	Direct mounting on a cylindrical journal		
	(65) to 100 mm		m6
	(100) to 140 mm		n6
	Mounting on a tapered journal, see tolerances in *chapter 1*, **pages 14-16**		
	Support bearing seating		
	Cylindrical roller bearing	Spherical roller bearing	
	(40) to 100 mm	(40) to 65 mm	m5
		(65) to 100 mm	m6
Housing	For the wet section		G7

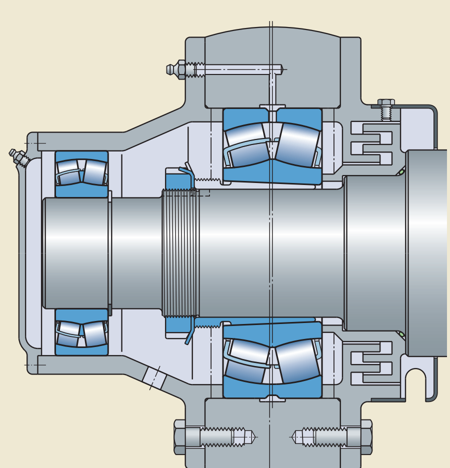
See also *chapter 1*, *General requirements and recommendations*, *Tolerances*, **pages 14–16**

In some old machines, the main bearing was positioned on the load direction line. This load was created by the contact housing/frame and, in some cases, the support bearing could become unloaded. As such, to avoid failures due to an unloaded bearing running at high speed, the main bearing is now often axially displaced a few millimetres inwards to load the support bearings.

If needed, space can be provided in one of the housings to allow for axial movement of the non-locating bearing.

Guide and stretch roll bearing arrangement

Fig. 9



Wire roll bearing arrangement with grease lubrication and protective cover

Fig. 10

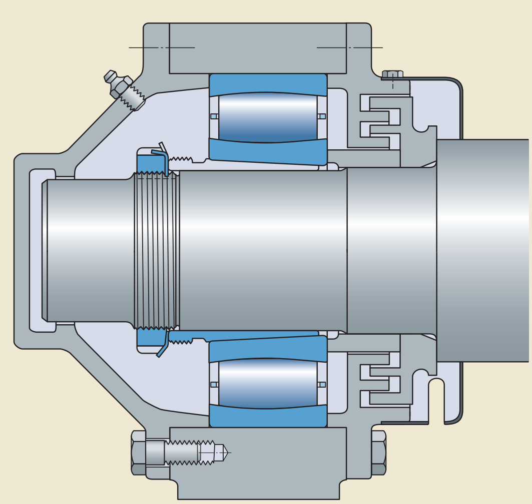


Fig. 10 shows a grease lubricated CARB toroidal roller bearing arrangement for wire rolls with improved protection against water and particle entrance. The housing is provided with a protective cover.

For CARB toroidal roller bearings, the grease must be supplied from the side. For spherical roller bearings, the grease can either be supplied from the side or via the groove and the holes in the outer ring. In designs incorporating a support bearing, separate arrangements must be made for its lubrication.

Bearing types

SKF recommends the use of spherical roller bearings of series 223 and 232 and CARB toriodal roller bearings of series C 23 and C 32, but spherical roller bearings of series 222 and CARB toroidal roller bearings of series C22 can also be used.

Both spherical roller bearings of series 222 and cylindrical roller bearings of series NUB 2, with wide inner ring, can be used as the support bearing.

The main bearings, as well as the support bearings, are usually selected with Normal radial internal clearance.

Selection of bearing size

Bearing selection should be based on life calculation according to the recommendations on **pages 2–3**, *chapter 1, General requirements and recommendations*. The recommended L_{10h} and L_{10ah} lives are 120 000 hours. If the mass of the wire roll is known, the maximum radial bearing load can be roughly estimated with the aid of the following equations

$$G = g\, m$$

$$K_r = 2\, q_1\, L + G$$

$$F_r = 0{,}5\, Kr$$

$F_a = \mu\, F_r$ (for a spherical roller bearing as non-locating bearing)

$F_a = 0$ (for a CARB toroidal roller bearing as non-locating bearing)

where
- G = roll weight, N
- g = 9,81 (acceleration of gravity), m/s^2
- m = roll mass, kg
- K_r = roll load, N
- q_1 = wire tension, N/mm
- L = wire width, mm
- F_r = radial bearing load, N
- F_a = axial bearing load, N
- μ = coefficient of friction between housing and outer ring (use μ = 0,15 in the calculation)

Generally, it can be assumed that the wire tension is 3–7 N/mm over the length of the roll. The axial bearing load caused by wire guidance can be ignored in the case of wire rolls. In some cases, the wire tension can lift the roll and make the bearing run with insufficient load, making rollers slide instead of roll.

Lubrication

The two most important factors for effective lubrication are the viscosity, achieving a satisfactory oil film, and the lubricant cleanliness with respect to water and solid particles. Protection against corrosion has top priority for this bearing position. Therefore, the lubricant must have good rust-inhibiting properties.

Sometimes oil lubrication rather than grease lubrication is selected for these bearings. There are several reasons for this. One is the increased operating temperatures in high-speed machines requiring excessive grease quantities when relubricating. Another reason is that there are other oil lubricated bearings nearby.

For further information, see *chapter 7, Lubrication*, **pages 8–16** and *examples 3* and *4* in *chapter 8, Lubrication examples*, **pages 6–9**.

Suction rolls

Fig. 11 shows a grease lubricated bearing arrangement of older design in which the front-side bearing is mounted at the end of the roll and the drive-side bearing is mounted on a withdrawal sleeve. Note that the stationary inner ring of the front-side bearing is mounted as a non-locating ring with a clearance fit on the sleeve to allow axial freedom of movement. Grease is supplied through holes in the inner ring. SKF bearings of this design have the suffix W513 in their designation, e.g. 23060 CC/W513.

One disadvantage with the bearing being mounted at the end of the roll is that it is difficult to make the internal seal so efficient that the ingress of water is eliminated. The suction box support bearing can be a sealed spherical roller bearing, with the seal on one side removed, to improve protection.

Suction rolls of this design are not so common today, but can be found in older low speed machines.

The design shown in **fig. 12** is an improved version of the design in **fig. 11**. This version has oil lubrication of the main bearings and grease lubrication of the internal bearing. In this case, the internal bearing can be a sealed spherical roller bearing with relubrication via the W33 feature in the outer ring. In modern machines, the internal bearing is also oil lubricated. With this design, both main bearings are mounted directly on the roll journals and are readily accessible for inspection. When bearings are mounted directly on the journal, oil injection grooves should be provided in the journal so that the bearings can be easily dismounted when the rolls are being serviced. In this design, space is provided in the housing to allow axial movement of the non-locating bearing.

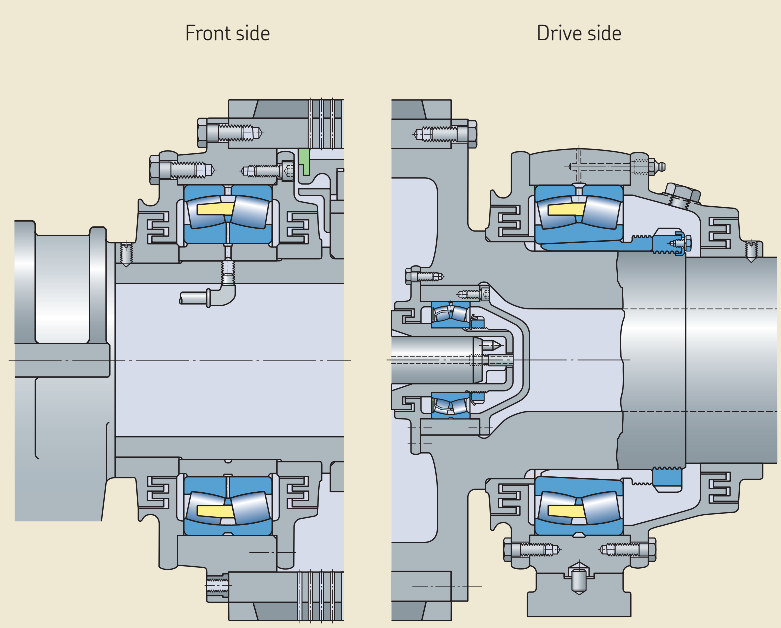
The suction box support bearing is often mounted on a cylindrical sleeve and in a

Journal and housing tolerances for suction rolls

Journal	Mounting on a sleeve	h9 (IT5/2)
	Front side bearing as shown in **fig 11**.	f6
	Note: For bearings with bore diameters above 800 mm there is, in theory, a small possibility that you will get a slight unwanted tight fit even though a loose fit is required.	
	Suction box support bearing	h6
	Mounting on a tapered journal, see tolerances in *chapter 1*, **pages 14-16**	
Housing	Stationary outer ring	G7
	Rotating outer ring	N7
	Rotating outer ring for suction rolls with wide opening at the shell for the vacuum zone	P7
	Suction box support bearing	N7

See also *chapter 1*, *General requirements and recommendations*, *Tolerances*, **pages 14–16**

Fig. 11

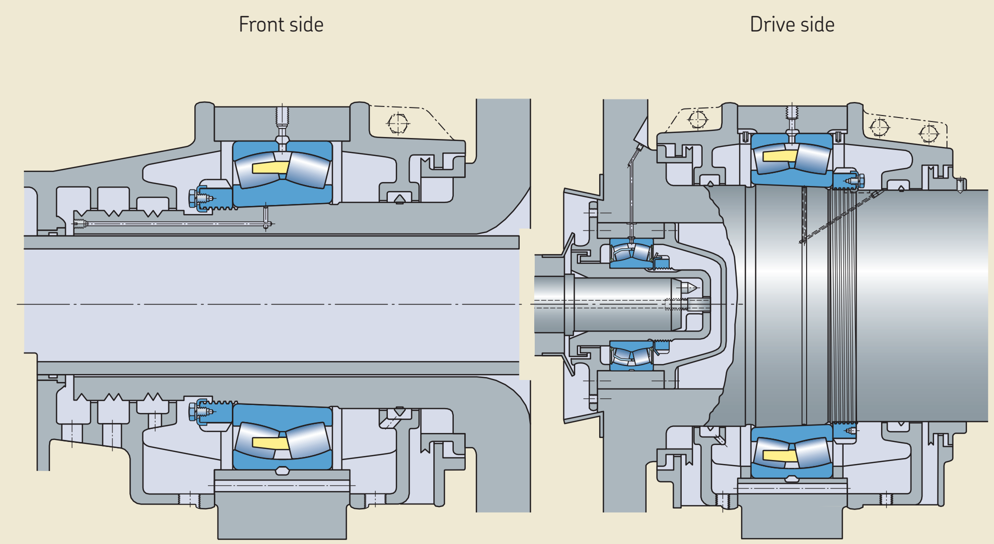


Suction roll bearing arrangements, grease lubricated housing which is bolted to the back wall of the suction roll.

A development of the design shown in **fig. 12** is to replace the solid shaft by one with a bore which makes it possible to drain the water at both sides (→ **fig. 13**). With this design, the drive shaft is provided with a shaft mounted gear.

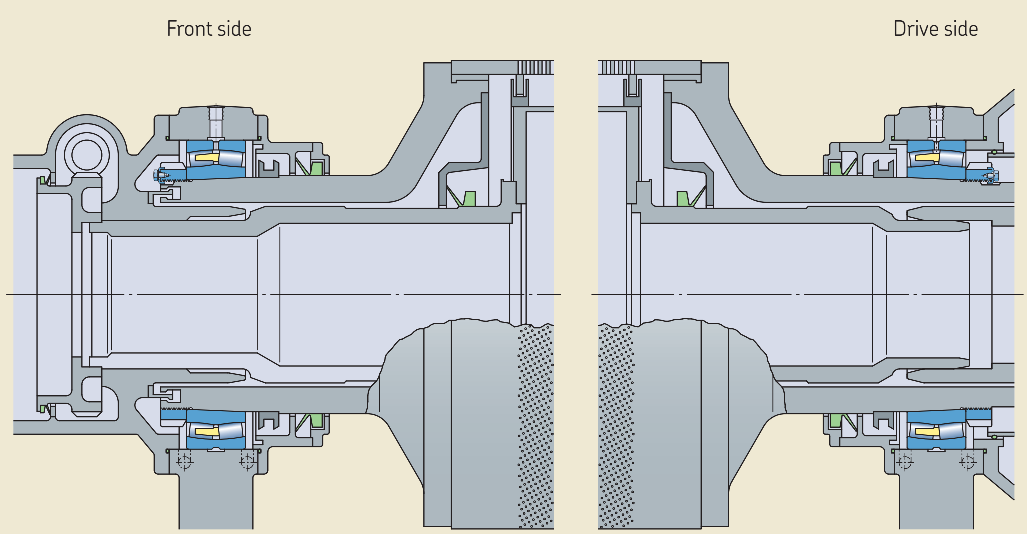
With high-speed paper machines, the frictional heat in the large bearings on the suction rolls is so great that large flows of circulating oil must be passed through the bearings to dissipate the heat. Therefore, it is important that large drainage ducts are incorporated in the design to cope with these large flows of oil.

Fig. 12



Suction roll bearing arrangements, oil lubricated

Fig. 13



Suction roll bearing arrangements without internal bearing, oil lubricated front side drive side

Bearing types

Spherical roller bearings of series 230 and 231 are commonly used for suction rolls and bearings of series 239 are often used for very large diameter journals. Bearings for suction rolls should have C3 radial internal clearance and improved running accuracy (VQ424 or C08).

If the suction roll is provided with an internal support bearing, a bearing of series 232, 223 and 241 should be selected. Normal or C3 radial internal clearance is used.

Selection of bearing size

Bearing selection should be based on life calculation according to the recommendations in *chapter 1*, *General requirements and recommendations*, **pages 3–4**. The recommended L_{10} and L_{10ah} lives are 120 000 hours. The loads from the following sources have to be considered:

- roll mass
- wire tension
- all press nips
- vacuum

Lubrication

The two most important factors for effective lubrication are the viscosity, achieving a satisfactory oil film, and the lubricant cleanliness with respect to water and solid particles. Protection against corrosion has top priority for this bearing position. Therefore, the lubricant must have good rust-inhibiting properties.

Oil lubrication is often selected for these bearings, especially in new machines. There are several reasons for this. One is the increased operating temperatures in high-speed machines requiring excessive grease quantities when relubricating.

The relative speeds of suction roll bearings are the highest of all bearings in paper machines. When large bearings rotate at high speeds, there is a risk of smearing i.e. sliding of unloaded rollers when they enter the loaded zone. This risk is even higher for press roll bearings because of their heavier rollers. Therefore, the lubricant requirements will be dictated by the press roll bearings.

For further information, see *chapter 7*, *Lubrication*, **pages 8–16** and the *Lubrication examples 5* and 6 in *chapter 8*, *Lubrication examples*, **pages 10–13**.