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SKF Pulp & Paper Practices

Mounting CARB toroidal roller bearing on a Yankee cylinder using the SKF Drive-up method

The importance of proper mounting and stores management

In my experience of working with mills all over the world I've seen a lot of problems caused by poor bearing mounting. As getting it right is so important, I'm sure that this issue of SKF Pulp & Paper Practices covering simple, fast and accurate modern mounting methods should be interesting for many of our readers.

Mounting, of course, is not the only thing we need to get right if we want our bearings to reach their service life potential. An appropriate bearing for the job needs to be selected in the first place and once mounted, it needs to be properly lubricated and monitored.

Mounting and lubricating bearings in the right way is crucial for the reliability of machines. Until now we assumed that the bearings and lubricants that are used are in good condition. Unfortunately, some bearings never even make it to the mounting stage. Often this is because they get damaged while they are in mill stores. This happens more frequently than you might think and can lead to significant inconvenience and expense. Even worse is when the bearings or lubricants have "hidden failures" and we only find out about them after installation. To help our readers avoid this, I'm writing an article on bearing and lubricant storage that will appear in the next issue of this newsletter.

Regards,
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SKF Drive-up method and SensorMount

In the first issue of SKF Pulp & Paper Practices we saw that the most common method to get the correct tight fit of the bearing on its seat, the radial clearance reduction method with feeler gauges, takes time and can lead to inadequate fits. The method is time consuming because the operator must put the rollers in their equilibrium position and measure the clearance several times while the bearing is driven up its taper seat. It can lead to inadequate fits because the method relies on the technician's "feeling".

There are other old mounting methods like measuring the axial drive-up but, regardless of how the drive-up is controlled, they always face one major issue i.e. the axial drive-up starting position. I learnt to find the starting position by hitting the nut spanner with a hammer. When there was a true interference fit, the sound became more metallic. For bearings mounted on a taper seat, we can also push the bearing with enough force along its seat that it bangs against it. Here, again, the starting position was dependent on the sound.

Another issue was how to control the drive-up if a hydraulic nut was used to push the bearing along the taper. It could sometimes be difficult to measure bearing inner ring axial displacement along its seat. If we could use another method, like the feeler gauge method, we would never mount a bearing on its taper seat by controlling the axial drive-up.

In some cases a feeler gauge couldn't be used because the bearing had a low section height, was partly hidden by the hydraulic nut and was mounted in a blind housing. The only option was to control the axial drive-up. Several makeshift solutions were used like welding a metal strip on the hydraulic nut piston. A dial gauge on a magnetic support would give the piston displacement and thus the inner ring axial displacement.

To know if the drive-up was correct without knowing the starting position, the only way was to measure the bearing's radial clearance before placing the hydraulic nut. Then the bearing was driven up its seat to around half or less of the desired axial drive-up. Subsequently, the hydraulic nut was removed to be able to measure the radial clearance again. Knowing the clearance reduction obtained, it was easy to know how much more drive-up was necessary to have the correct tight fit.

Example:

According to the SKF General Catalogue, a 23080 CACK/W33 has a reduction of radial clearance range from 0,170 to 0,230 mm. That corresponds to an axial drive-up of between 2,6 and 3,6 mm. The bearing has a radial clearance of 0,400 mm before drive-up and we want 0,200 mm clearance reduction. That means that we want $0{,}200 \times 3{,}6 / 0{,}230 = 3{,}13$ mm drive-up.

Put the bearing on its taper seat, check the radial clearance, screw tight the hydraulic nut and pump oil into the nut while controlling the axial drive-up. **Fig. 1** shows a case where the axial displacement of the adapter sleeve under the bearing is followed. After 1,5 mm axial drive-up, the nut is dismounted and clearance checked: 0,050 mm clearance reduction instead of $1{,}5 \times 0{,}230 / 3{,}6 = 0{,}095$ mm estimated. It means that the real starting point, where the inner ring start to expend was further away than expected. There is now $3{,}6\,(0{,}200 - 0{,}050) / 0{,}230 = 2{,}35$ mm more axial drive-up needed for the desired clearance reduction.

Tired of such old, imprecise and time-consuming methods?

Well, SKF can help and once you have started to use a modern method, we're sure you won't want to change back. Even those who have used the old methods all their life, and who swear by them, change their mind after having tested the modern methods. There are two of these: the SKF Drive-up method and SensorMount.

Let's start with the easiest, fastest and most modern: SensorMount

Fig. 1 Axial displacement of the adapter sleeve

SensorMount

The bearing, large size ones only for the moment, is equipped with a sensor on the inner ring. This is connected to a handheld device which indicates a value which correlates with the interference fit.

After having checked and oiled the mating surfaces, simply:

1 Put the bearing on its seat
2 Screw the hydraulic nut against the bearing
3 Connect the sensor to the handheld device
4 Connect the hydraulic nut to a hydraulic pump
5 Switch on the device and zero the display

The displayed value is equal to the internal clearance reduction in mm divided by the bearing bore in meters (→ **fig. 2**).

Example of a ZE 24184 ECACK30/C3W33 bearing mounted on a press roll for which you want a clearance reduction of 0,210 mm. The bearing diameter is 0,420 m. So, the correct interference fit is obtained when the display indicates **0,50** (= 0,210 / 0,420). Pretty easy so far, isn't it?

Drive the bearing up along its seat until the handheld device indicates 0,50 and wait 15 to 20 minutes before releasing the oil pressure in the hydraulic nut. After that, cut the sensor wire, replace the hydraulic nut with a lock nut and that's all. Yes, really, that's all.

This method isn't influenced by:

- the operator's experience and feeling
- bearing size
- shaft design (hollow shaft or not)
- conditions of the mating surfaces (roughness / slight fretting corrosion etc.) and their lubrication

No calculations are needed, except in special cases. We recommend 0,50 as the final displayed value.

The following **figs. 3** to **7** show the SensorMount being used to mount bearings on solid press rolls at a Metso facility in Finland.

Fig. 3 Eerikki Makinen, SKF Finland's application engineering manager, explaining the CARB toroidal roller bearing mounting procedure with SensorMount

Fig. 4 The handheld device shows 0,420 and the Metso's technician gets ready to switch off the air drive oil pump connected to the HMV hydraulic nut.

Fig. 2 SensorMount. Note that injecting oil between bearing and shaft is not compulsory.

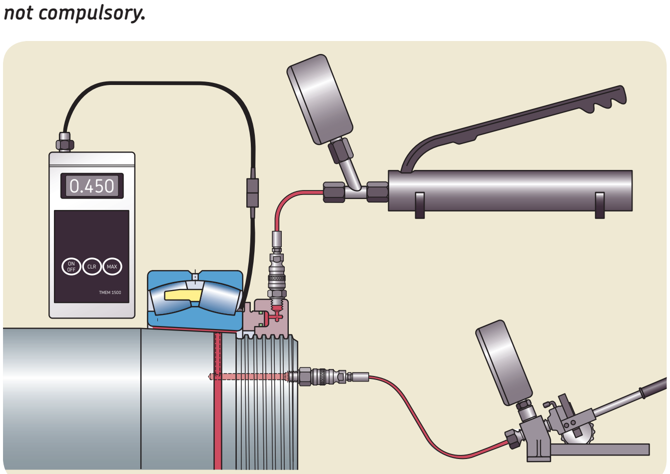


Fig. 5 0.500, the correct interference fit is obtained and the air driven oil pump is switched off.

Fig. 6 On the other side, the spherical roller bearing is also equipped to be mounted with SensorMount.

Fig. 7 A Metso technician cuts off the sensor cable.

Note that SensorMount bearings have either the prefix ZE (e.g. ZE 24184 ECAK30/C3W33) or ZEB (e.g. ZEB 24184 ECAK30/C3W33).

With the ZE version, the sensor is positioned on the smaller bore diameter side. **Figs. 3** to **7** show ZE bearings mounted directly on a tapered journal. The sensor is on the hydraulic nut side, not the press roll side. If the same bearing was mounted on a withdrawal sleeve, the bearing smaller bore diameter side plus the sensor, would have been on the press roll side and thus not really accessible. Bearings with prefix ZEB have the sensor positioned on the larger bore diameter side.

There are a couple of additional things worth noting about SensorMount. Firstly, that sensors and cables can be replaced, or added, if the dismounted bearings are sent to an SKF remanufacturing centre. Secondly, that the hand-held device (SKF TMEM 1500) isn't supplied with the bearings.

As only large bearings (contact SKF for sizes) can be supplied with a sensor, I have now to write about the SKF Drive-up method which is suitable for all CARB toroidal roller bearings, spherical roller bearings and self-aligning ball bearing with bore diameters equal or greater than 50 mm.

SKF Drive-up method

Please do not be scared by my explanations of the SKF Drive-up method. It's simple. Well, it isn't as simple as using SensorMount, but it's much faster and reliable than the feeler gauge method.

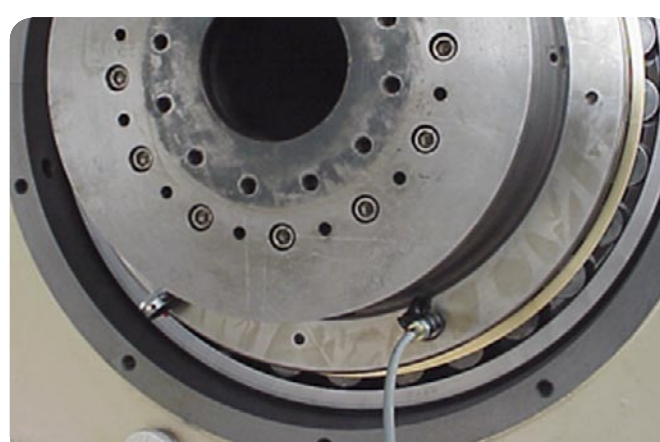
Knowing how the bearing is mounted, the bearing designation, the shaft design (bore and material) and the hydraulic nut size will allow you to obtain two values from the drive-up software or table. One value is a pressure, the other is a distance. For example, for a 24184 ECACK30/C3W33 mounted on a press roll on a tapered plain steel journal, the values would be 3,62 MPa and 6,24 mm.

To mount this bearing:

1 Oil the bearing seat
2 Place the bearing on its seat
3 Screw the hydraulic nut in place against the bearing

Fig. 8 A CARB toroidal roller bearing, mounted with the SKF Drive-up method, on a Yankee cylinder at Delipapier, France in 1999. The SKF engineer controls the axial bearing displacement indicated by the dial gauge that can be seen in fig. 9.

Fig. 9 The dial gauge hidden by the journal shown in fig. 8



4 Connect the hydraulic nut to a hydraulic pump and pump until the pressure gauge indicates 3,62 MPa.
5 Then place a dial gauge in the hydraulic nut. It will follow the nut's piston, thus the bearing axial displacement
6 Pump oil in the hydraulic nut until the dial gauge indicates that the piston has moved 6,24 mm. Do not release oil pressure in the nut for the moment
7 Now the most important thing is to take your coffee break or if you have old fashioned colleagues mounting another bearing not far away and trying to follow internal clearance reduction with a feeler gauge, tease them! After that, you can release oil pressure from the nut.

That's it. You have finished and you can do something else while your colleagues are still playing with their feeler gauge.

It's simple and easy. Most of those who use the drive-up method for the first time are suspicious and do final radial clearances checks with feeler gauges even though it is not needed.

Oil pressure and drive-up displacements are given in tables that are in various SKF documents, but we recommend the use of the on-line software at www.skf.com/mount/ which is continuously updated or the SKF Drive-up method software on CD.

To proceed following the SKF Drive-up method, there is a need for the following equipment (→ **figs. 10** and **11**):

1 a hydraulic nut
2 a hydraulic pump
3 a pressure gauge appropriate for the mounting conditions
4 a bearing axial displacement measuring device. SKF recommends a dial gauge that follows the hydraulic nut piston displacement.

The idea is to measure the axial displacement of the bearing along its tapered seat in an accurate way. The main difficulty with the old methods was to find the starting position. The SKF Drive-up method gives a reliable starting position.

Those who change the cylinder head gasket on car engines using the angle tightening method for the cylinder head bolts will quickly see the similarity. The bolt angle tightening method is much more precise than full tightening with a torque wrench, but needs pre-tightening to remove all clearance. This pre-tightening is done with a torque wrench and is, in general, between 10% and 40%, of the torque needed to obtain the correct tightening. The pre-tightening gives the starting point from which the angle displacement of the bolt head (or the nut) is undertaken. The philosophy of the SKF Drive-up method is similar since pre-tightening is done to find the starting point of the final axial displacement. The pre-tightening is here a slight interference fit of the bearing on its seat due to a pre-axial displacement under a predetermined axial load. Above this initial interference fit, reduction in the radial internal clearance may be regarded as being directly proportional to the axial drive-up. The SKF Drive-up method isn't new, we've been using it for 20 years.

Using a torque wrench (torque on the bearing lock nut) to get the starting position isn't the best solution for two reasons:

1 Axial load, that pushes the bearing along its taper seat, will depend too much on the good conditions of the contact between the lock nut's threads and the face in contact with the bearing plus the friction in theses contact surfaces. If the axial load is created by a hydraulic nut, all this can be forgotten and axial load will depend directly on the hydraulic nut size and oil pressure.
2 Why waste time trying to measure torque, especially on big lock nuts, when the axial load can be revealed by measuring the pressure of the oil injected in the hydraulic nut that that will be used to push the bearing for the final drive-up? I know some who still use a huge hammer on innocent lock nuts to drive-up big bearings, but that's another story.

The starting position in the SKF Drive-up method is given by the oil pressure of the oil injected into a SKF HMV hydraulic nut. The oil pressure is quite low, a few MPa, so a very accurate pressure gauge is needed. I recommend, of course, the SKF TMJG 100D digital gauge.

Fig. 10 Tools needed for the SKF Drive-up method

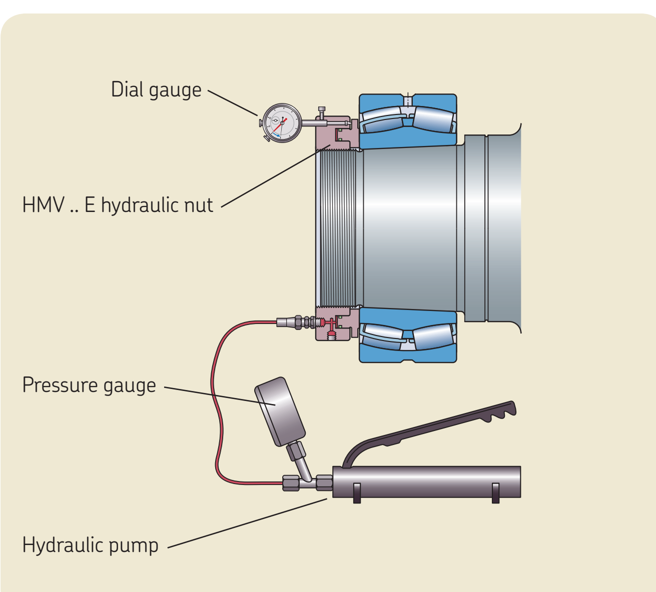


Fig. 11 Tools needed for the SKF Drive-up method

The starting position will give a high enough interference fit to be sure that there is intimate contact between the bearing and its seat, but not too much interference fit so that any starting point deviation will have a negligible influence on the final interference fit. With the SKF Drive-up method recommendations, the starting position corresponds to around 20% of the final interference fit if the default value of recommended drive-up is chosen. It can be near 10% for bearings mounted with a very tight fit.

The interference fit at the starting position depends on:

1 The sliding friction in the contact surface (bearing/shaft, bearing/sleeve and/or sleeve /shaft). If there is too much friction, for the same oil pressure in the hydraulic nut the bearing will have too low axial pre-displacement. Too low friction means too much axial pre-displacement.
2 The bearing inner ring thickness. The thicker the inner ring, the more resistance to drive there will be. So, for same oil pressure in the hydraulic nut, the bearing will have less axial pre-displacement.
3 Conicity of the tapered seat. Either 1/12 either 1/30.
4 Number of sliding surfaces.
5 Circularity and straightness error forms.

For point one, sliding friction depends on surface conditions and their lubrication. If necessary, clean the surfaces with sand paper to remove bumps. Always lubricate the sliding surfaces, but never inject oil in the mating surface while the bearing is driven up to its starting position.

Points two and three above depend on the bearing designation. This means that pressure values given by SKF software or tables are only valid for SKF bearings.

Concerning point four, in general there are either

- one sliding surface (→ **figs. 12** and **13**)
- two sliding surfaces (→ **figs. 14** and **15**)

The number of sliding surfaces will influence the oil pressure needed to get to the starting position.

Fig. 12 Bearing mounted directly on tapered shaft

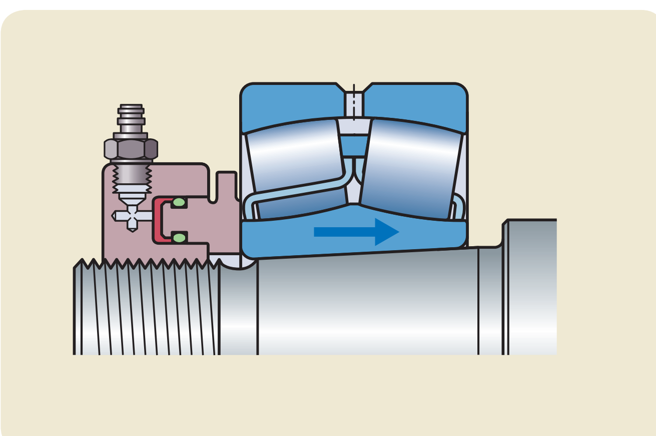


Fig. 13 Bearing mounted on a adapter sleeve and pushed

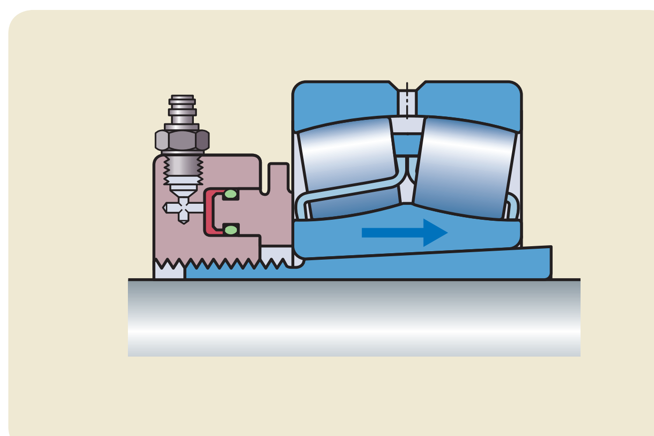


Fig. 14 Bearing mounted on an adapter sleeve which is pulled and slides between bearing and shaft

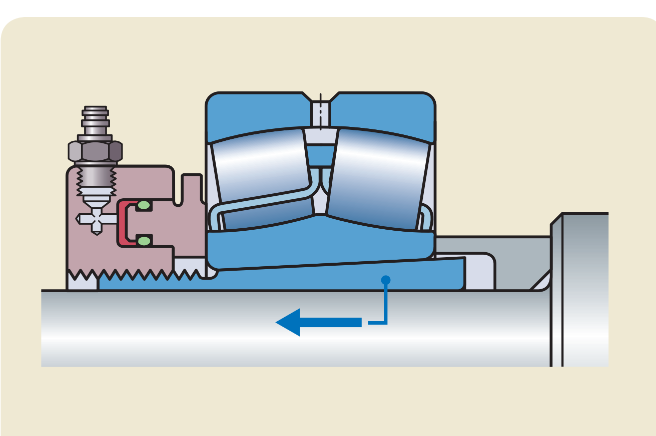
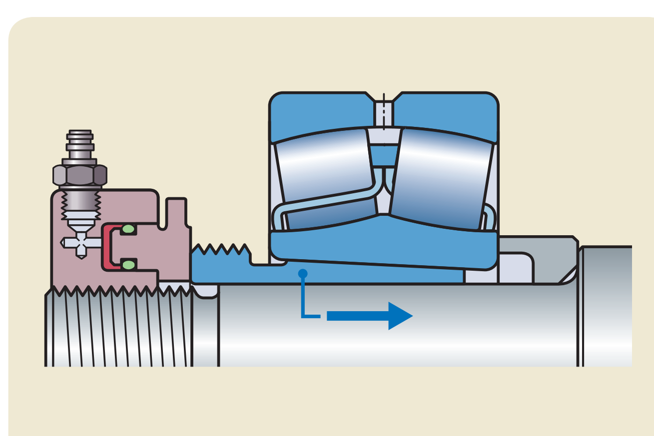


Fig. 15 Bearing mounted on a withdrawal sleeve which is pushed between bearing and shaft.



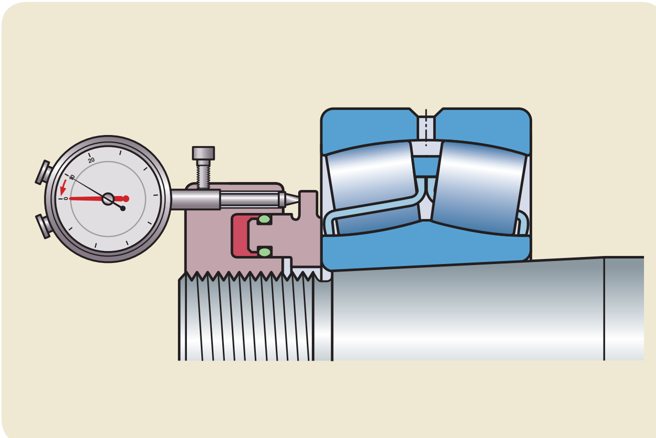


Fig. 16 The dial gauge follows the axial displacement of the hydraulic nut piston, thus the inner ring displacement

Example: for a drying cylinder bearing 23152 CCK/C4W33 we need, with the same hydraulic nut size, 2,9 MPa when it is mounted on a tapered journal and 4,9 MPa when it is mounted on an adapter sleeve.

During the drive-up to reach the starting position, look at the oil pressure and don't bother about the axial displacement.

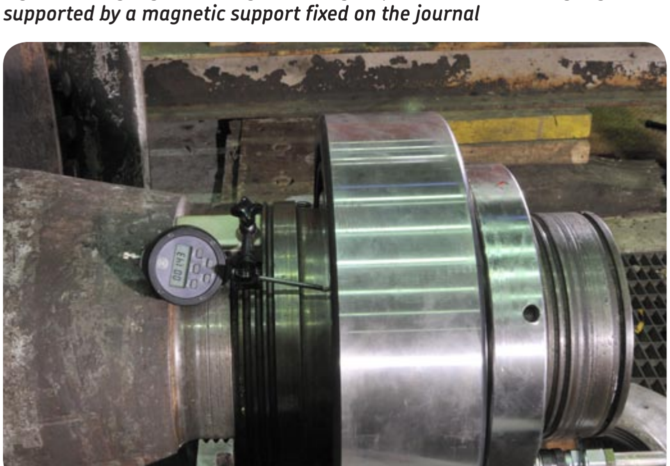
Once the starting position is reached, it's time to fit the dial gauge to follow the bearing inner ring drive-up.

SKF proposes hydraulic nuts in which a dial gauge is placed in a hole to follow the piston displacement (→ **fig. 16**). These hydraulic nuts, standard for about 15 years, have the suffix "E".

SKF HMV 48 is an old size 48 hydraulic nut without the hole and piston design for the dial gauge.

SKF HMV 48 E is a size 48 hydraulic nut designed for the SKF Drive-up method.

Fig. 17 Dial gauge following inner ring displacement. The dial gauge is supported by a magnetic support fixed on the journal



Choose a good quality dial gauge and check that it can follow the nut piston for the total distance of the drive-up. Some dial gauges might need an extension rod.

If you have an old hydraulic nut, either you place the dial gauge as shown in **fig. 1** or like in **fig. 17** or you mount an SKF adapter HMVA 42/200 for nuts from size 42 to 200 (→ **fig. 18**). For practical reasons, I would recommend the use of a hydraulic nut designed for the SKF Drive-up method.

Final axial drive-up will depend on

1. The desired interference fit. To make it easy, as most people think "clearance reduction", the software allows you to enter a clearance reduction. By default, software and many tables give a clearance reduction equal to 0,45‰ of the bearing bore diameter. The value is like the one used for SensorMount. For the pulp and paper industry, we recommend 0,50 instead of 0,45 (see important notes at the end of this article). The value can be even higher than 0,50 in some cases.
2. Bearing design features such as the inner ring thickness. What's valid for SKF bearings might not be valid for other brands.
3. Shaft design. Very large bore diameters need higher axial drive-up to get the correct interference fit. Be careful! Most tables give the drive-up value for solid plain shafts.
4. Interference reduction due to smoothing. If the bearing has been mounted several times and/or the bearing seat is slightly worn, the interference reduction due to smoothing is lower. The influence of the smoothing is so small that it can be ignored for large bearings.
5. Shaft material characteristics. Be careful! Most tables give drive-up values for steel shafts.

Once the dial gauge is in position and the axial drive-up value is known, pump oil into the hydraulic nut and at the same time control

Fig. 18 SKF adapter HMVA 42/200

the dial gauge. Follow the axial drive-up on the dial gauge and do not bother about the oil pressure.

Be aware that after the drive-up is finished and the coffee break taken, when you release the oil pressure from the hydraulic nut, the needle of the dial gauge will move backwards. It isn't the bearing that has moved down its seat. It is the nut's piston that has moved due to the fact that the piston's seals were elastically deformed during the bearing drive-up.

Let's recap with an example of how I use the SKF Drive-up method

A CARB C3152 K/C4 is to be mounted on a drying cylinder. The journal is made of steel and has a 130 mm bore diameter. The taper seat is directly on the journal and the lock nut and thus the hydraulic nut should be size 52, just like the bearing.

I use the SKF Drive-up method CD to find the starting position oil pressure and axial drive-up displacement after the starting position. I replace the 0,45‰ default value by 0,50‰. **Fig. 19** shows a screen print.

The software enables me to print the inputs and the results which are 2,76 MPa and 1,679 mm. In addition, the print gives information about suitable tools and the mounting procedure (→ **fig. 20**).

On site, I check the bearing seat conditions and oil it. I might, if I have time, check the bearing/seat contact with Prussian blue before oiling it.

Then, having placed the bearing on its seat ready for drive-up, I screw the HMV 52 E hydraulic nut against the bearing and connect it to the SKF 729124 SRB hydraulic pump equipped with an accurate pressure gauge.

I place the two rings of the CARB torodidal roller bearing, without any axial offset. Offset measured by eye as there is no need to be precise. The reason for this is to avoid internal bearing preload during drive-up. Then I will pump until the oil pressure stabilises at 2,76 Mpa.

Then it's time to put the dial gauge in the hydraulic nut taking care that the dial gauge needle will be able to follow the nut's piston at 2 mm (higher than 1,679 mm) axial displacement. Then I pump, taking care that the needle moves with ease, until it has moved to a distance between 1,67 and 1,69 mm.

After the dial gauge indicates the requested axial displacement, I leave it for 10 minutes. There's no need for more as it isn't a very big bearing. Then, the oil pressure in the hydraulic nut will be released and the hydraulic nut replaced by the lock nut.

Do you still want to use the inaccurate and time-consuming feeler gauge method?

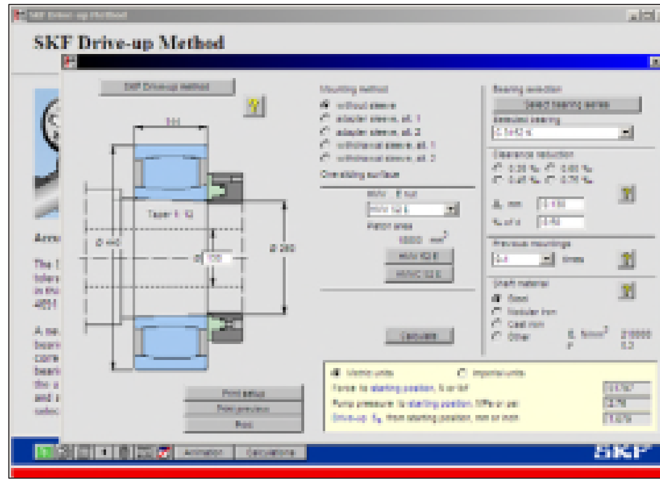
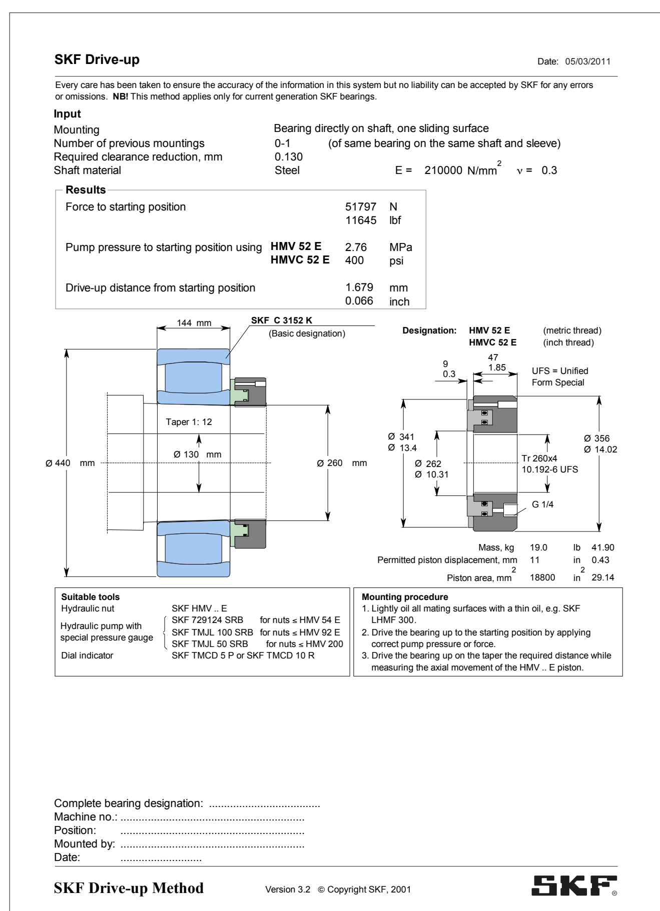


Fig. 19 Screen capture of the SKF Drive-up software

Fig. 20 Recap of the results of the software calculation



SKF Drive-up Date: 05/03/2011

Every care has been taken to ensure the accuracy of the information in this system but no liability can be accepted by SKF for any errors or omissions. **NB!** This method applies only for current generation SKF bearings.

Input

Mounting	Bearing directly on shaft, one sliding surface
Number of previous mountings	0-1 (of same bearing on the same shaft and sleeve)
Required clearance reduction, mm	0.130
Shaft material	Steel E = 210000 N/mm^2 ν = 0.3

Results

Force to starting position		51797	N
		11645	lbf
Pump pressure to starting position using	**HMV 52 E**	2.76	MPa
	HMVC 52 E	400	psi
Drive-up distance from starting position		1.679	mm
		0.066	inch

Mass, kg	19.0	lb	41.90
Permitted piston displacement, mm	11	in	0.43
Piston area, mm^2	18800	in^2	29.14

Suitable tools

Hydraulic nut	SKF HMV .. E	
Hydraulic pump with special pressure gauge	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
Dial indicator	SKF TMCD 5 P or SKF TMCD 10 R	

Mounting procedure

1. Lightly oil all mating surfaces with a thin oil, e.g. SKF LHMF 300.
2. Drive the bearing up to the starting position by applying correct pump pressure or force.
3. Drive the bearing up on the taper the required distance while measuring the axial movement of the HMV .. E piston.

Complete bearing designation: ....
Machine no.: ....
Position: ....
Mounted by: ....
Date: ....

SKF Drive-up Method Version 3.2 © Copyright SKF, 2001

SKF

Additional important notes:

It is recommended to inject oil between the bearing and its seat during drive-up to reduce friction and avoid surface damages. For large bearings, if oil isn't injected in the sliding surfaces, the axial load that pushes the bearing can deform the hydraulic nut. The nut is wrenched backward and the axial displacement indicated on the dial gauge, located on the nut, will be higher than the real bearing displacement along its tapered seat. One part of the displacement shown is actual axial drive-up of the inner ring, but without oil injection between inner ring bore and shaft and/or sleeve, a large part of the displacement shown is simply hydraulic nut deflection. In cases with two sliding surfaces, it is also recommended to inject oil between the sleeve and shaft.

Do not inject oil in the mating surface during pre-displacement when the SKF Drive-up method is used, but only after the starting position.

The 0,45 default value is given to allow enough interference fit to avoid inner ring creep on the bearing seat and fretting corrosion in the mating surfaces and, at the same time, to give the lowest inner ring internal stress due to the tight fit. Bearing fatigue life is reduced when increasing the drive-up. The value is given for "normal" loads. As a simple guide line, I consider that maximum "normal" load is equal to 10% of the dynamic basic load rating (C_{dyn}) of the bearing. Note that inner ring creep and the fretting corrosion depend also on the clearance in the bearing. As noted in issue 2 of SKF Pulp & Paper Practices, the larger the clearance, the larger is the load on the most loaded roller and the larger is the risk of fretting corrosion and inner ring creep. **For the pulp and paper industry, we recommend to take 0,50 instead of 0,45.**

Higher interference fits and thus higher values, up to 0,90 in some rare cases, may be needed in cases of very high load and/or too high clearance and/or bearing seating with a very large bore and/or steep thermal gradients resulting from rapid start-ups.

The 0,45 default value gives a lower clearance reduction than what is normally recommended when the feeler gauge method is used. This is normal. One reason is that in the past, with the feeler gauge method, the lack of accuracy could lead to too low interference fit. So, it was accepted to recommend clearance reduction values giving higher interference fits than were really needed.

"Hydraulic" pump and "hydraulic" nut doesn't means that any hydraulic oil is adequate. This is especially valid when injecting oil in the bearing/shaft (or sleeve) contact surface for dismounting purposes. Most hydraulic oils have too low viscosities. Use SKF LHMF 300 oil, and for dismounting, use SKF LHDF 900.

Some have complained that using SensorMount has resulted in loose fits when the bearing was mounted, during a very short machine stop, on a hot journal. In fact, the old mounting methods take time and the bearing inner ring has more time to get close to the journal temperature before the end of the drive-up. Whatever the mounting method used, a correct tight fit is obtained when the bearing inner ring temperature is at the same temperature as the journal on which it is mounted. I recommend that, whatever is the mounting method used, the bearing should be heated up with an SKF TIH induction heater (with automatic demagnetization) to the shaft temperature. If the bearing is too big to use such a heater, it should be left on its seat to heat up and on the journal to cool down.

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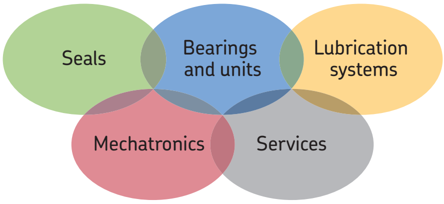

The Power of Knowledge Engineering

Drawing on five areas of competence and application-specific expertise amassed over more than 100 years, SKF brings innovative solutions to OEMs and production facilities in every major industry worldwide. These five competence areas include bearings and units, seals, lubrication systems, mechatronics (combining mechanics and electronics into intelligent systems), and a wide range of services, from 3-D computer modelling to advanced condition monitoring and reliability and asset management systems. A global presence provides SKF customers uniform quality standards and worldwide product availability.

SKF Global Pulp & Paper Segment

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