

SKF Pulp & Paper Practices

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The main tools for the SKF Drive-up Method: A dial indicator and a hydraulic nut

“Step by step guide to optimal bearing mounting”

As many of you know, the SKF Drive-up Method was developed in response to the inaccuracy of traditional bearing mounting methods. A great deal has been written about it in previous issues of SKF Pulp & Paper Practices and I know that many of our pulp and paper customers use it. We have strived to make the tools simple to use and following comments from users, including many from the pulp and paper industry, we upgraded our digital pressure gauge with a backlit screen and the ability to zero the pressure to make the method even easier.

Nevertheless, even with such an accurate yet simple method there are always questions about the practical aspects. As such, this issue of SKF Pulp & Paper Practices has been written to give you a detailed, step by step explanation of the SKF Drive-up

Method. I urge you to read this issue as I have twenty years' experience with the method and I still learnt a few things. This goes to show that even an old dog can learn new tricks!



Keep learning!

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The SKF Drive-up Method, step by step

In November last year I demonstrated the SKF Drive-up Method to a group of maintenance and production staff from different mills belonging to a well-known paper manufacturing group. Some were already familiar with the method, but it was completely new to some of them. The maintenance team from one of the mills requested a step by step procedure with photographs. This issue of SKF Pulp & Paper Practices is a direct result of that request.

Please note that all the photographs in this issue show a medium sized spherical roller bearing mounted directly on a tapered seat on a training rig. Also that what is written here is valid for all sizes of spherical roller bearings, CARB toroidal roller bearings and self-aligning ball bearings with tapered bores used in all industries.

Before reading further, I recommend that you look at SKF Pulp & Paper Practices 3 which explains the background of the SKF Drive-up Method. It was published in 2011 and a few things have changed since then:

- 1 The recommended SKF digital pressure gauge is now SKF THGD 100 rather than SKF TMJG 100D.
- 2 The suffix of the pump supplied with the SKF digital pressure gauge has changed. For spherical roller bearings, it is now DU. For example, the pump SKF 729124 supplied with the gauge previously had a SKF 729124SRB designation, but now it is SKF 729124DU. The same applies for pumps SKF TMJL 50 and TMJL 100. An easy way to remember this is that DU stands for drive-up.
- 3 There is a new version of the SKF Drive-up software. I'll give instructions on how to use it in the next issue of SKF Pulp & Paper Practices.

Recommended products for the SKF Drive-up Method (→ figure 1)

1 An SKF HMV hydraulic nut that is designed to accept a dial indicator which follows the axial displacement of the hydraulic nut piston. Such nuts have the suffix E. SKF HMVC ... E nuts have inch threads while SKF HMV ... E/A101 nuts have no thread. Please note that a HMV 20 E nut is shown in the photographs in this document. If you have an old SKF HMV nut that does not take a dial indicator, please see page 7 of SKF Pulp & Paper Practices 3 for some solutions. If you are using an hydraulic nut from a supplier other than SKF, you will need to know the internal dimensions to calculate the relation between the hydraulic pressure and the axial force.

- 2 A good quality dial indicator with 0,01 mm graduation and, if possible, a range above the bearing axial drive-up value. By default, I recommend a 10 mm range indicator such as the SKF TMCD 10R shown in this document. Do not forget that several extension rods of different lengths could be needed for the dial indicator contact point. I recommend avoiding balance scales and digital indicators. But I recommend reverse reading scales since they are much easier to use as the needle moves counter clockwise during drive-up (see step 9 of the procedure further on).
- 3 A good quality pressure gauge with enough precision (0,1 MPa or better) for low pressures between 0,5 and 10 MPa and which can tolerate at least 50 MPa. SKF recommends the SKF THGD 100 shown in this document.



Fig. 1 Products for the SKF Drive-Up Method

4 A hydraulic pump with a maximum pressure below that recommended for the pressure gauge used which has an oil reservoir large enough to not have to be refilled during drive-up. SKF recommends the following pumps which include the SKF THGD 100 pressure gauge: SKF 729124 DU for SKF hydraulic nut sizes HMV 54 E or smaller; SKF TMJL 100 DU for SKF hydraulic nut sizes HMV 92E or smaller; SKF TMJL 50 DU for all SKF hydraulic nuts.

Check bearing seat condition and take corrective actions if necessary

Used bearing seats can have fretting corrosion, micro smearing marks and other damage. In such cases, first remove all superficial corrosion and lubricant residues with a scrub pad and White Spirit (mineral spirit) or other greasy solvent and then remove protuberances with a honing stone (→ figure 2). Large protuberances can be partially removed using a steel file and great care, but finishing should be done with a honing stone. Move your finger over the damaged area to see if more material needs to be removed. You should also check for micro cracks and use the dye penetrant inspection method if in doubt. Very small dents relative to bearing size are not a concern if there are no protuberances.

Prussian blue checks are recommended with the new bearings. If the contact surface between the bearing and its seat is less than 90% for new shafts or below 80% for used ones, further investigation is needed to check that the seat dimensions are within tolerances. See SKF Pulp & Paper Practices 13 and 14 for more information.



Fig. 2 Tools: scrub pad, steel file, honing stone and a finger

Additional recommendations:

- 1 Bearing seats should be cleaned as hard particles can damage bearing bores and/or shafts during drive-up.
- 2 Locking and hydraulic nut threads should be cleaned and repaired if damaged.
- 3 All observations and the measuring report should be included in the mounting report.

The following pages show the step by step procedure for the SKF Drive-up Method with one step per page.

N.B. it is assumed that the bearing and its seat are the same temperature. If not, see pages 2-3 of SKF Pulp & Paper Practices 11. If the bearing is colder than the shaft, the best solution is to use an SKF induction heater to bring it up to the same temperature as the shaft.

Step 1: Oil the bearing seat and the hydraulic nut thread

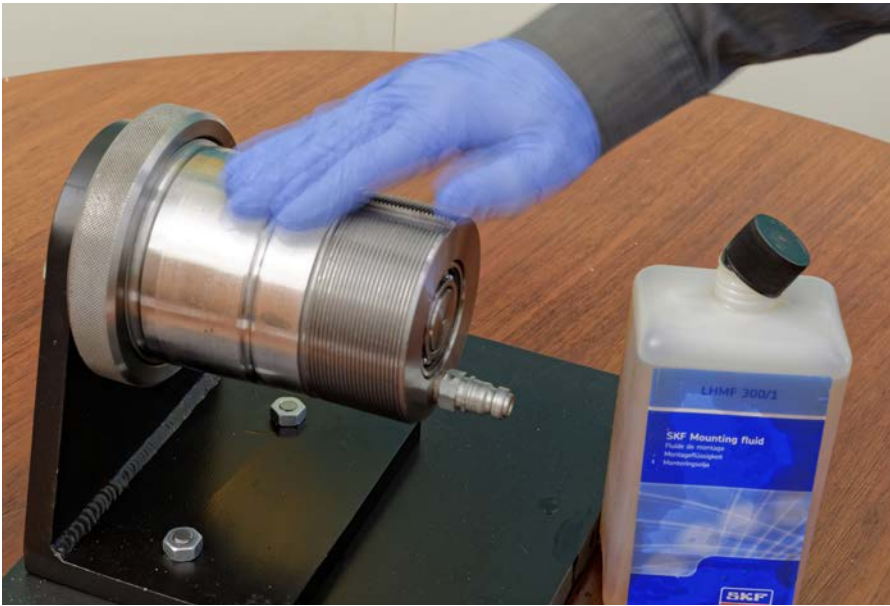


Fig. 3 Oil the bearing seat and the hydraulic nut thread

Additional notes

SKF recommends using SKF mounting fluid LHM 300 which is purpose designed for SKF injection mounting methods.

- Do not use grease.
- Do not use high viscosity oils.
- Oils, compatible with the bearing lubricant that will be used, with a viscosity range between ISO VG 100 and ISO VG 150 are adequate.

It is necessary to lubricate the contact between the bearing and its seat to avoid micro smearing damage and, mainly, to avoid high friction while driving up the bearing to the SKF Drive-up Method starting position. If the mating surfaces are dry, the pump pressure to reach the starting position will be applied before the bearing has actually reached its starting position.

Many customers try dry mounting after experiencing bearings moving down their tapered seats after final adjustment and releasing the hydraulic nut oil pressure. If a bearing moves down the seat, it means that the oil in the bearing/shaft contact has not had time to escape. For more information, see step 13.

Note that if bearings and journals are outside normal temperature ranges (e.g. when mounting outside in winter or mounting on a warm dryer cylinder when the machine has just stopped), the recommendations above need to be changed. As a rule of thumb, the oil used for bearing mounting should have around 300 mm²/s viscosity at the temperature of the shaft and the bearing.

Step 2: Place the bearing on its tapered seat



Fig. 4 Place the bearing on its tapered seat



Fig. 5 Using a spring for easier handling during mounting or Prussian blue tests

Additional notes

- Before placing the bearing on its tapered seat, wipe the preservative off the bore with a clean rag. Some preservatives have adequate viscosity and don't need to be wiped out, but if in doubt, wipe it off.
- For heavy bearings, or if the bearing has to be mounted with its heavy housing, SKF recommends using a sling attached to a crane via a spring (→ figure 5).

Step 3: Mount the hydraulic nut and tighten it by hand



Fig. 6 Mount the hydraulic nut and tighten it by hand

Additional notes

- The nut isn't only close to the bearing, it's tightened against it. The reason for this is to avoid too much axial displacement of the hydraulic nut piston before the starting position is reached. If there is too much axial displacement of the piston out of the nut, the piston seals might be forced out of the nut during final axial drive-up. As such, you should check that the nut piston is well pushed into the nut.
- Tightening the hydraulic nut by hand with the supplied rod, but without the use of an extension is normally enough for most bearing sizes if the threads are clean, in good condition and lubricated.

Step 4: Connect the pump to the hydraulic nut



Fig. 7 Connect the pump to the hydraulic nut

Additional notes

- Do not connect another pump to inject oil between bearing and its seat. This is to avoid the bearing exceeding the axial starting position when starting position pump pressure is reached. Do not forget to fill the pump completely (even if it is possible to refill the pump with oil during the mounting procedure).
- SKF recommends SKF mounting fluid LHM 300.
- If SKF LHM 300 is not available, use oil with a viscosity between ISO VG 100 and ISO VG 320 or the SKF dismantling fluid LHDF 900 if the temperature is not too cold.

Step 5: Switch on the digital pressure gauge and reset to zero

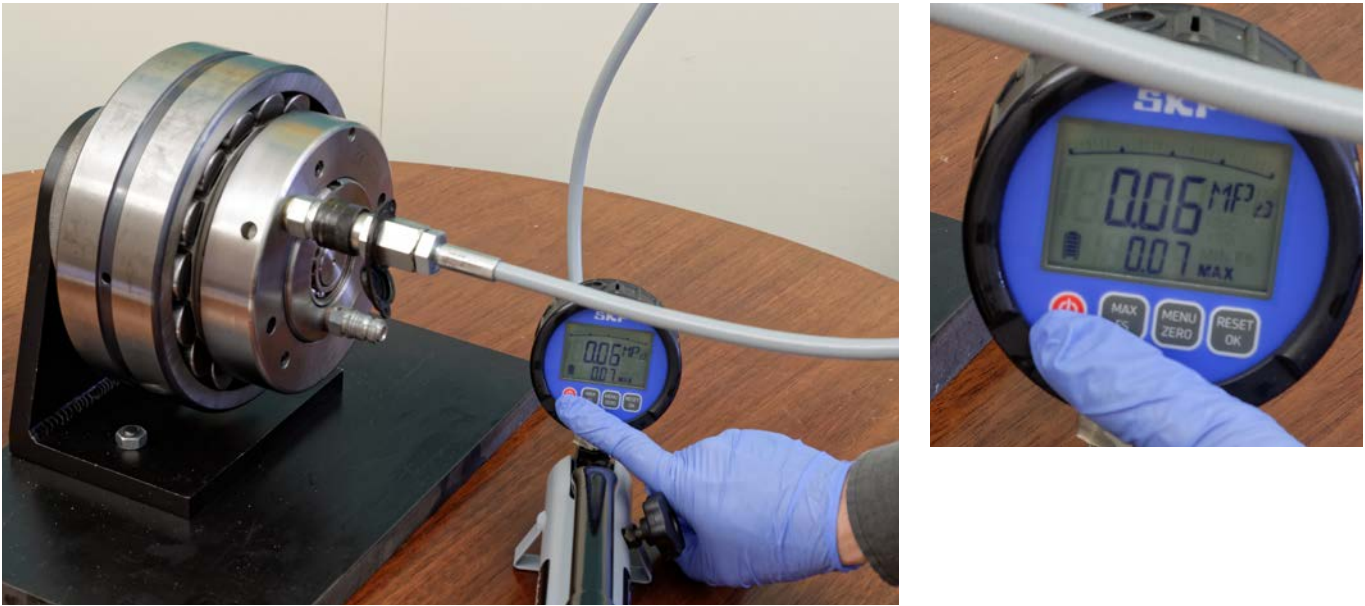


Fig. 8 Switch on the digital pressure gauge

Additional notes

- With rare exceptions, the indicated pressure values on the SKF THGD 100 digital gauge are not zero when switched on.
- To set the values to zero, first be sure that pump oil release valve is open and then set the zero point by pressing Menu/Zero briefly. "ZEro on" will be displayed. Then press RESET/OK which initiates the zero point correction and 0,0 MPa (or psi) will be indicated.
- However, $\pm 10\%$ of the starting pressure is a suitable tolerance for the starting pressure reading when using the SKF THGD 100. As such, even if it is recommended to reset the zero pressure point, it is not always necessary to do so.

Step 6: Pump until the starting position pressure is obtained

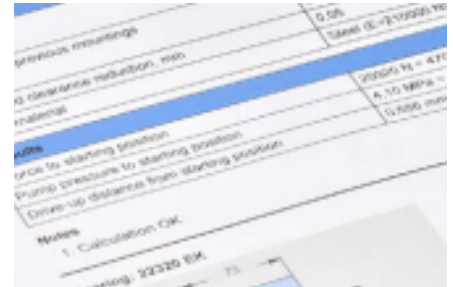
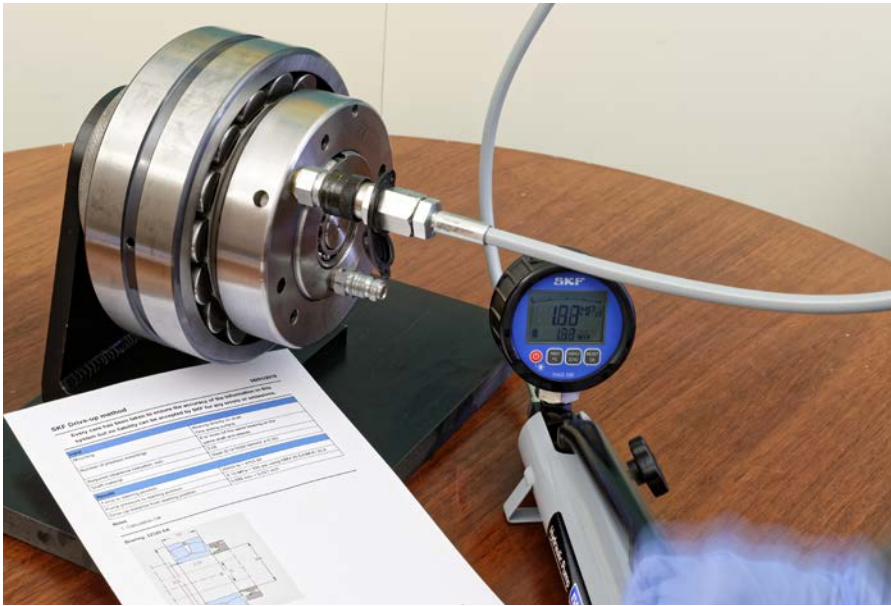


Fig. 9 Pump until the starting position pressure is obtained

Additional notes

- For the bearing shown – an SKF 22320 E spherical roller bearing on a plain steel tapered shaft with 0,50% d radial clearance reduction – the pump pressure to starting position is equal to 4,1 MPa. You can find the explanation for the 0,50% d in SKF Pulp & Paper Practices 3.
 - For other bearings, get the information from the equipment manufacturer, use the SKF Drive-Up Method software or contact your local SKF application engineering department.
 - The SKF Drive-Up Method will only give correct results for SKF bearings since the results are influenced by the inner ring geometry. For bearings that are not listed in the software, please contact your local SKF application engineering department.
- Focus on pressure pump, not the bearing axial drive-up along its seat. For the same pump pressure, there can be different values of axial drive-up until the starting position is reached depending on the real shapes and condition of the shaft and the bearing inner ring and how tight was the hydraulic nut tightened by hand. However, if the nut piston moves out too much, without the pressure increasing, stop pumping. This happened to me once in 20 years. In fact the thread on the shaft and in the nut were damaged and repaired roughly just before the bearing mounting, giving a hard point when rotating the nut, just when it was close to the bearing. As a result tightening the nut by hand didn't push the bearing hard enough against its seat. In the beginning, you may need several pump strokes so that the pressure starts to increase. Very soon afterwards the pressure increases rapidly, so you need to be gentle with the lever to avoid going too far above the required pressure.

Step 7: Stop pumping when the starting pressure is reached

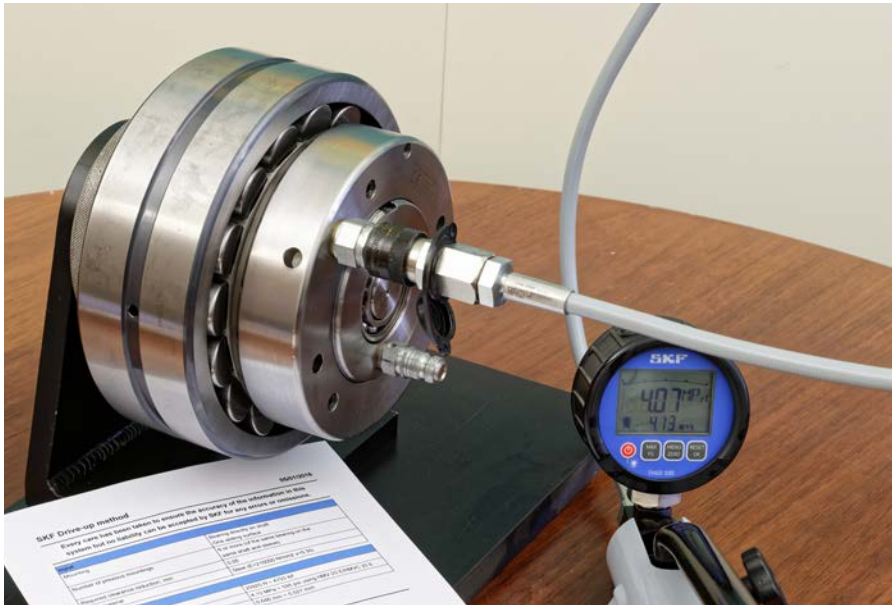


Fig. 10 Stop pumping when the starting pressure is reached

Additional notes

- Once the pump pressure to starting position is reached, it can be noted that pump pressure decreases a little. A small action on the pump lever can make the pressure go back to the requested pressure, or maybe above, and then the pressure will decrease a little again.
- Remember that it is not necessary to be exactly at the pump pressure to the starting position. There is a tolerance accepted of $\pm 10\%$ with a good precision pressure gauge such as the THGD 100. In this case, the pump pressure to starting position is 4,1 MPa. Allowing for the tolerance, adequate pump pressure is between 3,7 and 4,5 MPa.
- The pressure gauge photograph shows that the highest pressure was 4,13 MPa and that it decreased and stabilized at 4,07 MPa. There is no need to pump again to have current pump pressure at 4,1 MPa. However, I tried to reach 4,1 MPa for another photograph, but quickly went above and left it like that as it was still in tolerances (\rightarrow figure 11), 4,2 MPa max, 4,13 MPa current pressure, which will continue to decrease to 4,04 MPa before final drive-up.

Step 8: Place the dial indicator in the hydraulic nut so that it can follow the axial displacement of the bearing until the final drive-up value is reached



Fig. 11 Place the dial indicator in the hydraulic nut so that it can follow the axial displacement of the bearing until the final drive up value is reached

Additional notes

- The dial indicator must be pushed in far enough that it follows the nut piston until the end of the required drive-up. In this case, the axial drive up after the starting position is 0,686 mm (→ **figure 9**). The dial indicator must be pushed in far enough that its point contact can still move more than 0,686 mm without contacting the dial indicator stop or getting out of the scale range. It might be necessary to add extension rods.
- My method is to place the dial indicator so that the point contact touches the piston and the small needle is in the scale. Then, push the dial indicator into the nut a distance equal to or larger than the requested final axial drive-up.
- On very large bearings the final axial drive-up can be larger than the dial indicator range. This is not an issue. For example, if the range of my dial indicator is 10 mm and the final drive-up is 13 mm, I will first drive-up 10 mm then dismount the dial indicator, add an extension rod and reposition the dial indicator for the last 3 mm axial drive-up.
- Check that the dial indicator contact point is free to move (→ **figure 11**). I had a bad experience with a cheap dial indicator which would stop when the contact point was moving slowly. In another case, the contact point attached to an extension rod wouldn't move co-axially with the dial indicator stem and was touching the wall of the dial indicator nut hole. That stopped moving as well during the drive-up.
- Take care that the red screw is tightened on the dial indicator stem rather than the spindle. Otherwise there is a risk of damaging the spindle. Try to gently move the dial indicator backwards and forwards when you're tightening the screw. If it moves, you're tightening the screw on the spindle.
- Do not replace the red plastic screw holding the dial indicator in the hydraulic nut with a metal one. If you do, you risk damaging the dial indicator stem or spindle.

Step 9: Set dial indicator to zero (or to the required final drive-up value)

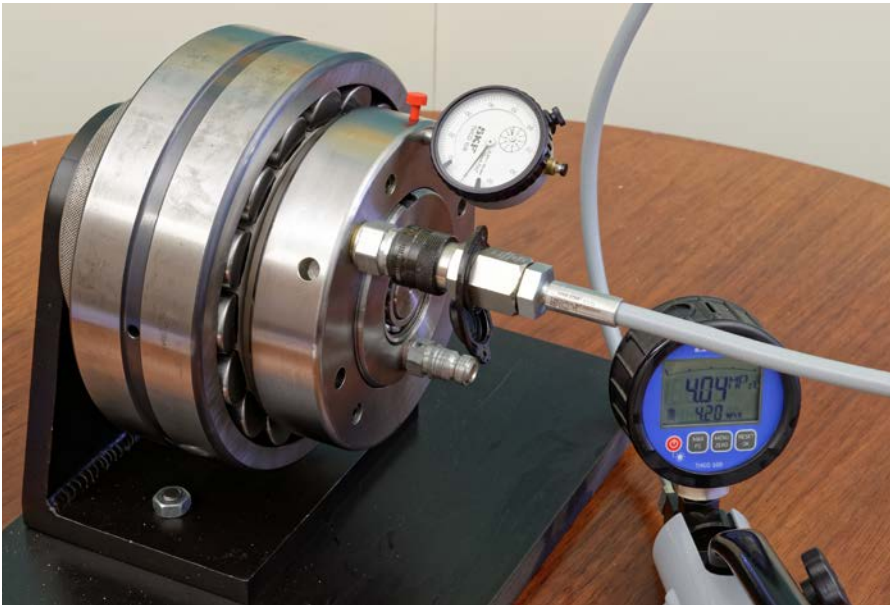


Fig. 12 Set dial indicator to zero

Additional notes

- Setting the dial indicator to zero is my preferred method. As the larger needle moves counter clockwise on the SKF TMCD 10R, I calculate the value which the needle must reach.
- One full revolution is 1 mm and the axial drive-up in this case is 0,686 mm (→ figure 9), so the larger needle must move from zero to 1,000 minus 0,686 = 0,314 mm (rounded to 0,31 mm).
- If the axial drive-up is greater than a mm (e.g. 2,35 mm), I count two full revolutions from zero and continue until the needle points to 1,00-0,35 = 0,65 mm.
- Some prefer to set the dial indicator to the requested axial drive-up by setting the needle on 0,686 mm (rounded to 0,69 mm) and then driving-up the bearing until the needle reaches zero. If, for example, the drive up is 2,35 mm, they would set the dial indicator needle on 0,35 mm. During drive-up, as soon as the needle reaches zero for the first time, they will count two more revolutions. I prefer setting the dial indicator to zero, because I'm used to my personal dial indicator which has a reverse scale. Starting from zero, I have a direct reading of the current drive-up position.

Step 10: Start drive-up and check dial indicator needle movement

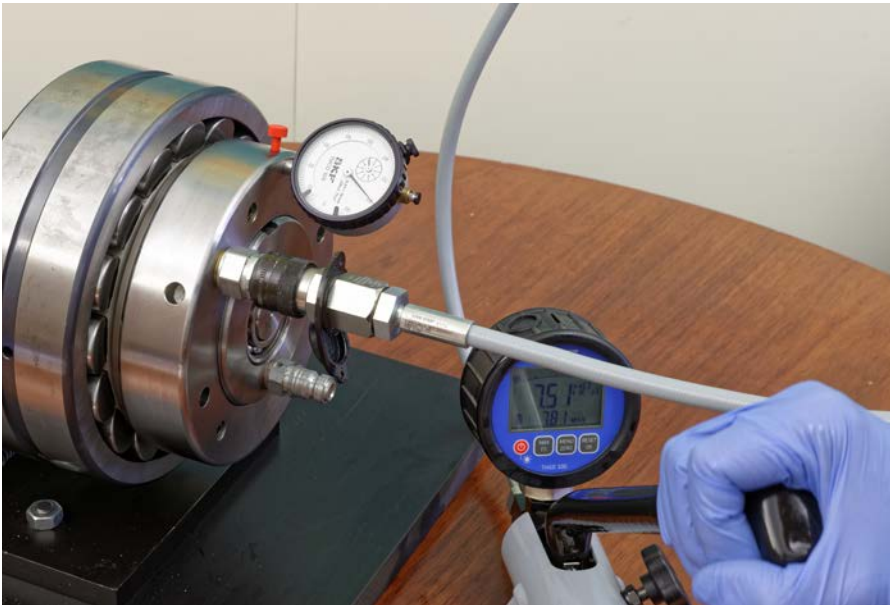


Fig. 13 Start drive-up and check dial indicator needle movement

Additional notes

- Injecting oil between the bearing inner ring and its seat to decrease friction is an option at the beginning of this stage for very large bearings. If so, SKF LHM 300 mounting fluid should be used. Higher viscosity oils should be avoided as it will take longer for them to exit the mating surfaces. For the viscosity, follow the recommendations given in step 1.
- When pumping, check the needle movement. I recommend that the person operating the pump also pays attention to the position of the needle. They are able to judge if something is wrong e.g. operating the pump lever and feeling the pressure increase, but the needle does not move. However, note that there is always a small delay between the needle starting to move and the pump pressure increasing because the friction of adhesion when the bearing is not moving is higher than the friction of sliding when it is.

- Focus on the current axial drive-up value rather than the pump pressure. For the same axial drive-up, the pressure can vary depending on the friction between the bearing and its seat. While the axial drive-up value is the important thing, keep an eye on the pump pressure to avoid exceeding pump/nut/pressure gauge maximum pressure.

For your information, the maximum working oil pressure for SKF HMV hydraulic nuts with permitted piston displacement is as follows:

- HMV(C) 60E and smaller:
80 MPa (11 600 psi)
- HMV(C) 62-100E:
40 MPa (5 800 psi)
- HMV(C) 102E and larger:
25 MPa (3 600 psi)

There is a risk of expelling the piston seal out of the nut with higher pressures. If this happens, it's easy to replace the seals, but it takes time. It happened to me once, not during a SKF Drive-up Method procedure, but while pushing a 3,5 ton bearing against its adjusted spacer with an air-driven hydraulic pump (the SKF THAP). The result? One hour lost. The permitted piston displacement is indicated in the *SKF Maintenance and Lubrication Products catalogue*. For the HMV 20 E used in the example, the permitted displacement is 5 mm.

Step 11: Pump until final axial drive-up value from starting position is reached



Fig. 14 Final axial position is reached

Additional notes

- SKF doesn't give any tolerances on the final value.
- In the past, there was a $\pm 5\%$ on the final value read on the dial indicator for drying and Yankee cylinders. A value of $\pm 5\%$ in this case would be $\pm 0,034$ so a range between 0,652 and 0,720 mm axial drive-up and thus 0,28 to 0,35 mm on the dial indicator scale. Anyone who has already used the SKF Drive-Up Method can tell that this tolerance is really huge since it is very easy to get very close to the final requested value by $\pm 0,01$ mm or less.

Step 12: When the final drive-up value is reached do not release hydraulic nut pressure, take a coffee break instead



Fig. 15 When the final drive-up value is reached, take a coffee break

Additional notes

- By “take a coffee break” I mean leave time for the oil between the bearing and its seat to escape from the mating surfaces. If the hydraulic nut oil pressure is released too early, the bearing could displace axially down its tapered seat and, in some cases, displace enough to lose any tight fit when the hydraulic nut is dismounted. To avoid this, some people dry mount the bearings, but this risks damaging the mating surfaces and needs much higher oil pressures which can lead to hydraulic nut piston seal damage. Don't do this as the bearing seat needs to be oiled for the SKF Drive-up Method. Without oil, the tight fit of the bearing on its seat will be lower than expected and the bearing service life will be reduced. See SKF Pulp & Paper Practices 16 for more information.
- The coffee break should be between 5 and 30 minutes if SKF LGMF 300 mounting fluid is used at normal temperature.
- The typical time per application is about 10 minutes for felt roll bearings, 20 minutes for drying cylinder bearings and 30 minutes for large press roll bearings.
- Bearing size can be used as a rough guideline. Rough because it also depends on bearing width: 10 minutes for bearings with bore diameter below 150 mm; 20 minutes for bearings with bore between 150 to 300 mm; 30 minutes for bearing with bore diameter larger than 300 mm. Note that at low temperatures, more time may be needed.

Step 13: Release the oil pressure and dismount the hydraulic nut



Fig. 16 The dial indicator needle moves backwards when the oil pressure is released

Additional notes

- When releasing the hydraulic nut oil pressure, the needle of the dial indicator moves backwards around 0,05 mm. Some believe that the bearing has moved. This is not the case if step 12 has been followed properly. It is only the hydraulic nut piston that moves backwards due to the elasticity of the piston seals. It is exactly the same thing that happens with the pistons on the brake callipers of your car. The brake pads move away from the disk when you release pressure on the brake pedal because the pistons move back in the callipers due to the elasticity of the seals.
- Do not forget to push back the hydraulic nut piston for the next bearing mounting. There are several methods, but the pump needs to be still connected to the hydraulic nut so that the oil can go back in the pump reservoir. One widely-used method is to further tighten the nut by hand before dismounting the hydraulic nut. Normally, the axial force needed to push the piston back is lower than the axial force necessary to push the bearing further along its seat. If so, the bearing will not move, but the piston will be pushed back into the nut.
- The recommended method is to dismount the nut, reconnect it to the pump and to use at least three C-clamps, located at 120° intervals around the nut, to push the piston back evenly without jamming it.

Closing remarks

The additional notes and the recommended coffee break make some people believe that the SKF Drive-up Method is more complicated and time-consuming than the feeler gauge method. This is not the case.

A lot of time is lost with the feeler gauge method finding the initial clearance and checking the clearance during drive-up. In addition, the feeler gauge method is based on feeling the clearance gap which is influenced by the position of the different bearing elements. It's much less accurate than the SKF Drive-up Method.

In the second half of the 1990s I had to mount CARB bearings on some drying cylinders at a paper mill. A man from the machine builder was also there mounting bearings, so we shared the work to speed the process up. I used two hydraulic nuts and two pumps and spent my "coffee break" dismantling an old bearing before driving-up a new bearing on another cylinder. I was much faster than the other man who didn't trust the SKF Drive-up Method and was using the feeler gauge method. I was slowed down by the limited number of hoists available to lift the cylinders, so I had quite a lot of waiting time and real coffee breaks while the man from the machine builder was struggling to measure CARB bearing clearance with a feeler gauge (see SKF Pulp & Paper Practices 13). After this, the machine builder started to use the SKF Drive-up Method.

Some people ask me why I do not check the bearing internal radial clearance. In most cases, I don't check initial bearing clearance, but for some applications I do a quick check just to make sure that clearance is within the range indicated in the bearing designation. I don't check final bearing clearance after mounting with the SKF Drive-up Method or with SKF SensorMount. I did it the first few times I used the SKF Drive-up Method, but experience has shown me that it's not necessary.



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