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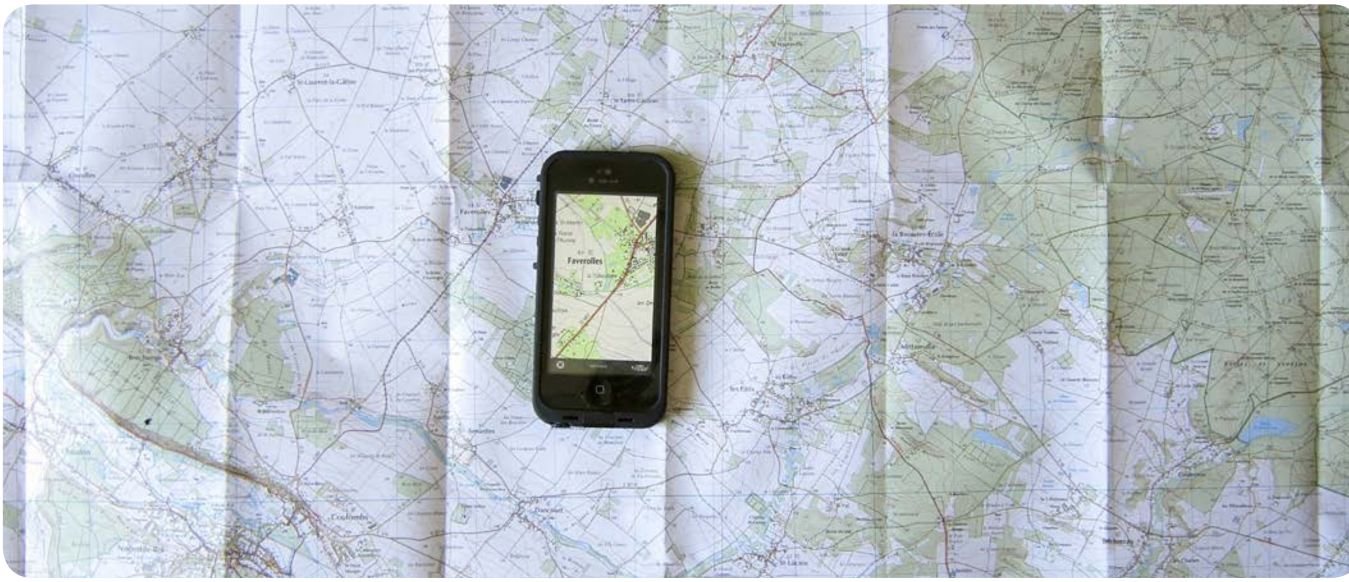
SKF Pulp & Paper Practices



Digital vs. paper information

Last year I was emailed a detailed drawing of a suction roll. The problem is that I have a 24 inch computer monitor and I could not make out any detail if I displayed the whole thing. This meant that I spent a lot of time zooming in and out on different parts of the drawing.

Two months later I received a copy of the 1m by 4m drawing rolled up in a cardboard tube. I mounted it on the wall of my office and very quickly came to the conclusion that there was either a design error or a drawing error. This was something I had missed when looking at it on my monitor.

With the drawing on my wall, I was able to discuss the bearing assembly with colleagues and make some quick modifications with pencil. This was not the first and doubtless will not be the last time I felt nostalgic for the days of drawing tables and paper drawings. One day perhaps, I might have a large A0 size monitor with good screen resolution, but I cannot see it being as light and as portable as a piece of paper of the same size.

Two weeks ago, I went off-road. In the past, I would have used a 1:25 000 scale paper map and a compass or relied on GPS. This time I made the mistake of just taking my smartphone and an app with a 1:25 000 scale map on it. As you've probably guessed by now, I was only able to see the details of a very small part of the map. You can imagine how much time I wasted zooming in and out checking where I wanted to go and how I should get there. In hindsight, I'd have been much better off sticking to my usual method which is a paper map for an overview and GPS as the main tool for directions while driving.

Some of my colleagues argue that an electronic device allows you to travel with more catalogues, brochures and technical documents than you could realistically carry. This is true and I do use my smartphone and laptops during customer visits to search for information in the SKF rolling bearings catalogue, for example. However, I always use hard copies when I'm in the office as it's much easier to turn the page and I don't need to be constantly zooming in and out. For me, digital information is a supplement to, rather than a replacement for, paper products.

Regards,
Philippe Gachet
Senior technical consultant
SKF Pulp & Paper global segment

Fulfilling promises and responding to questions

In this issue of SKF Pulp & Paper Practices I will address a number of different issues:

1. ***Whether there is a method to make sure that there is a good shaft/bearing contact when checking the seat with Prussian blue.***
2. ***The number of diameter measurements needed to check ovality.***
3. ***T_m values for high precision radial run out bearings e.g. SKF C08, VQ424 and VA460 variants.***
4. ***Bearing failure pie chart differences.***

1. Good shaft/bearing contact when checking a bearing seat with Prussian blue?

I was asked a question by an equipment manufacturer after *issue 13 of SKF Pulp & Paper Practices* was published. He wanted to know whether there was a reliable and accurate way to ensure that a bearing has intimate contact with its seat. He was talking about heavy bearings which need a crane to lift them. A typical example would be a Yankee bearing (→ **figure 1**).

As you can see, the bearing is suspended by a fixed length strap from a crane. If you were to push this bearing without moving the crane at the same speed, the bearing would move upwards. A maintenance worker could not slam this bearing in place. If it was held in place by hand, it would be resting on the top of the journal. This is why most of the Prussian blue can be seen on the top.

I listed my recommendations on what to do about this in *issue 13*. They included using a spring on the crane strap and the use of the nut and hammer method to ensure good contact without too much drive-up.

The equipment manufacturer wanted to know if there was a better and less subjective approach than my nut and hammer method that didn't require experienced fitters. One that relied on hydraulic pressure or applying torque to a lock nut perhaps. I promised to give him an answer in *issue 15 of SKF Practices* and a promise is a promise.

Fig. 1 *Prussian blue check with poor bearing/shaft contact*

I quickly discarded the idea of torque on a nut as it is not accurate enough. The possibility for variation depending on friction in the threads and between the nut and the bearing inner ring plus thread cleanliness and condition is too great. Also, as you don't use a simple torque wrench on a 500 mm or larger nut anyway, I decided to forget it.

I then undertook some research in the archives as this is a similar issue to the one to determine the position before axial drive-up using the axial drive-up figures quoted in the bearing catalogues. The SKF catalogue *Rolling bearings* clearly states that the drive-up data tables are to be used as a guideline only as it is difficult to establish the exact starting position. I drew a blank with my research.

Note that the SKF Drive-up method gives a starting position with some clearance reduction. This is not the same starting position for axial drive-up values quoted in the SKF catalogue *Rolling bearings* in which there is no clearance reduction, just the position before clearance reduction. As such, using the oil pressure injected in a hydraulic nut from the SKF Drive-up method is not suitable for Prussian blue checking. Neither is the difficult to determine starting position from the old method because the bearing has already deformed to take the shaft form and we don't want this to happen in a Prussian blue check. For a short recap about the different positions, see **table 1**.

The question is how much pressure is needed in the hydraulic nut to hold the bearing in position with circumferential contact, but without forcing it to take the form of its seat. As the Prussian blue check would be correct if the shaft was vertical and the bearing was resting on its own weight, I calculated the pressure necessary to push a bearing with an axial load equal to its weight, to offset the axial load due to the taper angle pushing the bearing down the tapered journal and to overcome the friction between the bearing and the journal.

Table 1

Definitions of bearing positions as stated in this article

a **Bearing position for Prussian blue checking**
The bearing should rest on the journal just like if it was resting on the journal in a vertical position. With its axis in the vertical position, the bearing rings will not deform under their own weight and will be concentric with the journal. In theory, the bearing should just touch the journal as if the bearing bore and shaft tapered seat are perfect tapers with the same angle and 100% of the surfaces will be in contact. Any further displacement of the bearing, due to its own weight for example, could force the bearing to start to take the shaft form if it is not a perfect taper. In practice, due to manufacturing tolerances, a slight further displacement should be accepted, but to what value?

b **Starting position in the axial drive-up method**
The position just before the bearing inner ring expends radially.

c **Starting position in the SKF Drive-up method**
The position in which the bearing inner ring has already radially expended with a radial clearance reduction of 0,00009 times the bearing bore diameter.

Note that the distance between position **a** and **b** or **a** and **c** depend on the real form of the bearing bore and the tapered seat on the journal.

I knew that the pressure values would be smaller than the ones used to find the starting position, but they are smaller than I expected:

- 0,03 MPa for a 22320 which is a 13,5 kg bearing
- 0,08 MPa for a 23176 which is a 230 kg bearing
- 0,30 MPa for a 241/900 which is a 3 350 kg bearing

An issue is that the pressure gauges used for the SKF Oil Injection and SKF Drive-up methods are not very precise at such small values as 0.03 MPa (the SKF THGD 100 digital gauge, for instance, is rated at +/–0,1 MPa) and that suitable gauges could not withstand the pressures that the pumps used could deliver.

Next, I tried the hands on approach with a 22320 EK bearing. First, I slammed the bearing on to its tapered seat and used a micrometer set to zero as the reference (→ **figure 2**). This is the right position for the Prussian blue method for a bearing of this size and it can easily be removed by hand. Then I positioned the bearing with the nut and hammer plus sound method (→ **figure 3**). The bearing was driven-up further and needed to be gently hammered to dismount it, but the distance was less than 0,08 mm even after three attempts. Finally, a hydraulic nut was used to position the bearing (→ **figure 4**). The idea was to measure the oil pressure when the bearing was in the slam position and then again in the sound position and to note the position of the bearing with the calculated pressure.

The result with the hydraulic nut was that the pressure needed was higher than the calculated pressure even before the bearing reached the slam position. The main reason, which I hadn't accounted for, was the friction of the hydraulic nut piston seals.

I also found that the pressure is nearly constant before and while passing the slam position and while passing the sound position. The pressure increases quickly as the bearing inner rings starts to take the shape of the journal after reaching a position around 0,2–0,3 mm beyond the slam position. The SKF Drive-up method starting position with 4,1 MPa is never reached in the range of the micrometer.

An additional finding was that the curve pressure/position is not consistent. The test has poor repeatability. Pressure variation was more than 50% of the calculated pressure.

The conclusion, in my opinion, is that the sound method is more reliable than the hydraulic nut method. I do not think that it is worth continuing with and trying to know the range of pressure in which seat form errors are still apparent. There are too many considerations to take account of. As such, if a less subjective method is needed, then I think a 3D inspection with a portable coordinate measuring device is the way to do it.

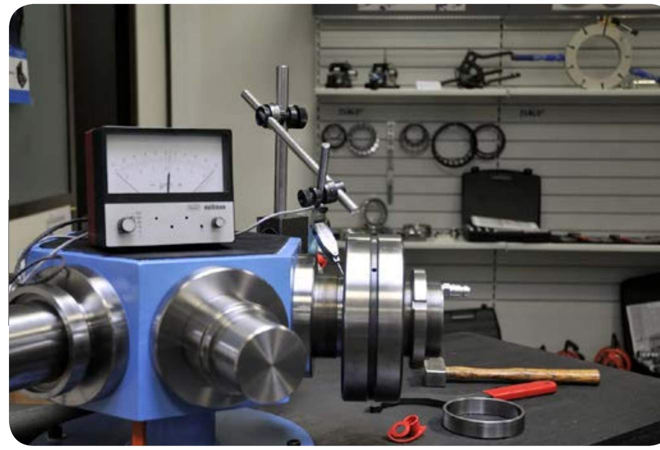


Fig. 2 *Bearing position after being slammed into place*

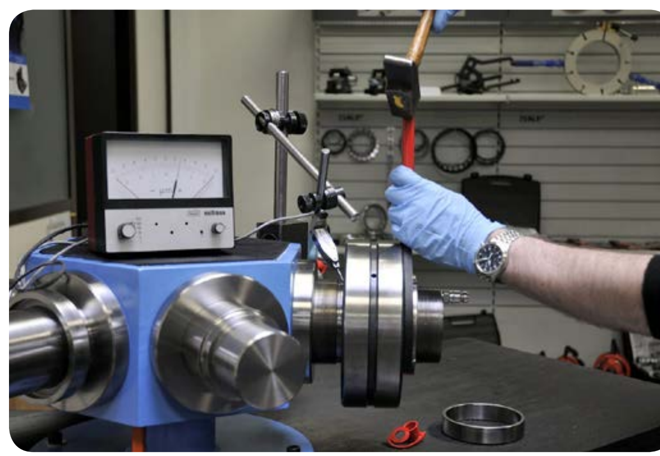
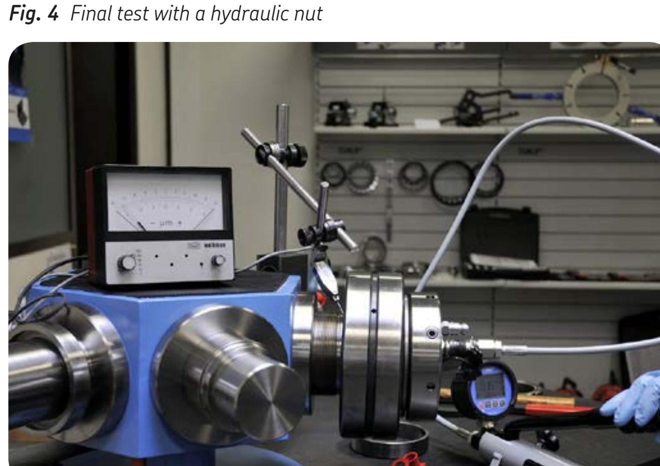


Fig. 3 *Bearing position with the nut and hammer plus sound method once the sound becomes more metallic*

Fig. 4 *Final test with a hydraulic nut*



2. The number of diameter measurements needed to check ovality

Joe B Conyers from SKF USA sent an email after reading *SKF Pulp & Paper Practices 13* to tell me that taking three measurements around the journal was not enough to check circularity, but four measurements should be enough.

Joe was right. Regardless of what sometimes happens in the field, four measurements should be the minimum to be considered good practice (→ **figure 5**).

While taking more measurements does lead to a clearer picture of form errors, a balance needs to be struck between accuracy and practicality. While thinking about this I wondered how many bearing and machine issues were due to form errors that were not discovered during measuring. I checked our archives and did not find a single case. This, of course, does not mean that they don't exist.

My time spent in the archives was useful though as I spotted a number of things. I saw that most reports had four diameter measurements, but some had only three. I also noted that in some reports the diameter values were close to the maximum of the tolerances, in or out. It was a pity that the type and precision class of the tools used was not indicated though.

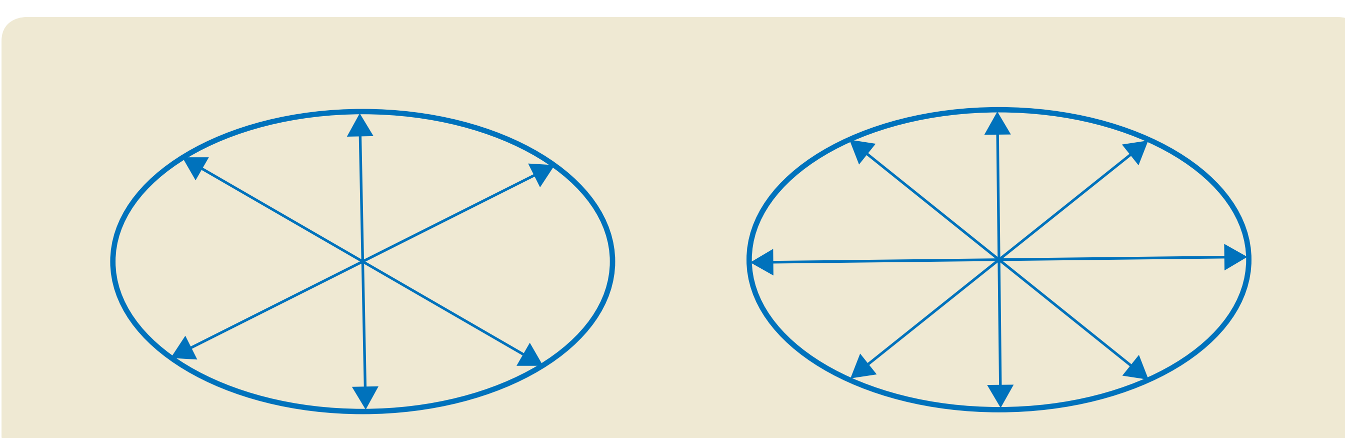
Coming back to good practice, I think that the direction of the load should be indicated and documented as bearing seat circularity can increase or decrease the load on the most heavily loaded rolling element and therefore affect bearing fatigue life. So, having a bearing seat cylindricity/circularity that is out of tolerance is not always bad.

In cases where the direction of the load is fixed relative to the bearing seat, at least one measurement should be taken in the load direction.

Table 2 shows an example of a measuring report form for a cylindrical bearing seat. Note that it is designed for one bearing seat only, so simply cross out the drawing that is not applicable. Note also that some industries like steel use bearings with four rows of rolling elements and measurements can be taken in more than just two radial planes.

Table 3 is an example of a measuring report when using the SKF 9205 taper gauge.

Fig. 5 *Increasing the number of diameter measurements increases the possibility to get measurements close to the minimum and maximum diameter*



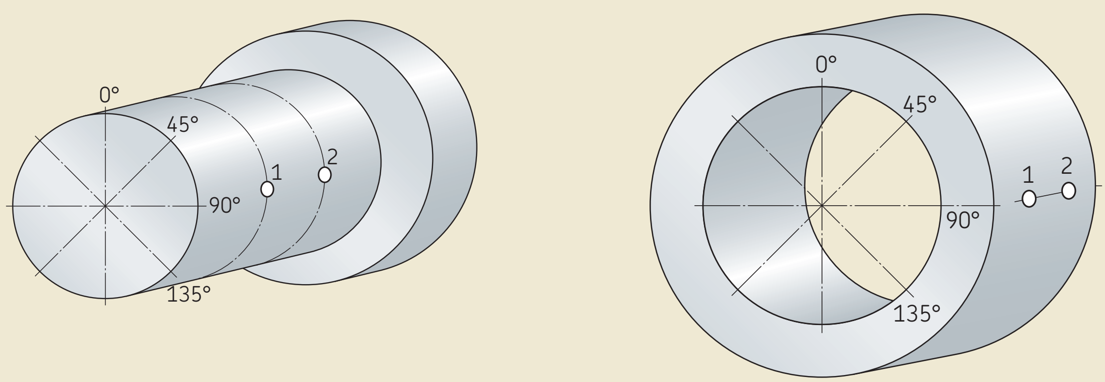
3. T_m values for high precision radial run out bearings

After publishing *SKF Pulp & Paper Practices 14*, I was asked about the T_m values for bearings with C08, VQ424 and VA460 suffixes i.e. bearings with reduced radial run out tolerances. The reason was that the values listed in **table 1** in that issue state that they are for normal precision SKF bearings only.

The answer is that the bore of such bearings are manufactured to the normal precision shown in the SKF catalogue *Rolling bearings* unless indicated otherwise by an additional suffix. As such, in most cases, simply use the values shown in *SKF Pulp & Paper Practices 14*.

Machine	
Application and position	
Bearing designation	
Measuring tool type	
Precision class or accuracy	
Zero setting standard bar	Type:
Last standard bar control	Date:

Draw on drawing direction of load

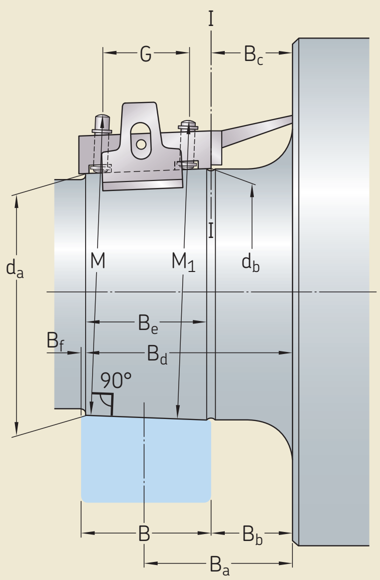


Nominal diameter:		mm:	Tolerance on diameter: Tolerance on cylindricity:			
All values in mm	0	45°	90°	135°	Deviation	Total deviation
Plane 1						
Plane 2						
Comments on straightness :						

Comments:	
Date:	Name:

Table 2 *Measuring form report for a cylindrical seat*

Machine	
Application and position	
Bearing designation	
Measuring tool type	
Precision class or accuracy	
Zero setting standard bar	Type:
Last standard bar control	Date:



B =
B_c =
B_e =
B_a =
B_f =
G =

SKF Gauge 9205... - ....

B_d =
d_a =
d_b =
M = +/–
Circularity =
M_1–M =

If adjusted spacer
B_b =
B_h =

All values in mm	0	45°	90°	135°	Deviation	ΔM
M						
M_1						
M_1–M						
If adjusted spacer: B_{be} =						
Comments on straightness :						

Comments:	
Date:	Name:

Table 3 *Measuring report form for a tapered seat checked with the SKF 9205 tool*

4. Bearing failure pie charts

I remember a presentation to a group of customers from different French paper mills and being questioned about failure causes. I had told them that 25% of bearings fail due to inadequate lubrication. They queried this. One told me that he was always led to believe that 43% fail due to this cause. Another consulted the SKF Maintenance products catalogue and said 36% is written here.

In fact, all the figures are correct, but we need to understand how they have been estimated and to know that they are for industries and applications in general. This leads to a situation where the main bearing failure cause, in general, is lubrication whereas we know that the main cause in paper machines is water ingress.

The 43% comes from an SKF France estimation based on bearing failure analysis for all industries (→ **diagram 1**). SKF Sweden came up with different estimates and the 36% comes from them (→ **diagram 2**). SKF USA had different estimates (→ **diagram 3**). As did other SKF countries. For consistency in SKF documents, it was decided to use the Swedish estimate.

The differences between the estimates, in my opinion, are due to the following reasons:

1 The types of industries present in the countries.
2 How the local SKF engineer classes the bearing failure.
3 Simplification of the pie charts to show only the main causes
4 Culture, experience etc.

Bearing failure analysis, for instance, is not as simple as it might sound. For example, water ingress in the lubricant leads to inadequate lubrication, but if there is no sign of corrosion and if there is incomplete information, the failure cause could be noted as inadequate lubrication.

The 25% from my presentation was derived from the main bearing failure cause in paper machines and based on discussions between mill maintenance people and SKF engineers (→ **diagram 4**). As I was presenting to a European audience, I used the European figures. For a group from the USA and Brazil, the figures would have been different (→ **diagram 5**). Nevertheless, water ingress would still be the main failure cause.

For paper or tissue machines, it is possible to examine applications in more detail (→ **diagram 6**). You will note that no percentages are indicated. This is done on purpose as I believe that estimates based on known cases do not reflect reality with sufficient precision.

SKF has not created estimates for all the bearing applications in all the different types of mill and, to be frank, I'm a little reluctant to do such a study. Not because it is time-consuming, but because I prefer that the analysis is done on the mill level to facilitate specific corrective actions. Sometimes this can lead to big surprises as the following story shows.

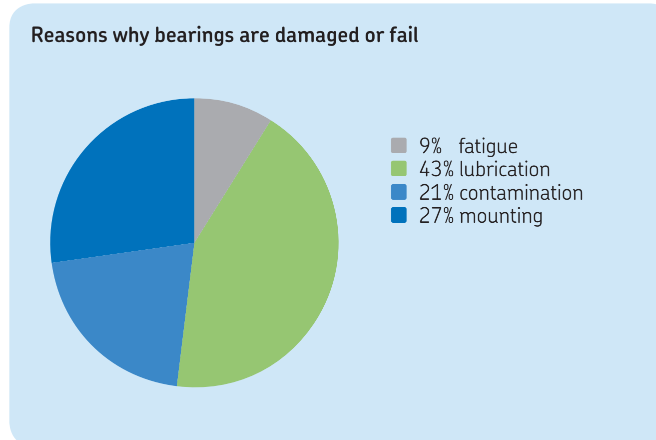


Diagram 1 *SKF France's estimation of damage or failure causes for all industries*

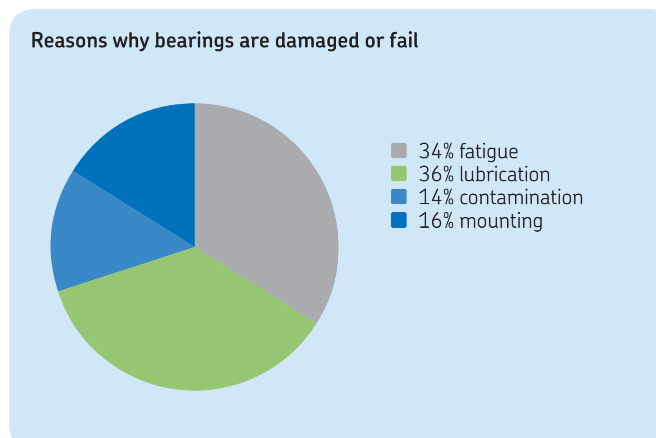


Diagram 2 *SKF Sweden's estimation of damage or failure causes for all industries*

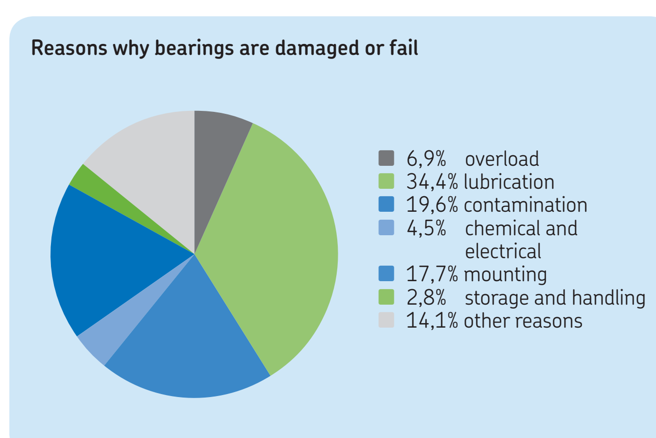


Diagram 3 *SKF USA's estimation of damage of failure causes for all industries*

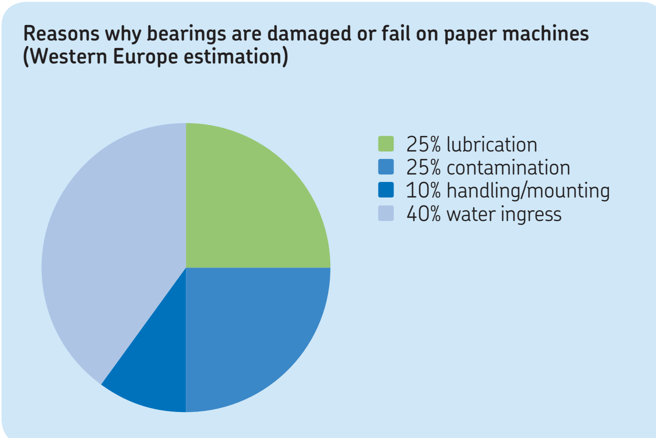


Diagram 4 *The main causes of bearing damage or failures in paper machines in Western Europe*

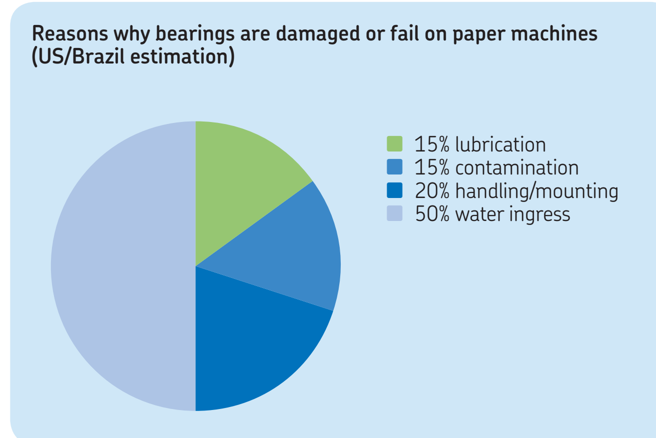


Diagram 5 *The main causes of bearing damage or failures in paper machines in the USA and Brazil*

A good SKF customer was sending us bearings for failure analysis perhaps once or twice a year. Over the years, a picture built up showing that the main causes were lubrication and water ingress.

An Integrated Maintenance Solutions (IMS) contract was later signed with the mill. To reduce their bearing consumption, we agreed that all dismounted bearings would be stored with some paperwork indicating the bearing application, position and the reason for dismounting them. Every quarter I would travel to the mill to examine the bearings together with some of the mill's operations and maintenance people. The idea was that this would be a form of training for them.

We didn't undertake detailed failure analysis on all the bearings. We reserved that for the critical ones. Nevertheless, we did examine all the bearings. Most of them would never have been sent to SKF for failure analysis as they weren't in a critical application or they were comparatively cheap or they were not the cause of unplanned stops. Normally, they would have just been scrapped.

After a few visits to the mill, it quickly became apparent that most bearings were failing due to solid contamination rather than water ingress or inadequate lubrication.

What should we learn from this story? That bearing failure cause pie charts are based on reports and statistics compiled by manufacturers from failures that they have seen. Also that measuring and creating pie charts is one thing, but that selecting the right and most appropriate corrective actions is what really counts.

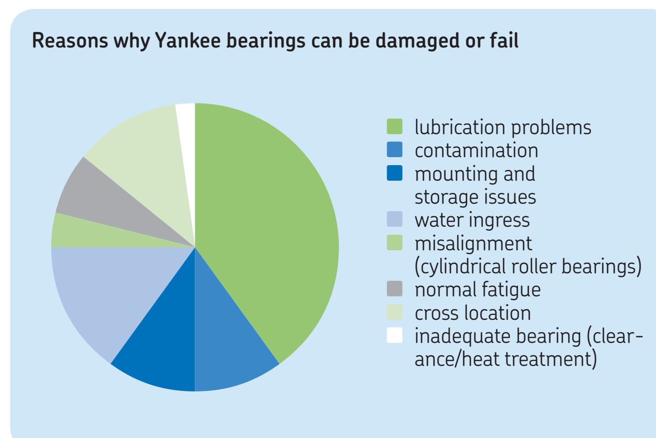


Diagram 6 *The main causes of Yankee bearing damage or failures*

Regards,
Philippe Gachet
Senior technical consultant
Philippe.gachet@skf.com

The Power of Knowledge Engineering

Combining products, people, and application-specific knowledge, SKF delivers innovative solutions to equipment manufacturers and production facilities in every major industry worldwide. Having expertise in multiple competence areas supports SKF Life Cycle Management, a proven approach to improving equipment reliability, optimizing operational and energy efficiency and reducing total cost of ownership.

These competence areas include bearings and units, seals, lubrication systems, mechatronics, and a wide range of services, from 3-D computer modelling to cloud-based condition monitoring and asset management services.

SKF's global footprint provides SKF customers with uniform quality standards and worldwide product availability. Our local presence provides direct access to the experience, knowledge and ingenuity of SKF people.

SKF Global Pulp & Paper Segment

Contact/Responsible editor
philippe.gachet@skf.com

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